FUEL SYSTEM

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GENERAL INFORMATION

INTRODUCTION

Throughout this group, references may be made to a particular vehicle by letter or number designation. A chart showing the breakdown of these designations is included in the Introduction Section at the front of this service manual.

The Evaporation Control System, is also considered part of the fuel system. The system reduces the emission of fuel vapor into the atmosphere.

The description and function of the Evaporation Control System is found in Group 25 of this manual.

FUEL REQUIREMENTS

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

Use unleaded gasolines having a minimum posted octane of 87.

If your vehicle develops occasional light spark knock (ping) at low engine speeds this is not harmful. However; continued heavy knock at high speeds can cause damage and should be reported to your dealer immediately. Engine damage as a result of heavy knock operation may not be covered by the new vehicle warranty.

In addition to using unleaded gasoline with the proper octane rating, those that contain detergents, corrosion and stability additives are recommended. Using gasolines that have these additives will help improve fuel economy, reduce emissions, and maintain vehicle performance.

Poor quality gasoline can cause problems such as hard starting, stalling, and stumble. If you experience these problems, try another brand of gasoline before considering service for the vehicle.

GASOLINE/OXYGENATE BLENDS

Some fuel suppliers blend unleaded gasoline with materials that contain oxygen such as alcohol, MTBE (Methyl Tertiary Butyl Ether) and ETBE (Ethyl Tertiary Butyl Ether). Oxygenates are required in some areas of the country during winter months to reduce carbon monoxide emissions. The type and amount of oxygenate used in the blend is important.

The following are generally used in gasoline blends:

Ethanol - (Ethyl or Grain Alcohol) properly blended, is used as a mixture of 10 percent ethanol and 90 percent gasoline. Gasoline blended with ethanol may be used in your vehicle.

MTBE/ETBE - Gasoline and MTBE (Methyl Tertiary Butyl Ether) blends are a mixture of unleaded gasoline and up to 15 percent MTBE. Gasoline and ETBE (Ethyl Tertiary Butyl Ether) are blends of gasoline and up to 17 percent ETBE. Gasoline blended with MTBE or ETBE may be used in your vehicle.

Methanol - Methanol (Methyl or Wood Alcohol) is used in a variety of concentrations blended with unleaded gasoline. You may encounter fuels contain-

ing 3 percent or more methanol along with other alcohols called cosolvents.

DO NOT USE GASOLINES CONTAINING METHANOL.

Use of methanol/gasoline blends may result in starting and driveability problems and damage critical fuel system components.

Problems that are the result of using methanol/gasoline blends are not the responsibility of Chrysler Corporation and may not be covered by the vehicle warranty.

Reformulated Gasoline

Many areas of the country are requiring the use of cleaner-burning fuel referred to as **Reformulated Gasoline**. Reformulated gasolines are specially blended to reduce vehicle emissions and improve air quality.

Chrysler Corporation strongly supports the use of reformulated gasolines whenever available. Although your vehicle was designed to provide optimum performance and lowest emissions operating on high quality unleaded gasoline, it will perform equally well and produce even lower emissions when operating on reformulated gasoline.

Materials Added to Fuel

Indiscriminate use of fuel system cleaning agents should be avoided. Many of these materials intended for gum and varnish removal may contain active solvents of similar ingredients that can be harmful to fuel system gasket and diaphragm materials.

FUEL REQUIREMENTS—DIESEL ENGINE

WARNING: Do not use alcohol or gasoline as a fuel blending agent. They can be unstable under certain conditions and hazardous or explosive when mixed with diesel fuel.

Use good quality diesel fuel from a reputable supplier in your Dodge truck. For most year-round service, number 2 diesel fuel meeting ASTM specification D-975 will provide good performance. If the vehicle is exposed to extreme cold (below 0°F/-18°C), or is required to operate at colder-than-normal conditions for prolonged periods, use climatized No. 2 diesel fuel or dilute the No. 2 diesel fuel with 50% kerosene or No. 1 diesel fuel. This will provide better protection from fuel gelling or wax-plugging of the fuel filters.

Diesel fuel is seldom completely free of water. To prevent fuel system trouble, including fuel line freezing in winter, drain the accumulated water from the fuel/water separator using the fuel/water separator drain provided. If you buy good-quality fuel and follow the cold-weather advice above, fuel conditioners should not be required in your vehicle If available in your area, a high cetane “premium” diesel fuel may offer improved cold starting and warm-up performance

FUEL DELIVERY SYSTEM-GASOLINE ENGINE

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DESCRIPTION AND OPERATION

FUEL DELIVERY SYSTEM—GASOLINE POWERED ENGINES

The fuel delivery system consists of:

- the fuel pump module containing the electric fuel pump, fuel filter/fuel pressure regulator, rollover valve (certain modules), fuel gauge sending unit (fuel level sensor) and a separate fuel filter located at bottom of pump module
- fuel tubes/lines/hoses
- quick-connect fittings
- fuel injector rail
- fuel injectors
- fuel tank
- fuel tank filler/vent tube assembly
- fuel tank filler tube cap
- accelerator pedal
- throttle cable

Fuel is returned through the fuel pump module and back into the fuel tank through the fuel filter/fuel pressure regulator. A separate fuel return line from the engine to the tank is not used with any gasoline powered engine.

The fuel tank assembly consists of: the fuel tank, fuel pump module assembly, fuel pump module locknut/gasket and rollover valve(s) (refer to Group 25, Emission Control System for rollover valve information).

A fuel filler/vent tube assembly using a pressure/vacuum fuel filler cap is used. On vehicles equipped with the California emissions package, the fuel filler tube contains a spring-loaded flap (door) located below the fuel fill cap. The flap is used as a secondary way of sealing the fuel tank if the fuel fill cap has not been properly tightened. It is part of EVAP monitor system when vehicle is equipped with a Leak Detection Pump (LDP).

Also to be considered part of the fuel system is the evaporation control system. This is designed to reduce the emission of fuel vapors into the atmosphere. The description and function of the Evaporative Control System is found in Group 25, Emission Control Systems.

Both fuel filters (at bottom of fuel pump module and within fuel pressure regulator) are designed for

DESCRIPTION AND OPERATION (Continued)

extended service. They do not require normal scheduled maintenance. Filters should only be replaced if a diagnostic procedure indicates to do so.

FUEL PUMP MODULE

The fuel pump module on all gas powered engines is installed in the top of the fuel tank (Fig. 1) or (Fig. 2). The fuel pump module (Fig. 1), (Fig. 2) or (Fig. 3) contains the following:

- A combination fuel filter/fuel pressure regulator
- Electric fuel pump
- Fuel pump reservoir
- A separate in-tank fuel filter (at bottom of module)
- Rollover valve (certain modules)
- Fuel gauge sending unit (fuel level sensor)
- Fuel supply line connection at filter/regulator
- A threaded locknut retaining pump module to fuel tank
- A gasket between tank flange and module
- Auxiliary non-pressurized fuel supply fitting (not all engines)

The fuel gauge sending unit (fuel level sensor), and pick-up filter (at bottom of module) may be serviced separately. If the electrical fuel pump requires service, the entire fuel pump module must be replaced. The fuel filter/fuel pressure regulator may be serviced separately. Refer to Fuel Filter/Fuel Pressure Regulator Removal/Installation for additional information.

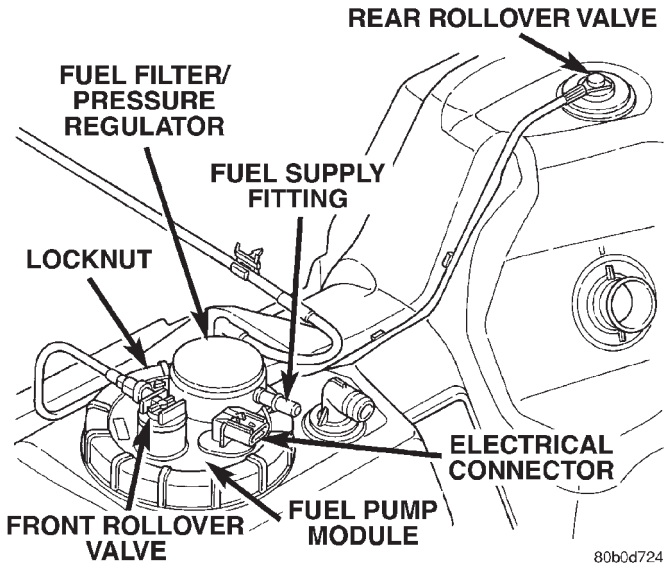


Fig. 1 Top View Fuel Pump Module—Gas Powered With 26 or 34 Gallon Tank—Typical

FUEL PUMP

The fuel pump used in this system has a permanent magnet electric motor. The pump is part of the fuel pump module. Fuel is drawn in through a filter

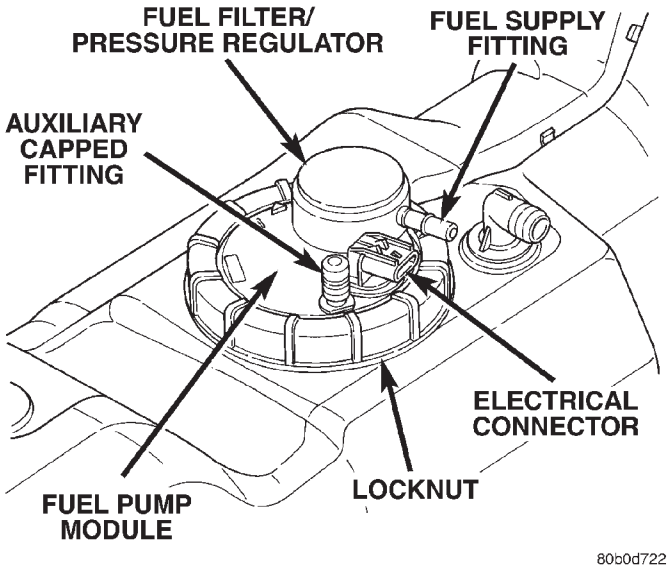


Fig. 2 Top View Fuel Pump Module—Gas Powered With 35 Gallon Tank—Typical

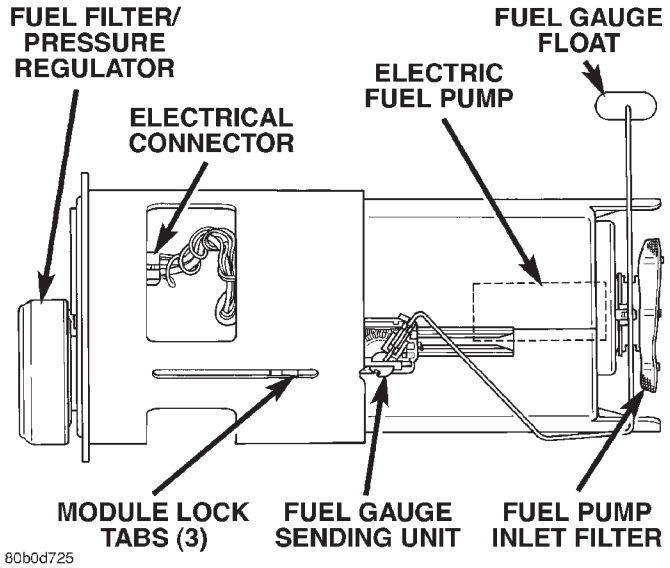


Fig. 3 Fuel Pump Module Components—Gas Powered Engines (Typical Module Shown)

at the bottom of the module and pushed through the electric motor gearset to the pump outlet.

Check Valve Operation: The pump outlet contains a one-way check valve to prevent fuel flow back into the tank and to maintain fuel supply line pressure (engine warm) when pump is not operational. It is also used to keep the fuel supply line full of gasoline when pump is not operational. After the vehicle has cooled down, fuel pressure may drop to 0 psi (cold fluid contracts), but liquid gasoline will remain in fuel supply line between the check valve and fuel injectors. **Fuel pressure that has dropped to 0 psi on a cooled down vehicle (engine off) is a**

DESCRIPTION AND OPERATION (Continued)

normal condition. Refer to the Fuel Pressure Leak Down Test in this group for more information.

Voltage to operate the electric pump is supplied through the fuel pump relay.

FUEL GAUGE SENDING UNIT

The fuel gauge sending unit (fuel level sensor) 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 resistor track is used to send electrical signals to the Powertrain Control Module (PCM) for fuel gauge operation and for OBD II emission requirements.

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

After this fuel level signal is sent to the PCM, the PCM will transmit the data across the CCD bus circuits to the instrument panel. Here it is translated into the appropriate fuel gauge level reading.

For OBD II emission monitor requirements: A voltage signal is sent from the resistor track on the sending unit to the PCM to indicate fuel level. The purpose of this feature is to prevent the OBD II system from recording/setting false misfire and fuel system monitor trouble codes. The feature is activated if the fuel level in the tank is less than approximately 15 percent of its rated capacity. If equipped with a Leak Detection Pump (EVAP system monitor), this feature will also be activated if the fuel level in the tank is more than approximately 85 percent of its rated capacity.

FUEL FILTER/FUEL PRESSURE REGULATOR

A combination fuel filter and fuel pressure regulator (Fig. 4) is used on all engines. It is located on the top of the fuel pump module. A separate frame mounted fuel filter is not used with any engine.

Both fuel filters (at bottom of fuel pump module and within fuel pressure regulator) are designed for extended service. They do not require normal scheduled maintenance. Filters should only be replaced if a diagnostic procedure indicates to do so.

Fuel Pressure Regulator Operation: The pressure regulator is a mechanical device that is not controlled by engine vacuum or the powertrain control module (PCM).

The regulator is calibrated to maintain fuel system operating pressure of approximately 339 kPa ± 34 kPa (49.2 psi ± 5 psi) at the fuel injectors. It contains a diaphragm, calibrated springs and a fuel return valve. The internal fuel filter (Fig. 4) is also part of the assembly.

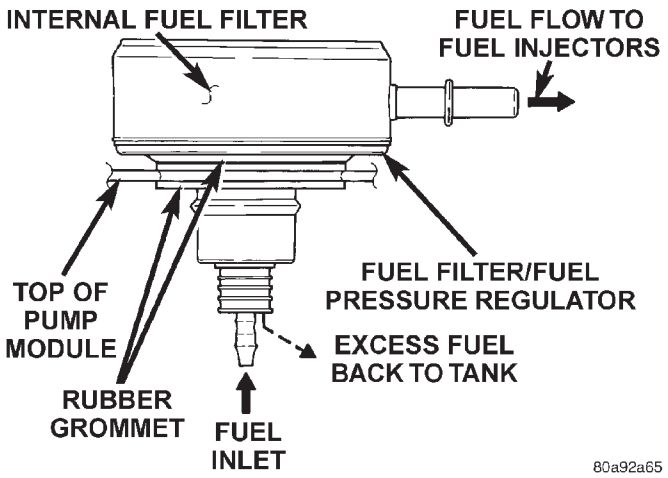


Fig. 4 Side View—Filter/Regulator

Fuel is supplied to the filter/regulator by the electric fuel pump through an opening tube at the bottom of filter/regulator (Fig. 4).

The regulator acts as a check valve to maintain some fuel pressure when the engine is not operating. This will help to start the engine. A second check valve is located at the outlet end of the electric fuel pump. **Refer to Fuel Pump—Description and Operation for more information. Also refer to the Fuel Pressure Leak Down Test and the Fuel Pump Pressure Tests.**

If fuel pressure at the pressure regulator exceeds approximately 49.2 psi, an internal diaphragm opens and excess fuel pressure is routed back into the tank through the bottom of pressure regulator.

FUEL TANK

All models pass a full 360 degree rollover test without fuel leakage. To accomplish this, fuel and vapor flow controls are required for all fuel tank connections.

All models are equipped with either one or two rollover valves mounted into the top of the fuel tank (or pump module). Refer to Group 25, Emission Control System for rollover valve information.

An evaporation control system is connected to the rollover valve(s) to reduce emissions of fuel vapors into the atmosphere. When fuel evaporates from the fuel tank, vapors pass through vent hoses or tubes to a charcoal canister where they are temporarily held. When the engine is running, the vapors are drawn into the intake manifold. Certain models are also equipped with a self-diagnosing system using a Leak Detection Pump (LDP). Refer to Group 25, Emission Control System for additional information.

ROLLOVER VALVE(S)

Refer to Group 25, Emission Control System for information.

DESCRIPTION AND OPERATION (Continued)

FUEL INJECTORS

The fuel injectors (Fig. 5) are electrical solenoids. The injector contains a pintle that closes off an orifice at the nozzle end. When electric current is supplied to the injector, the armature and needle move a short distance against a spring, allowing fuel to flow out the orifice. Because the fuel is under high pressure, a fine spray is developed in the shape of a pencil stream. The spraying action atomizes the fuel, adding it to the air entering the combustion chamber.

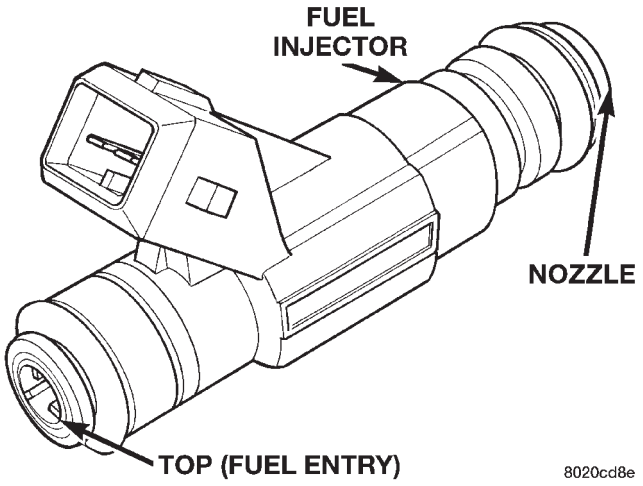


Fig. 5 Fuel Injector—Typical

An individual fuel injector is used for each individual cylinder. The top (fuel entry) end of the injector is attached into an opening on the fuel rail.

The nozzle (outlet) ends of the injectors are positioned into openings in the intake manifold just above the intake valve ports of the cylinder head. The engine wiring harness connector for each fuel injector is equipped with an attached numerical tag (INJ 1, INJ 2 etc.). This is used to identify each fuel injector.

The injectors are energized individually in a sequential order by the powertrain control module (PCM). The PCM will adjust injector pulse width by switching the ground path to each individual injector on and off. Injector pulse width is the period of time that the injector is energized. The PCM will adjust injector pulse width based on various inputs it receives.

During start up, battery voltage is supplied to the injectors through the ASD relay. When the engine is operating, voltage is supplied by the charging system. The PCM determines injector pulse width based on various inputs.

FUEL RAIL—3.9/5.2/5.9L ENGINES

The fuel rail supplies the necessary fuel to each individual fuel injector and is mounted to the intake manifold (Fig. 6). The fuel pressure regulator is not mounted to the fuel rail on any engine. It is located on the fuel tank mounted fuel pump module. Refer to Fuel Filter/Fuel Pressure Regulator in this section of group for information.

The fuel rail is not repairable.

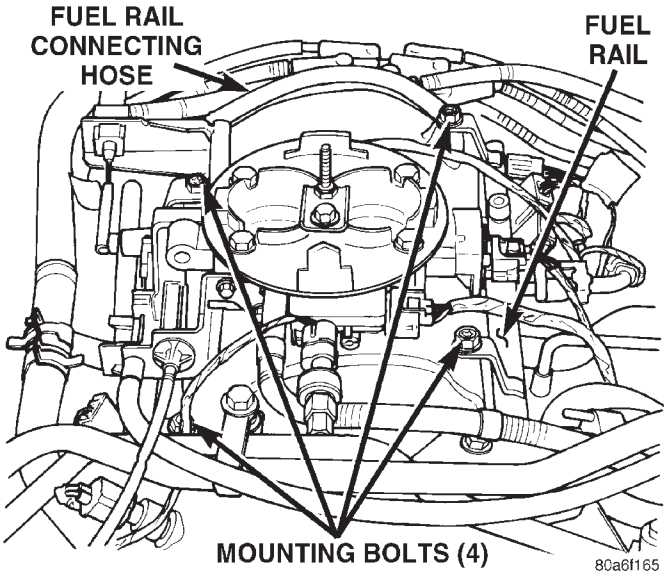


Fig. 6 Fuel Rail—3.9/5.2/5.9L Engine—Typical

CAUTION: The left and right sections of the fuel rail are connected with a flexible connecting hose. Do not attempt to separate the rail halves at this connecting hose. Due to the design of this connecting hose, it does not use any clamps. Never attempt to install a clamping device of any kind to the hose. When removing the fuel rail assembly for any reason, be careful not to bend or kink the connecting hose.

FUEL RAIL—8.0L ENGINE

The fuel rail supplies the necessary fuel to each individual fuel injector and is mounted to the lower half of the two-piece intake manifold (Fig. 7). The metal, one-piece fuel rail is not repairable.

FUEL TANK FILLER TUBE CAP

The loss of any fuel or vapor out of filler neck is prevented by the use of a pressure-vacuum fuel tank filler tube cap. Relief valves inside the cap will release fuel tank pressure at predetermined pressures. Fuel tank vacuum will also be released at predetermined values. This cap must be replaced by a similar unit if replacement is necessary. This is in order for the system to remain effective.

DESCRIPTION AND OPERATION (Continued)

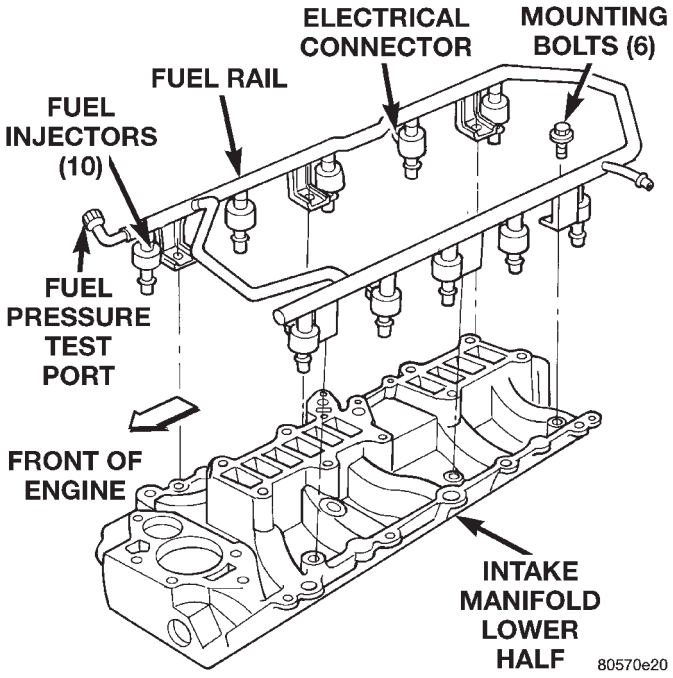


Fig. 7 Fuel Rail—8.0L Engine

CAUTION: Remove fuel tank filler tube cap before servicing any fuel system component. This is done to help relieve tank pressure. If equipped with a California emissions package and a Leak Detection Pump (LDP), the secondary seal below the fill cap must be pressed (opened) to relieve fuel tank pressure.

QUICK-CONNECT FITTINGS

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. Some are equipped with safety latch clips. Refer to 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.

DIAGNOSIS AND TESTING

FUEL PUMP PRESSURE TEST—ALL ENGINES WITH PRESSURE TEST PORT

Use this test in conjunction with the Fuel Pump Capacity Test, Fuel Pressure Leak Down Test and Fuel Pump Amperage Test found elsewhere in this group.

Check Valve Operation: The electric fuel pump outlet contains a one-way check valve to prevent fuel flow back into the tank and to maintain fuel supply line pressure (engine warm) when pump is not operational. It is also used to keep the fuel supply line full of gasoline when pump is not operational. After the vehicle has cooled down, fuel pressure may drop to 0 psi (cold fluid contracts), but liquid gasoline will remain in fuel supply line between the check valve and fuel injectors. **Fuel pressure that has dropped to 0 psi on a cooled down vehicle (engine off) is a normal condition.** When the electric fuel pump is activated, fuel pressure should **immediately** (1–2 seconds) rise to specification.

All fuel systems are equipped with a fuel tank module mounted, combination fuel filter/fuel pressure regulator. The fuel pressure regulator is not controlled by engine vacuum.

WARNING: THE FUEL SYSTEM IS UNDER CONSTANT FUEL PRESSURE EVEN WITH THE ENGINE OFF. BEFORE DISCONNECTING FUEL LINE AT FUEL RAIL, THIS PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE.

(1) Remove protective cap at fuel rail test port. Connect the 0–414 kPa (0-60 psi) fuel pressure gauge (from gauge set 5069) to test port pressure fitting on fuel rail (Fig. 8).

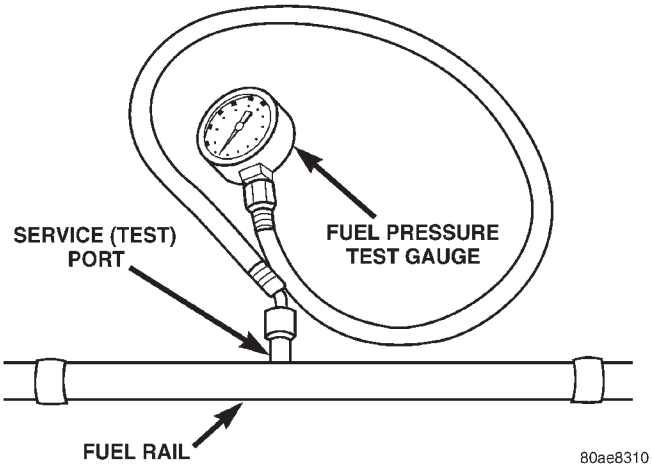


Fig. 8 Fuel Pressure Test Gauge (Typical Gauge Installation at Test Port)

(2) Start and warm engine and note pressure gauge reading. Fuel pressure should be 339 kPa ± 34 kPa (49.2 psi ± 5 psi) at idle.

(3) If engine runs, but pressure is below 44.2 psi, check for a kinked fuel supply line somewhere between fuel rail and fuel pump module. If line is not kinked, but specifications for either the Fuel Pump Capacity, Fuel Pump Amperage or Fuel Pressure

DIAGNOSIS AND TESTING (Continued)

Leak Down Tests were not met, replace fuel pump module assembly. Refer to Fuel Pump Module Removal/Installation.

(4) If operating pressure is above 54.2 psi, electric fuel pump is OK, but fuel pressure regulator is defective. Replace fuel filter/fuel pressure regulator. Refer to Fuel Filter/Fuel Pressure Regulator Removal/Installation for more information.

(5) Install protective cap to fuel rail test port.

FUEL PUMP CAPACITY TEST

Before performing this test, verify fuel pump pressure by performing the Fuel Pump Pressure Test. Use this test in conjunction with the Fuel Pressure Leak Down Test found elsewhere in this group.

(1) Release fuel system pressure. Refer to the Fuel Pressure Release Procedure in this group.

(2) Disconnect fuel supply line at fuel rail. Refer to Quick-Connect Fittings in the Service Procedures section of this group for procedures. Some engines may require air cleaner housing removal before line disconnection.

(3) Connect appropriate Fuel Line Pressure Test Adapter Tool Hose (number 6631, 6923, 6541 or 6539) into disconnected fuel supply line. Insert other end of Adaptor Tool hose into a graduated container.

(4) Remove fuel fill cap.

(5) To activate fuel pump and pressurize system, obtain DRB scan tool and actuate ASD Fuel System Test.

(6) A good fuel pump will deliver at least 1/4 liter of fuel in 7 seconds. Do not operate fuel pump for longer than 7 seconds with fuel line disconnected as fuel pump module reservoir may run empty.

(a) If capacity is lower than specification, but fuel pump can be heard operating through fuel fill cap opening, check for a kinked/damaged fuel supply line somewhere between fuel rail and fuel pump module.

(b) If line is not kinked/damaged, and fuel pressure is OK, but capacity is low, replace fuel filter/fuel pressure regulator. The filter/regulator may be serviced separately on certain applications. Refer to Fuel Filter/Fuel Pressure Regulator Removal/Installation for additional information.

(c) If both fuel pressure and capacity are low, replace fuel pump module assembly. Refer to Fuel Pump Module Removal/Installation.

FUEL PRESSURE LEAK DOWN TEST

Use this test in conjunction with the Fuel Pump Pressure Test and Fuel Pump Capacity Test.

Check Valve Operation: The electric fuel pump outlet contains a one-way check valve to prevent fuel flow back into the tank and to maintain fuel supply line pressure (engine warm) when pump is not operational. It is also used to keep the fuel supply line full of gasoline when pump is not operational. After the vehicle has cooled down, fuel pressure may drop to 0 psi (cold fluid contracts), but liquid gasoline will remain in fuel supply line between the check valve and fuel injectors. **Fuel pressure that has dropped to 0 psi on a cooled down vehicle (engine off) is a normal condition.** When the electric fuel pump is activated, fuel pressure should **immediately** (1–2 seconds) rise to specification.

Abnormally long periods of cranking to restart a **hot** engine that has been shut down for a short period of time may be caused by:

- Fuel pressure bleeding past a fuel injector(s).
- Fuel pressure bleeding past the check valve in the fuel pump module.

(1) Disconnect the fuel inlet line at fuel rail. Refer to Fuel Tubes/Lines/Hoses and Clamps in this section of the group for procedures. On some engines, air cleaner housing removal may be necessary before fuel line disconnection.

(2) Connect the appropriate Fuel Line Pressure Test Adapter Tool (number 6539, 6631, 6541 or 6923) between the disconnected fuel line and fuel rail (Fig. 9) or (Fig. 10).

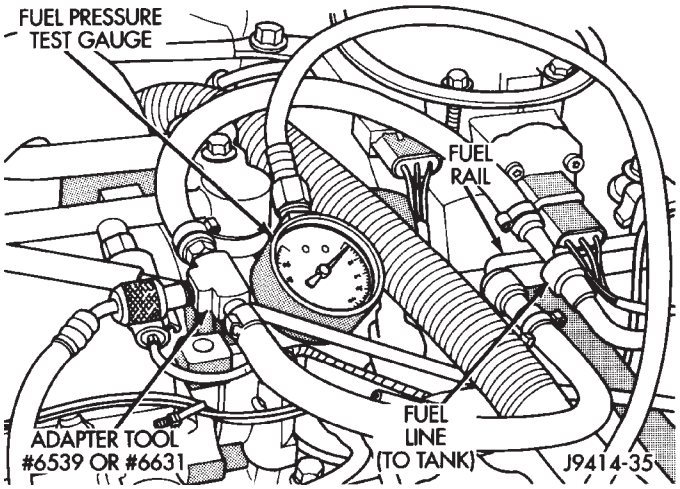


Fig. 9 Connecting Adapter Tool—Typical

(3) Connect the 0-414 kPa (0-60 psi) fuel pressure test gauge (from Gauge Set 5069) to the test port on the appropriate Adaptor Tool. **The fittings on both tools must be in good condition and free from any small leaks before performing the proceeding test.**

(4) Start engine and bring to normal operating temperature.

(5) Observe test gauge. Normal operating pressure should be 339 kPa ± 34 kPa (49.2 psi ± 5 psi).

(6) Shut engine off.

DIAGNOSIS AND TESTING (Continued)

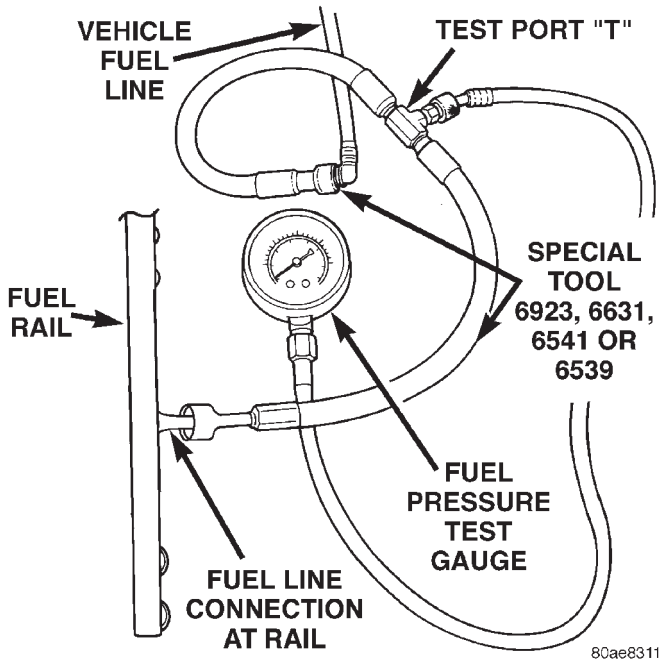


Fig. 10 Connecting Adapter Tool—Typical

(7) Pressure should not fall below **30 psi for five minutes.**

(8) If pressure falls below 30 psi, it must be determined if a fuel injector, the check valve within the fuel pump module, or a fuel tube/line is leaking.

(9) Again, start engine and bring to normal operating temperature.

(10) Shut engine off.

(11) **Testing for fuel injector or fuel rail leakage:** Clamp off the rubber hose portion of Adaptor Tool between the fuel rail and the test port “T” on Adapter Tool. If pressure now holds at or above 30 psi, a fuel injector or the fuel rail is leaking.

(12) **Testing for fuel pump check valve, filter/ regulator check valve or fuel tube/line leakage:** Clamp off the rubber hose portion of Adaptor Tool between the vehicle fuel line and test port “T” on Adapter Tool. If pressure now holds at or above 30 psi, a leak may be found at a fuel tube/line. If no leaks are found at fuel tubes or lines, one of the check valves in either the electric fuel pump or filter/ regulator may be leaking.

Note: A quick loss of pressure usually indicates a defective check valve in the filter/regulator. A slow loss of pressure usually indicates a defective check valve in the electric fuel pump.

The electric fuel pump is not serviced separately. Replace the fuel pump module assembly. The filter/ regulator may be replaced separately on certain applications. Refer to Fuel Filter/Fuel Pressure Regulator Removal/Installation for additional information.

FUEL PUMP AMPERAGE TEST

This amperage (current draw) test is to be done in conjunction with the Fuel Pump Pressure Test, Fuel Pump Capacity Test and Fuel Pressure Leak Down Test. Before performing the amperage test, be sure the temperature of the fuel tank is above 50° F (10° C).

The DRB Scan Tool along with the DRB Low Current Shunt (LCS) adapter (Fig. 11) and its test leads will be used to check fuel pump amperage specifications.

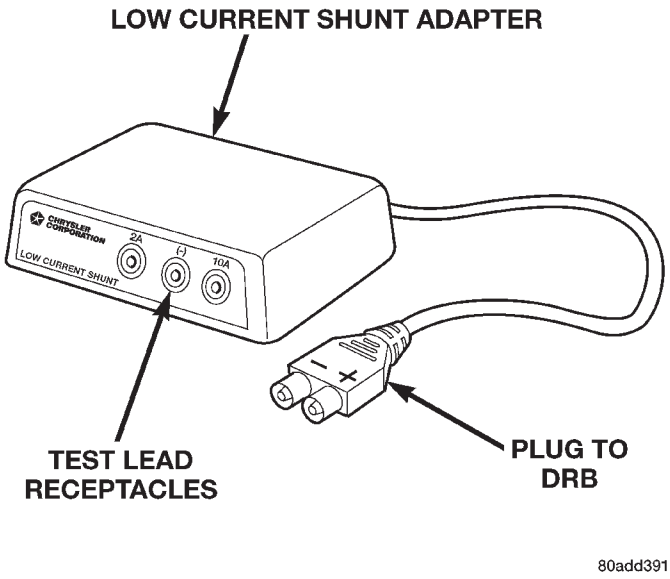


Fig. 11 Low Current Shunt Adapter

(1) Obtain LCS adapter.

(2) Plug cable from LCS adapter into DRB scan tool at SET 1 receptacle.

(3) Plug DRB into vehicle 16–way connector (data link connector).

(4) Connect (-) and (+) test cable leads into LCS adapter receptacles. Use **10 amp (10A +)** receptacle and common (-) receptacles.

(5) Gain access to MAIN MENU on DRB screen.

(6) Press DVOM button on DRB.

(7) Using left/right arrow keys, highlight CHANNEL 1 function on DRB screen.

(8) Press ENTER three times.

(9) Using up/down arrow keys, highlight RANGE on DRB screen (screen will default to 2 amp scale).

(10) Press ENTER to change 2 amp scale to 10 amp scale. **This step must be done to prevent damage to DRB scan tool or LCS adapter (blown fuse).**

(11) Remove cover from Power Distribution Center (PDC).

(12) Remove fuel pump relay from PDC. Refer to label on PDC cover for relay location.

DIAGNOSIS AND TESTING (Continued)

WARNING: BEFORE PROCEEDING TO NEXT STEP, NOTE THE FUEL PUMP WILL BE ACTIVATED AND SYSTEM PRESSURE WILL BE PRESENT. THIS WILL OCCUR AFTER CONNECTING TEST LEADS FROM LCS ADAPTER INTO FUEL PUMP RELAY CAVITIES. THE FUEL PUMP WILL OPERATE EVEN WITH IGNITION KEY IN OFF POSITION. BEFORE ATTACHING TEST LEADS, BE SURE ALL FUEL LINES AND FUEL SYSTEM COMPONENTS ARE CONNECTED.

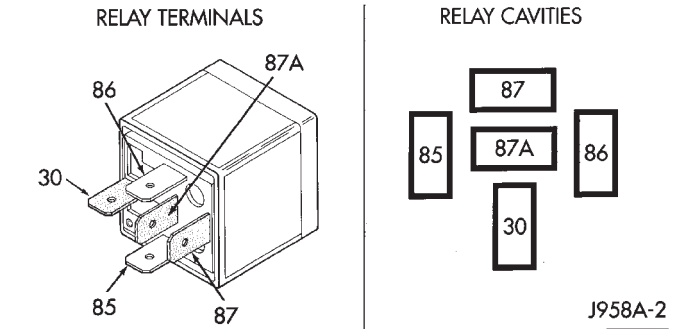
CAUTION: TO PREVENT POSSIBLE DAMAGE TO THE VEHICLE ELECTRICAL SYSTEM AND LCS ADAPTER, THE TEST LEADS MUST BE CONNECTED INTO RELAY CAVITIES EXACTLY AS SHOWN IN FOLLOWING STEPS.

Depending upon vehicle model, year or engine configuration, three different types of relays may be used: Type-1, type-2 and type–3.

(13) If equipped with **type–1 relay** (Fig. 12), attach test leads from LCS adapter into PDC relay cavities number 30 and 87. For location of these cavities, refer to numbers stamped to bottom of relay (Fig. 12).

(14) If equipped with **type–2 relay** (Fig. 13), attach test leads from LCS adapter into PDC relay cavities number 30 and 87. For location of these cavities, refer to numbers stamped to bottom of relay (Fig. 13).

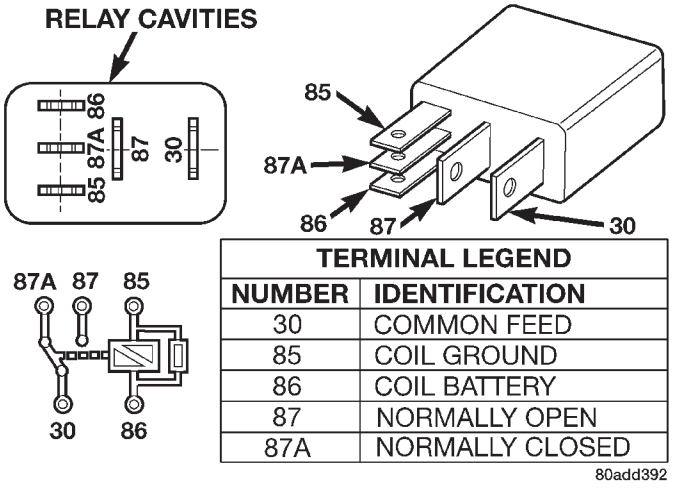
(15) If equipped with **type–3 relay** (Fig. 14), attach test leads from LCS adapter into PDC relay cavities number 3 and 5. For location of these cavities, refer to numbers stamped to bottom of relay (Fig. 14).



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

Fig. 12 Type–1 Relay

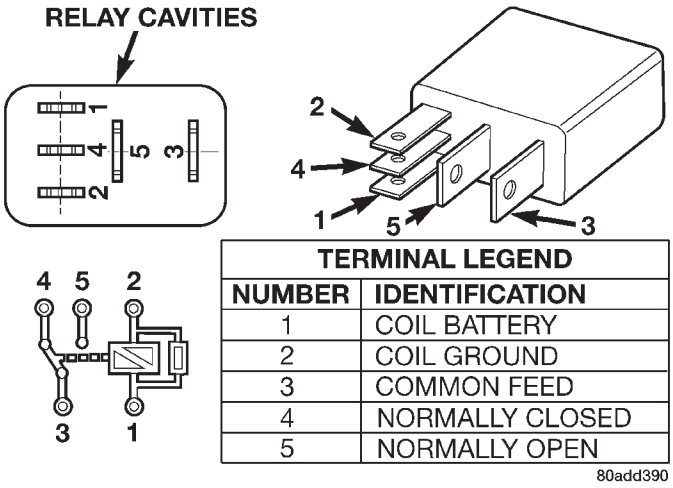
(16) When LCS adapter test leads are attached into relay cavities, fuel pump **will be activated.** Determine fuel pump amperage on DRB screen. Amperage should be below 10.0 amps. If amperage is below 10.0 amps, and specifications for the Fuel Pump Pressure, Fuel Pump Capacity and Fuel Pressure Leak Down tests were met, the fuel pump module is OK.



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

80add392

Fig. 13 Type–2 Relay



TERMINAL LEGEND	
NUMBER	IDENTIFICATION
1	COIL BATTERY
2	COIL GROUND
3	COMMON FEED
4	NORMALLY CLOSED
5	NORMALLY OPEN

80add390

Fig. 14 Type–3 Relay

(17) If amperage is more than 10.0 amps, replace fuel pump module assembly. The electric fuel pump is not serviced separately.

(18) Disconnect test leads from relay cavities immediately after testing.

FUEL GAUGE SENDING UNIT

The fuel gauge sending unit contains a variable resistor (track). As the float moves up or down, electrical resistance will change. Refer to Group 8E, Instrument Panel and Gauges for Fuel Gauge testing. To test the gauge sending unit only, it must be removed from vehicle. The unit is part of the fuel pump module. Refer to Fuel Pump Module Removal/Installation for procedures. Measure the resistance across the sending unit terminals. With float in up position, resistance should be 20 ohms ±6 ohms.

DIAGNOSIS AND TESTING (Continued)

With float in down position, resistance should be 220 ohms ±6 ohms.

FUEL INJECTOR TEST

To perform a complete test of the fuel injectors and their circuitry, refer to DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the injector only, refer to the following:

Disconnect the fuel injector wire harness connector from the injector. Place an ohmmeter across the injector electrical terminals. Resistance reading should be approximately 12 ohms ±1.2 ohms at 20°C (68°F).

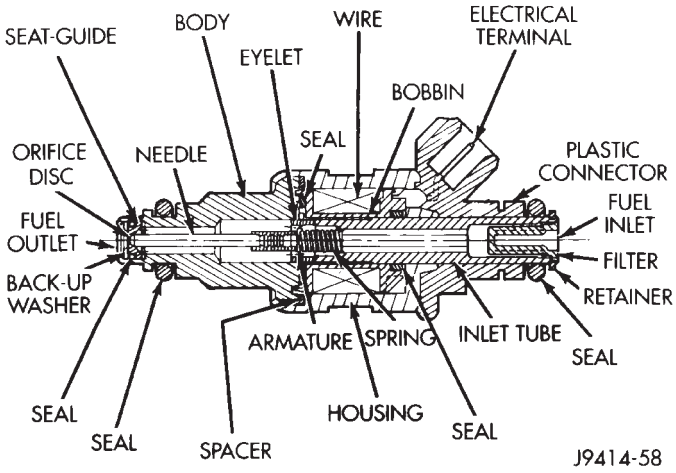


Fig. 15 Fuel Injector Internal Components—Typical

SERVICE PROCEDURES

FUEL SYSTEM PRESSURE RELEASE PROCEDURE

Use following procedure if fuel rail is or is not equipped with fuel pressure test port.

(1) Remove fuel fill cap.

(2) The fuel filler tube contains a spring-loaded flap (door) located below fuel fill cap. The flap is used as a secondary way of sealing fuel tank if fuel fill cap has not been properly tightened. It is part of EVAP monitor system when vehicle is equipped with a Leak Detection Pump (LDP). **The vehicle may be equipped with flap installed into fuel filler tube even though vehicle is not equipped with LDP and EVAP monitor system.** Place a nonmetallic object into fuel fill tube and press on flap to relieve any tank pressure.

(3) Remove Fuel Pump relay from Power Distribution Center (PDC). For location of relay, refer to label on underside of PDC cover.

(4) Start and run engine until it stalls.

(5) Attempt restarting engine until it will no longer run.

(6) Turn ignition key to OFF position.

CAUTION: Steps 1, 2, 3 and 4 must be performed to relieve high pressure fuel from within fuel rail. Do not attempt to use following steps to relieve this pressure as excessive fuel will be forced into a cylinder chamber.

(7) Unplug connector from any injector.

(8) Attach one end of a jumper wire with alligator clips (18 gauge or smaller) to either injector terminal.

(9) Connect other end of jumper wire to positive side of battery.

(10) Connect one end of a second jumper wire to remaining injector terminal.

CAUTION: Powering an injector for more than a few seconds will permanently damage the injector.

(11) Momentarily touch other end of jumper wire to negative terminal of battery for no more than a few seconds.

(12) Place a rag or towel below fuel line quick-connect fitting at fuel rail.

(13) Disconnect quick-connect fitting at fuel rail. Refer to Quick-Connect Fittings in this section.

(14) Return fuel pump relay to PDC.

(15) One or more Diagnostic Trouble Codes (DTC's) may have been stored in PCM memory due to fuel pump relay removal. The DRB scan tool must be used to erase a DTC. Refer to Group 25, Emission Control System. See On-Board Diagnostics.

FUEL TUBES/LINES/HOSES AND CLAMPS

Also refer to the section on Quick-Connect Fittings.

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSES, FITTINGS OR LINES, THE FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE IN THIS GROUP.

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

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

The lines/tubes/hoses used on fuel injected vehicles are of a special construction. This is due to the higher fuel pressures and the possibility of contami-

SERVICE PROCEDURES (Continued)

nated fuel in this system. If it is necessary to replace these lines/tubes/hoses, only those marked EFM/EFI may be used.

If equipped: The hose clamps used to secure rubber hoses on fuel injected vehicles 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 high-pressure fuel leaks.

Use new original equipment type hose clamps. Tighten hose clamps to 3 N·m (25 in. lbs.) torque.

QUICK-CONNECT FITTINGS

Also refer to the Fuel Tubes/Lines/Hoses and Clamps section.

Different types of quick-connect fittings are used to attach various fuel system components. These are: a single-tab type, a two-tab type, a plastic retainer ring type or a latch clip type. Certain fittings may require the use of a special tool for disconnection.

SINGLE-TAB TYPE

This type of fitting is equipped with a single pull tab (Fig. 16). The tab is removable. After the tab is removed, the quick-connect fitting can be separated from the fuel system component.

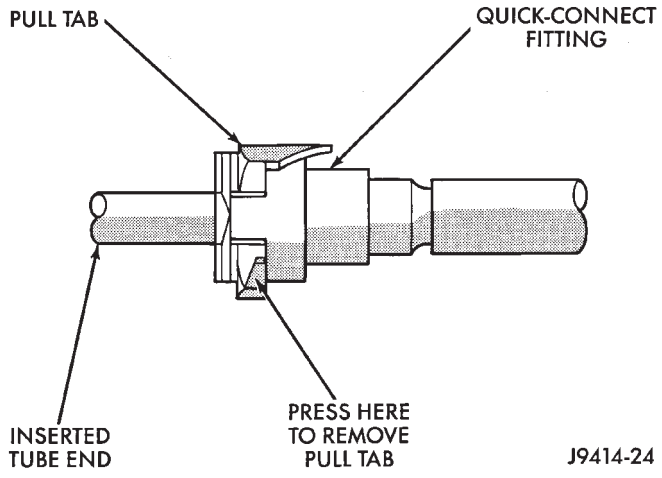


Fig. 16 Single-Tab Type Fitting

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

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSES, FITTINGS OR LINES, THE FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE IN THIS GROUP.

DISCONNECTION/CONNECTION

(1) Perform fuel pressure release procedure. Refer to Fuel Pressure Release Procedure in this group.

(2) Disconnect negative battery cable from battery.

(3) Clean fitting of any foreign material before disassembly.

(4) Press release tab on side of fitting to release pull tab (Fig. 17).

CAUTION: If this release tab is not pressed prior to releasing the pull tab, the pull tab will be damaged.

(5) While pressing release tab on side of fitting, use a screwdriver to pry up pull tab (Fig. 17).

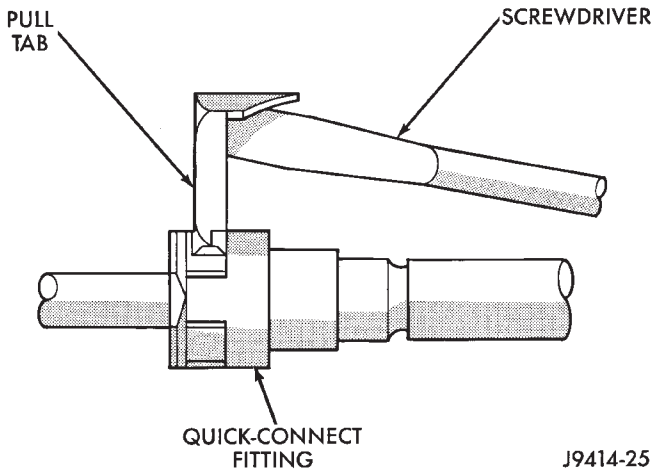


Fig. 17 Disconnecting Single-Tab Type Fitting

(6) Raise pull tab until it separates from quick-connect fitting (Fig. 18). Discard old pull tab.

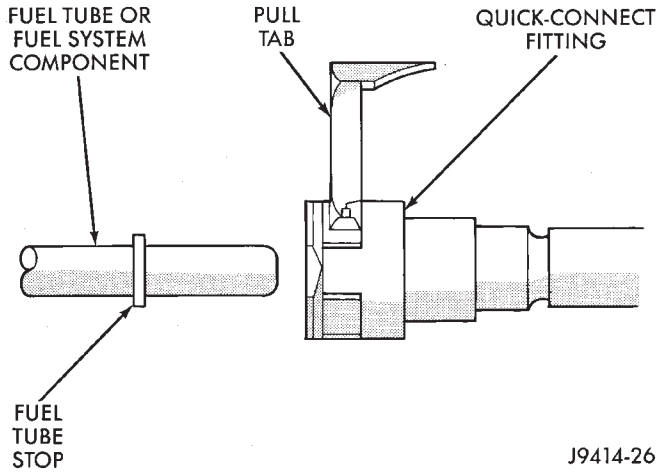


Fig. 18 Removing Pull Tab

SERVICE PROCEDURES (Continued)

(7) Disconnect quick-connect fitting from fuel system component being serviced.

(8) Inspect quick-connect fitting body and fuel system component for damage. Replace as necessary.

(9) Prior to connecting quick-connect fitting to component being serviced, check condition of fitting and component. Clean parts with a lint-free cloth. Lubricate with clean engine oil.

(10) Insert quick-connect fitting into fuel tube or fuel system component until built-on stop on fuel tube or component rests against back of fitting.

(11) Obtain a new pull tab. Push new tab down until it locks into place in quick-connect fitting.

(12) Verify a locked condition by firmly pulling on fuel tube and fitting (15-30 lbs.).

(13) Connect negative cable to battery.

(14) Start engine and check for leaks.

TWO-TAB TYPE FITTING

This type of fitting is equipped with tabs located on both sides of the fitting (Fig. 19). These tabs are supplied for disconnecting the quick-connect fitting from component being serviced.

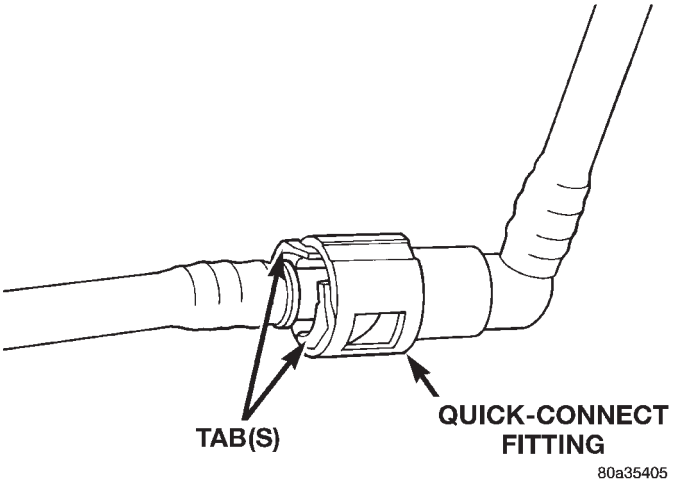


Fig. 19 Typical Two-Tab Type Quick-Connect Fitting

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

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSES, FITTINGS OR LINES, THE FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL PRESSURE RELEASE PROCEDURE IN THIS GROUP.

DISCONNECTION/CONNECTION

(1) Perform fuel pressure release procedure. Refer to Fuel Pressure Release Procedure in this group.

(2) Disconnect negative battery cable from battery.

(3) Clean fitting of any foreign material before disassembly.

(4) To disconnect quick-connect fitting, squeeze plastic retainer tabs (Fig. 19) against sides of quick-connect fitting with your fingers. Tool use is not required for removal and may damage plastic retainer. Pull fitting from fuel system component being serviced. The plastic retainer will remain on component being serviced after fitting is disconnected. The o-rings and spacer will remain in quick-connect fitting connector body.

(5) Inspect quick-connect fitting body and component for damage. Replace as necessary.

CAUTION: When the quick-connect fitting was disconnected, the plastic retainer will remain on the component being serviced. If this retainer must be removed, very carefully release the retainer from the component with two small screwdrivers. After removal, inspect the retainer for cracks or any damage.

(6) Prior to connecting quick-connect fitting to component being serviced, check condition of fitting and component. Clean parts with a lint-free cloth. Lubricate with clean engine oil.

(7) Insert quick-connect fitting to component being serviced and into plastic retainer. When a connection is made, a click will be heard.

(8) Verify a locked condition by firmly pulling on fuel tube and fitting (15-30 lbs.).

(9) Connect negative cable to battery.

(10) Start engine and check for leaks.

PLASTIC RETAINER RING TYPE FITTING

This type of fitting can be identified by the use of a full-round plastic retainer ring (Fig. 20) usually black in color.

CAUTION: The interior components (o-rings, spacers, retainers) of this type of quick-connect fitting are not serviced separately. Do not attempt to repair damaged fittings or fuel lines/tubes. If repair is necessary, replace the complete fuel tube assembly.

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSES, FITTINGS OR LINES, THE FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE IN THIS GROUP.

SERVICE PROCEDURES (Continued)

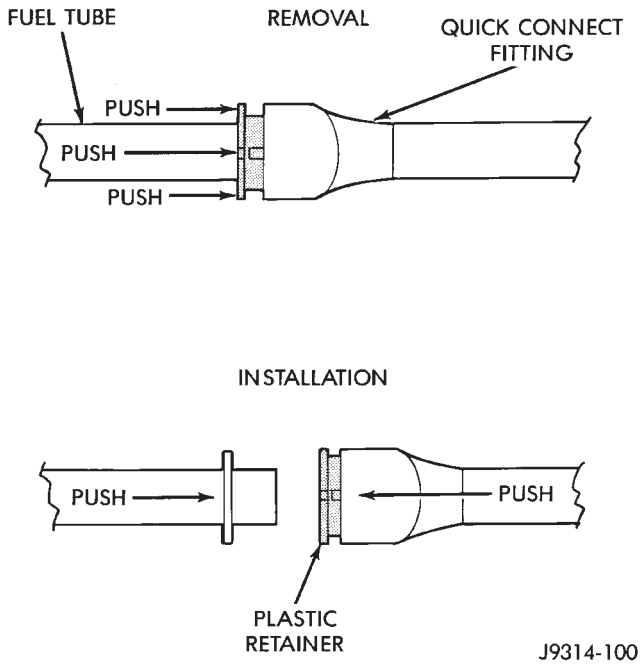


Fig. 20 Plastic Retainer Ring Type Fitting

DISCONNECTION/CONNECTION

(1) Perform fuel pressure release procedure. Refer to Fuel Pressure Release Procedure in this section.

(2) Disconnect negative battery cable from battery.

(3) Clean fitting of any foreign material before disassembly.

(4) To release fuel system component from quick-connect fitting, firmly push fitting towards component being serviced while firmly pushing plastic retainer ring into fitting (Fig. 20). With plastic ring depressed, pull fitting from component. **The plastic retainer ring must be pressed squarely into fitting body. If this retainer is cocked during removal, it may be difficult to disconnect fitting. Use an open-end wrench on shoulder of plastic retainer ring to aid in disconnection.**

(5) After disconnection, plastic retainer ring will remain with quick-connect fitting connector body.

(6) Inspect fitting connector body, plastic retainer ring and fuel system component for damage. Replace as necessary.

(7) Prior to connecting quick-connect fitting to component being serviced, check condition of fitting and component. Clean parts with a lint-free cloth. Lubricate with clean engine oil.

(8) Insert quick-connect fitting into component being serviced until a click is felt.

(9) Verify a locked condition by firmly pulling on fuel tube and fitting (15-30 lbs.).

(10) Connect negative battery cable to battery.

(11) Start engine and check for leaks.

LATCH CLIP FITTING (FUEL LINE-TO-FUEL RAIL)

A tethered latch clip (Fig. 21) is used to secure the fuel line to the fuel rail. A special tool will be necessary to separate fuel line from fuel rail after latch clip is removed. This same latch clip may also be used to secure other different fuel system components.

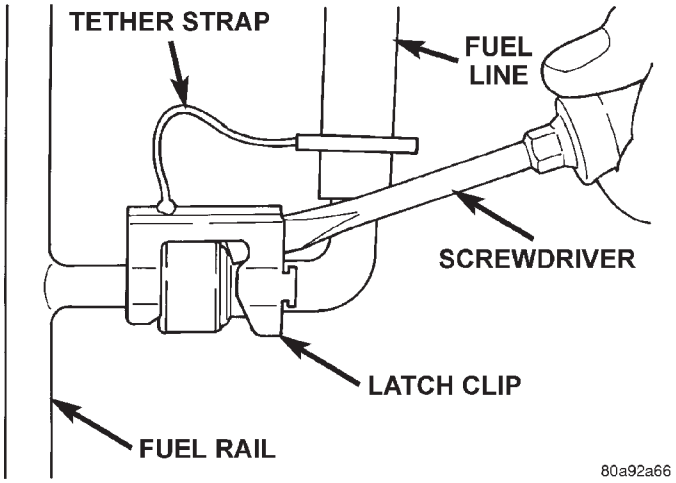


Fig. 21 Latch Clip Removal

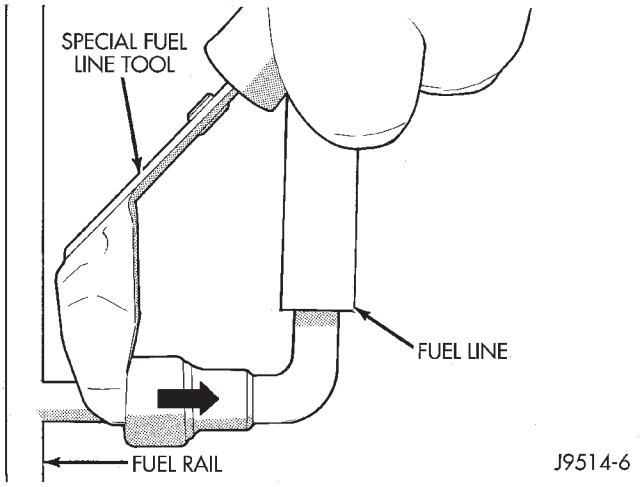


Fig. 22 Fuel Line Disconnection

CAUTION: The interior components (o-rings, spacers, retainers) of this type of quick-connect fitting are not serviced separately. Do not attempt to repair damaged fittings or fuel lines/tubes. If repair is necessary, replace the complete fuel tube assembly.

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSES, FITTINGS OR LINES, THE FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE IN THIS GROUP.

SERVICE PROCEDURES (Continued)

DISCONNECTION/CONNECTION

(1) Perform fuel pressure release procedure. Refer to Fuel Pressure Release Procedure in this group.

(2) Disconnect negative battery cable from battery.

(3) Clean fitting of any foreign material before disassembly.

(4) Pry up on latch clip with a screwdriver (Fig. 21).

(5) Slide latch clip toward fuel rail while lifting with screwdriver.

(6) Insert special fuel line removal tool (Snap-On number FIH 9055-1 or equivalent) into fuel line (Fig. 22). Use this tool to release locking fingers in end of line.

(7) With special tool still inserted, pull fuel line from fuel rail.

(8) After disconnection, locking fingers will remain within quick-connect fitting at end of fuel line.

(9) Prior to connecting fuel line to fuel rail, check condition of both fittings. Clean parts with a lint-free cloth. Lubricate with clean engine oil.

(10) Insert fuel line onto fuel rail until a click is felt.

(11) Install latch clip (snaps into position). **If latch clip will not fit, this indicates fuel line is not properly installed to fuel rail. Recheck fuel line connection.**

(12) Verify a locked condition by firmly pulling on fuel line and fitting (15-30 lbs.).

(13) Connect negative battery cable to battery.

(14) Start engine and check for leaks.

REMOVAL AND INSTALLATION

FUEL FILTER/FUEL PRESSURE REGULATOR

REMOVAL

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE, EVEN WITH ENGINE OFF. BEFORE SERVICING FUEL FILTER/FUEL PRESSURE REGULATOR, FUEL SYSTEM PRESSURE MUST BE RELEASED.

Refer to Fuel System Pressure Release in Fuel Delivery System section of this group.

The fuel filter/fuel pressure regulator is located at top of fuel pump module (Fig. 24) or (Fig. 25).

Fuel pump module removal is not necessary.

(1) Drain fuel tank and remove tank. Refer to Fuel Tank Removal/Installation.

(2) The fuel filter/regulator is pressed into a rubber grommet. Remove by twisting and pulling straight up (Fig. 26).

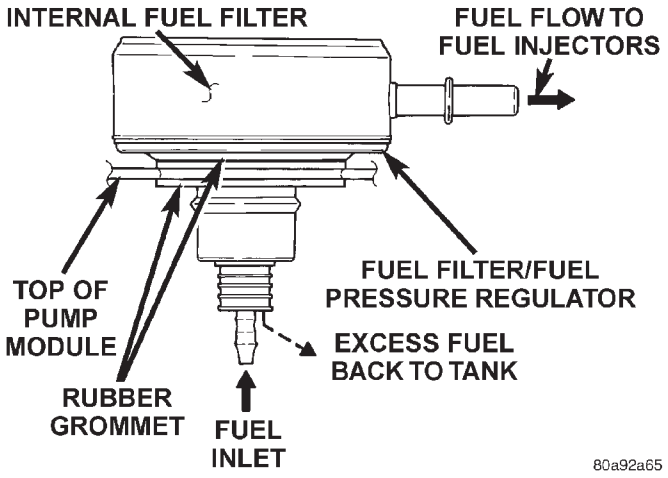


Fig. 23 Fuel Filter/Fuel Pressure Regulator

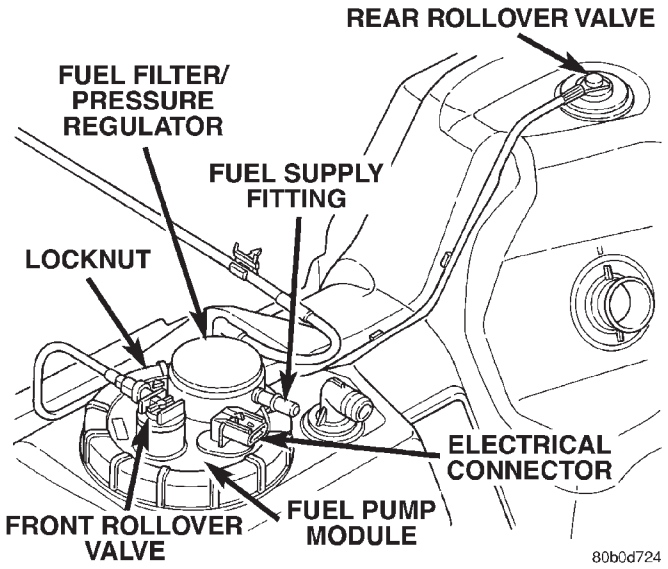


Fig. 24 Filter/Regulator Location—With 26 or 34 Gallon Fuel Tank

CAUTION: Do not pull filter/regulator more than three inches from fuel pump module. Damage to coiled fuel tube (line) may result.

(3) Gently cut old fuel tube (line) clamp (Fig. 27) taking care not to damage plastic fuel tube. Remove and discard old fuel tube clamp.

(4) Remove plastic fuel tube from filter/regulator by gently pulling downward. Remove filter/regulator from fuel pump module.

INSTALLATION

(1) Install a new clamp over plastic fuel tube.

(2) Install filter/regulator to fuel tube. Rotate filter/regulator in fuel tube (line) (Fig. 28) until it is pointed to drivers side of vehicle (Fig. 24) or (Fig. 25).

REMOVAL AND INSTALLATION (Continued)

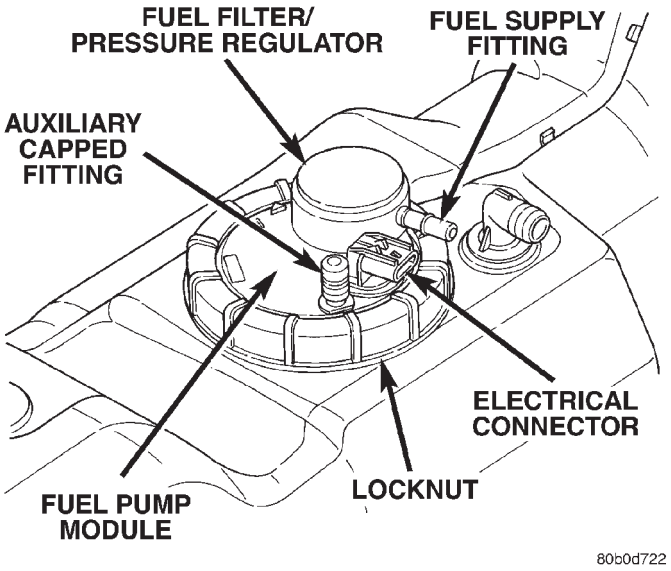


Fig. 25 Filter/Regulator Location—With 35 Gallon Fuel Tank

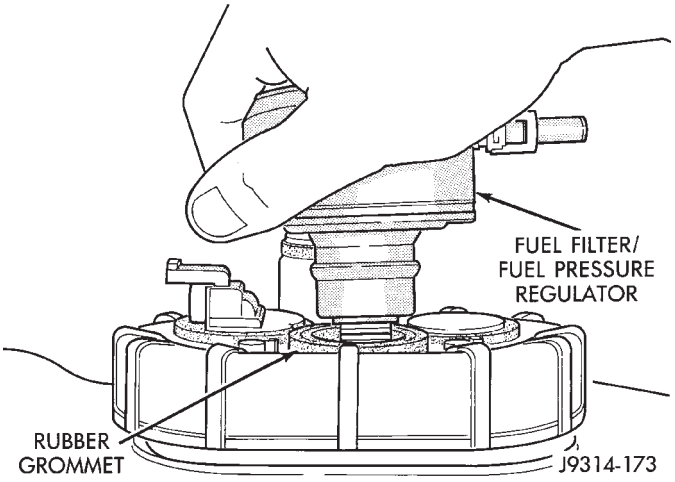


Fig. 26 Filter/Regulator Removal and Installation—TYPICAL

(3) Tighten line clamp to fuel line using special Hose Clamp Pliers number C-4124 or equivalent (Fig. 28). **Do not use conventional side cutters to tighten this type of clamp.**

(4) Press filter/regulator (by hand) into rubber grommet. The assembly should be pointed towards drivers side of vehicle (Fig. 24) or (Fig. 25).

(5) Install fuel tank. Refer to Fuel Tank Removal/Installation.

(6) Check for fuel leaks.

FUEL PUMP MODULE

REMOVAL

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF).

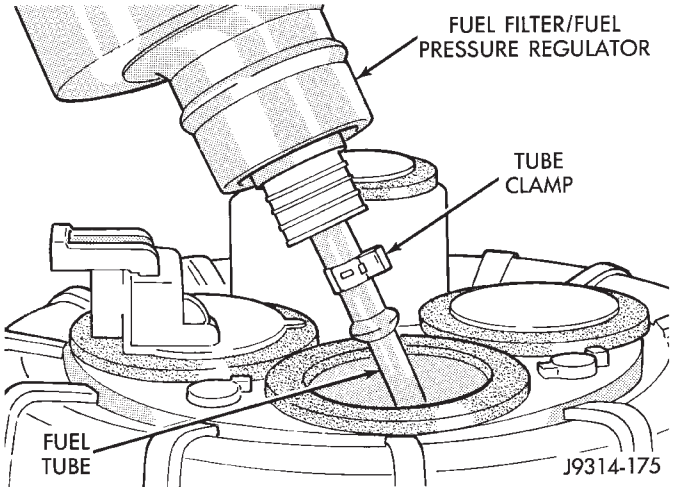


Fig. 27 Fuel Tube and Clamp—TYPICAL

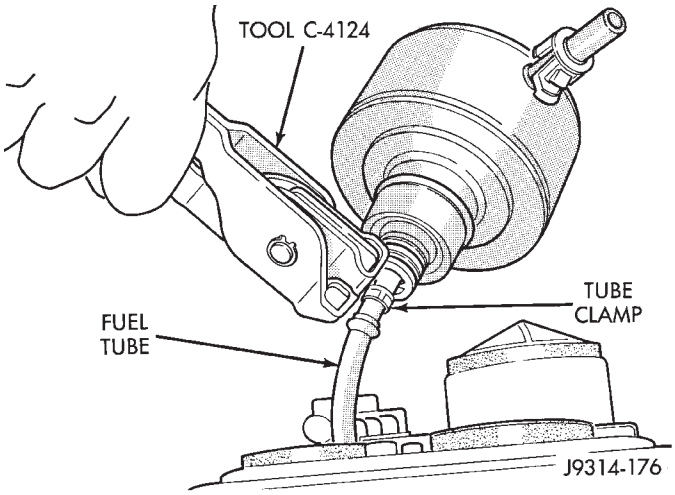


Fig. 28 Tightening Fuel Tube Clamp—TYPICAL

BEFORE SERVICING THE FUEL PUMP MODULE, THE FUEL SYSTEM PRESSURE MUST BE RELEASED.

(1) Drain and remove fuel tank. Refer to Fuel Tank—All Engines in the Removal/Installation section.

(2) The plastic fuel pump module locknut is threaded onto fuel tank (Fig. 29) or (Fig. 30). Install Special Tool 6856 to locknut and remove locknut (Fig. 31). The fuel pump module will spring up when locknut is removed.

(3) Remove module from fuel tank.

INSTALLATION

CAUTION: Whenever the fuel pump module is serviced, the rubber gasket must be replaced.

(1) Using a new gasket, position fuel pump module into opening in fuel tank.

REMOVAL AND INSTALLATION (Continued)

(2) Position locknut over top of fuel pump module. Install locknut finger tight.

(3) Rotate module until positioned as shown in (Fig. 29) or (Fig. 30). This step must be performed to prevent float from contacting side of fuel tank. Be sure fuel filter/fuel pressure regulator is pointed to drivers side of vehicle.

(4) Install Special Tool 6856 to locknut.

(5) Tighten locknut to 24–44 N·m (18–32 ft. lbs.) torque.

(6) Install fuel tank. Refer to Fuel Tank—All Engines in the Removal/Installation section.

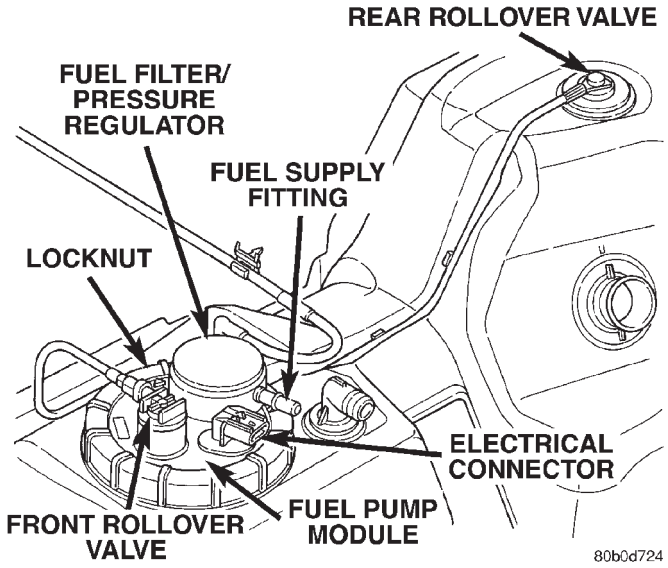


Fig. 29 Fuel Pump Module—26 or 34 Gallon Fuel Tank

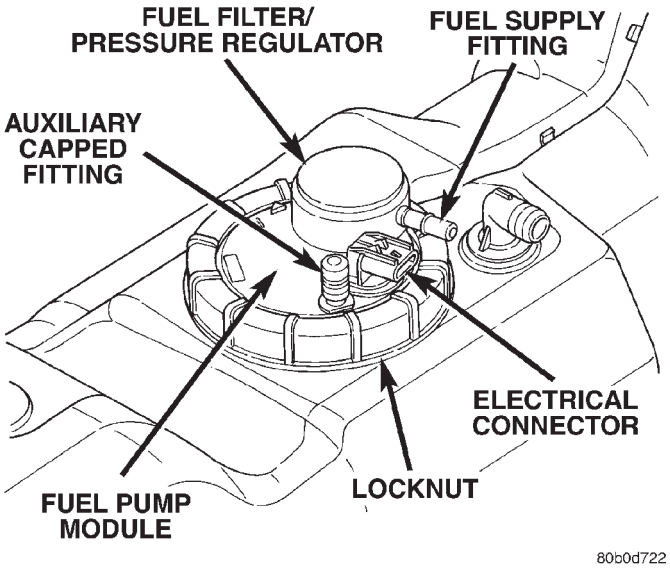


Fig. 30 Fuel Pump Module—35 Gallon Fuel Tank

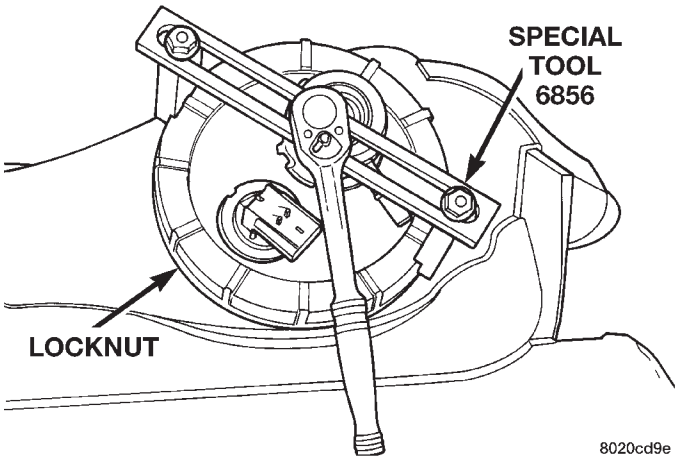


Fig. 31 Locknut Removal/Installation—TYPICAL

FUEL PUMP INLET FILTER

The fuel pump inlet filter (strainer) is located on the bottom of the fuel pump module (Fig. 32). The fuel pump module is located inside of fuel tank.

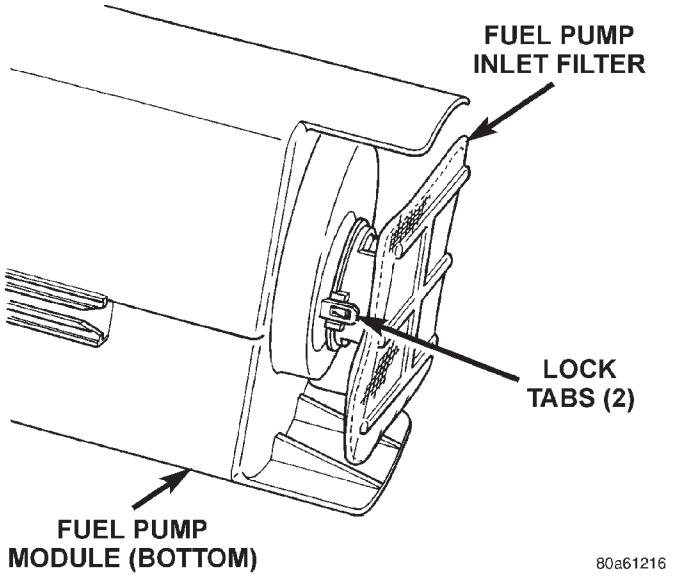


Fig. 32 Fuel Pump Inlet Filter

REMOVAL

(1) Remove fuel tank. Refer to Fuel Tank Removal/Installation.

(2) Remove fuel pump module. Refer to Fuel Pump Module Removal/Installation.

(3) Remove filter by carefully prying 2 lock tabs at bottom of module with 2 screwdrivers. Filter is snapped to module.

(4) Clean bottom of pump module.

INSTALLATION

(1) Snap new filter to bottom of module. Be sure o-ring is in correct position.

REMOVAL AND INSTALLATION (Continued)

(2) Install fuel pump module. Refer to Fuel Pump Module Removal/Installation.

(3) Install fuel tank. Refer to Fuel Tank Removal/ Installation.

FUEL GAUGE SENDING UNIT

The fuel gauge sending unit (fuel level sensor) and float assembly is located on the side of fuel pump module (Fig. 33). The fuel pump module is located inside of fuel tank.

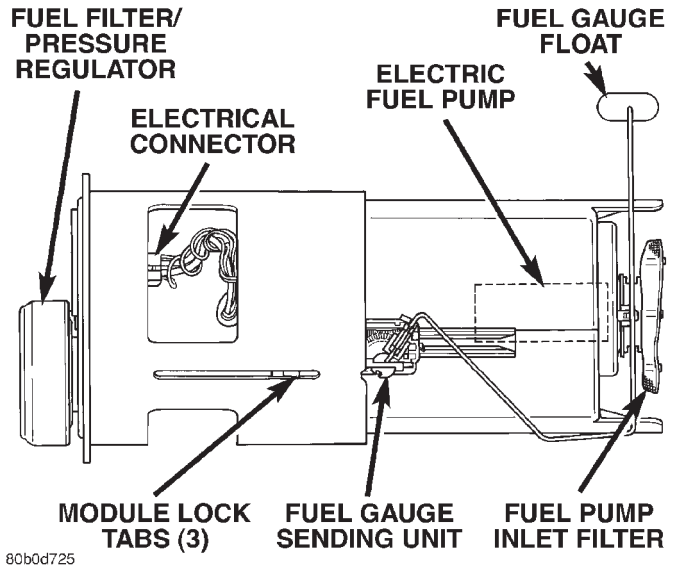


Fig. 33 Fuel Gauge Sending Unit Location— TYPICAL Module

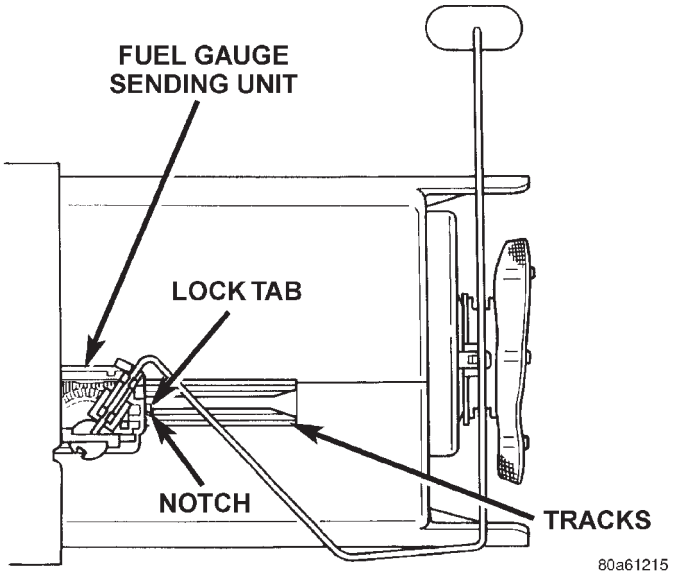


Fig. 34 Fuel Gauge Sending Unit Lock Tab/Tracks

REMOVAL

(1) Remove fuel tank. Refer to Fuel Tank–All Engines in the Removal/Installation section.

(2) Remove fuel pump module. Refer to Fuel Pump Module Removal/Installation.

(3) Unplug 4–way electrical connector (Fig. 33).

(4) Disconnect 2 sending unit wires at 4–way connector. The locking collar of connector must be removed before wires can be released from connector. Note location of wires within 4–way connector.

(5) The sending unit is retained to pump module with a small lock tab and notch (Fig. 34). Carefully push lock tab to the side and away from notch while sliding sending unit downward on tracks for removal. Note wire routing while removing unit from module.

INSTALLATION

(1) Position sending unit into tracks. Note wire routing.

(2) Push unit on tracks until lock tab snaps into notch.

(3) Connect 2 sending unit wires into 4–way connector and install locking collar.

(4) Connect 4–way electrical connector to module.

(5) Install fuel pump module. Refer to Fuel Pump Module Removal/Installation.

(6) Install fuel tank. Refer to Fuel Tank–All Engines in the Removal/Installation section.

FUEL INJECTOR RAIL—3.9L/5.2L/5.9L ENGINES

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH ENGINE TURNED OFF). BEFORE SERVICING FUEL RAIL ASSEMBLY, FUEL SYSTEM PRESSURE MUST BE RELEASED.

To release fuel pressure, refer to Fuel System Pressure Release Procedure found in this group.

CAUTION: The left and right fuel rails are replaced as an assembly. Do not attempt to separate the rail halves at the connecting hose (Fig. 35). Due to the design of this connecting hose, it does use any clamps. Never attempt to install a clamping device of any kind to the hose. When removing the fuel rail assembly for any reason, be careful not to bend or kink the connecting hose.

REMOVAL

(1) Remove negative battery cable at battery.

(2) Remove air cleaner.

(3) Perform fuel pressure release procedure.

(4) Remove throttle body from intake manifold. Refer to Throttle Body removal in this group.

(5) If equipped with air conditioning, remove the A-shaped A/C compressor-to-intake manifold support bracket (three bolts) (Fig. 36).

(6) Disconnect electrical connectors at all fuel injectors (Fig. 37). The factory fuel injection wiring

REMOVAL AND INSTALLATION (Continued)

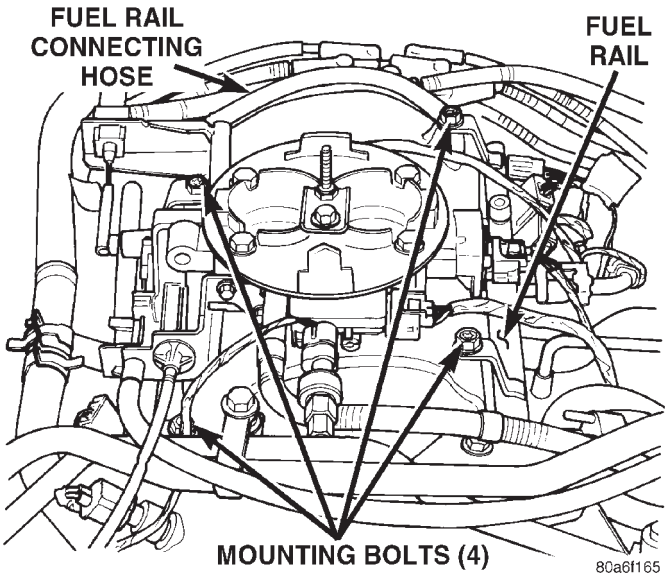


Fig. 35 Fuel Rail Assembly—Typical

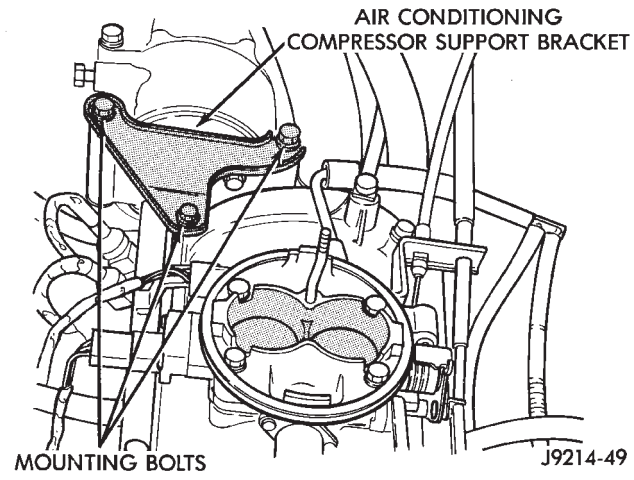


Fig. 36 A/C Compressor Support Bracket—Typical

harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification.

(7) 3.9L (V-6) engine only: Disconnect electrical connector at intake manifold air temperature sensor. Do not remove sensor.

(8) Disconnect fuel tube (line) at side of fuel rail. Refer to Quick-Connect Fittings for procedures,

(9) Remove the remaining fuel rail mounting bolts.

(10) Gently rock and pull the **left** fuel rail until the fuel injectors just start to clear the intake manifold. Gently rock and pull the **right** fuel rail until the fuel injectors just start to clear the intake manifold. Repeat this procedure (left/right) until all fuel injectors have cleared the intake manifold.

(11) Remove fuel rail (with injectors attached) from engine.

(12) Remove the clip(s) retaining the injector(s) to fuel rail (Fig. 38) or (Fig. 39).

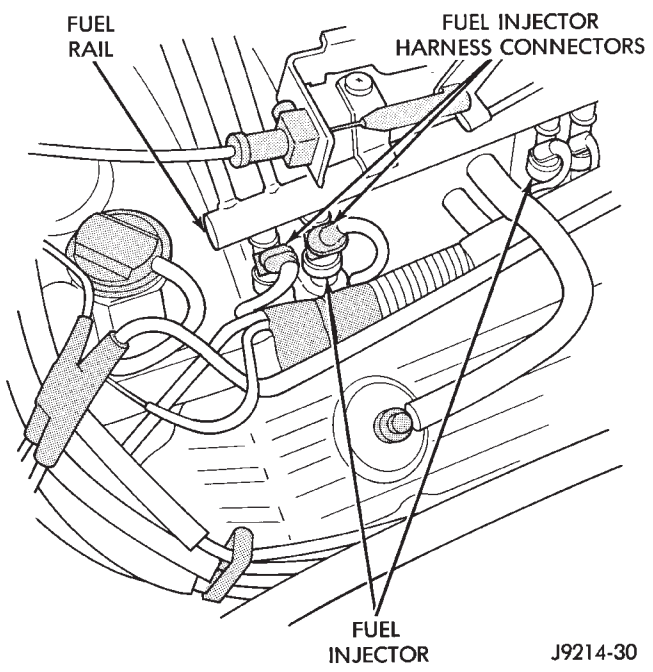


Fig. 37 Fuel Injector Connectors—Typical

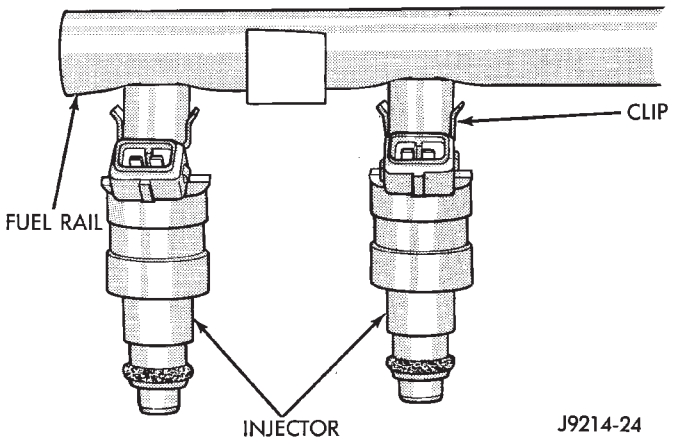


Fig. 38 Fuel Injector Mounting—Typical

INSTALLATION

(1) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.

(2) Install injector(s) and injector clip(s) to fuel rail.

(3) Position the fuel rail/fuel injector assembly to the injector openings on the intake manifold.

(4) Guide each injector into the intake manifold. Be careful not to tear the injector o-ring.

(5) Push the **right** fuel rail down until fuel injectors have bottomed on injector shoulder. Push the **left** fuel rail down until fuel injectors have bottomed on injector shoulder.

(6) Install fuel rail mounting bolts.

(7) Connect electrical connector to intake manifold air temperature sensor.

REMOVAL AND INSTALLATION (Continued)

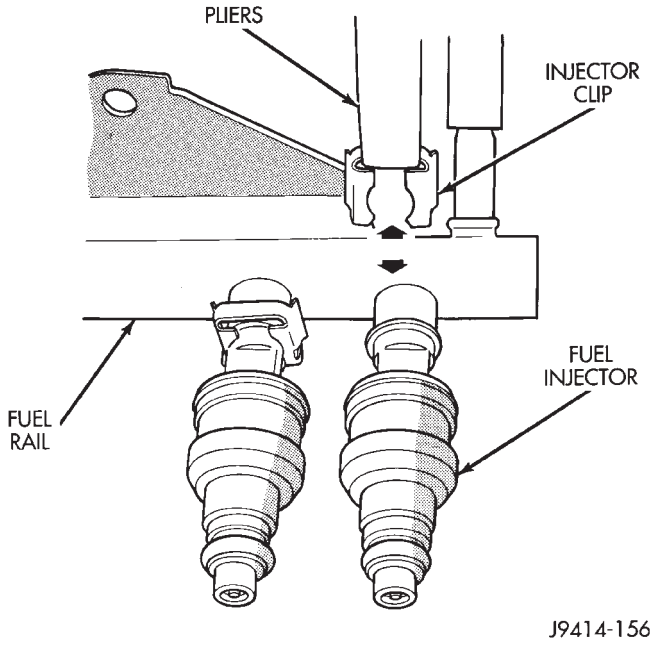


Fig. 39 Injector Retaining Clips—Typical Injector

(8) Connect wiring to all fuel injectors. The injector wiring harness is numerically tagged.

(9) Install the A/C support bracket (if equipped).

(10) Install throttle body to intake manifold. Refer to Throttle Body installation in this section of the group.

(11) Install fuel tube (line) at side of fuel rail. Refer to Quick-Connect Fittings for procedures.

(12) Install air cleaner.

(13) Connect battery cable to battery.

(14) Start engine and check for leaks.

FUEL INJECTOR RAIL—8.0L V-10 ENGINE

REMOVAL

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE EVEN WITH THE ENGINE OFF. BEFORE SERVICING FUEL RAIL, FUEL SYSTEM PRESSURE MUST BE RELEASED.

(1) Remove negative battery cable at battery.

(2) Remove air cleaner housing and tube.

(3) Perform fuel pressure release procedure. Refer to Fuel Delivery System section of this group.

(4) Disconnect throttle body linkage and remove throttle body from intake manifold. Refer to Throttle Body removal in this group.

(5) Remove ignition coil pack and bracket assembly (Fig. 40) at intake manifold and right engine valve cover (four bolts).

(6) Remove upper half of intake manifold. Refer to Group 11, Exhaust System and Intake Manifold for procedures.

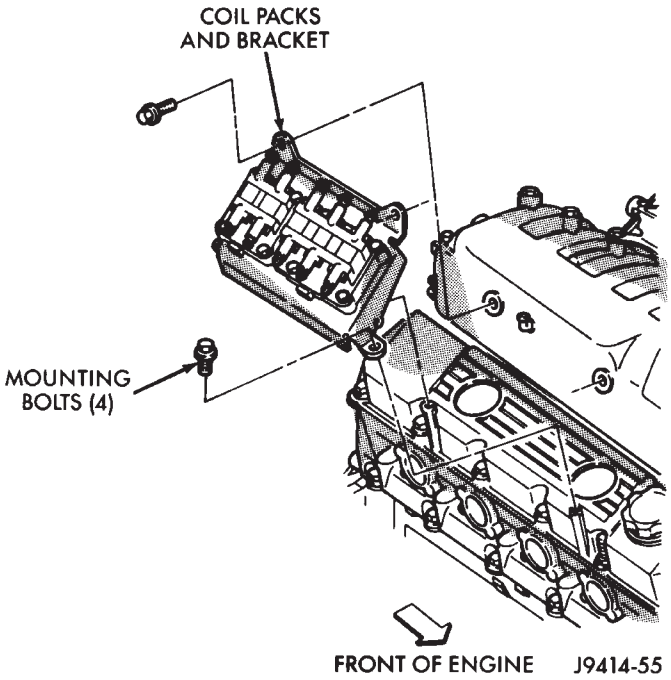


Fig. 40 Ignition Coil Pack and Mounting Bracket—8.0L V-10 Engine

(7) Disconnect electrical connectors at all fuel injectors. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification.

(8) Disconnect fuel line quick-connect fitting at left-rear end of fuel rail. A special 3/8 inch fuel line disconnection tool will be necessary.

(9) Remove the six fuel rail mounting bolts from the lower half of intake manifold (Fig. 41).

(10) Gently rock and pull the **left** fuel rail until the fuel injectors just start to clear the intake manifold. Gently rock and pull the **right** fuel rail until the fuel injectors just start to clear the intake manifold. Repeat this procedure (left/right) until all fuel injectors have cleared the intake manifold.

(11) Remove fuel rail (with injectors attached) from engine.

(12) Remove the clip(s) retaining the injector(s) to fuel rail (Fig. 38) or (Fig. 39).

INSTALLATION

(1) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.

(2) Install injector(s) and injector clip(s) to fuel rail.

NOTE: The fuel injector electrical connectors on all 10 injectors should be facing to the right (passenger) side of the vehicle (Fig. 41).

(3) Position the fuel rail/fuel injector assembly to the injector openings on the intake manifold.

REMOVAL AND INSTALLATION (Continued)

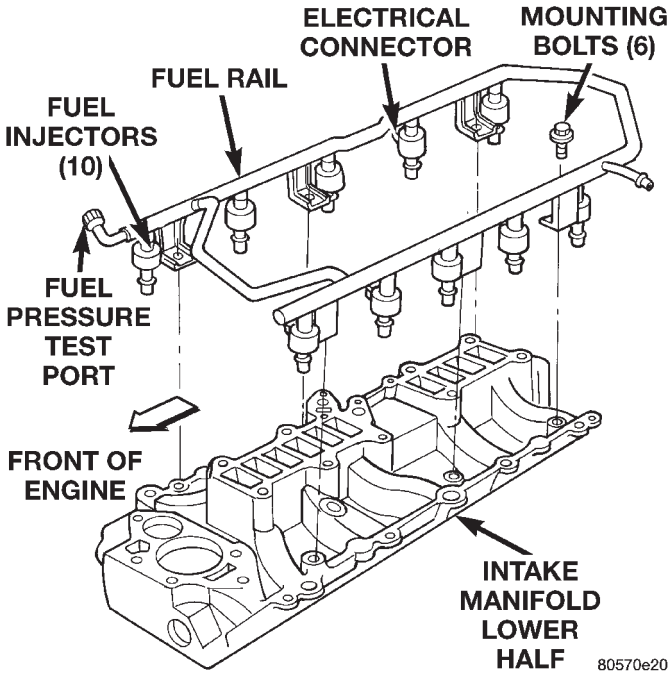


Fig. 41 Fuel Rail Mounting Bolts—8.0L V-10 Engine—Typical

(4) Guide each injector into the intake manifold. Be careful not to tear the injector o-ring.

(5) Push the **right** fuel rail down until fuel injectors have bottomed on injector shoulder. Push the **left** fuel rail down until fuel injectors have bottomed on injector shoulder.

(6) Install the six fuel rail mounting bolts into the lower half of intake manifold. Tighten bolts to 15 N·m (136 in. lbs.) torque.

(7) Connect wiring to all fuel injectors. The injector wiring harness is numerically tagged.

(8) Install upper half of intake manifold. Refer to Group 11, Exhaust System and Intake Manifold for procedures.

(9) Connect main fuel line at fuel rail. Refer to Quick-Connect Fittings for procedures.

(10) Install ignition coil pack and bracket assembly at intake manifold and right engine valve cover (four bolts).

(11) Install throttle body to intake manifold. Refer to Throttle Body removal in this group.

(12) Install throttle body linkage to throttle body.

(13) Install air cleaner tube and housing.

(14) Install negative battery cable at battery.

(15) Start engine and check for leaks.

FUEL INJECTOR(S)—ALL GAS ENGINES

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE EVEN WITH THE ENGINE TURNED OFF. BEFORE SERVICING THE FUEL INJECTOR(S), THE FUEL SYSTEM PRESSURE MUST BE RELEASED.

To release fuel pressure, refer to the Fuel System Pressure Release Procedure.

To remove one or more fuel injectors, the fuel rail assembly must be removed from engine.

REMOVAL

(1) Remove air cleaner assembly.

(2) Remove fuel injector rail assembly. Refer to Fuel Injector Rail removal in this section.

(3) Remove the clip(s) retaining the injector(s) to fuel rail (Fig. 38) or (Fig. 39).

(4) Remove injector(s) from fuel rail.

INSTALLATION

(1) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.

(2) Install injector(s) and injector clip(s) to fuel rail.

(3) Install fuel rail assembly. Refer to Fuel Injector Rail installation.

(4) Install air cleaner.

(5) Start engine and check for leaks.

FUEL TANK—ALL ENGINES

WARNING: GASOLINE POWERED ENGINES: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE EVEN WITH THE ENGINE OFF. BEFORE SERVICING THE FUEL TANK, FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO THE FUEL SYSTEM PRESSURE RELEASE PROCEDURE BEFORE SERVICING THE FUEL TANK.

Two different procedures may be used to drain fuel tank (lowering tank or using DRB scan tool). When equipped with a diesel engine, the DRB scan tool cannot be used (no electric fuel pump).

The quickest draining procedure involves lowering the fuel tank.

Gasoline Powered Engines: As an alternative procedure, the electric fuel pump may be activated allowing tank to be drained at fuel rail connection. Refer to DRB scan tool for fuel pump activation procedures. Before disconnecting fuel line at fuel rail, release fuel pressure. Refer to the Fuel System Pressure Release Procedure in this group for procedures. Attach end of special test hose tool number 6541, 6539, 6631 or 6923 at fuel rail disconnection (tool number will depend on model and/or engine application). Position opposite end of this hose tool to an approved gasoline draining station. Activate fuel pump and drain tank until empty.

REMOVAL AND INSTALLATION (Continued)

If electric fuel pump is not operating, tank must be lowered for fuel draining. Refer to following procedures.

REMOVAL

(1) Remove fuel tank filler tube cap.

(2) Perform Fuel System Pressure Release procedure as described in this group.

(3) Gasoline Engines: Disconnect negative battery cable at battery. Diesel Engines: Disconnect both negative battery cables at both batteries.

(4) Raise vehicle on hoist.

(5) Open fuel fill door and remove screws mounting fuel filler tube assembly to body. Do not disconnect rubber fuel fill or vent hoses from tank at this time.

(6) Place a transmission jack under center of fuel tank. Apply a slight amount of pressure to fuel tank with transmission jack.

(7) Remove fuel tank mounting strap nuts from mounting strap studs (Fig. 42). If equipped, remove fuel tank shield bolts.

(8) Lower fuel tank only enough to allow access to top of tank. The 2 tank fittings (where rubber fuel fill and vent hose connections are made) must be positioned above tank level. Rotate tank slightly to allow these fittings to be above tank level.

WARNING: WRAP SHOP TOWELS AROUND HOSES TO CATCH ANY GASOLINE SPILLAGE.

(9) While working over left rear tire/wheel, disconnect rubber fuel vent hose at fuel tank (Fig. 42) (vent hose is the smallest of 2 hoses). Position fuel siphoning/drain hose into this fitting at tank. Drain fuel into an approved portable holding tank or a properly labeled gasoline (or diesel fuel) safety container.

(10) Disconnect rubber fuel fill hose at fuel tank (Fig. 42).

(11) **Gas Powered Engines:**

(a) While working over left rear tire/wheel, disconnect wiring harness connector from electrical connector at top of fuel pump module (Fig. 43) or (Fig. 44).

(b) If equipped with 26 or 34 gallon fuel tank, two EVAP lines are connected to rollover valves. Disconnect EVAP line from rollover valve at top of module (Fig. 43). Disconnect other EVAP line from rollover valve near rear of tank (Fig. 43).

(c) If equipped with 35 gallon fuel tank, two EVAP lines are connected to rollover valves. Disconnect EVAP lines from rollover valves at top-front and top-rear of fuel tank (Fig. 45).

(d) Disconnect fuel supply line at fuel filter/fuel pressure regulator supply fitting (Fig. 43) or (Fig. 44). Refer to Quick-Connect Fittings for procedures.

(12) **Diesel Powered Engines:**

(a) While working over left rear tire/wheel, disconnect wiring harness connector from electrical connector at top of fuel tank module (Fig. 46).

(b) Disconnect fuel supply and fuel return lines at the fuel tank module fittings (Fig. 46). Refer to Quick-Connect Fittings for procedures.

(13) Gasoline Engines: If fuel pump module removal is necessary, refer to Fuel Pump Module Removal/Installation in this group. Diesel Engines: If fuel tank module removal is necessary, refer to Fuel Tank Module Removal/Installation in this group.

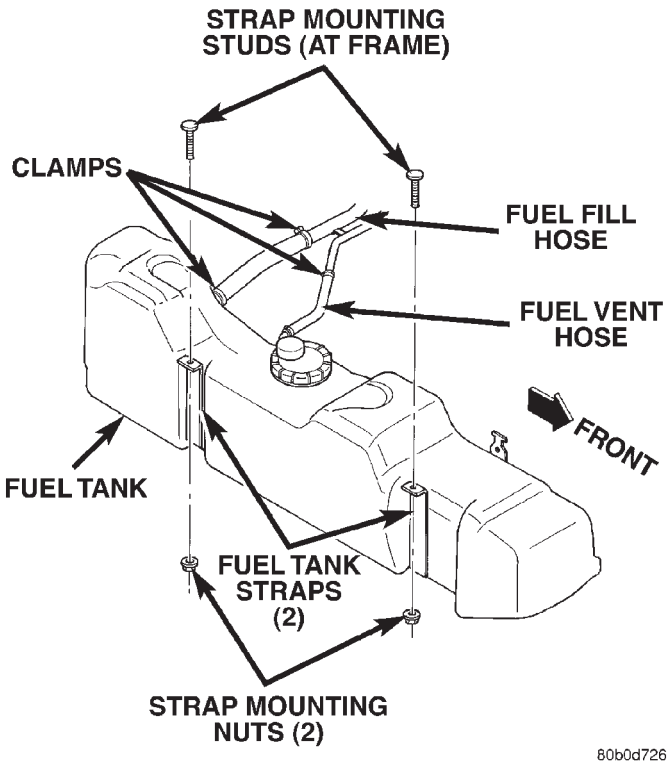


Fig. 42 Fuel Tank Mounting—Typical

INSTALLATION

(1) Gasoline Engines: If fuel pump module is being installed, refer to Fuel Pump Module Removal/Installation in this group. Diesel Engines: If fuel tank module is being installed, refer to Fuel Tank Module Removal/Installation in this group.

(2) Place fuel tank on top of transmission jack.

(3) Install rubber fill and vent lines to tank. Tighten hose clamps to 2.3 N·m (20 in. lbs.) torque.

(4) Raise tank into position while guiding fill and vent hoses to body. Raise tank only enough to allow access to top of tank.

(5) **Gas Powered Engines:**

(a) Connect electrical connector to fuel pump module.

(b) Connect EVAP hoses at rollover valves.

REMOVAL AND INSTALLATION (Continued)

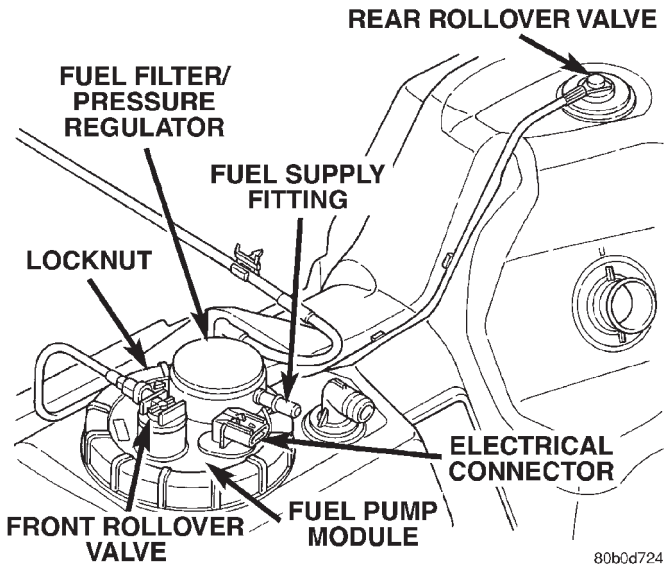


Fig. 43 Fuel Pump Module—Gas Engine With 26 or 34 Gallon Tank

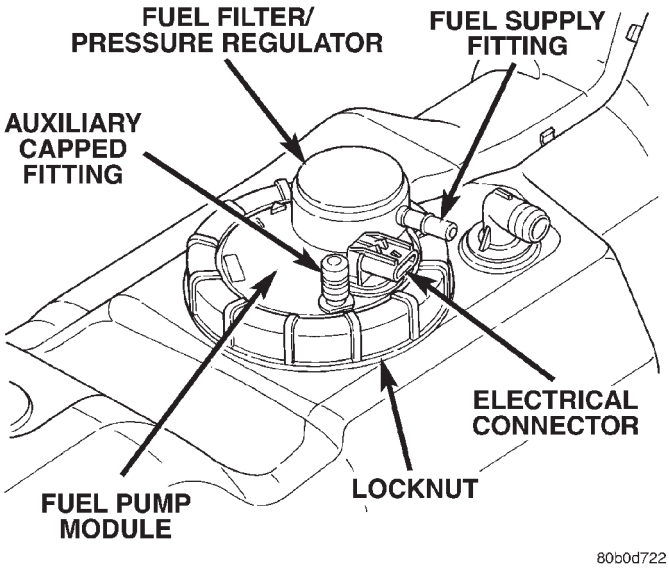


Fig. 44 Fuel Pump Module—Gas Engine With 35 Gallon Tank

(c) Connect fuel supply line at fuel filter/fuel pressure regulator. Refer to Quick-Connect Fittings for procedures.

(6) **Diesel Powered Engines:**

(a) Connect electrical connector to fuel tank module.

(b) Connect fuel supply and fuel return lines to fuel tank module fittings. Refer to Quick-Connect Fittings in this group.

(7) Connect two mounting straps and mounting strap nuts.

(8) Tighten strap nuts to 41 N·m (30 ft. lbs.) torque. Do not over tighten retaining strap nuts.

(9) Remove transmission jack.

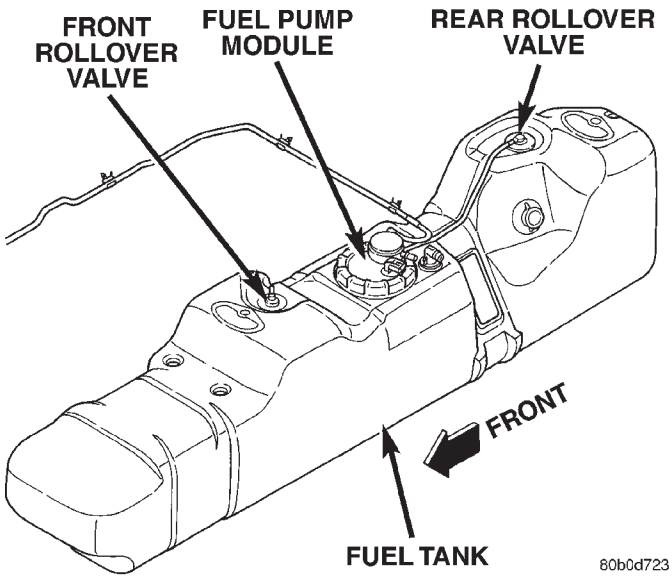


Fig. 45 Rollover Valve Locations—Gas Engine With 35 Gallon Tank

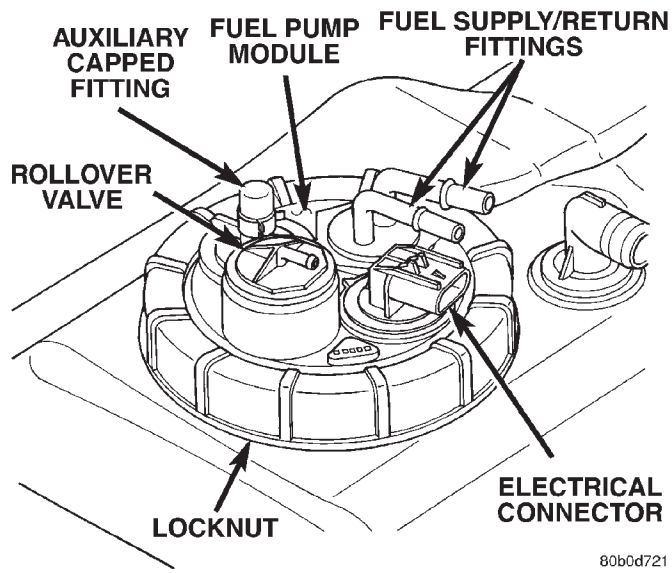


Fig. 46 Fuel Tank Module—Diesel Engine

(10) Connect fuel filler tube assembly to body.

(11) Refill fuel tank and inspect all hoses and lines for leaks.

(12) Connect negative battery cable(s) to battery(s).

FUEL TANK FILLER TUBE CAP

If replacement of the fuel tank filler tube cap is necessary, it must be replaced with an identical cap to be sure of correct system operation.

CAUTION: Remove the fuel tank filler tube cap to relieve fuel tank pressure. The cap must be removed prior to disconnecting any fuel system component or before draining the fuel tank.

REMOVAL AND INSTALLATION (Continued)

ACCELERATOR PEDAL

REMOVAL

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

(1) From inside the vehicle, hold up the accelerator pedal. Remove the plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 47). The plastic cable retainer snaps into pedal the arm.

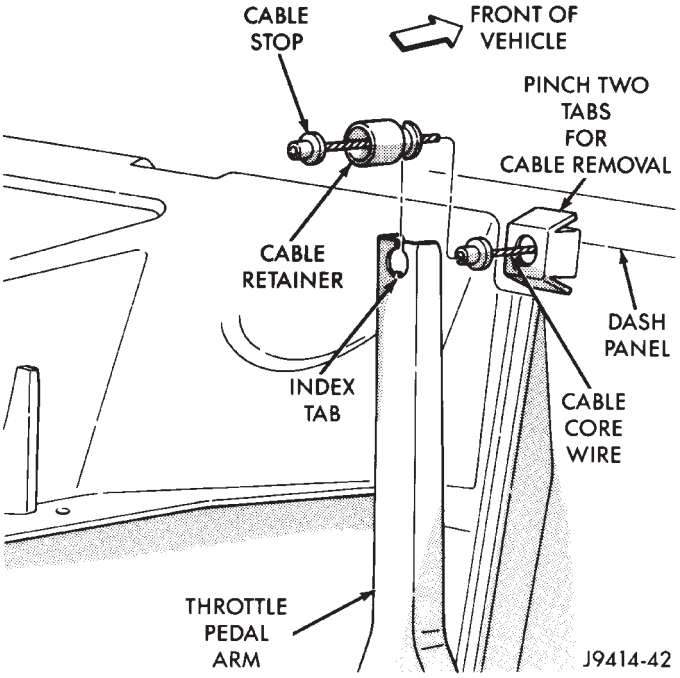


Fig. 47 Cable Removal/Installation

(2) Insert a small screwdriver into the square holes located on the pivots/bushings (Fig. 48). Twist the screwdriver to disengage the pivot locks from the pivot pin. Pivots will be damaged when removing. Discard old pivots.

(3) Remove pedal/bracket assembly from vehicle.

INSTALLATION

(1) Position pedal/bracket assembly over the pivot pin (Fig. 48).

(2) Install two new pivots/bushings. Using large pliers, press both of the bushings together until they bottom on the sides of the pedal/bracket assembly. Bushing retaining ears will snap into position when properly installed.

(3) From inside the vehicle, hold up the accelerator pedal. Install the throttle cable core wire and plastic cable retainer into and through the upper end of the pedal arm (the plastic retainer is snapped into the pedal arm). When installing the plastic retainer to the accelerator pedal arm, note the index tab on the pedal arm (Fig. 47). Align the index slot on the plastic cable retainer to this index tab.

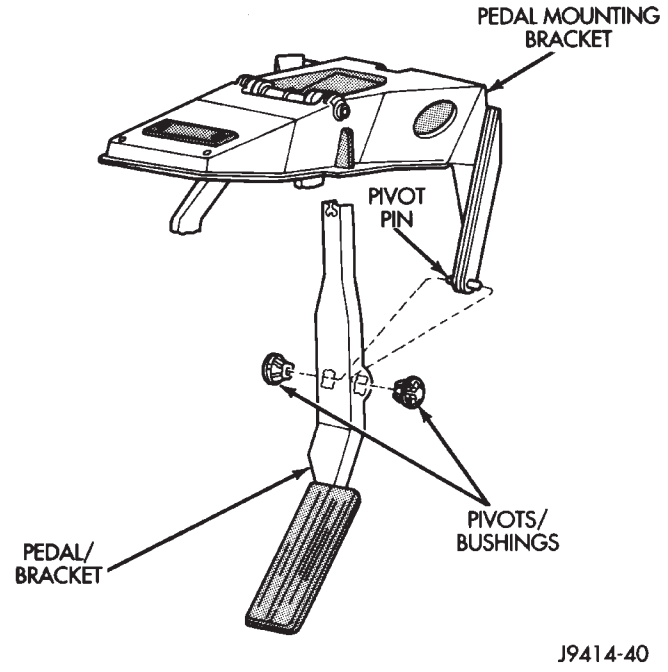


Fig. 48 Accelerator Pedal—Removal or Installation

THROTTLE CABLE

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

REMOVAL

(1) From inside the vehicle, hold up the accelerator pedal. Remove the plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 47). The plastic cable retainer snaps into pedal the arm.

(2) Remove the cable core wire at the pedal arm.

(3) Remove the air cleaner housing.

(4) From inside the vehicle, pinch both sides of the plastic cable housing retainer tabs at the dash panel (Fig. 47).

(5) Remove cable housing from dash panel and pull the cable into the engine compartment.

(6) **3.9L/5.2L/5.9L Engines:** Disconnect the cable from the routing/holddown clip at the radiator fan shroud.

(7) **8.0L V-10 Engine:** Remove the throttle cable socket at throttle lever ball. (Fig. 50) (snaps off).

(8) **3.9L/5.2L/5.9L Engines:** Slip the cable end rearward from pin on throttle body (Fig. 49).

(9) Remove cable housing at throttle body mounting bracket by pressing on release tab with a small

REMOVAL AND INSTALLATION (Continued)

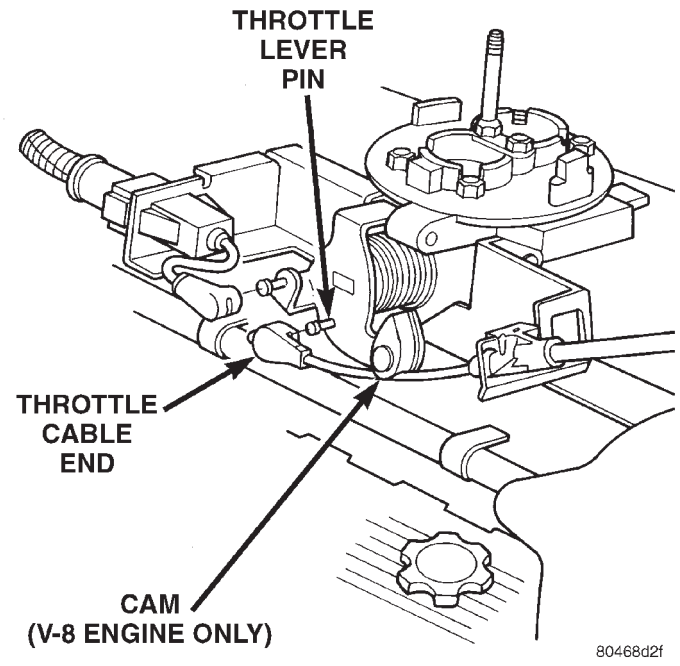


Fig. 49 Throttle Cable at Throttle Body—3.9L/5.2L/5.9L Engines—Typical

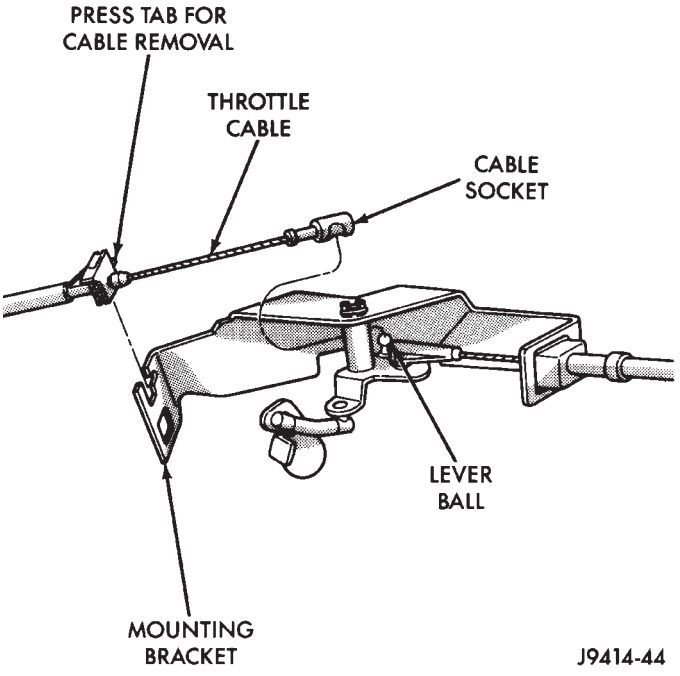


Fig. 50 Throttle Cable at Throttle Body—8.0L V-10 Engine

screwdriver (Fig. 51) or (Fig. 50). **To prevent cable housing breakage, press on the tab only enough to release the cable from the bracket.** Lift the cable housing straight up from bracket while pressing on release tab. Remove throttle cable from vehicle.

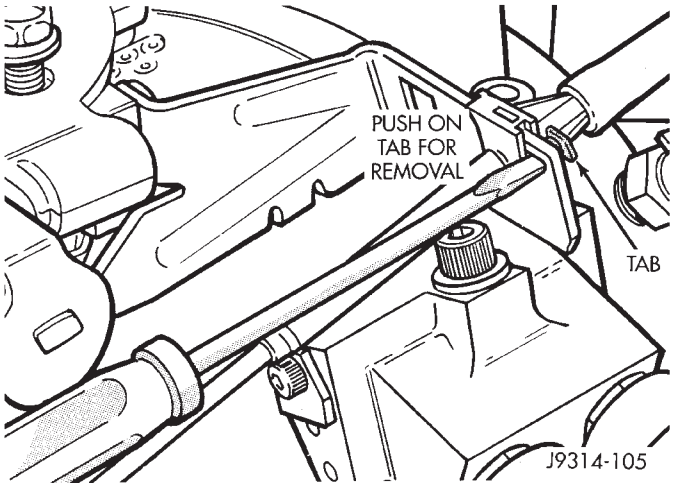


Fig. 51 Cable Release Tab—3.9L/5.2L/5.9L Engines—Typical

INSTALLATION

(1) **3.9L/5.2L/5.9L Engines:**

(a) Rotate and hold the throttle cam in the full wide open position. Snap the cable end onto lever pin (Fig. 49).

(b) Connect cable to throttle body mounting bracket (push down and lock).

(c) Connect cable to fan shroud routing clip.

(2) **8.0L V-10 Engine:**

(a) Connect cable end socket to throttle body lever ball (snaps on) (Fig. 50).

(b) Connect cable to throttle body mounting bracket (push down and lock).

(3) Install the remaining cable housing end into and through the dash panel opening (snaps into position). The two plastic pinch tabs (Fig. 47) should lock the cable to dash panel.

(4) From inside the vehicle, hold up the accelerator pedal. Install the throttle cable core wire and plastic cable retainer into and through the upper end of the pedal arm (the plastic retainer is snapped into the pedal arm). When installing the plastic retainer to the accelerator pedal arm, note the index tab on the pedal arm (Fig. 47). Align the index slot on the plastic cable retainer to this index tab.

SPECIFICATIONS

VECI LABEL

If anything differs between the specifications found on the Vehicle Emission Control Information (VECI) label and the following specifications, use specifications on VECI label. The VECI label is located in the engine compartment.

FUEL TANK CAPACITY—GAS ENGINES

MODEL	LITERS	U.S. GALLONS
Standard (Gas Powered)	98	26
138″ Wheelbase With Extended Cab (Gas Powered)	129	34
Optional/Heavy-Duty Engines (Gas Powered)	132	35
Nominal refill capacities are shown. A variation may be observed from vehicle to vehicle due to manufacturing tolerance and refill procedure.		

FUEL SYSTEM PRESSURE—GAS ENGINES

All Gasoline Powered Engines: 339 kPa ± 34 kPa (49.2 psi ± 5 psi)

TORQUE CHART

DESCRIPTION	TORQUE
Fuel Pump Module Locknut	24–44 N·m (18–32 ft. lbs.)
Fuel Rail Mounting Bolts—3.9L/5.2L/5.9L Engines	23 N·m (200 in. lbs.)
Fuel Rail Mounting Bolts—8.0L Engine	15 N·m (136 in. lbs.)
Fuel Tank Mounting Nuts	41 N·m (30 ft. lbs.)
Fuel Hose Clamps	1 N·m (15 in. lbs.)

FUEL INJECTION SYSTEM-GASOLINE ENGINES

INDEX

GENERAL INFORMATION

INTRODUCTION

All gasoline powered engines are equipped with sequential Multi-Port Fuel Injection (MFI). The MFI system provides precise air/fuel ratios for all driving conditions.

The powertrain control module (PCM) (Fig. 1) operates the fuel system.

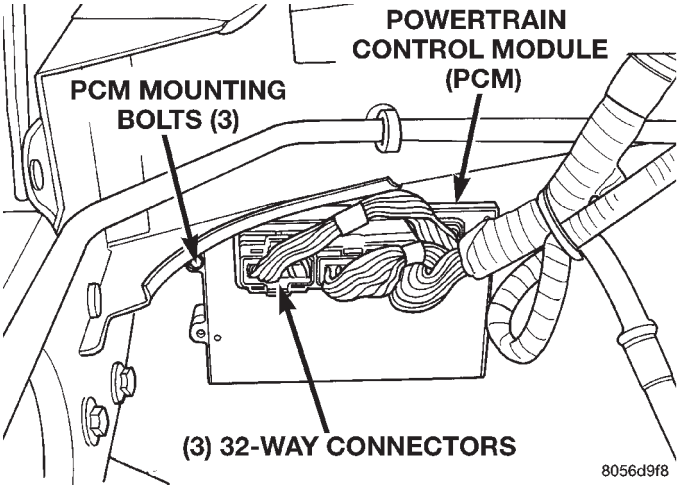


Fig. 1 Powertrain Control Module (PCM)

MODES OF OPERATION

As input signals to the powertrain control module (PCM) change, the PCM adjusts its response to the output devices. For example, the PCM must calculate different injector pulse width and ignition timing for idle than it does for wide open throttle (WOT).

The PCM will operate in two different modes: **Open Loop and Closed Loop**.

During Open Loop modes, the powertrain control module (PCM) receives input signals and responds only according to preset PCM programming. Input from the oxygen (O2S) sensors is not monitored during Open Loop modes.

During Closed Loop modes, the PCM will monitor the oxygen (O2S) sensors input. This input indicates to the PCM whether or not the calculated injector pulse width results in the ideal air-fuel ratio. This ratio is 14.7 parts air-to-1 part fuel. By monitoring the exhaust oxygen content through the O2S sensor, the PCM can fine tune the injector pulse width. This is done to achieve optimum fuel economy combined with low emission engine performance.

The fuel injection system has the following modes of operation:

- Ignition switch ON
- Engine start-up (crank)
- Engine warm-up
- Idle
- Cruise
- Acceleration
- Deceleration
- Wide open throttle (WOT)
- Ignition switch OFF

The ignition switch On, engine start-up (crank), engine warm-up, acceleration, deceleration and wide open throttle modes are Open Loop modes. The idle and cruise modes, (with the engine at operating temperature) are Closed Loop modes.

IGNITION SWITCH (KEY-ON) MODE

This is an Open Loop mode. When the fuel system is activated by the ignition switch, the following actions occur:

- The powertrain control module (PCM) pre-positions the idle air control (IAC) motor.
- The PCM determines atmospheric air pressure from the MAP sensor input to determine basic fuel strategy.
- The PCM monitors the engine coolant temperature sensor input. The PCM modifies fuel strategy based on this input.
- Intake manifold air temperature sensor input is monitored.
- Throttle position sensor (TPS) is monitored.
- The auto shutdown (ASD) relay is energized by the PCM for approximately three seconds.
- The fuel pump is energized through the fuel pump relay by the PCM. The fuel pump will operate for approximately three seconds unless the engine is operating or the starter motor is engaged.
- The O2S sensor heater element is energized via the ASD relay. The O2S sensor input is not used by the PCM to calibrate air-fuel ratio during this mode of operation.

ENGINE START-UP MODE

This is an Open Loop mode. The following actions occur when the starter motor is engaged.

The powertrain control module (PCM) receives inputs from:

- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Starter motor relay
- Camshaft position sensor signal

The PCM monitors the crankshaft position sensor. If the PCM does not receive a crankshaft position sensor signal within 3 seconds of cranking the engine, it will shut down the fuel injection system.

The fuel pump is activated by the PCM through the fuel pump relay.

Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control

GENERAL INFORMATION (Continued)

the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.

The PCM determines the proper ignition timing according to input received from the crankshaft position sensor.

ENGINE WARM-UP MODE

This is an Open Loop mode. During engine warm-up, the powertrain control module (PCM) receives inputs from:

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal (in the distributor)
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)

Based on these inputs the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM adjusts engine idle speed through the idle air control (IAC) motor and adjusts ignition timing.
- The PCM operates the A/C compressor clutch through the clutch relay. This is done if A/C has been selected by the vehicle operator and requested by the A/C thermostat.
- When engine has reached operating temperature, the PCM will begin monitoring O2S sensor input. The system will then leave the warm-up mode and go into closed loop operation.

IDLE MODE

When the engine is at operating temperature, this is a Closed Loop mode. At idle speed, the powertrain control module (PCM) receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal (in the distributor)
- Battery voltage
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Oxygen sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM monitors the O2S sensor input and adjusts air-fuel ratio by varying injector pulse width. It also adjusts engine idle speed through the idle air control (IAC) motor.
- The PCM adjusts ignition timing by increasing and decreasing spark advance.
- The PCM operates the A/C compressor clutch through the clutch relay. This happens if A/C has been selected by the vehicle operator and requested by the A/C thermostat.

CRUISE MODE

When the engine is at operating temperature, this is a Closed Loop mode. At cruising speed, the powertrain control module (PCM) receives inputs from:

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal (in the distributor)
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Oxygen (O2S) sensors

Based on these inputs, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then adjust the injector pulse width by turning the ground circuit to each individual injector on and off.
- The PCM monitors the O2S sensor input and adjusts air-fuel ratio. It also adjusts engine idle speed through the idle air control (IAC) motor.
- The PCM adjusts ignition timing by turning the ground path to the coil on and off.
- The PCM operates the A/C compressor clutch through the clutch relay. This happens if A/C has been selected by the vehicle operator and requested by the A/C thermostat.

ACCELERATION MODE

This is an Open Loop mode. The powertrain control module (PCM) recognizes an abrupt increase in throttle position or MAP pressure as a demand for increased engine output and vehicle acceleration. The

GENERAL INFORMATION (Continued)

PCM increases injector pulse width in response to increased throttle opening.

DECELERATION MODE

When the engine is at operating temperature, this is an Open Loop mode. During hard deceleration, the powertrain control module (PCM) receives the following inputs.

- Air conditioning select signal (if equipped)
- Air conditioning request signal (if equipped)
- Battery voltage
- Engine coolant temperature sensor
- Crankshaft position sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal (in the distributor)
- Park/neutral switch (gear indicator signal—auto. trans. only)
- Vehicle speed sensor

If the vehicle is under hard deceleration with the proper rpm and closed throttle conditions, the PCM will ignore the oxygen sensor input signal. The PCM will enter a fuel cut-off strategy in which it will not supply a ground to the injectors. If a hard deceleration does not exist, the PCM will determine the proper injector pulse width and continue injection.

Based on the above inputs, the PCM will adjust engine idle speed through the idle air control (IAC) motor.

The PCM adjusts ignition timing by turning the ground path to the coil on and off.

WIDE OPEN THROTTLE MODE

This is an Open Loop mode. During wide open throttle operation, the powertrain control module (PCM) receives the following inputs.

- Battery voltage
- Crankshaft position sensor
- Engine coolant temperature sensor
- Intake manifold air temperature sensor
- Manifold absolute pressure (MAP) sensor
- Throttle position sensor (TPS)
- Camshaft position sensor signal (in the distributor)

During wide open throttle conditions, the following occurs:

- Voltage is applied to the fuel injectors with the ASD relay via the PCM. The PCM will then control the injection sequence and injector pulse width by turning the ground circuit to each individual injector on and off. The PCM ignores the oxygen sensor input signal and provides a predetermined amount of additional fuel. This is done by adjusting injector pulse width.
- The PCM adjusts ignition timing by turning the ground path to the coil on and off.

IGNITION SWITCH OFF MODE

When ignition switch is turned to OFF position, the PCM stops operating the injectors, ignition coil, ASD relay and fuel pump relay.

DESCRIPTION AND OPERATION

POWERTRAIN CONTROL MODULE (PCM)

The powertrain control module (PCM) (Fig. 1) operates the fuel system. The PCM was formerly referred to as the SBEC or engine controller. The PCM is a pre-programmed, triple microprocessor digital computer. It regulates ignition timing, air-fuel ratio, emission control devices, charging system, certain transmission features, speed control, air conditioning compressor clutch engagement and idle speed. 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 Powertrain Control Module (PCM) Outputs. The sensors and switches that provide inputs to the PCM are considered Powertrain Control Module (PCM) Inputs.

The PCM adjusts ignition timing based upon inputs it receives from sensors that react to: engine rpm, manifold absolute pressure, engine coolant temperature, throttle position, transmission gear selection (automatic transmission), vehicle speed and the brake switch.

The PCM adjusts idle speed based on inputs it receives from sensors that react to: throttle position, vehicle speed, transmission gear selection, engine coolant temperature and from inputs it receives from the air conditioning clutch switch and brake switch.

Based on inputs that it receives, the PCM adjusts ignition coil dwell. The PCM also adjusts the generator charge rate through control of the generator field and provides speed control operation.

NOTE: PCM Inputs:

- A/C request (if equipped with factory A/C)
- A/C select (if equipped with factory A/C)
- Auto shutdown (ASD) sense
- Battery temperature
- Battery voltage
- Brake switch
- CCD bus (+) circuits
- CCD bus (-) circuits
- Camshaft position sensor signal

DESCRIPTION AND OPERATION (Continued)

- Crankshaft position sensor
- Data link connection for DRB scan tool
- Engine coolant temperature sensor
- Fuel level
- Generator (battery voltage) output
- Ignition circuit sense (ignition switch in on/off/crank/run position)
- Intake manifold air temperature sensor
- Leak detection pump (switch) sense (if equipped)
- Manifold absolute pressure (MAP) sensor
- Oil pressure
- Output shaft speed sensor
- Overdrive/override switch
- Oxygen sensors
- Park/neutral switch (auto. trans. only)
- Power ground
- Sensor return
- Signal ground
- Speed control multiplexed single wire input
- Throttle position sensor
- Transmission governor pressure sensor
- Transmission temperature sensor
- Vehicle speed inputs from ABS or RWAL system

NOTE: PCM Outputs:

- A/C clutch relay
- Auto shutdown (ASD) relay
- CCD bus (+) circuits
- CCD bus (-) circuits
- Data link connection for DRB scan tool
- EGR valve control solenoid (if equipped)
- EVAP canister purge solenoid
- Five volt sensor supply (primary)
- Five volt sensor supply (secondary)
- Fuel injectors
- Fuel pump relay
- Generator field driver (-)
- Generator field driver (+)
- Generator lamp (if equipped)
- Idle air control (IAC) motor
- Ignition coil
- Leak detection pump (if equipped)
- Malfunction indicator lamp (Check engine lamp). Driven through CCD circuits.
- Overdrive indicator lamp (if equipped)
- Service Reminder Indicator (SRI) Lamp (MAINT REQ'D lamp). Driven through CCD circuits.
- Speed control vacuum solenoid
- Speed control vent solenoid
- Tachometer (if equipped). Driven through CCD circuits.
- Transmission convertor clutch circuit
- Transmission 3–4 shift solenoid
- Transmission relay
- Transmission temperature lamp (if equipped)
- Transmission variable force solenoid

AIR CONDITIONING (A/C) CONTROLS—PCM INPUT

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

A/C SELECT SIGNAL: When the A/C switch is in the ON position, an input signal is sent to the powertrain control module (PCM). The signal informs the PCM that the A/C has been selected. The PCM adjusts idle speed to a pre-programmed rpm through the idle air control (IAC) motor to compensate for increased engine load.

A/C REQUEST SIGNAL: Once A/C has been selected, the powertrain control module (PCM) receives the A/C request signal from the clutch cycling pressure switch. The input indicates that the evaporator pressure is in the proper range for A/C application. The PCM uses this input to cycle the A/C compressor clutch (through the A/C relay). It will also determine the correct engine idle speed through the idle air control (IAC) motor position.

If the A/C low-pressure switch or high-pressure switch opens (indicating a low or high refrigerant pressure), 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.

If the switch opens, (indicating that evaporator is not in proper pressure range), the PCM will not receive the A/C request signal. The PCM will then remove the ground from the A/C relay, deactivating the A/C compressor clutch.

AUTOMATIC SHUTDOWN (ASD) RELAY SENSE—PCM INPUT

A 12 volt signal at this input indicates to the PCM that the ASD has been activated. The ASD relay is located in the Power Distribution Center (PDC). The PDC is located in the engine compartment (Fig. 2). Refer to label on PDC cover for relay location. The relay is used to connect the oxygen sensor heater element(s), ignition coil(s) and fuel injectors to 12 volt + power supply.

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

BATTERY TEMPERATURE SENSOR—PCM INPUT

Provides a signal to the PCM corresponding to the battery temperature. Refer to Group 8C, Charging System for additional information.

BATTERY VOLTAGE—PCM INPUT

The battery voltage input provides power to the Powertrain Control Module (PCM). It also informs

DESCRIPTION AND OPERATION (Continued)

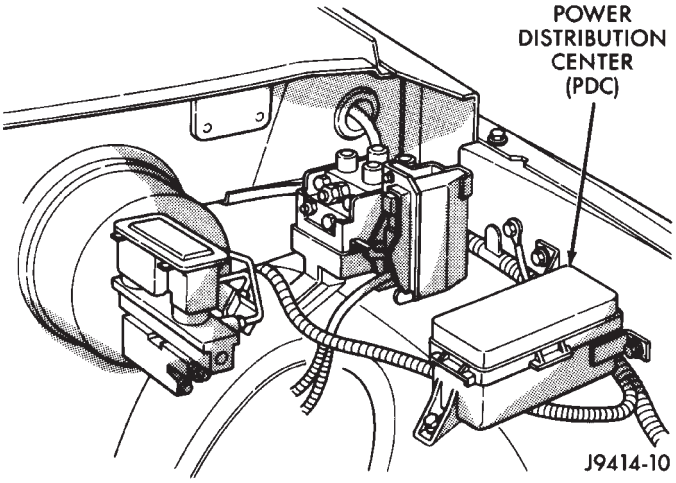


Fig. 2 Power Distribution Center (PDC)

the PCM what voltage level is supplied to the ignition coil and fuel injectors.

If battery voltage is low, the PCM will increase injector pulse width (period of time that the injector is energized). This is done to compensate for the reduced flow through injector caused by the lowered voltage.

BRAKE SWITCH—PCM INPUT

When the brake light switch is activated, the Powertrain Control Module (PCM) receives an input indicating that the brakes are being applied. After receiving this input, the PCM maintains idle speed to a scheduled rpm through control of the Idle Air Control (IAC) motor. The brake switch input is also used to supply/deny power to the speed control servo solenoids.

CAMSHAFT POSITION SENSOR—3.9L/5.2L/5.9L ENGINES—PCM INPUT

A sync signal is provide by the camshaft position sensor located in the distributor (Fig. 3). The sync signal from this sensor works in conjunction with the crankshaft position sensor to provide the powertrain control module (PCM) with inputs. This is done to establish and maintain correct injector firing order.

Refer to Camshaft Position Sensor in Group 8D, Ignition System for more information.

CAMSHAFT POSITION SENSOR—8.0L ENGINE—PCM INPUT

A sync signal is provide by the camshaft position sensor. The sensor is located on the side of the timing chain case/cover (Fig. 4). The sync signal from this sensor works in conjunction with the crankshaft position sensor to provide the powertrain control module (PCM) with inputs. This is done to establish and maintain correct injector firing order.

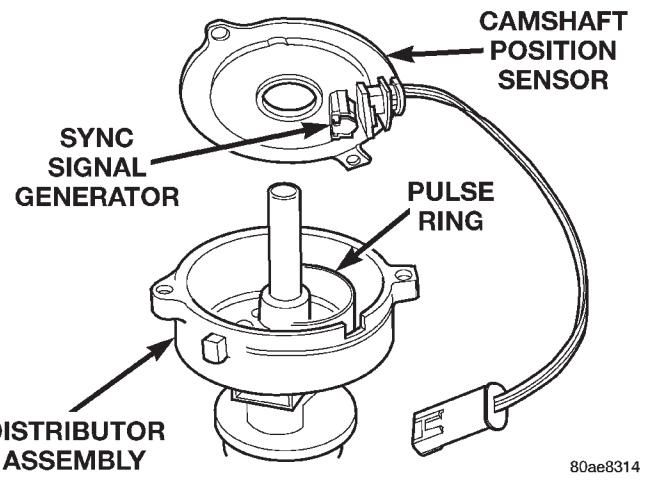


Fig. 3 Camshaft Position Sensor—3.9L/5.2L/5.9L Engines

Refer to Camshaft Position Sensor in Group 8D, Ignition System for more information.

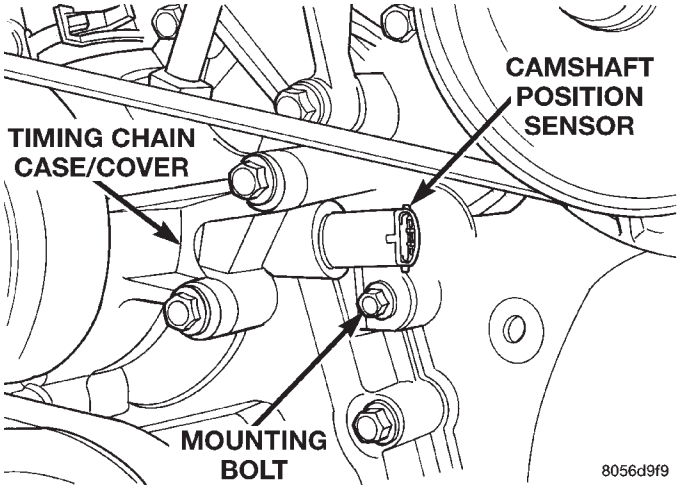


Fig. 4 Camshaft Position Sensor—8.0L Engine

CRANKSHAFT POSITION SENSOR—3.9L/5.2L/5.9L ENGINES—PCM INPUT

This sensor is a hall effect device that detects notches in the flywheel (manual transmission) or flexplate (automatic transmission).

This sensor is used to indicate to the powertrain control module (PCM) that a spark and or fuel injection event is to be required. The output from this sensor, in conjunction with the camshaft position sensor signal, is used to differentiate between fuel injection and spark events. It is also used to synchronize the fuel injectors with their respective cylinders.

The sensor is bolted to the cylinder block near the rear of the right cylinder head (Fig. 5).

Refer to Group 8D, Ignition System for more crankshaft position sensor information.

The engine will not operate if the PCM does not receive a crankshaft position sensor input.

DESCRIPTION AND OPERATION (Continued)

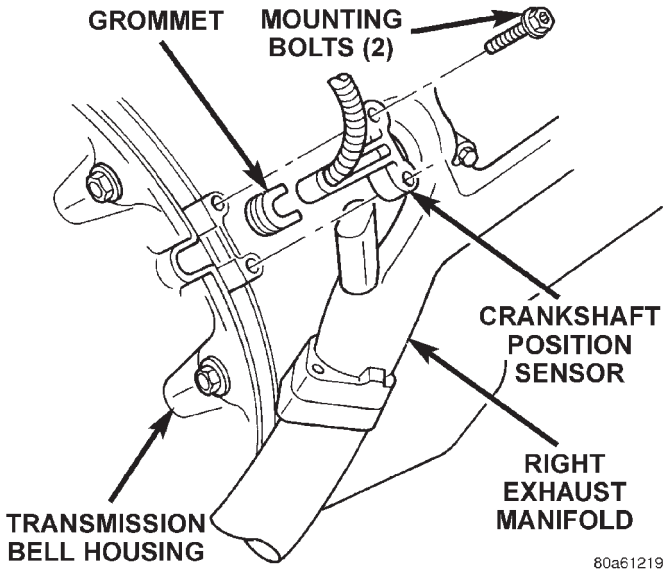


Fig. 5 Crankshaft Position Sensor—3.9L/5.2L/5.9L Engines—Typical

CRANKSHAFT POSITION SENSOR—8.0L ENGINE—PCM INPUT

This sensor is a hall effect device that detects notches in the engine crankshaft.

It is used to indicate to the powertrain control module (PCM) that a spark and or fuel injection event is to be required. The output from this sensor, in conjunction with the camshaft position sensor signal, is used to differentiate between fuel injection and spark events. It is also used to synchronize the fuel injectors with their respective cylinders.

The sensor is bolted to the side of the cylinder block (Fig. 6).

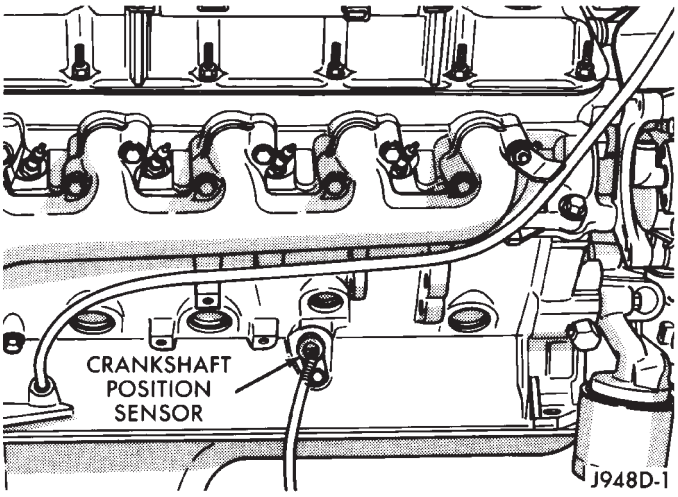


Fig. 6 Crankshaft Position Sensor—8.0L Engine—Typical

Refer to Group 8D, Ignition System for more crankshaft position sensor information.

The engine will not operate if the PCM does not receive a crankshaft position sensor input.

ENGINE COOLANT TEMPERATURE SENSOR—3.9L/ 5.2L/5.9L ENGINES—PCM INPUT

The engine coolant temperature sensor is installed next to the thermostat housing (Fig. 7) and protrudes into the water jacket. The sensor provides an input voltage to the powertrain control module (PCM) relating coolant temperature. The PCM uses this input along with inputs from other sensors to determine injector pulse width and ignition timing. As coolant temperature varies, the coolant temperature sensor resistance will change. This change in resistance results in a different input voltage to the PCM.

When the engine is cold, the PCM will operate in Open Loop cycle. It will demand slightly richer air-fuel mixtures and higher idle speeds. This is done until normal operating temperatures are reached.

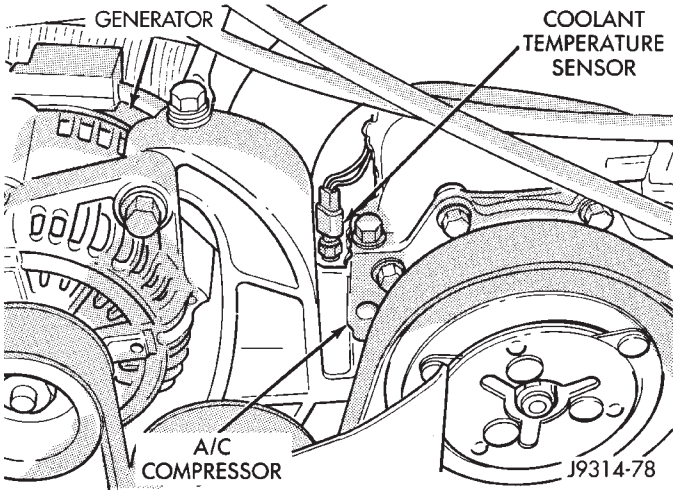


Fig. 7 Engine Coolant Temperature Sensor—3.9L/ 5.2L/5.9L Engines—Typical

ENGINE COOLANT TEMPERATURE SENSOR—8.0L ENGINE—PCM INPUT

The engine coolant temperature sensor is installed in the thermostat housing (Fig. 8) and protrudes into the water jacket. The sensor provides an input voltage to the powertrain control module (PCM) relating coolant temperature. The PCM uses this input along with inputs from other sensors to determine injector pulse width and ignition timing. As coolant temperature varies, the coolant temperature sensor resistance will change. This change in resistance results in a different input voltage to the PCM.

When the engine is cold, the PCM will operate in Open Loop cycle. It will demand slightly richer air-fuel mixtures and higher idle speeds. This is done until normal operating temperatures are reached.

DESCRIPTION AND OPERATION (Continued)

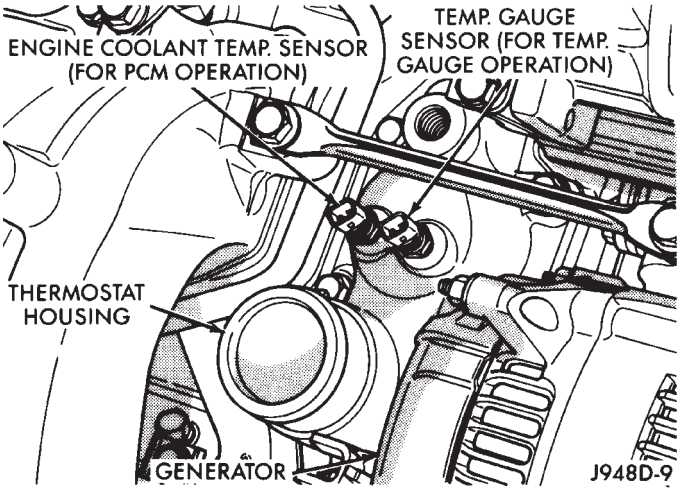


Fig. 8 Engine Coolant Temperature Sensor—8.0L Engine—Typical

FIVE VOLT SENSOR SUPPLY—PRIMARY

Supplies the required 5 volt power source to the crankshaft position sensor, camshaft position sensor, MAP sensor and throttle position sensor.

FIVE VOLT SENSOR SUPPLY—SECONDARY

Supplies the required 5 volt power source to the transmission pressure sensor (if equipped).

FUEL LEVEL SENSOR—PCM INPUT

The Powertrain Control Module (PCM) sends a 5 volt signal to the fuel level sensor (fuel gauge sending unit). The fuel level sensor will then return a signal to the PCM to indicate fuel level. The purpose of this feature is to prevent a false setting of misfire and fuel system monitor trouble codes. This is if the fuel level is less than approximately 15 percent, or, if equipped with a Leak Detection Pump (LDP), more than approximately 85 percent of its rated capacity. This input is also used to send a signal to the PCM for fuel gauge operation via the CCD bus circuits.

IGNITION CIRCUIT SENSE—PCM INPUT

The ignition circuit sense input tells the Powertrain Control Module (PCM) the ignition switch has energized the ignition circuit. Refer to the wiring diagrams for circuit information.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—3.9L/5.2L/5.9L ENGINES—PCM INPUT

The intake manifold air temperature sensor is installed in the intake manifold with the sensor element extending into the air stream (Fig. 9). The sensor provides an input voltage to the powertrain control module (PCM) indicating intake manifold air temperature. The input is used along with inputs from other sensors to determine injector pulse width. As the temperature of the air-fuel stream in the manifold varies, the sensor resistance changes. This results in a different input voltage to the PCM.

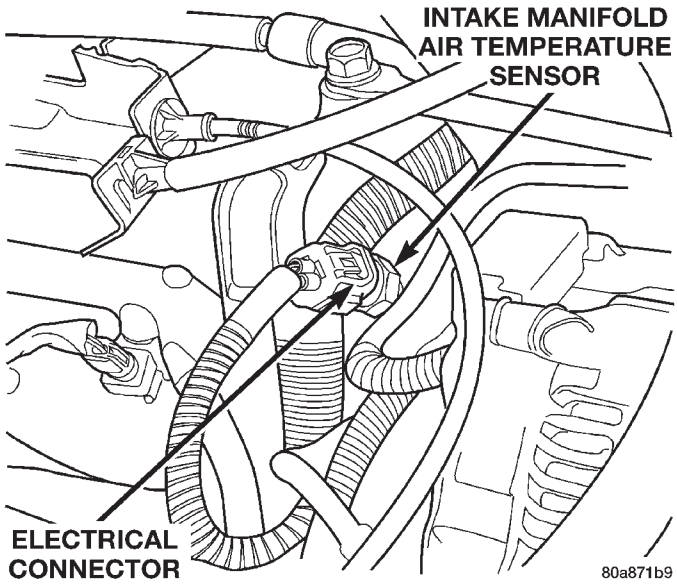


Fig. 9 Intake Manifold Air Temperature Sensor—3.9L/5.2L/5.9L Engine—Typical

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—8.0L ENGINE—PCM INPUT

The intake manifold air temperature sensor is installed in the intake manifold with the sensor element extending into the air stream (Fig. 10). The sensor provides an input voltage to the powertrain control module (PCM) indicating intake manifold air temperature. The input is used along with inputs from other sensors to determine injector pulse width. As the temperature of the air-fuel stream in the manifold varies, the sensor resistance changes. This results in a different input voltage to the PCM.

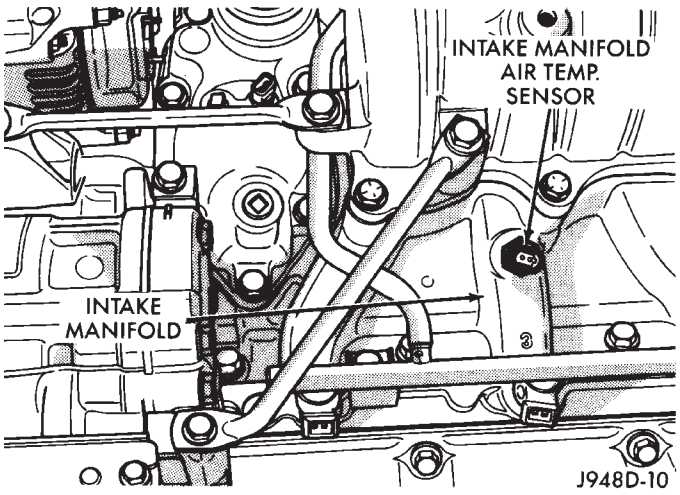


Fig. 10 Intake Manifold Air Temperature Sensor—8.0L Engine—Typical

DESCRIPTION AND OPERATION (Continued)

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—3.9L/5.2L/5.9L ENGINES—PCM INPUT

The MAP sensor reacts to absolute pressure in the intake manifold. It provides an input voltage to the powertrain control module (PCM). As engine load changes, manifold pressure varies. The change in manifold pressure causes MAP sensor voltage to change. The change in MAP sensor voltage results in a different input voltage to the PCM. The input voltage level supplies the PCM with information about ambient barometric pressure during engine start-up (cranking) and engine load while the engine is running. The PCM uses this input along with inputs from other sensors to adjust air-fuel mixture.

The MAP sensor is mounted on the side of the engine throttle body (Fig. 11). The sensor is connected to the throttle body with a rubber L-shaped fitting.

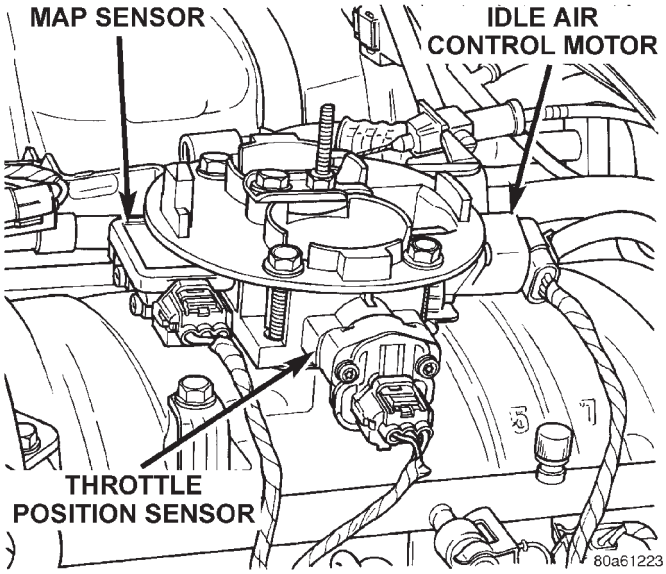


Fig. 11 MAP and Throttle Position Sensor Location—3.9L/5.2L/5.9L Engines—Typical

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—8.0L ENGINE—PCM INPUT

The MAP sensor reacts to absolute pressure in the intake manifold. It provides an input voltage to the powertrain control module (PCM). As engine load changes, manifold pressure varies. The change in manifold pressure causes MAP sensor voltage to change. The change in MAP sensor voltage results in a different input voltage to the PCM. The input voltage level supplies the PCM with information about ambient barometric pressure during engine start-up (cranking) and engine load while the engine is running. The PCM uses this input along with inputs from other sensors to adjust air-fuel mixture.

The MAP sensor is mounted into the right side of the intake manifold. (Fig. 12).

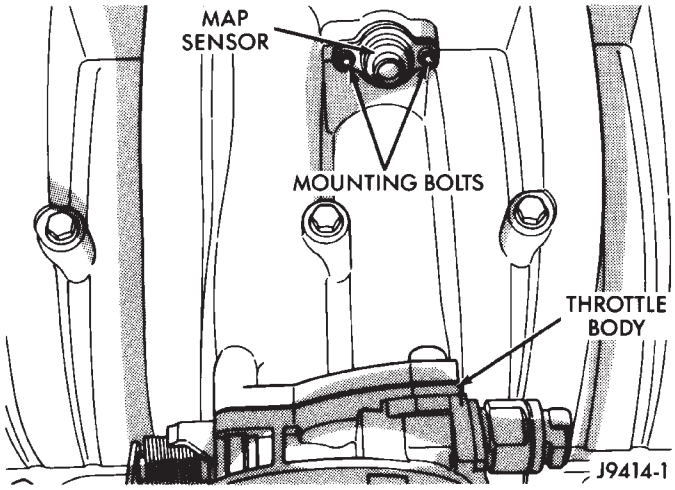


Fig. 12 MAP Sensor Location—8.0L Engine—Typical

OIL PRESSURE SENSOR—PCM INPUT

Sends a signal from the oil pressure sending unit to the Powertrain Control Module (PCM) relating to engine oil pressure.

OUTPUT SHAFT SPEED SENSOR—PCM INPUT

This sensor generates a signal to the PCM relating to the speed of the transmission main drive shaft. This input is used with 4–speed electronic transmissions only.

OVERDRIVE/OVERRIDE SWITCH—PCM INPUT

On vehicles equipped with an automatic transmission and overdrive, the powertrain control module (PCM) regulates the 3-4 overdrive up-shift and downshift through the overdrive solenoid. This solenoid is located in the transmission. An overdrive/override push-button switch is located at the end of transmission shift lever.

The overdrive/override push-button switch is normally open (overdrive allowed) when the lamp is not illuminated. It momentarily closes (overdrive not allowed) when the operator presses the switch and the lamp is illuminated. Overdrive will revert to ON (lamp off) each time the ignition switch in turned on. The transmission downshifts if the operator presses the override switch while in overdrive.

Refer to Group 21 for more transmission information.

OXYGEN SENSOR (O2S)—3.9L/5.2L/5.9L LDC ENGINES—PCM INPUT

Two heated O2S sensors are used (upstream and downstream). The sensors produce voltages from 0 to 1 volt, depending upon the oxygen content of the exhaust gas in the exhaust manifold. When a large amount of oxygen is present (caused by a lean air/fuel mixture), the sensors produces a low voltage.

DESCRIPTION AND OPERATION (Continued)

When there is a lesser amount present (rich air/fuel mixture) it produces a higher voltage. By monitoring the oxygen content and converting it to electrical voltage, the sensors act as a rich-lean switch.

The oxygen sensors are equipped with a heating element that keeps the sensors at proper operating temperature during all operating modes. Maintaining correct sensor temperature at all times allows the system to enter into closed loop operation sooner. Also, it allows the system to remain in closed loop operation during periods of extended idle.

In Closed Loop operation, the PCM monitors the O2S sensor input (along with other inputs) and adjusts the injector pulse width accordingly. During Open Loop operation, the PCM ignores the O2 sensor input. The PCM adjusts injector pulse width based on preprogrammed (fixed) values and inputs from other sensors.

The Automatic Shutdown (ASD) relay supplies battery voltage to both the upstream and downstream heated oxygen sensors. The oxygen sensors are equipped with a heating element. The heating elements reduce the time required for the sensors to reach operating temperature.

UPSTREAM HEATED OXYGEN SENSOR

The upstream O2S sensor is located in the exhaust downpipe (Fig. 13). It provides an input voltage to the PCM. The input tells the PCM the oxygen content of the exhaust gas. The PCM uses this information to fine tune fuel delivery to maintain the correct oxygen content at the downstream oxygen sensor. The PCM will change the air/fuel ratio until the upstream sensor inputs a voltage that the PCM has determined will make the downstream sensor output (oxygen content) correct.

The upstream oxygen sensor also provides an input to determine catalyst efficiency. Refer to Group 25 Emissions, On-Board Diagnostics, Catalyst Monitor for more information.

DOWNSTREAM HEATED OXYGEN SENSOR

The downstream heated oxygen sensor is located near the outlet end of the catalytic convertor (Fig. 13). The downstream is also used to determine the correct air fuel ratio. As the oxygen content changes at the downstream the PCM calculates how much air fuel ratio change is required. The PCM then looks at the upstream oxygen sensor voltage and changes fuel delivery until the upstream sensor voltage changes enough to correct the downstream sensor voltage (oxygen content).

The downstream oxygen sensor also provides an input to determine catalyst efficiency. Refer to Group 25 Emissions Control Systems, On-Board Diagnostics, Catalyst Monitor for more information.

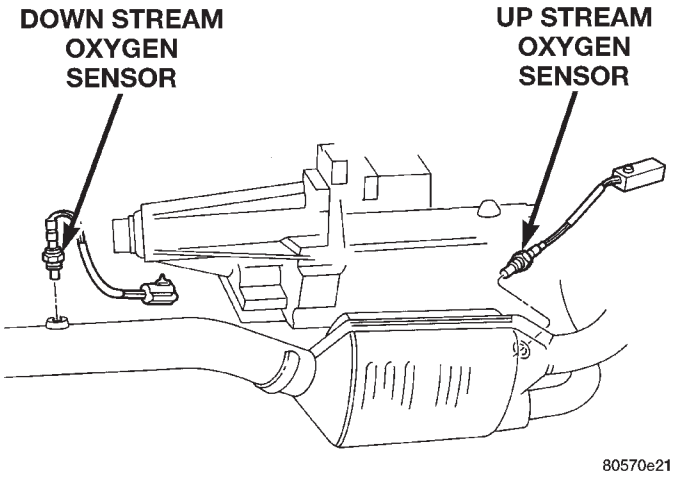


Fig. 13 Upstream/Downstream Oxygen Sensors—LDC Engines

OXYGEN SENSOR (O2S)—HDC ENGINES—PCM INPUT

A total of two heated O2S sensors are used (left and right) on HDC engines. On the 5.9L HDC engine, the left O2S sensor will monitor cylinders 1, 3, 5 and 7. The right sensor will monitor cylinders 2, 4, 6 and 8. On the 8.0L V-10 HDC engine, the left O2S sensor will monitor cylinders 1, 3, 5, 7 and 9. The right sensor will monitor cylinders 2, 4, 6, 8 and 10.

The sensors produce voltages from 0 to 1 volt, depending upon the oxygen content of the exhaust gas in the exhaust manifold. When a large amount of oxygen is present (caused by a lean air/fuel mixture), the sensors produces a low voltage. When there is a lesser amount present (rich air/fuel mixture) it produces a higher voltage. By monitoring the oxygen content and converting it to electrical voltage, the sensors act as a rich-lean switch.

The oxygen sensors are equipped with a heating element that keeps the sensors at proper operating temperature during all operating modes. Maintaining correct sensor temperature at all times allows the system to enter into closed loop operation sooner. Also, it allows the system to remain in closed loop operation during periods of extended idle.

In Closed Loop operation, the PCM monitors the O2S sensor input (along with other inputs) and adjusts the injector pulse width accordingly. During Open Loop operation, the PCM ignores the O2 sensor input. The PCM adjusts injector pulse width based on preprogrammed (fixed) values and inputs from other sensors.

The Automatic Shutdown (ASD) relay supplies battery voltage to both oxygen sensors. The oxygen sensors are equipped with a heating elements. The heating elements reduce the time required for the sensors to reach operating temperature.

DESCRIPTION AND OPERATION (Continued)

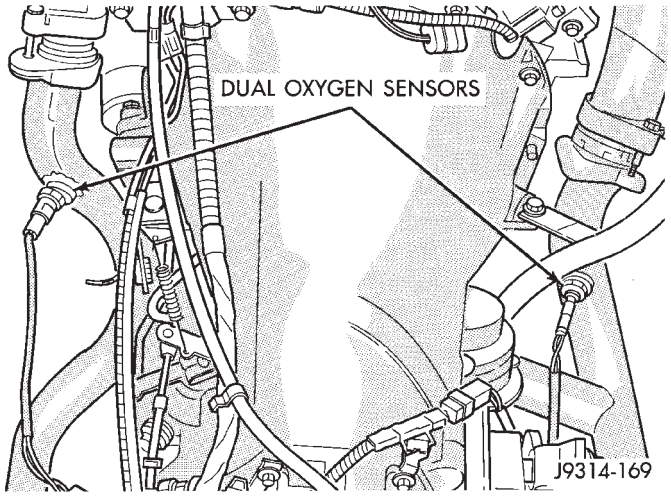


Fig. 14 Left/Right Heated Oxygen Sensors—HDC Engines

OXYGEN SENSOR (O2S)—8.0L MDC ENGINES—PCM INPUT

The 8.0L V-10 engine, when equipped with a Medium Duty Emission Cycle (MDC) package, will use four heated O2S sensors. They are: Left, right, pre-catalyst and post catalyst. The left, right and post catalyst sensors will fine-tune air-fuel ratio. The pre-catalyst and post catalyst sensors will determine catalytic converter efficiency.

Two of these sensors are installed into the left and right exhaust manifold downpipes (Fig. 14). On the 8.0L V-10 MDC engine, the left O2S sensor will monitor cylinders 1, 3, 5, 7 and 9. The right sensor will monitor cylinders 2, 4, 6, 8 and 10.

The sensors produce voltages from 0 to 1 volt, depending upon the oxygen content of the exhaust gas in the exhaust manifold. When a large amount of oxygen is present (caused by a lean air/fuel mixture), the sensors produces a low voltage. When there is a lesser amount present (rich air/fuel mixture) it produces a higher voltage. By monitoring the oxygen content and converting it to electrical voltage, the sensors act as a rich-lean switch.

The oxygen sensors are equipped with a heating element that keeps the sensors at proper operating temperature during all operating modes. Maintaining correct sensor temperature at all times allows the system to enter into closed loop operation sooner. Also, it allows the system to remain in closed loop operation during periods of extended idle.

In Closed Loop operation, the PCM monitors the O2S sensor input (along with other inputs) and adjusts the injector pulse width accordingly. During Open Loop operation, the PCM ignores the O2 sensor input. The PCM adjusts injector pulse width based on preprogrammed (fixed) values and inputs from other sensors.

The Automatic Shutdown (ASD) relay supplies battery voltage to both oxygen sensors. The oxygen sensors are equipped with a heating elements. The heating elements reduce the time required for the sensors to reach operating temperature.

PRE-CATALYST OXYGEN SENSOR

The pre-catalyst O2S sensor is located in the inlet end of the catalytic converter (Fig. 15). It provides an input voltage to the PCM. By comparing the input from the pre-catalyst O2S sensor, with the input from the post catalyst oxygen sensor, the PCM calculates catalytic convertor efficiency.

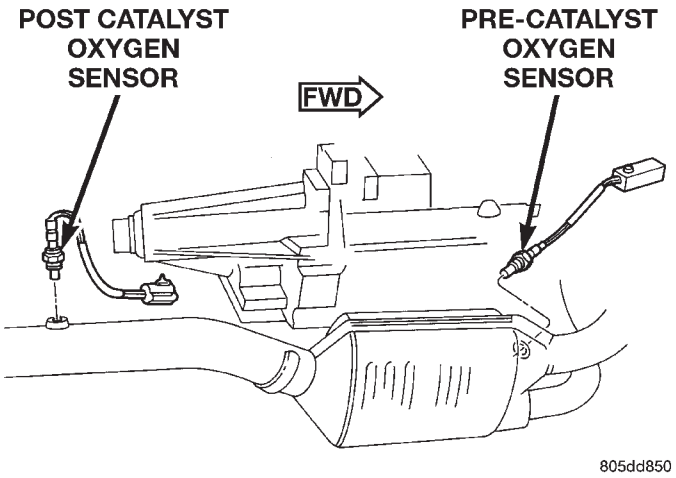


Fig. 15 Pre-Catalyst/Post Catalyst Oxygen Sensors—MDC Engines

POST CATALYST OXYGEN SENSOR

The post catalyst heated oxygen sensor threads into the outlet end of the catalytic convertor (Fig. 15). The post catalyst heated oxygen sensor input is used to detect catalytic convertor deterioration and fine tune the air fuel ratio. As the convertor deteriorates, the input from this sensor begins to match the pre-catalyst sensor input except for a slight time delay. By comparing the inputs from both of these sensors, the PCM calculates catalytic convertor efficiency.

When the catalytic converter efficiency drops below emission standards, the PCM stores a diagnostic trouble code and illuminates the Malfunction Indicator Lamp (MIL). For more information, refer to Group 25, Emission Control Systems.

POWER GROUND

The power ground is used to control ground circuits for the following powertrain control module (PCM) loads:

- Generator field winding
- Fuel injectors
- Ignition coil
- Certain relays/solenoids

DESCRIPTION AND OPERATION (Continued)

PTO SWITCH SENSE—PCM INPUT

This Powertrain Control Module (PCM) input is used only on models equipped with aftermarket Power Take Off (PTO) units.

The input is used only to tell the PCM that the PTO has been engaged. The PCM will disable (temporarily shut down) certain OBD II fault codes when the PTO is engaged.

Operation: When the aftermarket PTO switch has been engaged, a 12V + signal is sent through circuit G113 to PCM pin A13. The PCM will then sense and determine that the PTO has been activated.

SENSOR RETURN—PCM INPUT

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

SIGNAL GROUND—PCM INPUT

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

SPEED CONTROL SWITCHES—PCM INPUT

Six different speed control functions, using three momentary contact switches, are monitored through this **multiplexed** input. The resistance monitored at this input, in combination with the length of time the PCM measures the resistance, determines which switch feature has been selected. The three switches are: On/Off, Set/Coast, Cancel and Resume/Accelerate.

Refer to Group 8H, Vehicle Speed Control System for further speed control information.

TRANSMISSION PARK/NEUTRAL SWITCH—PCM INPUT

The park/neutral switch is located on the transmission housing and provides an input to the powertrain control module (PCM). This will indicate that the automatic transmission is in Park, Neutral or a drive gear selection. This input is used to determine idle speed (varying with gear selection), fuel injector pulse width, ignition timing advance and vehicle speed control operation. Refer to Group 21, Transmissions, for testing, replacement and adjustment information.

TRANSMISSION GOVERNOR PRESSURE SENSOR—PCM INPUT

Provides a signal proportional to the transmission governor pressure. It provides feedback for control of the governor pressure solenoid, which regulates transmission governor pressure. This input is used with 4–speed electronic transmissions only.

TRANSMISSION TEMPERATURE SENSOR—PCM INPUT

This input is used in the shift operation for 4–speed electronic transmissions only. The temperature data is used for: torque converter clutch operation, overdrive shift, low temperature shift compensation, wide open throttle shift strategy and governor pressure transducer calibration.

THROTTLE POSITION SENSOR (TPS)—3.9L/5.2L/5.9L ENGINES—PCM INPUT

The throttle position sensor (TPS) is mounted on the throttle body (Fig. 11). The TPS is a variable resistor that provides the powertrain control module (PCM) with an input signal (voltage) that represents throttle blade position. The sensor is connected to the throttle blade shaft. As the position of the throttle blade changes, the resistance of the TPS changes.

The PCM supplies approximately 5 volts to the TPS. The TPS output voltage (input signal to the PCM) represents the throttle blade position. The PCM receives an input signal voltage from the TPS. This will vary in an approximate range of from .25 volts at minimum throttle opening (idle), to 4.8 volts at wide open throttle. Along with inputs from other sensors, the PCM uses the TPS input to determine current engine operating conditions. In response to engine operating conditions, the PCM will adjust fuel injector pulse width and ignition timing.

THROTTLE POSITION SENSOR (TPS)—8.0L ENGINE—PCM INPUT

The throttle position sensor (TPS) is mounted on the throttle body (Fig. 16). The TPS is a variable resistor that provides the powertrain control module (PCM) with an input signal (voltage) that represents throttle blade position. The sensor is connected to the throttle blade shaft. As the position of the throttle blade changes, the resistance of the TPS changes.

The PCM supplies approximately 5 volts to the TPS. The TPS output voltage (input signal to the PCM) represents the throttle blade position. The PCM receives an input signal voltage from the TPS. This will vary in an approximate range of from .25 volts at minimum throttle opening (idle), to 4.8 volts at wide open throttle. Along with inputs from other sensors, the PCM uses the TPS input to determine current engine operating conditions. In response to engine operating conditions, the PCM will adjust fuel injector pulse width and ignition timing.

VEHICLE SPEED AND DISTANCE—PCM INPUT

The Vehicle Speed Sensor (VSS) is no longer used for any Dodge truck in the 1998 model year.

Vehicle speed and distance covered are measured by the Rear Wheel Speed Sensor. The sensor is

DESCRIPTION AND OPERATION (Continued)

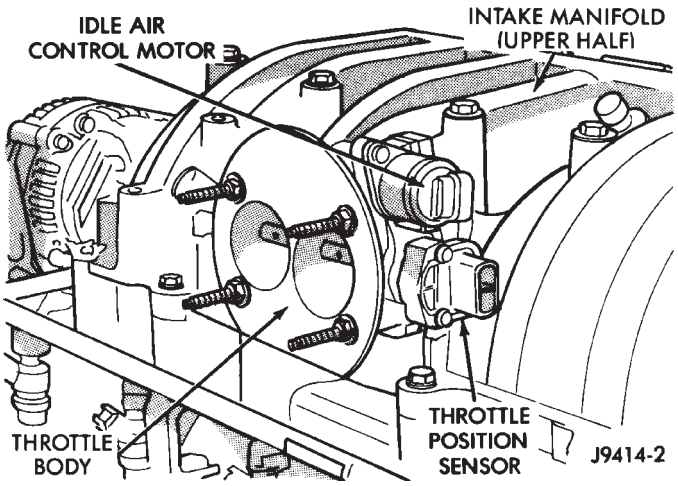


Fig. 16 Sensor Location—8.0L Engine

mounted to the rear axle. A signal is sent from this sensor to the Controller Antilock Brake (CAB) computer. A signal is then sent from the CAB to the Powertrain Control Module (PCM) to determine vehicle speed and distance covered. The PCM will then determine strategies for fuel system and speed control system operation.

Refer to Odometer and Trip Odometer in Group 8E, Instrument Panel for additional information.

AIR CONDITIONING (A/C) CLUTCH RELAY—PCM OUTPUT

The A/C relay is located in the Power Distribution Center (PDC) (Fig. 17). Refer to label on PDC cover for relay location.

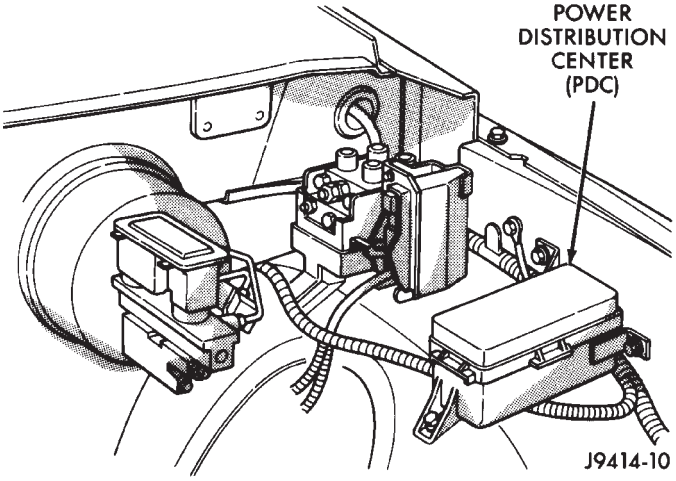


Fig. 17 Power Distribution Center (PDC)

The powertrain control module (PCM) activates the A/C compressor through the A/C clutch relay. The PCM regulates A/C compressor operation by switching the ground circuit for the A/C clutch relay on and off.

When the PCM receives a request for A/C, it will adjust idle air control (IAC) motor position. This is done to increase idle speed. The PCM will then activate the A/C clutch through the A/C clutch relay. The PCM adjusts idle air control (IAC) stepper motor position to compensate for increased engine load from the A/C compressor.

By switching the ground path for the relay on and off, the PCM is able to cycle the A/C compressor clutch. This is based on changes in engine operating conditions. If, during A/C operation, the PCM senses low idle speeds or a wide open throttle condition, it will de-energize the relay. This prevents A/C clutch engagement. The relay will remain de-energized until the idle speed increases or the wide open throttle condition exceeds 15 seconds or no longer exists. The PCM will also de-energize the relay if coolant temperature exceeds 125°C (257°F) or low or high system pressure exists.

AUTO SHUTDOWN (ASD) RELAY—PCM OUTPUT

The ASD relay is located in the Power Distribution Center (PDC) (Fig. 17).

The ASD supplies battery voltage to the fuel injectors, ignition coil and oxygen (O2S) sensor heating elements. The ground circuit for the coil in the ASD relay is controlled by the powertrain control module (PCM). The PCM operates the relay by switching the ground circuit on and off.

CCD BUS (+/-) CIRCUITS-PCM OUTPUTS

The Powertrain Control Module (PCM) sends certain output signals through the CCD bus circuits. These signals are used to control certain instrument panel located items and to determine certain identification numbers.

Refer to Group 8E, Instrument Panel and Gauges for additional information.

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 or the Mopar Diagnostic System (MDS) with the powertrain control module (PCM). The data link connector (Fig. 18) is located at lower edge of instrument panel near steering column. For operation of the DRB scan tool, refer to the appropriate Powertrain Diagnostic Procedures service manual.

DUTY CYCLE EVAP PURGE SOLENOID VALVE-PCM OUTPUT

Refer to Group 25, Emission Control System for information.

DESCRIPTION AND OPERATION (Continued)

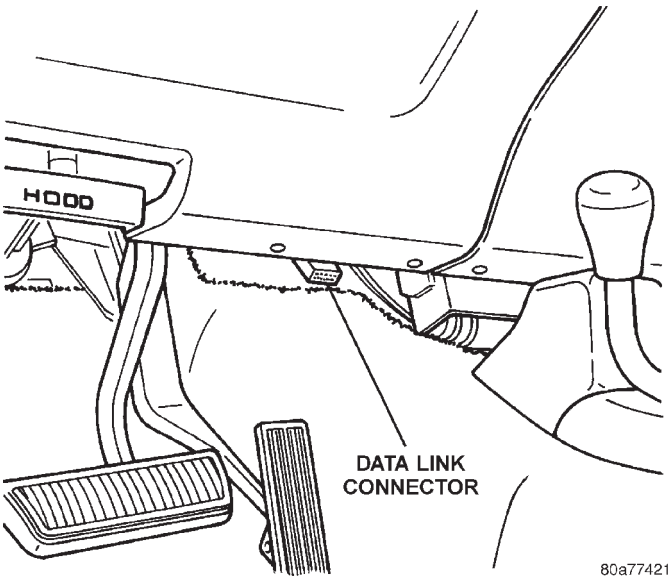


Fig. 18 16–Way Data Link Connector

FUEL INJECTORS—3.9L/5.2L/5.9L ENGINES—PCM OUTPUT

The fuel injectors are attached to the fuel rail (Fig. 19). 3.9L engines use six injectors. 5.2L and 5.9L engines use eight injectors.

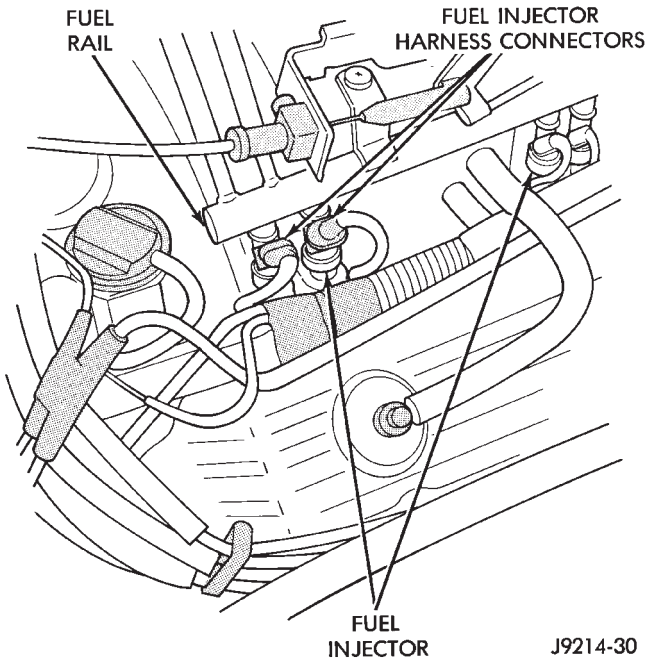


Fig. 19 Fuel Injectors—3.9L/5.2L/5.9L Engines—Typical

The nozzle ends of the injectors are positioned into openings in the intake manifold just above the intake valve ports of the cylinder head. The engine wiring harness connector for each fuel injector is equipped with an attached numerical tag (INJ 1, INJ 2 etc.). This is used to identify each fuel injector with its respective cylinder number.

The injectors are energized individually in a sequential order by the powertrain control module (PCM). The PCM will adjust injector pulse width by switching the ground path to each individual injector on and off. Injector pulse width is the period of time that the injector is energized. The PCM will adjust injector pulse width based on various inputs it receives.

During start up, battery voltage is supplied to the injectors through the ASD relay. When the engine is operating, voltage is supplied by the charging system. The PCM determines injector pulse width based on various inputs.

FUEL INJECTORS—8.0L ENGINE—PCM OUTPUT

The fuel injectors are attached to the fuel rail (Fig. 20). 8.0L V–10 engines use 10 injectors.

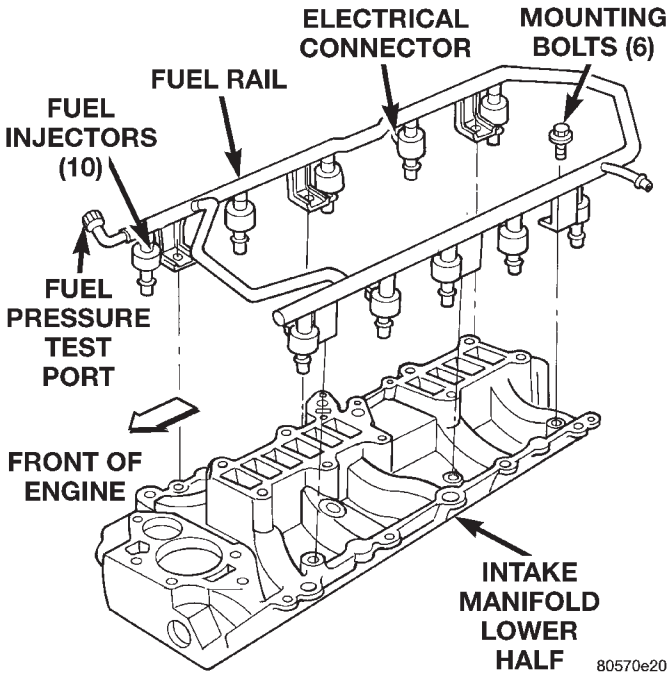


Fig. 20 Fuel Injectors—8.0L Engine—Typical

The nozzle ends of the injectors are positioned into openings in the intake manifold just above the intake valve ports of the cylinder head. The engine wiring harness connector for each fuel injector is equipped with an attached numerical tag (INJ 1, INJ 2 etc.). This is used to identify each fuel injector with its respective cylinder number.

The 10 injectors are energized individually in a sequential order by the powertrain control module (PCM). The PCM will adjust injector pulse width by switching the ground path to each individual injector on and off. Injector pulse width is the period of time that the injector is energized. The PCM will adjust

DESCRIPTION AND OPERATION (Continued)

injector pulse width based on various inputs it receives.

During start up, battery voltage is supplied to the injectors through the ASD relay. When the engine is operating, voltage is supplied by the charging system. The PCM determines injector pulse width based on various inputs.

FUEL PUMP RELAY—PCM OUTPUT

The PCM energizes the electric fuel pump through the fuel pump relay. Battery voltage is applied to the fuel pump relay when the ignition key is ON. The relay is energized when a ground signal is provided by the PCM.

The fuel pump will operate for approximately one second unless the engine is operating or the starter motor is engaged.

The fuel pump relay is located in the Power Distribution Center (PDC) (Fig. 17).

GENERATOR FIELD SOURCE (+)—PCM OUTPUT

This output from the Powertrain Control Module (PCM) regulates charging system voltage to the generator field source (+) circuit. The voltage range is 12.9 to 15.0 volts. Models of previous years had used the ASD relay (directly) to apply the 12 volt + power supply to the generator field source (+) circuit. Refer to Groups 8A and 8C for charging system information.

GENERATOR FIELD DRIVER (-)—PCM OUTPUT

This output from the Powertrain Control Module (PCM) regulates charging system ground control to the generator field driver (-) circuit. Refer to Groups 8A and 8C for charging system information.

GENERATOR LAMP—PCM OUTPUT

If the powertrain control module (PCM) senses a low charging condition in the charging system, it will illuminate the generator lamp (if equipped) on the instrument panel. For example, during low idle with all accessories turned on, the lamp may momentarily go on. Once the PCM corrects idle speed to a higher rpm, the lamp will go out. Refer to Groups 8A and 8C for charging system information.

IDLE AIR CONTROL (IAC) MOTOR—3.9L/5.2L/5.9L ENGINES—PCM OUTPUT

The IAC motor is mounted to the back of the throttle body (Fig. 11) and is controlled by the powertrain control module (PCM).

The throttle body has an air control passage that provides air for the engine at idle (the throttle plate is closed). The IAC motor pintle protrudes into the air control passage (Fig. 21) and regulates air flow through it. Based on various sensor inputs, the powertrain control module (PCM) adjusts engine idle speed by moving the IAC motor pintle in and out of the air control passage. The IAC motor is positioned when the ignition key is turned to the On position.

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the PCM.

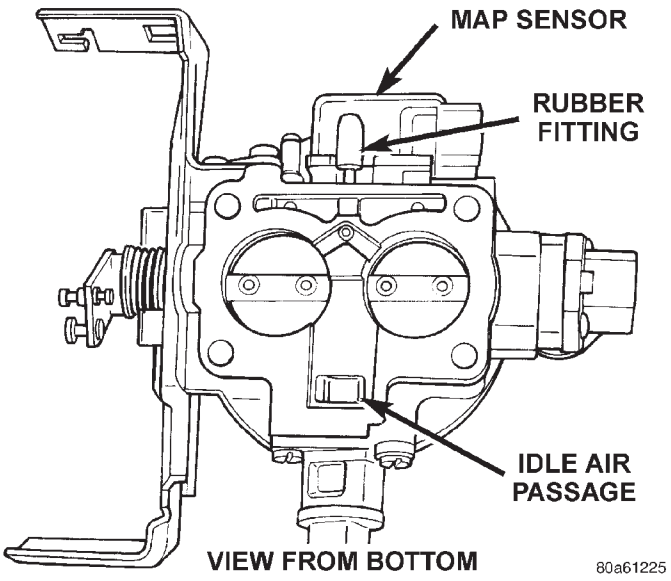


Fig. 21 Throttle Body Air Control Passage—3.9L/ 5.2L/5.9L Engines

IDLE AIR CONTROL (IAC) MOTOR—8.0L ENGINE—PCM OUTPUT

The IAC motor is mounted to the side of the throttle body (Fig. 22) and is controlled by the powertrain control module (PCM).

The throttle body has an air control passage that provides air for the engine at idle (the throttle plate is closed). The IAC motor pintle protrudes into the air control passage (Fig. 23) and regulates air flow through it. Based on various sensor inputs, the powertrain control module (PCM) adjusts engine idle speed by moving the IAC motor pintle in and out of the air control passage. The IAC motor is positioned when the ignition key is turned to the On position.

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the PCM.

IGNITION COIL—3.9L/5.2L/5.9L ENGINES—PCM OUTPUT

System voltage is supplied to the ignition coil positive terminal. The powertrain control module (PCM) operates the ignition coil. **Base (initial) ignition**

DESCRIPTION AND OPERATION (Continued)

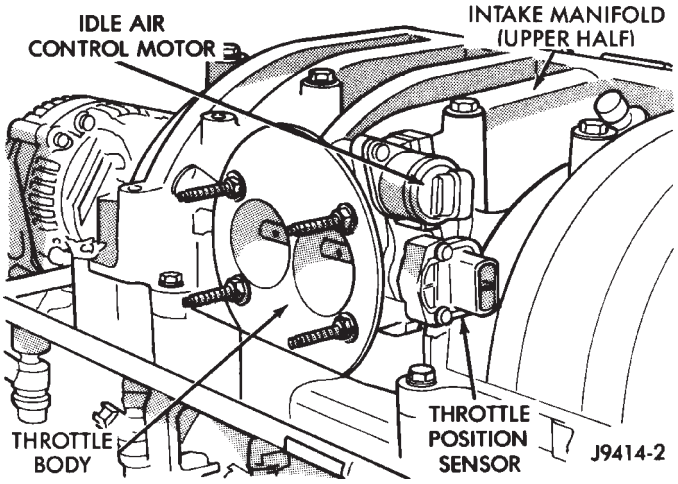


Fig. 22 Idle Air Control Motor Location—8.0L Engine

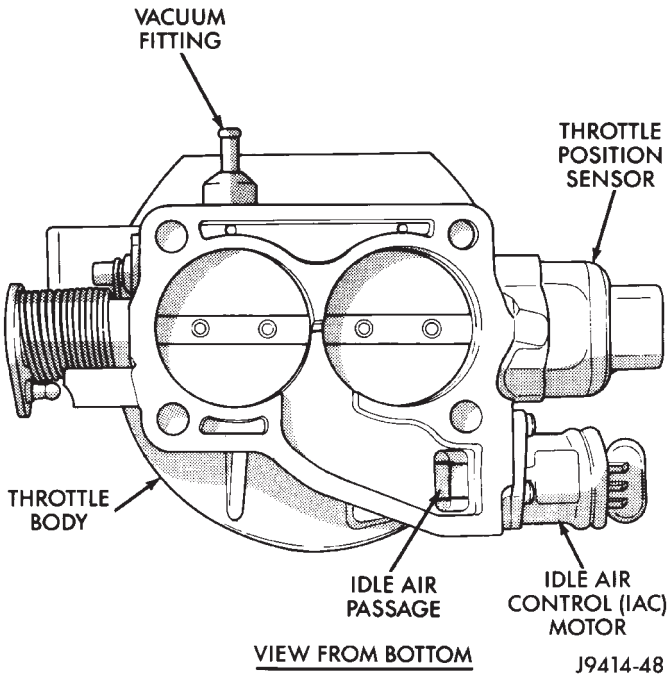


Fig. 23 Idle Air Control Passage—8.0L Engine

timing is not adjustable. The PCM adjusts ignition timing to meet changing engine operating conditions.

The ignition coil is located near the front of the right cylinder head (Fig. 24).

Refer to Group 8D, Ignition System for additional information.

IGNITION COILS—8.0L ENGINE—PCM OUTPUTS

System voltage is supplied to each of the five ignition coil positive terminals. The powertrain control module (PCM) operates the 5 paired ignition coils. **Base (initial) ignition timing is not adjustable.** The PCM adjusts ignition timing to meet changing engine operating conditions.

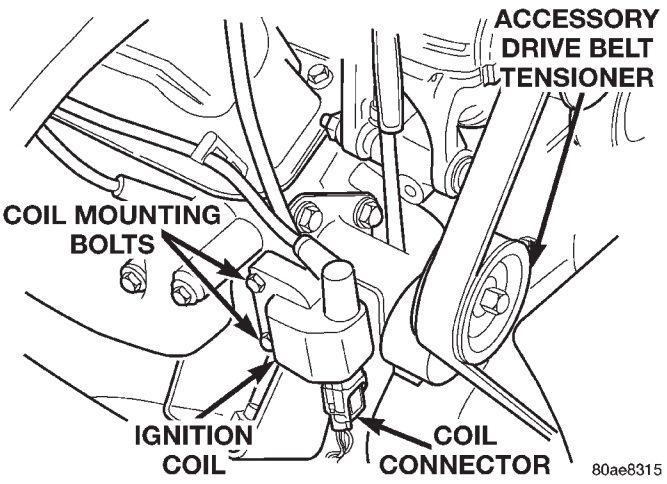


Fig. 24 Ignition Coil—3.9L/5.2L/5.9L Engines—Typical (5.2L Shown)

The ignition coil pack is located above the right engine valve cover (Fig. 25).

Refer to Group 8D, Ignition System for additional information.

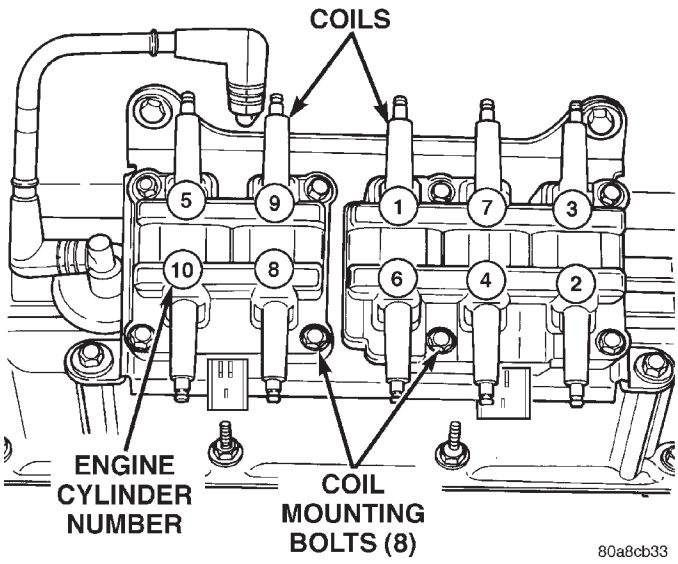


Fig. 25 Ignition Coil Packs—8.0L Engine

MALFUNCTION INDICATOR LAMP—PCM OUTPUT

Refer to Group 25, Emission Control System for information.

OVERDRIVE LAMP—PCM OUTPUT

This circuit controls a signal for the operation of the push-button overdrive lamp switch. When the lamp is illuminated, the overdrive is disengaged.

SPEED CONTROL SOLENOIDS—PCM OUTPUT

Speed control operation is regulated by the powertrain control module (PCM). The PCM controls the vacuum to the throttle actuator through the speed

DESCRIPTION AND OPERATION (Continued)

control vacuum and vent solenoids. Refer to Group 8H for Speed Control Information.

SERVICE REMINDER INDICATOR (SRI) LAMP—PCM OUTPUT

This circuit controls operation of the SRI lamp.

The instrument panel mounted service reminder indicator (SRI) lamp is used only on vehicles equipped with 5.9L V-8 heavy duty cycle (HDC) engines. The lamp is displayed on the instrument panel as the MAINT REQ'D lamp. When the lamp has been activated, certain service/maintenance must be performed.

For required service/maintenance stated in time or mileage, refer to Group 0, Lubrication and Maintenance. Also refer to Group 25, Emission Control System for additional information.

The SRI lamp is not used with diesel engines.

TACHOMETER—PCM OUTPUT

The powertrain control module (PCM) supplies engine rpm values to the instrument cluster tachometer. Refer to Group 8E for tachometer information.

THREE-FOUR SHIFT SOLENOID—PCM OUTPUT

This output is used to control the transmission three-four shift solenoid. It is used on 4–speed electronically controlled automatic transmissions only.

TORQUE CONVERTOR CLUTCH (TCC) SOLENOID—PCM OUTPUT

This circuit controls operation of the transmission mounted torque convertor clutch (TCC) solenoid used for torque convertor engagement.

The powertrain control module (PCM) will determine when to engage and disengage the solenoid by monitoring vehicle miles per hour (mph) versus the output voltage of the throttle position sensor. Also needed are various inputs from:

- Transmission temperature sensor
- Output shaft speed sensor
- Module timer
- Engine rpm
- MAP sensor
- Brake switch

MANUAL TRANSMISSION

If equipped with a manual transmission, this PCM output will control operation of the shift indicator lamp (if equipped with lamp). The lamp is controlled by the powertrain control module (PCM). The lamp illuminates on the instrument panel to indicate when the driver should shift to the next highest gear for best fuel economy. The PCM will turn the lamp OFF after 3 to 5 seconds if the shift of gears is not performed. The lamp will remain off until vehicle stops accelerating and is brought back to range of up-shift lamp operation. This will also happen if vehicle is shifted into fifth gear.

The indicator lamp is normally illuminated when the ignition switch is turned on and it is turned off when the engine is started up. With the engine running, the lamp is turned ON/OFF depending upon engine speed and load.

TRANSMISSION RELAY—PCM OUTPUT

The output to this relay provides battery voltage to the overdrive (OD), torque converter clutch (TCC) and governor pressure solenoids. Once battery voltage is applied to the solenoids, they are individually activated by the PCM through OD, TCC and governor pressure outputs. The relay is located in the Power Distribution Center (PDC). Refer to label on PDC cover for relay location.

GOVERNOR PRESSURE SOLENOID—PCM OUTPUT

This solenoid regulates the transmission fluid line pressure to produce the governor pressure necessary for transmission shift control. It is used on 4–speed electronic transmissions only.

THROTTLE BODY—3.9L/5.2L/5.9L ENGINES

Filtered air from the air cleaner enters the intake manifold through the throttle body (Fig. 26). Fuel does not enter the intake manifold through the throttle body. Fuel is sprayed into the manifold by the fuel injectors. The throttle body is mounted on the intake manifold. It contains an air control passage (Fig. 27) controlled by an idle air control (IAC) motor. The air control passage is used to supply air for idle conditions. A throttle valve (plate) is used to supply air for above idle conditions.

The throttle position sensor (TPS), idle air control (IAC) motor and manifold absolute pressure sensor (MAP) are attached to the throttle body. The accelerator pedal cable, speed control cable and transmission control cable (when equipped) are connected to the throttle arm.

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the PCM.

THROTTLE BODY—8.0L ENGINE

Filtered air from the air cleaner enters the intake manifold through the side mounted throttle body (Fig. 28). Fuel does not enter the intake manifold through the throttle body. Fuel is sprayed into the manifold by the fuel injectors. The throttle body is mounted on the intake manifold. It contains an air control passage (Fig. 29) controlled by an idle air con-

DESCRIPTION AND OPERATION (Continued)

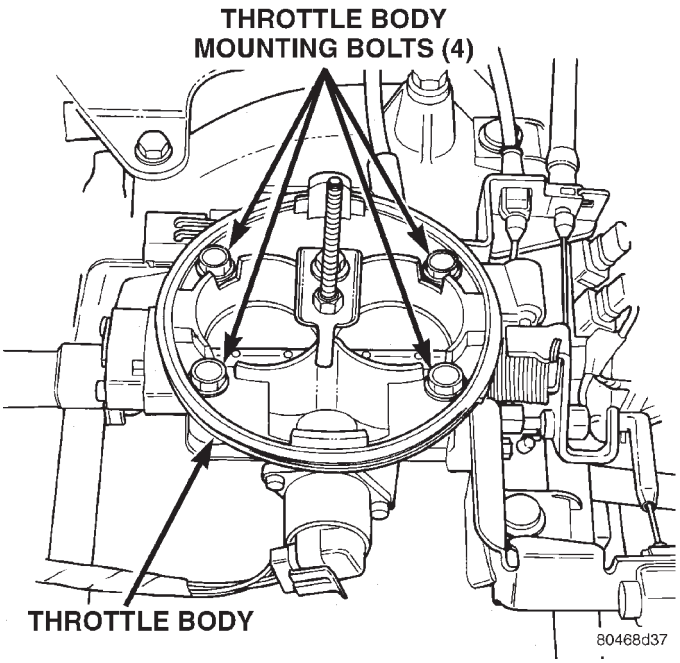


Fig. 26 Throttle Body—3.9L/5.2L/5.9L Engines

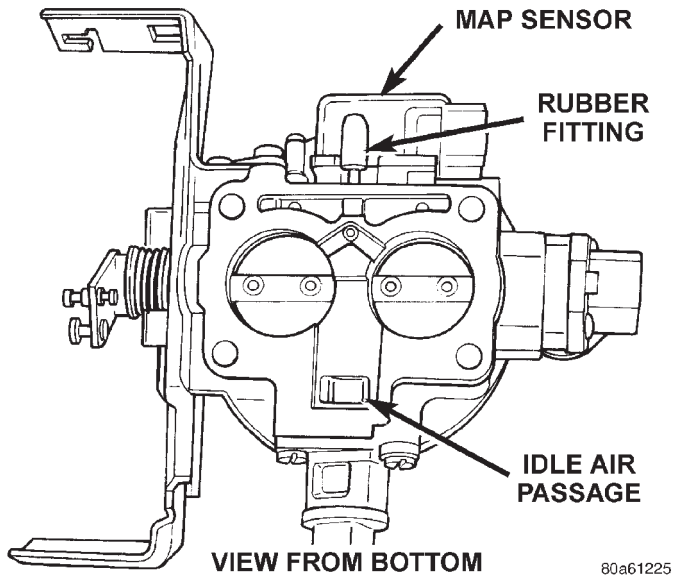


Fig. 27 Air Control Passage—3.9L/5.2L/5.9L Engines

trol (IAC) motor. The air control passage is used to supply air for idle conditions. A throttle valve (plate) is used to supply air for above idle conditions.

The throttle position sensor (TPS) and idle air control (IAC) motor are attached to the throttle body. The accelerator pedal cable, speed control cable and transmission control cable (when equipped) are connected to the throttle arm.

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle**

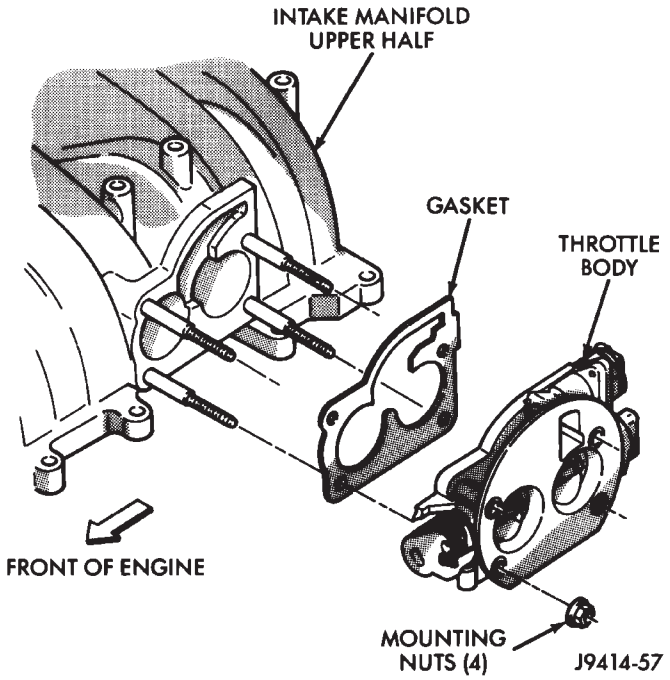


Fig. 28 Throttle Body—8.0L Engine

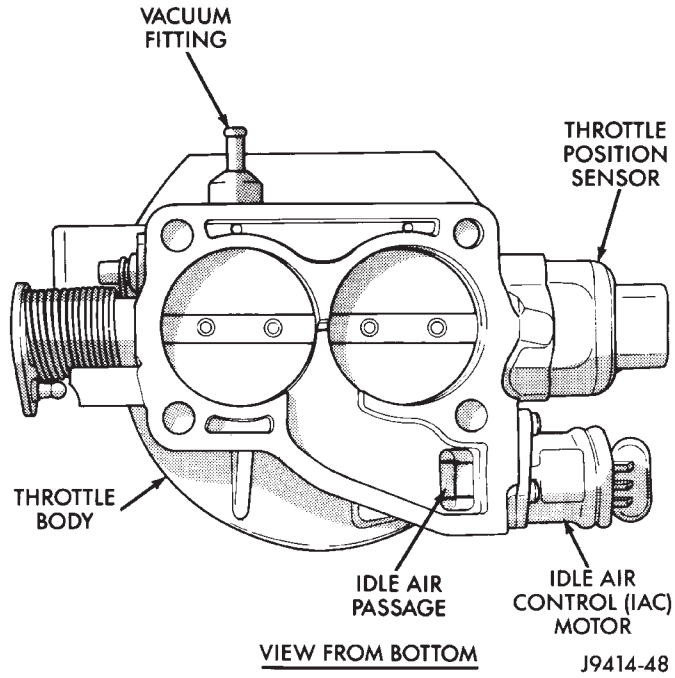


Fig. 29 Air Control Passage—8.0L Engine

speed using this screw. All idle speed functions are controlled by the PCM.

DIAGNOSIS AND TESTING

VISUAL INSPECTION—3.9L/5.2L/5.9L ENGINES

A visual inspection for loose, disconnected or incorrectly routed wires and hoses should be made. This

DIAGNOSIS AND TESTING (Continued)

should be done before attempting to diagnose or service the fuel injection system. A visual check will help spot these faults and save unnecessary test and diagnostic time. A thorough visual inspection will include the following checks:

(1) Verify that the three 32–way electrical connectors are fully inserted into the connector of the powertrain control module (PCM) (Fig. 30).

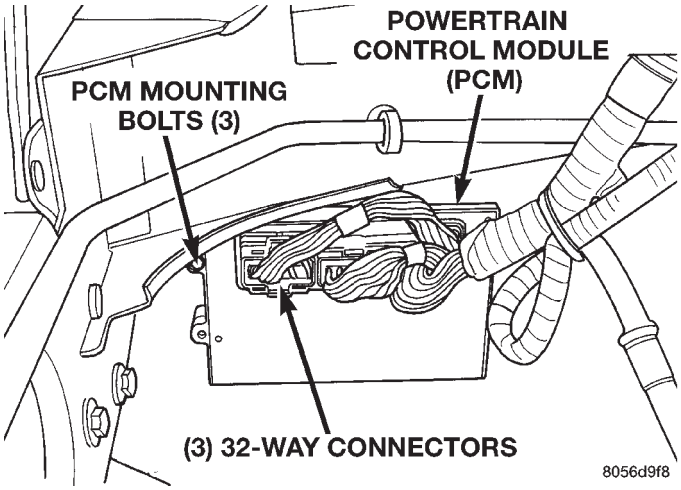


Fig. 30 Powertrain Control Module (PCM)

(2) Inspect the battery cable connections. Be sure that they are clean and tight.

(3) Inspect fuel pump relay and air conditioning compressor clutch relay (if equipped). Inspect the ASD relay connections. Inspect starter motor relay connections. Inspect relays for signs of physical damage and corrosion. The relays are located in the Power Distribution Center (PDC) (Fig. 31). Refer to label on PDC cover for relay location.

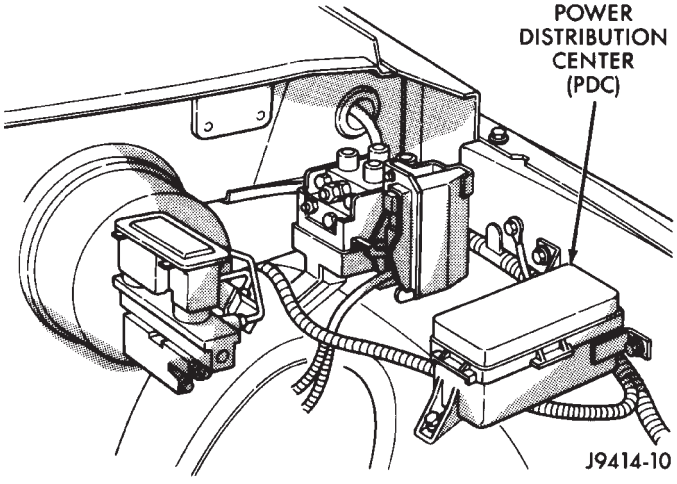


Fig. 31 Power Distribution Center (PDC)

(4) Inspect ignition coil connections. Verify that coil secondary cable is firmly connected to coil (Fig. 32).

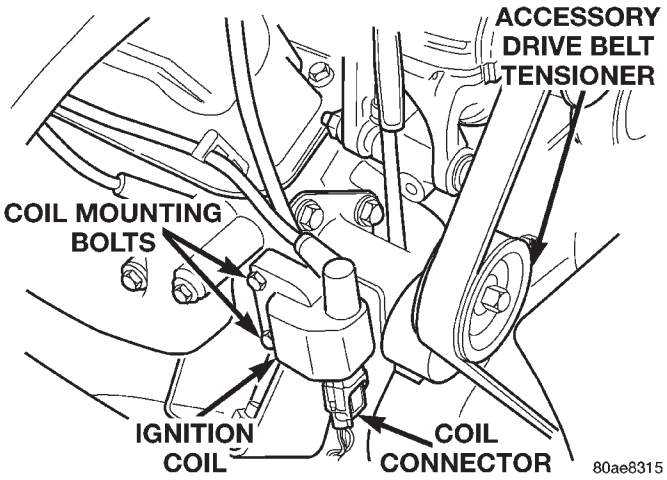


Fig. 32 Ignition Coil—3.9L/5.2L/5.9L Engines—Typical

(5) Verify that distributor cap is correctly attached to distributor. Be sure that spark plug cables are firmly connected to the distributor cap and the spark plugs are in their correct firing order. Be sure that coil cable is firmly connected to distributor cap and coil. Be sure that camshaft position sensor wire connector (at the distributor) is firmly connected to harness connector. Inspect spark plug condition. Refer to Group 8D, Ignition. Connect vehicle to an oscilloscope and inspect spark events for fouled or damaged spark plugs or cables.

(6) Verify that generator output wire, generator connector and ground wire are firmly connected to the generator.

(7) Inspect the system body grounds for loose or dirty connections. Refer to Group 8, Wiring for ground locations.

(8) Verify positive crankcase ventilation (PCV) valve operation. Refer to Group 25, Emission Control System for additional information. Verify PCV valve hose is firmly connected to PCV valve and manifold (Fig. 33).

(9) Inspect fuel tube quick-connect fitting-to-fuel rail connections.

(10) Verify that hose connections to all ports of vacuum fittings on intake manifold are tight and not leaking.

(11) Inspect accelerator cable, transmission throttle cable (if equipped) and cruise control cable connections (if equipped). Check their connections to the throttle arm of throttle body for any binding or restrictions.

(12) If equipped with vacuum brake booster, verify that vacuum booster hose is firmly connected to fitting on intake manifold. Also check connection to brake vacuum booster.

(13) Inspect the air cleaner inlet and air cleaner element for dirt or restrictions.

DIAGNOSIS AND TESTING (Continued)

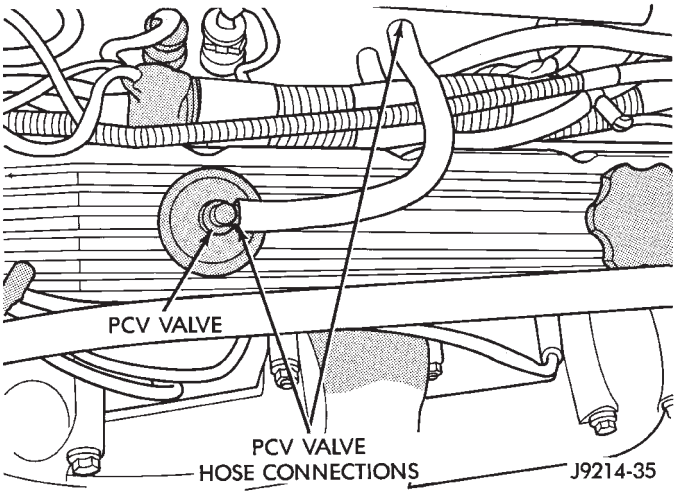


Fig. 33 PCV Valve Hose Connections—3.9L/5.2L/ 5.9L Engines—Typical

(14) Inspect radiator grille area, radiator fins and air conditioning condenser for restrictions.

(15) Verify that the intake manifold air temperature sensor wire connector is firmly connected to harness connector (Fig. 34).

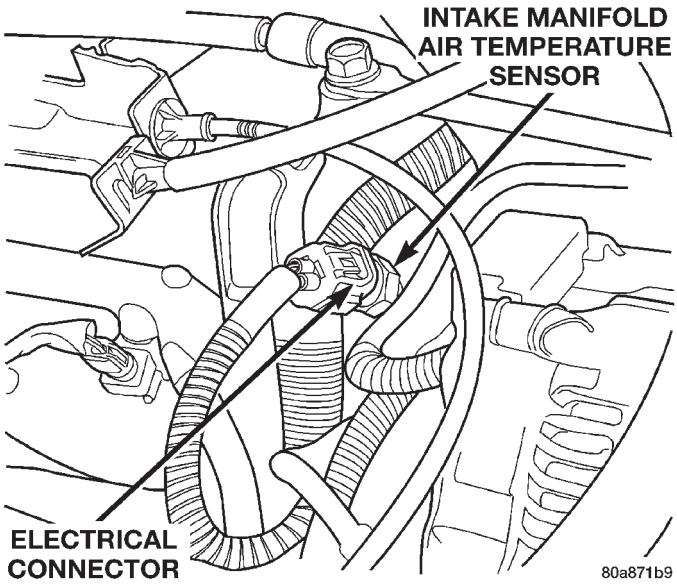


Fig. 34 Air Temperature Sensor—3.9L/5.2L/5.9L— Typical (V-8 Shown

(16) Verify that MAP sensor electrical connector is firmly connected to MAP sensor (Fig. 35). Also verify that rubber L-shaped fitting from MAP sensor to the throttle body is firmly connected (Fig. 36).

(17) Verify that fuel injector wire harness connectors are firmly connected to injectors in the correct order. Each harness connector is numerically tagged with the injector number (INJ 1, INJ 2 etc.) of its corresponding fuel injector and cylinder number.

(18) Verify harness connectors are firmly connected to idle air control (IAC) motor, throttle position sensor (TPS) and manifold absolute pressure (MAP) sensor (Fig. 35).

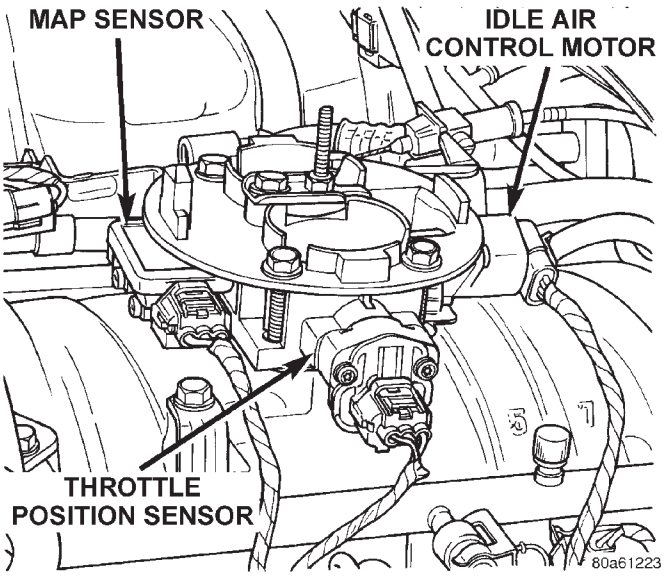


Fig. 35 Sensor and IAC Motor Location—Typical (V-8 Shown)

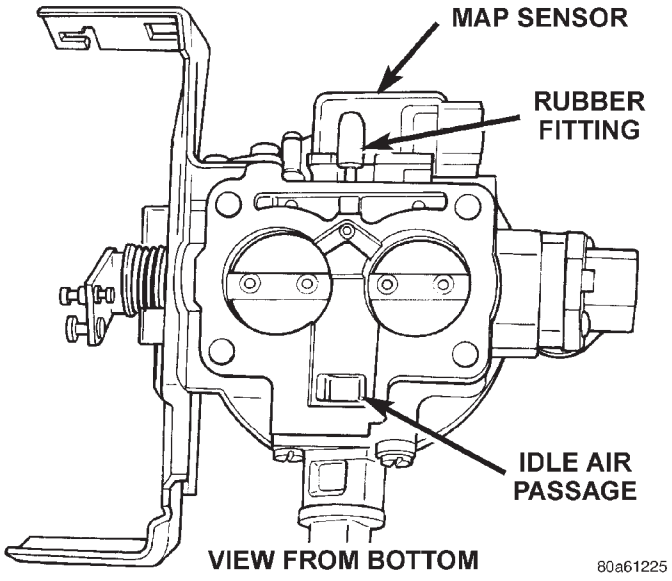


Fig. 36 Rubber L-Shaped Fitting—MAP Sensor-to-Throttle Body—3.9L/5.2L/5.9L Engines

(19) Verify that wire harness connector is firmly connected to the engine coolant temperature sensor (Fig. 37).

(20) Raise and support the vehicle.

(21) On 3.9L/5.2L/5.9L LDC engines, verify that both the upstream and downstream oxygen sensor wire connectors are firmly connected to the sensors. Inspect sensors and connectors for damage (Fig. 38).

(22) On 5.9L HDC engines, verify that both the left and right oxygen sensor wire connectors are

DIAGNOSIS AND TESTING (Continued)

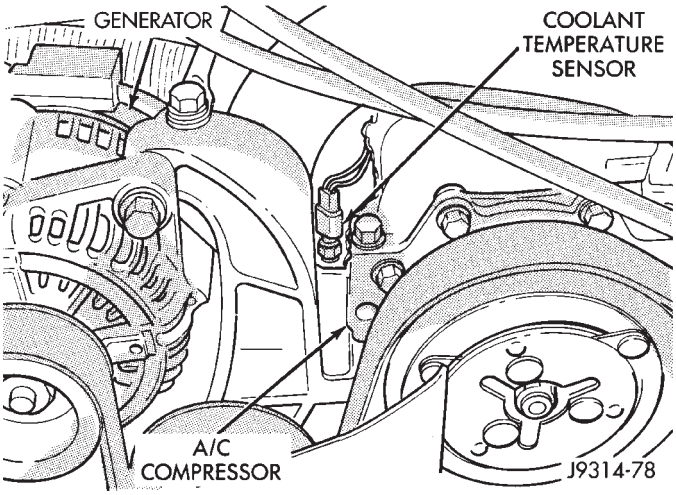


Fig. 37 Engine Coolant Temperature Sensor—3.9L/ 5.2L/5.9L Engines—Typical

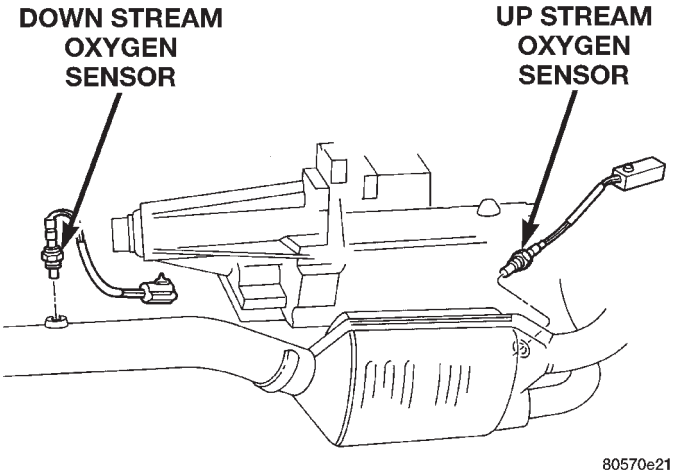


Fig. 38 Upstream/Downstream Oxygen Sensors— 3.9L/5.2L/5.9L LDC Engines

firmly connected to the sensors. Inspect sensors and connectors for damage (Fig. 39).

(23) Inspect for pinched or leaking fuel tubes. Inspect for pinched, cracked or leaking fuel hoses.

(24) Inspect for exhaust system restrictions such as pinched exhaust pipes, collapsed muffler or plugged catalytic convertor.

(25) If equipped with automatic transmission, verify that electrical harness is firmly connected to park/ neutral switch. Refer to Automatic Transmission section of Group 21.

(26) Verify electrical harness is firmly connected to rear wheel speed sensor. Verify rear wheel speed sensor is firmly attached to rear axle with proper air gap. Refer to Group 5, Brakes for information.

(27) If equipped with 4–wheel antilock brake system, verify electrical harness is firmly connected to each front wheel speed sensor. Verify both front

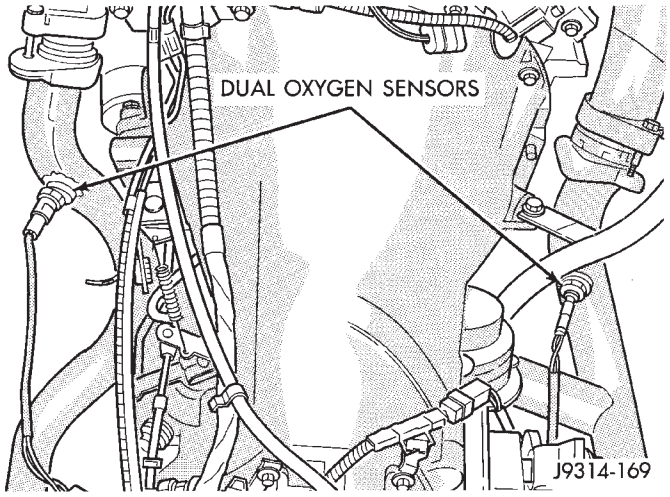


Fig. 39 Left/Right Oxygen Sensors—5.9L HDC Engines

wheel speed sensors are firmly attached. Refer to Group 5, Brakes for information.

(28) Verify that fuel pump/gauge sender unit wire connector is firmly connected to harness connector.

(29) Inspect fuel hoses at fuel pump/gauge sender unit for cracks or leaks.

(30) Inspect transmission torque convertor housing (automatic transmission) or clutch housing (manual transmission) for damage to timing ring on drive plate/flywheel.

(31) Verify that battery cable and solenoid feed wire connections to the starter solenoid are tight and clean. Inspect for chaffed wires or wires rubbing up against other components.

VISUAL INSPECTION—8.0L ENGINE

A visual inspection for loose, disconnected or incorrectly routed wires and hoses should be made. This should be done before attempting to diagnose or service the fuel injection system. A visual check will help spot these faults and save unnecessary test and diagnostic time. A thorough visual inspection will include the following checks:

(1) Verify that the three 32–way electrical connectors are fully inserted into the connector of the powertrain control module (PCM) (Fig. 40).

(2) Inspect the battery cable connections. Be sure that they are clean and tight.

(3) Inspect fuel pump relay and air conditioning compressor clutch relay (if equipped). Inspect the ASD relay connections. Inspect starter motor relay connections. Inspect relays for signs of physical damage and corrosion. The relays are located in the Power Distribution Center (PDC) (Fig. 41). Refer to label on PDC cover for relay location.

DIAGNOSIS AND TESTING (Continued)

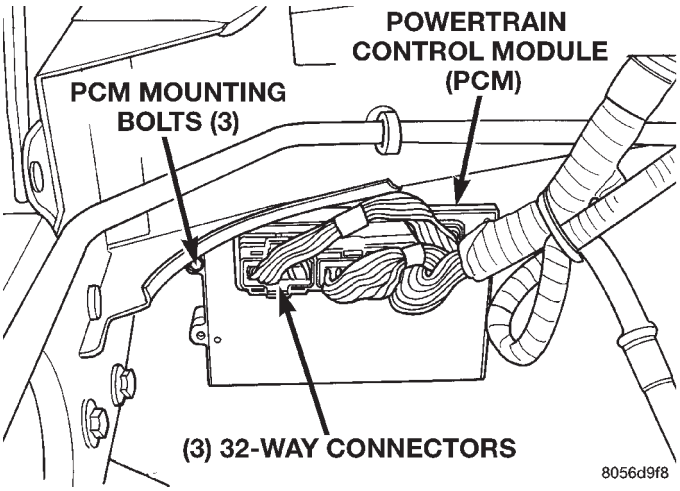


Fig. 40 Powertrain Control Module (PCM)

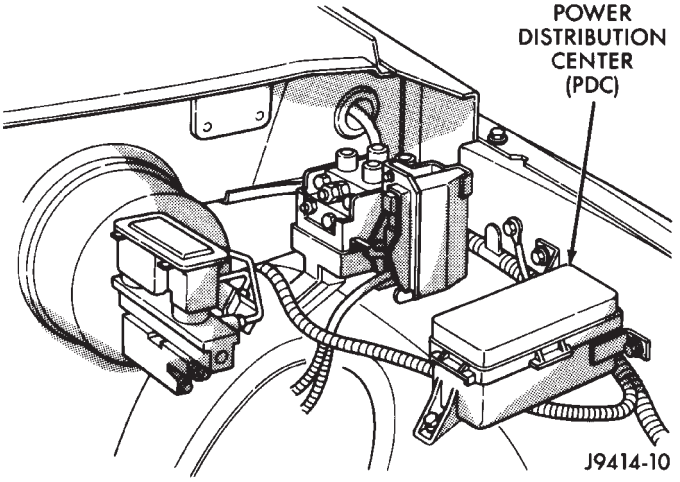


Fig. 41 Power Distribution Center (PDC)

(4) Inspect ignition coil pack primary connections. Verify that secondary cables are firmly connected to coils (Fig. 42).

(5) Be sure that spark plug cables are firmly connected and the spark plugs are in their correct firing order. Be sure that camshaft position sensor wire connector is firmly connected to harness connector. Inspect spark plug condition. Refer to Group 8D, Ignition. Connect vehicle to an oscilloscope and inspect spark events for fouled or damaged spark plugs or cables.

(6) Verify that generator output wire, generator connector and ground wire are firmly connected to the generator.

(7) Inspect the system body grounds for loose or dirty connections. Refer to Group 8, Wiring for ground locations.

(8) Verify crankcase ventilation (CCV) operation. Refer to Group 25, Emission Control System for additional information.

(9) Inspect fuel tube quick-connect fitting-to-fuel rail connections.

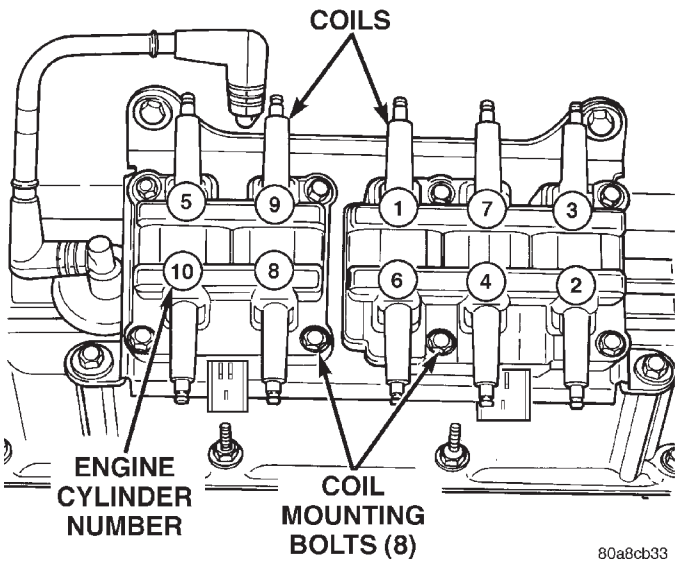


Fig. 42 Ignition Coil Pack—8.0L Engine

(10) Verify that hose connections to all ports of vacuum fittings on intake manifold are tight and not leaking.

(11) Inspect accelerator cable, transmission throttle cable (if equipped) and cruise control cable connections (if equipped). Check their connections to the throttle arm of throttle body for any binding or restrictions.

(12) If equipped with vacuum brake booster, verify that vacuum booster hose is firmly connected to fitting on intake manifold. Also check connection to brake vacuum booster.

(13) Inspect the air cleaner inlet and air cleaner element for dirt or restrictions.

(14) Inspect radiator grille area, radiator fins and air conditioning condenser for restrictions.

(15) Verify that the intake manifold air temperature sensor wire connector is firmly connected to harness connector (Fig. 43).

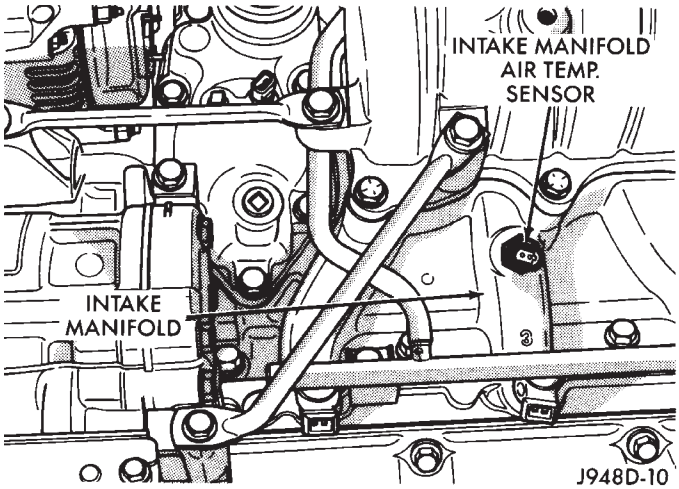


Fig. 43 Air Temperature Sensor—8.0L Engine

DIAGNOSIS AND TESTING (Continued)

(16) Verify that MAP sensor electrical connector is firmly connected to MAP sensor (Fig. 44).

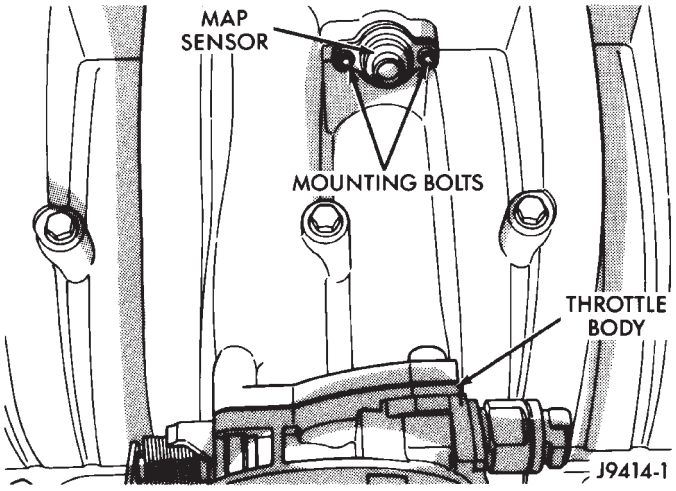


Fig. 44 Map Sensor —8.0L Engine

(17) Verify that fuel injector wire harness connectors are firmly connected to injectors in the correct order. Each harness connector is numerically tagged with the injector number (INJ 1, INJ 2 etc.) of its corresponding fuel injector and cylinder number.

(18) Verify harness connectors are firmly connected to idle air control (IAC) motor and throttle position sensor (TPS).

(19) Verify that wire harness connector is firmly connected to the engine coolant temperature sensor (Fig. 45).

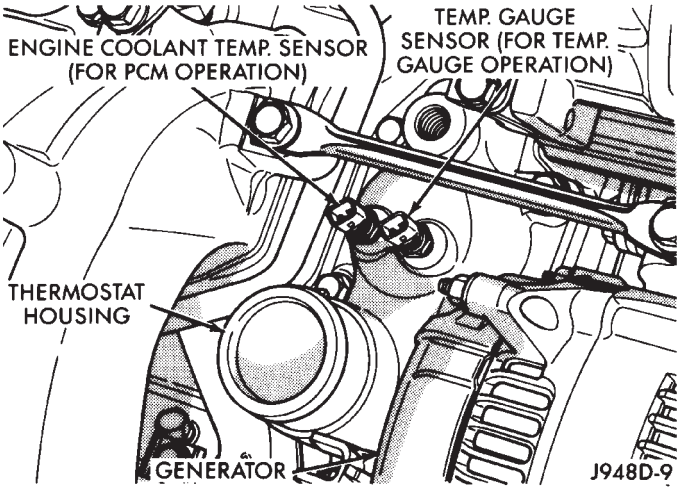


Fig. 45 Engine Coolant Temperature Sensor—8.0L Engine

(20) Raise and support the vehicle.

(21) On all 8.0L engines (HDC or MDC), verify that the left and right oxygen sensor wire connectors are firmly connected to the sensors. Inspect sensors and connectors for damage (Fig. 46).

(22) On 8.0L MDC engine, verify that the pre-catalyst and post catalyst oxygen sensor wire connectors are firmly connected to the sensors. Inspect sensors and connectors for damage (Fig. 47).

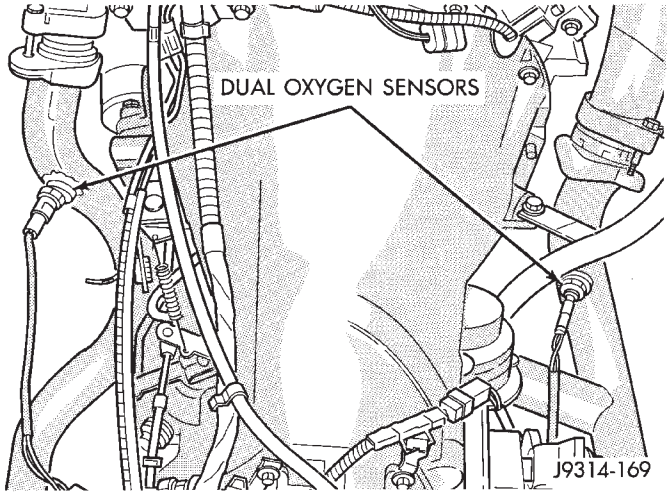


Fig. 46 Left/Right Oxygen Sensors

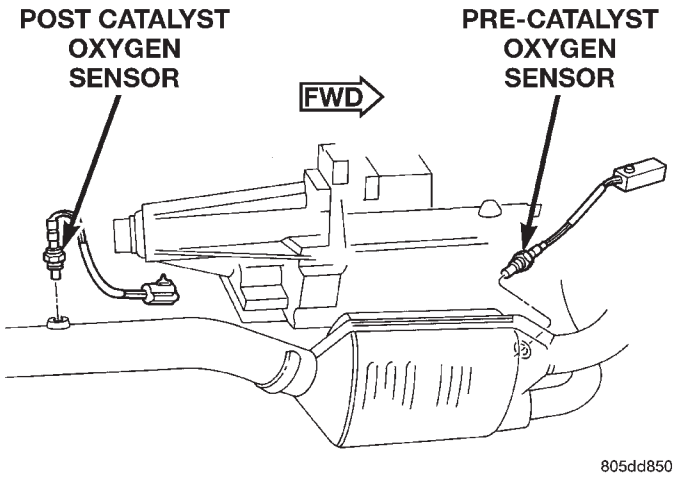


Fig. 47 Pre-Catalyst/Post Catalyst Oxygen Sensors

(23) Inspect for pinched or leaking fuel tubes. Inspect for pinched, cracked or leaking fuel hoses.

(24) Inspect for exhaust system restrictions such as pinched exhaust pipes, collapsed muffler or plugged catalytic convertor.

(25) If equipped with automatic transmission, verify that electrical harness is firmly connected to park/neutral switch. Refer to Automatic Transmission section of Group 21.

(26) Verify electrical harness is firmly connected to rear wheel speed sensor. Verify rear wheel speed sensor is firmly attached to rear axle with proper air gap. Refer to Group 5, Brakes for information.

(27) If equipped with 4–wheel antilock brake system, verify electrical harness is firmly connected to

DIAGNOSIS AND TESTING (Continued)

each front wheel speed sensor. Verify both front wheel speed sensors are firmly attached. Refer to Group 5, Brakes for information.

(28) Verify that fuel pump/gauge sender unit wire connector is firmly connected to harness connector.

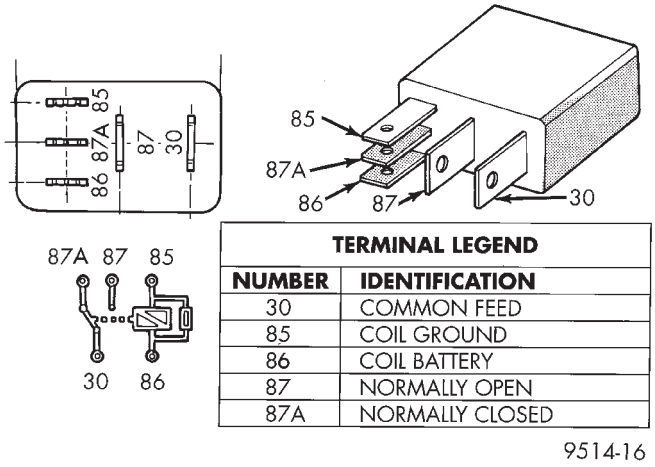
(29) Inspect fuel hoses at fuel pump/gauge sender unit for cracks or leaks.

(30) Inspect transmission torque convertor housing (automatic transmission) or clutch housing (manual transmission) for damage to timing ring on drive plate/flywheel.

(31) Verify that battery cable and solenoid feed wire connections to the starter solenoid are tight and clean. Inspect for chaffed wires or wires rubbing up against other components.

ASD AND FUEL PUMP RELAYS

The following description of operation and tests apply only to the Automatic Shutdown (ASD) and fuel pump relays. The terminals on the bottom of each relay are numbered (Fig. 48).



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

Fig. 48 ASD and Fuel Pump Relay Terminals

OPERATION

- Terminal number 30 is connected to battery voltage. For both the ASD and fuel pump 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 ASD and fuel pump 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.
- When the PCM energizes the ASD and fuel pump 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 ASD and fuel pump 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 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 ASD and fuel pump relay circuits. Refer to group 8W, Wiring Diagrams.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR TEST—3.9L/5.2L/5.9L ENGINES

To perform a complete test of MAP sensor (Fig. 49) and its circuitry, refer to DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the MAP sensor only, refer to the following:

(1) Inspect the rubber L-shaped fitting from the MAP sensor to the throttle body (Fig. 50). Repair as necessary.

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

(2) Test the MAP sensor output voltage at the MAP sensor connector between terminals A and B (Fig. 51). With the ignition switch ON and the engine OFF, output voltage should be 4-to-5 volts. The voltage should drop to 1-to-2.1 volts with a hot, neutral

DIAGNOSIS AND TESTING (Continued)

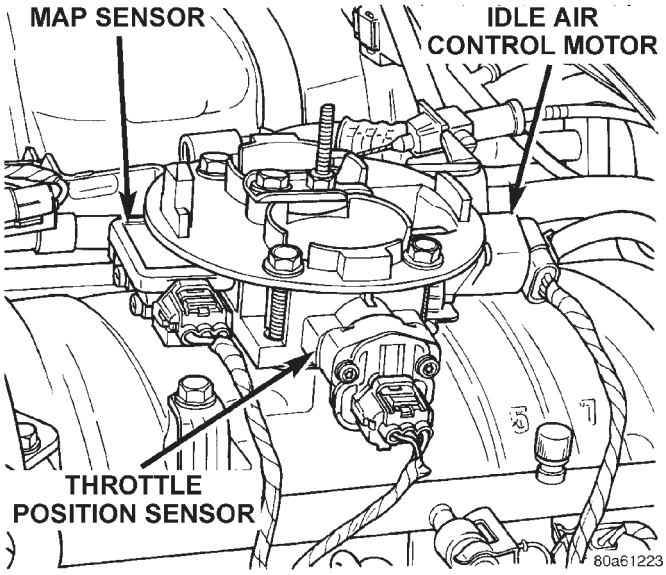


Fig. 49 Manifold Absolute Pressure (MAP) Sensor—3.9L/5.2L/5.9L Engines

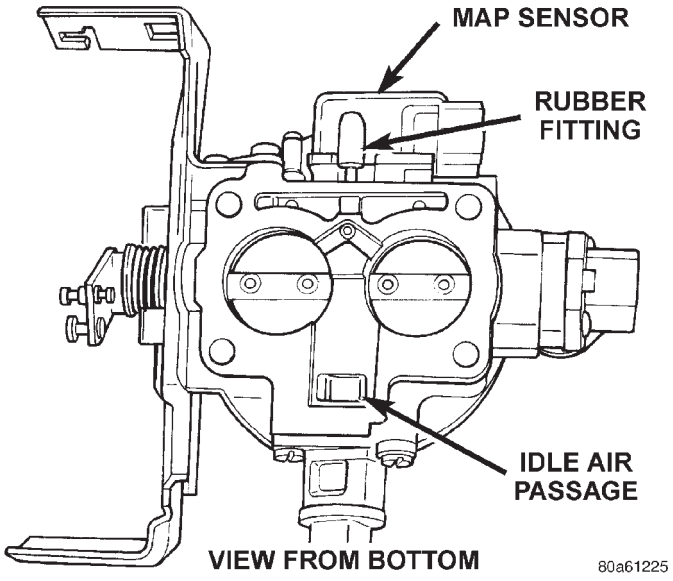


Fig. 50 Rubber L-Shaped Fitting—MAP Sensor-to-Throttle Body—3.9L/5.2L/5.9L Engines

idle speed condition. Voltage at higher elevations may be slightly lower 1–to-2.1 volts.

(3) Test powertrain control module (PCM) cavity A-27 for the same voltage described above to verify the wire harness condition. Repair as necessary.

(4) Test MAP sensor supply voltage at sensor connector between terminals A and C (Fig. 51) with the ignition ON. The voltage should be approximately 5 volts (±0.5V). Five volts (±0.5V) should also be at cavity A-17 of the PCM wire harness connector. Repair or replace the wire harness as necessary.

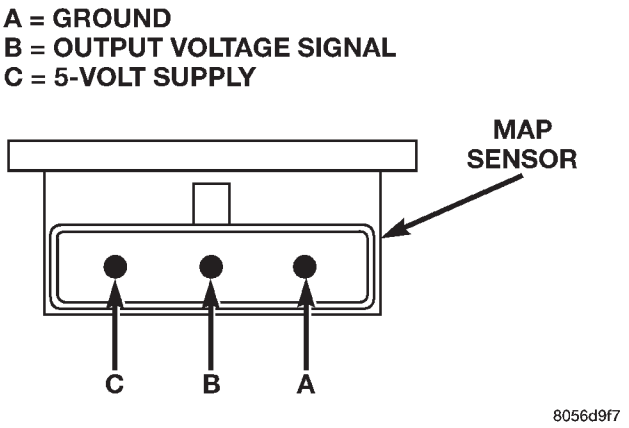


Fig. 51 MAP Sensor Connector Terminals—3.9L/5.2L/5.9L Engines

(5) Test the MAP sensor ground circuit at sensor connector terminal—A (Fig. 51) and PCM connector A-4. Repair the wire harness if necessary.

Refer to Group 8W, Wiring Diagrams for cavity locations.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR TEST—8.0L ENGINE

To perform a complete test of the MAP sensor (Fig. 52) and its circuitry, refer to DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the MAP sensor only, refer to the following:

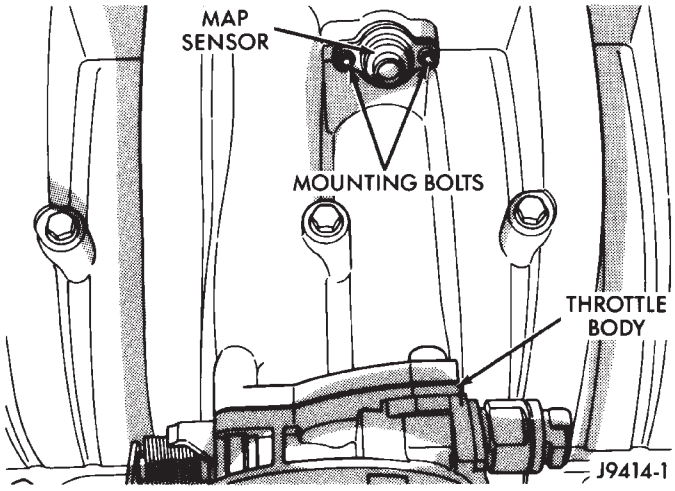


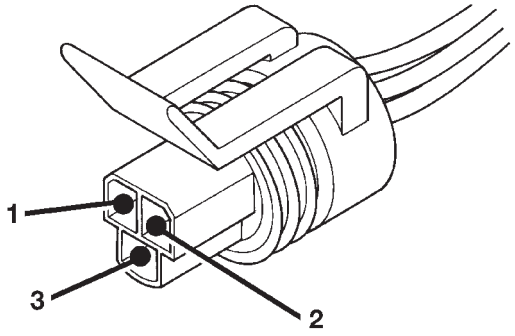
Fig. 52 Manifold Absolute Pressure (MAP) Sensor—8.0L Engine

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 3

DIAGNOSIS AND TESTING (Continued)

(Fig. 53). With the ignition switch ON and the engine OFF, 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.



CAVITY	FUNCTION
1	5-Volt Supply
2	Sensor Ground
3	Map Sensor Signal

805dd851

Fig. 53 MAP Sensor Connector Terminals—8.0L Engine

(2) Test powertrain control module (PCM) cavity A-27 for the same voltage described above to verify the wire harness condition. Repair as necessary.

(3) Test MAP sensor supply voltage at sensor connector between terminals 1 and 2 (Fig. 53) with the ignition ON. The voltage should be approximately 5 volts (±0.5V). Five volts (±0.5V) should also be at cavity A-17 of the PCM wire harness connector. Repair or replace the wire harness as necessary.

(4) Test the MAP sensor ground circuit at sensor connector terminal—2 (Fig. 53) and PCM connector A-4. Repair the wire harness if necessary.

Refer to Group 8W, Wiring Diagrams for cavity locations.

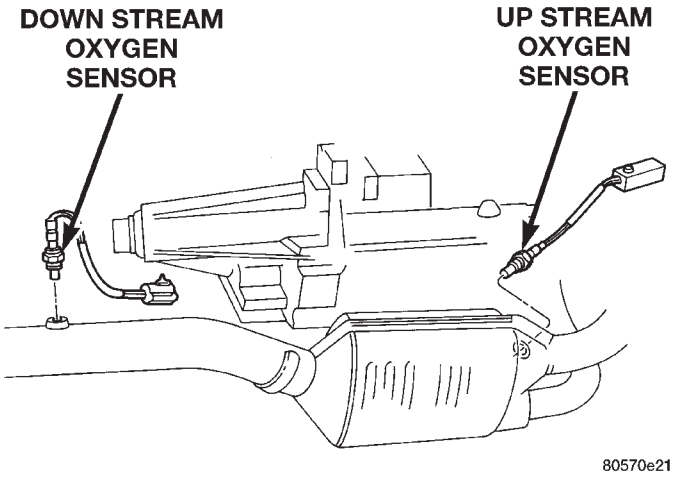
OXYGEN (O2S) SENSORS—3.9L/5.2L/5.9L LCD ENGINES

To perform a complete test of the O2S sensors and their circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the O2S sensors only, refer to the following:

The upstream O2S sensor is located on the inlet end of the catalytic converter (Fig. 54).

The downstream O2S sensor is located on the outlet end of the catalytic converter (Fig. 54).

Each O2S heating element can be tested with an ohmmeter as follows:



80570e21

Fig. 54 Upstream/Downstream Oxygen Sensor Location—3.9L/5.2L/5.9L LDC Engines

Disconnect the O2S sensor connector. Connect the ohmmeter test leads across the white wire terminals of the sensor connector. Resistance should be between 4.5 ± .5 ohms and 7 ohms. Replace the sensor if the ohmmeter displays an infinity (open) reading.

OXYGEN (O2S) SENSORS—5.9L HDC ENGINE

To perform a complete test of the dual (left and right) O2S sensors and their circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the O2S sensors only, refer to the following:

The left and right O2S sensors are located on the left and right exhaust downpipes (Fig. 55).

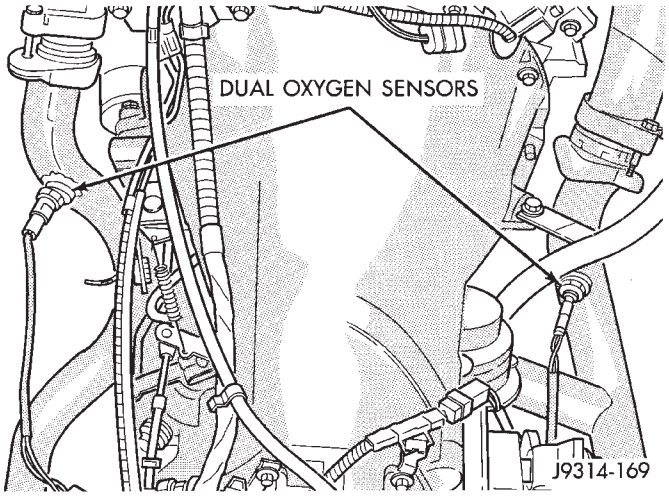


Fig. 55 Left/Right Oxygen Sensor Location—5.9L HDC Engine

Each O2S heating element can be tested with an ohmmeter as follows:

Disconnect the O2S sensor connector. Connect the ohmmeter test leads across the white wire terminals

DIAGNOSIS AND TESTING (Continued)

of the sensor connector. Resistance should be between 4.5 ± .5 ohms and 7 ohms. Replace the sensor if the ohmmeter displays an infinity (open) reading.

OXYGEN (O2S) SENSORS—8.0L HDC/MDC ENGINES

To perform a complete test of the O2S sensors and their circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the O2S sensors only, refer to the following:

A total of 4 oxygen sensors (left, right, pre-catalyst and post catalyst) are used with the 8.0L engine when equipped with the Medium Duty Emission Cycle (MDC) engine package.

Only 2 oxygen sensors (left and right) are used with the 8.0L engine when equipped with the Heavy Duty Emission Cycle (HDC) engine.

The pre-catalyst O2S sensor is located on the inlet end of the catalytic converter (Fig. 56).

The post catalyst O2S sensor is located on the outlet end of the catalytic converter (Fig. 56).

The left and right sensors are located on the left and right exhaust downpipes (Fig. 57).

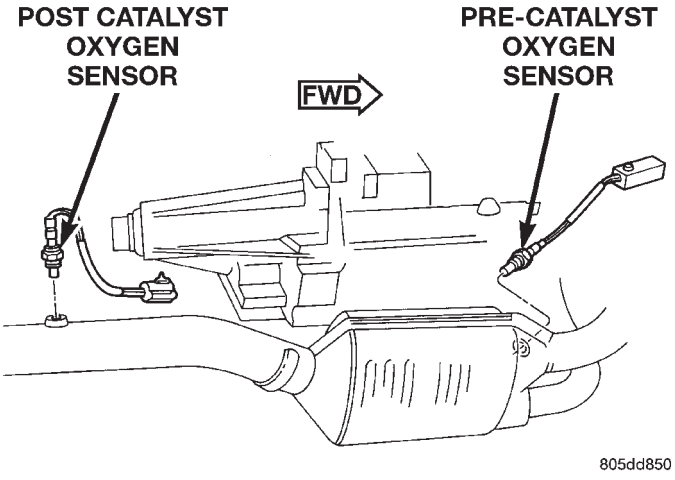


Fig. 56 Pre-Catalyst/Post Catalyst Oxygen Sensor Locations—HDC/MDC Engines

Each O2S heating element can be tested with an ohmmeter as follows:

Disconnect the O2S sensor connector. Connect the ohmmeter test leads across the white wire terminals of the sensor connector. Resistance should be between 4.5 ± .5 ohms and 7 ohms. Replace the sensor if the ohmmeter displays an infinity (open) reading.

CAMSHAFT AND CRANKSHAFT POSITION SENSORS

Refer to Group 8D, Ignition System for information.

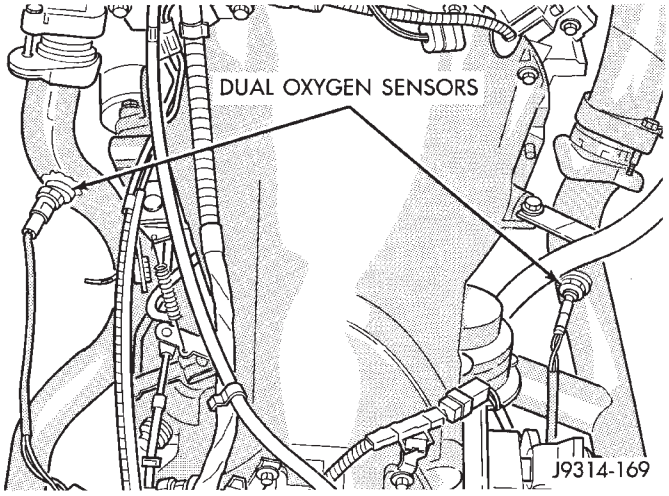


Fig. 57 Left/Right Oxygen Sensor Locations—HDC/MDC Engines

ENGINE COOLANT TEMPERATURE SENSOR—3.9L/5.2L/5.9L ENGINES

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

(1) Disconnect wire harness connector from coolant temperature sensor (Fig. 58).

(2) **Engines with air conditioning:** When removing the connector from sensor, do not pull directly on wiring harness. Fabricate an L-shaped hook tool from a coat hanger (approximately eight inches long). Place the hook part of tool under the connector for removal. The connector is snapped onto the sensor. It is not equipped with a lock type tab.

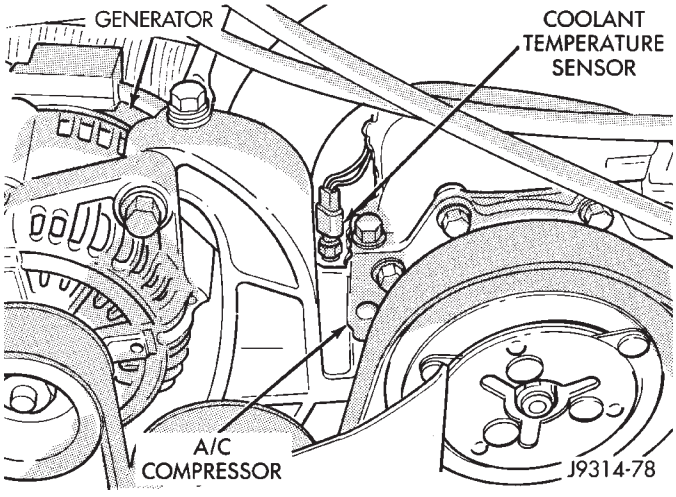


Fig. 58 Engine Coolant Temperature Sensor—3.9L/5.2L/5.9L Engines

(3) Test the resistance of the sensor with a high input impedance (digital) volt-ohmmeter. The resis-

DIAGNOSIS AND TESTING (Continued)

tance (as measured across the sensor terminals) should be as shown in the SENSOR RESISTANCE (OHMS)—COOLANT TEMPERATURE SENSOR/INTAKE AIR TEMPERATURE SENSOR chart. Replace the sensor if it is not within the range of resistance specified in chart.

SENSOR RESISTANCE (OHMS)—COOLANT TEMPERATURE SENSOR/INTAKE AIR TEMPERATURE SENSOR

TEMPERATURE		RESISTANCE (OHMS)	
°CEL.	°FAHR.	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

(4) Test continuity of the wire harness between the PCM wire harness connector and the coolant sensor connector terminals. Refer to Group 8, Wiring for terminal/cavity locations. Repair the wire harness if an open circuit is indicated.

(5) After tests are completed, connect electrical connector to sensor. The sensor connector is symmetrical (not indexed). It can be installed to the sensor in either direction.

ENGINE COOLANT TEMPERATURE SENSOR—8.0L ENGINE

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

(1) Disconnect wire harness connector from coolant temperature sensor (Fig. 59).

(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 as shown in the SENSOR RESISTANCE (OHMS)—COOLANT TEMPERATURE SENSOR/INTAKE AIR TEMPERATURE SENSOR chart. Replace the sensor if it is not within the range of resistance specified in the chart.

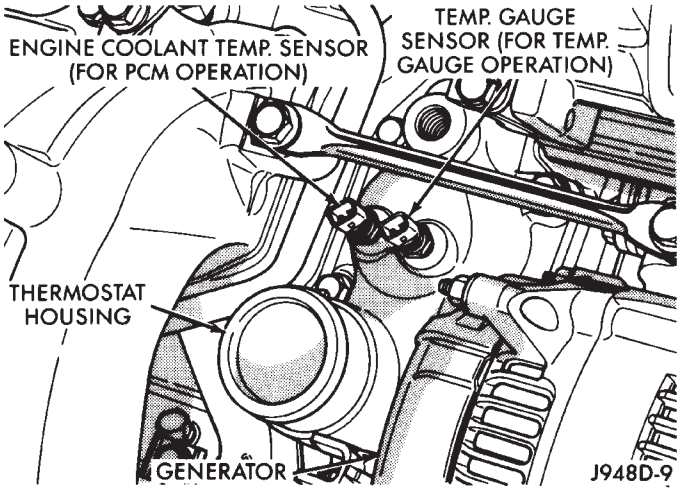


Fig. 59 Engine Coolant Temperature Sensor—8.0L Engine

(3) Test continuity of the wire harness between the PCM wire harness connector and the coolant sensor connector terminals. Refer to Group 8, Wiring for terminal/cavity locations. Repair the wire harness if an open circuit is indicated.

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

IDLE AIR CONTROL (IAC) MOTOR—3.9L/5.2L/5.9L ENGINES

To perform a complete test of the IAC motor and its circuitry, refer to DRB scan tool and appropriate Powertrain Diagnostics Procedures manual.

IDLE AIR CONTROL (IAC) MOTOR—8.0L ENGINE

To perform a complete test of the IAC motor and its circuitry, refer to DRB scan tool and appropriate Powertrain Diagnostics Procedures manual.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—3.9L/5.2L/5.9L ENGINES

To perform a complete test of the intake manifold air temperature sensor and its circuitry, refer to DRB tester and appropriate Powertrain Diagnostics Procedures manual. To test the sensor only, refer to the following:

(1) Disconnect the wire harness connector from the intake manifold air temperature sensor (Fig. 60).

(2) Test the resistance of the sensor with an input impedance (digital) volt-ohmmeter. The resistance (as measured across the sensor terminals) should be as shown in the SENSOR RESISTANCE (OHMS)—COOLANT TEMPERATURE SENSOR/INTAKE AIR TEMPERATURE SENSOR chart. Replace the sensor

DIAGNOSIS AND TESTING (Continued)

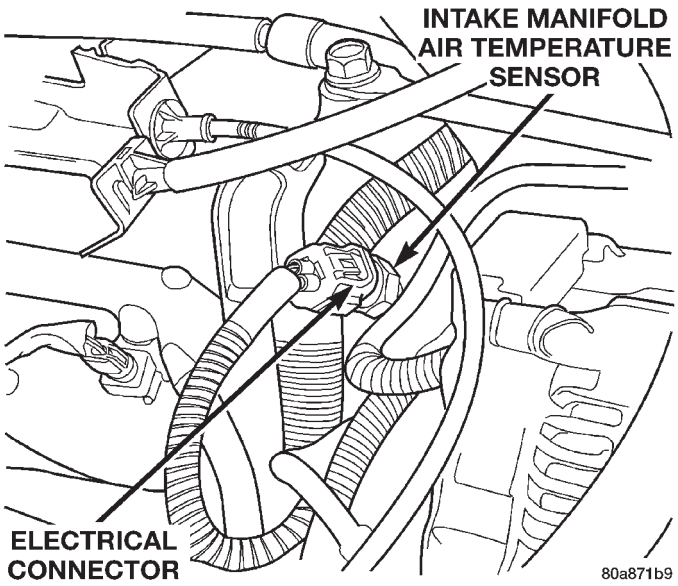


Fig. 60 Intake Manifold Air Temperature Sensor—3.9L/5.2L/5.9L Engines—Typical (V-8 Shown)

if it is not within range of resistance specified in chart.

(3) Test the resistance of the wire harness. Do this between the PCM wire harness connector A-15 and the sensor connector terminal. Also check between PCM connector A-4 to the sensor connector terminal. Repair the wire harness as necessary if the resistance is greater than 1 ohm.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—8.0L ENGINE

To perform a complete test of the intake manifold air temperature sensor and its circuitry, refer to DRB tester and appropriate Powertrain Diagnostics Procedures manual. To test the sensor only, refer to the following:

(1) Disconnect the wire harness connector from the intake manifold air temperature sensor (Fig. 61).

(2) Test the resistance of the sensor with an input impedance (digital) volt-ohmmeter. The resistance (as measured across the sensor terminals) should be as shown in the SENSOR RESISTANCE (OHMS)—COOLANT TEMPERATURE SENSOR/INTAKE AIR TEMPERATURE SENSOR chart. Replace the sensor if it is not within the range of resistance specified in chart.

(3) Test the resistance of the wire harness. Do this between the PCM wire harness connector A-15 and the sensor connector terminal. Also check between PCM connector A-4 to the sensor connector terminal. Repair the wire harness as necessary if the resistance is greater than 1 ohm.

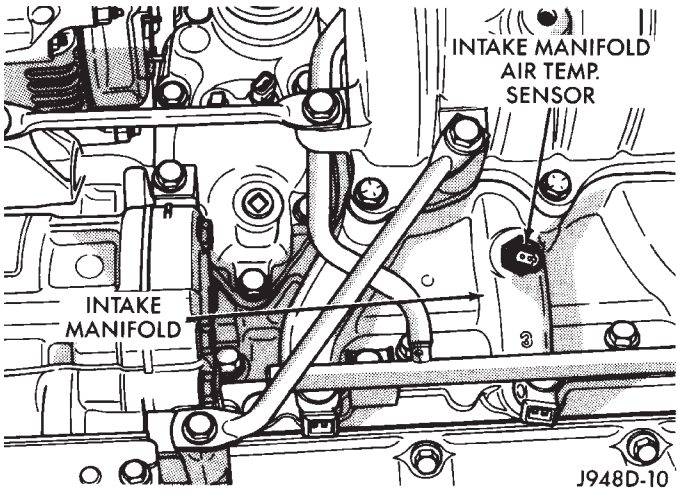


Fig. 61 Intake Manifold Air Temperature Sensor—8.0L Engine

THROTTLE POSITION SENSOR (TPS)—3.9L/5.2L/5.9L ENGINES

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

The TPS can be tested with a digital voltmeter. The center terminal of the TPS is the output terminal (Fig. 62).

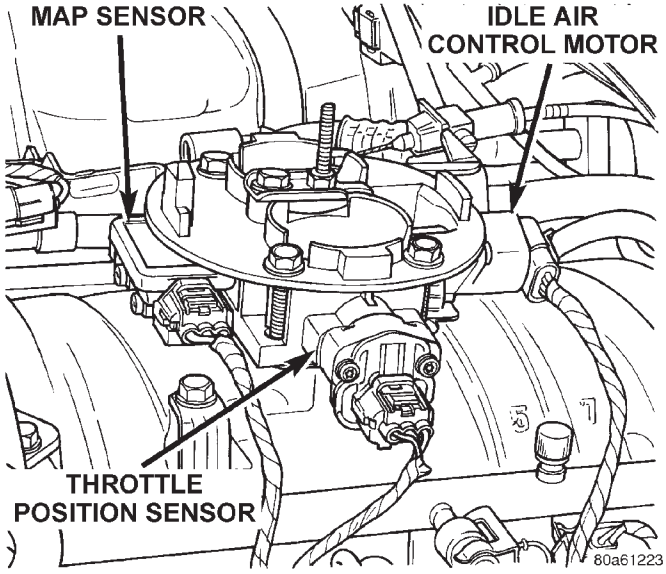


Fig. 62 TPS—3.9L/5.2L/5.9L Engines

With the ignition key in the ON position, check the TPS output voltage at the center terminal wire of the connector. Check this at idle (throttle plate closed) and at wide open throttle (WOT). At idle, TPS output voltage should be greater than .350 millivolts and less than 900 millivolts. At wide open throttle, TPS output voltage must be less than 4.5 volts. The out-

DIAGNOSIS AND TESTING (Continued)

put voltage should increase gradually as the throttle plate is slowly opened from idle to WOT.

THROTTLE POSITION SENSOR (TPS)—8.0L ENGINE

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

The TPS can be tested with a digital voltmeter. The center terminal of the TPS is the output terminal (Fig. 63).

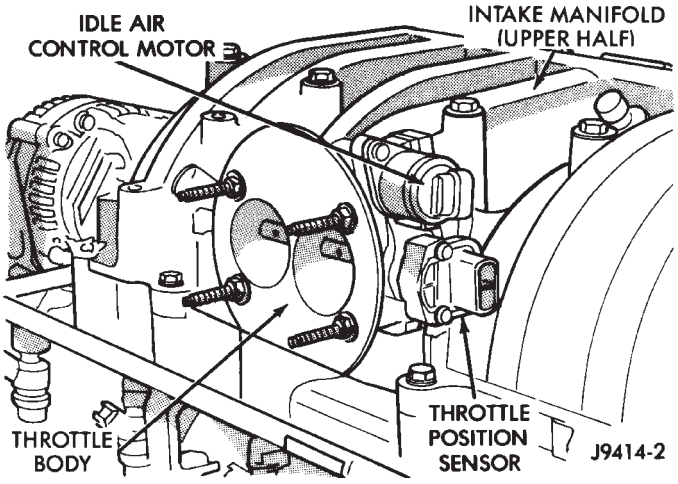


Fig. 63 TPS—8.0L Engine

With the ignition key in the ON position, check the TPS output voltage at the center terminal wire of the connector. Check this at idle (throttle plate closed) and at wide open throttle (WOT). At idle, TPS output voltage should be greater than .350 millivolts and less than 900 millivolts. At wide open throttle, TPS output voltage must be less than 4.5 volts. The output voltage should increase gradually as the throttle plate is slowly opened from idle to WOT.

THROTTLE BODY MINIMUM AIR FLOW CHECK PROCEDURE

3.9/5.2/5.9L ENGINES

The following test procedure has been developed to check throttle body calibrations for correct idle conditions. The procedure should be used to diagnose the throttle body for conditions that may cause idle problems. **This procedure should be used only after normal diagnostic procedures have failed to produce results that indicate a throttle body related problem. Be sure to check for proper operation of the idle air control motor before performing this test.**

A special fixed orifice tool (number 6714) (Fig. 64) must be used for the following test.

SPECIAL TOOL 6714

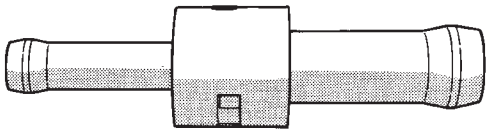


Fig. 64 Fixed Orifice Tool

(1) Start the engine and bring to operating temperature. Be sure all accessories are off before performing this test.

(2) Shut off the engine and remove the air duct at throttle body.

(3) Disconnect the vacuum line at the PCV valve (Fig. 65).

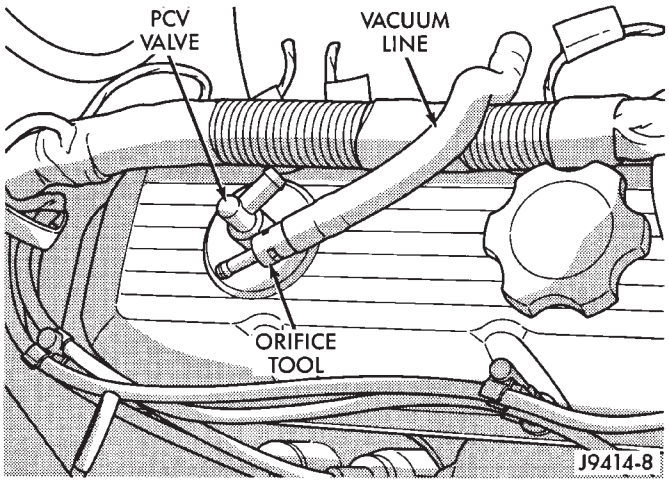


Fig. 65 Install Orifice Tool

(4) Install the 0.185 inch orifice tool (number 6714) into the disconnected vacuum line in place of the PCV valve (Fig. 65).

(5) Disconnect the idle purge vacuum line from fitting at throttle body. This vacuum line is located on the front of throttle body next to the MAP sensor (Fig. 66). Cap the fitting at throttle body after vacuum line has been removed.

(6) Connect the DRB scan tool to the 16–way data link connector. This connector is located under the instrument panel to the left of the steering column. Refer to the appropriate Powertrain Diagnostic Procedures service manual for DRB operation.

(7) Start the engine and allow to warm up.

(8) Using the DRB scan tool, scroll through the menus as follows: select—Stand Alone DRB III, select 1998 Diagnostics, select—Engine, select—System Test, select—Minimum Air Flow.

DIAGNOSIS AND TESTING (Continued)

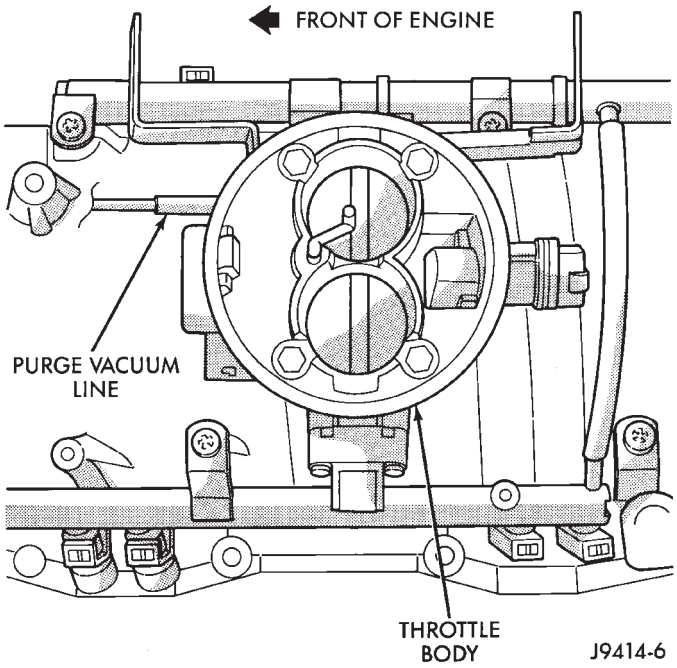


Fig. 66 Idle Purge Line

(9) The DRB scan tool will count down to stabilize the idle rpm and display the minimum air flow idle rpm. The idle rpm should be between **500 and 900 rpm.** If the idle speed is outside of these specifications, replace the throttle body. Refer to Throttle Body in the Component Removal/Installation section of this group.

(10) Disconnect the DRB scan tool from the vehicle.

(11) Remove cap from idle purge fitting at throttle body and install vacuum line.

(12) Remove orifice tool and connect vacuum line to PCV valve.

(13) Install air duct to throttle body.

REMOVAL AND INSTALLATION

AUTOMATIC SHUTDOWN (ASD) RELAY

The ASD relay is located in the Power Distribution Center (PDC) (Fig. 67). Refer to label on PDC cover for relay location.

REMOVAL

(1) Remove PDC cover.

(2) Remove relay from PDC.

(3) Check condition of relay terminals and PDC connector terminals for damage or corrosion. Repair if necessary before installing relay.

(4) Check for pin height (pin height should be the same for all terminals within the PDC connector). Repair if necessary before installing relay.

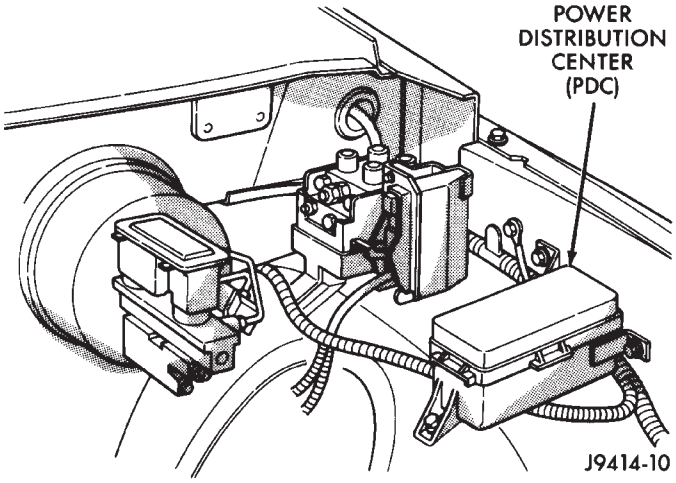


Fig. 67 Power Distribution Center (PDC)

INSTALLATION

(1) Install relay to PDC.

(2) Install cover to PDC.

FUEL PUMP RELAY

The fuel pump relay is located in the Power Distribution Center (PDC) (Fig. 67). Refer to label on PDC cover for relay location.

REMOVAL

(1) Remove PDC cover.

(2) Remove relay from PDC.

(3) Check condition of relay terminals and PDC connector terminals for damage or corrosion. Repair if necessary before installing relay.

(4) Check for pin height (pin height should be the same for all terminals within the PDC connector). Repair if necessary before installing relay.

INSTALLATION

(1) Install relay to PDC.

(2) Install cover to PDC.

THROTTLE BODY—3.9L/5.2L/5.9L ENGINES

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the powertrain control module (PCM).

REMOVAL

(1) Remove the air cleaner.

(2) Disconnect throttle body electrical connectors at MAP sensor, IAC motor and TPS (Fig. 68).

(3) Remove vacuum line at throttle body.

(4) Remove all control cables from throttle body (lever) arm. Refer to the Accelerator Pedal and Throttle Cable section of this group for additional information.

REMOVAL AND INSTALLATION (Continued)

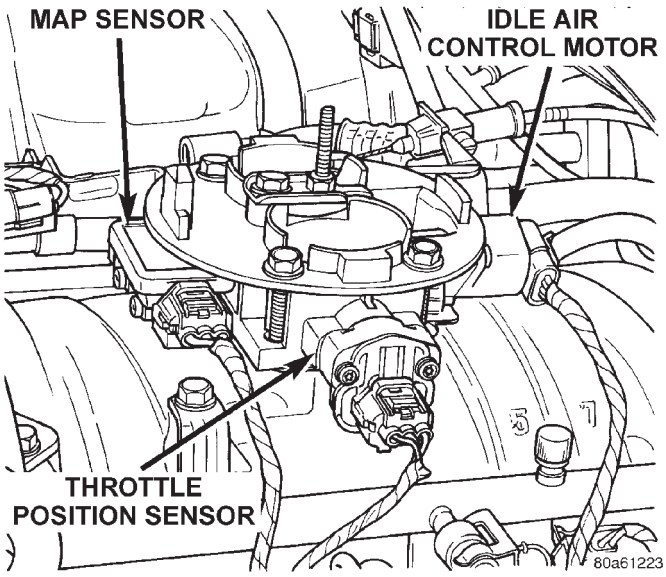


Fig. 68 Sensor Electrical Connectors—3.9L/5.2L/5.9L Engines—Typical

(5) Remove four throttle body mounting bolts (Fig. 69).

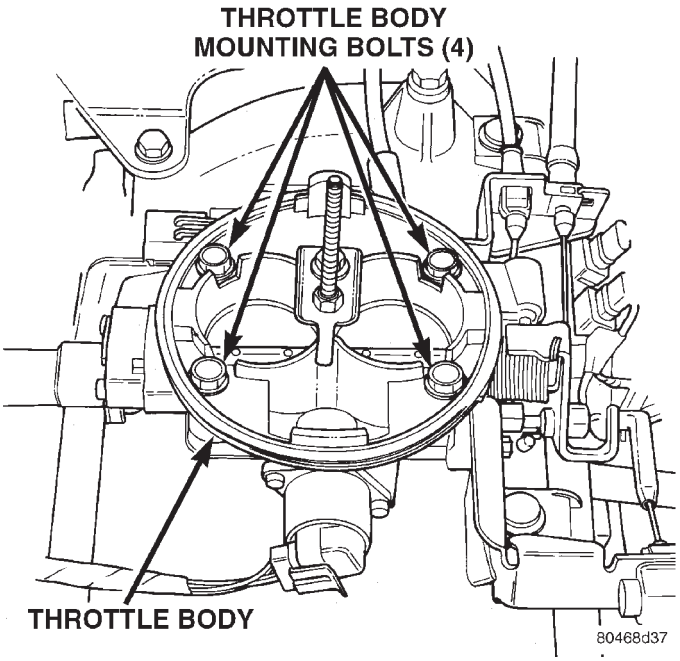


Fig. 69 Throttle Body Mounting Bolts—3.9L/5.2L/5.9L ENGINES—Typical

(6) Remove throttle body from intake manifold.

(7) Discard old throttle body-to-intake manifold gasket.

INSTALLATION

(1) Clean the mating surfaces of the throttle body and the intake manifold.

(2) Install new throttle body-to-intake manifold gasket.

(3) Install throttle body to intake manifold.

(4) Install four mounting bolts. Tighten bolts to 23 N·m (200 in. lbs.) torque.

(5) Install control cables.

(6) Install vacuum line to throttle body.

(7) Install electrical connectors.

(8) Install air cleaner.

THROTTLE BODY—8.0L ENGINE

A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the powertrain control module (PCM).

REMOVAL

(1) Remove the air cleaner cover.

(2) Remove the 4 air cleaner housing mounting nuts and remove housing from throttle body.

(3) Disconnect throttle body electrical connectors at the IAC motor and TPS.

(4) Remove all control cables from throttle body (lever) arm. Refer to the Accelerator Pedal and Throttle Cable section of this group for additional information.

(5) Remove four throttle body mounting nuts (Fig. 70).

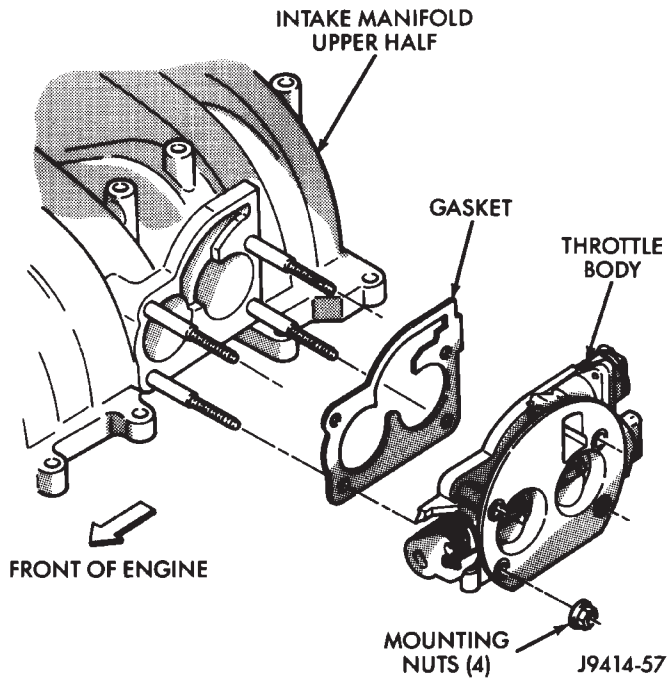


Fig. 70 Throttle Body Mounting Nuts—8.0L Engine

(6) Remove throttle body from intake manifold.

(7) Discard old throttle body-to-intake manifold gasket.

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

(1) Clean the mating surfaces of the throttle body and the intake manifold.

(2) Install new throttle body-to-intake manifold gasket.

(3) Install throttle body to intake manifold.

(4) Install four mounting nuts. Tighten nuts to 22 N·m (192 in. lbs.) torque.

(5) Install control cables.

(6) Install electrical connectors.

(7) Install air cleaner housing to throttle body.

(8) Install 4 air cleaner housing mounting nuts. Tighten nuts to 11 N·m (96 in. lbs.) torque.

(9) Install air cleaner housing cover.

THROTTLE POSITION SENSOR (TPS)—3.9L/5.2L/5.9L ENGINES

REMOVAL

The TPS is located on the side of the throttle body.

(1) Remove air intake tube at throttle body.

(2) Disconnect TPS electrical connector.

(3) Remove two TPS mounting bolts (Fig. 71).

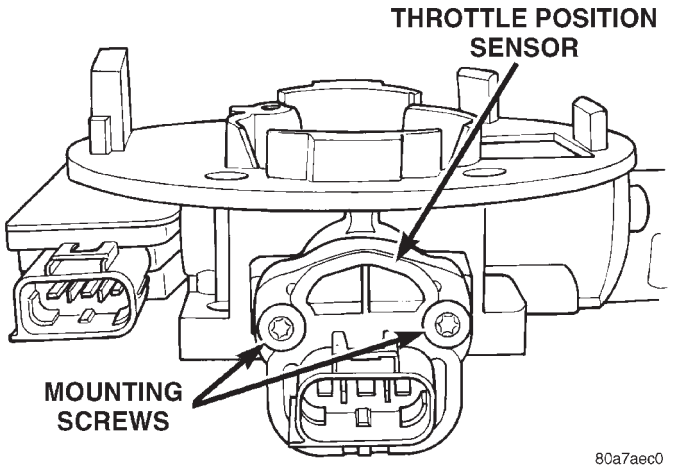


Fig. 71 TPS Mounting Bolts—3.9L/5.2L/5.9L Engines

(4) Remove TPS from throttle body.

INSTALLATION

The throttle shaft end of the throttle body slides into a socket in the TPS (Fig. 72). The TPS must be installed so that it can be rotated a few degrees. If the sensor will not rotate, install the sensor with the throttle shaft on the other side of the socket tangs. The TPS will be under slight tension when rotated.

(1) Install the TPS and two retaining bolts.

(2) Tighten bolts to 7 N·m (60 in. lbs.) torque.

(3) Manually operate the throttle control lever by hand to check for any binding of the TPS.

(4) Connect TPS electrical connector to TPS.

(5) Install air intake tube.

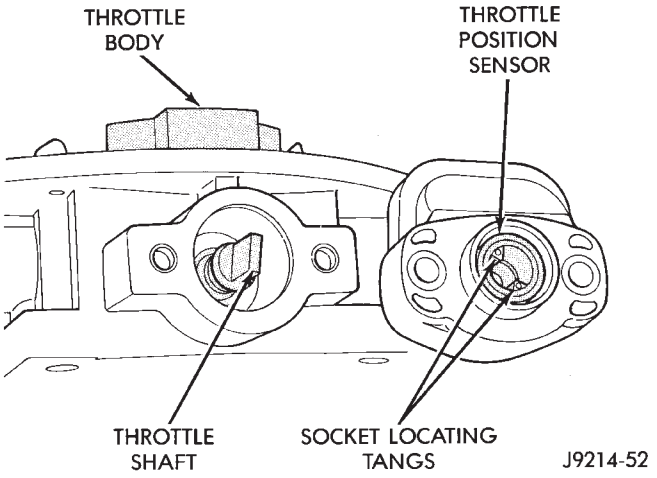


Fig. 72 Installation—3.9L/5.2L/5.9L Engines—Typical

THROTTLE POSITION SENSOR (TPS)—8.0L ENGINE

REMOVAL

The TPS is located on the side of the throttle body (Fig. 73).

(1) Remove air intake tube at air cleaner housing.

(2) Remove the air cleaner cover.

(3) Remove the 4 air cleaner housing mounting nuts and remove housing from throttle body.

(4) Disconnect TPS electrical connector.

(5) Remove two TPS mounting bolts (Fig. 73).

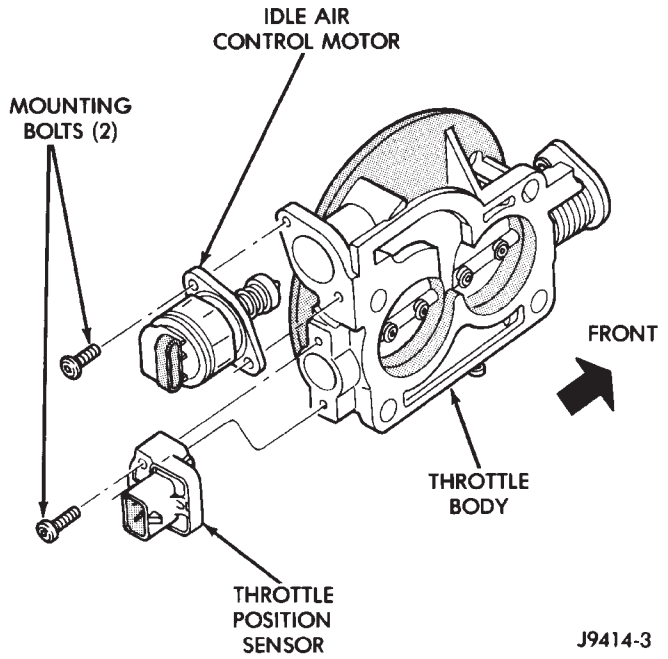


Fig. 73 TPS Mounting Bolts—8.0L Engine

(6) Remove TPS from throttle body.

REMOVAL AND INSTALLATION (Continued)

INSTALLATION

The throttle shaft end of the throttle body slides into a socket in the TPS (Fig. 74). The TPS must be installed so that it can be rotated a few degrees. If the sensor will not rotate, install the sensor with the throttle shaft on the other side of the socket tangs. The TPS will be under slight tension when rotated.

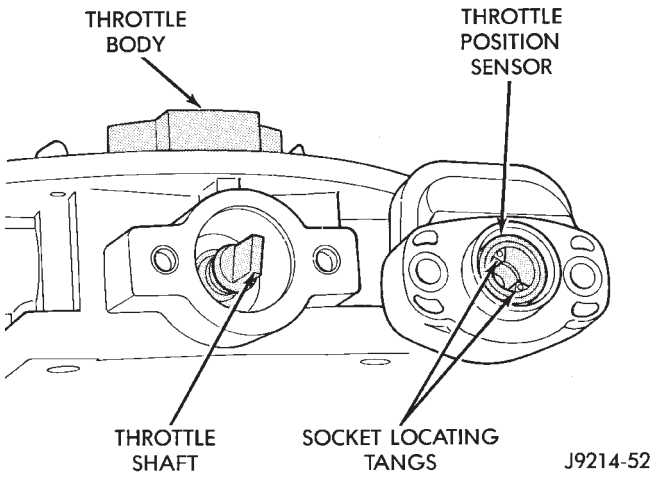


Fig. 74 Installation—Typical Mounting

(1) Install the TPS and two retaining bolts.
(2) Tighten bolts to 7 N·m (60 in. lbs.) torque.
(3) Manually operate the throttle control lever by hand to check for any binding of the TPS.
(4) Connect TPS electrical connector to TPS.
(5) Install air cleaner housing to throttle body.
(6) Install 4 air cleaner housing mounting nuts. Tighten nuts to 11 N·m (96 in. lbs.) torque.
(7) Install air cleaner housing cover.
(8) Install air intake tube to cover.

IDLE AIR CONTROL (IAC) MOTOR—3.9L/5.2L/5.9L ENGINES

The IAC motor is located on the back of the throttle body (Fig. 75).

REMOVAL

(1) Remove air cleaner assembly.
(2) Disconnect electrical connector from IAC motor.
(3) Remove two mounting bolts (screws) (Fig. 75).
(4) Remove IAC motor from throttle body.

INSTALLATION

(1) Install IAC motor to throttle body.
(2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
(3) Install electrical connector.
(4) Install air cleaner assembly.

IDLE AIR CONTROL (IAC) MOTOR—8.0L ENGINE

The IAC motor is located on the back of the throttle body (Fig. 76).

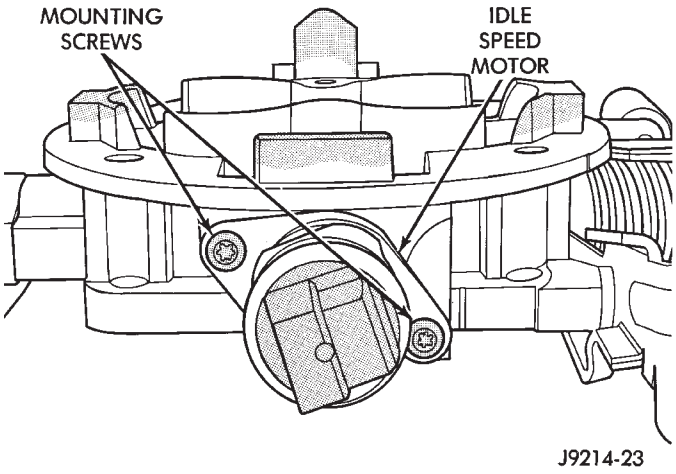


Fig. 75 Mounting Bolts (Screws)—IAC Motor—3.9L/ 5.2L/5.9L Engines

REMOVAL

(1) Remove the air cleaner cover.
(2) Remove the 4 air cleaner housing mounting nuts and remove housing from throttle body.
(3) Disconnect electrical connector from IAC motor.
(4) Remove two mounting bolts (screw).

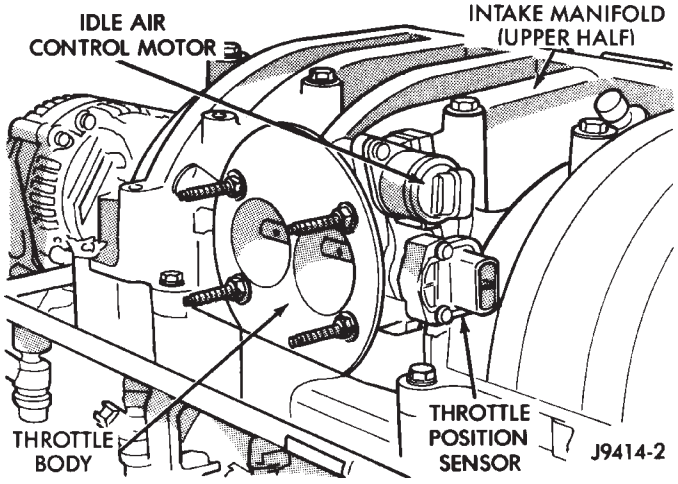


Fig. 76 IAC Motor—8.0L Engine

(5) Remove IAC motor from throttle body.

INSTALLATION

(1) Install IAC motor to throttle body.
(2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
(3) Install electrical connector.
(4) Install air cleaner housing to throttle body.
(5) Install 4 air cleaner housing mounting nuts. Tighten nuts to 11 N·m (96 in. lbs.) torque.
(6) Install air cleaner housing cover.

REMOVAL AND INSTALLATION (Continued)

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—3.9L/5.2L/5.9L ENGINES

The MAP sensor is located on the front of the throttle body (Fig. 77). An L-shaped rubber fitting is used to connect the MAP sensor to throttle body (Fig. 78).

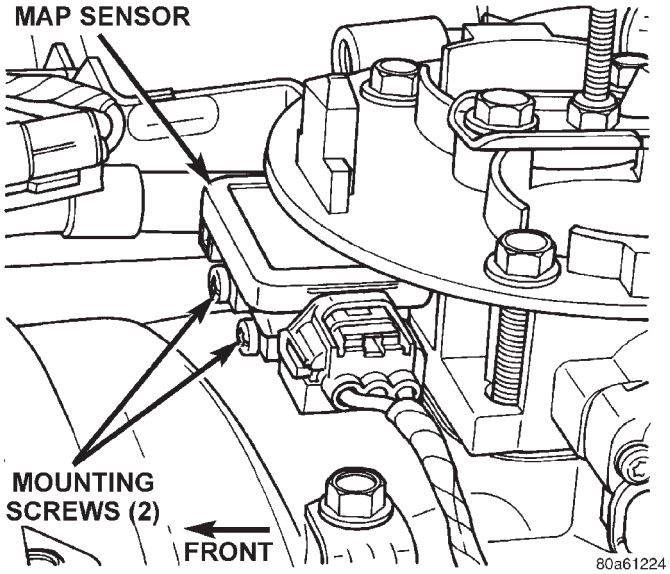


Fig. 77 MAP Sensor Location—3.9L/5.2L/5.9L Engines

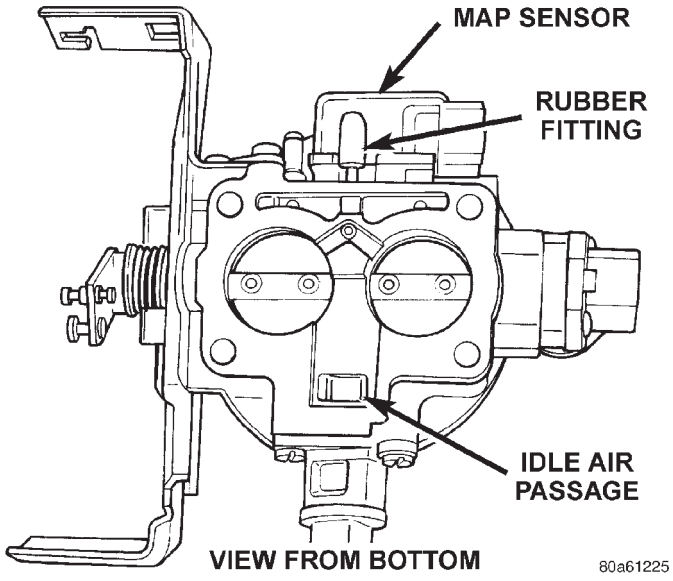


Fig. 78 MAP Sensor L-Shaped Rubber Fitting—3.9L/5.2L/5.9L Engines

REMOVAL

(1) Remove air cleaner assembly.

(2) Remove two MAP sensor mounting bolts (screws) (Fig. 77).

(3) While removing MAP sensor, slide the vacuum rubber L-shaped fitting (Fig. 78) from the throttle body.

(4) Remove rubber L-shaped fitting from MAP sensor.

INSTALLATION

(1) Install rubber L-shaped fitting to MAP sensor.

(2) Position sensor to throttle body while guiding rubber fitting over throttle body vacuum nipple.

(3) Install MAP sensor mounting bolts (screws). Tighten screws to 3 N·m (25 in. lbs.) torque.

(4) Install air cleaner.

MANIFOLD ABSOLUTE PRESSURE (MAP) SENSOR—8.0L ENGINE

The MAP sensor is mounted into the right upper side of the intake manifold (Fig. 79). A rubber gasket is used to seal the sensor to the intake manifold. The rubber gasket is part of the sensor and is not serviced separately.

REMOVAL

(1) Remove the electrical connector at the sensor.

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

(3) Remove the two sensor mounting bolts.

(4) Remove the sensor from the intake manifold.

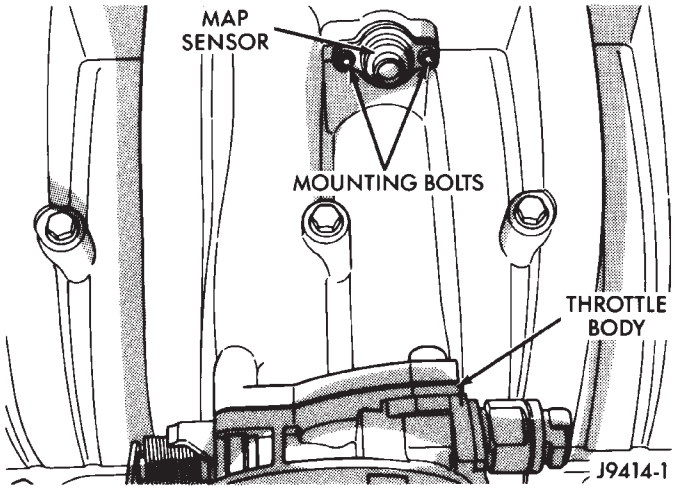


Fig. 79 MAP Sensor Location—8.0L V-10 Engine—Typical

INSTALLATION

(1) Check the condition of the sensor seal. Clean the sensor and lubricate the rubber gasket with clean engine oil.

(2) Clean the sensor opening in the intake manifold.

(3) Install the sensor into the intake manifold.

(4) Install sensor mounting bolts. Tighten bolts to 2 N·m (20 in. lbs.) torque.

(5) Install the electrical connector to sensor.

REMOVAL AND INSTALLATION (Continued)

DUTY CYCLE EVAP CANISTER PURGE SOLENOID

Refer to Group 25, Emission Control System for removal/installation procedures.

POWERTRAIN CONTROL MODULE (PCM)

The PCM is located in the engine compartment (Fig. 80).

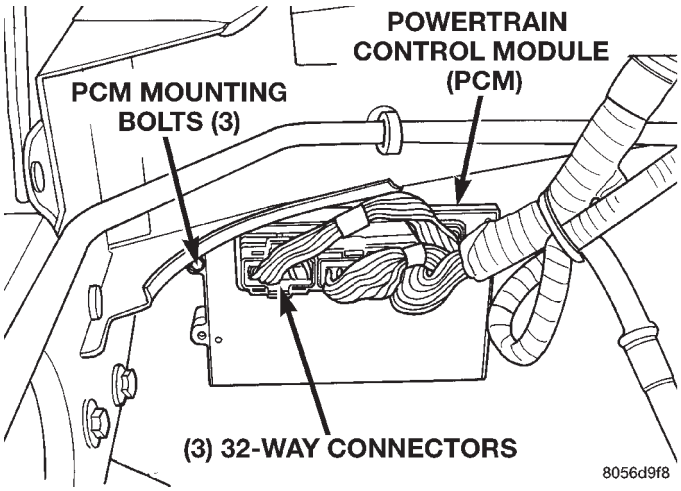


Fig. 80 PCM Location and Mounting

REMOVAL

To avoid possible voltage spike damage to the PCM, ignition key must be off, and negative battery cable must be disconnected before unplugging PCM connectors.

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

(2) Remove cover over electrical connectors. Cover snaps onto PCM.

(3) Carefully unplug the three 32–way connectors from PCM.

(4) Remove three PCM mounting bolts and remove PCM from vehicle.

INSTALLATION

(1) Install PCM and mounting bolts to vehicle.

(2) Tighten bolts to 4 N·m (35 in. lbs.).

(3) Check pin connectors in the PCM and the three 32–way connectors for corrosion or damage. Repair as necessary.

(4) Install three 32–way connectors.

(5) Install cover over electrical connectors. Cover snaps onto PCM.

(6) Install battery cable(s).

(7) Use the DRB scan tool to reprogram new PCM with vehicles original Identification Number (VIN) and original vehicle mileage. If this step is not done, a Diagnostic Trouble Code (DTC) may be set.

CRANKSHAFT POSITION SENSOR

Refer to Group 8D, Ignition System for removal/installation procedures.

CAMSHAFT POSITION SENSOR

For removal/installation procedures, refer to Group 8D, Ignition System. See Camshaft Position Sensor.

OXYGEN SENSORS—3.9L/5.2L/5.9L LDC/HDC ENGINES

On 3.9L/5.2L/5.9L LDC engines, the upstream and downstream O2S sensors are located at the inlet and outlet ends of the catalytic converter (Fig. 81).

On 5.9L HDC engines, the left and right O2S sensors are located on the left and right exhaust downpipes (Fig. 82).

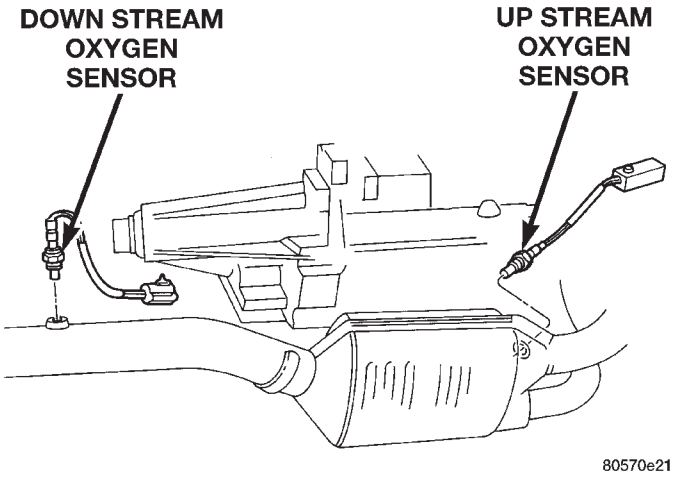


Fig. 81 Oxygen Sensor Location—3.9L/5.2L/5.9L LDC ENGINES

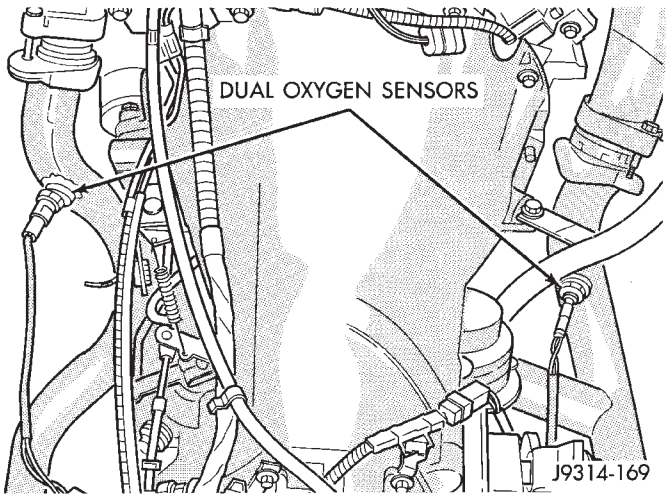


Fig. 82 Oxygen Sensor Location—5.9L HDC ENGINES

REMOVAL

WARNING: THE EXHAUST MANIFOLD, EXHAUST PIPES AND CATALYTIC CONVERTER BECOME VERY HOT DURING ENGINE OPERATION. ALLOW ENGINE TO COOL BEFORE REMOVING OXYGEN SENSOR.

REMOVAL AND INSTALLATION (Continued)

(1) Raise and support the vehicle.
(2) Disconnect the wire connector from the O2S sensor.

CAUTION: When disconnecting the sensor electrical connector, do not pull directly on wire going into sensor.

(3) Remove the O2S sensor. Snap-On oxygen sensor wrench (number YA 8875) may be used for removal and installation.

INSTALLATION

Threads of new oxygen sensors are factory coated with anti-seize compound to aid in removal. **DO NOT add any additional anti-seize compound to the threads of a new oxygen sensor.**

(1) Install the O2S sensor. Tighten to 30 N·m (22 ft. lbs.) torque.
(2) Connect the O2S sensor wire connector.
(3) Lower the vehicle.

OXYGEN SENSORS—8.0L ENGINES

On 8.0L MDC engines, the pre-catalyst and post catalyst O2S sensors are located at the inlet and outlet ends of the catalytic converter (Fig. 83).

On 8.0L MDC or HDC engines, the left and right O2S sensors are located on the left and right exhaust downpipes (Fig. 84).

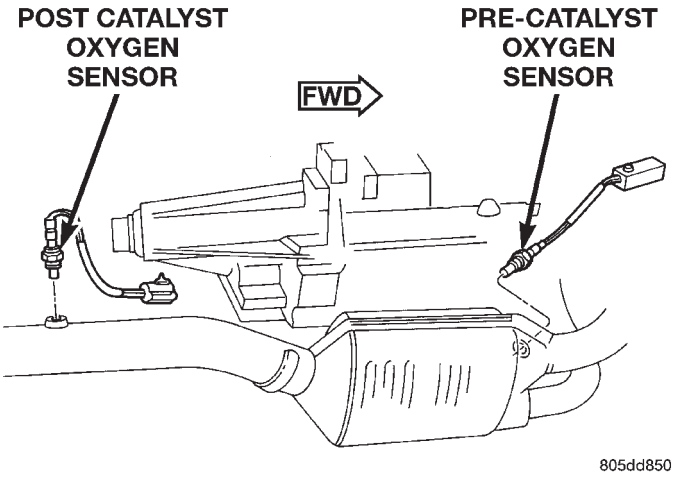


Fig. 83 Pre-Catalyst/Post Catalyst Oxygen Sensor Location—8.0L MDC Engines Only

REMOVAL

WARNING: THE EXHAUST MANIFOLD, EXHAUST PIPES AND CATALYTIC CONVERTER BECOME VERY HOT DURING ENGINE OPERATION. ALLOW ENGINE TO COOL BEFORE REMOVING OXYGEN SENSOR.

(1) Raise and support the vehicle.

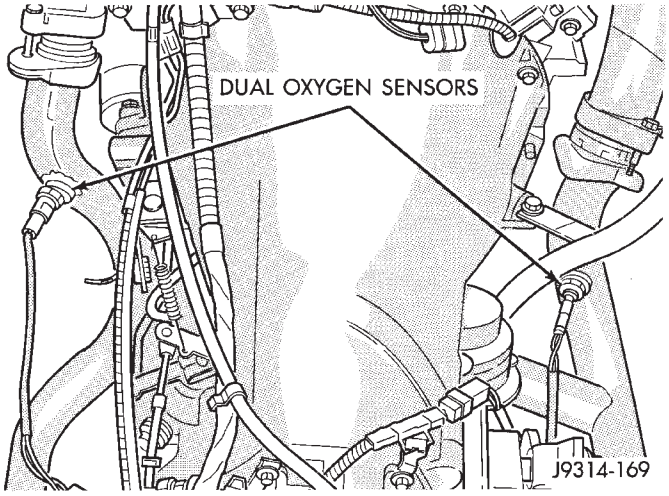


Fig. 84 Left/Right Oxygen Sensor Location—All 8.0L Engines

(2) Disconnect the wire connector from the O2S sensor.

CAUTION: When disconnecting the sensor electrical connector, do not pull directly on wire going into sensor.

(3) Remove the O2S sensor. Snap-On oxygen sensor wrench (number YA 8875) may be used for removal and installation.

INSTALLATION

Threads of new oxygen sensors are factory coated with anti-seize compound to aid in removal. **DO NOT add any additional anti-seize compound to the threads of a new oxygen sensor.**

(1) Install the O2S sensor. Tighten to 30 N·m (22 ft. lbs.) torque.
(2) Connect the O2S sensor wire connector.
(3) Lower the vehicle.

AIR CLEANER HOUSING/AIR CLEANER ELEMENT (FILTER)—3.9L/5.2L/5.9L ENGINES

For air cleaner element required maintenance schedules (listed in time or mileage intervals), refer to Group 0, Lubrication and Maintenance.

REMOVAL/INSTALLATION

CAUTION: Do not attempt to remove the air cleaner element (filter) from the housing by removing the top cover only. To prevent damage to the air cleaner housing, the entire air cleaner housing assembly must be removed from the engine for air cleaner element replacement.

(1) Remove the air inlet tube (Fig. 85) at the side of the air cleaner housing.

REMOVAL AND INSTALLATION (Continued)

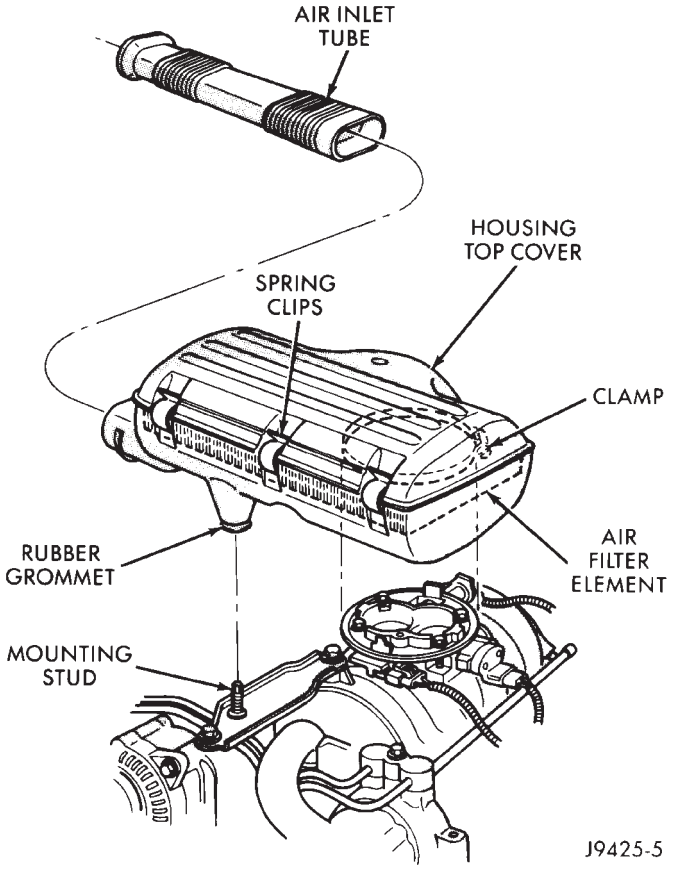


Fig. 85 Air Cleaner Housing—3.9L/5.2L/5.9L Engines

(2) A band-type screw clamp secures the air cleaner housing to the throttle body. Loosen, but do not remove, this screw clamp (Fig. 85). Note the clamp positioning tabs on the air cleaner housing.

(3) All Engines: Disconnect the breather hose at the rear of air cleaner housing.

(4) 5.9L V-8 HDC Engine Only: Disconnect the air pump hose at the air cleaner housing.

(5) The bottom/front of the air cleaner housing is equipped with a rubber grommet (Fig. 85). A mounting stud is attached to the intake manifold (Fig. 85) and is used to position the air cleaner housing into this grommet. Lift the assembly from the throttle body while slipping the assembly from the mounting stud (Fig. 85).

(6) Check condition of gasket at throttle body and replace as necessary.

(7) The housing cover is equipped with three (3) spring clips (Fig. 85) and is hinged at the rear with plastic tabs. Unlatch the clips from the top of air cleaner housing and tilt the housing cover up and rearward for cover removal.

(8) Remove the air cleaner element from air cleaner housing.

(9) Before installing a new air cleaner element, clean inside of air cleaner housing.

(10) Position air cleaner cover to tabs on rear of air cleaner housing. Latch the three spring clips to seal cover to housing.

(11) Position the air cleaner housing assembly to the throttle body while guiding the rubber grommet over the mounting stud. The lower part of the screw clamp should be below the top lip of the throttle body.

(12) Push down on air cleaner housing at rubber grommet to seat housing at intake manifold.

(13) Tighten throttle body-to-air cleaner housing clamp to 4 N·m (35 in. lbs.) torque.

(14) Install the air inlet tube at air cleaner housing inlet.

AIR CLEANER HOUSING/AIR CLEANER ELEMENT (FILTER)—8.0L V-10 ENGINE

For air cleaner element required maintenance schedules (listed in time or mileage intervals), refer to Group 0, Lubrication and Maintenance.

A small amount of engine oil wetting the inside of the air cleaner housing is normal. When servicing, wipe out the oil from the air cleaner housing.

REMOVAL/INSTALLATION

(1) Loosen the clamp (Fig. 86) and remove the air inlet tube (Fig. 87) at the front of the air cleaner housing cover.

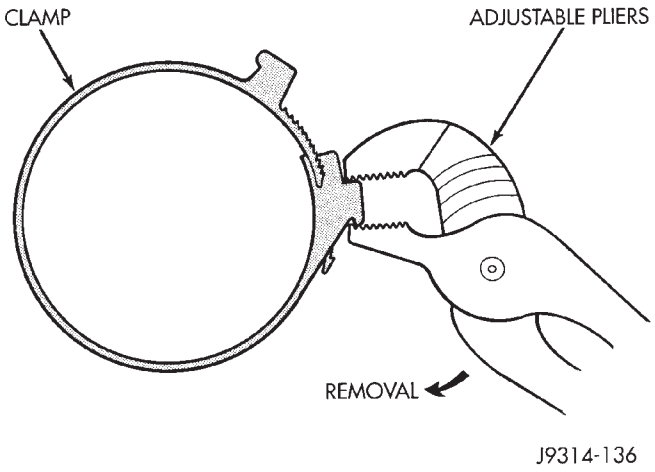


Fig. 86 Clamp Removal—8.0L Engine

(2) The air cleaner housing and air cleaner element cover are equipped with spring clips to seal the cover to housing (Fig. 87). Unlatch the clips from the air cleaner cover and remove cover from air cleaner housing.

(3) Remove the air cleaner element from air cleaner cover.

(4) Before installing a new air cleaner element, clean inside of air cleaner housing.

(5) If housing removal is necessary, remove the 4 housing-to-throttle body nuts.

REMOVAL AND INSTALLATION (Continued)

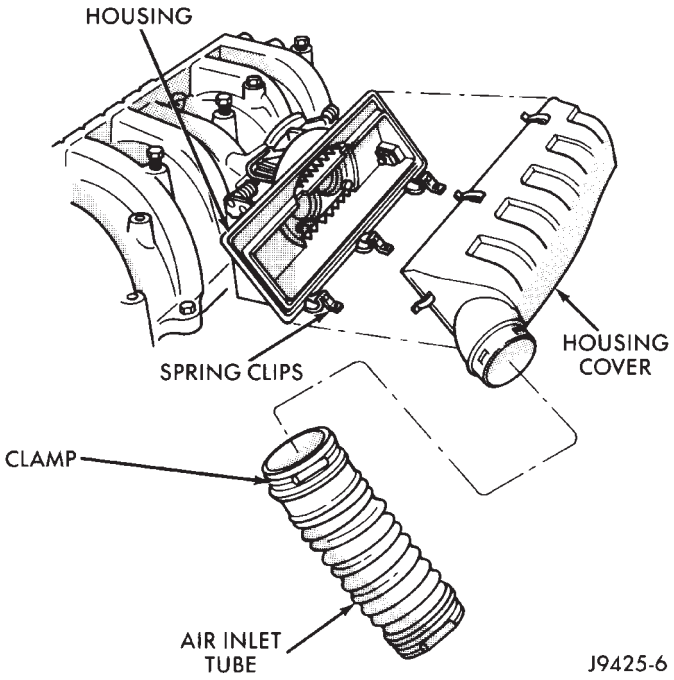


Fig. 87 Air Cleaner Housing—8.0L V-10 Engine

(6) After installing housing, tighten 4 nuts to 11 N·m (96 in. lbs.) torque.

(7) Position air cleaner element (filter) into air cleaner cover. Latch the spring clips to seal cover to housing.

(8) Install the air inlet tube at air cleaner housing inlet.

(9) Install and tighten clamp at air inlet tube (Fig. 88).

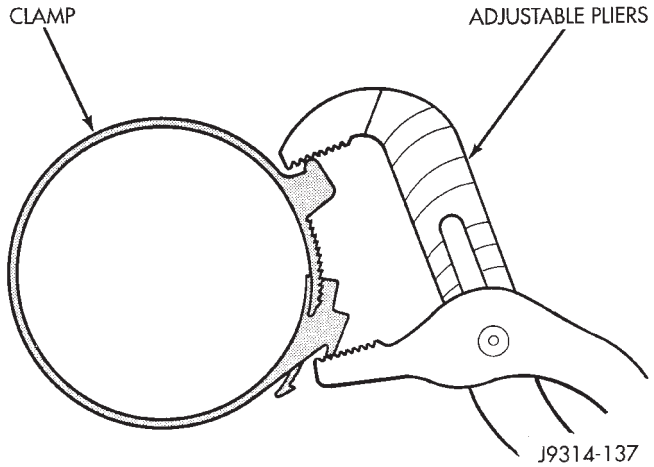


Fig. 88 Clamp Installation—8.0L Engine

ENGINE COOLANT TEMPERATURE SENSOR—3.9L/ 5.2L/5.9L ENGINES

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) Remove air cleaner assembly.

(3) Disconnect electrical connector from sensor (Fig. 89).

(4) **Engines with air conditioning:** When removing the connector from sensor, do not pull directly on wiring harness. Fabricate an L-shaped hook tool from a coat hanger (approximately eight inches long). Place the hook part of tool under the connector for removal. The connector is snapped onto the sensor. It is not equipped with a lock type tab.

(5) Remove sensor from intake manifold.

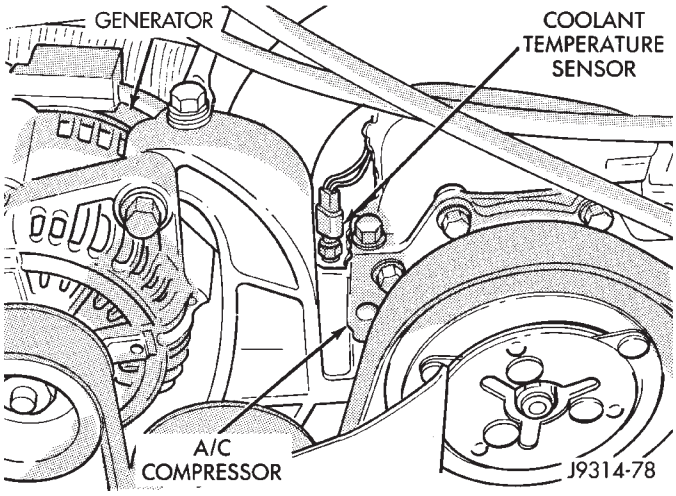


Fig. 89 Engine Coolant Temperature Sensor—3.9L/ 5.2L/5.9L Engines—Typical

INSTALLATION

(1) Install sensor.

(2) Tighten to 11 N·m (8 ft. lbs.) torque.

(3) Connect electrical connector to sensor. The sensor connector is symmetrical (not indexed). It can be installed to the sensor in either direction.

(4) Install air cleaner assembly.

(5) Replace any lost engine coolant. Refer to Group 7, Cooling System.

REMOVAL AND INSTALLATION (Continued)

ENGINE COOLANT TEMPERATURE SENSOR—8.0L ENGINE

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 (Fig. 90).
(3) Remove sensor from intake manifold.

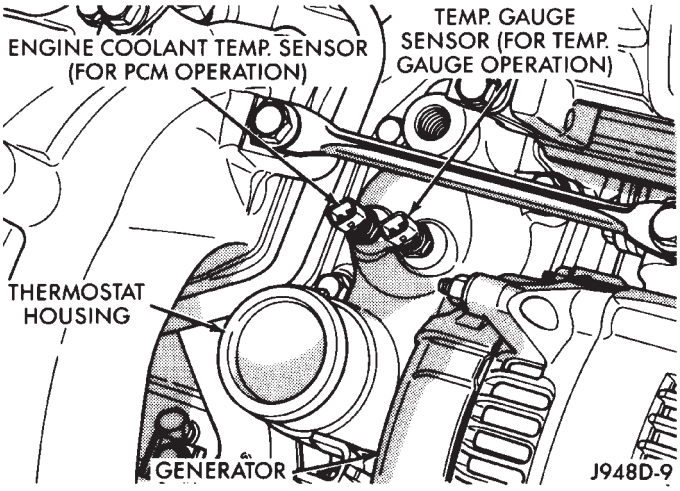


Fig. 90 Engine Coolant Temperature Sensor—8.0L Engine

INSTALLATION

(1) Install sensor.
(2) Tighten to 11 N·m (8 ft. lbs.) torque.
(3) Connect electrical connector to sensor.
(4) Replace any lost engine coolant. Refer to Group 7, Cooling System.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—3.9L/5.2L/5.9L ENGINES

The intake manifold air temperature sensor is located in the front/side of the intake manifold (Fig. 91).

REMOVAL

(1) Remove air cleaner assembly.
(2) Disconnect electrical connector at sensor (Fig. 91).
(3) Remove sensor from intake manifold.

INSTALLATION

(1) Install sensor to intake manifold. Tighten to 28 N·m (20 ft. lbs.) torque.

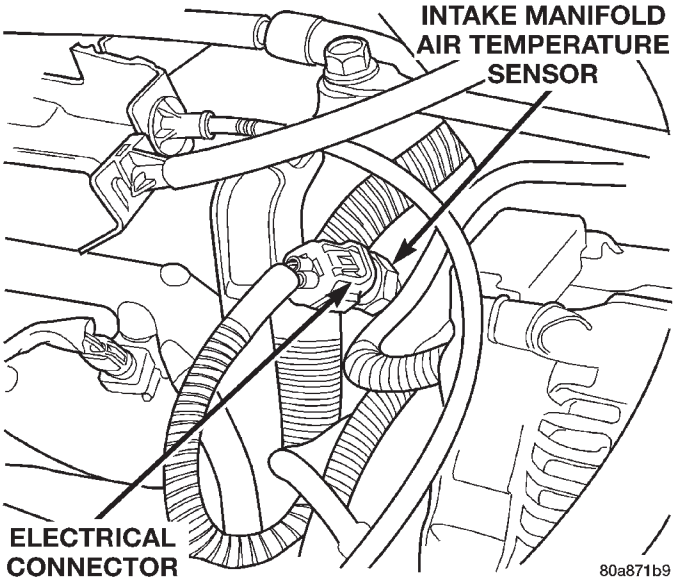


Fig. 91 Air Temperature Sensor—3.9L/5.2L/5.9L Engines—Typical (V-8 Shown)

(2) Install electrical connector.
(3) Install air cleaner.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—8.0L ENGINE

The intake manifold air temperature sensor is located in the side of the intake manifold near the front of throttle body (Fig. 92).

REMOVAL

(1) Disconnect electrical connector at sensor.
(2) Remove sensor from intake manifold.

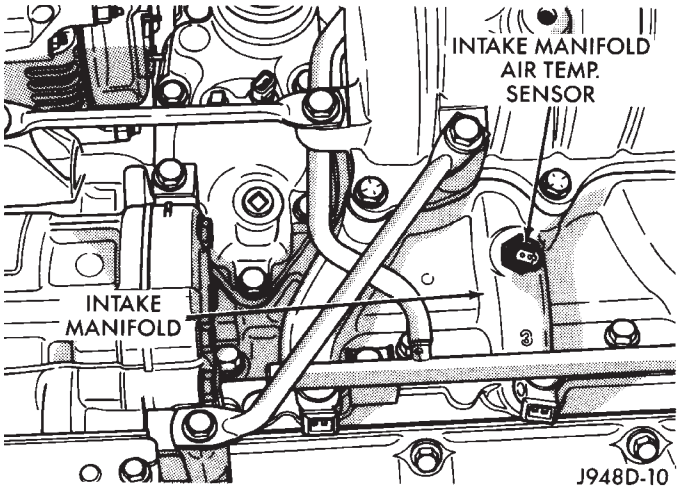


Fig. 92 Air Temperature Sensor—8.0L Engine

INSTALLATION

(1) Install sensor to intake manifold. Tighten to 28 N·m (20 ft. lbs.) torque.
(2) Install electrical connector.

SPECIFICATIONS

VECI LABEL

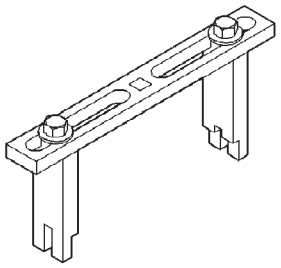
If anything differs between the specifications found on the Vehicle Emission Control Information (VECI) label and the following specifications, use specifications on VECI label. The VECI label is located in the engine compartment.

TORQUE CHART

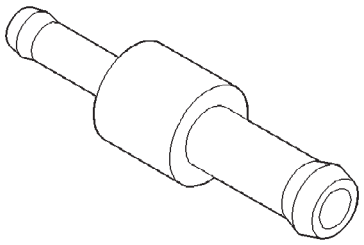
DESCRIPTION	TORQUE
Air Cleaner Housing Mount. Nuts—8.0L Engine	11 N·m (96 in. lbs.)
Air Cleaner Housing Metal Clamp—3.9L/5.2L/5.9L Engines	4 N·m (35 in. lbs.)
Crankshaft Position Sensor Mounting Bolts—All Engines	8 N·m (70 in. lbs.)
Camshaft Position Sensor Mounting—8.0L Engine	6 N·m (50 in. lbs.)
Engine Coolant Temperature Sensor—All Engines	11 N·m (96 in. lbs.)
Fuel Tank Mounting Nuts	41 N·m (30 ft. lbs.)
Fuel Hose Clamps	1 N·m (10 in. lbs.)
IAC Motor-To-Throttle Body Bolts	7 N·m (60 in. lbs.)
Intake Manifold Air Temp. Sensor—All Engines	28 N·m (20 ft. lbs.)
MAP Sensor Mounting Screws—3.9L/5.2L/5.9L Engines	3 N·m (25 in. lbs.)
MAP Sensor Mounting Screws—8.0L Engine	2 N·m (20 in. lbs.)
Oxygen Sensor—All Engines	30 N·m (22 ft. lbs.)
Powertrain Control Module Mounting Screws	4 N·m (35 in. lbs.)
Throttle Body Mounting Bolts—3.9L/5.2L/5.9L Engines	23 N·m (200 in. lbs.)
Throttle Body Mounting Bolts—8.0L Engine	22 N·m (192 in. lbs.)
Throttle Position Sensor Mounting Screws—All Engines	7 N·m (60 in. lbs.)

SPECIAL TOOLS

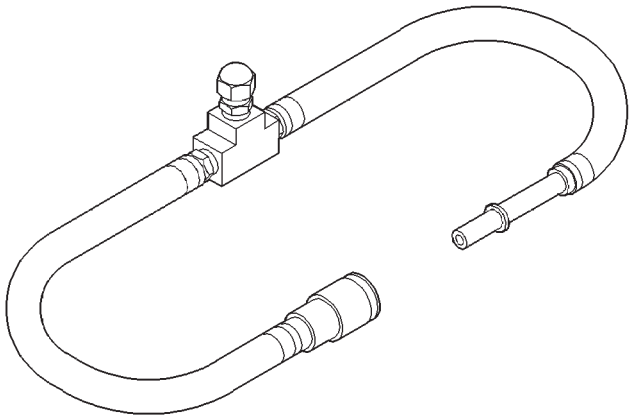
FUEL SYSTEM



Spanner Wrench—6856



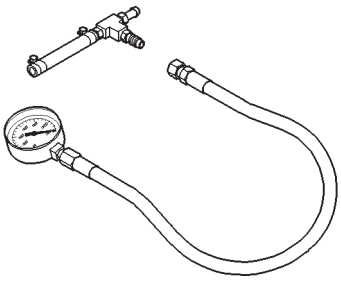
Fitting, Air Metering—6714



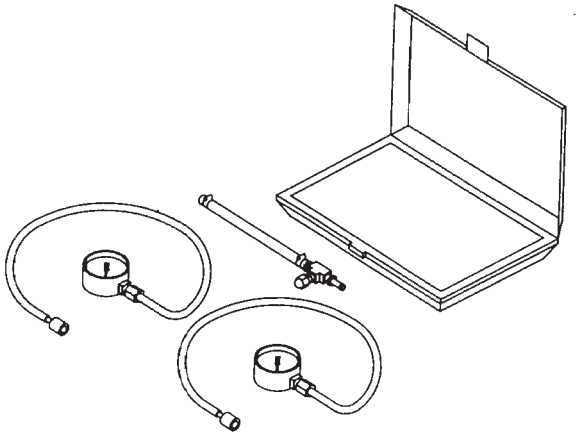
Adapters, Fuel Pressure Test—6541, 6539, 6631 or 6923

SPECIAL TOOLS (Continued)

O2S (Oxygen Sensor) Remover/Installer—C-4907



Test Kit, Fuel Pressure—C-4799-B



Test Kit, Fuel Pressure—5069

Fuel Line Removal Tool—6782

FUEL DELIVERY SYSTEM-DIESEL ENGINE

INDEX

DESCRIPTION AND OPERATION

FUEL DELIVERY SYSTEM—DIESEL POWERED ENGINE

Two different fuel systems are used for the diesel engine in the 1998 model year. The **early** '98 fuel system, using the two-valve-per-cylinder engine, will retain the mechanical fuel injection pump as used in previous model years. The **late** '98 fuel system, using the four-valve-per-cylinder engine, will use an electronic fuel injection pump with two control modules. This book will include information for the **early** '98 fuel system only.

This section of the group will cover diesel fuel delivery components **not controlled** by the powertrain control module (PCM). Various components, relays and switches are operated by the PCM. Refer to the Fuel Injection System—Diesel Engine sections of this group for components that are operated by the PCM.

NOTE: Diesel fuel delivery (except for operation of the intake manifold air heater and manifold air heater relays) is not directly regulated by the PCM.

The fuel delivery system of the 5.9L turbo-diesel engine consists of the:

- Accelerator pedal

DESCRIPTION AND OPERATION (Continued)

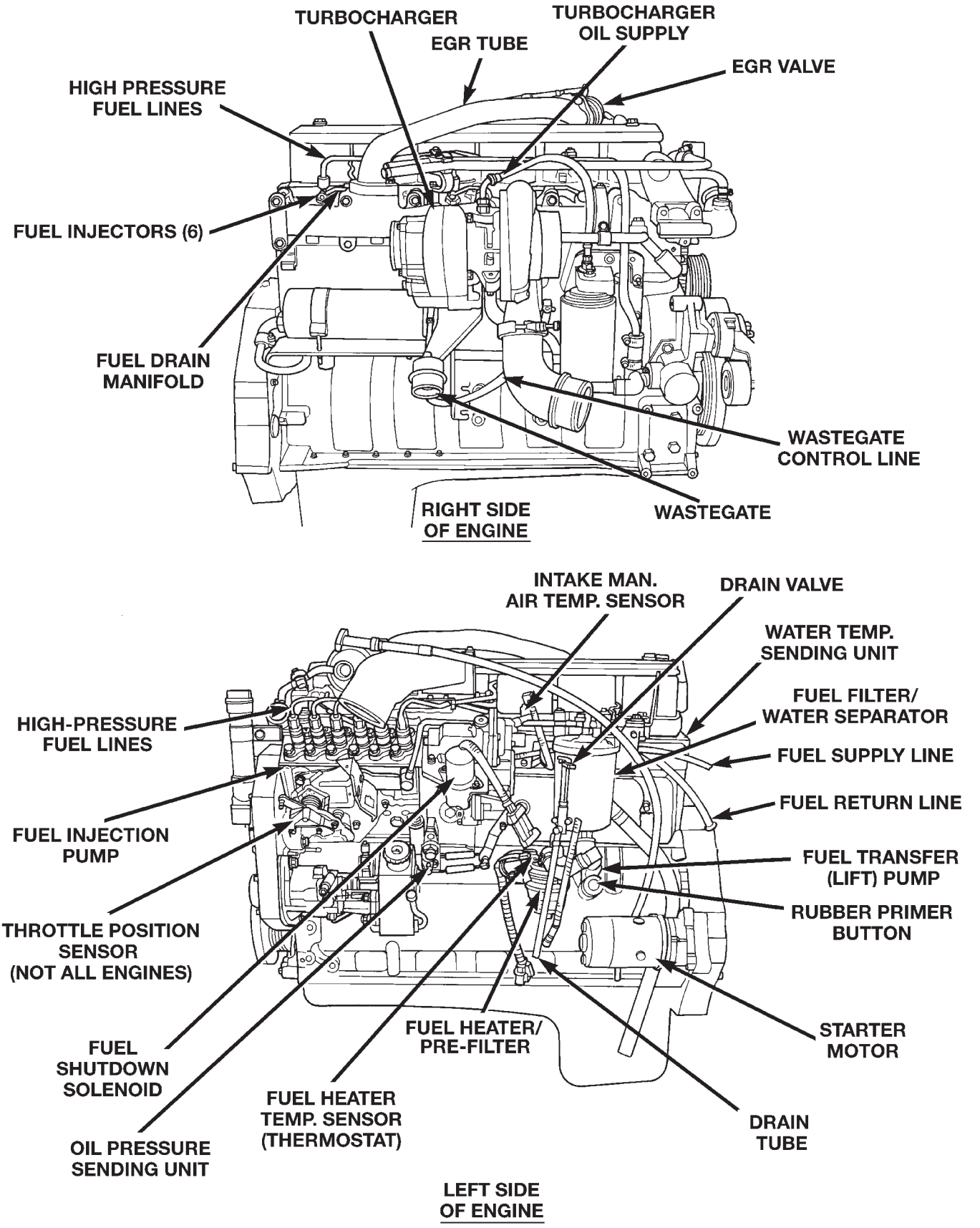


Fig. 1 Fuel System Components—Diesel Engine

DESCRIPTION AND OPERATION (Continued)

- Fuel drain manifold
- Fuel filter/water separator
- Fuel heater
- Fuel heater relay
- Fuel shutdown solenoid
- Fuel shutdown solenoid relay
- Fuel tank
- Fuel tank filler/vent tube assembly
- Fuel tank filler tube cap
- Fuel tank module containing the rollover valve, fuel gauge sending unit (fuel level sensor) and a separate fuel filter located at bottom of tank module
- Fuel tubes/lines/hoses
- High-pressure fuel injection pump
- High-pressure fuel injectors
- High-pressure fuel injector lines
- In-tank fuel filter (at bottom of fuel pump module)
- Low-pressure fuel supply lines
- Low-pressure fuel return line
- Low-pressure, mechanical, fuel transfer pump (fuel lift pump)
- Pre-filter (in the fuel heater)
- Quick-connect fittings
- Throttle cable

FUEL TANK MODULE

An electric fuel pump is **not used** in the fuel tank module for diesel powered engines. Fuel is supplied by the engine mounted fuel transfer pump and the fuel injection pump.

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

- Fuel reservoir
- A separate in-tank fuel filter
- Rollover valve
- Fuel gauge sending unit (fuel level sensor)
- Fuel supply line connection
- Fuel return line connection
- Auxiliary non-pressurized fuel supply fitting

FUEL GAUGE SENDING UNIT

The fuel gauge sending unit (fuel level sensor) is attached to the side of the fuel tank module. The sending unit consists of a float, an arm, and a variable resistor (track). The resistor track is used to send electrical signals to the Powertrain Control Module (PCM) for fuel gauge operation. After this signal is sent to the PCM, the PCM will transmit the data across the CCD bus circuits to the instrument panel. Here it is translated into the appropriate fuel gauge level reading.

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

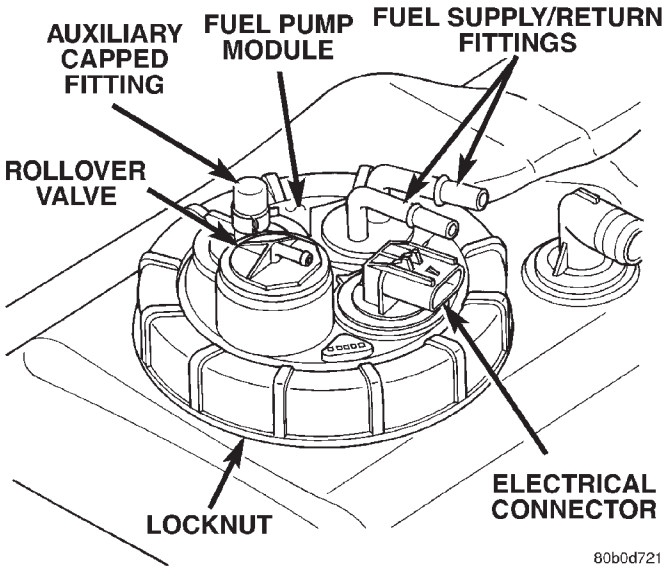


Fig. 2 Top View of Fuel Tank Module—Diesel

FUEL HEATER

The fuel heater is used to prevent diesel fuel from waxing during cold weather operation. The fuel heater is located on the left side of the engine above the starter motor (Fig. 3).

The heater assembly is equipped with a built-in sensor (thermostat) (Fig. 3) that senses fuel temperature. When the temperature is below 40 degrees F, the built-in sensor allows current to flow to the built-in heater element warming the fuel. When the temperature is above 80 degrees F, the sensor stops current flow to the heater element.

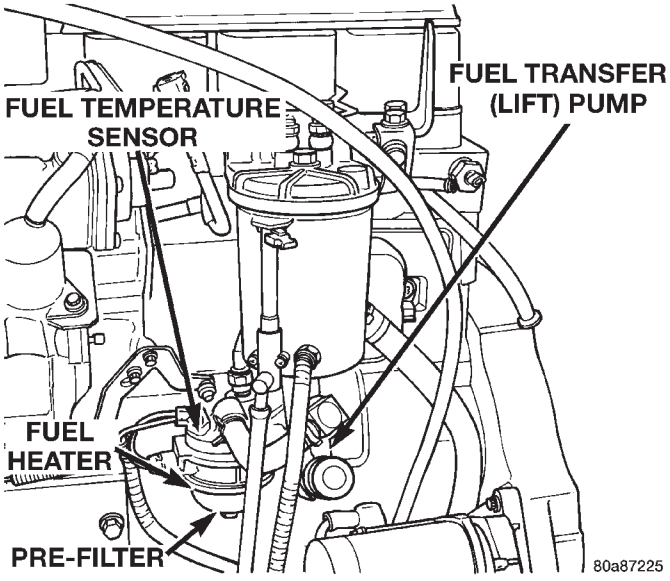


Fig. 3 Fuel Heater and Temperature Sensor Location

DESCRIPTION AND OPERATION (Continued)

Voltage to operate the fuel heater is supplied from the ignition switch and through the fuel heater relay. Also refer to Fuel Heater Relay.

The fuel heater and fuel heater relay are not controlled by the powertrain control module (PCM).

The built-in heater element operates on 12 volts, 300 watts at 0 degrees F.

The fuel heater assembly contains a pre-filter to prevent contaminants from entering the fuel transfer pump.

FUEL HEATER RELAY

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

The fuel heater relay is located in the engine compartment near the brake master cylinder (Fig. 4).

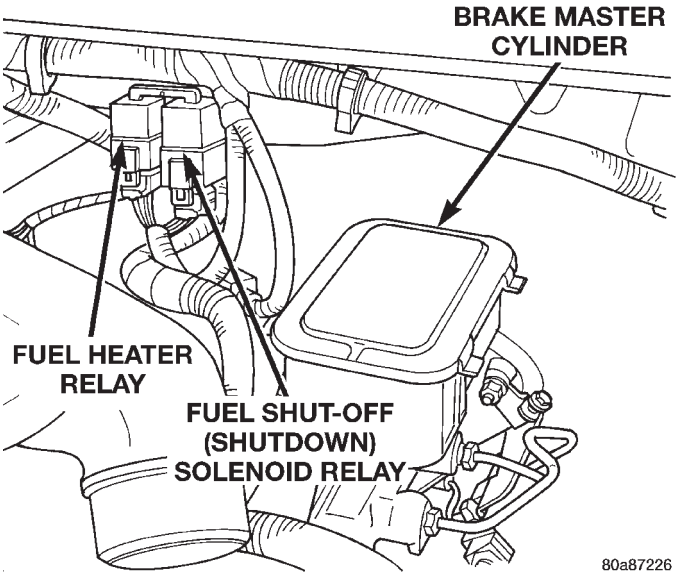


Fig. 4 Fuel Heater Relay—Diesel

FUEL TRANSFER PUMP

The fuel transfer pump (fuel lift pump) is located on the left-rear side of the engine cylinder block above the starter motor (Fig. 1) or (Fig. 3). This mechanically operated pump is not controlled by the powertrain control module (PCM).

The purpose of the fuel transfer pump is to supply (transfer) a low-pressure fuel source of approximately 172 Kpa (25 psi) to the injection pump and fuel filter/water separator from the fuel tank. Here, the low-pressure is raised to a high-pressure by the fuel injection pump for operation of the high-pressure fuel injectors. The transfer pump is driven by an eccentric on the engine camshaft that actuates a spring loaded piston within the pump (Fig. 5). Check valves within the pump, control direction of fuel flow and prevent fuel bleed-back during engine shut down.

The fuel transfer pump should never be operated without the pre-filter installed.

The fuel volume of the transfer pump will vary with engine rpm, but will always provide more fuel than the fuel injection pump requires. Excess fuel is returned to the fuel tank through an overflow valve. The valve is located on the side of the injection pump (Fig. 6) and is used to connect the fuel return line to the side of the injection pump. This valve opens at approximately 152 kPa (22 psi) and returns fuel to the fuel tank through the fuel return line.

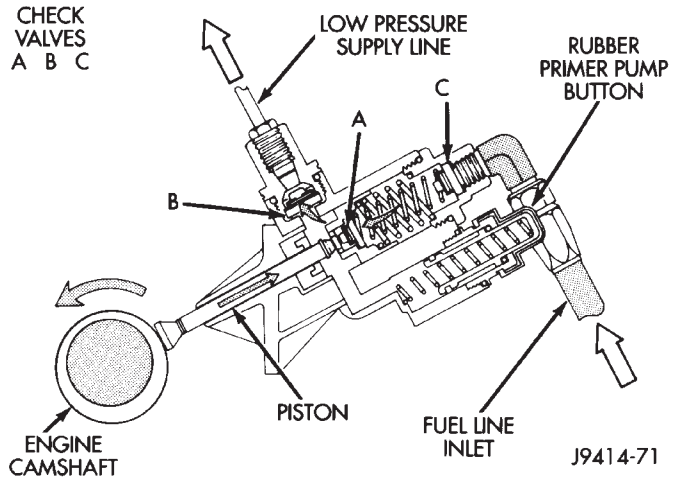


Fig. 5 Transfer Pump Operation—Typical Pump

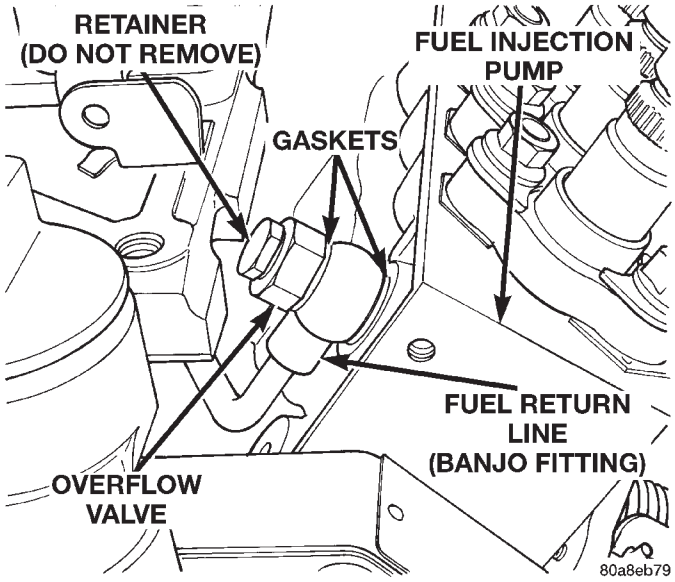


Fig. 6 Injection Pump Overflow Valve

The transfer pump has a primer button (Fig. 5). This rubber primer button is located on the pump housing. The purpose of the button is to prime and bleed air from the fuel system if the vehicle has run out of fuel. Refer to the Air Bleed Procedure in this section of the group for more information.

DESCRIPTION AND OPERATION (Continued)

OVERFLOW VALVE

Fuel volume from the fuel transfer pump will vary with engine rpm, but will always provide more fuel than the fuel injection pump requires. The overflow valve (pressure relief valve) is used to route excess fuel through the fuel return line and back to the fuel tank. The valve is located on the side of the injection pump (Fig. 6). The valve opens at approximately 152 kPa (22 psi). If the check valve within the assembly is sticking, low engine power may result. Refer to Fuel Transfer Pump for additional information.

FUEL TANK

The fuel tank is similar to the tank used with gasoline powered models. The tank is equipped with a separate fuel return line and a different fuel tank module for diesel powered models. A fuel tank mounted, electric fuel pump is not used with diesel powered models. Refer to Fuel Tank Module for additional information.

ROLLOVER VALVE(S)

Refer to Group 25, Emission Control System for information.

FUEL FILTER/WATER SEPARATOR

The fuel filter/water separator protects the fuel injection pump by removing water and contaminants from the fuel. The construction of the filter/separator allows fuel to pass through it, but helps prevent moisture (water) from doing so. Moisture collects at the bottom of the canister.

The fuel filter/water separator assembly is located on left side of engine above starter motor (Fig. 1).

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

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

A Water-In-Fuel (WIF) sensor is attached to side of canister. Refer to Water-In-Fuel Sensor for additional information.

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 120,000 KPA (17,405 PSI). 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.

QUICK-CONNECT FITTINGS—DIESEL ENGINE

Refer to Quick-Connect Fittings in the Fuel Delivery System—Gasoline Powered Engine section for information. Also refer to the Fuel Tubes/Lines/Hoses and Clamps section.

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 120,000 kPa (17,405 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.

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 INJECTION PUMP

The fuel injection pump is a Bosch P7100 series in-line type (Fig. 7). The injection pump is driven by the engine camshaft. A gear on the end of the pump shaft meshes with the camshaft gear. The pump is timed to the engine. Fuel injection occurs near the end of the compression stroke for each cylinder.

The RQV-K governor (Fig. 7) has a pump timing feature. This will allow the pump shaft to be oriented in a position corresponding to top dead center (TDC) for the compression stroke of cylinder number one. Indexing the governor flyweight assembly to the shaft during assembly establishes pump timing.

As engine speed increases, the internal pump pressure increases. An air-fuel control (AFC) (Fig. 8) on the governor ensures that regulated fuel delivery is matched to intake manifold pressure (turbocharger boost) for emission control.

The mechanical fuel transfer pump delivers fuel under a low- pressure of approximately 172 Kpa (25 psi) to the injection pump through the fuel filter/water separator. The injection pump then supplies high-pressure fuel of approximately 120,000 kPa (17,400

DESCRIPTION AND OPERATION (Continued)

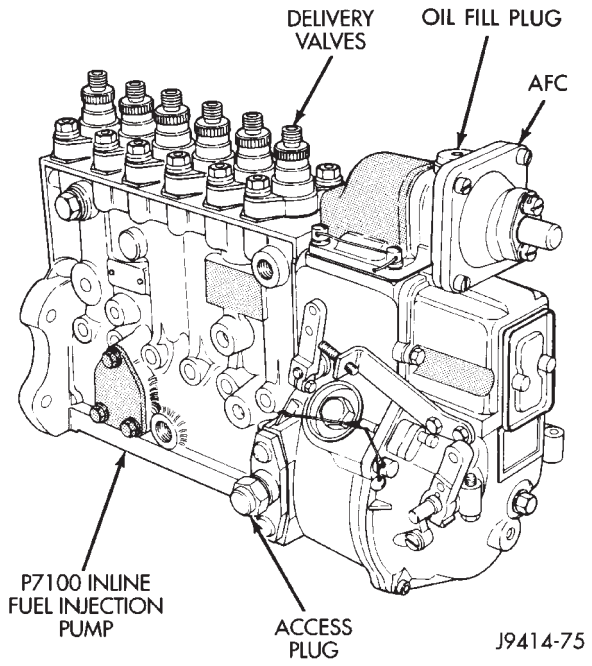


Fig. 7 Fuel Injection Pump

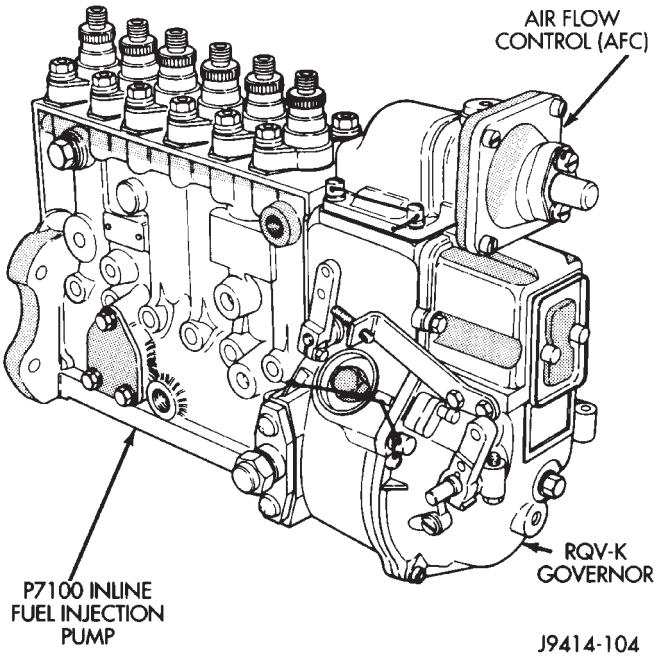


Fig. 8 Injection Pump Governor and AFC

psi) to each injector in precise metered amounts at the correct time.

Excess fuel is returned to the fuel tank by an overflow valve (Fig. 6) on the injection pump. This vent opens at approximately 152 kPa (22 psi) and returns fuel to the fuel tank through the fuel return line.

Diesel fuel and engine oil are used to cool the fuel injection pump. A separate oil feed line from the engine supplies engine oil to the pump. The oil returns to the engine through an opening at the front of pump.

A KSB (cold start) solenoid is not used.

The injection pump high idle speed is factory-sealed and is not adjustable. The low idle speed is adjustable. Refer to Idle Speed Adjustment.

For injection pump timing, refer to Fuel Injection Pump Timing.

FUEL INJECTORS

The fuel injectors are mounted on the left side of the cylinder head (Fig. 9). The injectors are connected to the fuel injection pump by the high-pressure fuel lines. A separate injector is used for each cylinder.

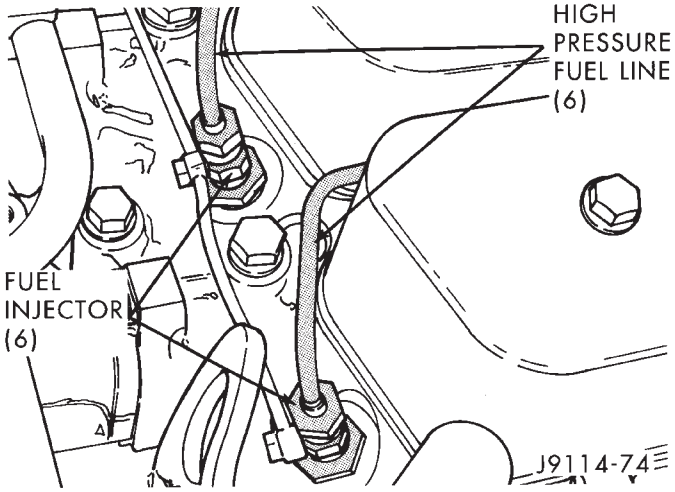


Fig. 9 Fuel Injectors—Typical

The injectors consist of the nozzle holder, o-ring water seal, shims, spring, needle valve and nozzle. 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 26,252 kPa (3,822 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 operating pressure setting. This is sometimes referred to as the “pop” 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.

FUEL SHUTDOWN SOLENOID

The fuel shutdown solenoid and fuel shutdown solenoid relay are not controlled by the powertrain control module (PCM).

DESCRIPTION AND OPERATION (Continued)

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 side of the pump (Fig. 10) and is connected to the pump with a lever.

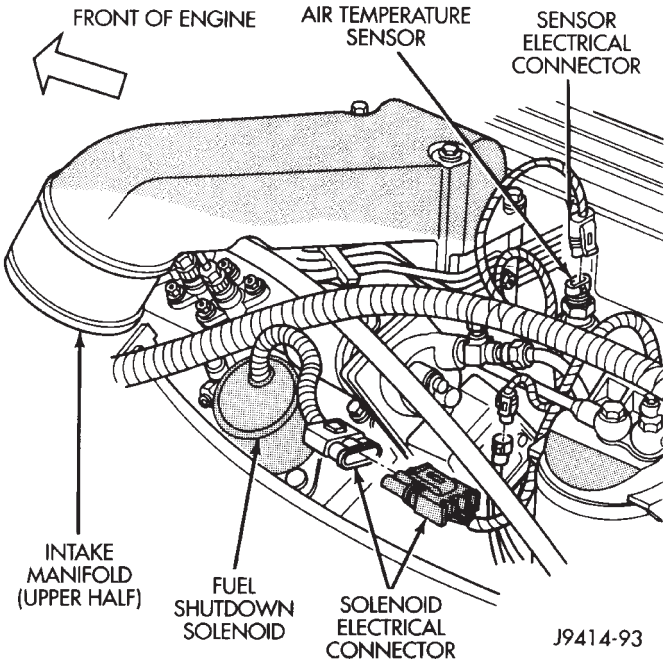


Fig. 10 Fuel Shutdown Solenoid Location

The solenoid controls starting and stopping of the engine regardless of the position of the accelerator pedal. When the ignition switch is off, the solenoid plunger is spring loaded (down) in the shutdown position (Fig. 11) and fuel is shut off to the injection pump.

Two different coils are located within the solenoid and a three-wire pigtail wire harness is attached to the solenoid.

When the ignition switch is turned to the CRANK (starter engaged) position, high-amperage current (approximately 40 amps at 12 volts) is supplied to one of the coils in the shutdown solenoid from the fuel shutdown solenoid relay. This high-amperage current allows the solenoid shaft to pull up on the injection pump lever. The injection pump shutdown lever is then positioned to the run position (Fig. 11).

When the ignition key is released to the ON position, a low-amperage current is supplied to the other coil in the solenoid. This is used to hold the solenoid shaft in the up position. Accelerator pedal position then controls fuel lever position for fuel control at the injection pump.

Voltage to operate the solenoid is supplied from the ignition switch and through the fuel shutdown solenoid relay. Also refer to Fuel Shutdown Solenoid Relay.

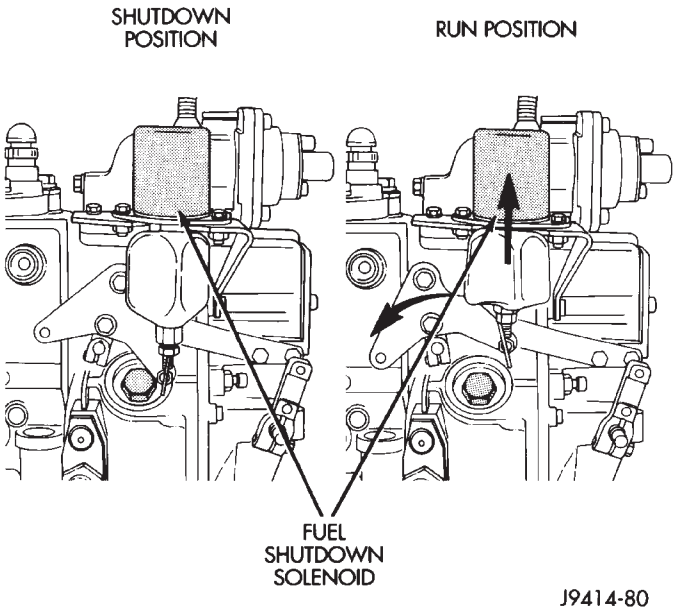


Fig. 11 Fuel Shutdown Solenoid Positions

If the shutdown solenoid is being replaced, its shaft length must be adjusted. For fuel shutdown solenoid removal, installation and solenoid shaft adjustment procedures, refer to Fuel Shutdown Solenoid in the Removal/Installation section of this group.

FUEL SHUTDOWN SOLENOID RELAY

Voltage to operate the fuel shutdown (shut-off) solenoid is supplied from the ignition switch and through the fuel shutdown solenoid relay. The Powertrain Control Module (PCM) has no control over the solenoid. The fuel shutdown solenoid relay is located in the engine compartment near the brake master cylinder (Fig. 12).

FUEL DRAIN MANIFOLD

Some fuel is continually vented from the fuel injection pump to cool the pump and the fuel injectors. 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 manifold (Fig. 13). Fuel in the drain manifold is then routed back to the fuel filter/water separator.

DIAGNOSIS AND TESTING

LOW-PRESSURE FUEL SYSTEM DIAGNOSIS

The Bosch P7100 inline fuel injection pump is very sensitive to fuel supply pressure variations. If this pressure is low or pulsating excessively, it may cause:

- Low rpm miss/instability
- White smoke

DIAGNOSIS AND TESTING (Continued)

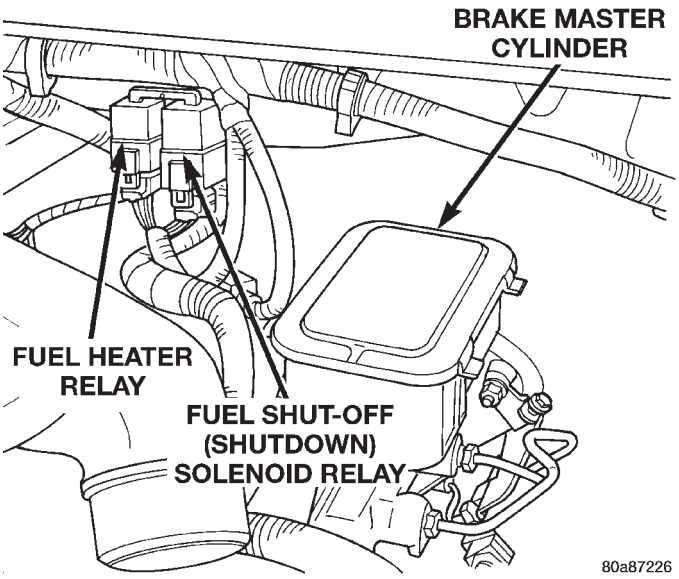


Fig. 12 Fuel Shutdown (Shut-Off) Solenoid Location

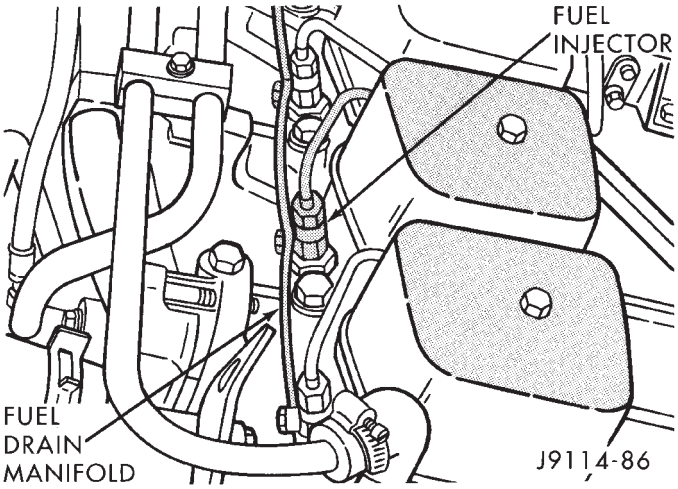


Fig. 13 Fuel Drain Manifold—Typical

- Hard starting
- Engine dies at idle (especially when hot)
- Low power
- Fuel filter cracking (caused by high pressure spikes with restricted overflow valve or fuel return line)

If the preceding symptoms/conditions exist:

(1) Check fuel shutoff solenoid adjustment. Improper adjustment could affect fuel delivery in the injection pump. Refer to Fuel Shutdown (Shutoff) Solenoid Removal/Installation for adjustment procedures.

(2) Visibly check the fuel supply line and fuel return line for kinks, bends or any other damage that would restrict fuel flow.

(3) In addition to contaminants or air, restrictions in the fuel supply to the injection pump caused by a clogged or dirty fuel filter can cause problems. A restricted pre-filter screen within the fuel heater may also have the same results. Refer to Group 0, Lubrication and Maintenance at the front of this manual for recommended filter replacement intervals in time or mileage. Be sure to clean the pre-filter each time the fuel filter is replaced. Refer to Fuel Heater Removal/Installation for pre-filter service procedures.

(4) Check fuel transfer (lift) pump supply pressure to the injection pump. Refer to the Fuel Transfer Pump Pressure/Capacity Test.

(a) Normal pressures are 17–22 psi at idle and 25–30 psi at rated rpm (2500 rpm) with no load.

(b) If supply pressure is low, restrict the fuel return line (pinch off fuel return hose). If pressure returns back to normal or above, the overflow valve must be replaced. Refer to the Fuel Transfer Pump Pressure/Capacity Test.

(c) If fuel supply pressure remains low with the fuel return line pinched, the fuel transfer pump must be replaced. Refer to the Fuel Transfer Pump Pressure/Capacity Test.

(d) High pressure at idle speed indicates a restriction. **Make sure the overflow valve has been installed at the fuel return line (pump outlet) and not at the fuel supply line (pump inlet).**

(e) Fuel pressure must be checked after each corrective action. Other possible causes can be found in the Service Diagnosis, Diesel Performance section of Group 9, Engines.

Whenever the fuel injection pump is being replaced or removed for calibration, the overflow valve must stay with the pump. Make sure a new overflow valve is used with a new injection pump and the old (original) overflow valve is returned to the authorized repair facility with the old injection pump.

AIR IN FUEL SYSTEM

Air will enter the fuel system whenever fuel supply lines, separator filters, injection pump, high-pressure lines or injectors are removed or disconnected. 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 transfer pump 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 transfer pump. Inspect the fuel tank and fuel lines for damage that might allow air into the system.

For air bleeding, refer to the Air Bleed Procedure.

DIAGNOSIS AND TESTING (Continued)

FUEL SUPPLY RESTRICTIONS

LOW-PRESSURE LINES

Fuel supply line restrictions or a defective fuel transfer pump 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. Also refer to the Fuel Transfer Pump Pressure Test section of this group for restriction tests.

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 TRANSFER PUMP PRESSURE/CAPACITY TEST

For operation of the fuel transfer pump (lift pump) primer button, refer to the Air Bleed Procedure in this group.

The fuel transfer pump is located on the left side of the engine and above the starter motor (Fig. 14).

An improperly operating fuel transfer pump can cause low engine power, excessive white smoke and/or hard engine starting.

Before performing pump pressure testing, inspect the fuel supply and return lines for restrictions, kinks or leaks.

Fuel leaking from the weep hole in the pump casing indicates a leaking pump. The transfer pump must then be replaced.

Low transfer pump output can be caused by a worn eccentric (cam lobe) on the engine camshaft.

In addition to contaminants or air, restrictions in the fuel supply to the injection pump caused by a clogged or dirty fuel filter can cause problems. This may be: low power, poor starting or excessive white smoke. A restricted pre-filter screen within the fuel

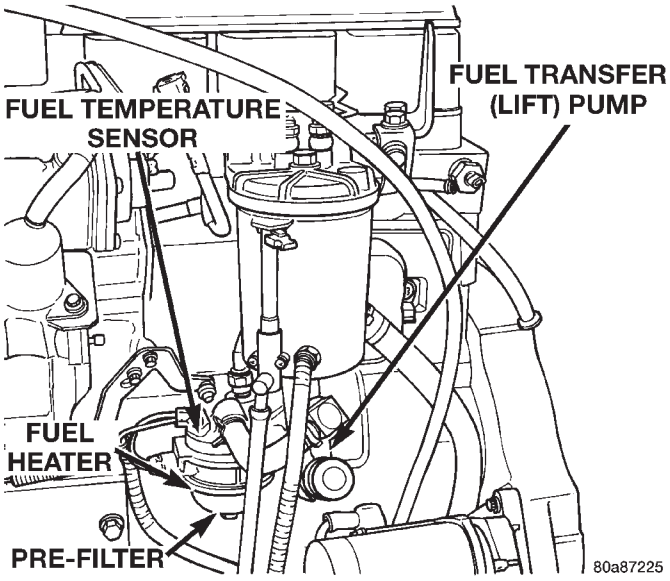


Fig. 14 Fuel Transfer Pump Location

heater may also have the same results. Refer to Group 0, Lubrication and Maintenance at the front of this manual for recommended filter replacement intervals in time or mileage. Be sure to clean the pre-filter each time the fuel filter is replaced. Refer to Fuel Heater Removal/Installation for pre-filter service procedures.

OUTPUT PRESSURE TEST

(1) Place a drain pan below injection pump.

(2) Remove banjo bolt and gaskets from fuel inlet line fitting at side of injection pump (Fig. 15).

(3) Install Special Tool 6976 and tool gaskets from tool kit 6977 in place of the banjo bolt (Fig. 16). Tighten tool into injection pump.

(4) Install a 0-60 or 0-100 psi fuel pressure gauge to adapter tool 6976 (Fig. 16).

(5) Start and warm engine and record fuel pressure. Pressure should be 117–152 kPa (17–22 psi) at idle speed. Pressure of 172–207 kPa (25–30 psi) should be seen after raising engine speed to its rated rpm (2,500 rpm) with no load.

(6) If fuel pressure falls below specifications, do not automatically condemn the transfer pump. The fuel filter or pre-filter may be dirty or clogged. If either of the filters are at fault, the pressure reading will rise after servicing. Recheck fuel pressure after servicing filters.

(7) If pressure is still low, the **overflow valve** (pressure relief valve) (Fig. 17) may be defective. To determine if the overflow valve is causing the low pressure condition:

(a) Locate and disconnect fuel return line quick-connect fitting at left-rear of engine (Fig. 18).

DIAGNOSIS AND TESTING (Continued)

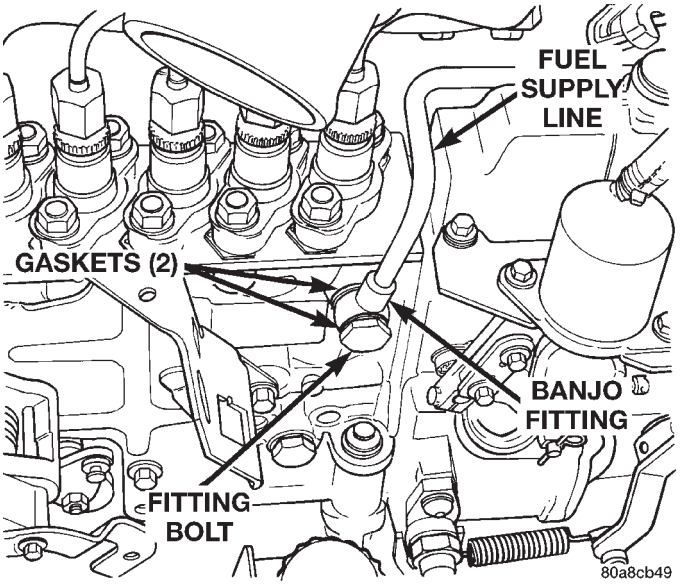


Fig. 15 Fuel Inlet Line at Injection Pump

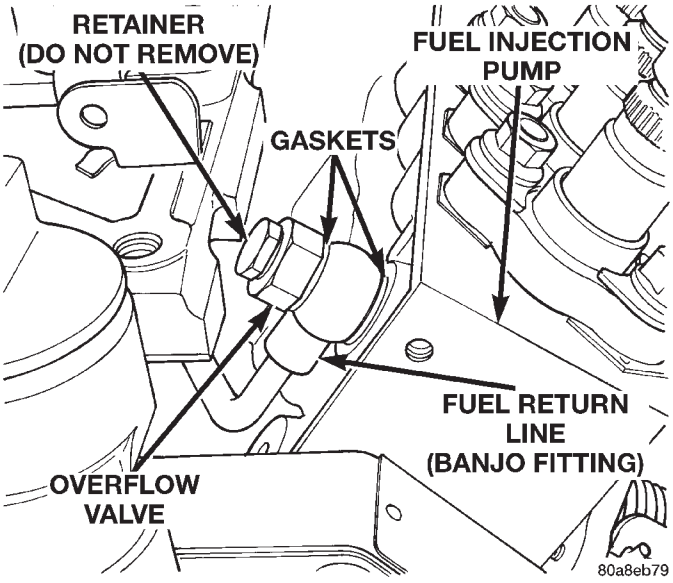


Fig. 17 Overflow Valve Location

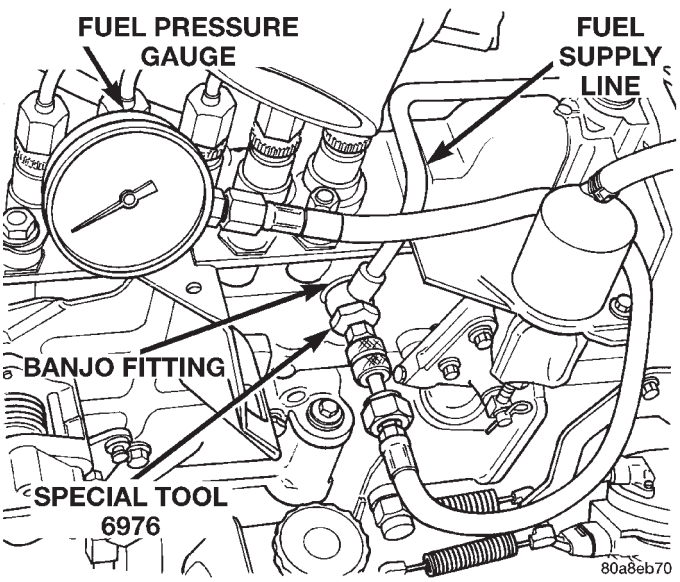


Fig. 16 Checking Fuel Pump Pressure

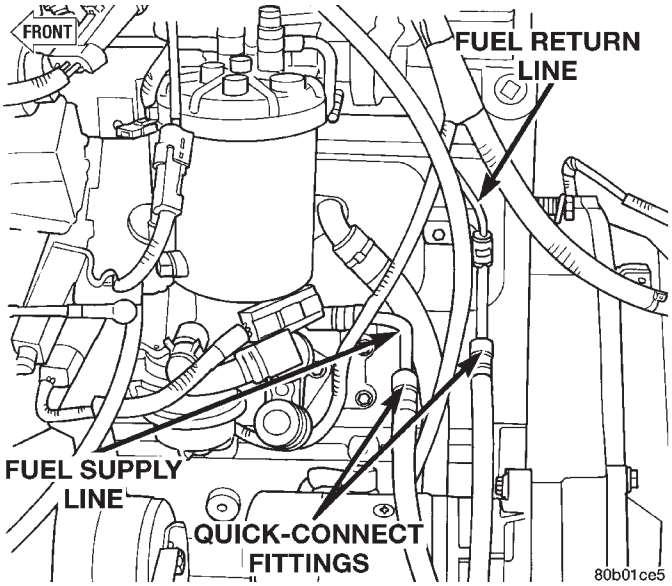


Fig. 18 Fuel Return and Supply Line Quick-Connect Locations

(b) Install Special Rubber Adapter Hose Tool 6539 into ends of disconnected fuel return line (Fig. 19).

(c) Using smooth-jaw pliers, carefully pinch off rubber hose portion of tool 6539 (Fig. 19). **Tool 6539 MUST be installed for this test. Do not attempt to directly pinch off rubber portion of fuel return line. Although outside of fuel return line is rubber, the inside is not. Damage to fuel return line will result in possible fuel leak.**

(d) If pressure goes back up to normal or above, the overflow valve must be replaced. Before condemning the valve, make sure it is located (has been installed) at the fuel return line (pump outlet) and **not** at the fuel supply line (pump inlet).

(e) If pressure remains low with return line pinched, the fuel filter or pre-filter may be restricted or the fuel transfer pump may be defective.

(f) If filters are in good condition and pressure is still low, replace the fuel transfer pump.

(8) After testing, install banjo fitting bolt into fuel supply line and tighten to 24 N·m (18 ft. lbs.) torque.

FUEL VOLUME TEST

Fuel volume-versus-engine cranking rpm are used for the test.

DIAGNOSIS AND TESTING (Continued)

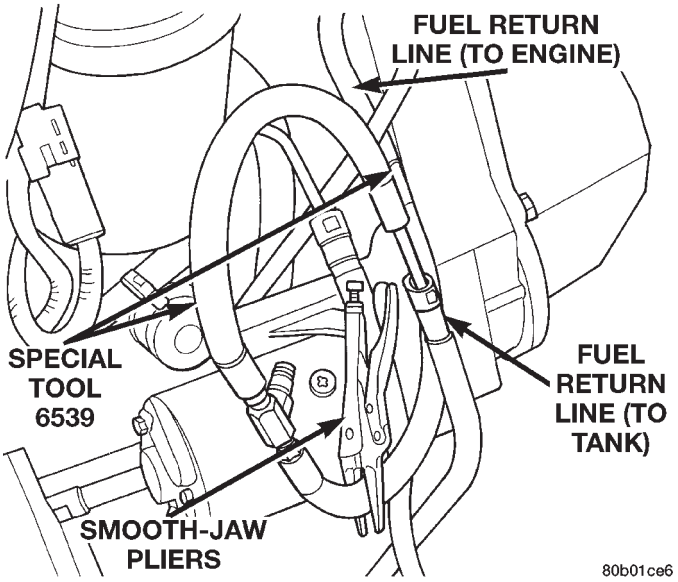


Fig. 19 Pinching Off Fuel Return Hose

WARNING: TO PREVENT THE ENGINE FROM STARTING, DISCONNECT THE PIGTAIL HARNESS AT THE FUEL SHUTDOWN SOLENOID (Fig. 20). USE CAUTION AS RESIDUAL FUEL MAY CAUSE THE ENGINE TO START AND RUN TEMPORARILY. ATTEMPT TO START THE ENGINE A FEW TIMES UNTIL IT QUITS BEFORE PERFORMING THE FUEL VOLUME TEST.

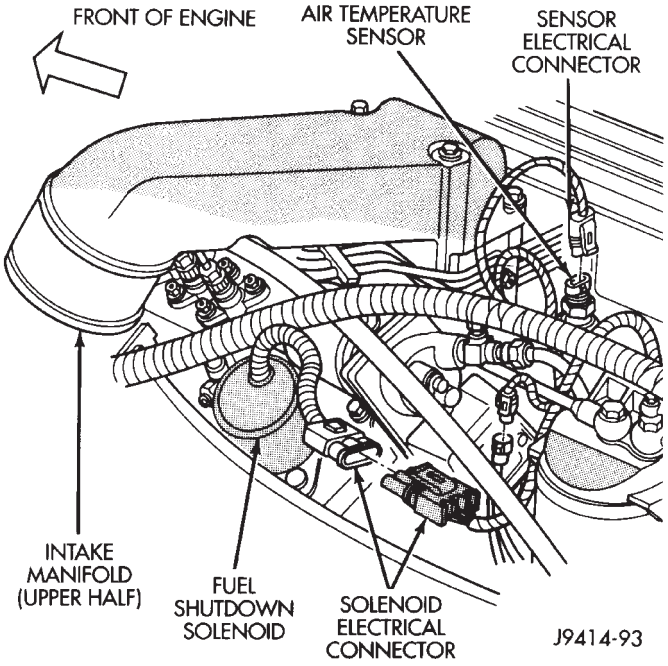


Fig. 20 Fuel Shutdown Solenoid Electrical Connector

(1) Connect a hand held tachometer to the engine. Use Cummins part number 3377462 or an equivalent.

(2) Remove the clamp bolt retaining fuel drain manifold line to cylinder head. This clamp/bolt is located to the left of number–5 cylinder valve cover.

(3) Two fuel lines are attached to top of fuel filter/water separator using banjo fittings and special bolts. Remove the **rear** banjo fitting bolt at the inlet line.

(4) Carefully position the fuel drain manifold line to the side/rear.

(5) Install and tighten Special Adapter Tool 6836 into the top of the fuel inlet line (Fig. 21).

(6) Connect a temporary rubber fuel hose to adapter 6836 (Fig. 21).

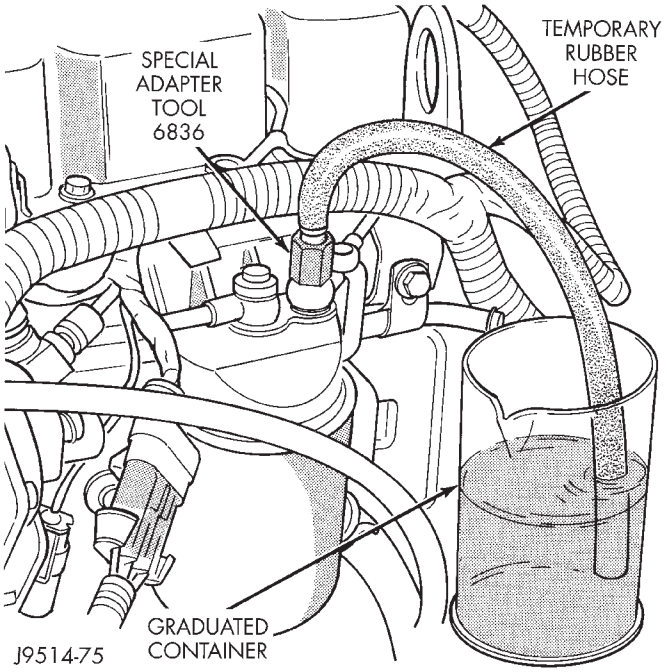


Fig. 21 Performing Fuel Volume Test—Typical

(7) Place the other end of this temporary hose into a graduated container (Fig. 21).

(8) Crank the engine for 30 seconds. Measure the fuel volume in the container after 30 seconds of engine cranking time. **Do not crank the engine for more than 30 seconds at a time. Starter motor damage may result.**

(9) To determine the correct fuel volume, refer to Fuel Volume Specifications (Fig. 22). To use the specifications chart, refer to the following procedure:

- Draw a straight vertical line at the measured rpm.
- Draw a straight horizontal line at the measured fuel volume.
- If these two lines intersect below the flow line (Fig. 22), this indicates a defective fuel transfer pump, a restricted fuel line, or a plugged fuel filter or pre-filter.
- If these two lines intersect above the flow line (Fig. 22), this indicates acceptable fuel flow.

DIAGNOSIS AND TESTING (Continued)

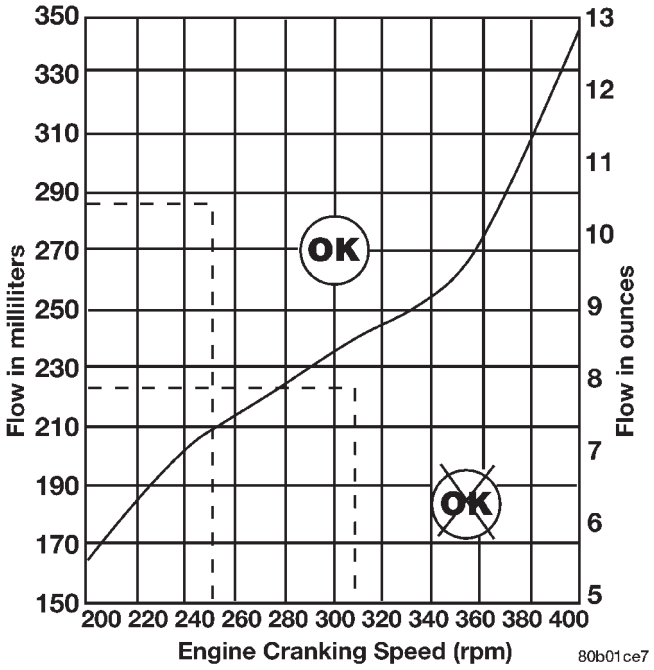


Fig. 22 Fuel Volume Specifications

OVERFLOW VALVE TEST

A sticking check valve within the overflow valve may cause low power. Refer to the Fuel Transfer Pump Pressure/Capacity Test. Overflow valve testing is covered in this test.

Whenever the fuel injection pump is being replaced or removed for calibration, the overflow valve must stay with the pump. Make sure a new overflow valve is used with a new or rebuilt injection pump and the old (original) overflow valve is returned to authorized repair facility with the old injection pump.

Make sure the overflow valve is correctly installed at the fuel return line (pump outlet) (Fig. 17) and not incorrectly installed at the fuel supply line (pump inlet).

FUEL HEATER TEST

The fuel heater is used to prevent diesel fuel from waxing during cold weather operation.

NOTE: The fuel heater element, fuel heater relay and fuel heater temperature sensor are not controlled by the powertrain control module (PCM).

A malfunctioning fuel heater can cause a wax build-up in the fuel filter/water separator. Wax build-up in the filter/separator can cause engine starting problems and prevent the engine from revving up. It can also cause blue or white fog-like exhaust. If the heater is not operating in cold temperatures, the engine may not operate due to fuel waxing.

The fuel heater is located on the left side of the engine above the starter motor (Fig. 23).

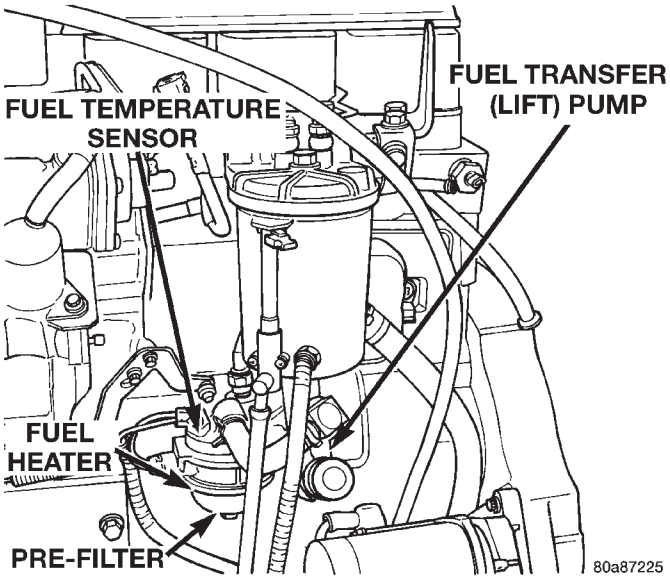


Fig. 23 Fuel Heater Location

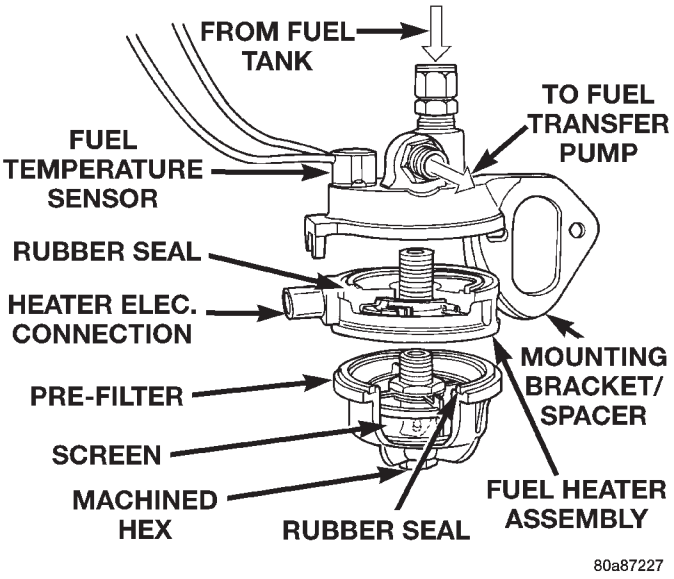


Fig. 24 Fuel Heater Assembly

The heater assembly is equipped with a built-in fuel temperature sensor (thermostat) (Fig. 24) or (Fig. 23) that senses fuel temperature. When the fuel temperature is below 40 degrees F, the sensor allows current to flow to the built-in heater element to warm the fuel. When the fuel temperature is above 80 degrees F, the sensor stops current flow to the heater element (circuit is open).

Voltage to operate the fuel heater element is supplied from the ignition switch, through the fuel heater relay (Fig. 25) (also refer to Fuel Heater Relay), to the fuel temperature sensor and on to the fuel heater element.

DIAGNOSIS AND TESTING (Continued)

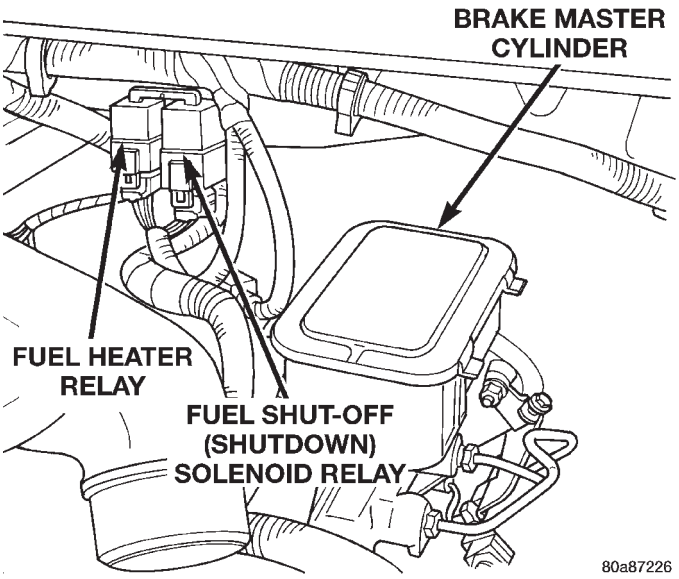


Fig. 25 Fuel Heater Relay Location—Diesel

The built-in heater element operates on 12 volts, 300 watts at 0 degrees F. As temperature increases, power requirements decrease.

The fuel heater assembly contains a pre-filter (Fig. 24) to prevent contaminants from entering the fuel transfer pump.

A minimum of 7 volts is required to operate the fuel heater. The resistance value of the heater element is less than 1 ohm (cold) and up to 1000 ohms warm.

TESTING

(1) Remove the electrical connector at the side of the fuel heater (Fig. 24).

(2) Using an ohmmeter, check the resistance across the two terminals on the side of the heater. Resistance should be approximately 1 ohm (cold) to 1000 ohms (warm).

(3) With the electrical connector still unplugged from the fuel heater, check the electrical operation of the fuel temperature sensor (Fig. 24). Proceed to next step:

(4) Using an ohmmeter, check the resistance across the two terminals in the pigtail wire harness coming from the fuel temperature sensor. The sensor circuit should be open if the fuel temperature is above 80 degrees. The sensor circuit should be closed if the fuel temperature is below 40 degrees.

(5) Check for 12 volts at the disconnected temperature sensor connector with the ignition key ON. Refer to Group 8W, Wiring for electrical schematics.

(6) With ignition ON, check for 12 volts at the fuel heater relay connector. Refer to Group 8W, Wiring for electrical schematics.

(7) Check operation of the fuel heater relay (Fig. 25). Refer to Relay Test—Fuel Heater/Fuel Shutdown Solenoid in this section of the group.

RELAY TEST—FUEL HEATER/FUEL SHUTDOWN SOLENOID

The fuel heater and fuel shutdown solenoid relays are located in the engine compartment near the brake master cylinder (Fig. 25).

To test the fuel heater, refer to Fuel Heater Test in this section of the group. To test the fuel shutdown solenoid, refer to Fuel Shutdown Solenoid Test.

To test either of the relays only, refer to following:

The relay terminal numbers from (Fig. 26) can be found on the bottom of the relay.

- Terminal number 30 is connected to battery voltage and can be switched or B+ (hot) at all times.
- The center terminal number 87A is connected (a circuit is formed) to terminal 30 in the de-energized (normally OFF) position.
- Terminal number 87 is connected (a circuit is formed) to terminal 30 in the energized (ON) position. Terminal number 87 then supplies battery voltage to the component being operated.
- Terminal number 86 is connected to a switched (+) power source.
- Terminal number 85 is grounded by the powertrain control module (PCM).

TESTING

(1) Remove relay before testing.

(2) Using an ohmmeter, perform a resistance test between terminals 85 and 86. Resistance value (ohms) should be 75 ±5 ohms for resistor equipped relays.

(3) Connect the ohmmeter between terminals number 87A and 30. Continuity should be present at this time.

(4) Connect the ohmmeter between terminals number 87 and 30. Continuity should not be present at this time.

(5) Use a set of jumper wires (16 gauge or smaller). Connect one jumper wire between terminal number 85 (on the relay) to the ground side (-) of a 12 Volt power source.

(6) Attach the other jumper wire to the positive side (+) of a 12V power source. Do not connect this jumper wire to relay at this time.

CAUTION: Do not allow the ohmmeter to contact terminals 85 or 86 during these tests. Damage to ohmmeter may result.

(7) Attach the other jumper wire (12V +) to terminal number 86. This will activate the relay. Continuity should now be present between terminals number

DIAGNOSIS AND TESTING (Continued)

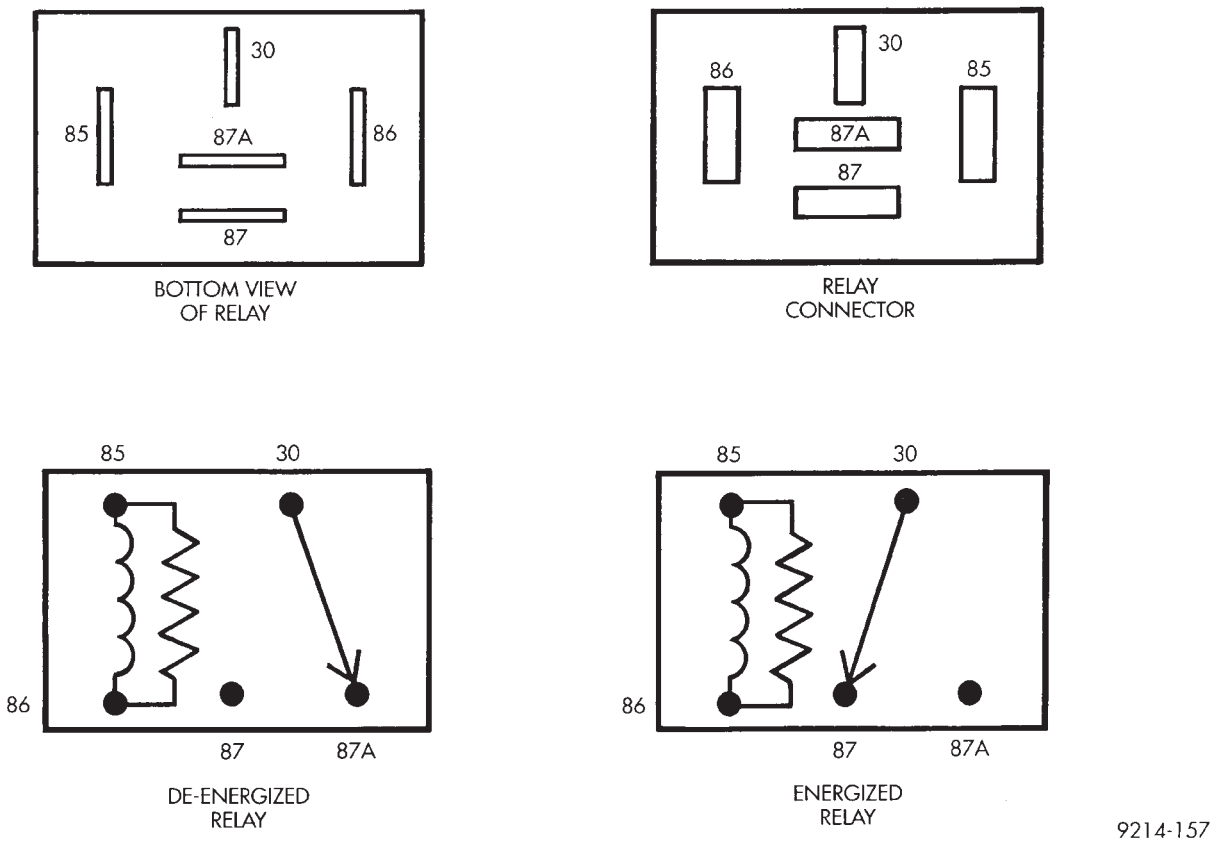


Fig. 26 Relay Terminals

87 and 30. Continuity should not be present between terminals number 87A and 30.

(8) Disconnect jumper wires from relay and 12 Volt power source.

(9) If continuity or resistance tests did not pass, replace relay. If tests passed, refer to Group 8W, Wiring Diagrams for (fuel system) relay wiring schematics and for additional circuit information.

FUEL INJECTOR TEST

A leaking fuel injector can cause fuel knock, poor performance, black smoke, poor fuel economy and rough engine idle. If the fuel injector needle valve does not operate properly, the engine may misfire and produce low power.

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 120,000 KPA (17,400 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. 27). Listen for a change in engine speed. After testing, tighten the line nut to 30 N·m (22 ft. lbs.) torque. If engine speed drops, the injector was operating normally. If engine speed remains the same, the injector may be malfunctioning. 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 Fuel Injectors in the Removal/Installation section of this group for procedures.

After the injector has been removed, install it to a bench-mount injector tester (Cummins part number 3376946 or equivalent) (Fig. 28). Position a container

DIAGNOSIS AND TESTING (Continued)

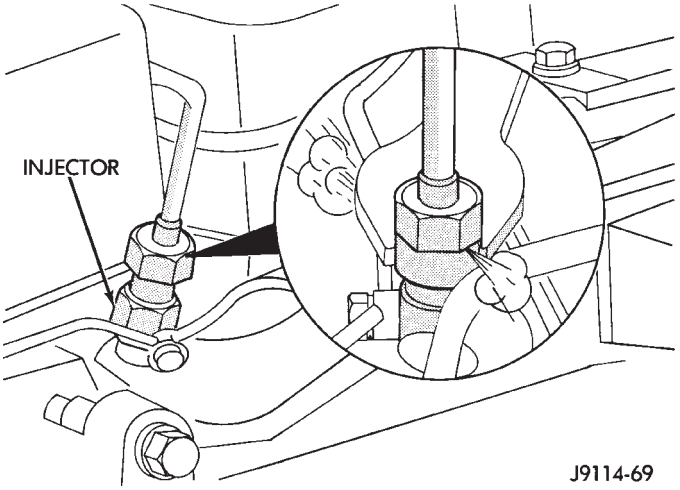


Fig. 27 Inspecting Injector Operation

below the injector before testing. Refer to operating instructions supplied with tester for procedures.

The opening pressure or "pop" pressure should be 23,400–26,800 kPa (234–268 bars) (3394–3887 psi). If the fuel injector needle valve is opening (popping) too early or too late, replace the injector.

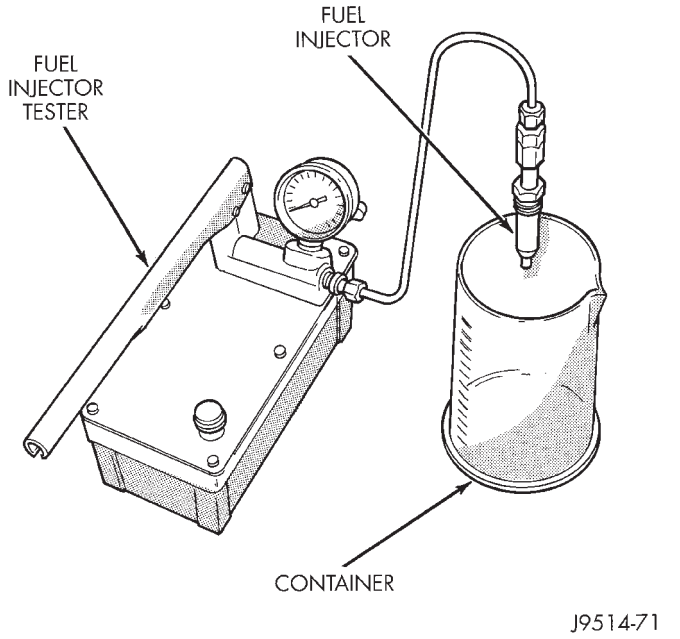


Fig. 28 Typical Fuel Injector Tester

FUEL INJECTION PUMP TEST

The Bosch P7100 inline fuel injection pump is very sensitive to fuel supply pressure variations. If supply pressure is low or pulsating excessively, it may cause problems that appear to be a defective injection pump. Before condemning the injection pump, be sure to check fuel transfer pump pressure. Refer to the Fuel Transfer Pump Pressure/Capacity Test. This test will include testing of the overflow valve. Also be sure fuel filter and pre-filter are in good condition. Visually check the fuel supply line and fuel return line for kinks, bends or any other damage that would restrict fuel flow.

Incorrect injection pump timing can cause poor performance, excessive smoke and emissions and poor fuel economy. Fuel injection pump timing can be checked and adjusted. Refer to Fuel Injection Pump Timing in this group for procedures.

Engine power is also effected by the governor setting and performance. **Do not attempt to adjust the governor. If the governor seals on the external adjustment screw are broken, the fuel rate may be out of adjustment. The warranty of the injection pump and the engine may be void if the seals have been tampered with or removed.**

If all of the preceding tests checked OK, the fuel injection pump must be removed and sent to an authorized diesel injection pump repair facility for testing and calibration. **Whenever the fuel injection pump is being replaced or removed for calibration, the overflow valve must stay with the pump. Make sure a new overflow valve is used with a new injection pump and the old (original) overflow valve is returned to the authorized repair facility with the old injection pump.**

Do not attempt to perform any disassembly of the injection pump. If disassembled, the warranty may be voided. The only serviceable components of the fuel injection pump are the fuel shutdown solenoid, overflow valve, breakover throttle lever, mounting o-ring, banjo washers and oil supply fittings.

FUEL SHUTDOWN SOLENOID TEST

NOTE: The fuel shutdown (shut-off) solenoid (Fig. 29) and fuel shutdown solenoid relay (Fig. 31) are not controlled by the powertrain control module (PCM).

(1) With the ignition switch off, the solenoid shaft should be down and the injection pump lever should be in the shutdown position (no fuel supply to injection pump) (Fig. 30).

(2) Turn the ignition switch to the CRANK (starter engage) position and observe the solenoid shaft and injection pump lever. The shaft should pull up (shaft retracted into the solenoid) and the pump lever should be in the run position (fuel being supplied to injection pump) (Fig. 30).

(3) Release the ignition key from the CRANK to the ON position. The shaft should remain in the up position and the pump lever should remain in the run position (fuel being supplied to injection pump) (Fig. 30). If the solenoid shaft is not moving, refer to the following:

DIAGNOSIS AND TESTING (Continued)

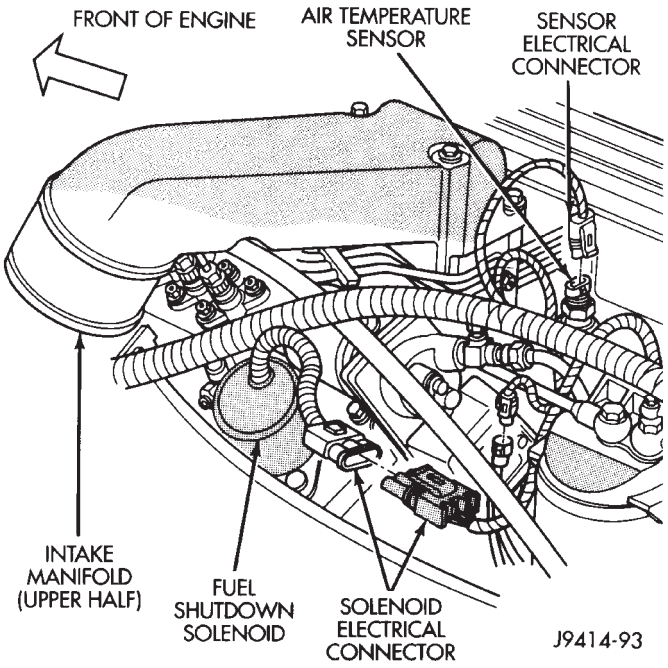


Fig. 29 Fuel Shutdown Solenoid Location

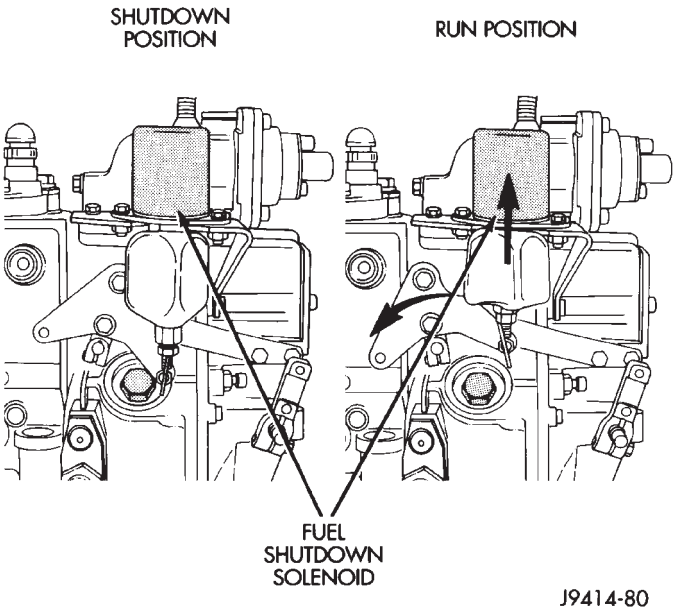


Fig. 30 Fuel Shutdown Solenoid Positions

(4) Disconnect the solenoid three-wire pigtail wire harness from the main engine harness.

(5) If the solenoid shaft did not move up when the ignition switch was in the CRANK position, check for 12 volts at the three-way connector. This will be the circuit coming from the fuel shutdown solenoid relay. Refer to Group 8W, for wire connector pin location and circuit identification. If 12 volts is not present at this circuit when the key is in the CRANK position, check the fuel shutdown solenoid relay. Refer to

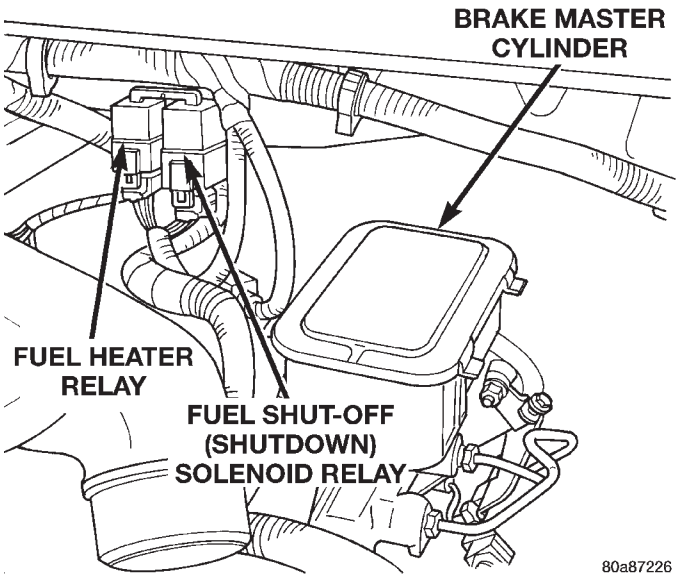


Fig. 31 Fuel Shutdown Solenoid Relay Location

Relay Test—Fuel Heater/Fuel Shutdown Solenoid in this section of the group. Also check the wiring between the relay and the solenoid.

(6) If the solenoid shaft moves up when the ignition switch is in the CRANK position, but moves down when the key is released from the CRANK to the ON position, check the circuit coming from the ignition switch for 12 volts. Refer to Group 8W, for wire connector pin location and circuit identification.

(7) If the shutdown solenoid is being replaced, its shaft length must be adjusted. Refer to Fuel Shutdown Solenoid Removal/Installation 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 120,000 kPa (17,400 PSI), USE EXTREME CAUTION WHEN INSPECTING FOR HIGH-PRESSURE FUEL LEAKS. DO NOT GET YOUR HAND 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. 32). 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.

DIAGNOSIS AND TESTING (Continued)

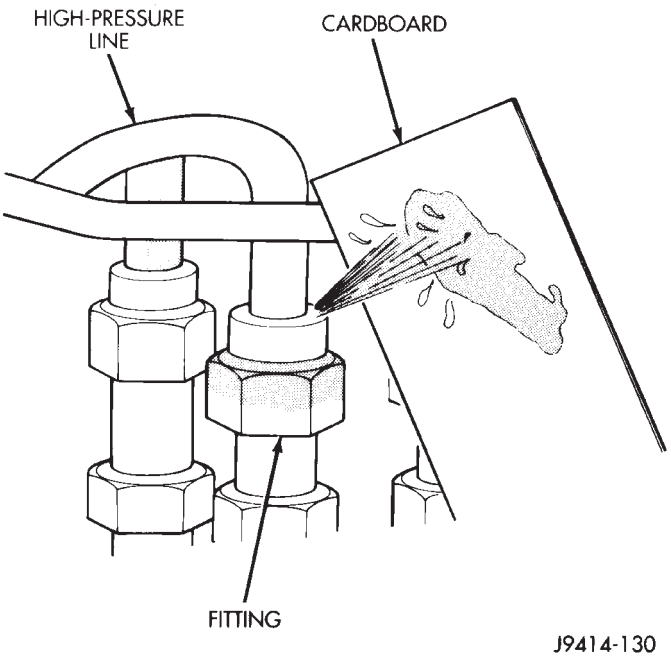


Fig. 32 Typical Test for Leaks with Cardboard

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.

IDLE SPEED ADJUSTMENT

The high idle stop screw is factory sealed and cannot be adjusted. Low-speed idle can be adjusted.

(1) Use an optical tachometer such as Snap-on No. MT139 or MTE (Cummins tool division) No. 3377462 to read the engine rpm.

(2) Bring the engine to normal operating temperature.

(3) Adjust the low idle speed at the low idle speed screw. The screw and locknut are located at the rear of the fuel injection pump (Fig. 33).

(4) Loosen the idle screw lock nut (Fig. 33). Adjust idle screw to obtain specified rpm. Refer to IDLE SPEEDS—DIESEL ENGINE chart.

(5) Tighten the locknut after adjustment.

SERVICE PROCEDURES

AIR BLEED PROCEDURE

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

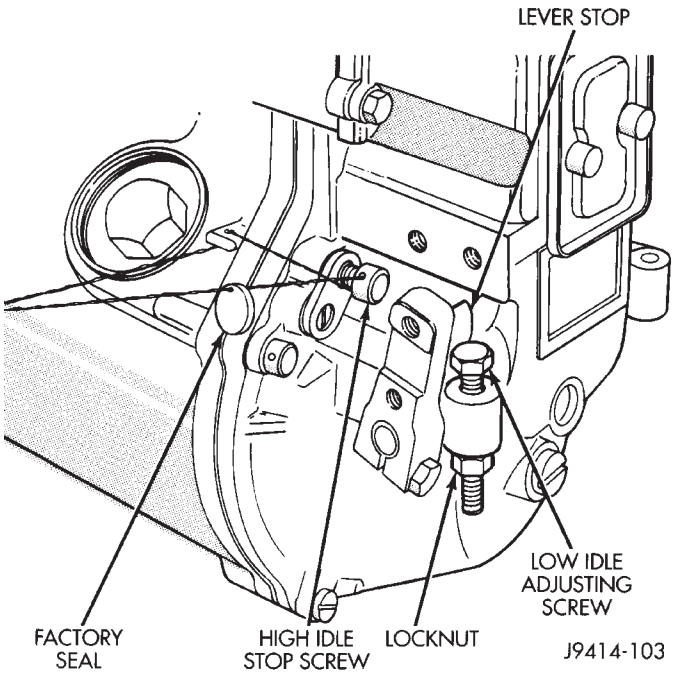


Fig. 33 Low Idle Speed Screw

IDLE SPEEDS—DIESEL ENGINE

LOW IDLE SPEED	HIGH IDLE SPEED
With automatic transmission: * 750-800 RPM with transmission in drive and air conditioning on.	Do not attempt to adjust high idle speed. High idle speed adjustment screw is factory sealed. Breaking seal will void injection pump warranty
With manual transmission: * 780 RPM with transmission in nuetral and air conditioning on.	
* With engine at operating temperature. Refer to text for idle adjustment 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.

MANUAL BLEEDING

Some air enters the fuel system when the filters or injection pump supply line are changed. This small amount of air is vented automatically from the injection pump through the fuel drain manifold. This is if the filter was changed according to instructions.

The system may have to be bled manually if:

- The vehicle fuel tank has been allowed to run empty
- The fuel filter is not filled before installation
- The fuel 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.

(1) Loosen the low-pressure bleed bolt (Fig. 34).

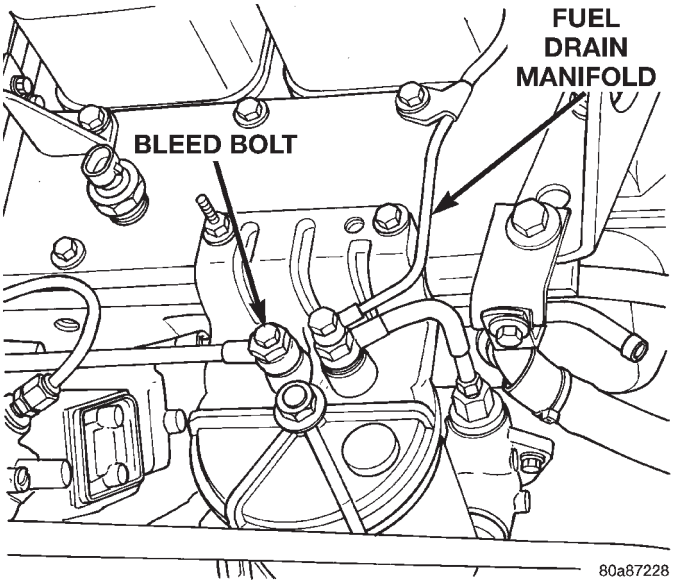


Fig. 34 Low-Pressure Bleed Bolt

(2) Operate the rubber push-button primer on the fuel transfer pump (Fig. 35). Do this until the fuel exiting the low-pressure bleed bolt is free of air.

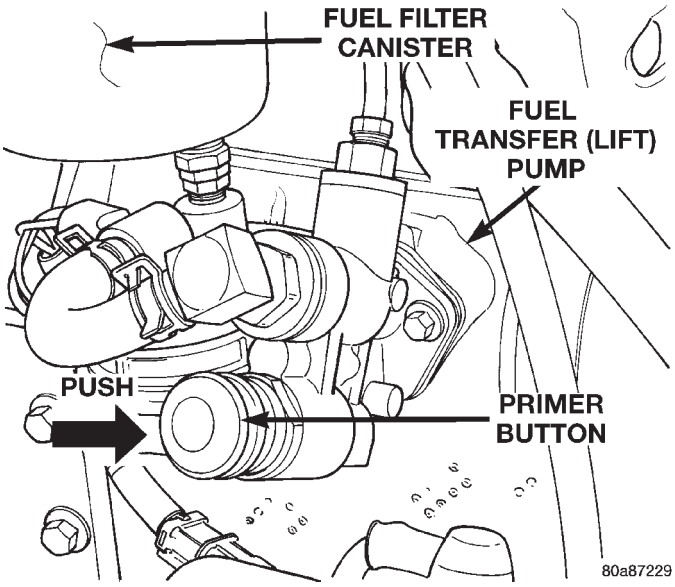


Fig. 35 Fuel Transfer Pump—Manual Operation

(3) Tighten low-pressure bleed screw to 8 N·m (6 ft. lbs.) torque.

FUEL INJECTION PUMP BLEEDING

WARNING: THE ENGINE MAY START WHEN CRANKING TO BLEED AIR FROM THE INJECTION PUMP. 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 two minutes between cranking intervals.

(1) Perform the previous procedure: Manual Bleeding.

(2) Crank the engine for 30 seconds at a time to allow air trapped in the injection pump to vent out the drain manifold. Observe the previous WARNING and CAUTION.

HIGH-PRESSURE FUEL LINE BLEEDING

WARNING: THE FUEL INJECTION PUMP SUPPLIES HIGH-PRESSURE FUEL OF AS HIGH AS 120,000 KPA (17,405 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. 36).

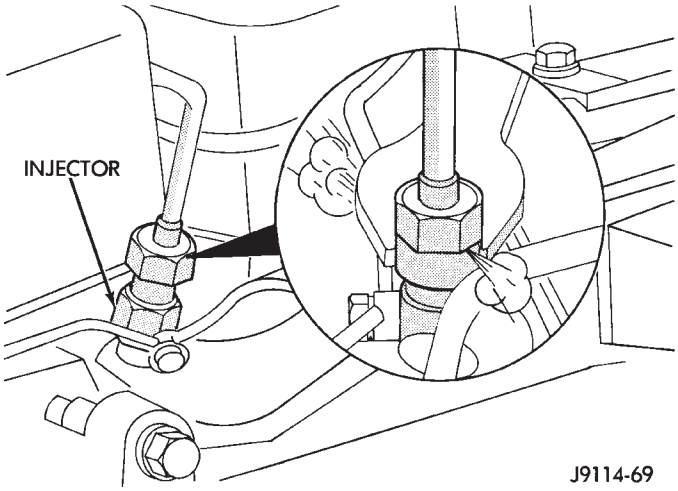


Fig. 36 Bleeding High-Pressure Fuel Lines

(2) Crank the engine until all air is bled from the line. **Do not operate the starter motor for longer**

SERVICE PROCEDURES (Continued)

than 30 seconds. Wait two minutes between cranking intervals.

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

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

FUEL INJECTION PUMP TIMING

(1) Thoroughly clean the engine and fuel system before attempting to remove any components. Pay special attention to the top of the fuel injection pump. Use compressed air to remove any water remaining on the fuel pump after the cleaning process.

CAUTION: DO NOT ALLOW ANY DIRT, DEBRIS, OR PAINT CHIPS TO ENTER THE FUEL SYSTEM WHILE IT IS OPEN. IF FOREIGN MATERIAL OF ANY TYPE IS ALLOWED INTO THE PUMP, LINES OR INJECTORS DURING THIS PROCESS IT COULD RESULT IN AN INJECTION PUMP OR FUEL INJECTOR MALFUNCTION.

NOTE: Locate top dead center (TDC) on cylinder #1.

(2) Remove the rubber access plug located in the rear flange of the engine on the exhaust manifold side. (Fig. 37).

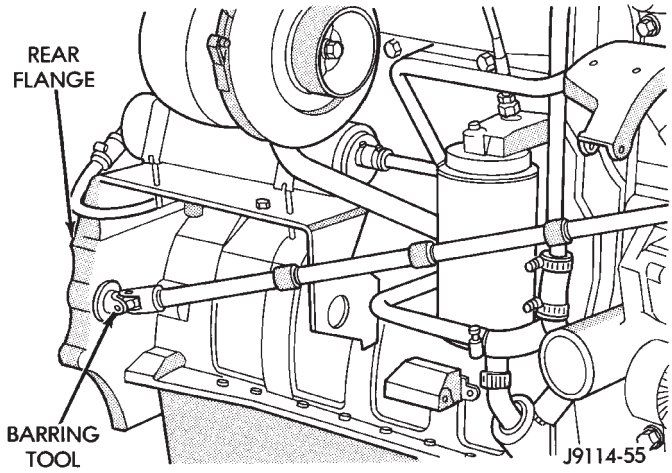


Fig. 37 Rotating Engine With Barring Tool

NOTE: Removing the #1 cylinder valve cover and first barring (rotating) the engine clockwise until both intake and exhaust valves are closed will speed up locating engine TDC as described later in step 4.

(3) Insert the barring tool number 7471B through the access hole and into the flywheel housing (Fig. 37).

(4) While holding tension on the timing pin (toward front of engine), slowly rotate the engine counterclockwise with the barring tool. Hold a slight rearward (pushing) pressure on the barring tool and continue to rotate the tool counterclockwise until the timing pin drops into the machined hole in the back of the camshaft gear. **When the barring tool is rotated counterclockwise, the vibration damper should be rotating clockwise as viewed from front.** When the pin aligns to the gear (Fig. 38), and the intake and exhaust valves are closed at the #1 cylinder, the engine is at the TDC position (compression stroke) at cylinder number 1. Place a paint mark on the dampener to indicate TDC. This mark is to be used as a reference point only and is not to be used for actual pump timing procedure. **Remove the pin. This will prevent damage when barring (rotating) the engine in later steps.**

NOTE: The pin is located above the power steering pump, below and to the inside of the fuel injection pump, on the rear of the cam gear housing (Fig. 39).

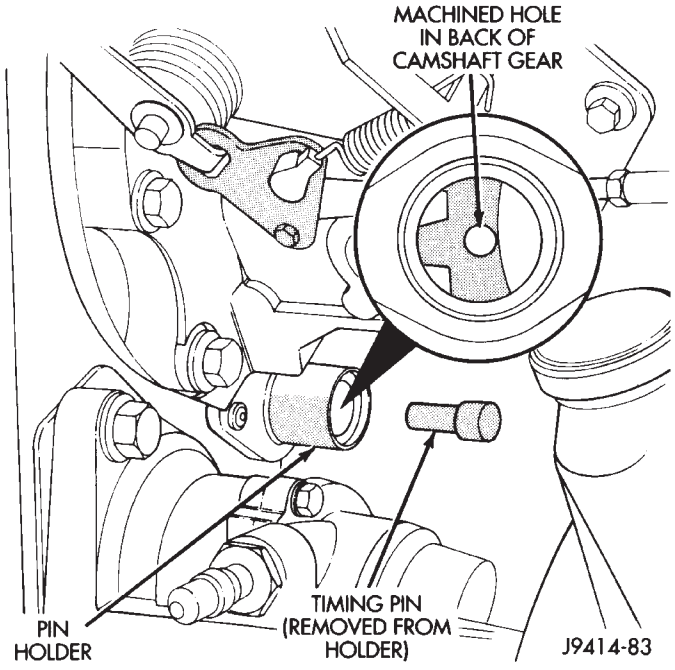


Fig. 38 Back of Camshaft Gear—Typical

(5) Remove #1 fuel injection line from the fuel pump (Fig. 40).

CAUTION: DO NOT BEND THE FUEL LINE. BENDING THE LINE WILL CAUSE LINE OR INJECTOR FAILURE.

(6) With the engine at TDC, loosen but do not remove, the front (#1) delivery valve holder using special socket #6840 (Fig. 41). Remove the socket

SERVICE PROCEDURES (Continued)

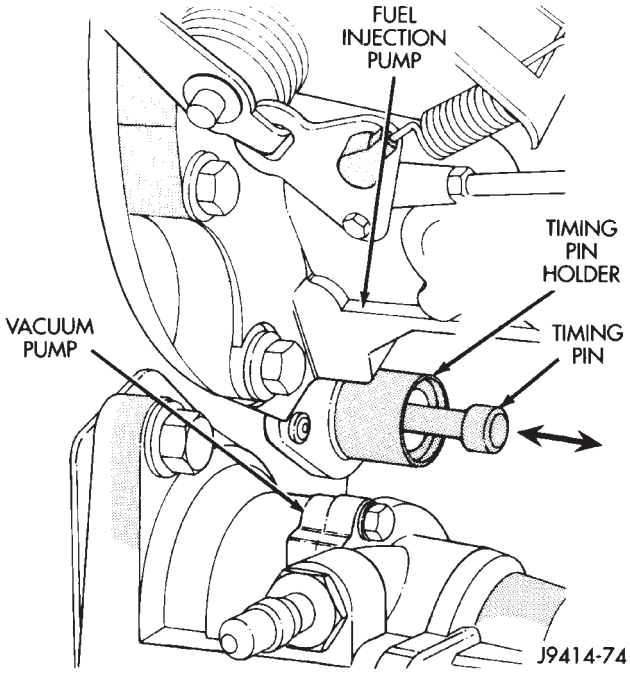


Fig. 39 Timing Pin and Location

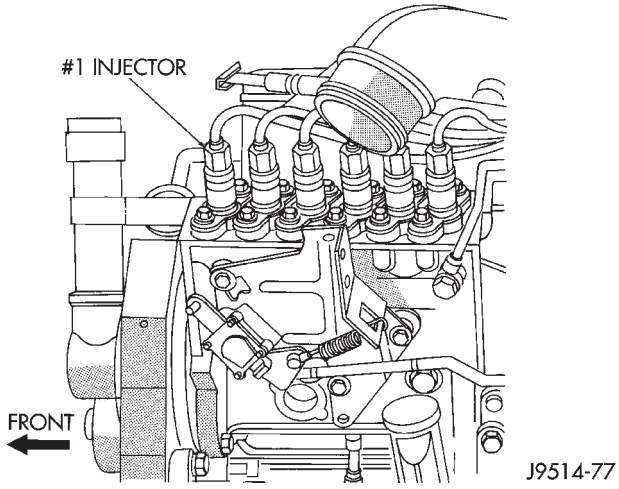


Fig. 40 Number 1 Injection Line

from the valve holder prior to removing the holder from the injection pump.

There is an external o-ring on the holder to help prevent debris from getting into the pump. This may create a slight resistance as the holder is unscrewed.

(7) Remove the delivery valve holder by carefully tipping the holder outboard with one hand while using the other hand to hold the spring, fill piece, and any shims from slipping out of the holder. Place these parts (Fig. 42) as an assembly on a clean surface.

(8) Using a magnet, remove the two piece delivery valve assembly from the pump (Fig. 43). Place these parts on a clean surface.

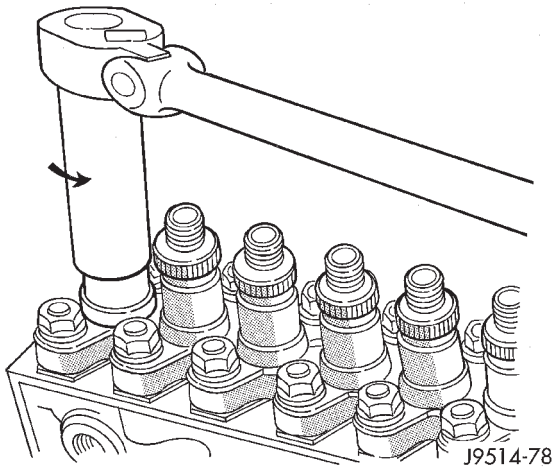


Fig. 41 Delivery Valve Holder Removal

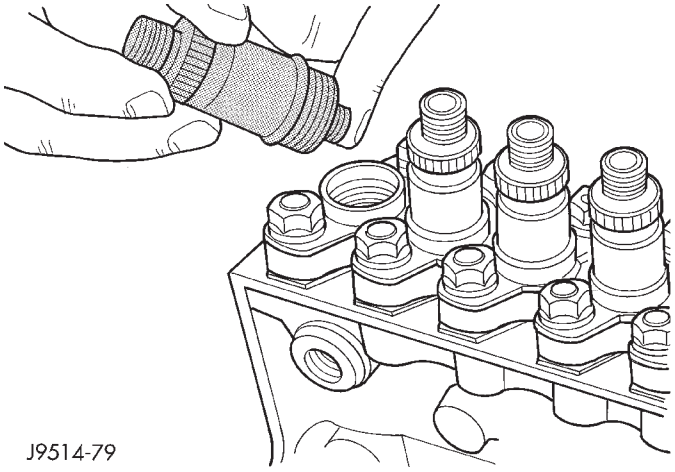


Fig. 42 Delivery Valve Holder

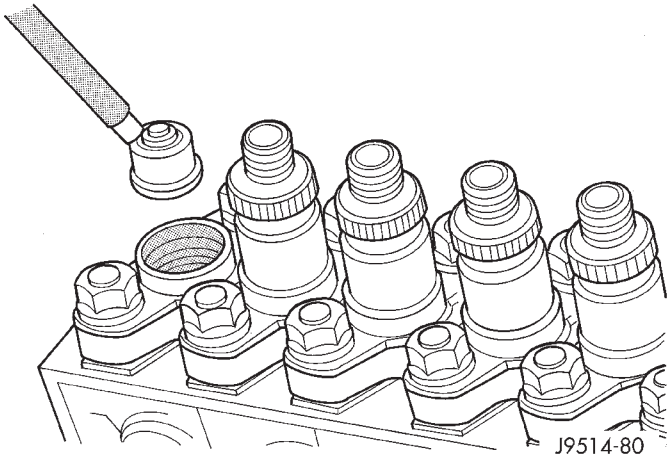


Fig. 43 Delivery Valve Assembly

(9) Install the dial indicator adaptor tool #6842 (Fig. 44) in place of the #1 delivery valve holder and tighten finger tight.

(10) Loosen the set screw on the dial indicator adaptor (Fig. 44). Install the dial indicator #6859 and dial indicator tip #6843 into the adapter. Position the

SERVICE PROCEDURES (Continued)

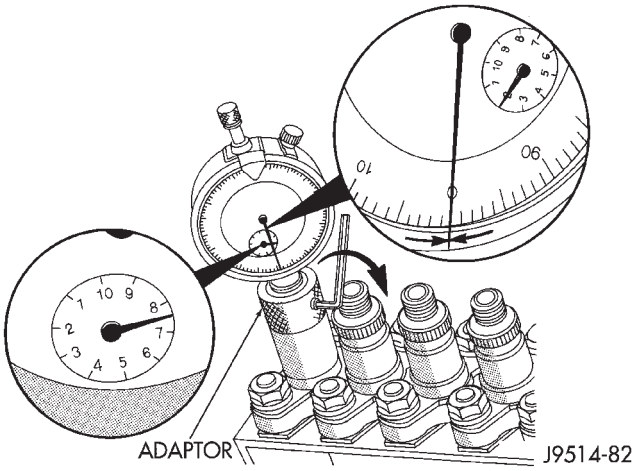


Fig. 44 Installing Special Adapter Tool

dial indicator to read between 7.0 and 9.0 mm and tighten the set screw (Fig. 44). The dial indicator is capable of measuring from 0-20.00 mm lift. The small inner dial is marked in increments of 1 mm. The large outer dial is marked in increments of 0.01 mm. One revolution of the outer dial is equal to 1 mm. The inner dial only indicates 0-10 mm, but will rotate twice as the indicator goes through the full range.

(11) **Be sure the timing pin is disengaged before rotating the engine to avoid damage to the timing pin.**

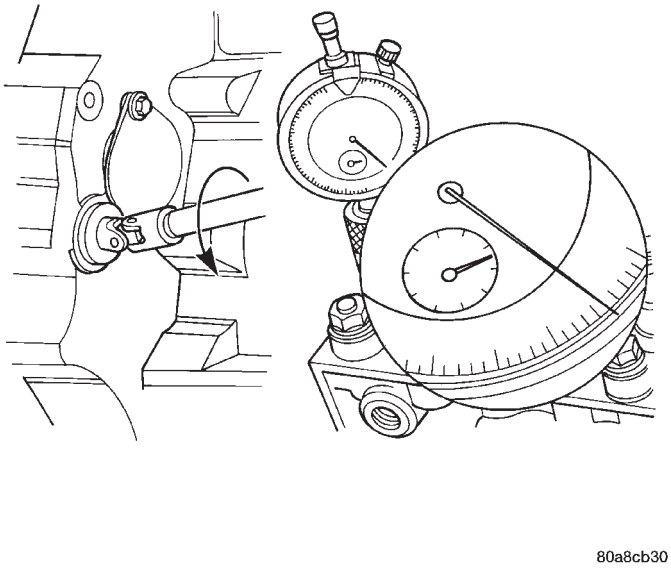


Fig. 45 Setting Dial Indicator

(12) Using the engine barring tool #7471B, rotate the engine in the direction opposite normal direction of engine rotation (counterclockwise from front of engine) 1/4 turn or until you see the dial indicator reading stop dropping. This is the inner base circle of the injection pump cam. Zero the indicator and note the reading on the small inner dial (Fig. 45).

(a) Slowly rotate engine clockwise to TDC. When at TDC, the timing pin should easily push into machined hole in back of camshaft gear. Pull pin from gear after verifying TDC position.

(b) Note the pump lift setting on the dial indicator (Fig. 45).

(c) Note the injection pump CPL number and "Timing-TDC" specification (in degrees) stamped into the engine data plate. The engine data plate is located on the left side of the timing gear cover (Fig. 46).

(d) Refer to the Fuel Injection Pump Plunger Lift charts. The charts contain a nominal timing specification and a pump plunger lift tolerance specification.

(e) If reading on dial indicator, and specification for pump plunger lift match, a fuel timing adjustment **will not** be necessary. Proceed to Step 26.

(f) If reading and specifications **do not match,** a fuel timing adjustment will be necessary. Proceed to next step.

FUEL INJECTION PUMP PLUNGER LIFT—49 STATE AUTO. TRANS. AND ALL CALIFOR. EGR EQUIPPED ENGINES

CPL 2174 AND 2308 (CALIFORNIA)	
STATIC TIMING (DEGREES BTDC)	PLUNGER LIFT AT TDC
14.0 (NOMINAL)	4.29 mm-4.61 mm

FUEL INJECTION PUMP PLUNGER LIFT—49 STATE MANUAL TRANSMISSION

CPL 2175	
STATIC TIMING (DEGREES BTDC)	PLUNGER LIFT AT TDC
13.5 (NOMINAL)	4.89 mm-5.25 mm

Adjusting Timing:

(13) Remove the oil filler tube (Fig. 47) and adapter elbow from the front of the timing gear housing.

(14) Loosen the injection pump shaft nut (use the barring tool to keep the engine from rotating). Before removing pump nut or washer, place a magnet to the end of the injection pump shaft (Fig. 48). This will prevent the nut or washer from falling into the timing gear cover which will require engine disassembly for recovery.

(15) Position a magnet to the end of the injection pump shaft. Install the special bearing and thrust washer kit #6862 (Fig. 49) over the injection pump shaft in this order: 1 thrust washer-1 bearing-1 thrust washer. The thrust washer/bearing kit is used

SERVICE PROCEDURES (Continued)

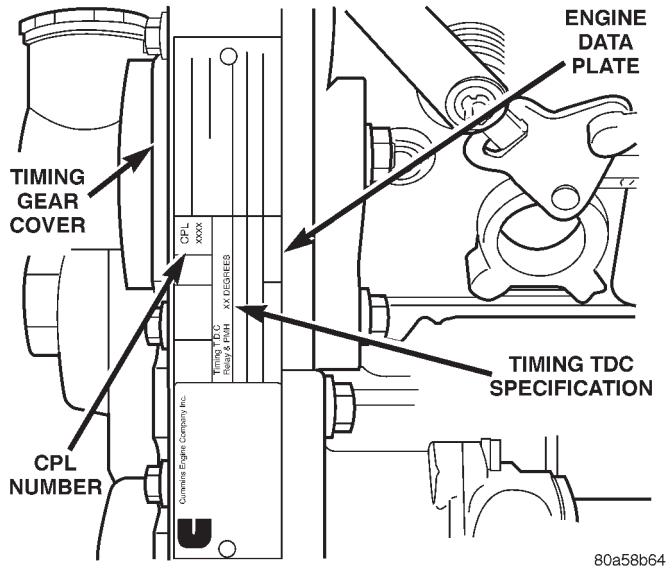


Fig. 46 Engine Data Plate and CPL Number

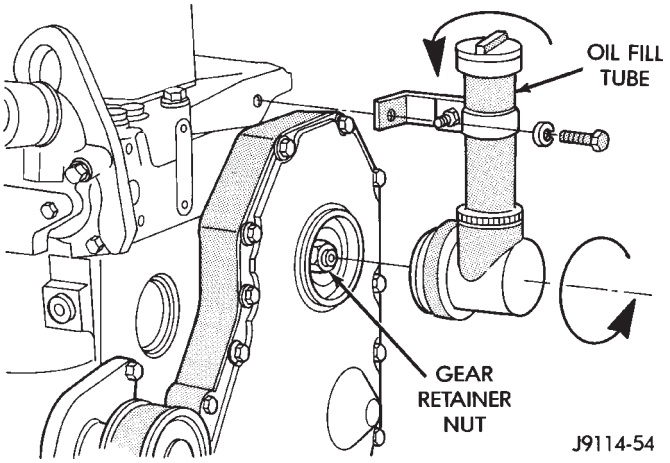


Fig. 47 Oil Filler Tube

to prevent the pump gear from rotating on the pump shaft when tightening the pump nut (step 22). Reinstall pump shaft nut allowing some clearance between the thrust washers. Do not tighten nut at this time.

(16) Slowly rotate the engine clockwise until reaching the required lift setting on the dial indicator. Refer to Fuel Injection Pump Plunger Lift charts. The injection pump should rotate with the engine since the injection pump gear is still locked to the injection pump shaft.

(17) With the injection pump at the correct plunger lift setting, use special gear puller tool #L-4407A to pull the injection pump gear off the taper of the injection pump input shaft. Leave the gear puller installed (Fig. 50). After the gear has been pulled, ensure the lift setting has not changed.

(18) Rotate the engine 20 to 30 degrees counterclockwise, then rotate the engine back clockwise to

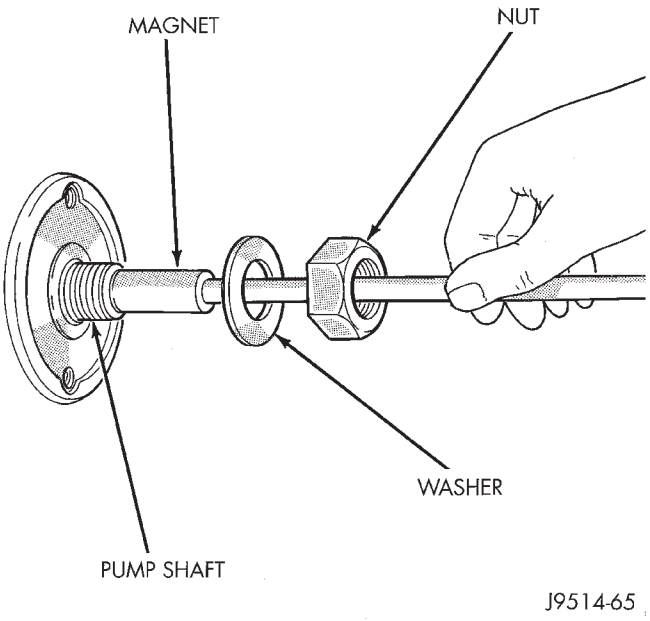


Fig. 48 Positioning Magnet to Pump Shaft

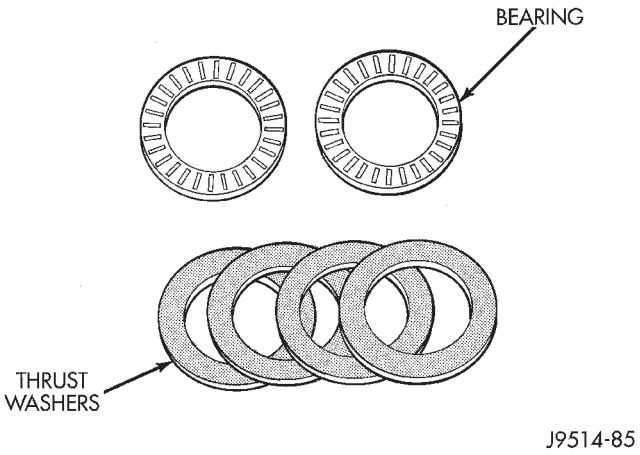


Fig. 49 Bearing/Thrust Washer Tools

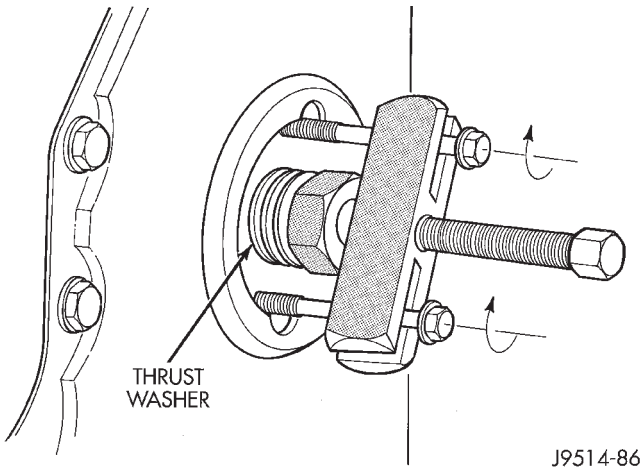


Fig. 50 Gear Puller Tool Installed

SERVICE PROCEDURES (Continued)

TDC (Fig. 51). This removes backlash from the geartrain.

The fuel pump gear and pump shaft tapers must be absolutely clean, dry and free of any oil or dirt. Oil or dirt will prevent seating of the taper and will result in possible slippage of the gear.

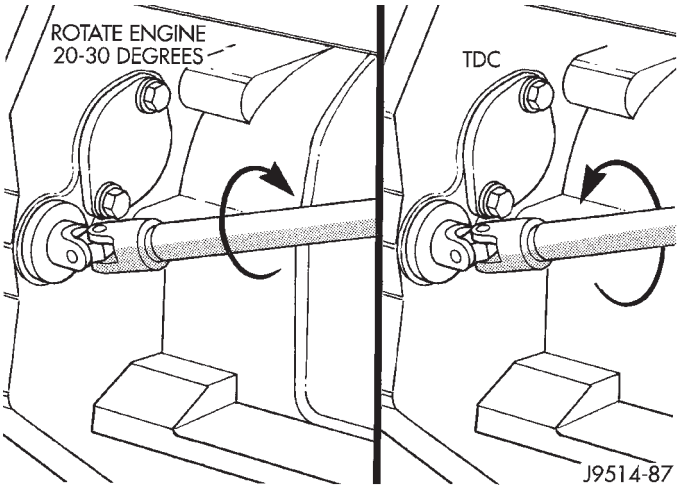


Fig. 51 Rotating Crankshaft

(19) Loosen, but do not remove the gear puller tool bolts. Using the gear puller, rotate pump gear counterclockwise by hand (Fig. 52), while pushing the gear onto the pump shaft. This will remove backlash between the injection pump and camshaft gears.

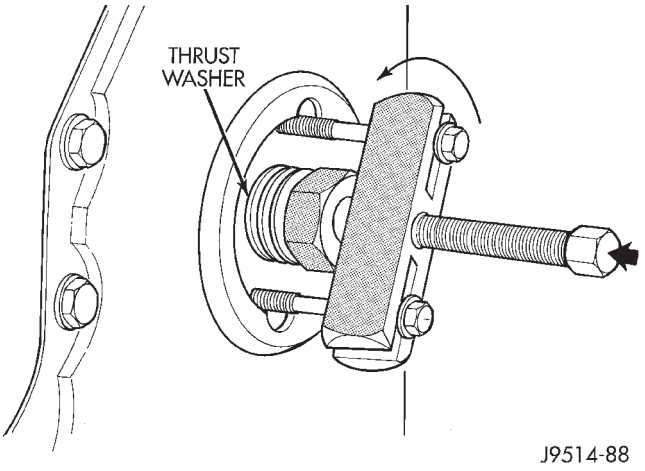


Fig. 52 Rotating Injection Pump Gear

(20) Hand tighten the pump shaft nut (Fig. 53). Remove the gear puller (Fig. 53).

(21) Tighten the pump shaft nut to 15 N·m (11 lb. ft.) torque to seat the gear to the pump shaft taper (Fig. 54).

(22) Remove injection pump shaft nut. Use a magnet on the end of the shaft while removing (Fig. 48).

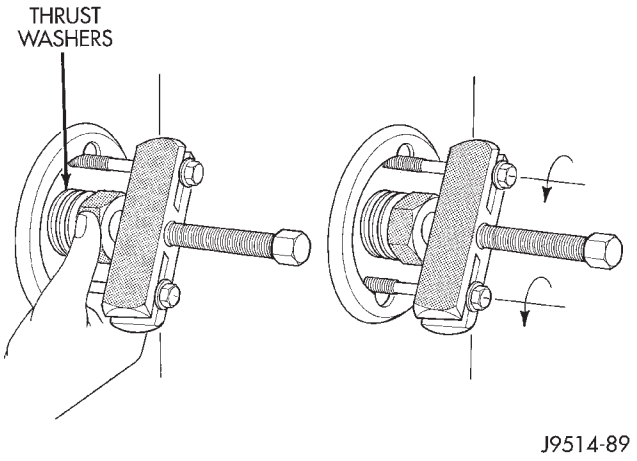


Fig. 53 Removing Gear Puller Tool

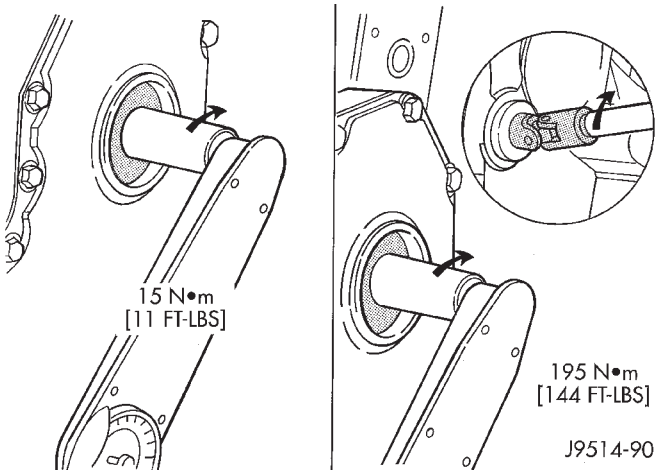


Fig. 54 Tightening Pump Nut

(23) Remove special bearing and thrust washers #6862 from pump shaft. Use a magnet on the end of the shaft while removing.

(24) While preventing the engine from rotating with the barring tool, tighten the shaft nut to 195 N·m (144 lb. ft.) torque (Fig. 54).

(25) Repeat steps 12 and 13 to verify that the final timing setting is correct. If the setting is not correct, repeat steps 15 through 25.

(26) Remove the dial indicator and adaptor from the injection pump.

CAUTION: THE FOLLOWING INSTALLATION AND TORQUING PROCEDURE MUST BE FOLLOWED EXACTLY. IMPROPER INSTALLATION OF THE DELIVERY VALVE WILL RESULT IN DAMAGE OR LEAKS.

(27) Install the delivery valve assembly on top of the sealing washer (Fig. 55) or (Fig. 43).

(28) Lubricate the threads and clamping surface of the delivery valve holder with a few drops of SAE 90

SERVICE PROCEDURES (Continued)

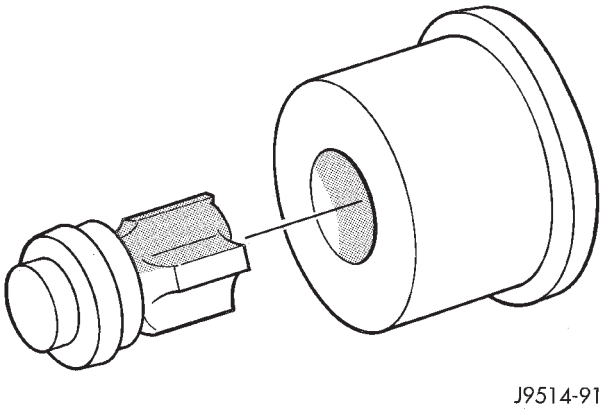


Fig. 55 Delivery Valve Assembly

hypoid gear oil. **Do not lubricate the metal delivery valve washer or its seating area.**

(29) Install the delivery valve holder assembly taking care not to displace the delivery valve spring, fill piece, or any shims (Fig. 56).

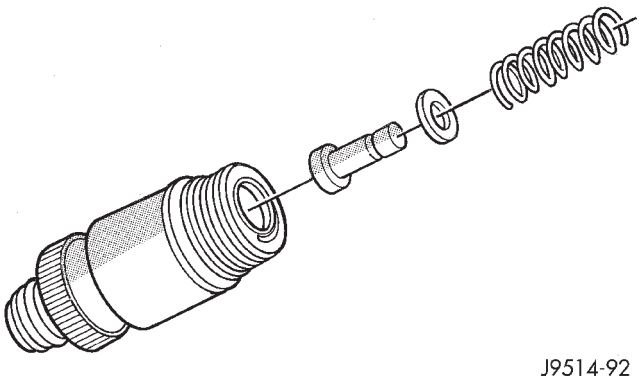


Fig. 56 Delivery Valve Holder

(30) Pre-tighten the delivery valve holder to 40 N·m (29 lb. ft.) torque (Fig. 57). Next, in one motion, tighten the holder to 115 N·m (85 ft. lbs.) torque (Fig. 57).

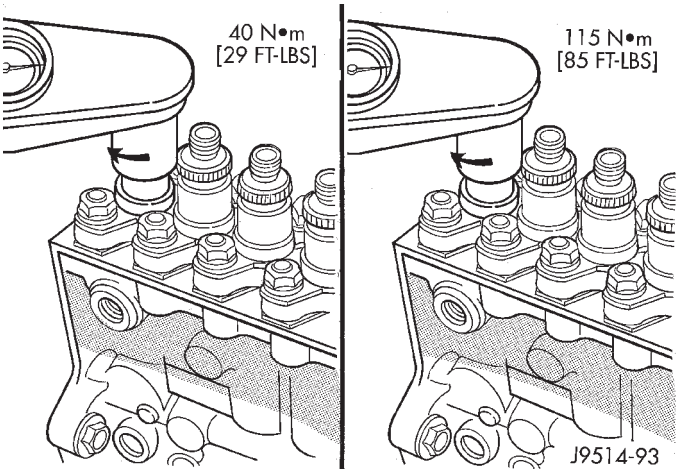


Fig. 57 Tightening Delivery Valve Holder

(31) Install remaining engine components removed during the timing process. Leave the injector end of the #1 high-pressure fuel line loose to facilitate bleeding the air out of the system.

WARNING: THE PRESSURE OF THE FUEL IN THE LINE IS SUFFICIENT TO PENETRATE THE SKIN AND CAUSE SERIOUS BODILY HARM.

(32) Crank the engine until fuel is observed at the #1 injector. Tighten the high-pressure line at the injector. Start the engine and check for leaks.

THROTTLE LINKAGE ADJUSTMENT—DIESEL ENGINE

Refer to WIDE-OPEN-THROTTLE CHECKS—DIESEL ENGINE for linkage adjustment procedures.

If Equipped With Throttle Position Sensor (TPS): Whenever the throttle linkage is adjusted, it will change TPS adjustment. Refer to THROTTLE POSITION SENSOR—DIESEL ENGINE, Removal/Installation/Adjustment in this group for procedures. Adjusting the TPS should always be the **last** adjustment.

WIDE-OPEN-THROTTLE CHECKS—DIESEL ENGINE

If “lack of power” is a complaint, one of the problems may be the inability of attaining wide-open-throttle (WOT). This is observed as throttle lever “breakover”. “Breakover” is the continued movement of the throttle lever **after** movement of the throttle lever-to-injection pump lever linkage rod has stopped (Fig. 58). WOT must continue up to, and slightly through throttle lever “breakover”. If “breakover” is not attained, WOT is not attained.

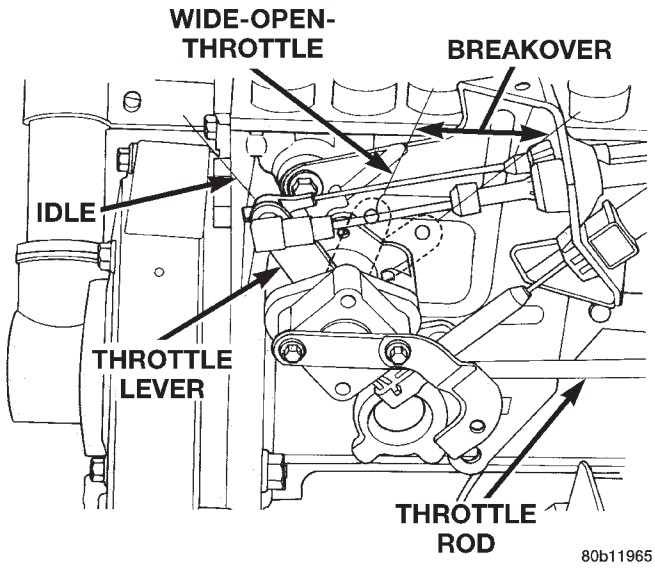


Fig. 58 Throttle Lever “Breakover”—Diesel Engine

SERVICE PROCEDURES (Continued)

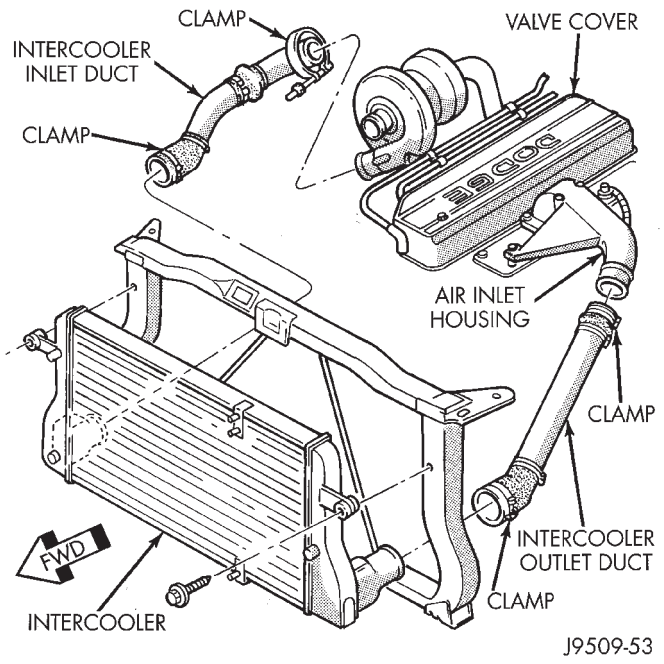


Fig. 59 Intercooler Outlet Duct

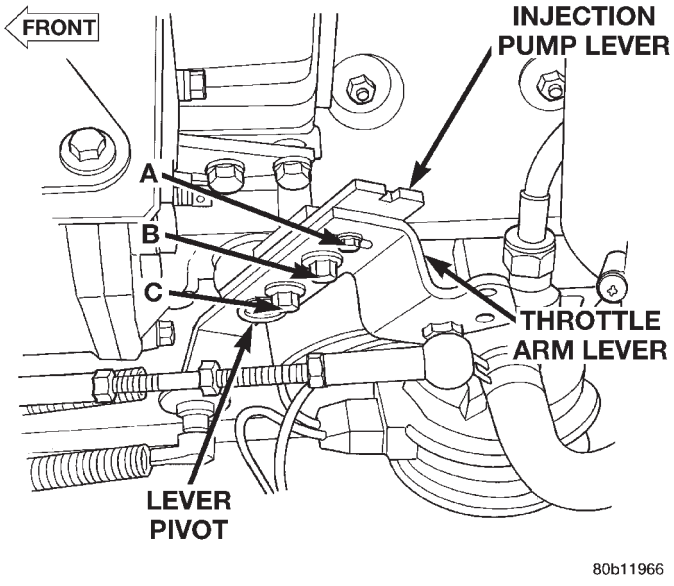


Fig. 60 Fuel Injection Pump Lever / Throttle Arm Lever

(1) Attach DRB scan tool to data link connector.

(2) Start engine and bring to operating temperature.

(3) Use DRB tool to check engine idle speed. Adjust idle speed if necessary. Refer to Idle Speed Adjustment for specifications. This step must be done before checking "breakover".

(4) Key OFF and engine OFF.

(5) Two people are needed for this portion of test. From inside vehicle, press accelerator pedal about half-way to floor. Movement of both throttle lever (Fig. 58) and throttle rod (Fig. 58) should be observed.

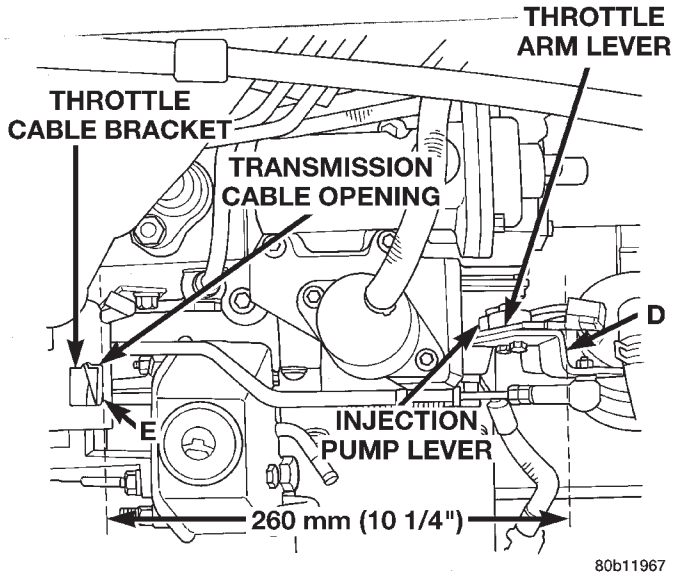


Fig. 61 Breakover Measurement

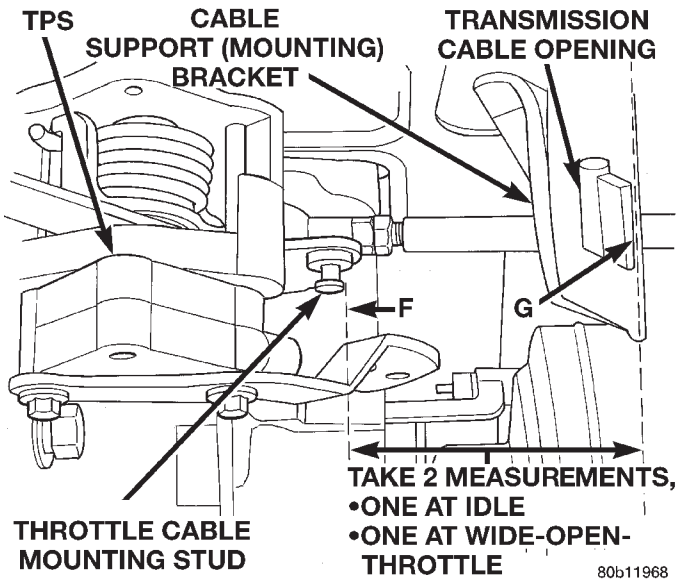


Fig. 62 Breakover Measurement Verification

(6) Continue to press accelerator pedal to the floor. If throttle lever "breakover" is operating correctly, the throttle rod (Fig. 58) should have stopped moving while the throttle lever (Fig. 58) continues to move towards the rear of vehicle.

(7) If "breakover" is not observed, the throttle linkage must be adjusted. If engine is equipped with a throttle position sensor (TPS), the TPS must also be adjusted **after** "breakover" position is set. Refer to THROTTLE POSITION SENSOR—DIESEL ENGINE in the Removal/Installation section of this group.

(8) At side of fuel injection pump, remove intercooler outlet duct from air inlet housing (Fig. 59).

SERVICE PROCEDURES (Continued)

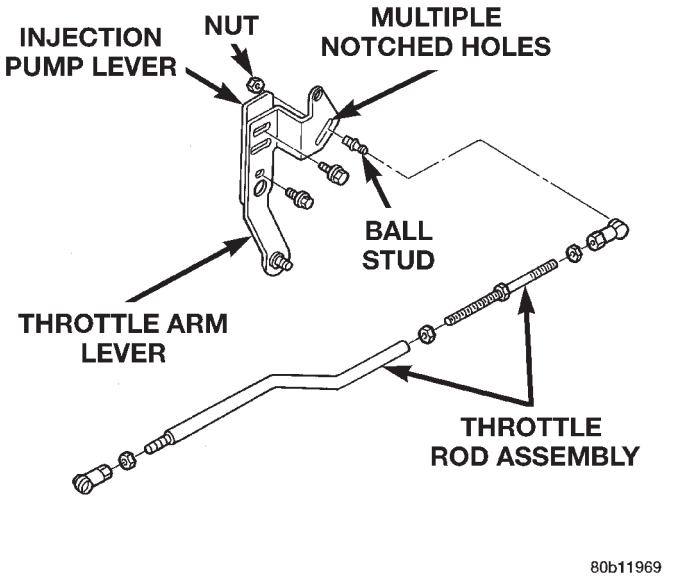


Fig. 63 Ball Stud and Notched Holes at Throttle Arm Lever

(9) Disconnect end of throttle cable at fuel injection pump. Refer to Throttle Cable in the Diesel Removal/Installation section.

(10) Disconnect end of transmission control (throttle valve) cable at fuel injection pump. Refer to Transmission Throttle Valve Cable in Group 21, Transmission.

(11) Disconnect end of speed control cable at fuel injection pump. Refer to Servo Cable in Group 8H, Speed Control System.

(12) Loosen, but do not remove, bolts A, B and C on throttle arm lever (Fig. 60).

(13) Move (pivot) throttle arm lever on injection pump lever (Fig. 60) to attain 260 mm (10 1/4") from point D at back of throttle arm lever, to point E at back of throttle cable bracket (Fig. 61). Take measurement through transmission throttle valve cable opening on throttle cable mounting bracket (Fig. 61). Make sure injection pump lever (Fig. 61) remains at **closed throttle position** during measurement

(14) Tighten bolts A, B and C to 10 N·m (89 in. lbs.) torque.

(15) Verify correct adjustment by measuring distance from back of throttle cable mounting stud on bellcrank (point F) (through transmission throttle valve cable opening) to the rear face of throttle cable mounting bracket (point G) (Fig. 62). This measurement (travel) must be taken twice; once at idle position and once at wide-open-throttle (WOT) position. Be sure injection pump lever (Fig. 61) remains at either idle or WOT position during both measurements. Record both measurements.

(16) The difference between the two measurements (travel) must be 34mm ± 2mm (1 11/32 in. ± 3/64 in.).

(17) If difference in measurement is OK, proceed to Step 22.

(18) If difference in measurement is too small, remove nut securing ball stud to throttle arm lever (Fig. 63) and remove ball stud from lever. Move ball stud upward/rearward one notch on pump lever. Multiple notched holes are provide on lever (Fig. 63). If difference in measurement is too great, move ball stud downward/forward one notch on lever. Each notched hole on throttle arm lever will give approximately a 2mm (3/64 in.) incremental adjustment in chosen direction.

(19) Tighten ball stud nut to 10 N·m (89 in. lbs.) torque.

(20) After repositioning ball stud, again, check for difference in measurement (travel) of 34mm ± 2mm (1 11/32 in. ± 3/64 in.). Readjust if necessary.

(21) After travel has been set, recheck "breakover".

(22) Connect end of throttle cable at fuel injection pump. Refer to Throttle Cable in the Diesel Removal/Installation section.

(23) Connect end of transmission control (throttle valve) cable at fuel injection pump. Refer to Transmission Throttle Valve Cable in Group 21, Transmission.

(24) Connect end of speed control cable at fuel injection pump. Refer to Servo Cable in Group 8H, Speed Control System.

(25) Install intercooler outlet duct to air inlet housing.

(26) If engine is equipped with a throttle position sensor (TPS), the TPS must also be adjusted. Refer to THROTTLE POSITION SENSOR—DIESEL ENGINE in the Removal/Installation section of this group.

REMOVAL AND INSTALLATION

ACCELERATOR PEDAL

Refer to the Fuel Delivery System—Gasoline Engine section for procedures.

FUEL DRAIN MANIFOLD

REMOVAL

(1) Remove two nuts retaining nameplate/cover to top of six engine valve covers (Fig. 64). Remove nameplate/cover from engine.

(2) Remove drain manifold fitting screws (bolts) at each of six injectors (Fig. 65).

(3) Remove fuel drain manifold holdown clamp/bolt (Fig. 66) at top/rear of intake manifold.

(4) Remove fuel drain manifold banjo fitting at top of fuel filter/water separator (one bolt) (Fig. 66).

(5) Remove fuel drain manifold fitting copper gaskets at each fuel injector.

REMOVAL AND INSTALLATION (Continued)

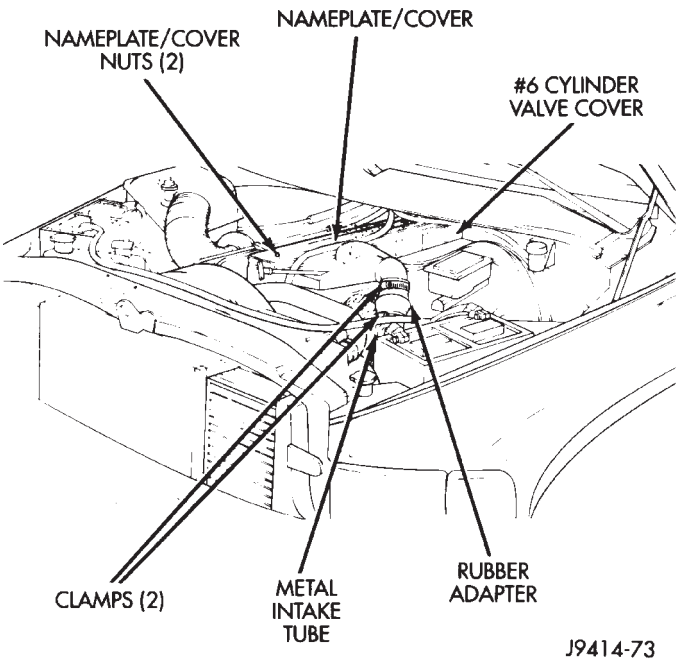


Fig. 64 Nameplate/Cover—Diesel

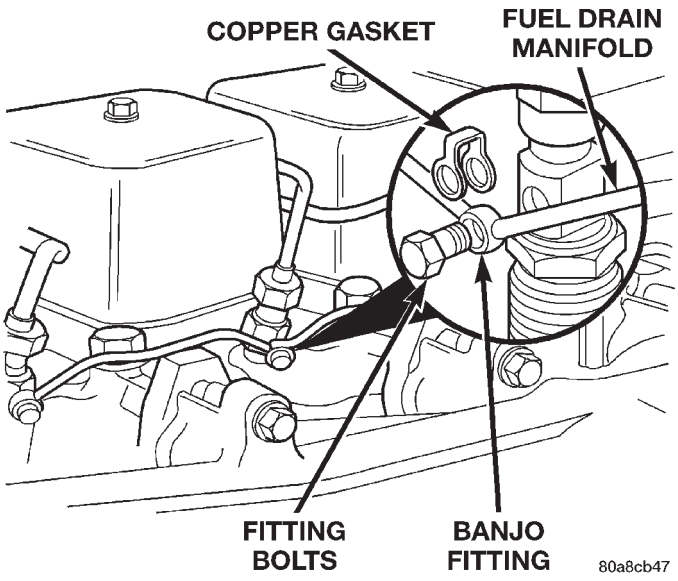


Fig. 65 Fuel Drain Manifold Fittings—Typical

(6) Remove manifold from engine.

INSTALLATION

(1) Using new copper gaskets on all fittings and assemble fuel drain manifold in reverse order of disassembly.

(2) Tighten drain manifold fitting screws (bolts) at injectors to 9 N·m (7 ft. lbs.) torque.

(3) Tighten drain manifold holdown clamp screws (bolts) to 13 N·m (10 ft. lbs.) torque.

(4) Install nameplate/cover.

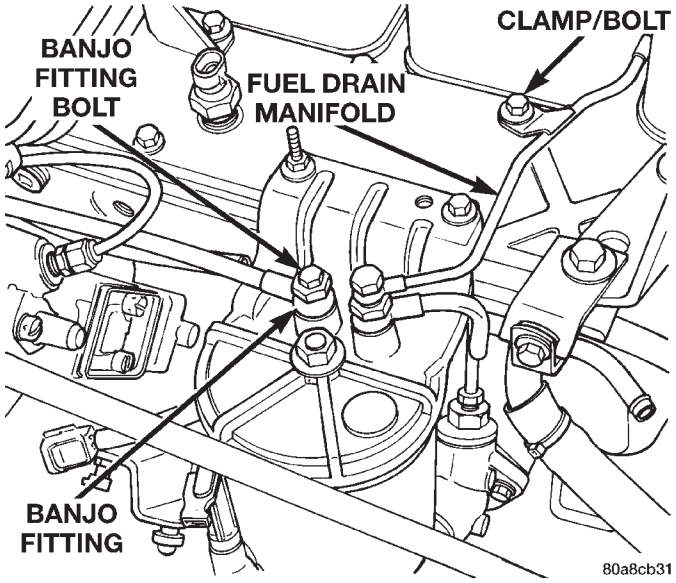


Fig. 66 Fuel Drain Manifold and Fuel Filter/Water Separator

FUEL FILTER/WATER SEPARATOR

Refer to the maintenance schedules in Group 0 in this manual for the recommended fuel filter replacement intervals. Whenever the fuel filter is being replaced, the pre-filter in the fuel heater assembly should be removed and cleaned. Refer to Fuel Heater Removal/Installation for procedures.

The fuel filter/water separator assembly is located on left/rear side of engine above starter motor (Fig. 67). The assembly contains a fuel filter cartridge and Water-In-Fuel (WIF) sensor.

REMOVAL

The canister drain valve (Fig. 67) or (Fig. 68) serves two purposes. One is to partially drain the filter canister of excess water. The other is to completely drain the canister for filter replacement.

DRAINING WATER FROM FILTER CANISTER: The filter should be drained whenever the water-in-fuel warning lamp remains illuminated. (Note that the lamp will be illuminated for approximately two seconds when ignition key is initially placed in ON position for a bulb check).

A drain hose is located at bottom of drain valve (Fig. 69). Place a drain pan under drain hose. **With engine not running,** rotate valve handle forward to DRAIN position (Fig. 68). Hold drain valve open until all water and contaminants have been removed and clean fuel exits the drain hose. If fuel filter or WIF sensor is being replaced, drain the canister completely. Dispose of mixture in drain pan according to applicable regulations. After draining operation, rotate valve handle rearward to CLOSE position (Fig. 68). If fuel filter or WIF sensor is being replaced, proceed to next step.

REMOVAL AND INSTALLATION (Continued)

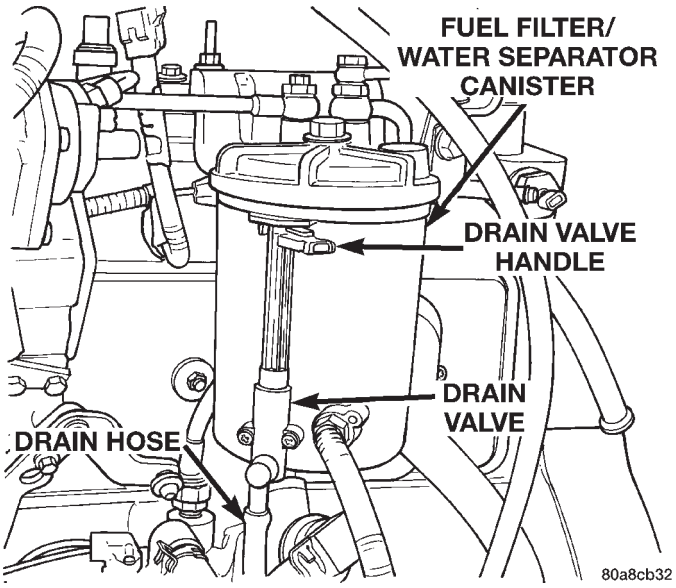


Fig. 67 Fuel Filter/Water Separator Location

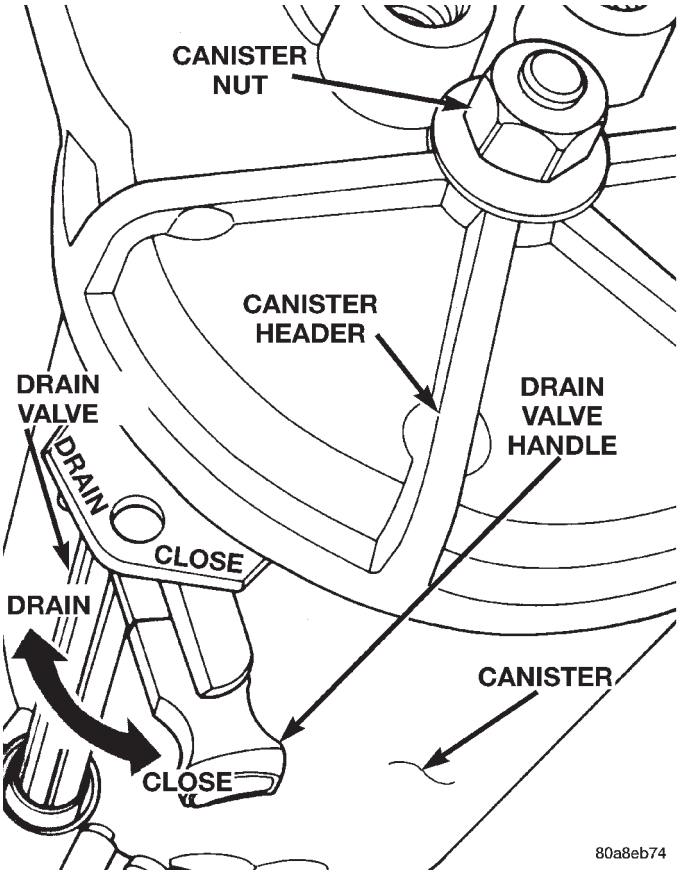


Fig. 68 Drain Valve at Fuel Filter/Water Separator

(1) Remove drain hose at drain valve (Fig. 69).

(2) Disconnect Water-In-Fuel (WIF) sensor electrical connector pigtail harness from main engine wiring harness. The WIF sensor is located at side of filter canister (Fig. 69).

(3) Remove filter canister nut at top of header (Fig. 68).

(4) Lower canister assembly from header.

(5) Remove and discard center o-ring (Fig. 69).

(6) Remove filter element (cartridge) from canister.

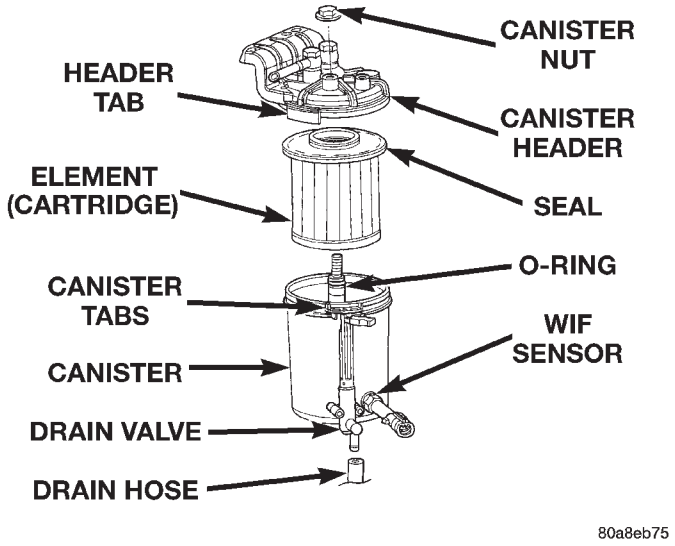


Fig. 69 Fuel Filter/Water Separator Components

(7) Remove WIF sensor and its seal from canister

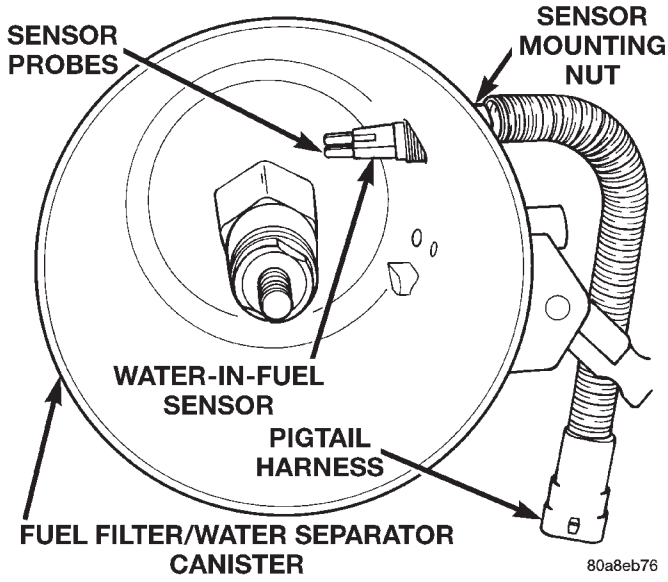


Fig. 70 Water-In-Fuel Sensor

(Fig. 70).

(8) Inspect WIF sensor probes (Fig. 70). Carefully clean contaminants from sensor probes with a cloth if necessary. Replace sensor if probes are covered with contaminants and will not clean up.

INSTALLATION

(1) Clean inside of canister.

(2) Install a new o-ring seal to WIF sensor.

(3) Install WIF sensor to canister. Tighten to 2–3 N·m (15–20 in. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

(4) If drain valve assembly is being replaced, tighten mounting screws to 3–5 N·m (30–40 in. lbs.) torque.

(5) Install new seal between canister and canister header.

If filter canister is not filled with clean diesel fuel before installation, manual air bleeding of the fuel system may be necessary (temporary rough engine running may occur). If necessary, refer to the Air Bleed Procedure in this group for procedures.

(6) Fill filter canister with clean diesel fuel.

(7) Apply a light film of clean diesel oil to seals.

(8) Position canister assembly to canister header. Note that the locating tabs on canister should align into header tab on canister header (Fig. 69). This step must be followed to prevent damage to canister or header and to prevent contact of drain valve into throttle linkage.

(9) Install canister nut and tighten to 14 N·m (10 ft. lbs.) torque.

(10) Connect electrical connector to WIF sensor.

(11) Connect drain hose to bottom of drain valve.

(12) Start engine and check for leaks.

FUEL TANK

Refer to Fuel Tank—All Engines in the Fuel Delivery System—Gasoline engines section for procedures.

FUEL TANK MODULE

REMOVAL

(1) Drain and remove fuel tank. Refer to Fuel Tanks—All Engines for procedures.

(2) The plastic fuel tank module locknut is threaded onto fuel tank (Fig. 71). Install Special Tool 6856 to locknut and remove locknut (Fig. 72). The fuel tank module will spring up when locknut is removed.

(3) Remove module from fuel tank.

INSTALLATION

CAUTION: Whenever the fuel tank module is serviced, the rubber gasket must be replaced.

(1) Using a new gasket, carefully position fuel tank module into opening in fuel tank.

(2) Position locknut over top of fuel tank module. Install locknut finger tight.

(3) The fuel line connectors, rollover valve and fuel gauge electrical connector should all be pointed to drivers side of vehicle. Rotate module if necessary before tightening locknut. This step must be performed to prevent the float from contacting side of fuel tank.

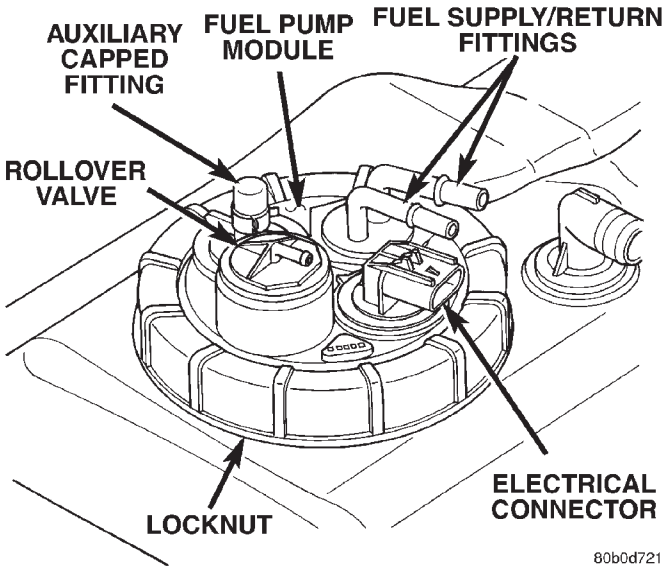


Fig. 71 Top View of Fuel Tank Module—Diesel

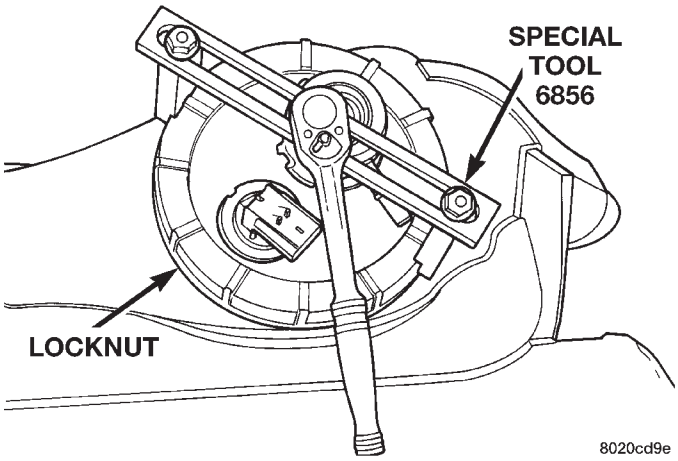


Fig. 72 Locknut Removal/Installation—TYPICAL

(4) Tighten locknut to 24–44 N·m (18–32 ft. lbs.) torque.

(5) Install fuel tank. Refer to Fuel Tanks—All Engines for procedures.

FUEL HEATER

The fuel heater element assembly is located inside of fuel heater housing and above pre-filter (Fig. 73). The fuel temperature sensor is located at top of fuel heater housing (Fig. 73).

If upper section of fuel heater assembly housing is to be removed, the fuel transfer pump must first be removed. The mounting bracket/spacer (Fig. 74) on fuel heater is shared with fuel transfer pump. Refer to Fuel Transfer Pump Removal/Installation for procedures.

REMOVAL AND INSTALLATION (Continued)

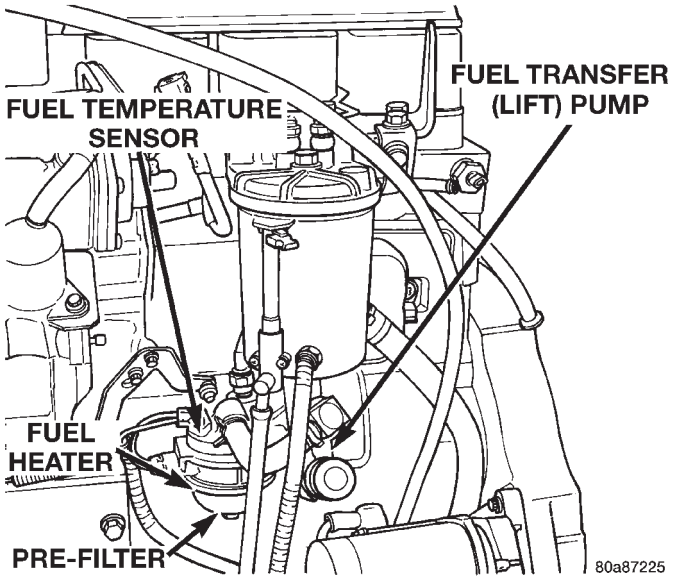


Fig. 73 Fuel Heater and Fuel Temperature Sensor Location

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Remove starter motor. Refer to Group 8B for procedures.

(3) Disconnect electrical connector at front of fuel heater housing (Fig. 73).

(4) Place a drain pan below fuel heater.

(5) A machined hex is located on bottom of pre-filter housing (Fig. 74). From under vehicle, attach a socket to this hex and remove (unscrew) pre-filter.

(6) Remove fuel heater assembly from housing.

(7) Remove pre-filter and screen from housing.

(8) Remove and discard rubber seals between housing sections.

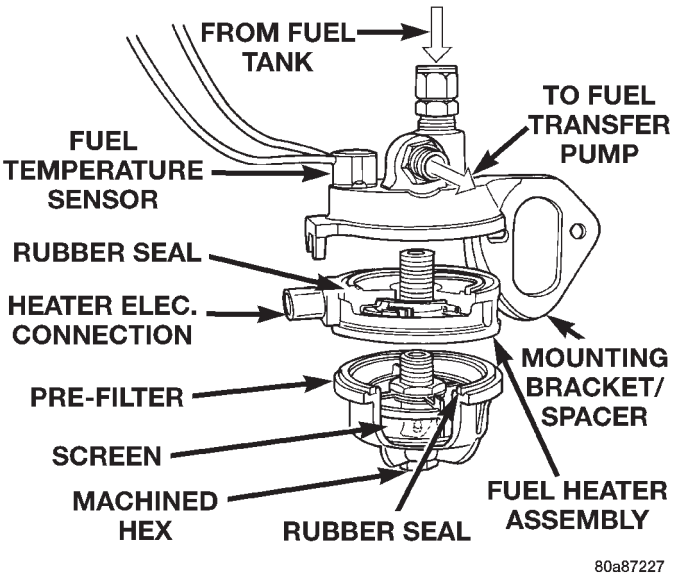


Fig. 74 Fuel Heater and Pre-Filter

INSTALLATION

(1) Clean pre-filter and screen.

(2) Clean all other components before assembly.

(3) Install screen and pre-filter into housing.

(4) Install new rubber seals between housing sections.

(5) Install fuel heater assembly and housing sections.

(6) Rotate fuel heater until fuel temperature sensor is pointed towards front of vehicle.

(7) Tighten hex at bottom of housing.

(8) Connect electrical connector at front of fuel heater housing.

(9) Install starter motor. Refer to Group 8B for procedures.

(10) Connect both negative battery cables at both batteries.

FUEL HEATER RELAY

The fuel heater relay is located in the engine compartment near the brake master cylinder (Fig. 75).

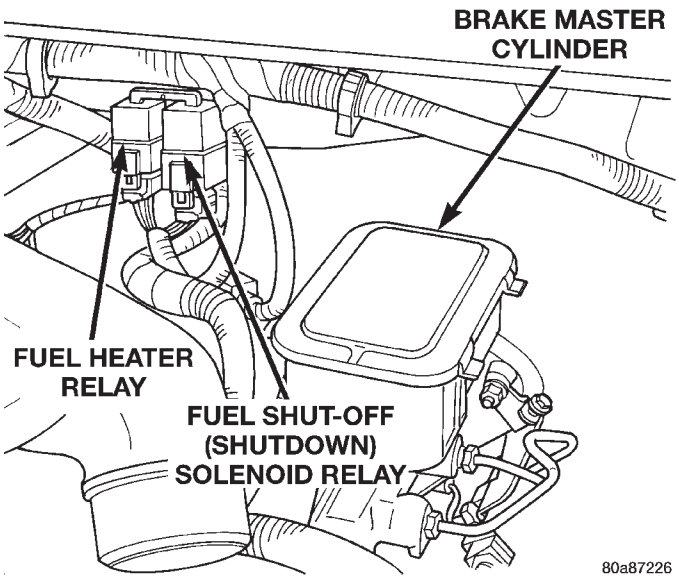


Fig. 75 Fuel Heater Relay—Diesel

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect the electrical connector at the relay.

(3) Remove the relay from the mounting bracket.

INSTALLATION

(1) Check the terminals within connector for damage or corrosion. Also check pin height of terminals within connector. Pin heights should be the same. Repair as necessary before connecting relay.

(2) Install the relay to the mounting bracket.

(3) Connect the electrical connector.

(4) Connect battery cables to both batteries.

REMOVAL AND INSTALLATION (Continued)

FUEL INJECTION PUMP

New or remanufactured fuel injection pumps should have a new overflow valve (Fig. 81) temporarily installed into side of pump. **Do not install a used overflow valve into a new or remanufactured injection pump.** If pump is being sent to an authorized repair facility for calibration or testing, be sure to temporarily install old overflow valve into pump.

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect electrical connector at throttle position sensor on side of injection pump (if equipped) (Fig. 76).

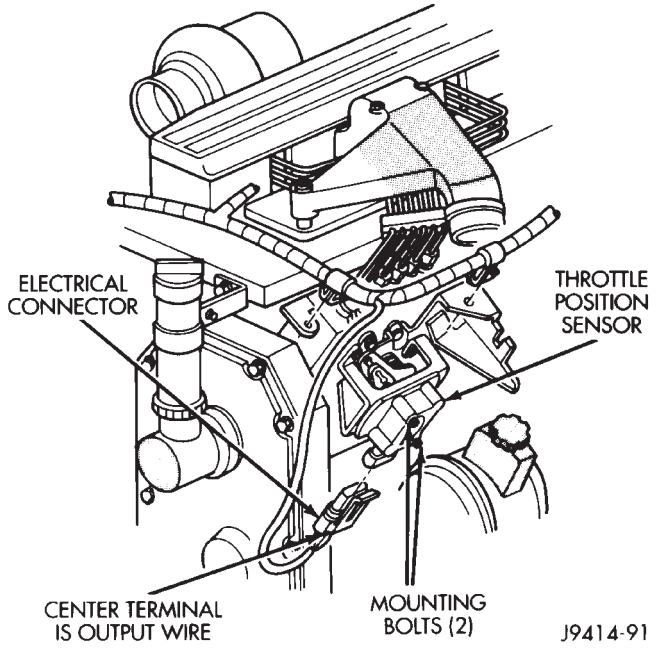


Fig. 76 Throttle Position Sensor—Diesel

(3) Disconnect electrical connector at fuel shutdown solenoid. (Fig. 77).

(4) Remove EGR tube (if equipped). Refer to Group 25, Emission Control System for procedures.

(5) Disconnect main engine wiring harness at top of injection pump and position to side.

(6) Remove metal intake manifold-to-intercooler connecting tube.

(7) Remove engine oil dipstick tube mounting clamp and bolt (Fig. 78). Position dipstick tube to side.

(8) Disconnect two air heater cable nuts (Fig. 78).

(9) Remove five intake manifold bolts (Fig. 78). Discard both old air heater base gaskets.

(10) Remove throttle control bracket, cables and linkage assembly from side of pump (three bolts). Position assembly to side.

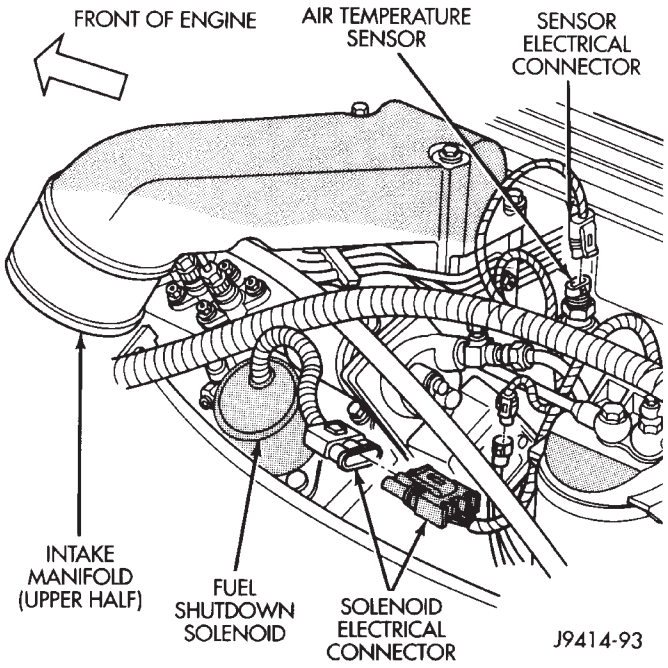


Fig. 77 Fuel Shutdown Solenoid Location

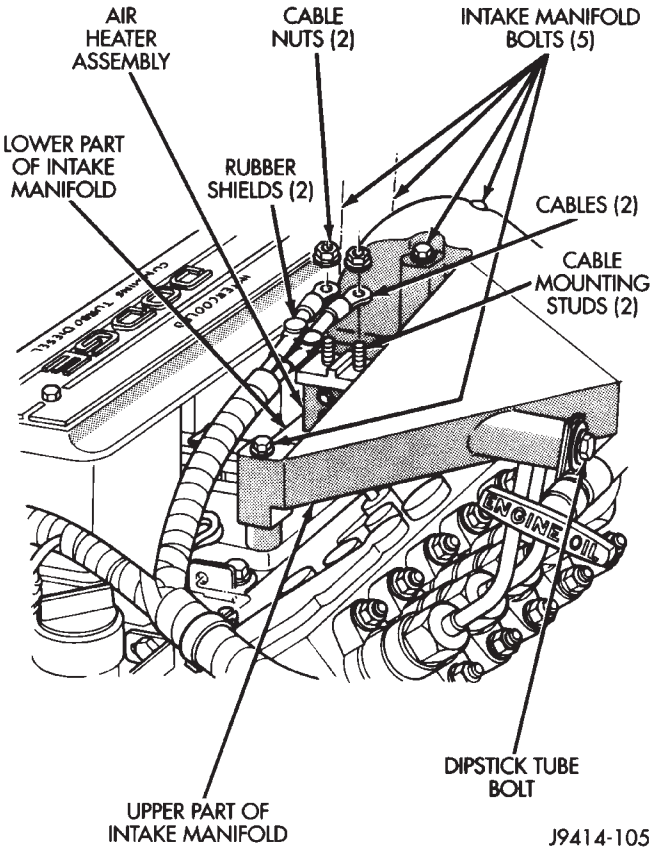


Fig. 78 Intake Manifold Air Heater

(11) Disconnect control line fitting and control from air flow control (AFC) valve at rear of injection pump (Fig. 79).

REMOVAL AND INSTALLATION (Continued)

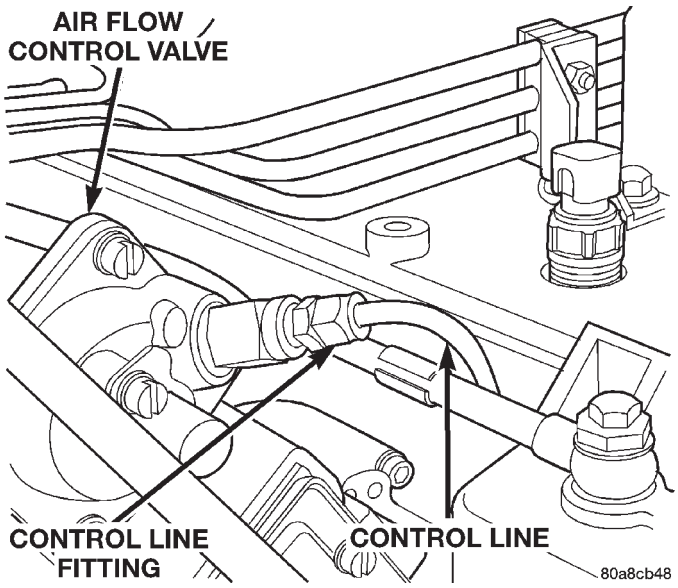


Fig. 79 Control Line at AFC Valve

(12) Remove fuel supply line at both ends (injection pump and fuel filter/water separator) (Fig. 80). For procedures, refer to Fuel Injection Pump Supply Line in this group. Place a rag beneath fitting to catch excess fuel.

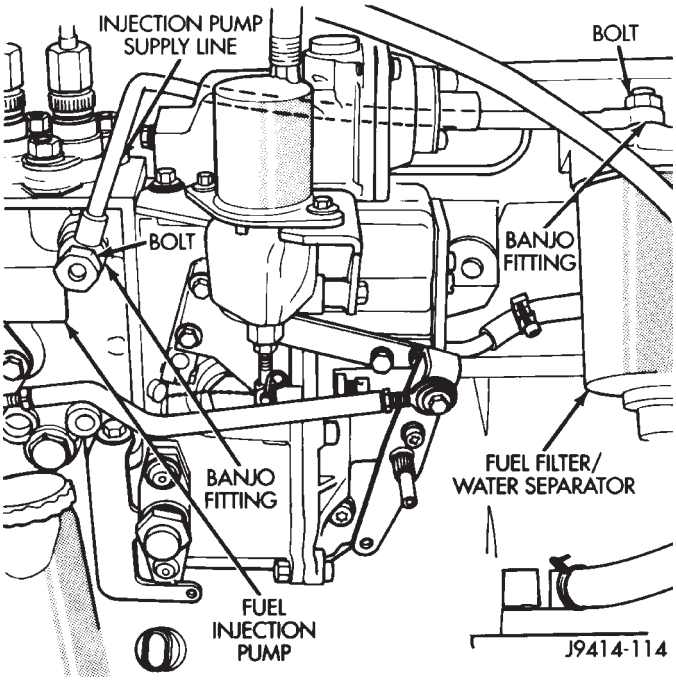


Fig. 80 Fuel Injection Pump Supply Line

(13) The overflow valve is used to retain fuel return line banjo fitting to injection pump. Remove overflow valve and fuel return line at pump (Fig. 81). Place a rag beneath banjo fitting to catch excess fuel.

(14) Disconnect six (6) high-pressure fuel lines from fuel delivery valve holders at top of injection pump (Fig. 82). For procedures, refer to High-Pressure Fuel Lines in this group. Place a rag beneath fittings to catch excess fuel.

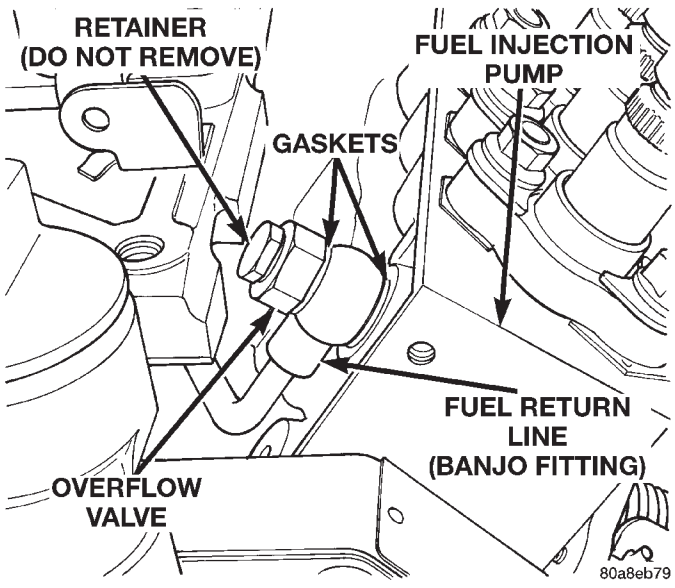


Fig. 81 Injection Pump Overflow Valve

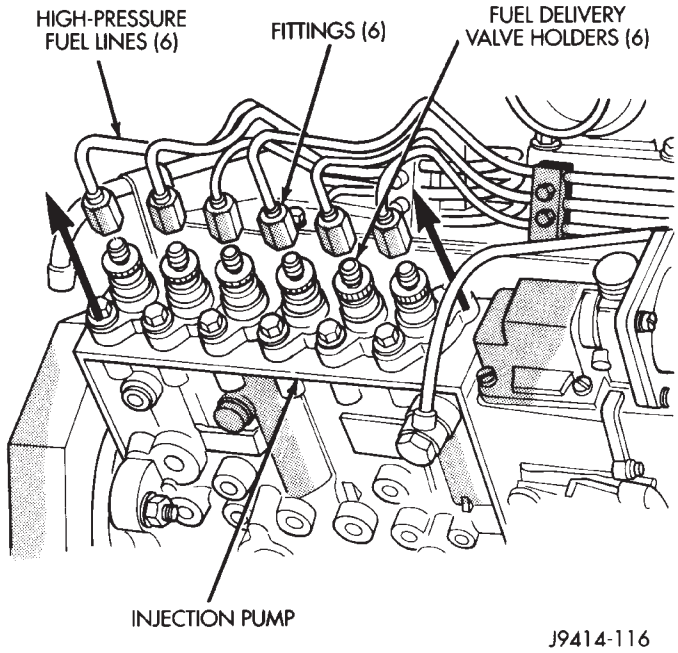


Fig. 82 Fuel Delivery Valve Holders and Pressure Lines

(15) Disconnect engine oil supply line at side of pump (Fig. 83).

(16) Remove oil fill tube bracket mounting bolt (Fig. 84).

(17) Remove oil fill tube from tube-to-gear housing adapter (Fig. 84). Tube is removed by screwing counterclockwise from adapter.

REMOVAL AND INSTALLATION (Continued)

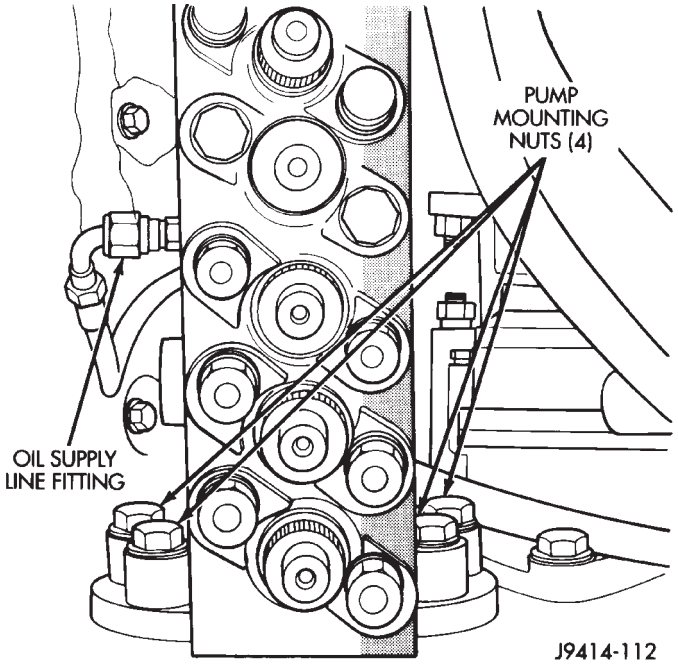


Fig. 83 Engine Oil Supply Line—Pump Mounting Nuts

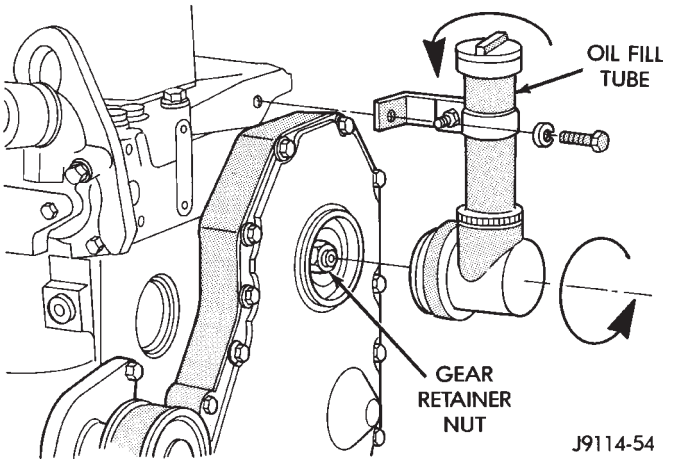


Fig. 84 Oil Fill Tube, Adapter and Mounting Bracket

(18) Remove oil fill tube adapter from gear housing (Fig. 84). Adapter is removed by screwing counterclockwise from gear housing.

(19) **The engine is equipped with a built-in moveable timing pin.** This pin is located above power steering pump, below and to inside of fuel injection pump, on rear of cam gear housing (Fig. 85). The pin will engage into a machined hole in the back of camshaft gear (Fig. 86). It is designed to position engine to TDC (Top Dead Center) on compression stroke of number 1 cylinder.

(20) Remove rubber air tube connecting turbocharger to air cleaner housing.

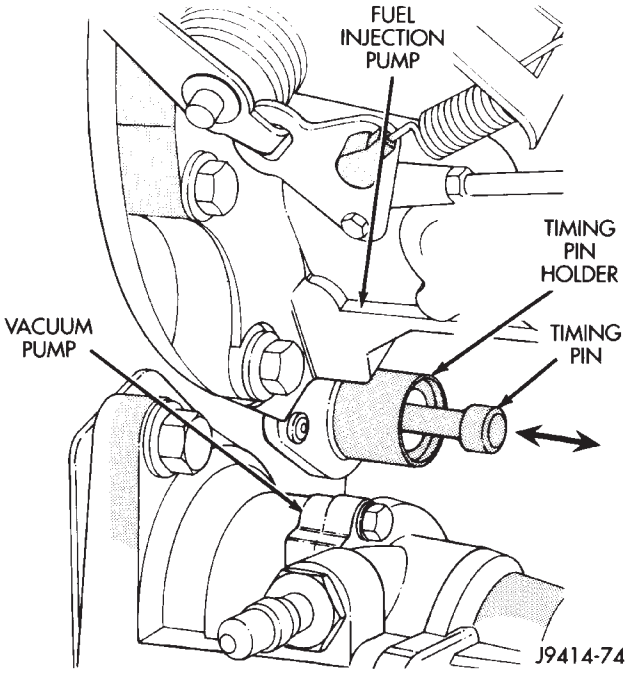


Fig. 85 Timing Pin and Location

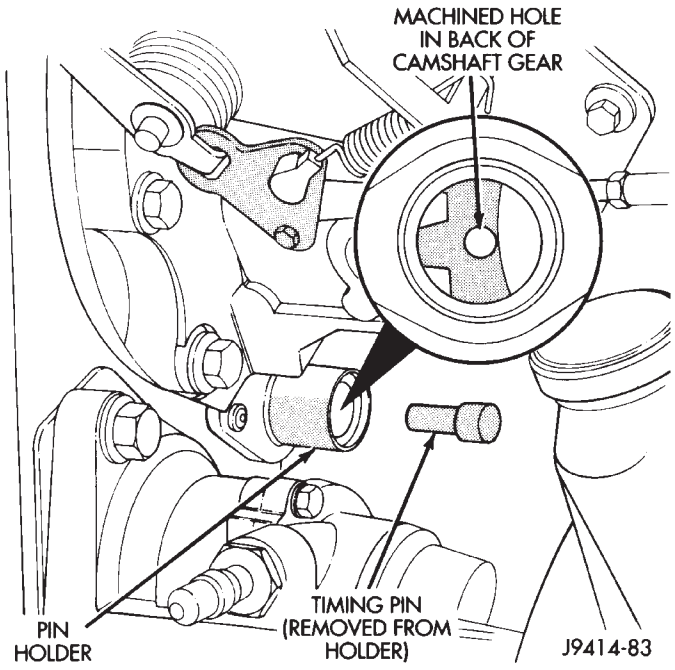


Fig. 86 Back of Camshaft Gear—Typical

(21) The engine can be rotated with a barring tool such as Snap-On No. SP371, MTE No. 3377371 (Cummins Tool Division), or an equivalent.

(22) The opening for barring tool is located in rear flange of engine on exhaust manifold side (Fig. 87). Remove rubber access plug covering this opening.

(23) Insert barring tool into flywheel housing opening (Fig. 87).

REMOVAL AND INSTALLATION (Continued)

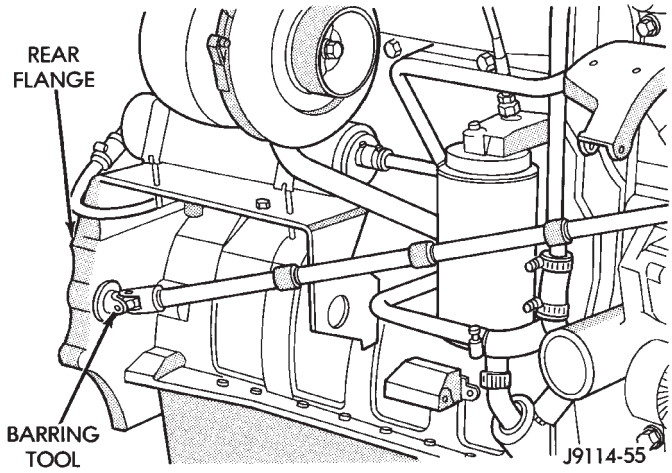


Fig. 87 Rotating Engine with Barring Tool—Typical

(24) While holding tension on timing pin (towards front of engine), very slowly rotate engine (counterclockwise as viewed from front) with barring tool. Rotating barring tool counterclockwise will rotate crankshaft clockwise. Continue to rotate until timing pin drops into machined hole in back of camshaft gear. When pin aligns to gear, engine is now at TDC position (compression stroke) at cylinder number 1.

CAUTION: When installing fuel injection pump and to achieve proper injection pump timing, engine MUST be in TDC position (compression stroke) at cylinder number 1.

Before proceeding to next step, and to prevent shearing of timing pin, temporarily remove timing pin from back of gear.

(25) Remove nut and washer retaining injection pump gear to injection pump shaft (Fig. 88).

(26) Place a shop towel below retainer nut in gear housing cover opening to prevent nut or washer from falling into gear housing.

CAUTION: If gear retainer nut or washer drops into gear housing, cover must be removed to retrieve them before engine is started.

(27) Use a T-bar type puller (Fig. 89) to separate injection pump gear from injection pump shaft. Attach two M8 X 1.24 MM (metric) screws through puller and into the two threaded holes supplied in pump gear. Pull injection pump gear forward until it loosens from injection pump shaft. **Pull on gear only enough to loosen it from injection pump shaft. Pulling gear too far may cause damage or breakage to gear cover.**

(28) Remove two (2) injection pump-to-lower mounting bracket bolts (Fig. 90).

(29) Remove four (4) injection pump-to-gear housing mounting nuts (Fig. 83).

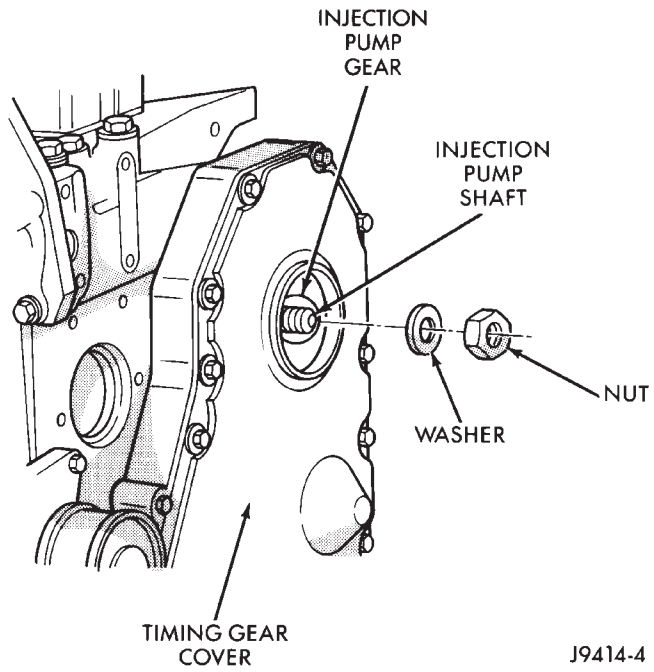


Fig. 88 Injection Pump Gear Washer and Nut

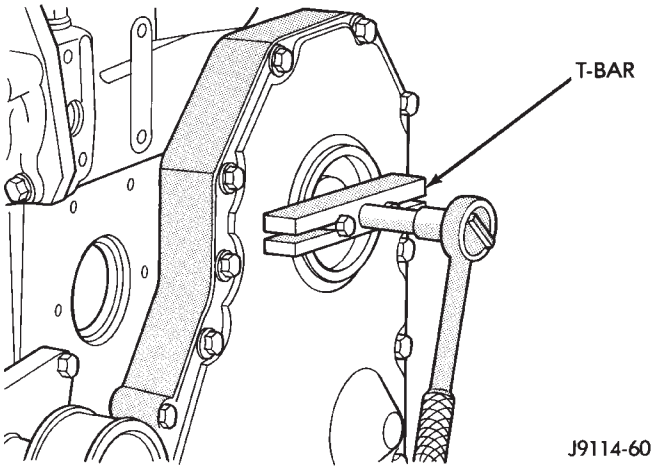


Fig. 89 Separating Injection Pump Gear from Pump Shaft

(30) Remove injection pump from gear housing. **Take care not to nick injection pump shaft on aluminum gear housing when removing pump.**

(31) Clean injection pump o-ring mounting surfaces on both gear housing and pump.

INSTALLATION

CAUTION: Before installing injection pump, be sure that number 1 cylinder is at Top Dead Center (compression stroke) position. Engage timing pin on rear of gear cover (Fig. 85) into rear of camshaft gear. Rotate crankshaft if necessary.

REMOVAL AND INSTALLATION (Continued)

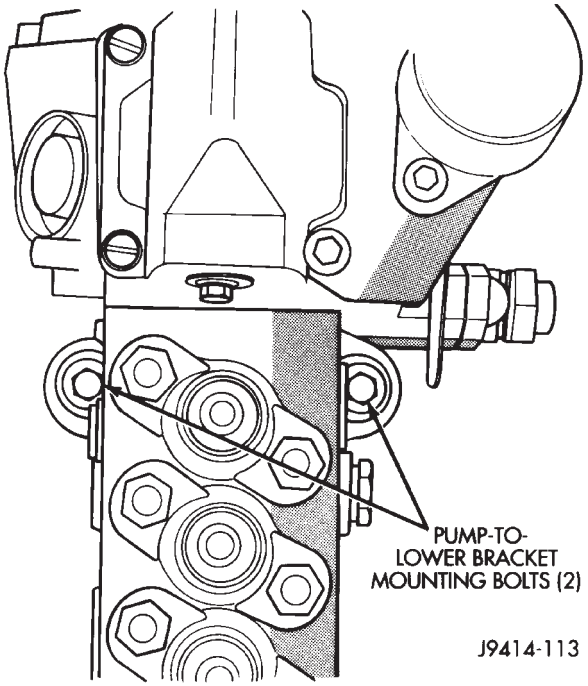


Fig. 90 Pump Mounting Bolts

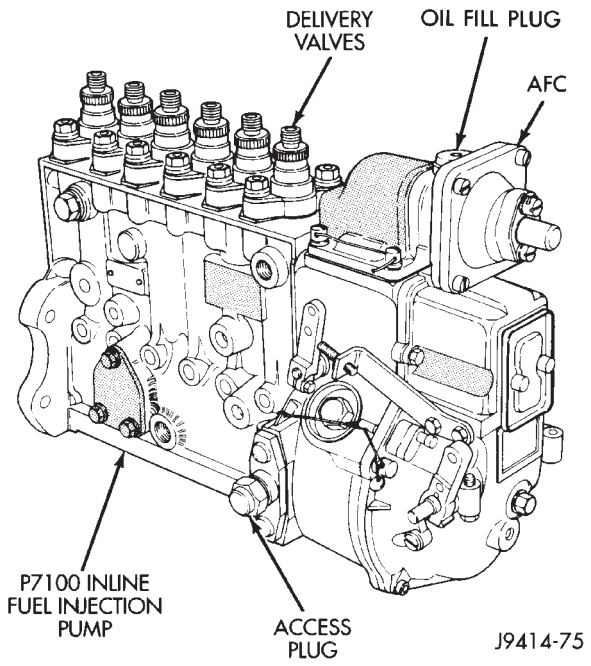


Fig. 91 Injection Pump Access Plug

Before injection pump installation, it must be set (pump shaft rotated) to a certain position to attain accurate pump timing. Remove access plug from side of pump (Fig. 91). Stored behind this access plug is a plastic timing pin tool (Fig. 92). This tool is used to align injection pump timing tooth (Fig. 93) to center of access hole.

Installing Original Pump: If original pump is being reinstalled, the pin tool should already be mounted with slotted end facing outward (Fig. 92). When position of this tool has been reversed, with slotted end facing inward, it is used as a pump timing pin tool.

Installing New or Rebuilt Pump: If a new or rebuilt pump is being installed, the pump should have been shipped with slotted end of timing pin tool engaged to timing tooth in pump.

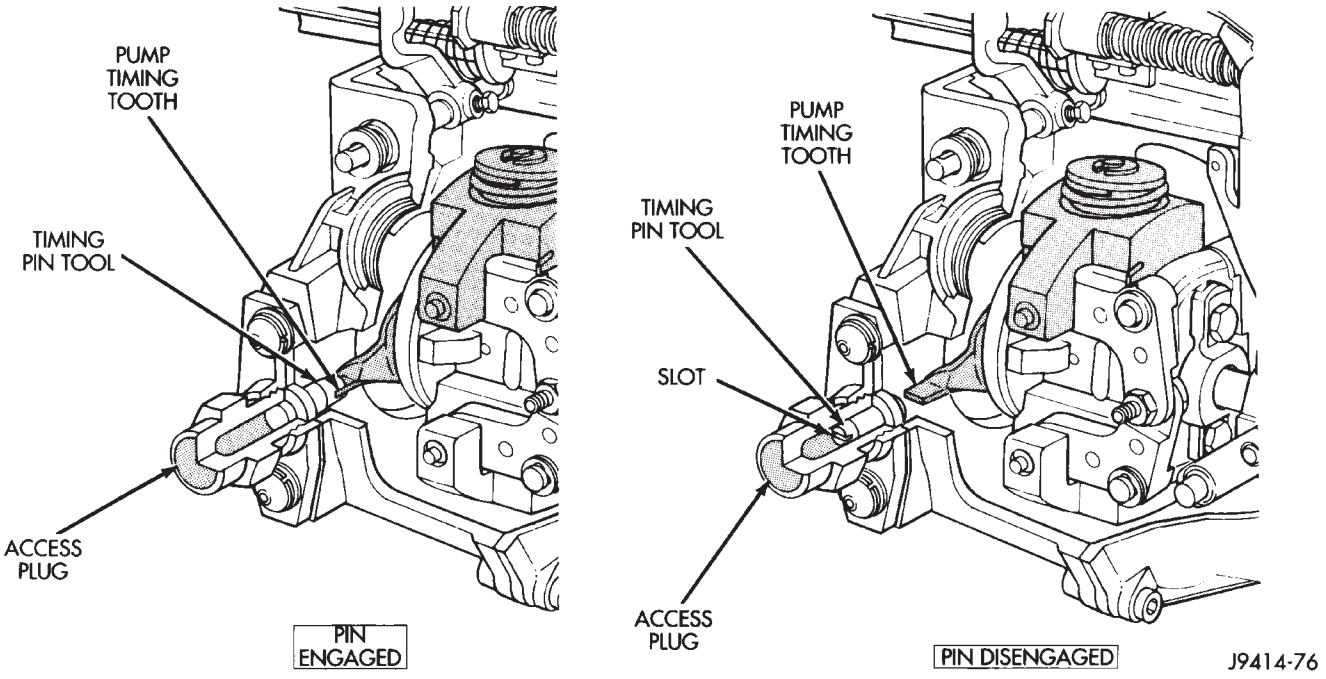


Fig. 92 Injection Pump Timing Pin Tool

REMOVAL AND INSTALLATION (Continued)

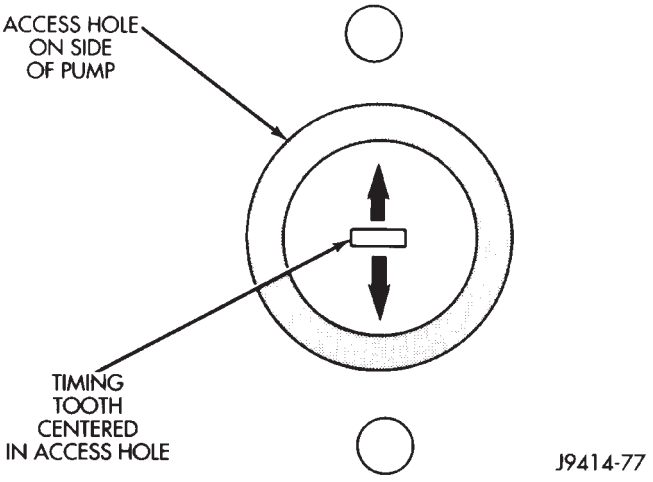


Fig. 93 Injection Pump Timing Tooth

To set injection pump timing on an original pump or when checking timing on a new pump, rotate pump shaft until timing tooth appears in center of plug opening (Fig. 93). Install slotted end of timing pin tool over timing tooth. The pump shaft may have to be rotated slightly to align tool to tooth. Do not force slots in tool over timing tooth.

After tool has been **temporarily** installed to timing tooth, install and loosely tighten access plug. New pumps should have been shipped with this tool already engaged.

(1) If original pump is being installed, check condition of rubber o-ring at pump mounting area. If o-ring has a colored stripe, it must be replaced.

(2) Apply clean engine oil to injection pump mounting flange opening in gear cover housing to allow easier pump installation (Fig. 94), but do not apply engine oil to pump o-ring seal at pump mounting area. **The machined tapers on both injection pump shaft and injection pump gear must be dry, clean and free of any dirt or oil. This will ensure proper gear-to-shaft tightening.**

(3) Position pump assembly to mounting flange on gear cover while aligning injection pump shaft through back of injection pump gear.

(4) Install four pump mounting nuts finger tight. **Do not attempt to tighten (pull) pump to gear cover using mounting nuts. Damage to pump or gear cover may occur. The pump must be positioned flat to its mounting flange before attempting to tighten mounting nuts.**

(5) Install two (vertical) pump mounting bracket bolts finger tight.

(6) Tighten four pump mounting nuts to 43 N·m (32 ft. lbs.) torque. Tighten two pump mounting bracket bolts. **To prevent damage to pump and mounting flange, tighten pump mounting nuts first.**

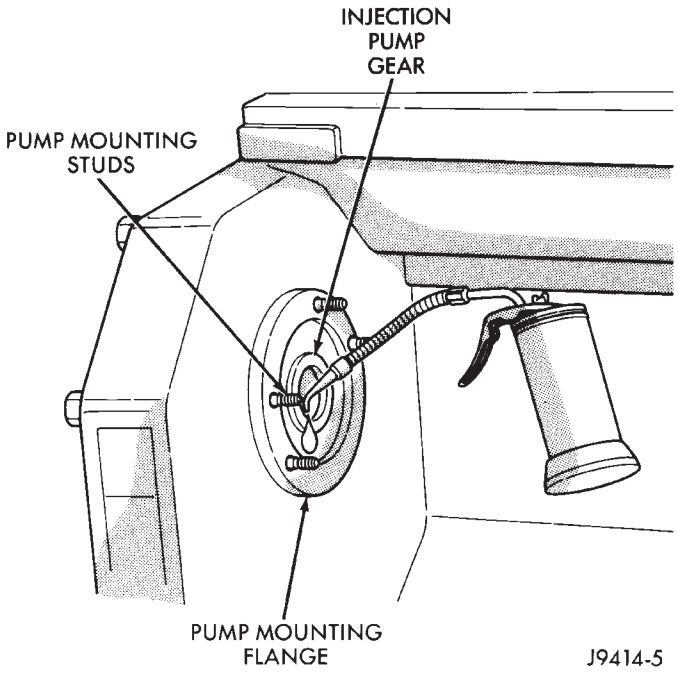


Fig. 94 Apply Oil to Gear Cover

(7) Install injection pump drive shaft-to-injection pump gear retaining nut and washer. **Do a preliminary tightening of this nut to 10 to 15 N·m (7 to 11 ft. lbs.) torque. Do not over tighten. This is not the final tightening torque. To prevent damage to timing pin, do not exceed this torque.**

(8) Disengage timing pin from the rear of camshaft gear by pulling it straight back.

(9) Remove access plug from injection pump (Fig. 91) and remove timing pin tool from pump.

(10) Do a final tightening of injection pump gear-to-injection pump shaft nut. Tighten to 195 N·m (144 ft. lbs.) torque. Use barring tool to prevent engine from rotating when tightening gear.

(11) After injection pump gear has received a final tightening, verify injection pump timing.

(a) Rotate engine counterclockwise with barring tool (clockwise as observed at crankshaft from front of vehicle). Continue rotating engine until timing pin aligns into hole at rear of camshaft gear (Fig. 86). The engine is now at TDC of number cylinder 1.

(b) With timing pin aligned into rear of camshaft gear, timing tooth should also be centered in access hole on side of injection pump (Fig. 93). Install timing pin tool (Fig. 92) to verify.

(c) If timing pin tool will not fit into timing tooth in pump, pump gear nut must be removed. Loosen pump gear from pump shaft with T-bar puller tool. With gear loosened, rotate injection pump shaft until it aligns to center of access hole on side of pump. Tighten injection gear nut and remove barring tool.

REMOVAL AND INSTALLATION (Continued)

(12) Remove timing pin tool from pump. Reverse position of this tool (Fig. 92). The slotted part of tool should be facing outward and will be stored in pump in this direction. Place tool back into pump. Install access plug and its sealing washer. Tighten plug to 15 N·m (11 ft. lbs.) torque.

(13) Install engine oil supply line to pump.

(14) Install fuel return line/overflow valve to pump. New or remanufactured fuel injection pumps should have a new overflow valve temporarily installed into side of pump. **Do not install a used overflow valve into a new or remanufactured pump.** Tighten valve to 30 N·m (24 ft. lbs.) torque.

(15) Install six high-pressure fuel lines to top of pump. Tighten lines to 30 N·m (22 ft. lbs.) torque.

(16) Install low-pressure fuel supply line to pump.

(17) Install AFC valve control line at rear of pump.

(18) **New or rebuilt P7100 series fuel injection pumps must be pre-lubricated before operation. Failure to do so may result in pre-mature governor wear.**

(a) Remove 10 mm hex plug (oil fill plug) on top of injection pump governor (Fig. 91).

(b) Add 750 ml (25 ounces) of clean engine oil through this opening.

(c) Install oil fill plug and tighten to 28 N·m (21 ft. lbs.) torque.

(19) Install throttle linkage assembly to pump. Tighten bolts to 24 N·m (18 ft. lbs.) torque.

(20) Connect electrical connector to fuel solenoid.

(21) Connect main engine wiring harness at top of injection pump.

(22) Install engine oil dipstick tube mounting clamp and bolt at opening to intake manifold.

(23) Install oil fill tube and tube adapter.

(24) Install oil fill tube bracket and mounting bolt.

(25) Install electrical connector to throttle position sensor (if equipped).

(26) Install air cleaner housing-to-turbocharger tube at air cleaner housing.

(27) Using a new gasket, install air heater assembly (five bolts).

(28) Install EGR tube (if equipped). Refer to Group 25, Emission Control System for procedures.

(29) Install intake manifold-to-intercooler tube.

(30) Check and adjust throttle linkage. Refer to Throttle Position Sensor in this group.

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

(32) Adjust low idle speed if required. Refer to Idle Speed Adjustment.

(33) Inspect throttle linkage to be sure that control lever is opening to full open position.

(34) Some engine oil was lost when removing pump. Check and adjust engine oil level.

FUEL INJECTORS

REMOVAL

(1) Disconnect both negative battery cables from both batteries.

(2) Remove high-pressure fuel lines. Refer to High-Pressure Fuel Lines in this section. **Do not bend any high-pressure fuel line to gain access to fuel injector.**

(3) Remove fuel drain manifold. Refer to Fuel Drain Manifold in this section.

(4) Thoroughly clean the area around injector.

CAUTION: When rust has formed on the fuel injector nut, the injector (when being removed) can rotate in the cylinder head. This may cause damage to the cylinder head bore. Use a rust penetrating solvent (Fig. 95) before attempting to loosen a rusted holddown nut.

(5) Hold injector body with one wrench while removing injector mounting nut with another (Fig. 96). If nut cannot be rotated, pry out the square cut rubber seal from top of injector mounting nut (Fig. 95) and apply rust penetrating solvent to top of nut. Remove injector from cylinder head.

(6) Remove injector mounting nut (Fig. 97) from injector.

(7) Remove and discard square cut rubber seal (Fig. 97) from injector mounting nut.

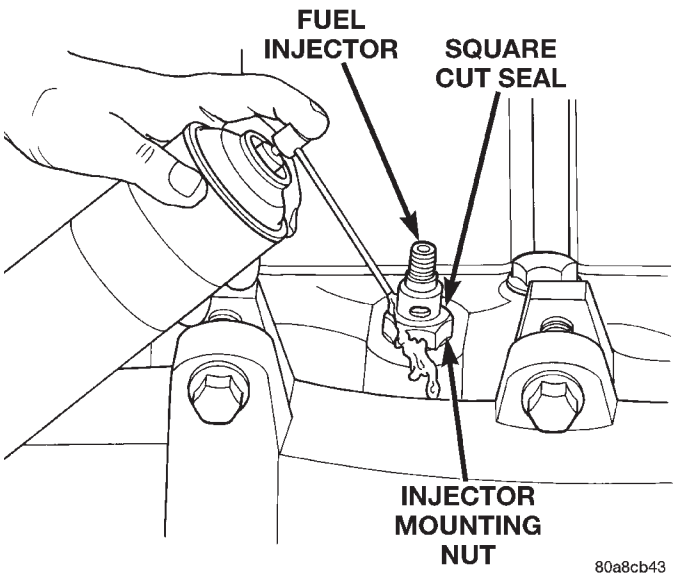


Fig. 95 Applying Rust Penetrating Solvent to Injector Mounting Nut

(8) If injector is tight in cylinder head, hit injector body with a brass drift to loosen it (Fig. 98).

(9) It may be necessary to tap the injector with an injector puller tool (Fig. 99). Use Cummins Fuel Injector Removal Tool number 3823276 or equivalent

REMOVAL AND INSTALLATION (Continued)

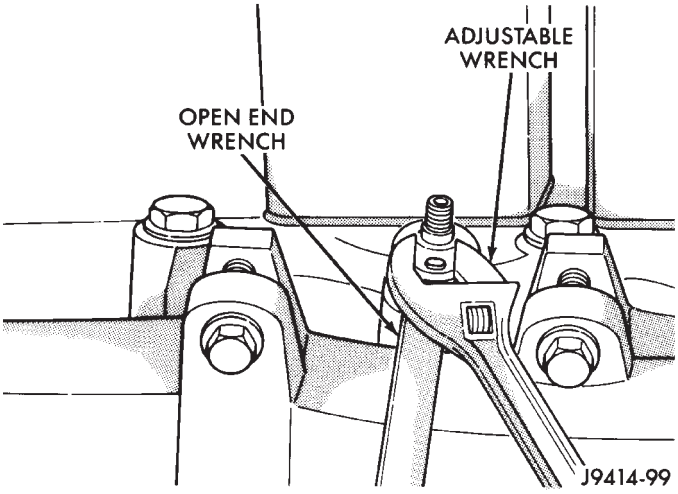


Fig. 96 Loosening Injector Mounting Nut

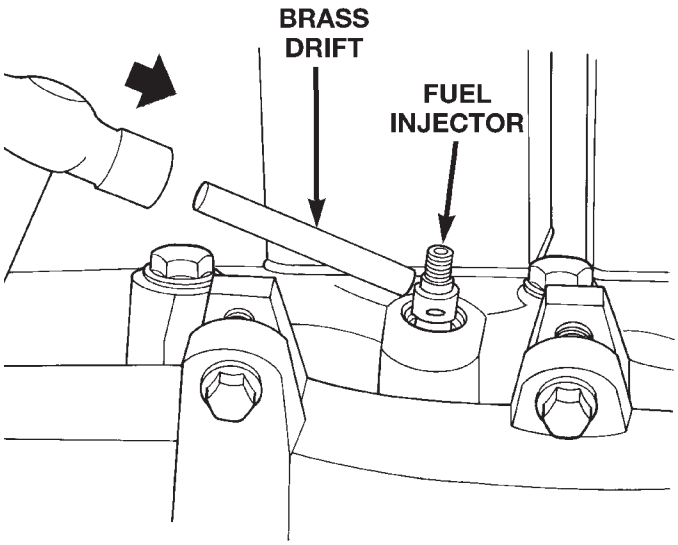


Fig. 98 Loosening Injector Body in Cylinder Head

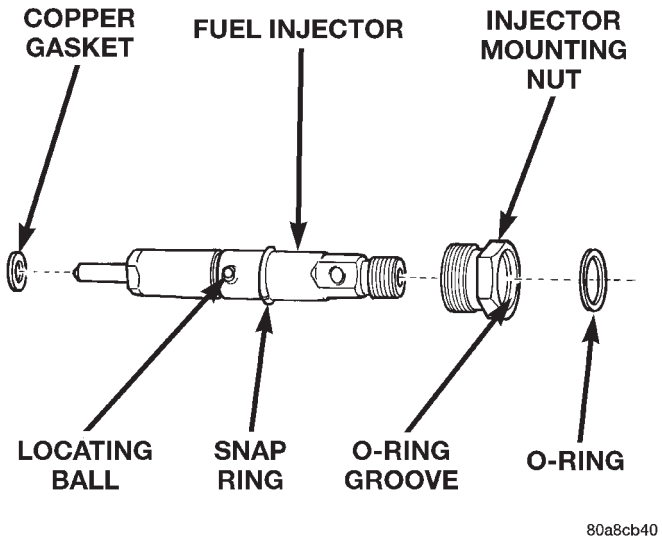


Fig. 97 Fuel Injector Assembly

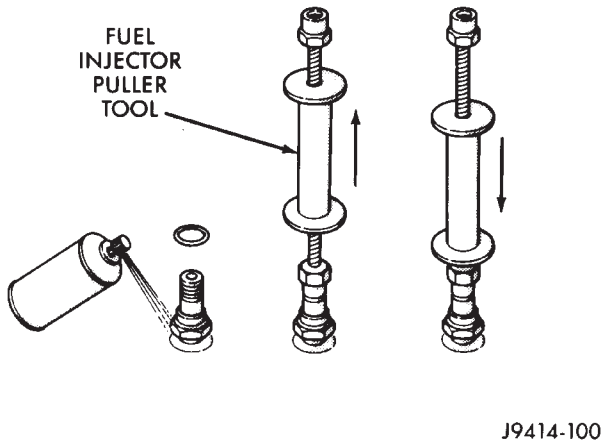


Fig. 99 Removing Injector with Puller Tool

injector removal tool. If the injector cannot be removed, carbon may have formed at the injector nozzle. In this case, use of carb cleaner is recommended. Spray the carb cleaner along the side of injector bore in the cylinder head. Continue to use the injector removal tool while spraying the injector.

(10) Remove and discard copper washer (gasket) (Fig. 97) from bottom of injector.

INSTALLATION

(1) Clean injector cylinder head bore with special Cummins wire brush tool or equivalent (Fig. 100).

(2) Install a new copper washer to bottom of injector (Fig. 97). Apply a light coating of clean engine oil to this washer. This will keep the washer in place during installation.

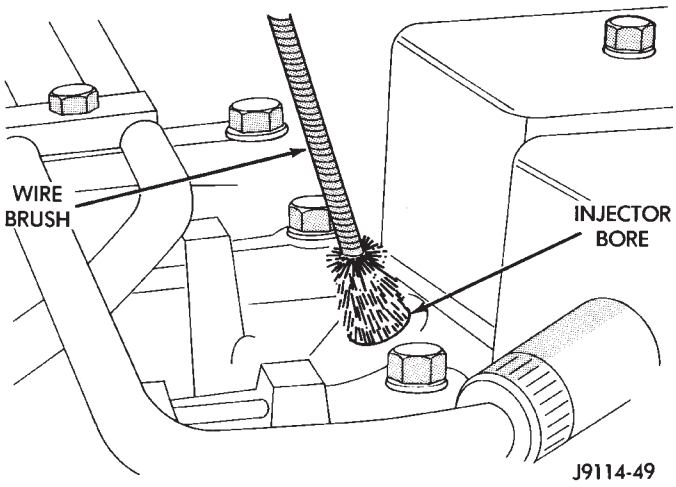


Fig. 100 Cleaning Cylinder Head Injector Bore

REMOVAL AND INSTALLATION (Continued)

(3) Apply a coating of anti-seize compound to the threads of the injector holddown nut and between top of nut and injector body (Fig. 101).

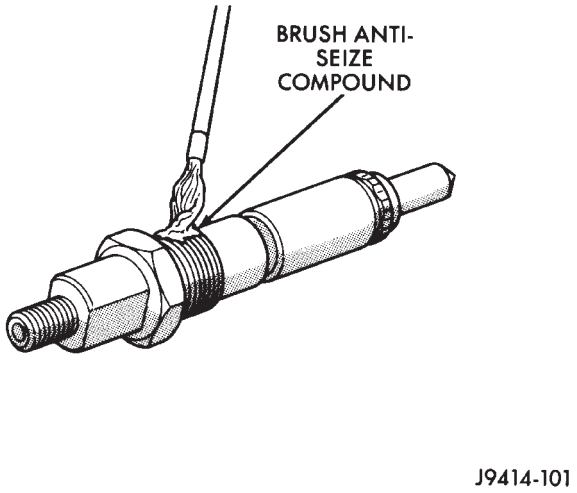


Fig. 101 Apply Anti-Seize Compound

(4) Install injector into cylinder head. **Align ball on side of injector into notch in cylinder head (Fig. 102).**

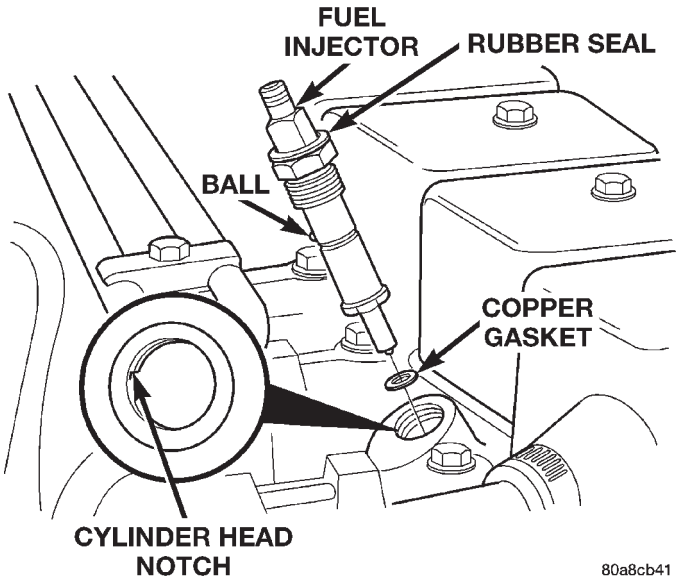


Fig. 102 Installing Injector

(5) Tighten injector holddown nut to 60 N·m (44 ft. lbs.) torque.

(6) After tightening injector holdown (mounting) nut, push the square cut rubber seal into groove on top of injector holdown nut (Fig. 103). This seal will prevent water from entering cylinder head bore.

(7) Connect fuel drain manifold to the injectors. Refer to Fuel Drain Manifold in this section.

(8) Connect high-pressure fuel lines. Refer to High-Pressure Fuel Lines in this section.

(9) Connect negative battery cables to both batteries.

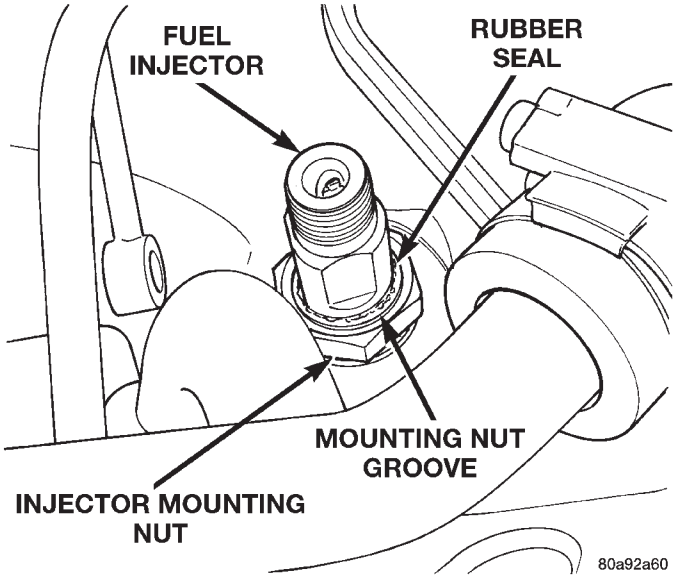


Fig. 103 Rubber Seal at Injector Mounting Nut

(10) Bleed the air from the high-pressure lines. Refer to High-Pressure Line Bleeding in the Air Bleed Procedure section of this group.

FUEL SHUTDOWN SOLENOID

REMOVAL

The fuel shutdown solenoid is mounted to a bracket located on the side of the fuel injection pump (Fig. 104).

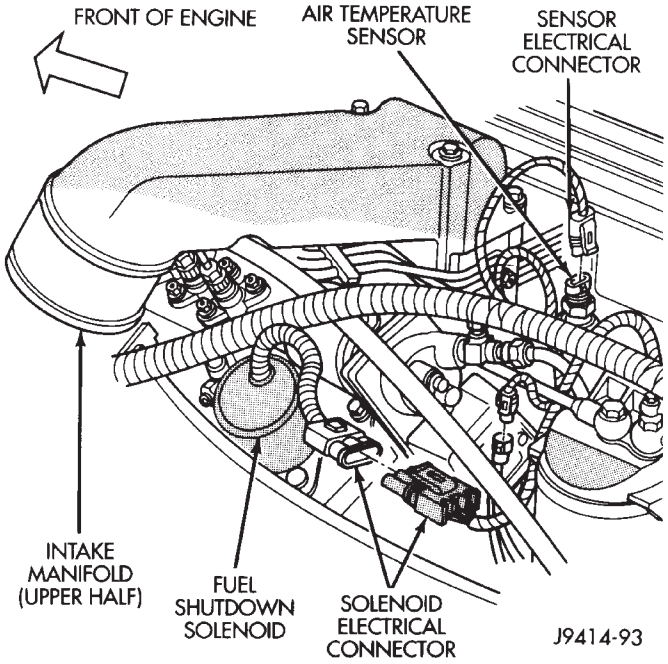


Fig. 104 Fuel Shutdown Solenoid Location

(1) Disconnect the solenoid electrical connector (Fig. 104).

REMOVAL AND INSTALLATION (Continued)

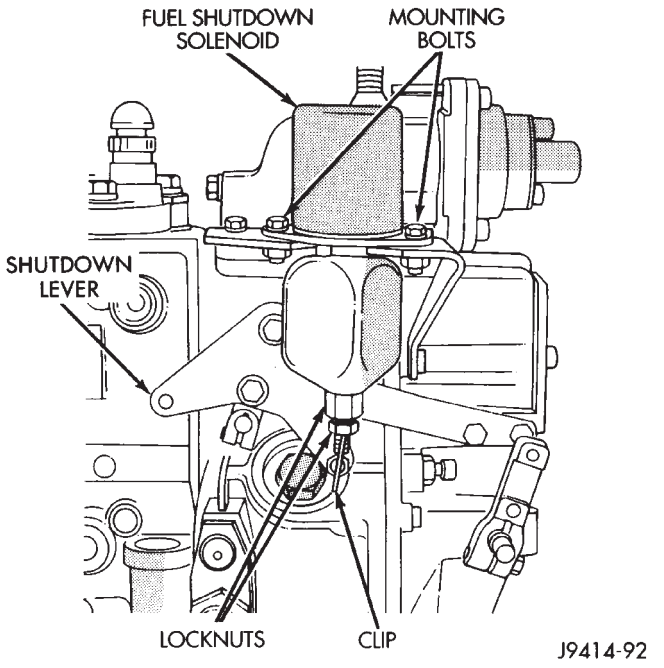


Fig. 105 Fuel Shutdown Solenoid Removal/ Installation

(2) Disconnect clip at injection pump shutdown lever (Fig. 105).
(3) Remove two solenoid mounting bolts.
(4) Remove solenoid from mounting bracket.

INSTALLATION

(1) Position solenoid to mounting bracket and injection pump lever.
(2) Install clip at injection pump lever.
(3) Install and tighten two mounting bolts.
(4) Check and adjust the shaft length of the solenoid. Refer to the following procedure:

SOLENOID SHAFT ADJUSTMENT

After replacing the fuel shutdown solenoid, the solenoid shaft length must be checked and if necessary, adjusted.
(1) Turn the ignition switch ON.
(2) Pull up (by hand) and hold on the solenoid lever (Fig. 106). **If the solenoid is operating correctly, it should remain in the UP position with the key in the ON position.**
(3) Take a measurement from the bottom of the solenoid mounting bracket to the top of the injection pump shutdown lever pin (Fig. 107).
(4) Dimension should be 66.9 mm (2.64 inches).
(5) If adjustment is necessary, loosen the shaft locknut and rotate the adjustment nut (Fig. 108) to attain dimension.

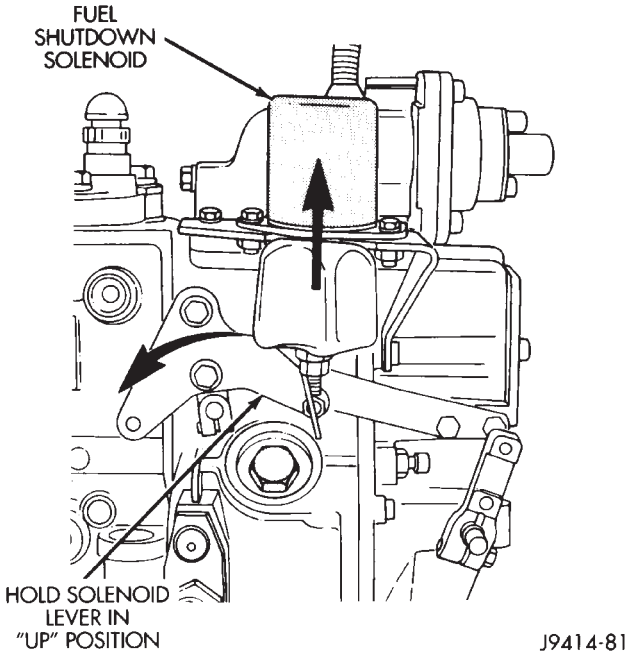


Fig. 106 Fuel Shutdown Solenoid Lever in Up Position

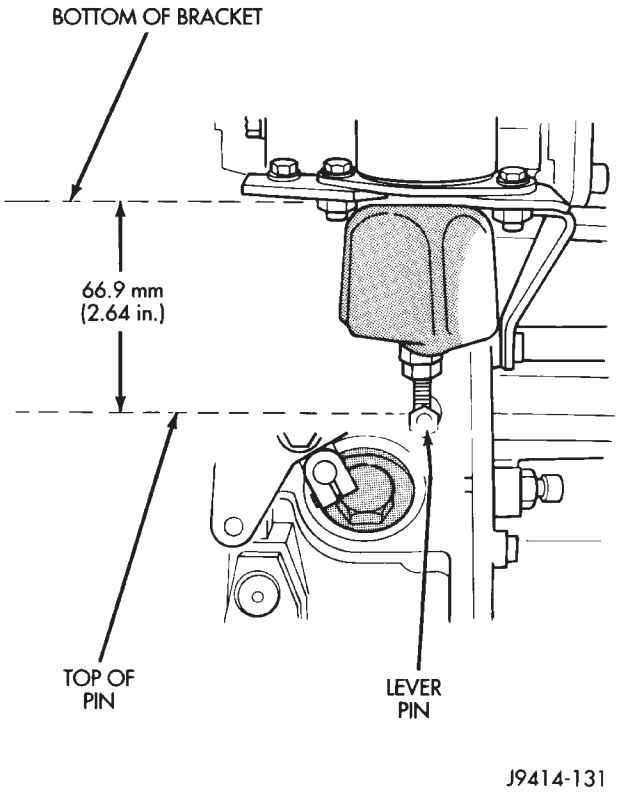


Fig. 107 Solenoid Measurement

REMOVAL AND INSTALLATION (Continued)

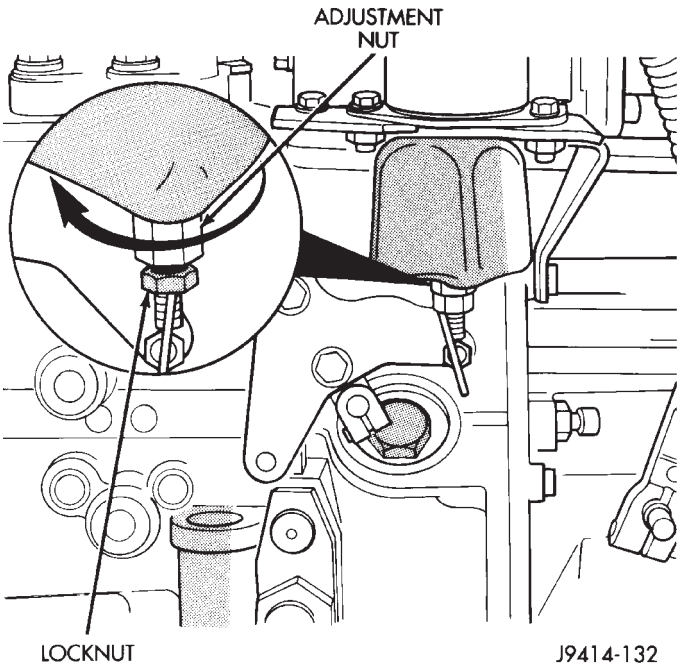


Fig. 108 Solenoid Adjustment

FUEL SHUTDOWN SOLENOID RELAY

The fuel shutdown solenoid relay is located in the engine compartment near the brake master cylinder (Fig. 109).

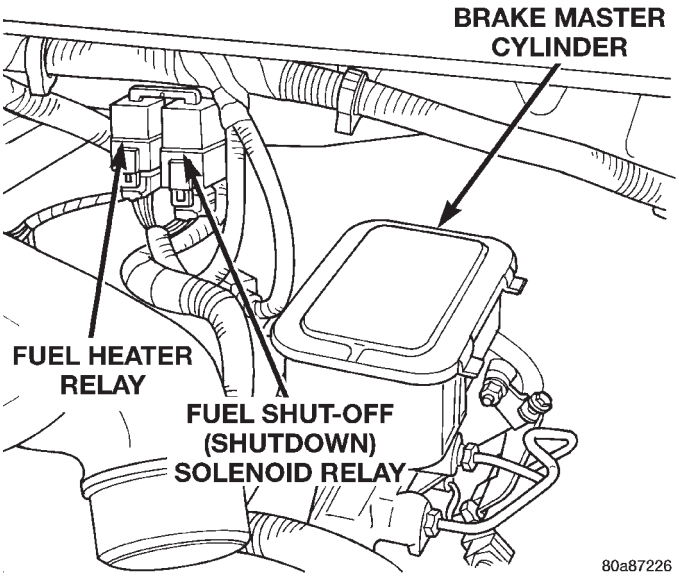


Fig. 109 Fuel Shutdown Solenoid Relay—Diesel

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect the electrical connector at the relay.

(3) Remove the relay from the mounting bracket.

INSTALLATION

(1) Check the terminals within connector for damage or corrosion. Also check pin height of terminals within connector. Pin heights should be the same. Repair as necessary before connecting relay.

(2) Install the relay to the mounting bracket.

(3) Connect the electrical connector.

(4) Connect battery cables to both batteries.

FUEL TRANSFER PUMP

For operation of the fuel transfer pump primer button, refer to the Air Bleed Procedure in this group.

The fuel transfer pump (fuel lift pump) is located on the left side of the engine and above the starter motor (Fig. 110). The mounting bracket/spacer for the fuel heater assembly is located between the engine block and the fuel transfer pump (Fig. 111). The fuel heater housing and its bracket assembly must also be removed when removing fuel pump.

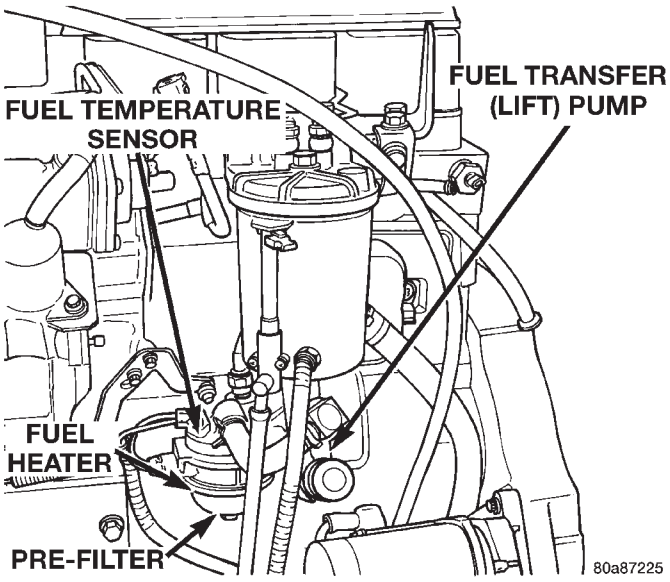


Fig. 110 Fuel Transfer Pump Location

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Thoroughly clean the area around transfer pump and fuel lines of any contamination.

(3) Remove starter motor. Refer to Starter in Group 8B for procedures.

(4) Place a drain pan below the pump.

(5) Remove fuel line fittings at top of both the fuel pump and fuel heater housing (Fig. 111). Use back-up wrench to prevent damage to fittings.

(6) Remove fuel hose clamps and rubber fuel hose (fuel heater housing-to-fuel pump) (Fig. 111).

(7) The engine camshaft lobe must be at its low point in relation to end of pump piston (Fig. 112). Before removing or installing pump, rotate engine until camshaft is at low point. If cam lobe is at high

REMOVAL AND INSTALLATION (Continued)

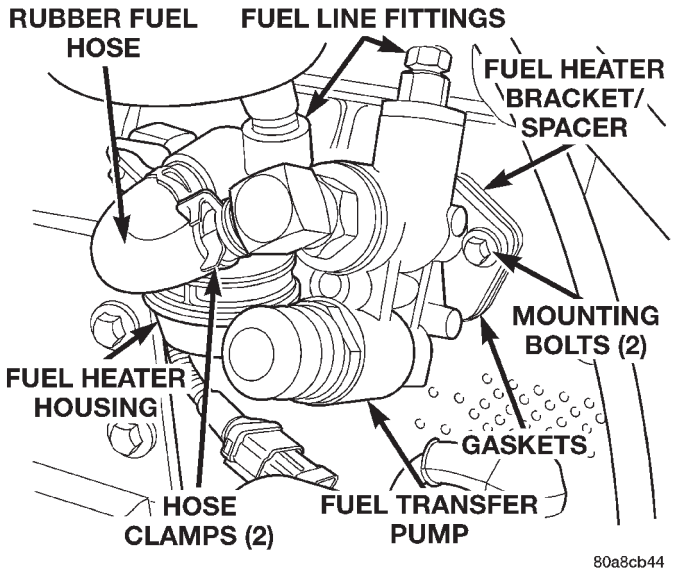


Fig. 111 Pump Removal/Installation

point, removal and installation of pump mounting bolts may be very difficult. Damage to pump may also occur.

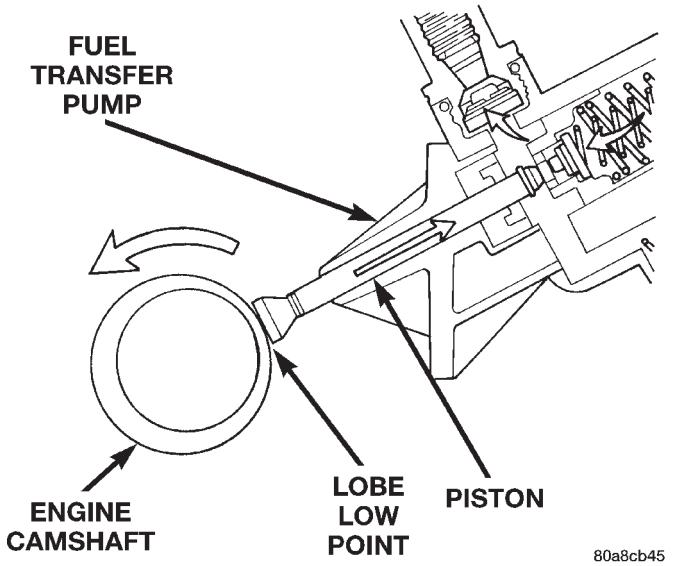


Fig. 112 Fuel Transfer Pump Piston at Engine Camshaft

NOTE: Locate top dead center (TDC) on cylinder #1.

(8) Remove the rubber access plug located in the rear flange of the engine on the exhaust manifold side. (Fig. 113).

NOTE: Removing the #1 cylinder valve cover and first barring (rotating) the engine clockwise until both intake and exhaust valves are closed will speed up locating engine TDC as described later in Step 10.

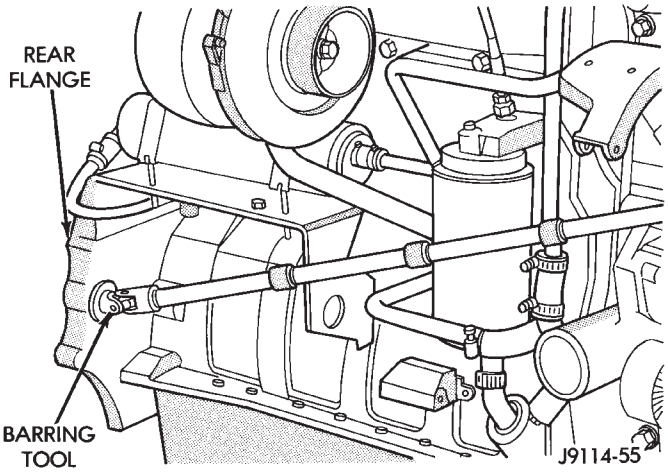


Fig. 113 Rotating Engine With Barring Tool

(9) Insert the barring tool number 7471B through the access hole and into the flywheel housing (Fig. 113).

(10) While holding tension on the timing pin (toward front of engine), slowly rotate the engine with the barring tool. Hold a slight rearward (pushing) pressure on the barring tool and continue to rotate the tool until the timing pin drops into the machined hole in the back of the camshaft gear. When the pin aligns to the gear (Fig. 114), and the intake and exhaust valves are closed at the #1 cylinder, the engine is at the TDC position (compression stroke) at cylinder number 1. **After TDC has been established, remove the pin. This will prevent pin damage when barring (rotating) the engine in later steps.**

NOTE: The pin is located above the power steering pump, below and to the inside of the fuel injection pump, on the rear of the cam gear housing (Fig. 115).

(11) After TDC has been established, rotate engine another 180–270 degrees. The camshaft lobe will now be at its lowest point.

(12) Remove two pump mounting bolts (Fig. 111).

(13) Remove the fuel pump and fuel heater assembly from the engine as one unit.

CAUTION: Do not allow pump plunger (piston) to catch on edge of hole in cylinder block during removal. Plunger may slide out and drop into engine.

INSTALLATION

(1) While fuel heater is off vehicle, disassemble it and clean pre-filter and screen. Install new seals to fuel heater. Refer to Fuel Heater Removal/Installation for procedures.

REMOVAL AND INSTALLATION (Continued)

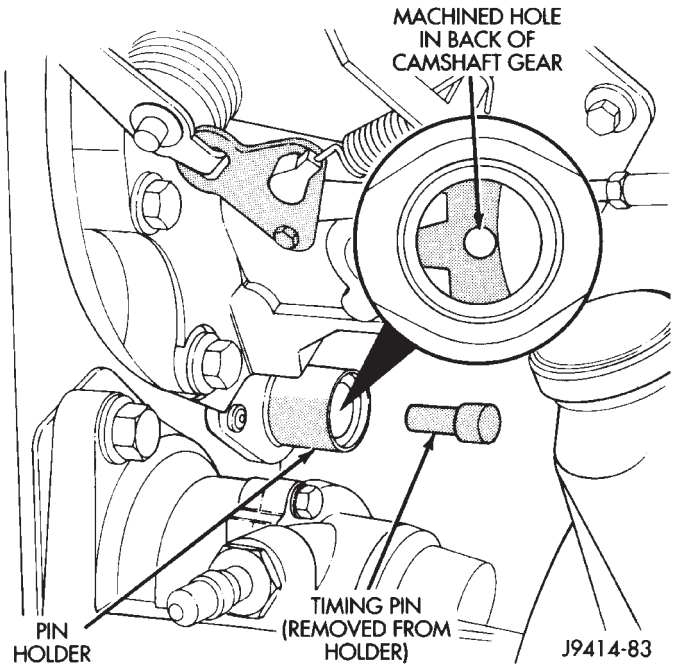


Fig. 114 Back of Camshaft Gear—Typical

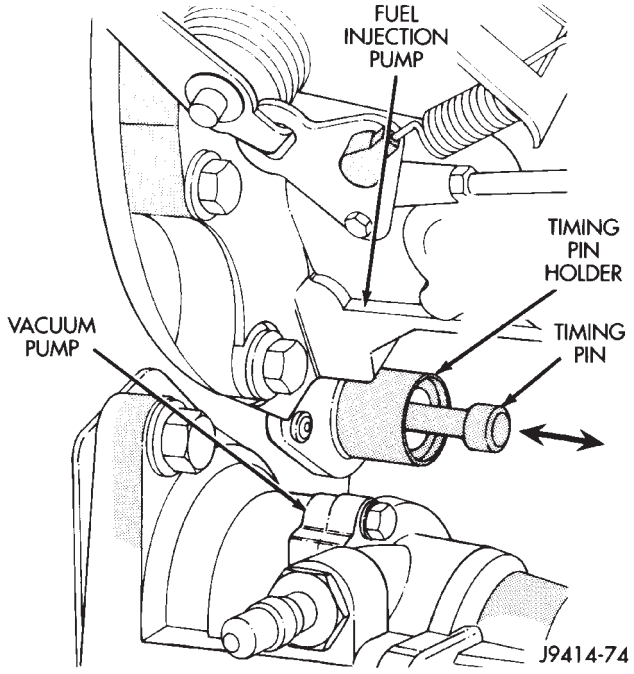


Fig. 115 Timing Pin and Location

(2) Clean the mating surfaces of the fuel heater mounting bracket, the fuel pump and the engine block of any gasket material.

(3) Position the new gaskets, the fuel heater housing mounting bracket and the fuel pump to the engine.

(4) Install the two mounting bolts into the engine. Tighten to 24 N·m (18 ft. lbs.) torque. **As these bolts are tightened, the plunger (piston) within the fuel pump is being compressed. Tighten these two bolts alternately to prevent damage to the fuel pump or camshaft.**

(5) Install fuel line fittings to pump and fuel heater. Tighten to 24 N·m (18 ft. lbs.) torque.

(6) Install a new fuel filter. Refer to Fuel Filter/Water Separator Removal/Installation for procedures.

(7) Install starter motor. Refer to Starter in Group 8B for procedures.

(8) Connect battery cables at both batteries.

(9) Bleed air from fuel system. Refer to the Air Bleed Procedure.

(10) Start engine and check for leaks.

OVERFLOW VALVE

Whenever the fuel injection pump is being replaced or removed for calibration, the overflow valve must stay with the pump. Make sure a new overflow valve is used with a new injection pump and the old (original) overflow valve is returned to the authorized repair facility with the old injection pump.

The overflow valve (pressure relief valve) is located at the inside/front of injection pump (Fig. 116). It connects the fuel return line (banjo fitting) to the pump. The valve has no internal serviceable parts and must be replaced as an assembly. Two sealing gaskets are used. One gasket is located between pump and banjo fitting. The other is located between the banjo fitting and end of valve.

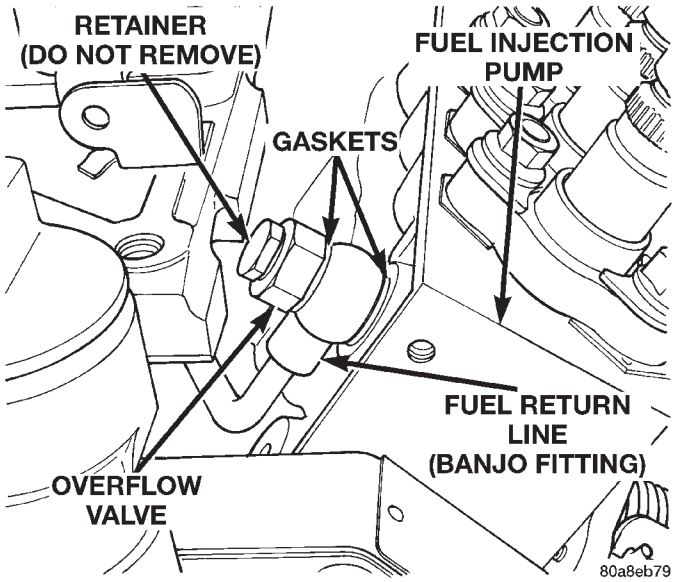


Fig. 116 Overflow Valve Location

REMOVAL

(1) Clean area around overflow valve and fuel return line at injection pump before removal.

(2) Remove valve assembly from pump and banjo fitting. **Do not remove retainer (Fig. 116) from valve. This retainer is spring-loaded.** If fuel

REMOVAL AND INSTALLATION (Continued)

return line must be positioned for removal, very carefully bend line.

(3) Discard old sealing gaskets.

INSTALLATION

(1) Install new sealing gaskets to valve.

(2) Install valve through banjo fitting and into pump.

(3) Tighten to 30 N·m (24 ft. lbs.) torque.

HIGH-PRESSURE FUEL 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.

Whenever the high-pressure lines are removed, they should be removed as a bundle (if possible). They should also be tagged for return to original position.

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 both negative battery cables from both batteries.

(2) Remove the nameplate/cover from the top of the six engine valve covers (two nuts) (Fig. 117).

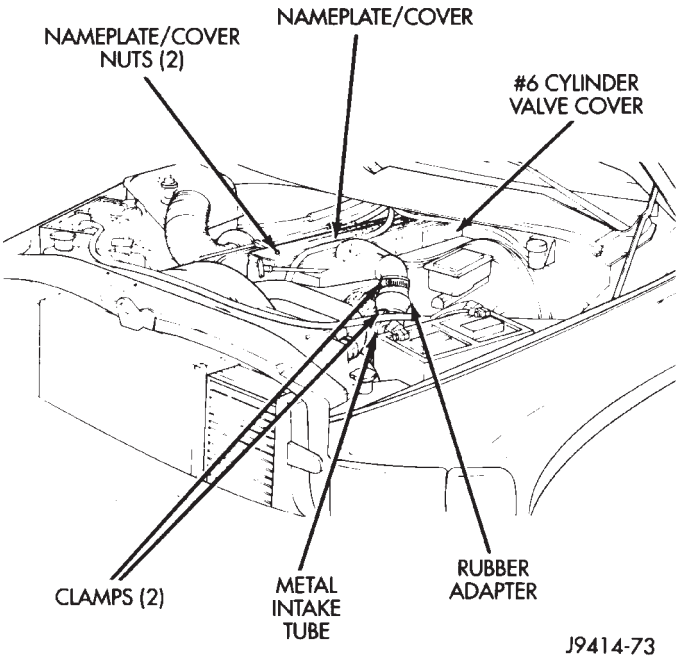


Fig. 117 Nameplate/Cover—Diesel

(3) Remove the necessary clamps holding the lines to the engine.

(4) Clean the area around each line. Disconnect each line at the top of each fuel injector (Fig. 118).

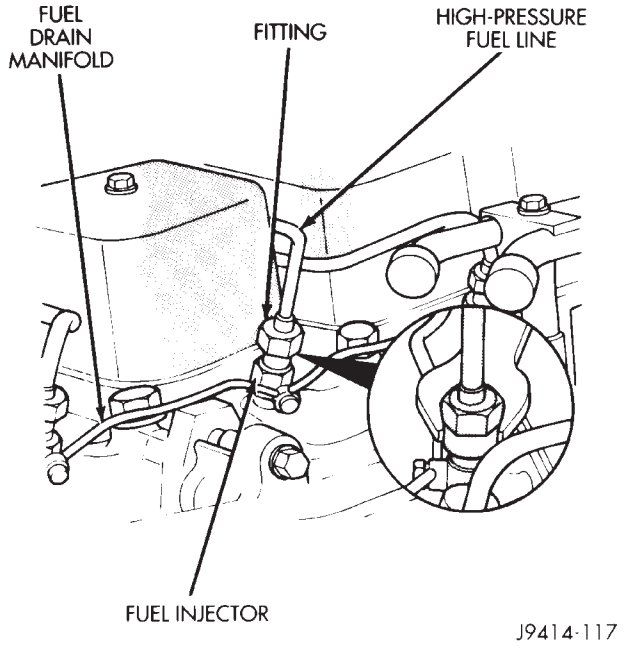


Fig. 118 Fuel Lines at Fuel Injectors

(5) Disconnect each high-pressure line fitting at each fuel injection pump delivery valve holder (Fig. 119).

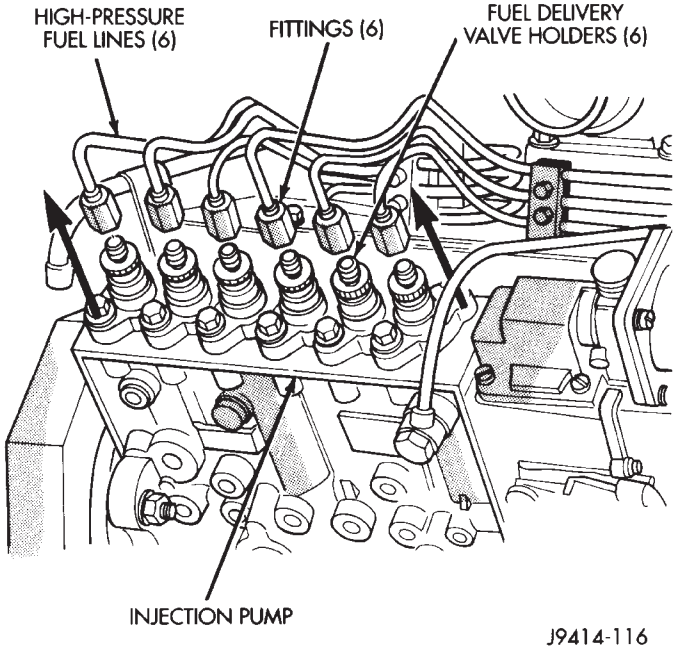


Fig. 119 Fuel Delivery Valve Holders and Pressure Lines

REMOVAL AND INSTALLATION (Continued)

(6) Very carefully remove each line from the engine. **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.

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 isolator and bracket holder bolts.

(3) Tighten each line at the delivery valve holder to 24 N·m (18 ft. lbs.) torque.

(4) Tighten each line at the fuel injector to 24 N·m (18 ft. lbs.) torque.

CAUTION: Be sure the lines are not contacting each other or any other component. Noise will result.

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

(6) Bleed air from the fuel system. Refer to High-Pressure Fuel Line Bleeding in the Air Bleed Procedure section of this group.

THROTTLE CABLE

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

REMOVAL

(1) From inside the vehicle, hold up the accelerator pedal. Remove the plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 120). The plastic cable retainer snaps into pedal the arm.

(2) Remove the cable core wire at the pedal arm.

(3) From inside the vehicle, pinch both sides of the plastic cable housing retainer tabs at the dash panel (Fig. 120).

(4) Remove cable housing from dash panel and pull the cable into the engine compartment.

(5) Remove the throttle cable socket at fuel injection lever ball (Fig. 121).

(6) A rubber/plastic grommet is molded to the cable (Fig. 121). This grommet is pressed into the back of the cable mounting bracket. Apply lubricant to the rubber grommet (Fig. 121) on both sides of the cable mounting bracket. Work the rubber grommet (rearward) through the mounting bracket with two small screwdrivers. Remove throttle cable from vehicle.

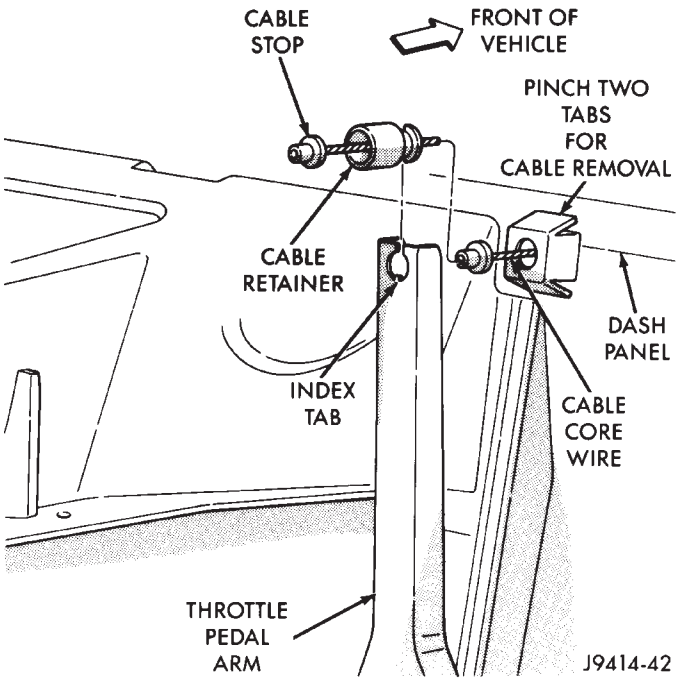


Fig. 120 Cable Removal/Installation

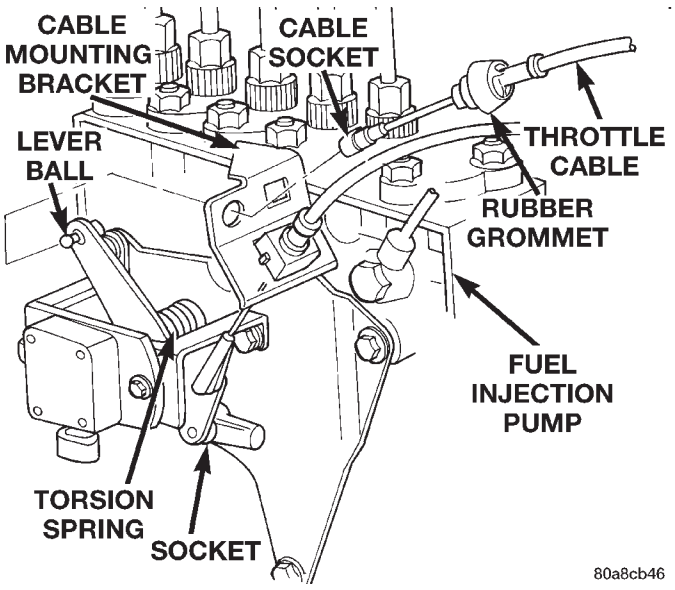


Fig. 121 Throttle Cable at Injection Pump—Diesel Engine

INSTALLATION

(1) Feed the cable through the rear of its mounting bracket (Fig. 121) until the rubber/plastic grommet locks into position on the bracket.

(2) Connect cable end socket to the fuel injection pump lever ball (snaps on).

(3) Install the remaining cable housing end into and through the dash panel opening (snaps into posi-

REMOVAL AND INSTALLATION (Continued)

tion). The two plastic pinch tabs (Fig. 120) should lock the cable to dash panel.

(4) From inside the vehicle, hold up the accelerator pedal. Install the throttle cable core wire and plastic cable retainer into and through the upper end of the pedal arm (the plastic retainer is snapped into the pedal arm). When installing the plastic retainer to the accelerator pedal arm, note the index tab on the pedal arm (Fig. 120). Align the index slot on the plastic cable retainer to this index tab.

SPECIFICATIONS

ENGINE DATA PLATE

If anything differs between the specifications found on the Engine Data Plate, and the specifications used in this manual, use specifications on data plate. The Engine Data Plate is located on the engine timing gear cover (Fig. 122).

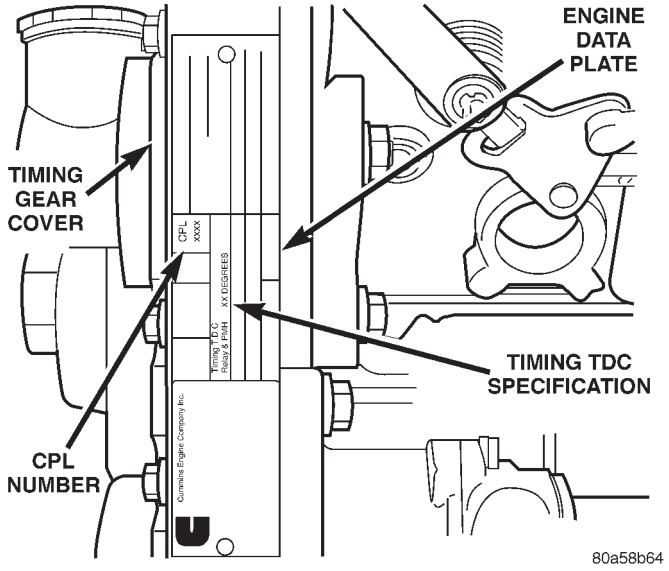


Fig. 122 Engine Data Plate Location

FUEL TANK CAPACITY—DIESEL ENGINE

MODEL	LITERS	U.S. GALLONS
138″ Wheelbase With Extended Cab (Diesel Powered)	129	34
All Other Diesel Powered Models	132	35
Nominal refill capacities are shown. A variation may be observed from vehicle to vehicle due to manufacturing tolerance and refill procedure.		

FUEL SYSTEM PRESSURES—DIESEL ENGINES

DESCRIPTION	PRESSURE
Fuel Transfer (Lift) Pump Pressure	.117–152 kPa (17–22 psi) at idle speed. At 2500 rpm (rated rpm), 172–207 kPa (25–30 psi)
Fuel Injector “Pop Off” Pressure	.23,400 kPa to 26,800 kPa (234 bars to 268 bars) (3,394 psi to 3,887 psi)

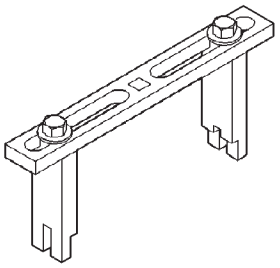
SPECIFICATIONS (Continued)

TORQUE CHART—DIESEL ENGINES

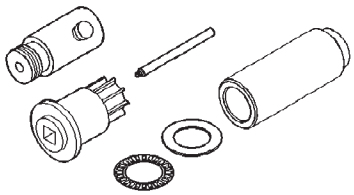
DESCRIPTION	TORQUE
Air-Fuel Control (AFC) Line Fitting	24 N·m (18 ft. lbs.)
Banjo Fitting at top of Filter/Separator	24 N·m (18 ft. lbs.)
Banjo Fitting at side of Fuel Injector	8 N·m (6 ft. lbs.)
Banjo Fitting—Fuel Supply Line at side of Injector Pump	24 N·m (18 ft. lbs.)
Engine Speed Sensor Nuts/Bolts	24 N·m (18 ft. lbs.)
Fuel Drain Manifold Fitting Bolts at Injectors	9 N·m (7 ft. lbs.)
Fuel Filter Mounting Nut	14 N·m (10 ft. lbs.)
Fuel Hose Clamps	1 N·m (15 in. lbs.)
Fuel Injector Retaining Nut	60 N·m (44 ft. lbs.)
Fuel Pump Module Locknut	24–44 N·m (18–32 ft. lbs.)
Fuel Tank Mounting Nuts	41 N·m (30 ft. lbs.)
Fuel Transfer Pump Mounting Bolts	24 N·m (18 ft. lbs.)
High-Pressure Fuel Line Fittings	24 N·m (18 ft. lbs.)
High-Presure Fuel Line Fitting Clamps	6 N·m (4 ft. lbs.)
Injector Pump Access Plug	15 N·m (11 ft. lbs.)
Injection Pump-to-Injection Pump Gear Nut	195 N·m (144 ft. lbs.)
Injection Pump Mounting Nuts	43 N·m (32 ft. lbs.)
Injection Pump Oil Fill Plug	28 N·m (21 ft. lbs.)
Intake Manifold Air Temp. Sensor	28 N·m (20 ft. lbs.)
Intake Manifold Air Heater Relay Bolts	4.5 N·m (40 in. lbs.)
Low-Pressure Bleed Bolt (Screw)	8 N·m (6 ft. lbs.)
Overflow Valve-to-Fuel Injection Pump	30 N·m (24 ft. lbs.)

SPECIAL TOOLS

DIESEL FUEL SYSTEM



Spanner Wrench—6856



Diesel Timing Kit—6714

FUEL INJECTION SYSTEM-DIESEL ENGINE

INDEX

GENERAL INFORMATION

INTRODUCTION

Various components, relays and switches are operated by the powertrain control module (PCM). **This section of the group will cover a description and operation of components controlled by the PCM for vehicles equipped with diesel powered engines.**

Diesel fuel injection system components, except for the intake manifold air heater elements, are **not** directly regulated by the PCM.

Refer to the Fuel Delivery System—Diesel Engine section of this group for fuel components **not** oper-

GENERAL INFORMATION (Continued)

ated or regulated by the PCM. These components are the:

- Fuel tank
- Fuel tank module
- Low and high-pressure fuel supply lines
- Low-pressure, mechanical, fuel transfer pump (fuel lift pump)
- High-pressure fuel injection pump
- Fuel filter/water separator
- Fuel heater
- Fuel heater relay
- Fuel shutdown solenoid
- Fuel shutdown solenoid relay
- High-pressure fuel injectors
- Fuel return line
- Fuel filter (strainer)
- Fuel drain manifold

DESCRIPTION AND OPERATION

POWERTRAIN CONTROL MODULE (PCM)—DIESEL

The powertrain control module (PCM) is located in the right-rear side of the engine compartment (Fig. 1). It is mounted to the dash panel cowl with three bolts. The PCM was formerly referred to as the SBEC or engine controller. Except for operation of the intake manifold air heater elements, the PCM does not regulate or control fuel system operation on the diesel engine.

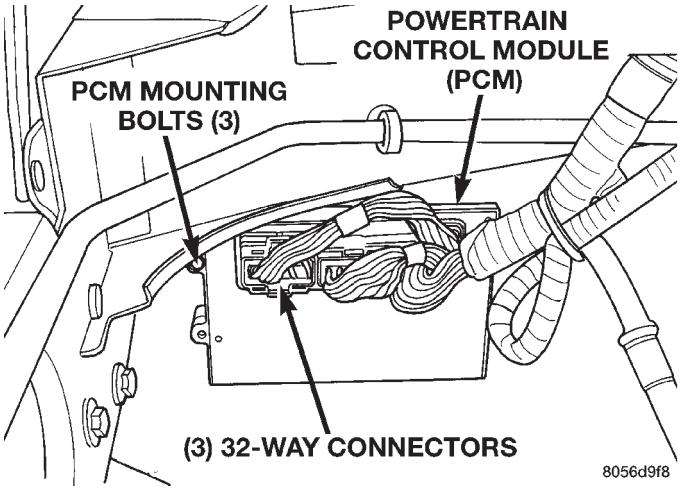


Fig. 1 PCM Location

The PCM is a pre-programmed, triple micro-processor digital computer. Although it does not regulate or control the fuel system on the diesel powered engine, it does operate or regulate the:

- Speed control system
- Charging system
- Certain warning lamps
- Transmission overdrive solenoid
- Torque convertor engagement
- Certain transmission shift features
- ASD relay
- Air conditioning operation
- Tachometer
- Intake manifold air heater

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.**

NOTE: PCM Inputs:

- A/C request (if equipped with factory A/C)
- A/C select (if equipped with factory A/C)
- Auto shutdown (ASD) sense
- Battery temperature
- Battery voltage
- Brake switch
- CCD bus (+) circuits
- CCD bus (-) circuits
- Data link connection for DRB scan tool
- Engine coolant temperature sensor (with EGR system)
- Engine speed sensor (rpm)
- Five volt sensor supply (primary)
- Five volt sensor supply (secondary)
- Generator (battery voltage) output
- Intake manifold air temperature sensor
- Oil pressure
- Output shaft speed sensor
- Overdrive/override switch
- Park/neutral switch (auto. trans. only)
- Power ground
- Sensor return
- Signal ground
- Speed control resume switch
- Speed control set switch
- Speed control on/off switch
- Throttle position sensor
- Transmission governor pressure sensor
- Transmission temperature sensor
- Water-in-fuel sensor
- Vehicle speed inputs from ABS or RWAL system

NOTE: 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
- Auto shutdown (ASD) relay

DESCRIPTION AND OPERATION (Continued)

- CCD bus (+) circuits (if equipped)
- CCD bus (-) circuits (if equipped)
- Data link connection for DRB scan tool
- EGR valve control solenoid (if equipped)
- Generator field driver (-)
- Generator field driver (+)
- Generator lamp (if equipped)
- Malfunction indicator lamp (Check engine lamp)
- Overdrive warning lamp (if equipped)
- Speed control vacuum solenoid
- Speed control vent solenoid
- Tachometer (if equipped)
- Transmission convertor clutch circuit
- Transmission 3–4 shift solenoid
- Transmission relay
- Transmission temperature lamp (if equipped)
- Transmission variable force solenoid (governor sol.)
- Wait-to-start lamp
- Water-in-fuel lamp
- Intake Manifold Air Heater Element #1
- Intake Manifold Air Heater Element #2

AIR CONDITIONING (A/C) CONTROLS—PCM INPUT

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

A/C SELECT SIGNAL: When the A/C switch is in the ON position, an input signal is sent to the powertrain control module (PCM). The signal informs the PCM that the A/C has been selected. The PCM adjusts idle speed to a pre-programmed rpm through the idle air control (IAC) motor to compensate for increased engine load.

A/C REQUEST SIGNAL: Once A/C has been selected, the powertrain control module (PCM) receives the A/C request signal from the clutch cycling pressure switch. The input indicates that the evaporator pressure is in the proper range for A/C application. The PCM uses this input to cycle the A/C compressor clutch (through the A/C relay). It will also determine the correct engine idle speed through the idle air control (IAC) motor position.

If the A/C low-pressure switch or high-pressure switch opens (indicating a low or high refrigerant pressure), 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.

If the switch opens, (indicating that evaporator is not in proper pressure range), the PCM will not receive the A/C request signal. The PCM will then remove the ground from the A/C relay, deactivating the A/C compressor clutch.

AUTOMATIC SHUTDOWN (ASD) SENSE—PCM INPUT

A 12 volt signal at this input indicates to the PCM that the ASD has been activated. The ASD relay is located in the power distribution center (PDC). The PDC is located in the engine compartment. For the location of the relay within the PDC, refer to PDC cover.

This input is used only to sense that the ASD relay is energized. If the powertrain control module (PCM) does not see 12 volts + at this input when the ASD should be activated, it will set a diagnostic trouble code (DTC).

BATTERY VOLTAGE—PCM INPUT

The battery voltage input provides power to the powertrain control module (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, minimum and maximum TPS value from the previous key-on and speed control adaptive memory.

BATTERY TEMPERATURE SENSOR—PCM INPUT

Provides a signal to the PCM corresponding to the battery temperature. Refer to Group 8C, Charging System for additional information.

BRAKE SWITCH—PCM INPUT

When the brake light switch is activated, the powertrain control module (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. It is also used for electrical operation of the transmission torque converter.

ENGINE SPEED SENSOR—PCM INPUT

The engine speed (rpm) sensor is mounted to the front of engine (Fig. 2). It generates an rpm signal to the PCM. The engine speed sensor input is used along with the vehicle speed sensor and throttle position sensor (TPS) inputs to determine when to shift the automatic transmission into and out of overdrive. The speed sensor signal is also used as an input for the ASD relay (for control of generator field), vehicle speed control, torque convertor electrical engagement and instrument panel mounted tachometer.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR—PCM INPUT

The intake manifold air temperature sensor is a variable, thermistor type. It reacts to temperature changes. At cold air temperatures, its resistance is

DESCRIPTION AND OPERATION (Continued)

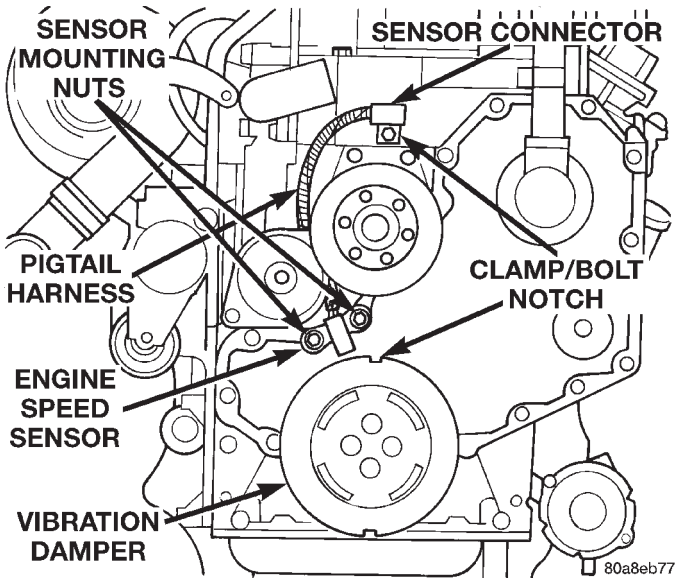


Fig. 2 Engine Speed Sensor Location—Diesel

high. As temperatures increase, its resistance will decrease.

The air temperature sensor element extends into the intake manifold air stream. It provides an input voltage to the PCM indicating intake manifold air temperature. The input from this sensor is used by the PCM to determine if and how long to activate the intake manifold air heater relays. When the relays are activated, current will flow through the relays to the intake manifold air heater element.

As the temperature of the air-fuel stream in the manifold varies, the sensor resistance will change. This will result in a different input voltage to the PCM.

The sensor is located on the top of the intake manifold and to the rear of the intake manifold air heater (Fig. 3).

Also refer to Intake Manifold Air Heater Relays for additional information.

INTAKE MANIFOLD AIR HEATER

The intake manifold air heater element assembly is located in the top of the intake manifold (Fig. 4).

The air heater is used to heat incoming air to the intake manifold to help engine starting and improve driveability with cool or cold outside temperatures.

Two heavy-duty cables (Fig. 5) connect the 2 air heater elements to the 2 air heater relays. Each of these cables will supply approximately 95 amps at 12 volts to an individual heating element within the heater block assembly.

Electrical supply for the 2 air heater elements (Fig. 5) is controlled by the powertrain control module (PCM) through the 2 air heater relays. Refer to Intake Manifold Air Heater Relays for more information.

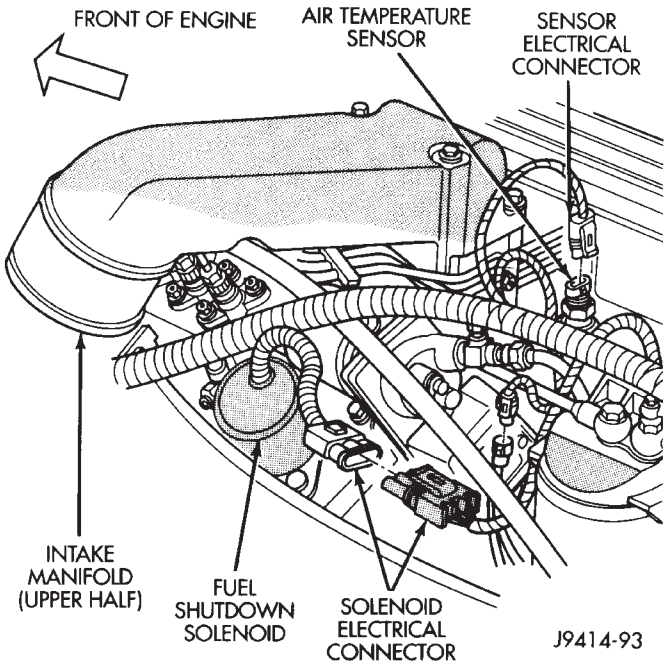


Fig. 3 Air Temperature Sensor Location—Diesel

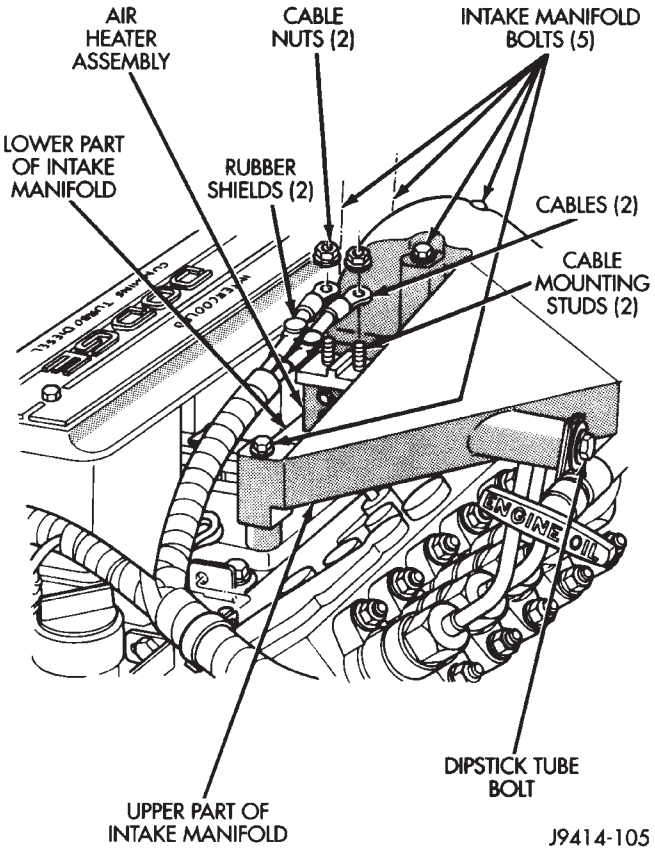


Fig. 4 Air Heater Location

DESCRIPTION AND OPERATION (Continued)

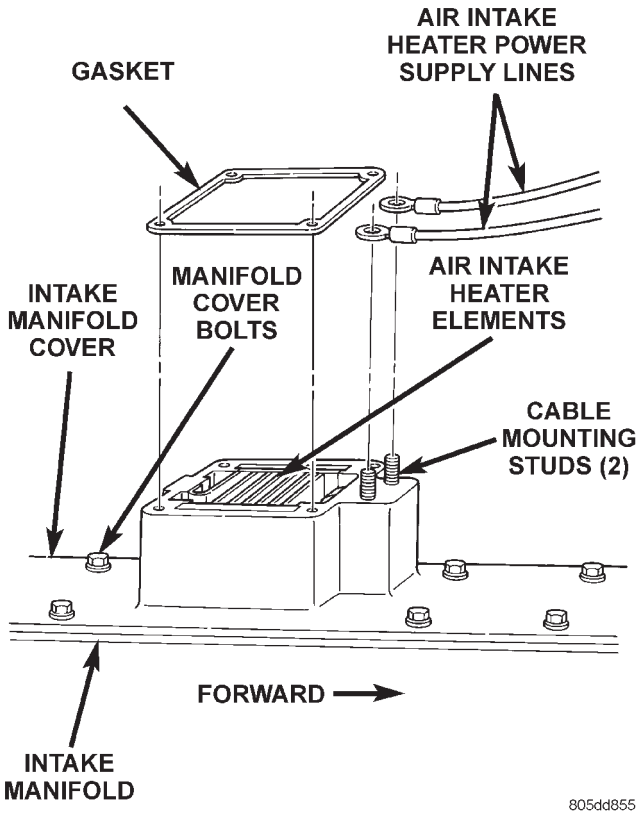


Fig. 5 Air Heater Elements

INTAKE MANIFOLD AIR HEATER RELAYS—PCM OUTPUT

The 2 relays are located in the engine compartment below the left battery (Fig. 6).

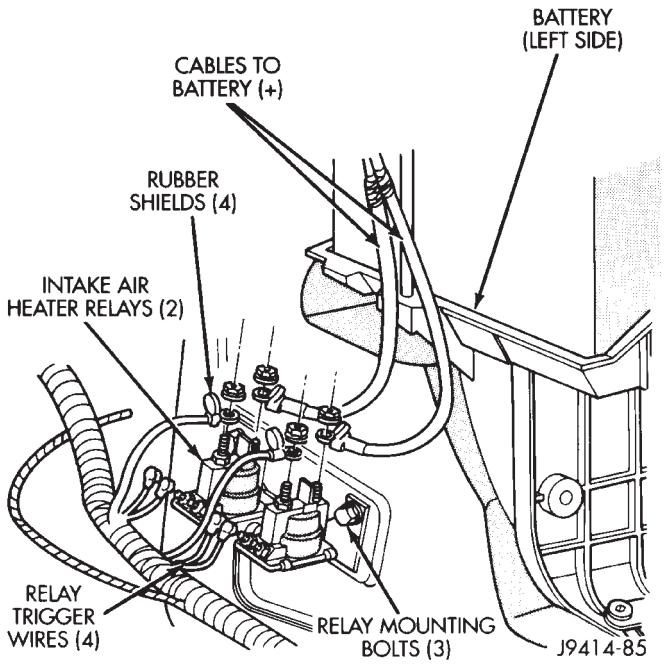


Fig. 6 Intake Manifold Air Heater Relays

The powertrain control module (PCM) operates the 2 heating elements within the air heater assembly through the 2 intake manifold air heater relays. The air heater elements are used to heat incoming air flowing into the intake manifold. This will help engine starting and improve driveability with cool or cold outside temperatures.

The relays may be energized by the PCM before and after cranking. This will depend on inputs the PCM receives from: the intake manifold air temperature sensor, the engine speed sensor and the vehicle speed sensor.

With a cool or cold engine, the air heater relays and the air heater elements may be activated for a maximum time of approximately 3 1/2 minutes. Refer to the following Air Heater Cycle Chart for a temperature/time comparison of relay engagement.

In this chart, Pre-Heat and Post-Heat times are mentioned. Pre-heat is the amount of time the relay circuits are activated when the ignition (key) switch is ON, but the engine has yet to be started. Post-heat is the amount of time the relay circuits are activated after the engine is operating.

The wait-to-start warning lamp is tied to this circuit. Lamp operation is also controlled by the PCM. The wait-to-start warning lamp **will not** be illuminated during the post-heat cycle.

The relays are not energized during engine cranking. When initially energized, they will make a clicking noise.

PREHEAT CYCLE

The PCM will supply a signal to the 2 relays when the ignition (key) switch is initially turned to the ON position. When this signal is supplied, electrical current is passed through the relays for operation of the 2 heating elements.

If the intake manifold air temperature is 15-19°C (59-66°F) or below, the air heater elements are energized and the wait-to-start warning lamp is illuminated. The heater is energized for a specific amount of time. Refer to the following Air Heater Cycle Chart for a temperature/time comparison of relay engagement.

Once the heater has cycled, the wait-to-start warning lamp goes out.

While the engine is cranked, the heater relays are not energized.

POST-HEAT CYCLE

After the pre-heat cycle is completed, the PCM must receive an engine crank signal (engine speed between 32 and 475 rpm) followed by an engine run signal (engine speed above 475 rpm). Intake manifold air temperature must also be below 15–19°C (59–66°F). All of these signals must be seen by the PCM before initiating the post-heat cycle.

DESCRIPTION AND OPERATION (Continued)

Depending upon intake manifold air temperature, engine rpm and predetermined PCM values, one or both of the relays and one or both of the heating elements may be activated. This may be observed as a large needle swing on the vehicle voltmeter and is due to the high-amperage draw of the heating elements. Each heating element will draw approximately 95 amps at 12 volts. **This voltmeter movement is a normal condition during the post-heat cycle.**

Refer to the following Air Heater Cycle Chart for a temperature/time comparison of relay engagement.

The PCM is also programmed with battery saving features. It will shut down the air heater relays if:

- the engine starter is operated during the pre-heat cycle.
- the engine stalls during the post-heat cycle.
- the engine starter is operated for more than 10 seconds during the post-heat cycle.
- the vehicle speed is above 18 mph during the post-heat cycle.

The post-heat cycle will continue for up to 3 1/2 minutes unless the PCM determines one or more of these preceding features interrupts the cycle strategy.

AIR HEATER CYCLE CHART

INTAKE MANIFOLD TEMPERATURE-KEY IN ON POSITION	PRE-HEAT CYCLE TIME-KEY ON, ENGINE NOT RUNNING	POST-HEAT CYCLE -IGNITION ON, ENGINE RUNNING
Above 15-19° C (59-66° F)	0 Seconds	No
-10° C to +19° C (15° F to 66° F)	10 Seconds	Yes
-18° C to -10° C (0° F to 15° F)	15 Seconds	Yes
Below -18° C (0° F)	30 Seconds	Yes

SPEED CONTROL SWITCHES—PCM INPUT

Six different speed control functions, using three momentary contact switches, are monitored through this **multiplexed** input. The resistance monitored at this input, in combination with the length of time the PCM measures the resistance, determines which switch feature has been selected. The three switches are: On/Off, Set/Coast, Cancel and Resume/Accelerate.

Refer to Group 8H, Vehicle Speed Control System for further speed control information.

PARK/NEUTRAL POSITION SWITCH—PCM INPUT

The park/neutral switch provides an input to the powertrain control module (PCM). This will indicate that the automatic transmission is in Park, Neutral or a Drive gear selection. This input is used to determine speed control strategy and electrical operation of both the overdrive and torque convertor solenoids. Refer to Group 21, Transmissions, for testing, replacement and adjustment information.

THROTTLE POSITION SENSOR—PCM INPUT

The throttle position sensor (TPS) is used only on diesel powered engines equipped with an automatic transmission and/or an EGR system.

The TPS is mounted on the side of the fuel injection pump (Fig. 7). The TPS provides an input to the PCM. It senses how far the throttle is open (past the idle position). The PCM uses the TPS input, along with vehicle speed sensor and engine speed sensor inputs to determine 3-4 upshift (overdrive) and 4-3 downshift. It is also used with the vehicle speed sensor and engine speed sensor inputs to engage and disengage the torque convertor solenoid. This solenoid is used for torque convertor engagement.

The TPS is a linear potentiometer. The PCM supplies 5 volts to the sensor. TPS output voltage to the PCM will vary. At idle speed, the voltage should be 1.0 volt (± .2 volts). At wide open throttle (WOT), the output voltage must be 2.2-to-2.9 volts higher than at idle speed.

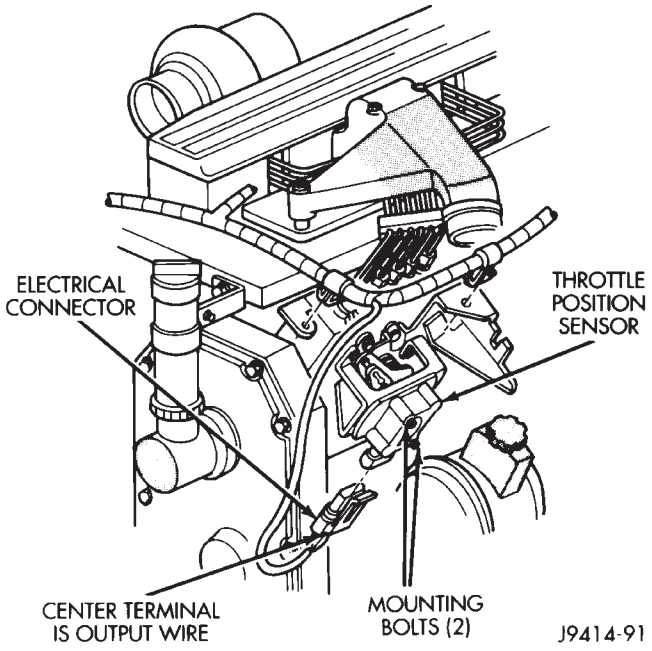


Fig. 7 Throttle Position Sensor Location—Diesel

TRANSMISSION TEMPERATURE SENSOR—PCM INPUT

DIESEL WITH AUTOMATIC TRANSMISSIONS ONLY

The transmission temperature sensor is a variable, thermistor type. It reacts to temperature changes. At

DESCRIPTION AND OPERATION (Continued)

cold transmission oil temperatures, its resistance is high. As temperatures increase, its resistance will decrease.

The transmission temperature sensor is used on models equipped with an automatic transmission. Its purpose is to help control transmission fluid overheating. If transmission overheating has been determined by this sensor (temp. above approximately 280 degrees F), an input is sent to the powertrain control module (PCM). The PCM will then force a 4-3 downshift. Once transmission temperature has cooled below specifications, a 3-4 upshift will be allowed. An instrument panel mounted transmission temperature warning lamp is also used.

This sensor is located in the transmission cooling line on the side of the transmission (Fig. 8).

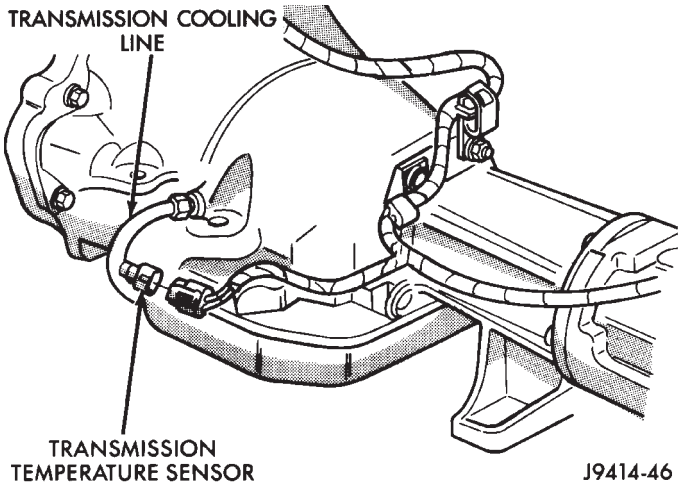


Fig. 8 Transmission Temperature Sensor Location—Typical

TRANSMISSION GOVERNOR PRESSURE SENSOR—PCM INPUT

Provides a signal proportional to the transmission governor pressure. It provides feedback for control of the governor pressure solenoid, which regulates transmission governor pressure. This input is used with 4–speed electronic transmissions only.

VEHICLE SPEED AND DISTANCE—PCM INPUT

The Vehicle Speed Sensor (VSS) is no longer used for any Dodge truck in the 1998 model year.

Vehicle speed and distance covered are measured by the Rear Wheel Speed Sensor. The sensor is mounted to the rear axle. A signal is sent from this sensor to the Controller Antilock Brake (CAB) computer. A signal is then sent from the CAB to the Powertrain Control Module (PCM) to determine vehicle speed and distance covered. The PCM will then determine strategies for fuel system and speed control system operation.

Refer to Odometer and Trip Odometer in Group 8E, Instrument Panel for additional information.

WATER-IN-FUEL SENSOR—PCM INPUT

The water-in-fuel (WIF) sensor is located at the bottom of the fuel filter/water separator canister (Fig. 9).

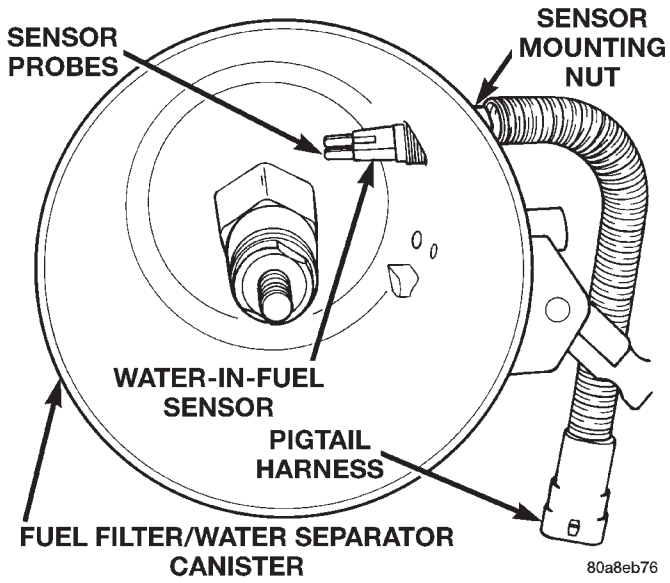


Fig. 9 Water-in-Fuel Sensor Location

The sensor sends an input to the powertrain control module (PCM) when it senses water in the fuel filter/water separator. As the water level in the filter/separator increases, the resistance across the WIF sensor decreases. This decrease in resistance is sent as a signal to the PCM and compared to a high water standard value. Once the value reaches 30 to 40 kilohms, the PCM will activate the instrument panel mounted, water-in-fuel warning lamp. This all takes place when the ignition key is initially put in the ON position. The PCM continues to monitor the input at the end of the intake manifold air heater post-heat cycle.

WATER-IN-FUEL WARNING LAMP—PCM INPUT

The PCM turns the water-in-fuel indicator lamp to the ON position if water is detected in the fuel. The water-in-fuel indicator lamp is located in the instrument panel. The lamp will illuminate for about two seconds each time the ignition key is initially turned to the ON position as a bulb check.

Also refer to Water-In-Fuel Sensor—PCM Input for additional information.

DESCRIPTION AND OPERATION (Continued)

AIR CONDITIONING CLUTCH RELAY—PCM OUTPUT

The A/C relay is located in the Power Distribution Center (PDC) (Fig. 10). Refer to label on PDC cover for relay location.

The powertrain control module (PCM) activates the A/C compressor through the A/C clutch relay. The PCM regulates A/C compressor operation by switching the ground circuit for the A/C clutch relay on and off.

The PCM will also de-energize the relay if coolant temperature exceeds 125°C (257°F).

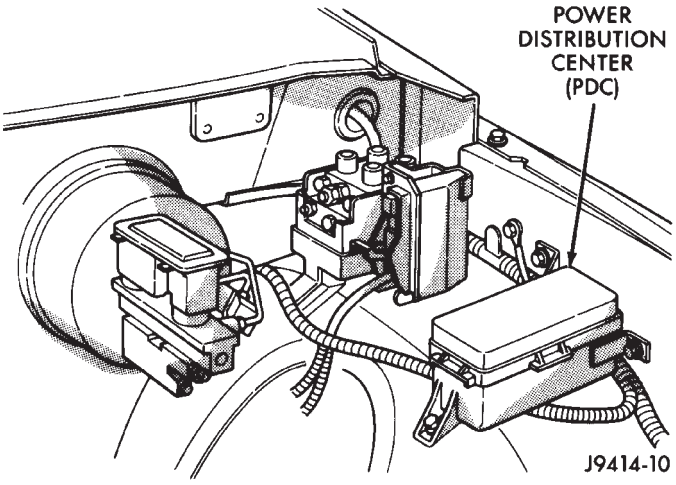


Fig. 10 Power Distribution Center (PDC) Location

AUTOMATIC SHUTDOWN (ASD) RELAY—PCM OUTPUT

This circuit controls operation of the ASD relay. It provides the necessary power to operate the generator field control for charging system operation.

The ASD relay is located in the power distribution center (PDC). The PDC is located in the engine compartment. For location of relay within the PDC, refer to PDC cover.

GENERATOR FIELD SOURCE (+)—PCM OUTPUT

This output from the Powertrain Control Module (PCM) regulates charging system voltage to the generator field source (+) circuit. The voltage range is 12.9 to 15.0 volts. Models of previous years had used the ASD relay (directly) to apply the 12 volt + power supply to the generator field source (+) circuit. Refer to Groups 8A and 8C for charging system information.

GENERATOR FIELD DRIVER (-)—PCM OUTPUT

This output from the Powertrain Control Module (PCM) regulates charging system ground control to the generator field driver (-) circuit. Refer to Groups 8A and 8C for charging system information.

GENERATOR LAMP—PCM OUTPUT

If the powertrain control module (PCM) senses a low charging condition in the charging system, it will illuminate the generator lamp (if equipped) on the instrument panel. For example, during low idle with all accessories turned on, the lamp may momentarily go on. Once the PCM corrects idle speed to a higher rpm, the lamp will go out. Refer to Groups 8A and 8C for charging system information.

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 or the Mopar Diagnostic System (MDS) with the powertrain control module (PCM). The data link connector (Fig. 11) is located at lower edge of instrument panel near steering column. For operation of the DRB scan tool, refer to the appropriate Powertrain Diagnostic Procedures service manual.

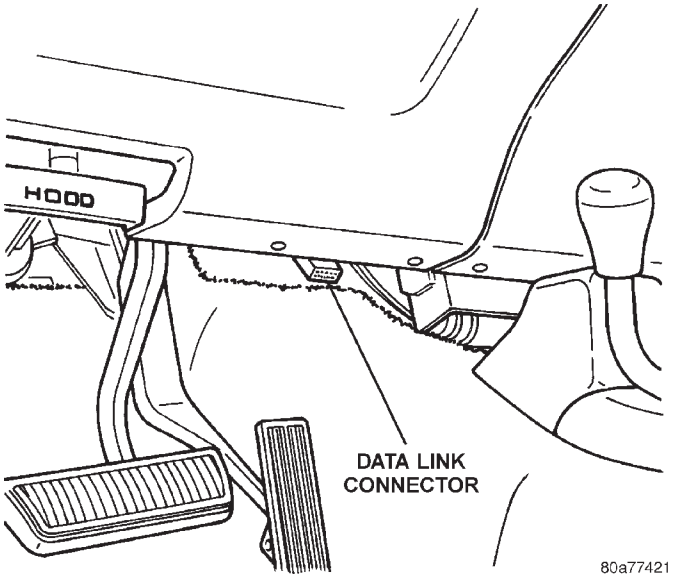


Fig. 11 16–Way Data Link Connector

MALFUNCTION INDICATOR LAMP—PCM OUTPUT

Refer to Group 25, Emission Control System for information.

OVERDRIVE LAMP—PCM OUTPUT

This circuit controls a signal for the operation of the instrument panel mounted push-button overdrive lamp switch. When the lamp is illuminated, the overdrive is disengaged.

OVERDRIVE/OVERRIDE SWITCH-PCM INPUT

On vehicles equipped with an automatic transmission and overdrive, the powertrain control module (PCM) regulates the 3-4 overdrive up-shift and down-

DESCRIPTION AND OPERATION (Continued)

shift through the overdrive solenoid. This solenoid is located in the transmission. An overdrive/override push-button switch is located at the end of the shift lever.

The overdrive/override push-button switch is normally open (overdrive allowed) when the lamp is not illuminated. It momentarily closes (overdrive not allowed) when the operator presses the switch and the lamp is illuminated. Overdrive will revert to ON (lamp off) each time the ignition switch in turned on. The transmission downshifts if the operator presses the override switch while in overdrive.

Refer to Group 21 for more transmission information.

SPEED CONTROL SOLENOIDS—PCM OUTPUT

Speed control operation is regulated by the powertrain control module (PCM). The PCM controls the vacuum to the throttle actuator through the speed control vacuum and vent solenoids. Refer to Group 8H for Speed Control Information.

TACHOMETER—PCM OUTPUT

The powertrain control module (PCM) supplies engine rpm values to the instrument cluster tachometer. Refer to Group 8E for tachometer information.

TORQUE CONVERTOR CLUTCH (TCC) SOLENOID—PCM OUTPUT

This circuit controls operation of the transmission mounted torque convertor clutch (TCC) solenoid used for torque convertor engagement.

The powertrain control module (PCM) will determine when to engage and disengage the solenoid by monitoring vehicle miles per hour (mph) versus the output voltage of the throttle position sensor. Also needed are various inputs from:

- Transmission temperature sensor
- Output shaft speed sensor
- Module timer
- Engine rpm
- Throttle position sensor (if equipped)
- Brake switch

TRANSMISSION TEMPERATURE WARNING LAMP—PCM OUTPUT

AUTOMATIC TRANSMISSION ONLY

An instrument panel mounted lamp is used to warn of a possible transmission fluid overheating condition. When transmission fluid temperature has been determined to be above approximately 280 degrees F by the transmission temperature sensor, a signal is sent to the powertrain control module (PCM). The PCM will then control warning lamp operation. The lamp will illuminate for about two seconds each time the ignition key is initially turned to the ON position as a bulb check.

This feature is used with certain heavy-duty automatic transmissions only.

Also refer to Transmission Temperature Sensor—PCM Input for additional information.

WAIT-TO-START LAMP WARNING LAMP—PCM OUTPUT

The wait-to-start warning lamp is turned on and off by the PCM based on the intake manifold air temperature sensor input. The lamp is located on the instrument panel.

The lamp is turned on when the ignition is first activated. If the PCM reads intake manifold air temperature below 15–19°C (59–66°F), it will turn the wait-to-start warning lamp on for the air heater preheat cycle. The lamp stays on until the preheat cycle is over.

The wait-to-start lamp will flash on and off if the intake manifold air temperature sensor input to the PCM is below minimum value or above maximum value. The PCM stores a DTC when these conditions occur.

Refer to Intake Manifold Air Heater for additional information.

DIAGNOSIS AND TESTING

VISUAL INSPECTION

A visual inspection 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) Verify pigtail electrical connector from water-in-fuel (WIF) sensor is firmly attached to main engine wiring harness. The WIF sensor is located on side of Fuel Filter/Water Separator canister. Inspect connector for corrosion or damaged wires.

(2) Check for water in fuel filter/water separator. A water drain is supplied on the filter/separator. Refer to Fuel Filter/Water Separator Removal/Installation for water draining operation.

(3) Verify fuel filter has been serviced according to Maintenance Schedules in Group 0, Lubrication and Maintenance.

(4) Verify pre-filter (within fuel heater) has been cleaned when fuel filter was serviced.

(5) Inspect air cleaner element (filter) for restrictions by using the built-on Filter Minder™ (Fig. 12). Do not remove the top of air cleaner housing to inspect condition of air cleaner element. Refer to Air Cleaner Housing/Air Cleaner Element in the Removal/Installation section for Filter Minder information.

DIAGNOSIS AND TESTING (Continued)

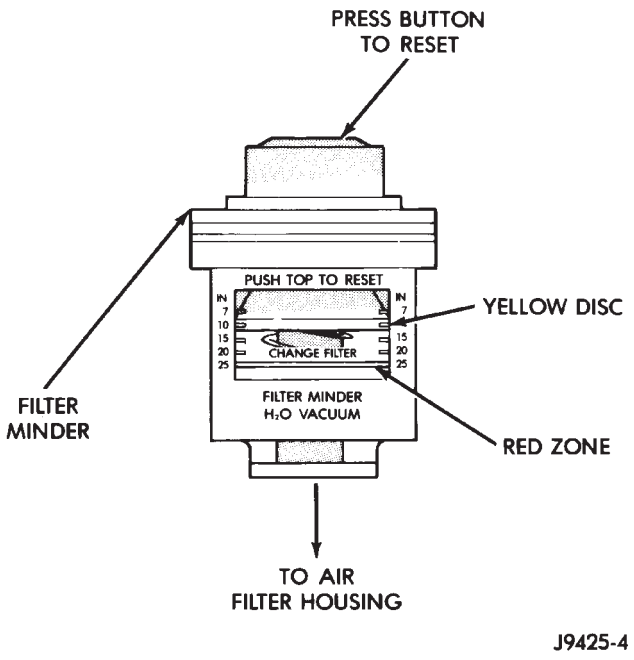


Fig. 12 Filter Minder™

(6) Check front of turbocharger intercooler for restrictions to airflow (insects, debris etc.). Clean if necessary.

(7) Be sure turbocharger output hose is firmly connected to charge air cooler (intercooler) inlet tube. Verify charge air cooler output hose is firmly connected to cooler and intake manifold.

(8) Verify turbocharger wastegate adjustment is correct. Refer to Group 11, Exhaust System and Intake Manifold for procedures.

(9) Verify throttle linkage is “breaking over”. Refer to Wide-Open-Throttle Checks—Diesel Engine for procedures.

(10) Verify correct throttle linkage adjustment. Refer to Wide-Open-Throttle Checks—Diesel Engine for procedures.

(11) Verify correct Throttle Position Sensor (TPS) output voltage. Refer to Throttle Position Sensor—Diesel Engine, Removal/Installation/Testing/Adjustment.

(12) Be sure battery connections (on both batteries) are tight and not corroded.

(13) Be sure three 32–way connectors are fully engaged into the powertrain control module (PCM) (Fig. 13).

(14) Verify electrical connector is firmly connected to fuel shutdown solenoid on the injection pump (Fig. 14). Inspect connector for corrosion or damage.

(15) Verify electrical connector is firmly connected to intake manifold air temperature sensor. Inspect connector for corrosion or damaged wires. The sensor is located on top of intake manifold (Fig. 14).

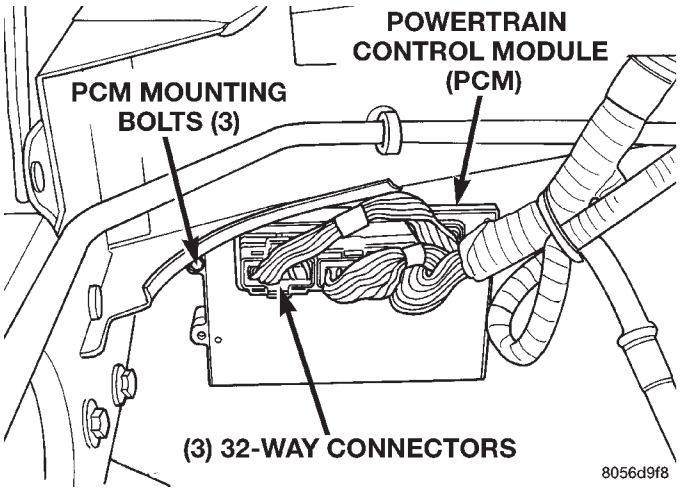


Fig. 13 PCM Location—Typical

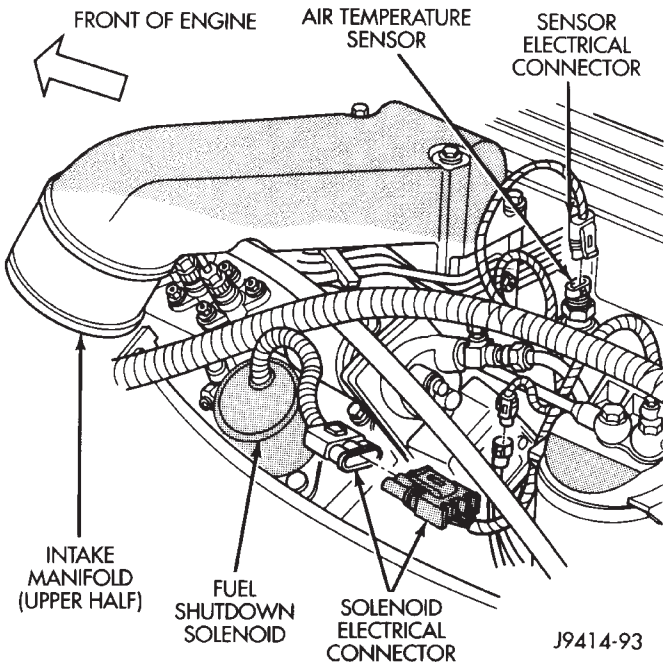


Fig. 14 Air Temperature Sensor and Fuel Shutdown Solenoid

(16) Be sure electrical connections at intake manifold air heater relays (Fig. 15) are tight and not corroded.

(17) Be sure intake manifold air heater electrical cable connections at intake manifold are tight and free of corrosion (Fig. 16).

(18) Inspect all fuel supply and return lines for signs of damage or kinking.

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

(20) Inspect throttle linkage and accelerator linkage for binding.

(21) Be sure throttle return spring is connected.

DIAGNOSIS AND TESTING (Continued)

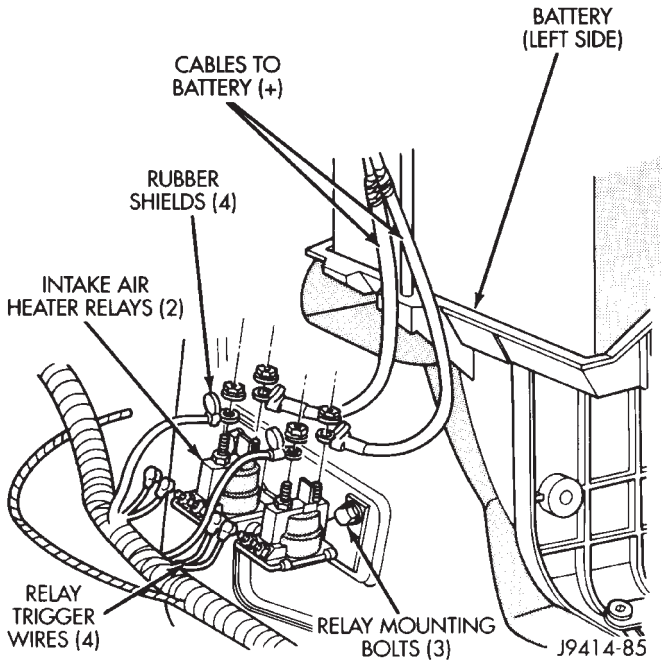


Fig. 15 Intake Manifold Air Heater Relays

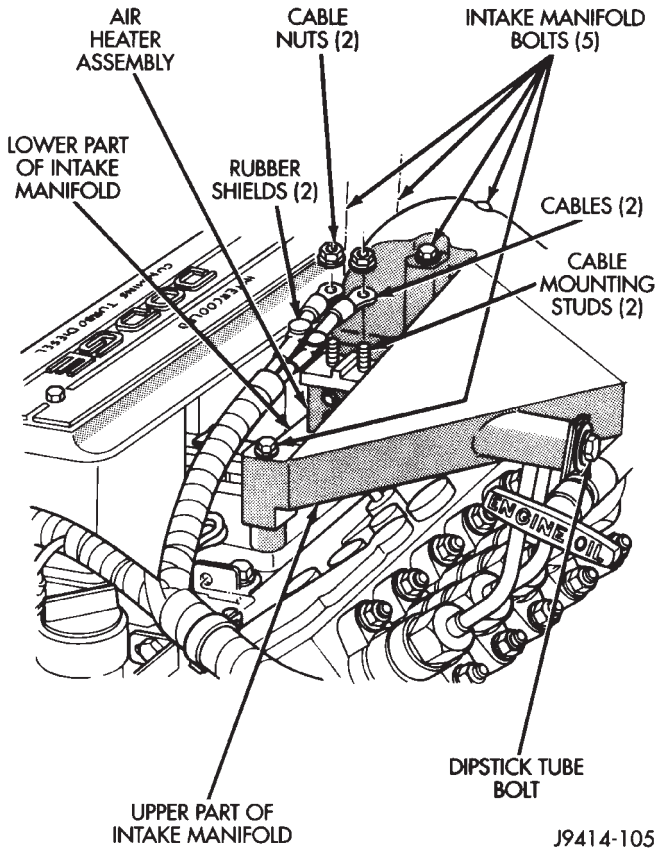


Fig. 16 Air Heater Cable Connections

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

(23) Be sure accessory drive belt is not damaged or slipping.

(24) Automatic Transmission Only: Be sure electrical connectors are firmly connected to plugs on transmission case.

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

AUTOMATIC SHUTDOWN (ASD) RELAY TEST

To perform a complete test of the ASD relay and its circuitry, refer to the DRB scan tool and appropriate Powertrain Diagnostics Procedures manual. To test the relay only, refer to Relays—Operation/Testing in this section of the group.

ENGINE SPEED SENSOR TEST

To perform a complete test of this sensor and its circuitry, refer to the appropriate Powertrain Diagnostic Procedures manual.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR TEST

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

(1) Disconnect wire harness connector from intake manifold air temperature sensor. The sensor is located on top of intake manifold and to rear of air heater (Fig. 17).

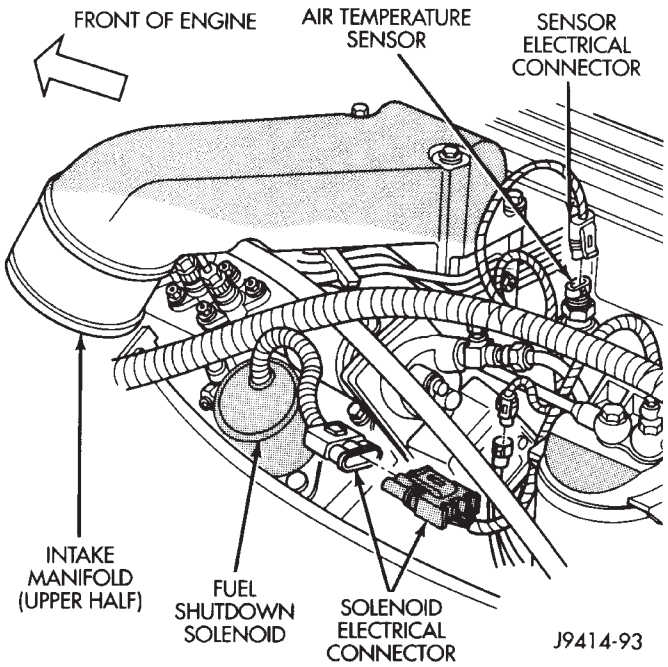


Fig. 17 Air Temperature Sensor Location—Diesel

(2) Test resistance of sensor with an input impedance (digital) volt-ohmmeter. The resistance (as measured across sensor terminals) should be as shown in

DIAGNOSIS AND TESTING (Continued)

the SENSOR RESISTANCE (OHMS)—INTAKE MANIFOLD AIR TEMPERATURE chart. Replace sensor if it is not within range of resistance specified in chart.

SENSOR RESISTANCE (OHMS)—INTAKE MANIFOLD AIR TEMPERATURE SENSOR

TEMPERATURE		RESISTANCE (OHMS)	
°CEL.	°FAHR.	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

(3) Test resistance of wire harness. Do this between powertrain control module (PCM) wire harness connector terminal A–15 and sensor connector terminal. Also check between PCM terminal A–4 (sensor return) to sensor connector terminal. Repair wire harness as necessary if resistance is greater than 1 ohm.

INTAKE MANIFOLD AIR HEATER TEST

The intake manifold air heater (Fig. 18) is controlled by the powertrain control module (PCM) through the intake manifold air heater relays (Fig. 19). This is done after a specified signal is sent to the PCM from the intake manifold air temperature sensor.

Two heating elements are located within the air heater assembly. A separate heavy-duty cable is connected to a separate terminal to supply power for each element.

PREHEAT/POST-HEAT CYCLE

Refer to the Intake Manifold Air Heater Relays—PCM Output for preheat/post heat cycle information.

The PCM provides a ground path for the intake manifold air heater relays. The ground path is provided if intake manifold air temperature is below 15-19°C (59-66°F) when the ignition key is initially placed in the ON position. When the ground is provided, the air heater is energized to start the preheat cycle.

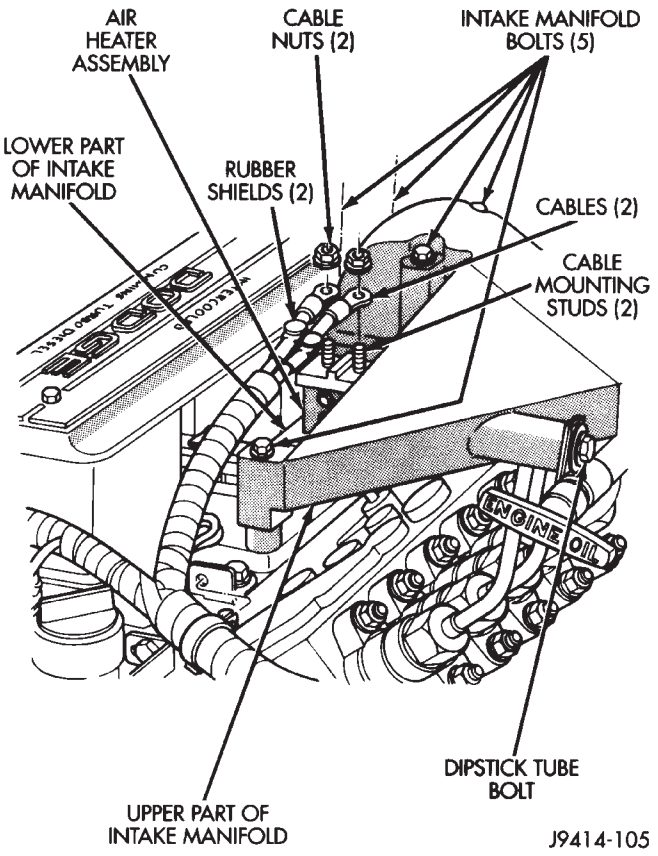


Fig. 18 Intake Manifold Air Heater

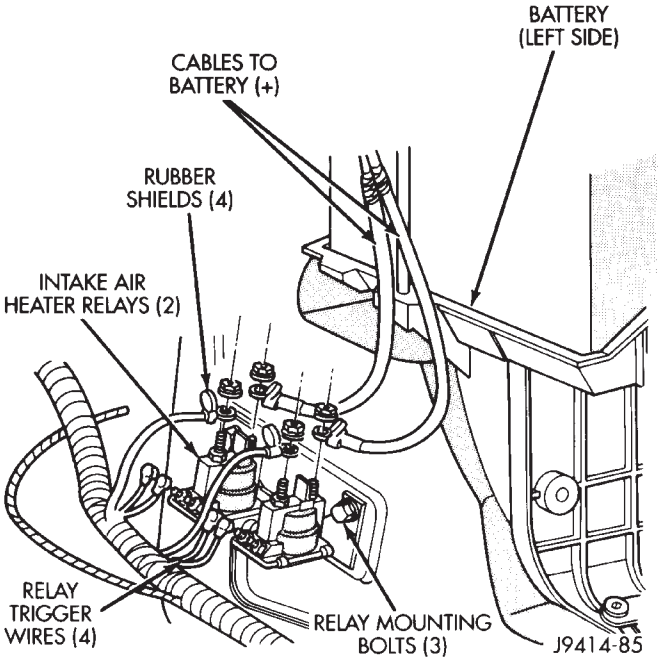


Fig. 19 Intake Manifold Air Heater Relays

DIAGNOSIS AND TESTING (Continued)

The preheat-cycle can be tested with a voltmeter or test light. If the intake manifold air temperature is above 15°C (59°F), the wait-to-start warning lamp will not illuminate and the air heater will not be energized.

(1) With the engine not running, and intake manifold air temperature below 15-19°C (59-66°F), turn the ignition key to the ON position.

(2) The wait-to-start warning lamp will come on and the air heater relays should click ON signaling the start of the preheat cycle. **If the engine starter is engaged before the preheat cycle of the heaters is complete, the PCM will stop the remaining preheat cycle.**

(3) Check for battery voltage at both air heater terminals (Fig. 18). **The heater will only be energized for 10 to 30 seconds.** Refer to the following Air Heater Cycle Chart for a time/temperature comparison.

AIR HEATER CYCLE CHART

INTAKE MANIFOLD TEMPERATURE-KEY IN ON POSITION	PRE-HEAT CYCLE TIME-KEY ON, ENGINE NOT RUNNING	POST-HEAT CYCLE-IGNITION ON, ENGINE RUNNING
Above 15-19° C (59-66° F)	0 Seconds	No
-10° C to +19° C (15° F to 66° F)	10 Seconds	Yes
-18° C to -10° C (0° F to 15° F)	15 Seconds	Yes
Below -18° C (0° F)	30 Seconds	Yes

HEATER TEST

(1) Disconnect both negative battery cables at both batteries.

(2) Lift the rubber shields from each of the cable connectors at the intake manifold air heater (Fig. 18) to expose the cable terminals. Do not disconnect cable nuts.

(3) Use an ohmmeter to test the resistance between the cable terminal (not the mounting stud) and a ground. The resistance should be zero (0). If not, inspect for corroded or dirty cable connections. Clean or repair the connections and retest before replacing heater. If resistance is now anything other than zero (0), proceed to next step.

(4) Disconnect both cables from the intake manifold heater (two nuts) (Fig. 18).

(5) Measure the resistance from each of the air heater terminal threaded studs to a ground. The resistance should be zero (0). If the ohmmeter is still reading anything other than zero (0), replace the intake manifold air heater elements. The heater elements are part of the intake manifold and will require manifold replacement.

(6) After testing and repairing, connect battery cables to both batteries.

INTAKE MANIFOLD AIR HEATER RELAY TEST

To test the intake manifold air heater, refer to the previous Intake Manifold Air Heater Test.

To test the intake manifold air heater relays, refer to the following:

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect the four small relay trigger wires at both relays (Fig. 19). Note position of wires before removal.

(3) Disconnect the four large cables at each of the relay terminals (four nuts) (Fig. 19). Note position of cables before removal.

(4) Attach an ohmmeter across two of the large studs on one of the relays.

(5) Attach a jumper wire (+ and -) to each of the small terminals on one of the relays. Polarity is not important.

(6) Momentarily touch the jumper wires to the vehicle battery (+ and -). The relay should click and the ohmmeter should show a closed circuit across the large terminals. If not, replace relay and bracket assembly.

(7) Repeat the same test on the opposite relay.

(8) After testing and repairing, connect battery cables to both batteries.

THROTTLE POSITION SENSOR TEST

The throttle position sensor (TPS) is used on diesel engines only when equipped with an automatic transmission and/or an Exhaust Gas Recirculation (EGR) system.

To perform a complete test of this sensor and its circuitry, refer to the appropriate Powertrain Diagnostic Procedures service manual. To test the sensor only, refer to Throttle Position Sensor in the Removal/Installation section of this group. This will give adjustment, testing and removal/installation procedures.

TRANSMISSION TEMPERATURE SENSOR TEST

AUTOMATIC TRANSMISSION ONLY

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

(1) Disconnect wire harness connector from temperature sensor. The sensor is located on side of transmission in transmission cooling line (Fig. 20).

(2) Test resistance of sensor with an input impedance (digital) volt-ohmmeter. The resistance (as measured across the sensor terminals) should be as shown in SENSOR RESISTANCE (OHMS)—TRANS-

DIAGNOSIS AND TESTING (Continued)

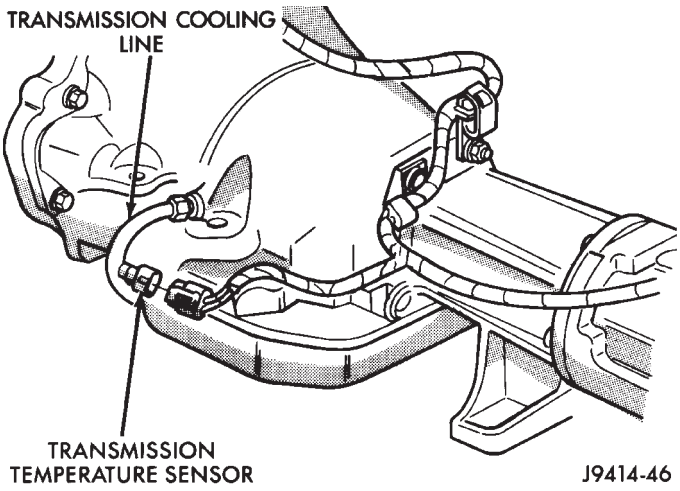


Fig. 20 Transmission Temperature Sensor Location—Typical

MISSION TEMPERATURE SENSOR resistance chart. Replace sensor if it is not within range of resistance specified in chart.

SENSOR RESISTANCE (OHMS)— TRANSMISSION TEMPERATURE SENSOR

TEMPERATURE		RESISTANCE (OHMS)	
°CEL.	°FAHR.	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

(3) Test resistance of the wire harness. Do this between powertrain control module (PCM) wire harness connector terminal B–1 and sensor connector terminal. Also check between PCM terminal A–4 to sensor connector terminal. Repair wire harness as necessary if resistance is greater than 1 ohm.

REMOVAL AND INSTALLATION

ENGINE SPEED SENSOR

The engine speed (rpm) sensor is located on the front of engine (Fig. 21). Spacers located behind the sensor are used to position sensor over the vibration damper.

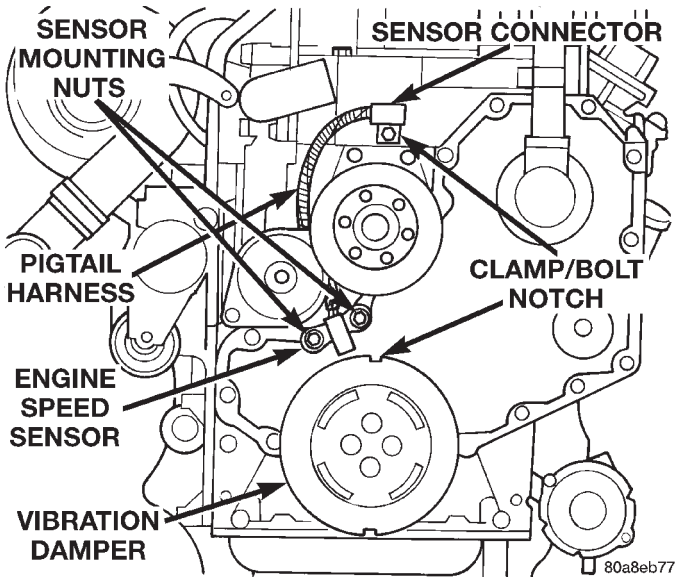


Fig. 21 Engine Speed Sensor Location—Diesel

REMOVAL

Before removing sensor and its pigtail wiring harness, note position and routing of harness. This routing must be maintained to prevent wiring from contacting belt or pulleys.

(1) Disconnect speed sensor pigtail harness from main engine wiring harness near front/top of engine (Fig. 21).

(2) Remove clip bolts from sensor pigtail wiring harness.

(3) Remove two speed sensor mounting nuts (Fig. 21) or (Fig. 22).

(4) Remove speed sensor and its mounting spacers from engine.

INSTALLATION/ADJUSTMENT

The engine speed sensor has 2 slotted holes (Fig. 22) to adjust its depth. A brass (non-magnetic) feeler gauge must be used to adjust sensor.

Sensor-to-vibration damper air gap: **1.25 MM (.049 in.) minimum to 1.30 MM (.051 in.) maximum.**

(1) Position speed sensor, its mounting spacers and two mounting nuts to engine. Install mounting nuts finger tight.

(2) Route sensor wiring harness behind engine pulleys. Install and tighten wiring harness clip bolts.

(3) Place feeler gauge between bottom of sensor and top of vibration dampener.

REMOVAL AND INSTALLATION (Continued)

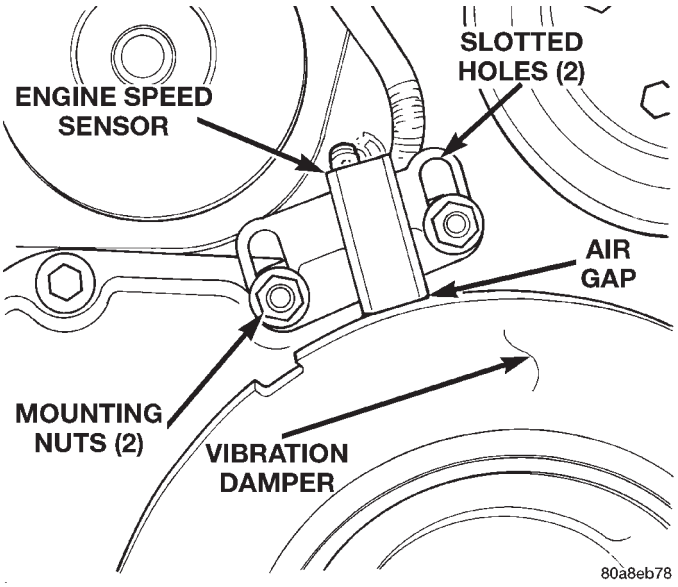


Fig. 22 Engine Speed Sensor—Removal/Installation/ Adjustment

(4) Gently seat (push down) sensor until it contacts feeler gauge. Sensor should be flat to feeler gauge. Slide sensor through slotted holes until flat to feeler gauge. **Be sure sensor is not near either of notches (Fig. 21) on vibration damper. If sensor is adjusted at or near these notches, it will be damaged when engine is started.**

(5) Tighten sensor mounting nuts to 24 N·m (18 ft. lbs.) torque.

(6) Remove feeler gauge.

(7) Connect sensor electrical pigtail connector to main engine wiring harness.

THROTTLE POSITION SENSOR—DIESEL ENGINE

This section will include the removal/installation/adjustment of the Throttle Position Sensor (TPS) plus TPS voltage tests. It also includes throttle linkage adjustment.

The TPS is used on diesel powered engines only when equipped with an automatic transmission and/or an Exhaust Gas Recirculation (EGR) system. If the TPS is to be replaced on a diesel engine, it must be tested and, if necessary, have throttle linkage adjusted after replacement.

REMOVAL

(1) Disconnect electrical connector on bottom of TPS (Fig. 23).

(2) Remove two TPS mounting bolts.

(3) Remove sensor from bracket.

INSTALLATION

(1) Position TPS to mounting bracket. The electrical connector should be facing downward.

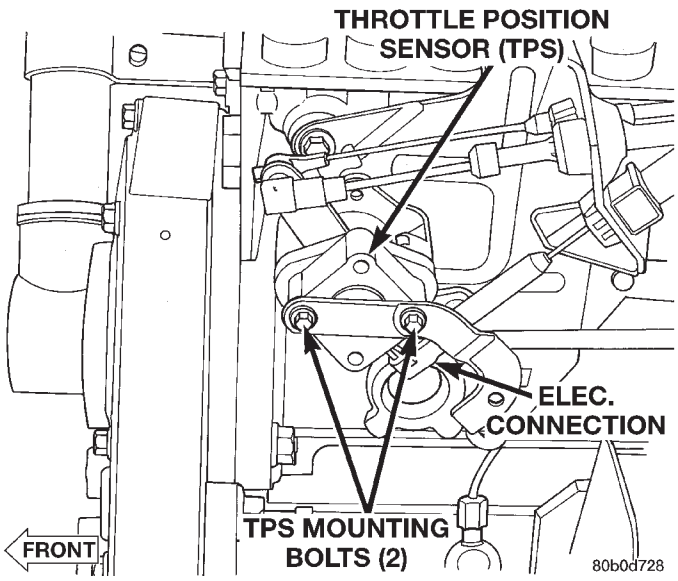


Fig. 23 Throttle Position Sensor Location—Diesel Engine

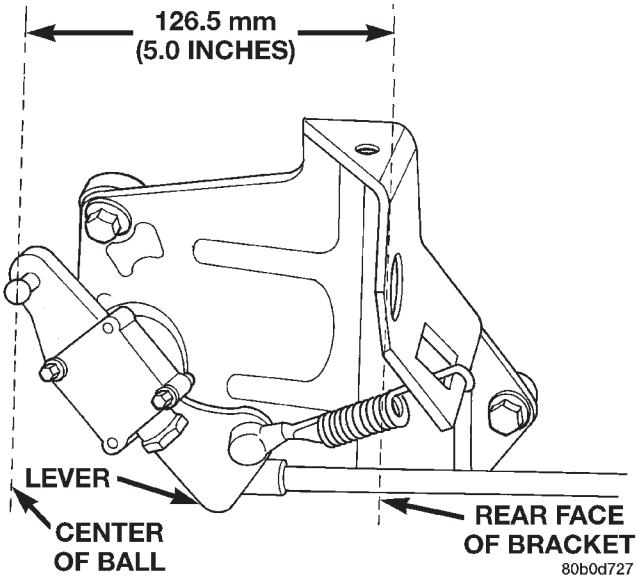


Fig. 24 TPS Linkage Measurement—Diesel

NOTE: The TPS is spring loaded. After positioning the TPS to its mounting bracket, rotate TPS on bracket in a counterclockwise direction until two bolt holes align.

(2) Install and tighten two bolts.

(3) Connect electrical connector on bottom of TPS.

(4) Operate throttle by hand to check for binding.

(5) Be sure of wide open throttle (WOT) when accelerator pedal is pressed to the floor. This is checked by observing throttle lever "breakover" position. Refer to Wide-Open-Throttle Checks—Diesel Engine for procedures. Linkage adjustments for "breakover" must be made **before** attempting to test or adjust TPS.

REMOVAL AND INSTALLATION (Continued)

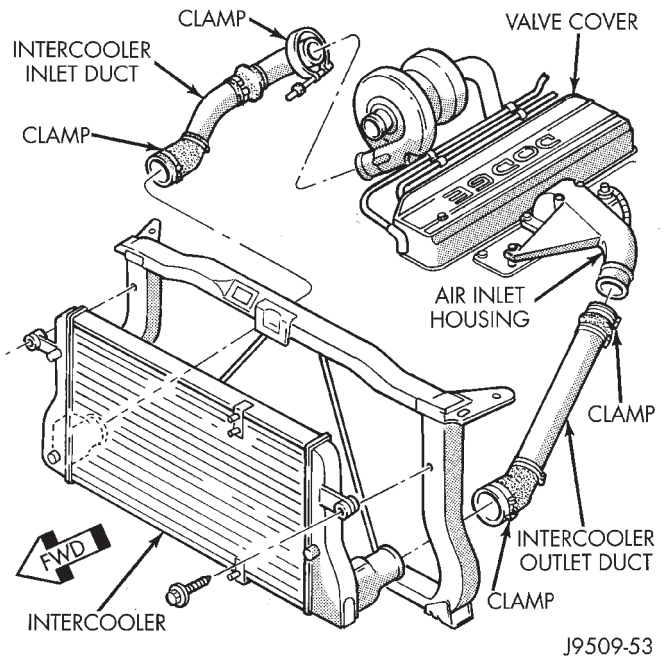


Fig. 25 Intercooler Outlet Duct

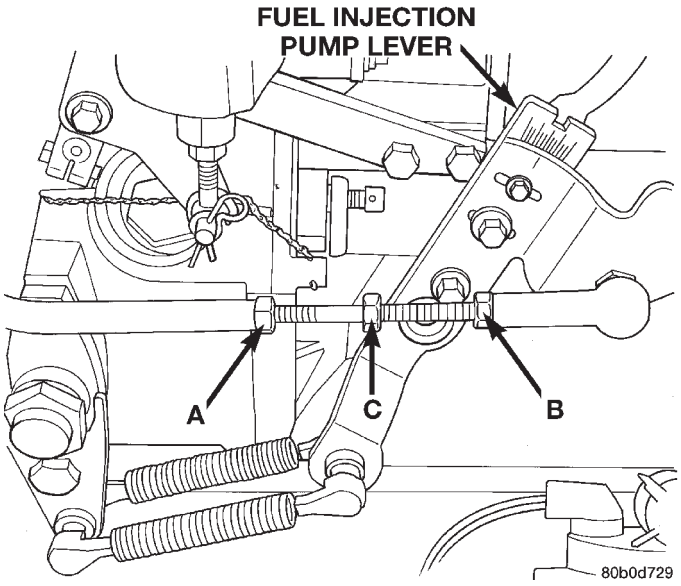


Fig. 26 Throttle Lever Linkage Rod Adjustment—Diesel

(6) After proper "breakover" is observed, test TPS voltage and (if necessary) adjust throttle linkage rod. Refer to the following:

THROTTLE POSITION SENSOR TESTING AND ADJUSTMENT / THROTTLE LINKAGE ADJUSTMENT

CAUTION: Before attempting to test TPS, verify linkage adjustment dimension (Fig. 24). This dimension MUST be 126.5 mm (5.0 inches) BEFORE testing.

(1) Attach DRB scan tool to data link connector.

(2) Warm engine to operating temperature and confirm correct engine idle speed and adjust if necessary. **This step must be done before testing TPS. Refer to Idle Speed Adjustment for specifications.**

(3) Shut engine off.

(4) Access the SENSOR display screen on DRB tool.

(5) Turn ignition switch to ON position. Do not start engine.

(6) TPS voltage should be 1.0 volt (± .2 volt) with linkage at idle position. At wide open throttle (WOT), output voltage must be 2.2-to-2.9 volts higher than at idle speed. If voltage is not correct, proceed to adjusting linkage.

(7) The throttle rod (Fig. 26) connecting throttle lever to fuel injection pump lever is adjustable.

(8) At side of fuel injection pump, remove intercooler outlet duct from air inlet housing (Fig. 25).

(9) Loosen rod nuts A (right-hand-thread) and B (left-hand-thread) while holding studnut C with another wrench (Fig. 26).

(10) Rotate studnut C (Fig. 26) on linkage rod (lengthen or shorten) to achieve 1.0 volt (± .2 volts) on voltmeter with linkage in idle position. At wide open throttle (WOT), output voltage must be 2.2-to-2.9 volts higher than at idle speed. **DO NOT lengthen or shorten linkage rod more than 1 mm from dimension shown in (Fig. 24). If voltage requirements cannot be met by linkage adjustment (125.6 to 127.6 mm), replace TPS.**

(11) Tighten rod nuts A and B (Fig. 26) after adjustment. **After tightening nuts, be sure the rod assembly will rotate (slightly) without binding at each ball end.** If binding occurs, loosen one of the nuts and back off until binding is eliminated. Retighten nut.

(12) With engine OFF, operate throttle from accelerator pedal and check for throttle lever action and binding. Be sure throttle lever stop is against low idle speed screw after throttle is released.

(13) Again, check and verify low idle speed. Adjust if necessary.

(14) Install intercooler outlet duct to air inlet housing.

AIR CLEANER HOUSING/AIR CLEANER ELEMENT

TESTING AIR CLEANER ELEMENT

Do not attempt to unnecessarily remove the top of the air cleaner housing for air cleaner element inspection on diesel engines.

The air cleaner (filter) housing is equipped with an air Filter Minder™ gauge (Fig. 27). This air flow restriction gauge will determine when the air cleaner element is restricted and should be replaced.

REMOVAL AND INSTALLATION (Continued)

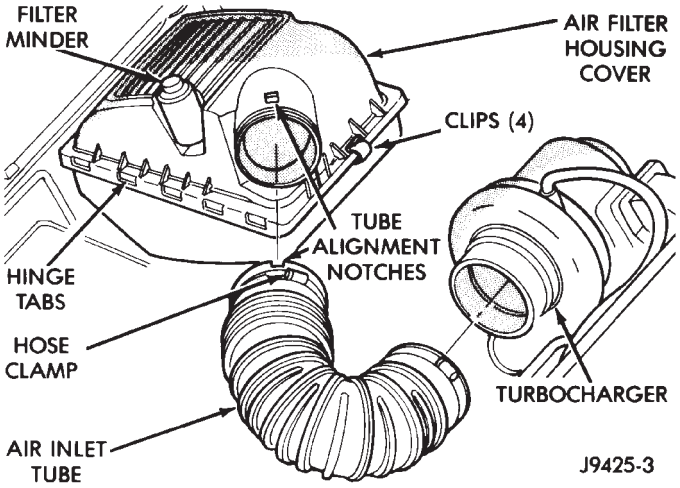


Fig. 27 Filter Minder—Location—Diesel Engine

The Filter Minder™ consists of a diaphragm and calibrated spring sealed inside of a plastic housing (Fig. 28). A yellow colored disc attached to the diaphragm moves along a graduated scale on the side of the Filter Minder. After the engine has been shut off, a ratcheting device located within the Filter Minder will hold the yellow disc at the highest restriction that the air cleaner element has experienced. A drop in air pressure due to an air cleaner element restriction moves the diaphragm and the yellow disc will indicate the size of the air drop.

CAUTION: Certain engine degreasers or cleaners may discolor or damage the plastic housing of the Filter Minder. Cover and tape the Filter Minder if any engine degreasers or cleaners are to be used.

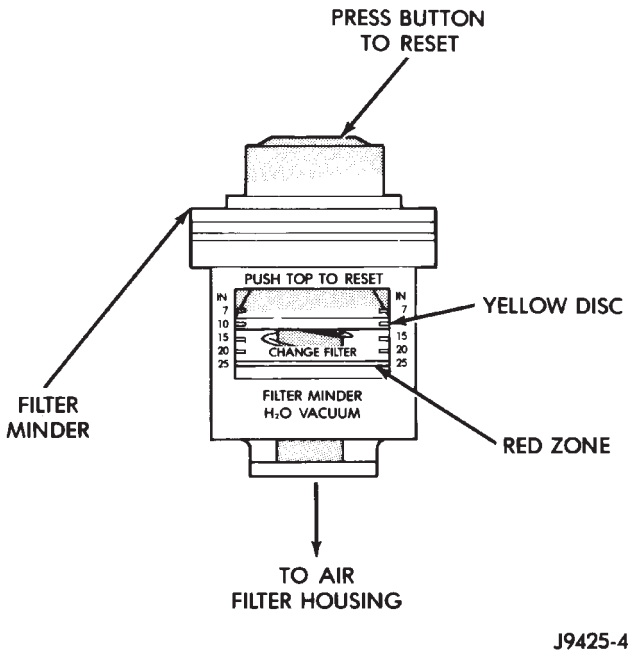


Fig. 28 Filter Minder™—Diesel Engine

To test, turn the engine off. If the yellow disc (Fig. 28) has reached the red colored zone on the graduated scale, the air cleaner element should be replaced. Refer to the proceeding removal/installation paragraphs.

Resetting the Filter Minder: After the air cleaner (filter) element has been replaced, press the rubber button on the top of the Filter Minder (Fig. 28). This will allow the yellow colored disc to reset. After the button has been pressed, the yellow disc should spring back to the UP position.

If the Filter Minder gauge has reached the red colored zone, and after an examination of the air cleaner (filter) element, the element appears to be clean, the high reading may be due to a temporary condition such as snow build-up at the air intake. Temporary high restrictions may also occur if the air cleaner (filter) element has gotten wet such as during a heavy rain or snow. If this occurs, allow the element to dry out during normal engine operation. Reset the rubber button on the top of the Filter Minder and retest after the element has dried.

REMOVAL/INSTALLATION

(1) Loosen the air inlet tube clamp at air cleaner housing inlet (Fig. 27). Remove this tube at air cleaner housing cover.

(2) The housing cover is equipped with four (4) spring clips (Fig. 27) and is hinged at the front with plastic tabs. Unlatch the clips from the top of air cleaner housing and tilt the housing cover up and forward for cover removal.

(3) Remove the air cleaner element from air cleaner housing.

(4) Before installing a new air cleaner element, clean inside of air cleaner housing.

(5) Position air cleaner cover to tabs on front of air cleaner housing. Latch the four spring clips to seal cover to housing.

(6) Install the air inlet tube at air cleaner housing inlet. Note the hose alignment notches at both the inlet hose and air cleaner cover (Fig. 27).

(7) Position the tube clamp to the inlet tube and tighten to 3 N·m (25 in. lbs.) torque.

INTAKE MANIFOLD AIR TEMPERATURE SENSOR

The intake manifold air temperature sensor is located on the top of intake manifold and to the rear of the intake manifold heater (Fig. 29).

REMOVAL

(1) Disconnect the electrical connector at the sensor.

(2) Remove the sensor (Fig. 29) the from intake manifold.

REMOVAL AND INSTALLATION (Continued)

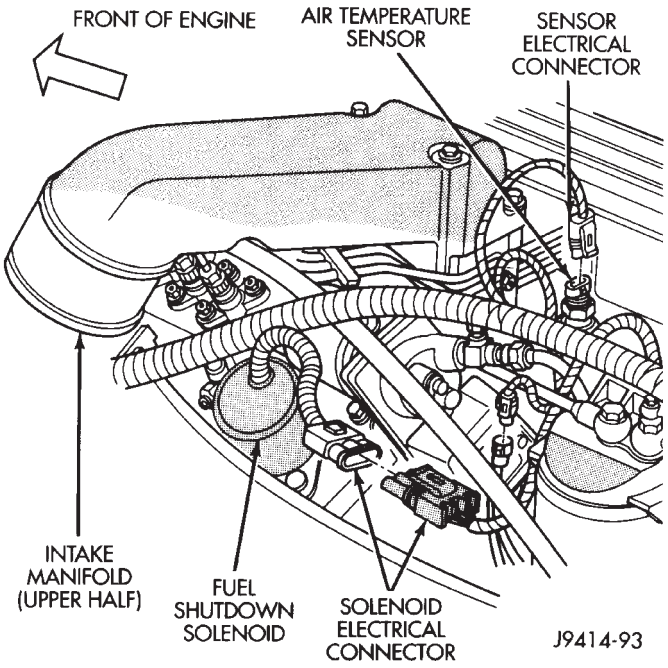


Fig. 29 Air Temperature Sensor Location—Diesel

INSTALLATION

(1) Install sensor to intake manifold. Tighten to 28 N·m (20 ft. lbs.) torque.

(2) Install electrical connector.

INTAKE MANIFOLD AIR HEATER ELEMENTS

The intake manifold air heater elements are located within the top cover of the intake manifold (Fig. 30). If replacement of the elements is necessary, the intake manifold cover must be removed. Refer to Intake Manifold Removal/Installation in Group 11.

INTAKE MANIFOLD AIR HEATER RELAYS

The relays are located in the engine compartment, bolted to the left inner fender below the left battery (Fig. 31).

REMOVAL

The mounting bracket and both relays are replaced as an assembly.

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect the four relay trigger wires at both relays (Fig. 31). Note the position of wiring before removing.

(3) Lift the four rubber shields from the four cables (Fig. 31).

(4) Remove the four nuts at the cable connectors (Fig. 31). Note the position of wiring before removing.

(5) Remove the three relay mounting bracket bolts (Fig. 31) and remove relay assembly.

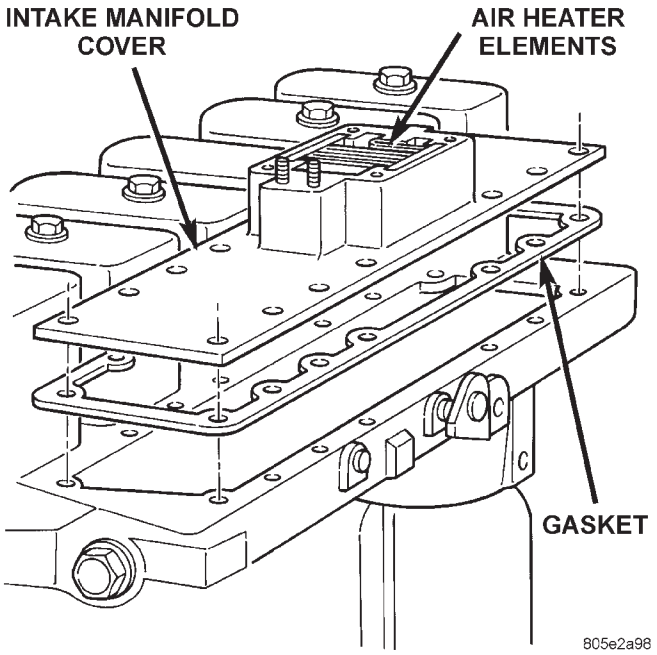


Fig. 30 Intake Manifold Air Heater Elements

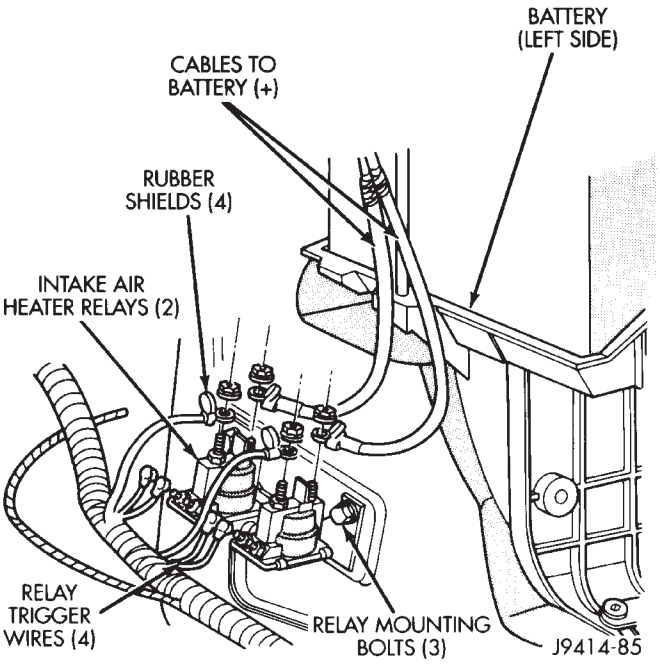


Fig. 31 Intake Manifold Air Heater Relays

INSTALLATION

(1) Install the relay assembly to the inner fender. Tighten mounting bolts to 4.5 N·m (40 in. lbs.) torque.

(2) Connect the eight electrical connectors to the relays.

(3) Connect battery cables to both batteries.

REMOVAL AND INSTALLATION (Continued)

WATER-IN-FUEL SENSOR

The Water-In-Fuel (WIF) sensor is located at the side of fuel filter/water separator canister. Refer to Fuel Filter/Water Separator Removal/Installation for WIF sensor removal/installation procedures.

SPECIFICATIONS

TORQUE CHART—DIESEL ENGINE

DESCRIPTION	TORQUE
Engine Speed Sensor Nuts	24 N·m (18 ft. lbs.)
Intake Manifold Air Temp. Sensor	28 N·m (20 ft. lbs.)
Intake Manifold Air Heater Relay Bolts	4.5 N·m (40 in. lbs.)
PCM Mounting Bolts	4 N·m (35 in. lbs.)