FUEL SYSTEM

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GENERAL INFORMATION

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% 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-DIESEL ENGINE

INDEX

DESCRIPTION AND OPERATION

FUEL DELIVERY SYSTEM—DIESEL ENGINE

Two different fuel systems (early and late) are used for the diesel engine in this model year. The **early** fuel system, using the two-valve-per-cylinder engine, will retain the mechanical fuel injection pump as used in previous model years. The **late** fuel system, using the four-valve-per-cylinder engine, will use an **electronic** fuel injection pump with three control modules. This book will include information for the **late** fuel system only.

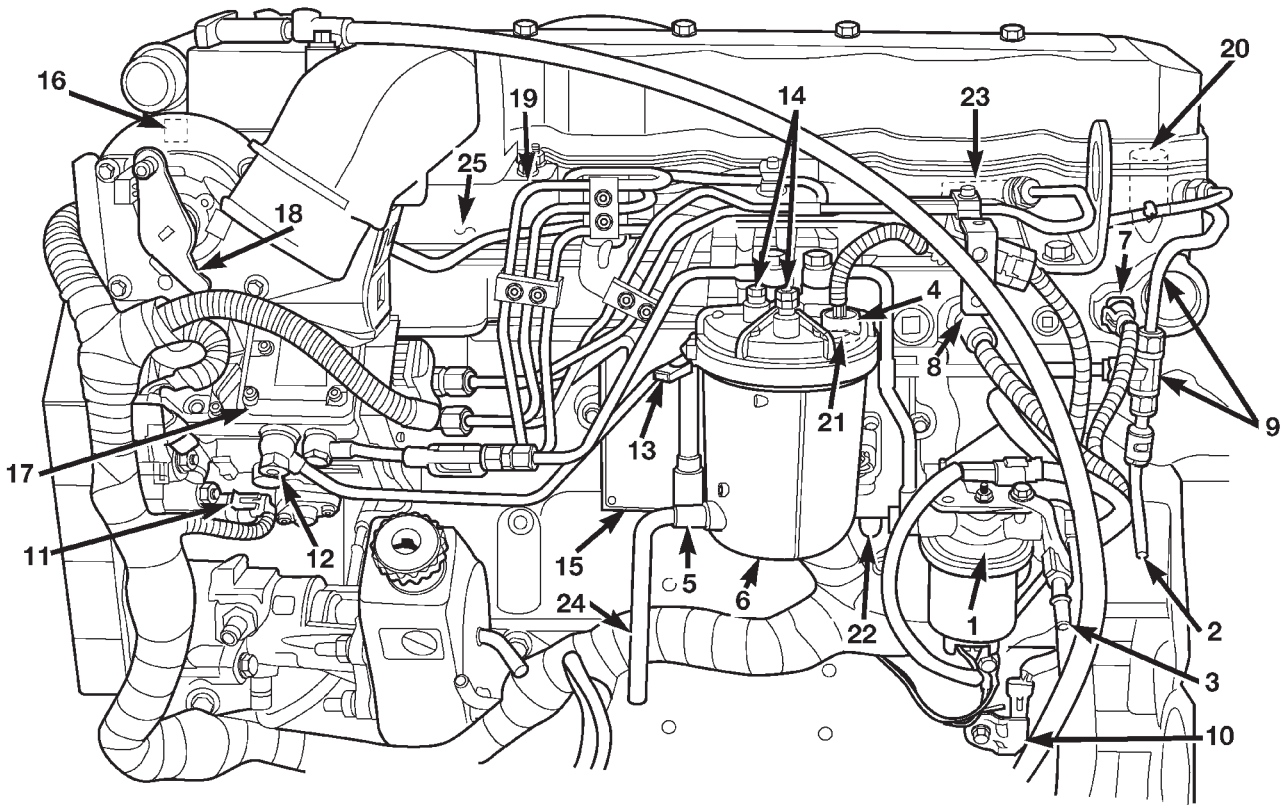
Also refer to the Powertrain Control Module (PCM) or Engine Control Module sections.

Some fuel system components are shown in (Fig. 1).

The fuel delivery system consists of the:

- Accelerator pedal
- Air cleaner housing/element
- Fuel drain manifold (passage)
- Fuel filter/water separator
- Fuel heater
- Fuel heater relay
- Fuel transfer (lift) pump
- Fuel injection pump
- Fuel injectors
- Fuel heater temperature sensor
- 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 injector lines
- In-tank fuel filter (at bottom of fuel tank module)
- Low-pressure fuel supply lines
- Low-pressure fuel return line
- Overflow valve
- Quick-connect fittings
- Throttle cable
- Water draining

DESCRIPTION AND OPERATION (Continued)



1. FUEL TRANSFER (LIFT) PUMP
2. FUEL RETURN LINE (TO FUEL TANK)
3. FUEL SUPPLY LINE (LOW-PRESSURE, TO ENGINE)
4. FUEL HEATER
5. WATER-IN-FUEL (WIF) SENSOR
6. FUEL FILTER/WATER SEPARATOR
7. IAT SENSOR
8. MAP (BOOST) SENSOR
9. FUEL DRAIN MANIFOLD
10. CKP SENSOR
11. CMP SENSOR
12. OVERFLOW VALVE
13. DRAIN VALVE
14. FUEL PRESSURE TEST PORTS
15. ECM
16. ECT SENSOR
17. FUEL INJECTION PUMP
18. THROTTLE LEVER BELLCRANK AND APPS
19. HIGH-PRESSURE FUEL LINES
20. FUEL INJECTORS
21. FUEL HEATER TEMPERATURE SENSOR (THERMOSTAT)
22. OIL PRESSURE SENSOR
23. FUEL INJECTOR CONNECTOR
24. DRAIN TUBE
25. INTAKE MANIFOLD AIR HEATER/ELEMENTS

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Fig. 1 Fuel System Components—Diesel Engine

DESCRIPTION AND OPERATION (Continued)

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

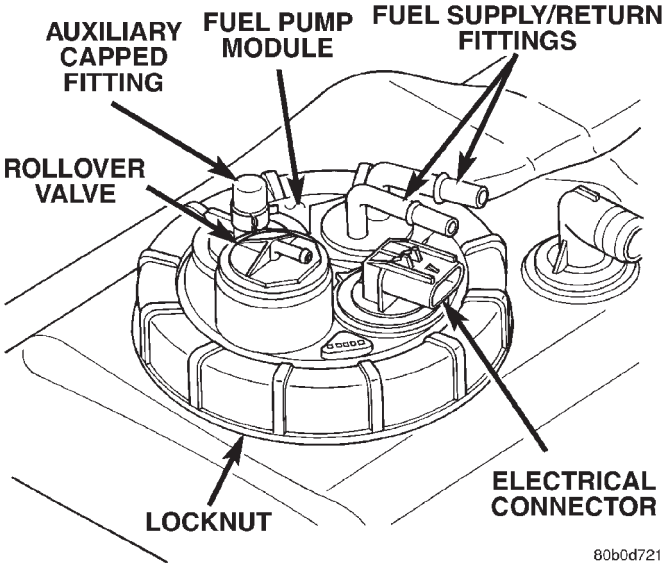


Fig. 2 Top View of Fuel Tank Module—Diesel

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.

FUEL HEATER

The fuel heater is used to prevent diesel fuel from waxing during cold weather operation. The fuel heater assembly is located in the top of the fuel filter housing (Fig. 3).

The heater/element assembly is equipped with a temperature sensor (thermostat) that senses fuel temperature. This sensor is attached to the fuel heater/element assembly (Fig. 4) (bottom view). When the temperature is below 45 ±8 degrees F, the sensor allows current to flow to the heater element warming the fuel. When the temperature is above 75 ±8 degrees F, the sensor stops current flow to the heater element.

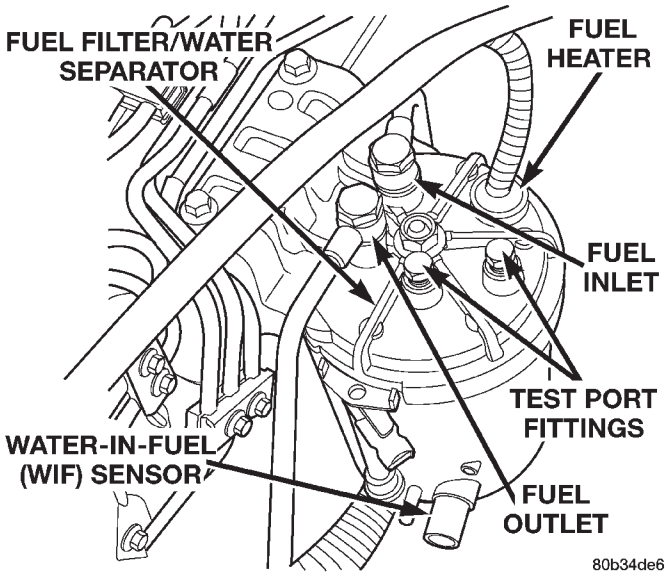


Fig. 3 Fuel Heater Location

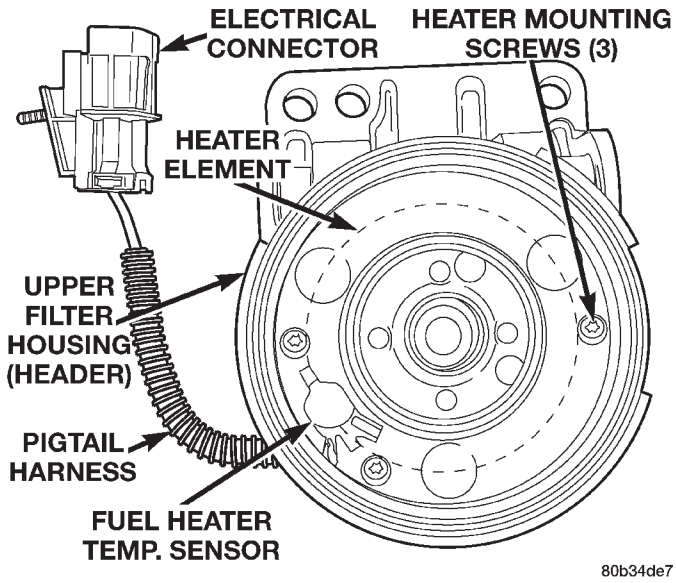


Fig. 4 Fuel Heater Temperature Sensor Location

DESCRIPTION AND OPERATION (Continued)

Battery voltage to operate the fuel heater element is supplied from the ignition switch and through the fuel heater relay. Also refer to Fuel Heater Relay. **The fuel heater element and fuel heater relay are not computer controlled.**

The heater element operates on 12 volts, 300 watts at 0 degrees F.

FUEL HEATER RELAY

Battery voltage to operate the fuel heater element is supplied from the ignition switch through the fuel heater relay. **The fuel heater element and fuel heater relay are not computer controlled.**

The fuel heater relay is located in Power Distribution Center (PDC) (Fig. 5). Refer to label on inside of PDC cover for relay location.

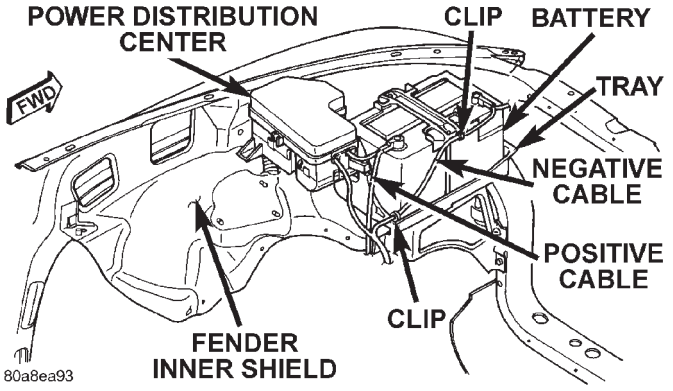


Fig. 5 Power Distribution Center Location

FUEL TRANSFER (LIFT) 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. 6). The 12–volt electric vane-type pump is operated and controlled by the Engine Control Module (ECM). The ECM is bolted to the left side of the engine block behind the fuel filter (Fig. 7).

The purpose of the fuel transfer pump is to supply (transfer) a low-pressure fuel source: **from** the fuel tank, **through** the fuel filter/water separator and **to** the fuel injection pump. Here, the low-pressure is raised to a high-pressure by the fuel injection pump for operation of the high-pressure fuel injectors. Check valves within the pump, control direction of fuel flow and prevent fuel bleed-back during engine shut down.

Normal current flow to the pump is 12 amperes.

With the engine running, the pump has **2** modes of operation: Mode 1: 100 percent duty-cycle with a minimum pressure of 10 psi **except when the engine is cranking.** Mode 2: 25 percent duty-cycle with minimum pressure of 7 psi **with the engine cranking**

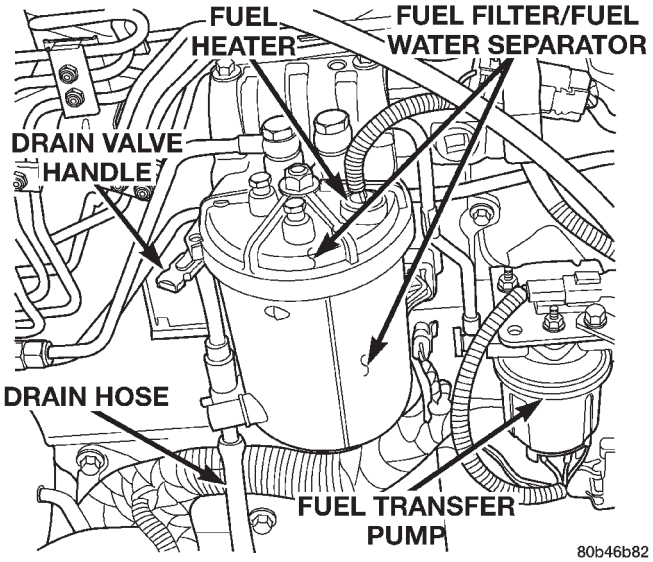


Fig. 6 Fuel Transfer Pump Location

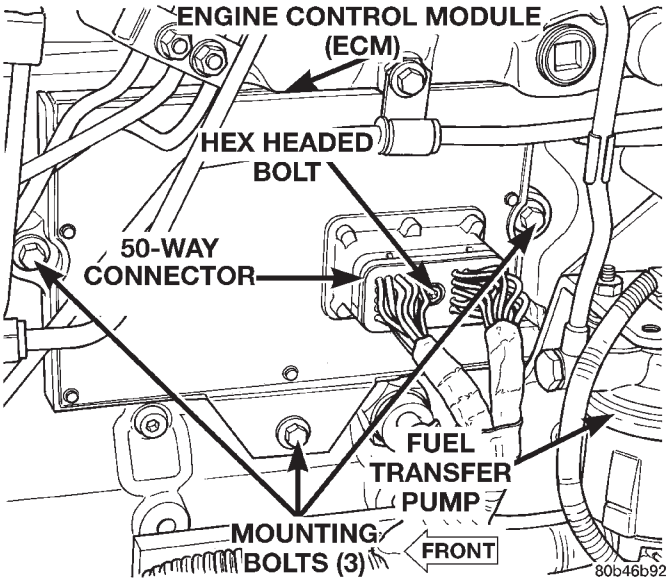


Fig. 7 Engine Control Module (ECM) Location

The 25 percent duty-cycle is used to limit injection pump inlet pressure until the engine is running.

The transfer pump is self-priming: When the key is first turned on (without cranking engine), the pump will operate for approximately 2 seconds and then shut off. The pump will also operate for up to 25 seconds after the starter is engaged, and then disengaged and the engine is not running. The pump shuts off immediately if the key is on and the engine stops running.

DESCRIPTION AND OPERATION (Continued)

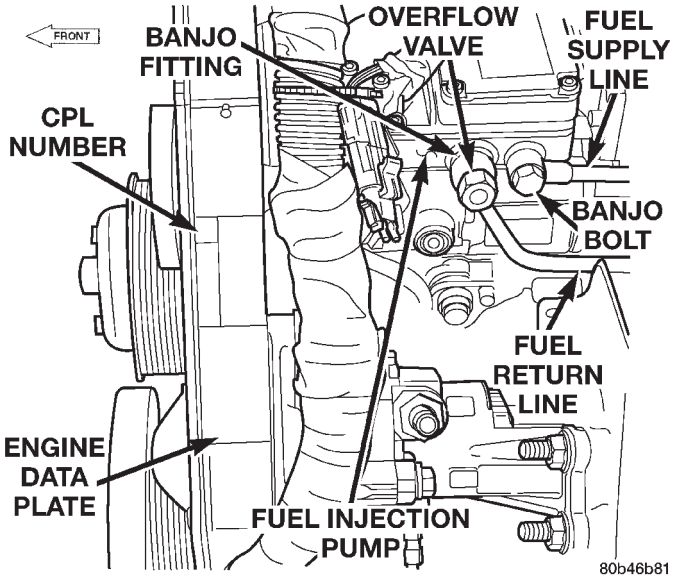


Fig. 8 Injection Pump Overflow Valve Location

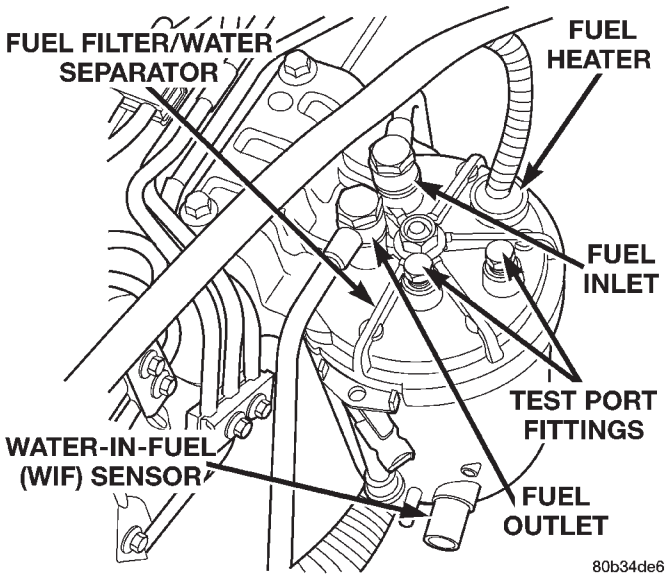


Fig. 9 Fuel Filter/Water Separator Location

The fuel volume of the transfer pump will always provide more fuel than the fuel injection pump requires. Excess fuel is returned from the injection pump through an overflow valve. The valve is located on the side of the injection pump (Fig. 8). It is also used to connect the fuel return line to the side of the injection pump. This valve opens at approximately 97 kPa (14 psi) and returns fuel to the fuel tank through the fuel return line.

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. 9). The assembly also includes the fuel heater and Water-In-Fuel (WIF) sensor.

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 Removal/Installation section.

A Water-In-Fuel (WIF) sensor is attached to side of canister. Refer to Water-In-Fuel Sensor Description/Operation.

The fuel heater is installed into the top of the filter/separator housing. Refer to Fuel Heater Description/Operation.

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.

DESCRIPTION AND OPERATION (Continued)

FUEL INJECTION PUMP

The Bosch VP44 fuel injection pump (Fig. 10) is a solenoid-valve controlled-radial-piston-distributor type pump. The pump is mounted to the rear of the timing gear housing on the left side of engine (Fig. 11).

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. The VP44 is controlled by an integral (and non-serviceable) Fuel Pump Control Module (FPCM) (Fig. 11). The FPCM can operate the engine as an engine controller if a Crankshaft Position Sensor (CKP) signal is not present.

Fuel from the transfer (lift) pump enters the VP44 where it is pressurized and then distributed through high-pressure lines to the fuel injectors. The VP44 is cooled by the fuel that flows through it. A greater quantity of fuel is required for cooling the VP44 than what is necessary for engine operation. Because of this, approximately 70 percent of fuel entering the pump is returned to the fuel tank through the overflow valve and fuel return line. Refer to Overflow Valve Description/Operation for additional information.

The VP44 is not self-priming. At least two fuel injectors must be bled to remove air from the system. When servicing the fuel system, disconnecting components up to the pump will usually not require air bleeding from the fuel system. However, removal of the high-pressure lines, removal of the VP44 pump, or allowing the vehicle to completely run out of fuel, will require bleeding air from the high-pressure lines at the fuel injectors.

VP44 timing is matched to engine timing by an offset keyway that fits into the pump shaft. This keyway has a stamped number on it that is matched to a number on the VP44 pump (each keyway is calibrated to each pump).

When removing/installing the VP44, the same numbered keyway must always be installed. Also, the arrow on the top of the keyway should be installed pointed to the rear of pump.

Because of electrical control, the injection pump high and low idle speeds are not adjustable. Also, adjustment of fuel pump timing is not required and is not necessary.

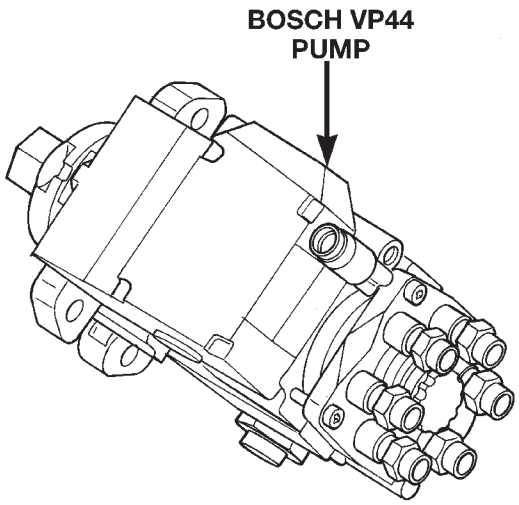


Fig. 10 Bosch VP44 Fuel Injection Pump

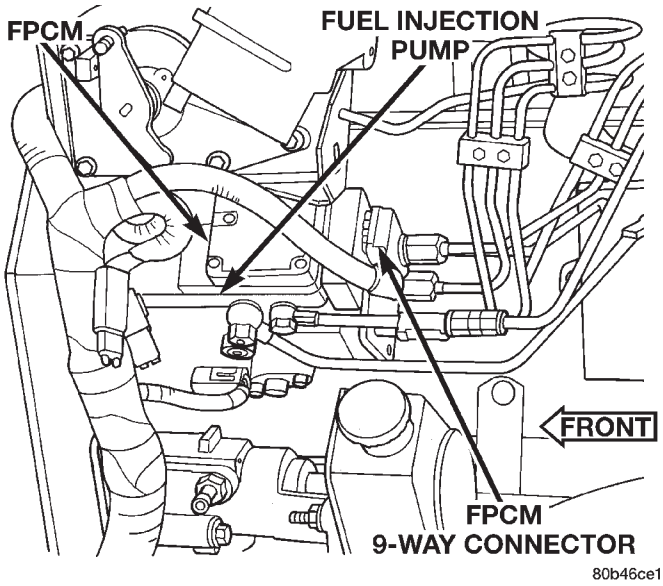


Fig. 11 Fuel Injection Pump Location

DESCRIPTION AND OPERATION (Continued)

FUEL INJECTORS

Six individual, high-pressure fuel injectors are used. The injectors are vertically mounted (Fig. 12) into a bored hole in the top of the cylinder head. This bored hole is located between the intake/exhaust valves.

High-pressure fuel is supplied from the injection pump, through a high-pressure fuel line, through a steel connector and into the fuel injector. When fuel pressure rises to approximately 31,026 kPa (4,500 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 nozzle opening pressure. This is sometimes referred to as the “pop” pressure setting.

Each fuel injector is connected to each high-pressure fuel line with a steel connector (Fig. 13). This steel connector is positioned into the cylinder head and sealed with an o-ring. The connectors are sealed to the high-pressure fuel lines with fittings (Fig. 13). The ferrule (Fig. 13) on the end of the high-pressure fuel line pushes against the steel connector when the fuel line fitting is torqued into the cylinder head. This torquing force provides a sealing pressure between both the fuel line-to-connector and the fuel connector-to-fuel injector. **The fitting torque is very critical.** If the fitting is under torqued, the mating surfaces will not seal and a high-pressure fuel leak will result. If the fitting is over torqued, the connector and injector will deform and also cause a high-pressure fuel leak. This leak will be inside the cylinder head and will not be visible. The result will be a possible fuel injector miss-fire and low power.

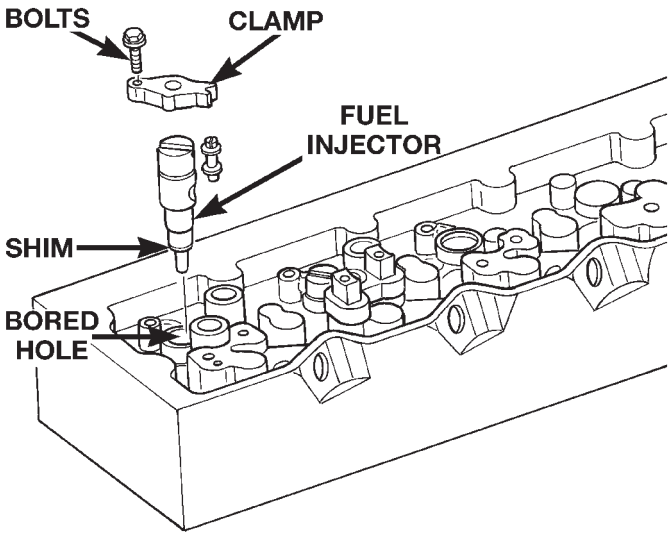


Fig. 12 Fuel Injector Location

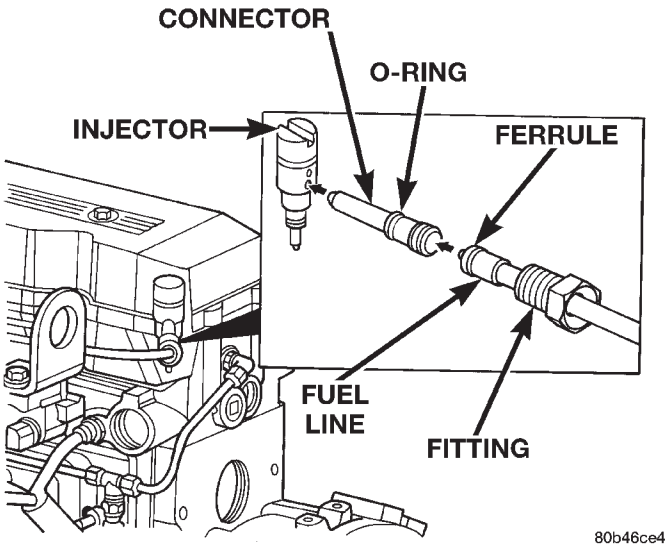


Fig. 13 Fuel Injector Connections

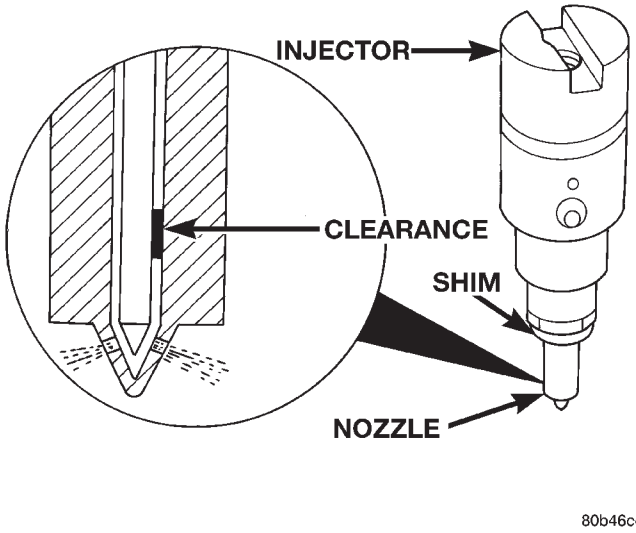


Fig. 14 Fuel Injector Spray Pattern

The fuel injectors use hole type nozzles (Fig. 14). High-pressure flows into the side of the injector and causes the injector needle to lift and fuel to be injected. The clearances in the nozzle bore (Fig. 14) are extremely small and any sort of dirt or contaminants will cause the injector to stick. Because of this, it is very important to do a thorough cleaning of any lines before opening up any fuel system component. Always cover or cap any open fuel connections before a fuel system repair is performed.

DESCRIPTION AND OPERATION (Continued)

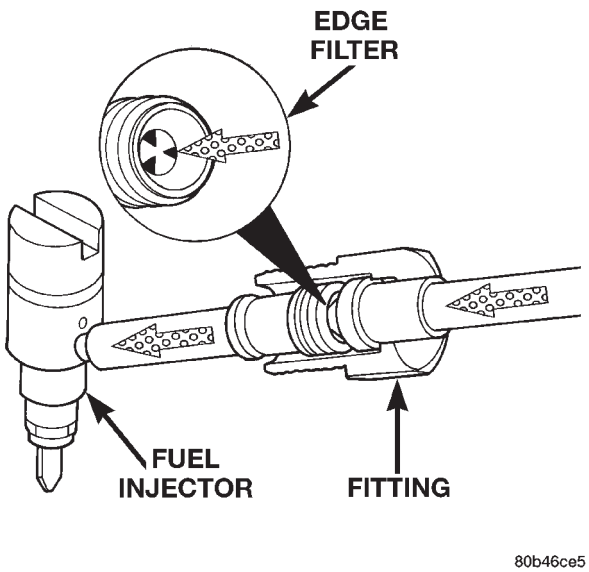


Fig. 15 Fuel Injector Edge Filter

Each fuel injector connector tube contains an edge filter (Fig. 15) that breaks up small contaminants that enter the injector. The edge filter uses the injectors pulsating high-pressure to break up most particles so they are small enough to pass through the injector. **The edge filters are not a substitute for proper cleaning and covering of all fuel system components during repair.**

The bottom of each fuel injector is sealed to the cylinder head with a **1.5mm** thick copper shim (gasket) (Fig. 14). The correct thickness shim must always be re-installed after removing an injector.

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.

QUICK-CONNECT FITTINGS

Different types/sizes of quick-connect fittings are used to attach various fuel system components. These may be: a single-tab type, a two-tab type or a plastic retainer ring-type. Most fittings on diesel applications are the two-tab type. Refer to Quick-Connect Fittings Removal/Installation for more information.

CAUTION: The interior components (o-rings, spacers) of quick-connect fittings are not serviced separately, but new clips 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.

LOW-PRESSURE FUEL LINES

All fuel lines up to the fuel injection pump are considered low-pressure. This includes the fuel lines from: the fuel tank to the fuel transfer pump, and the fuel transfer pump to the fuel injection pump. The fuel return lines, the fuel drain manifold and the fuel drain manifold lines are also considered low-pressure lines. High-pressure lines are used between the fuel injection pump and the fuel injectors. Also refer to High-Pressure Fuel Lines Description/Operation.

HIGH-PRESSURE FUEL LINES

The high-pressure fuel lines are the 6 lines located between the fuel injection pump and the fuel injector connector tubes (Fig. 16). All other fuel lines are considered low-pressure lines.

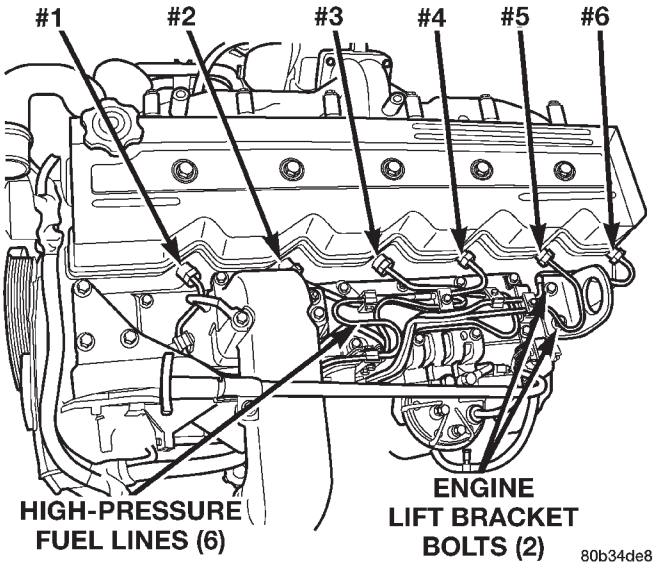


Fig. 16 High-Pressure Fuel Lines

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. If lines are ever kinked or bent, they must be replaced. Use only 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.

DESCRIPTION AND OPERATION (Continued)

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

FUEL DRAIN MANIFOLD PASSAGE

When the engine is running, and during injection, a small amount of fuel flows past the injector nozzle and is not injected into the combustion chamber. This fuel is used to lubricate the fuel injectors. Excess fuel drains into the fuel drain manifold (or passage). The fuel drain manifold is actually a rifled passage within the cylinder head (Fig. 17). Fuel is drained from this passage into a line at the rear of the cylinder head (Fig. 17). After exiting the cylinder head, fuel is routed (returned) back to the fuel tank. A "T" is installed into the fuel return line (Fig. 17). This "T" is used to allow excess fuel from the injection pump to be returned into the fuel tank. A one-way check valve within the overflow valve prevents fuel (from the fuel drain manifold) from entering the fuel injection pump.

A **small** amount of fuel is returned from the fuel injectors, while a **large** amount (about 70% of supplied fuel) is returned from the fuel injection pump.

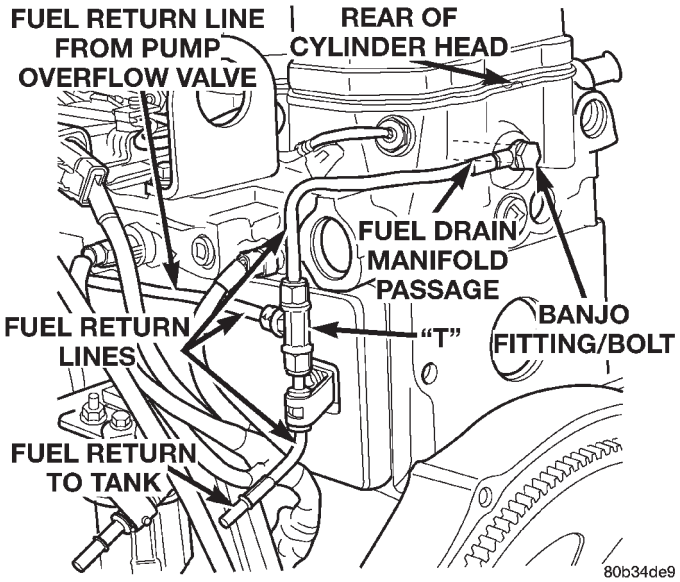


Fig. 17 Fuel Drain Manifold Passage

OVERFLOW VALVE

Fuel volume from the fuel transfer (lift) pump will always provide more fuel than the fuel injection pump requires. The overflow valve (a pressure relief valve) is used to route excess fuel through the fuel return line and back to the fuel tank. Approximately 70% of supplied fuel is returned to the fuel tank. The valve is located on the side of the injection pump (Fig. 18). It is also used to connect the fuel return line (banjo fitting) to the fuel injection pump. The valve opens at approximately 97 kPa (14 psi). If the check valve within the assembly is sticking, low engine power, hard starting or white smoke may result.

If a Diagnostic Trouble Code (DTC) has been stored for "decreased engine performance due to high injection pump fuel temperature", the overflow valve may be stuck in closed position.

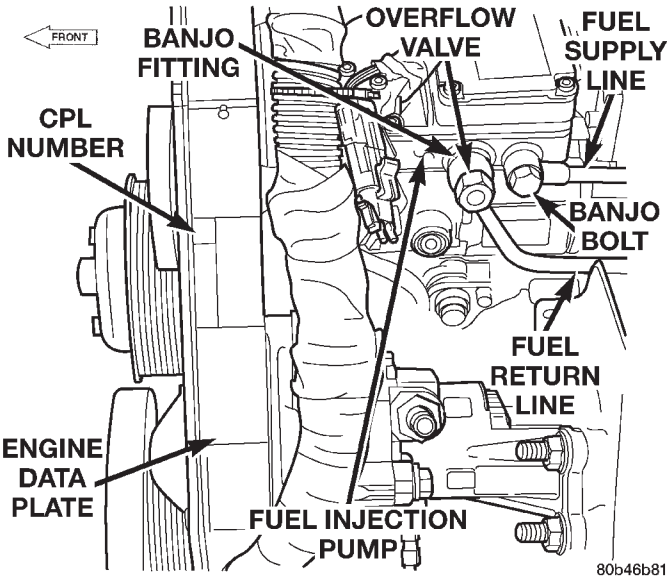


Fig. 18 Overflow Valve Location

DIAGNOSIS AND TESTING

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.

FUEL SUPPLY RESTRICTIONS

LOW-PRESSURE LINES

Fuel supply line restrictions or a defective fuel transfer pump can cause starting problems and prevent engine from revving up. The starting problems include; low power and/or white fog like exhaust.

Test all fuel supply lines for restrictions or blockage. Flush or replace as necessary. Bleed fuel system of air once a fuel supply line has been replaced. Refer to Air Bleed Procedure for procedures.

To test for fuel line restrictions, a vacuum restriction test may be performed. Refer to Fuel Transfer Pump Pressure Test.

HIGH-PRESSURE LINES

Restricted (kinked or bent) high-pressure lines can cause starting problems, poor engine performance, engine mis-fire and white 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 correct replacement line.

CAUTION: All high-pressure fuel lines must be clamped securely in place in holders. Lines cannot contact each other or other components. Do not attempt to weld high-pressure fuel lines or to repair lines that are damaged. If line is kinked or bent, it must be replaced. Use only recommended lines when replacement of high-pressure fuel line is necessary.

FUEL TRANSFER PUMP PRESSURE TEST

The following tests will include: pressures tests of fuel transfer pump (engine running and engine cranking), a pressure drop test of fuel filter, a test for supply side restrictions, and a test for air in fuel supply side.

Refer to Fuel Transfer Pump Description/Operation for an operational description of transfer pump.

The fuel transfer (lift) pump is located on left side of engine and above starter motor (Fig. 19).

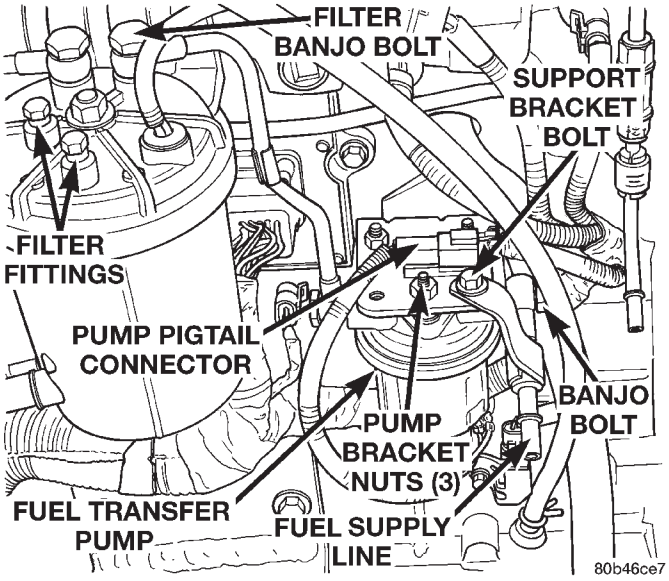


Fig. 19 Fuel Transfer Pump Location

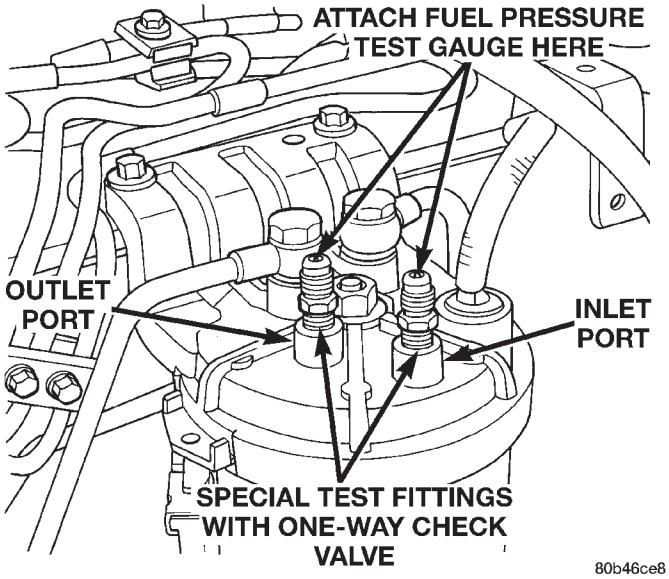


Fig. 20 Fuel Pressure Test Port Fitting Location

DIAGNOSIS AND TESTING (Continued)

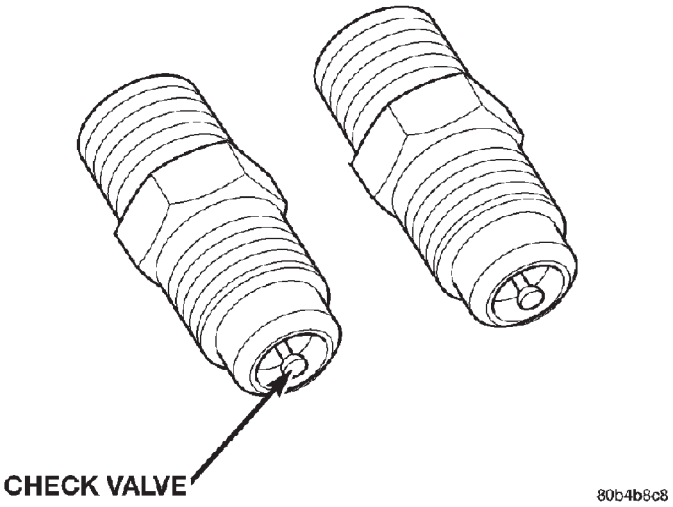


Fig. 21 Fuel Pressure Test Port Fittings

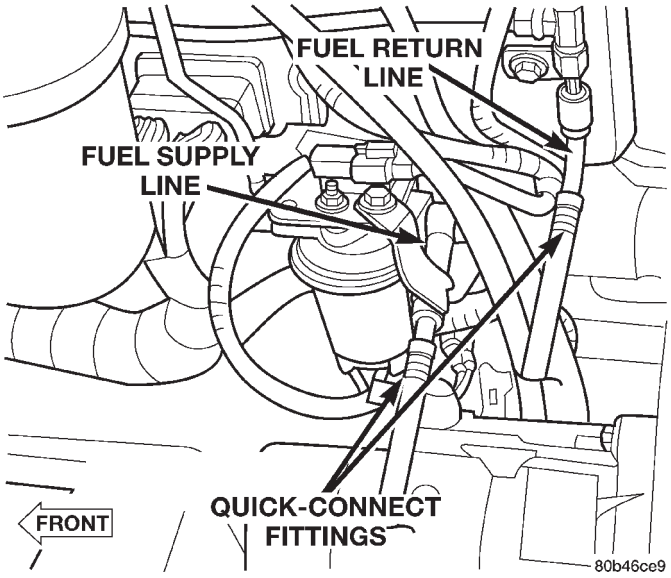


Fig. 22 Fuel Return and Supply Line Quick-Connect Locations

An improperly operating fuel transfer pump, a plugged or dirty fuel filter, or a defective overflow valve can cause low engine power, excessive white smoke and/or hard engine starting.

Before performing following tests, inspect fuel supply and return lines for restrictions, kinks or leaks.

Fuel leaking from pump casing indicates a leaking pump which must be replaced.

Pressure Test: Because the transfer pump is operating at two different pressure cycles (engine running and engine cranking), two different pressure tests will be performed.

(1) Remove 2 existing filter fittings (plugs) at top of fuel filter housing (Fig. 19) (clean area around fittings before fitting removal). In place of 2 fittings

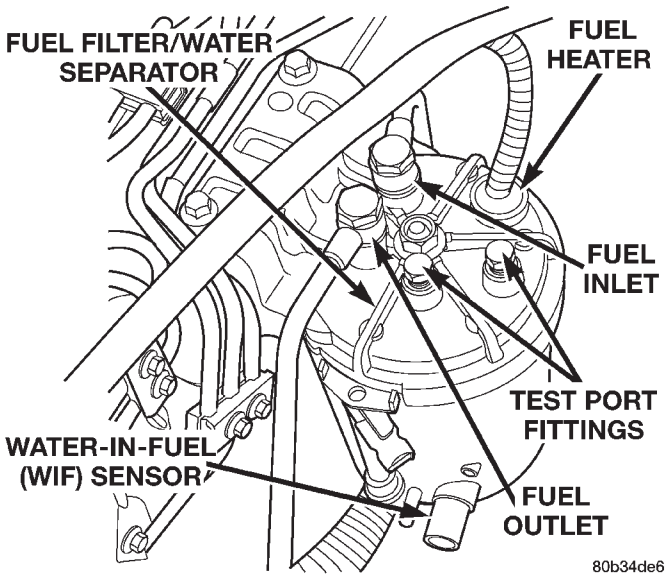


Fig. 23 Test Port at Fuel Inlet

(plugs), install 2 special fittings (Fig. 20). These special fittings are equipped with a spring-loaded shut-off valve (one-way check valve) and are commercially available from a Tube Fitting Supplier. Use Parker® Access Valve, Male Connector part number AVU1-2 or equivalent (Fig. 21).

(2) Install Special Fuel Pressure Test Gauge 6828 (or equivalent) to special fitting at INLET PORT (Fig. 20).

(3) To prevent engine from starting, remove fuel system relay (fuel injection pump relay). Relay is located in Power Distribution Center (PDC). Refer to label under PDC cover for relay location.

(4) Using key, crank engine over while observing gauge. Pressure should be 5–7 psi.

(5) Re-install fuel system relay to PDC.

(6) Start engine and record fuel pressure. Pressure should be a **minimum** of 69 kPa (10 psi) at idle speed.

(7) Because fuel pump relay was removed, a Diagnostic Trouble Code (DTC) may have been set. After testing, use DRB scan tool to remove DTC.

Pressure Drop Test:

(8) Shut engine off and remove test gauge from INLET PORT. Re-attach 6828 test gauge to OUTLET PORT (Fig. 20). Start engine and record fuel pressure. Pressure should not be more than 34 kPa (5 psi) lower than INLET PORT pressure test. If so, replace fuel filter.

Fuel Supply Restriction Test:

Due to very small vacuum specifications, the DRB scan tool along with the Periphal Expansion Port (PEP) Module and 0–15 psi transducer must be used.

(9) Verify transfer pump pressure is OK before performing restriction test.

DIAGNOSIS AND TESTING (Continued)

(10) Locate and disconnect fuel supply line quick-connect fitting at left-rear of engine (Fig. 22). After disconnecting line, plastic clip will remain attached to metal fuel line at engine. Carefully remove clip from metal line. Snap same clip into fuel supply hose.

(11) Install Special Rubber Adapter Hose Tool 6631 (3/8") into ends of disconnected fuel supply line.

(12) Install transducer from PEP module to brass "T" fitting on tool 6631.

(13) Hook up DRB scan tool to transducer.

(14) Start engine and record vacuum reading with engine speed at high-idle (high-idle means engine speed is at 100 percent throttle and no load). The fuel restriction test **MUST** be done wth engine speed at high-idle.

(15) If vacuum reading is **less** than 6 in/hg. (0–152 mm hg.), test is OK. If vacuum reading is **higher** than 6 in/hg. (152 mm hg.), restriction exists in fuel supply line or in fuel tank module. Check fuel supply line for damage, dents or kinking. If OK, remove module and check module and lines for blockage. Also check fuel pump inlet filter at bottom of module for obstructions.

Testing For Air Leaks in Fuel Supply Side:

(16) A 3–foot section of 1/4" I.D. clear tubing and a 1/8" NPT fitting are required for this test.

(17) Two test port fittings (plugs) are located at top of fuel filter housing (Fig. 23). Remove fitting at fuel **inlet** side of housing (towards rear of filter housing). Clean area around fitting before removal. In place of test port fitting (plug), install a 1/8" NPT fitting having a 1/4" O.D. nipple.

(18) Attach and clamp clear hose to fitting nipple.

(19) Place other end of hose into a clear container.

(20) The fuel transfer pump can be put into a 25 second run mode if key is turned to crank position and released back to run position without starting engine.

(21) Allow air to purge from empty hose before examining for air bubbles. Air bubbles should not be present.

(22) If bubbles are present, check for leaks in supply line to fuel tank.

(23) If supply line is not leaking, remove fuel tank module and remove filter at bottom of module (filter snaps to module). Check for leaks between supply nipple at top of module, and filter opening at bottom of module. Replace module if necessary.

OVERFLOW VALVE TEST

Fuel volume from the fuel transfer (lift) pump will always provide more fuel than the fuel injection pump requires. The overflow valve (a pressure relief valve) is used to route excess fuel through the fuel return line and back to the fuel tank. Approximately 70% of supplied fuel is returned to the fuel tank. The valve is located on the side of the injection pump (Fig. 24). It is also used to connect the fuel return line (banjo fitting) to the fuel injection pump. The valve opens at approximately 97 kPa (14 psi). If the check valve within the assembly is sticking, low engine power or hard starting may result.

If a Diagnostic Trouble Code (DTC) has been stored for "decreased engine performance due to high injection pump fuel temperature", the overflow valve may be stuck in closed position.

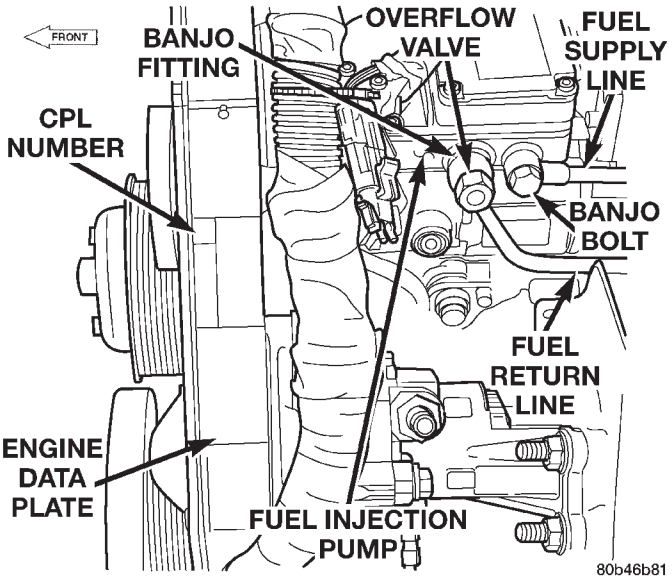


Fig. 24 Overflow Valve Location

A rubber tipped blow gun with regulated air line pressure is needed for this test.

(1) Clean area around overflow valve and fuel return line at injection pump before removal.

(2) Remove valve from pump and banjo fitting.

(3) Discard old sealing gaskets.

(4) Set regulated air pressure to approximately 97 kPa (14–16 psi).

(5) Using blow gun, apply pressure to overflow valve inlet end (end that goes into injection pump).

DIAGNOSIS AND TESTING (Continued)

(6) Internal check valve should release, and air should pass through valve at 97 kPa (14–16 psi). If not, replace valve.

(7) Reduce regulated air pressure to 10 psi and observe valve. Valve should stay shut. If not, replace valve.

(8) Install new sealing gaskets to valve.

(9) Install valve through banjo fitting and into pump.

(10) Tighten to 30 N·m (24 ft. lbs.) torque.

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 assembly is located in the top of the fuel filter housing (Fig. 25).

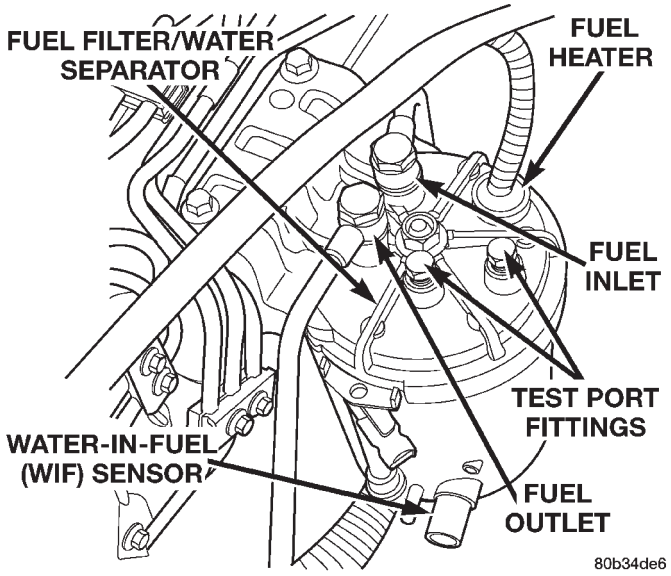


Fig. 25 Fuel Heater Location

The heater assembly is equipped with a built-in fuel temperature sensor (thermostat) (Fig. 26) that senses fuel temperature. When fuel temperature drops below 45 degrees ± 8 degrees F, the sensor allows current to flow to the built-in heater element to warm the fuel. When fuel temperature rises above

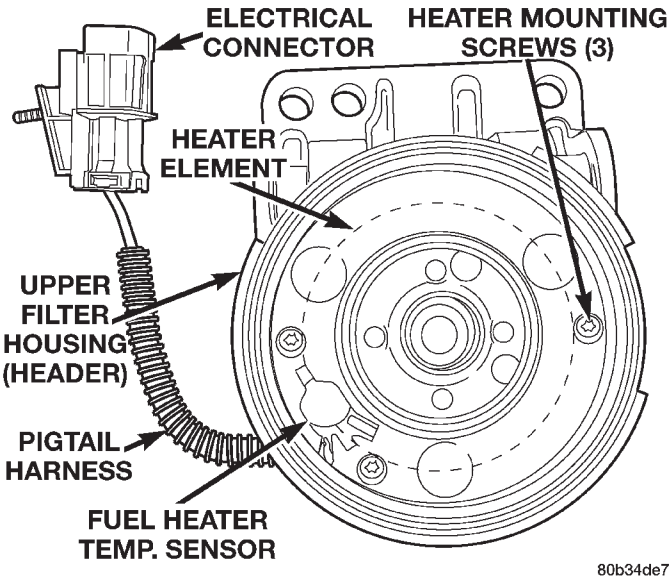


Fig. 26 Fuel Heater Assembly (Bottom View)

75 degrees ± 8 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 (also refer to Fuel Heater Relay), to the fuel temperature sensor and on to the fuel heater element.

The heater element operates on 12 volts, 300 watts at 0 degrees F. As temperature increases, power requirements decrease.

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) Disconnect heater pigtail harness (Fig. 26) from main engine harness. Connection is made above and slightly rearward of fuel filter. All heater testing will be done at these 2 connectors.

Turn key to ON position. 12 volts should be present at red wire (at engine harness side of connector). If not, check fuel heater relay and related wiring. Refer to Relay Test—Fuel Heater. If OK, proceed.

Turn key OFF. Check black wire (at engine harness side of connector) for ground continuity with an ohmmeter. If continuity is not present, correct ground circuit. If OK, proceed.

(2) With pigtail harness connector still unplugged and key OFF, check electrical/mechanical operation of fuel temperature sensor (Fig. 26). Proceed to next step:

(3) Using an ohmmeter, check resistance across two terminals in connector (at heater side of connector). Sensor circuit should be open if fuel tempera-

DIAGNOSIS AND TESTING (Continued)

ture has risen above 75 degrees ± 8 degrees F. Sensor circuit should be closed if fuel temperature has dropped below 45 degrees ± 8 degrees F. If not, replace fuel heater assembly. This same test can also be performed using a voltmeter, with key ON, and by back-probing connector.

RELAY TEST—FUEL HEATER

The fuel heater relay is located in the Power Distribution Center (PDC). Refer to label under PDC cover for relay location.

To test the fuel heater, refer to Fuel Heater Test.

To test the relay only, refer to following:

The relay terminal numbers from (Fig. 27) 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 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

The fuel injectors are located in the top of the cylinder head between the intake/exhaust valves (Fig. 28).

A leaking fuel injector can cause fuel knock, poor performance, black smoke, poor fuel economy and rough engine idle. If fuel injector needle valve does not operate properly, engine may misfire and produce low power.

A leak in injection pump-to-injector high-pressure fuel line can cause many of same symptoms as malfunctioning injector. Inspect for leaks in high-pressure lines before checking for 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 HIGH-PRESSURE LINES. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE 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 FUEL SYSTEM OF A HOT ENGINE. DO NOT ALLOW FUEL TO SPRAY ONTO EXHAUST MANIFOLD WHEN BLEEDING AIR FROM FUEL SYSTEM.

(1) To determine which fuel injector is malfunctioning, run engine and isolate each cylinder using DRB scan tool. Note RPM drop for each cylinder. As an alternative, loosen high-pressure fuel line fitting at fuel injector connector tube (Fig. 29). Listen for a change in engine speed. After testing, tighten line fitting to 40 N·m (30 ft. lbs.) torque. If engine speed drops, injector was operating normally. If engine speed remains same, injector may be malfunctioning. Test all injectors in same manner one at a time.

(2) Once injector has been found to be malfunctioning, remove it from engine and test it. Refer to Fuel Injector Removal/Installation.

DIAGNOSIS AND TESTING (Continued)

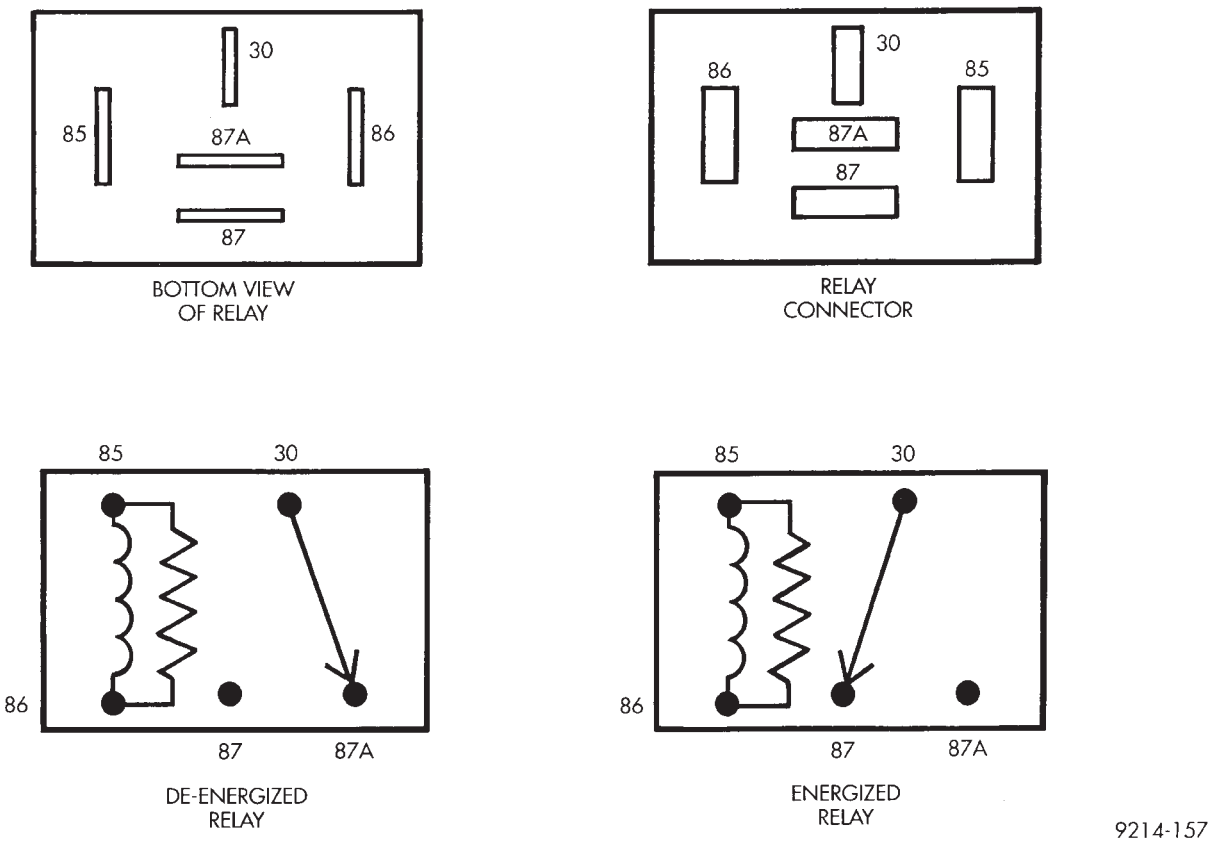


Fig. 27 Relay Terminals

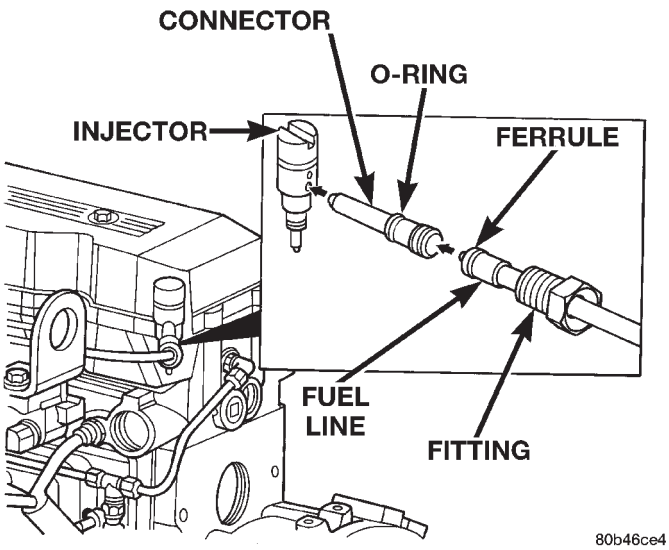


Fig. 28 Fuel Injector Connections

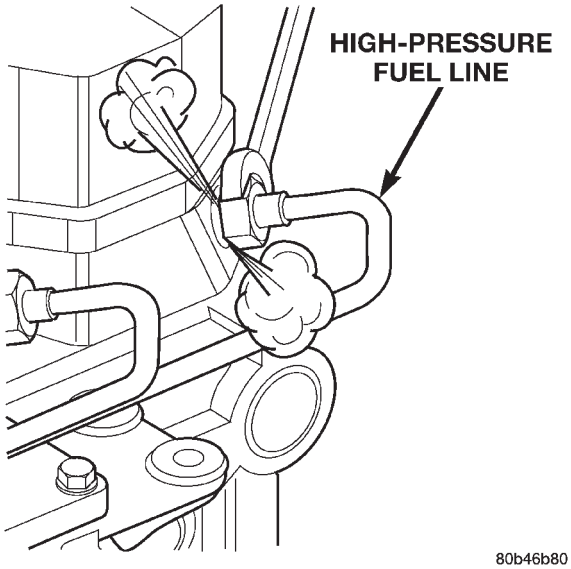


Fig. 29 Inspecting Injector Operation

DIAGNOSIS AND TESTING (Continued)

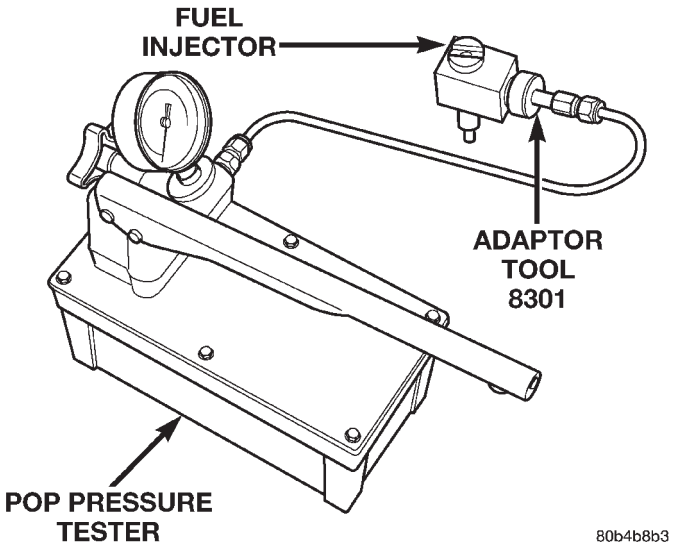


Fig. 30 Fuel Injector Tester and Adaptor Tool

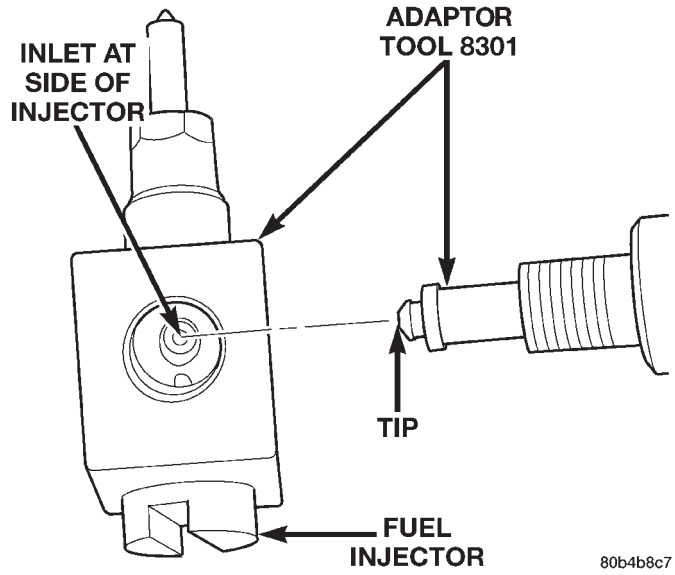


Fig. 31 Installing Injector to Adaptor Tool 8301

WARNING: FUEL INJECTOR TESTERS CAN DEVELOP EXTREMELY HIGH PRESSURES. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN AND CAUSE PERSONAL INJURY. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING. AVOID CONTACT WITH FUEL SPRAY WHEN OPERATING INJECTOR TESTOR.

(3) After injector has been removed, obtain bench-mount fuel injector tester OTC® (SPX®) part number 4210 (Fig. 30) (or equivalent). Install Special Tool number 8301 (Fuel Injector Adapter) to 4210 tester. Install fuel injector into 8301 adapter. Be sure tip of adapter tool 8301 is aligned to inlet hole at side of injector (Fig. 31) before tightening tool. Tighten tool 8301 to injector. Position container below injector before testing.

(4) Refer to operating instructions supplied with pressure tester for procedures.

(a) Check opening pressure or “pop” pressure. Pressure should be approximately 31,026 kPa (310 bars) or (4500 psi ± 250 psi). If fuel injector needle valve is opening (popping) too early or too late, replace injector.

(b) Perform a leak-down test on injector. Apply pressure with injector tester. The injector should not leak (drip) fuel with pressure at approximately 20 bars (291 psi) lower than pop pressure.

(c) Operate tester lever quickly several times to check injector spray pattern. Verify fuel is spraying from each injector nozzle hole. Injector should also spray evenly from each nozzle hole.

(d) Pay attention to size and shape of spray plumes. They should all be equal. If possible, compare spray pattern to that of a new fuel injector with same part number. Checking each plume for consistency is an excellent indicator of injector performance. Even if only one nozzle hole is plugged, significant performance problems could result.

(e) Look for burrs on injector inlet.

(f) Check nozzle holes for hole erosion or plugging.

(g) Inspect end of nozzle for burrs or rough machine marks.

(h) Look for cracks at nozzle end.

(i) Check nozzle color for signs of overheating. Overheating will cause nozzle to turn a dark yellow/tan or blue (depending on overheating temperature).

(j) Look at end of injector tube where it meets injector. A small, shiny band should be seen at this point. The band should have a consistent thickness. If not, injector could be leaking into fuel return.

(k) If any of these conditions occur, replace injector.

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.

DIAGNOSIS AND TESTING (Continued)

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.

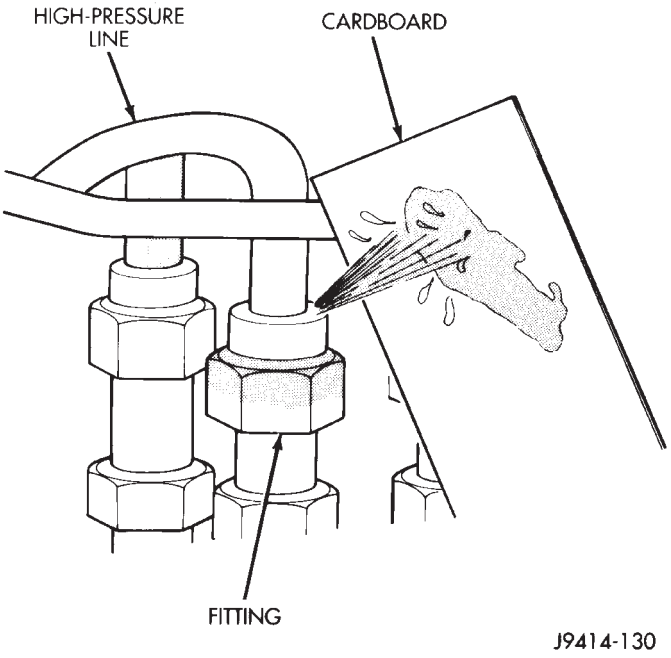


Fig. 32 Typical Test for Leaks with Cardboard

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.

FUEL INJECTION PUMP TIMING

With the Bosch VP44 injection pump, there are no mechanical adjustments needed for fuel injection timing. All timing and fuel adjustments are made by the Engine Control Module (ECM). However, if a Diagnostic Trouble Code (DTC) has been stored indicating an “engine sync error” or a “static timing error”, perform the following.

Note: If this DTC appears after installation of a new or rebuilt injection pump, the pump keyway has probably been installed backwards. Refer to Fuel Injection Pump Removal/Installation for keyway information.

(1) Remove plastic access cover, injection pump nut and washer (Fig. 33). Locate keyway behind washer.

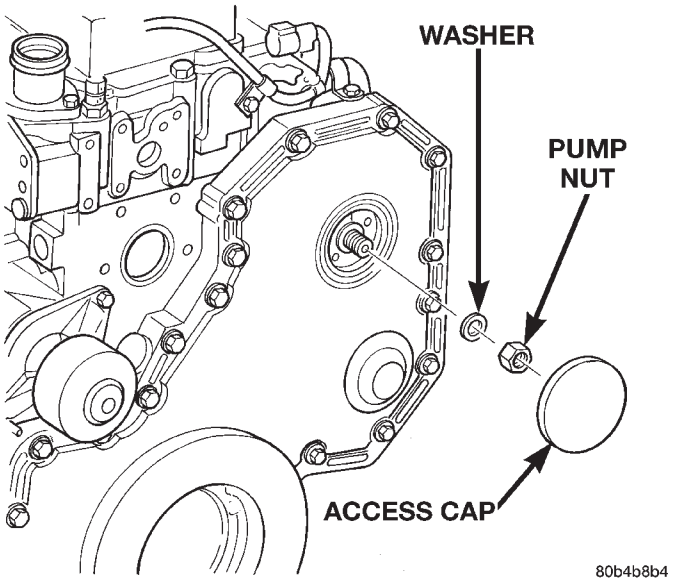


Fig. 33 Injection Pump Gear Access Cap

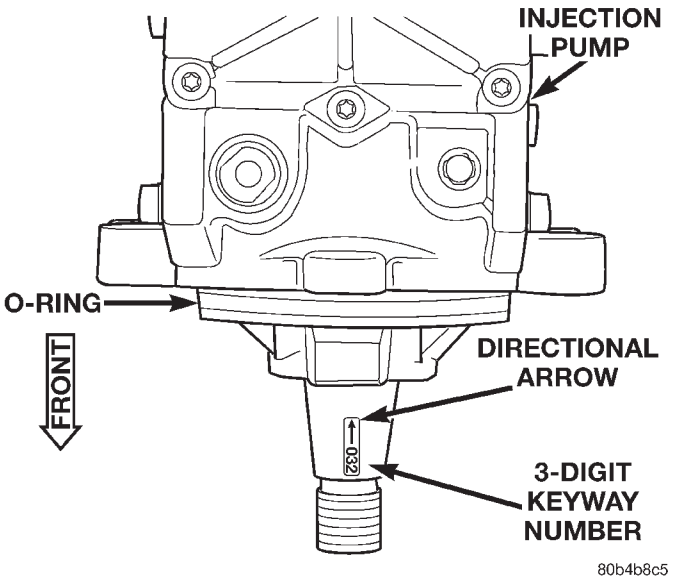


Fig. 34 Pump Keyway, Keyway Arrow and Keyway Number

(2) Be sure keyway aligning fuel injection pump shaft to injection pump gear is in proper position and pump gear has not slipped on pump shaft.

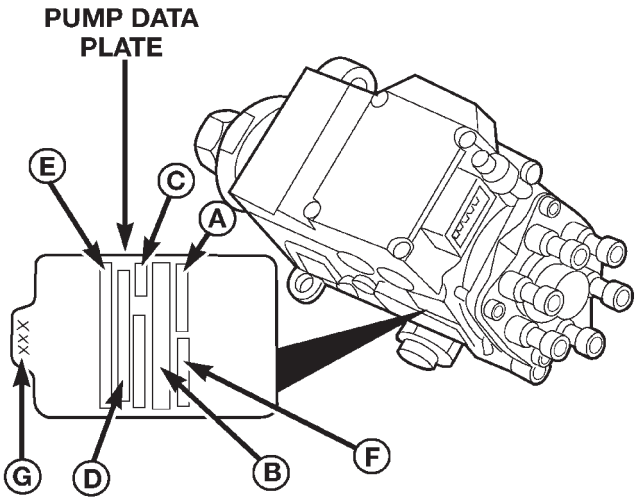
The following steps will require removing timing gear cover to gain access to timing gears. Refer to Group 9, Engines for procedures.

(3) Use a T-type puller to separate injection pump gear from pump shaft.

(4) Be sure keyway has been installed with arrow pointed to **rear** of pump (Fig. 34).

(5) **Pump timing has been calibrated to pump keyway. Be sure 3–digit number on pump keyway (Fig. 34) matches 3–digit number on fuel injection pump data plate. Plate is located on**

DIAGNOSIS AND TESTING (Continued)



A. ORDER NUMBER
B. BOSCH PART NUMBER
C. FACTORY CODE
D. CUMMINS PART NUMBER
E. MANUFACTURE DATE
F. PUMP SERIAL NUMBER
G. LAST THREE DIGITS OF KEY PART NUMBER

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Fig. 35 Pump Data Plate Location

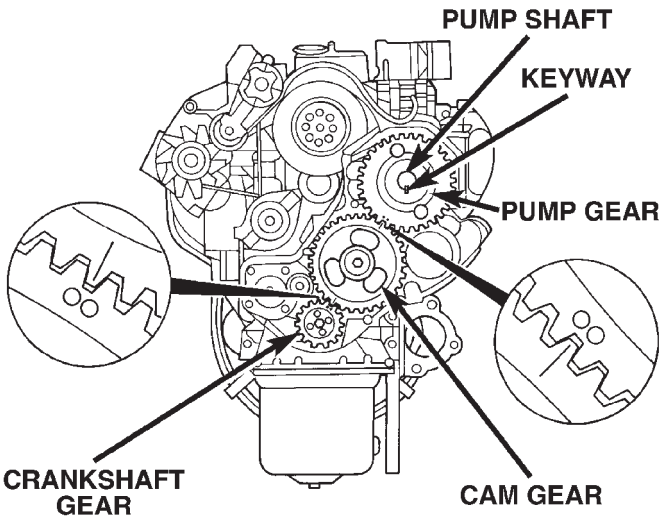

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Fig. 36 Checking Fuel Injection Pump Gear Timing

side of injection pump (Fig. 35). Twenty–one different calibrated keyways/pumps are available.

(6) Verify timing marks on crank, cam and pump are aligned (Fig. 36).

(7) Perform necessary gear alignment/repairs as needed.

(8) After repairs are completed, erase DTC using DRB Scan Tool.

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SERVICE PROCEDURES

CLEANING FUEL SYSTEM PARTS

CAUTION: Cleanliness cannot be overemphasized when handling or replacing diesel fuel system components. This especially includes the fuel injectors, high-pressure fuel lines and fuel injection pump. Very tight tolerances are used with these parts. Dirt contamination could cause rapid part wear and possible plugging of fuel injector nozzle tip holes. This in turn could lead to possible engine misfire. Always wash/clean any fuel system component thoroughly before disassembly and then air dry. Cap or cover any open part after disassembly. Before assembly, examine each part for dirt, grease or other contaminants and clean if necessary. When installing new parts, lubricate them with clean engine oil or clean diesel fuel only.

AIR BLEED PROCEDURE

A certain amount of air becomes trapped in the fuel system when fuel system components on the supply and/or high-pressure side are serviced or replaced. Primary air bleeding is accomplished using the electric fuel transfer (lift) pump. If the vehicle has been allowed to run completely out of fuel, the fuel injectors must also be bled as the fuel injection pump **is not** self-bleeding (priming).

Servicing or replacing components on the fuel return side will not require air bleeding.

WARNING: DO NOT BLEED AIR FROM THE FUEL SYSTEM OF A HOT ENGINE.

(1) Loosen, but do not remove, banjo bolt holding low-pressure fuel supply line to side of fuel injection pump (Fig. 37). Place a shop towel around banjo fitting to catch excess fuel.

The fuel transfer (lift) pump is self-priming: When the key is first turned on (without cranking engine), the pump operates for approximately 2 seconds and then shuts off. The pump will also operate for up to 25 seconds after the starter is engaged, and then disengaged and the engine is not running. The pump shuts off immediately if the key is on and the engine stops running.

(2) Turn key to CRANK position and quickly release key to ON position before engine starts. This will operate fuel transfer pump for approximately 25 seconds.

(3) If fuel is not present at fuel supply line after 25 seconds, turn key OFF. Repeat previous step until fuel is exiting at fuel supply line.

SERVICE PROCEDURES (Continued)

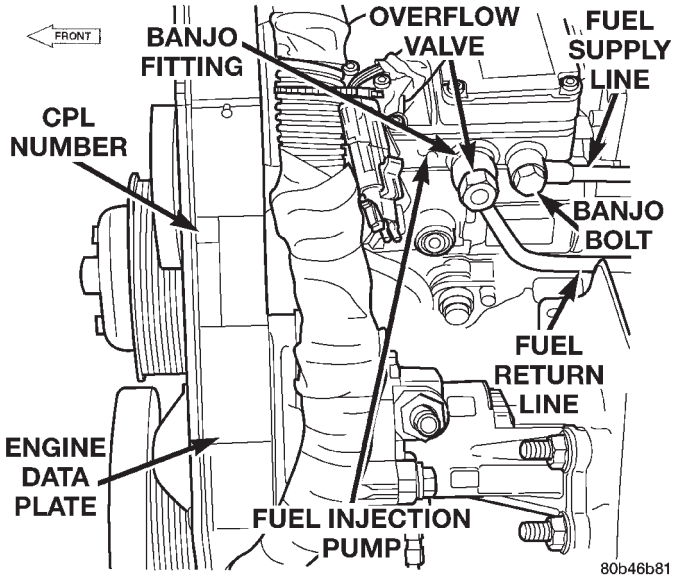


Fig. 37 Fuel Supply Line Banjo Bolt

(4) Tighten banjo bolt at fuel supply line to 24 N·m (18 ft. lbs.) torque. Primary air bleeding is now completed.

(5) Attempt to start engine. If engine will not start, proceed to following steps. **If engine does start, it may run erratically and be very noisy for a few minutes. This is a normal condition.**

(6) **Continue to next step if:**

- The vehicle fuel tank has been allowed to run empty
- The fuel injection pump has been replaced
- High-pressure fuel lines have been replaced
- Vehicle has not been operated after an extended period

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

(7) Perform previous air bleeding procedure steps using fuel transfer pump. Be sure fuel is present at fuel supply line (Fig. 37) before proceeding.

(8) Crank the engine for 30 seconds at a time to allow air trapped in the injection pump to vent out the drain manifold.

WARNING: THE FUEL INJECTION PUMP SUPPLIES EXTREMELY HIGH FUEL PRESSURE 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: ENGINE MAY START WHILE CRANKING STARTER MOTOR.

Engine may start, may run erratically and be very noisy for a few minutes. This is a normal condition.

(9) Thoroughly clean area around injector fittings where they join injector connector tubes.

(10) Bleed air by loosening high-pressure fuel line fittings (Fig. 38) at cylinders number 3, 4 and 5.

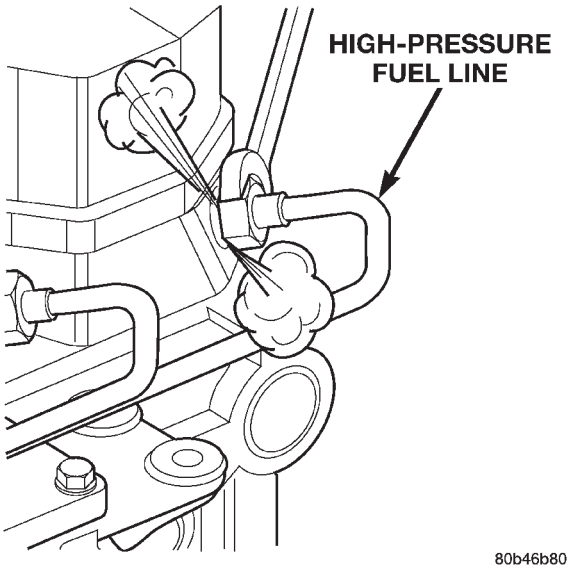


Fig. 38 Bleeding High-Pressure Fuel Lines at Injectors

(11) Continue bleeding injectors until engine runs smoothly. It may take a few minutes for engine to run smooth.

(12) Tighten fuel line(s) at injector(s) to 40 N·m (30 ft. lbs.) torque.

WATER DRAINING AT FUEL FILTER

Refer to Fuel Filter/Water Separator removal/installation for procedures.

REMOVAL AND INSTALLATION

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 vehicle, hold up accelerator pedal. Remove plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 39). The plastic cable retainer snaps into pedal arm.

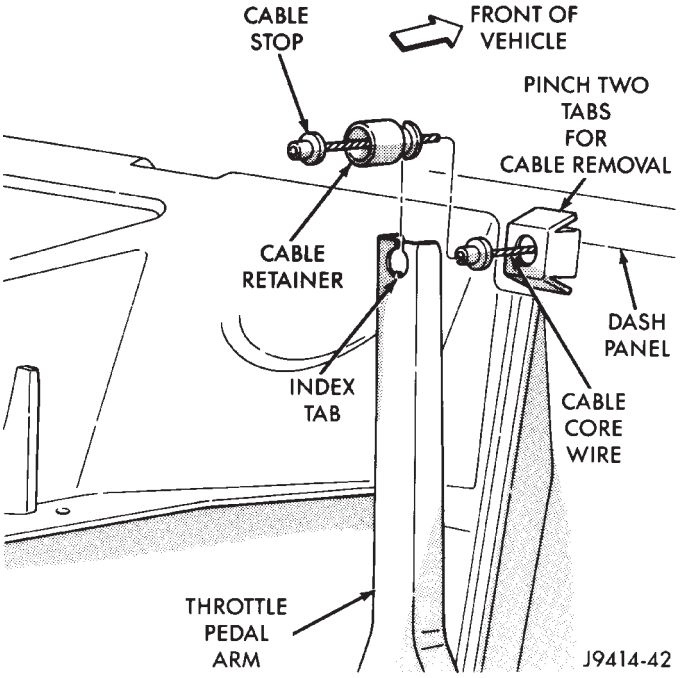


Fig. 39 Cable Removal/Installation at Pedal

(2) Insert a small screwdriver into square holes located on pivots/bushings (Fig. 40). Twist screwdriver to disengage pivot locks from 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 pivot pin (Fig. 40).

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

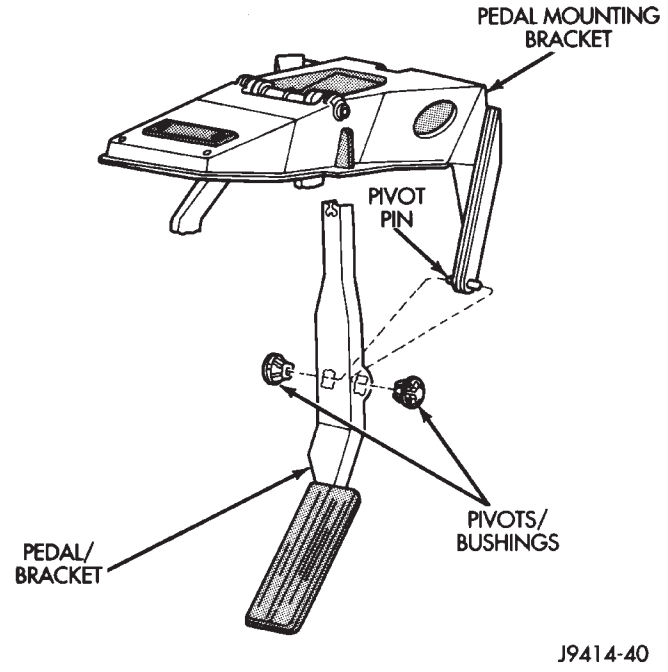


Fig. 40 Accelerator Pedal—Removal or Installation

(3) From inside vehicle, hold up accelerator pedal. Install throttle cable core wire and plastic cable retainer into and through upper end of pedal arm (the plastic retainer is snapped into pedal arm). When installing plastic retainer to accelerator pedal arm, note index tab on pedal arm (Fig. 39). Align index slot on plastic cable retainer to this index tab.

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) Disconnect both negative battery cables at both batteries.

(2) From inside vehicle, hold up accelerator pedal. Remove plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 39). The plastic cable retainer snaps into pedal arm.

(3) Remove cable core wire at pedal arm.

(4) From inside vehicle, pinch both sides of plastic cable housing retainer tabs at dash panel (Fig. 39).

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

REMOVAL AND INSTALLATION (Continued)

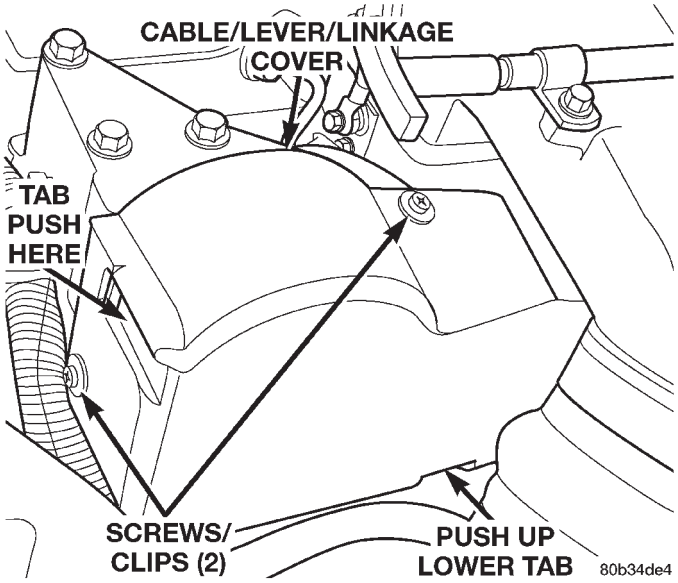


Fig. 41 Cable/Lever/Throttle Linkage Cover

(6) Remove cable cover (Fig. 41). Cable cover is attached with 2 Phillips screws, 2 plastic retention clips and 2 push tabs (Fig. 41). Remove 2 Phillips screws and carefully pry out 2 retention clips. After clip removal, push rearward on front tab, and upward on lower tab for cover removal.

(7) Using 2 screwdrivers, pry cable connector socket from throttle lever ball (Fig. 42). **Be very careful not to bend throttle lever arm.**

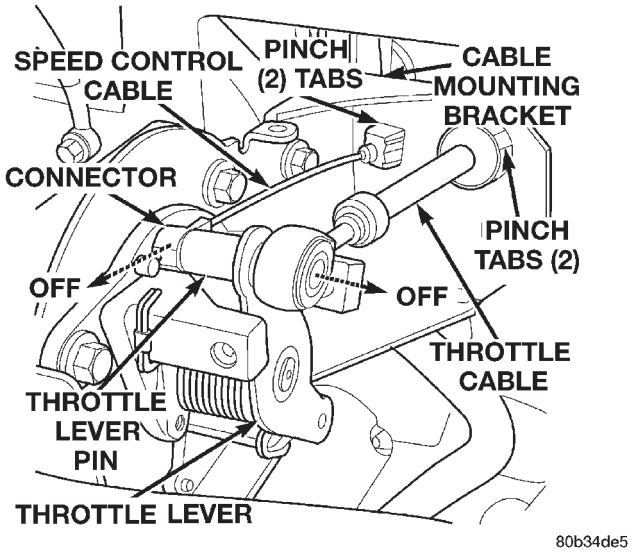


Fig. 42 Throttle Cable at Throttle Lever

(8) Squeeze 2 pinch tabs on sides of throttle cable at mounting bracket (Fig. 42) and push cable rearward out of bracket .

INSTALLATION

(1) Install cable through mounting hole on cable mounting bracket (Fig. 42). Cable snaps into bracket. Be sure 2 pinch tabs are secure.

(2) Using large pliers, connect cable end socket to throttle lever ball (snaps on).

(3) Install remaining cable housing end into and through dash panel opening (snaps into position). The two plastic pinch tabs (Fig. 39) should lock cable to dash panel.

(4) From inside vehicle, hold up accelerator pedal. Install throttle cable core wire and plastic cable retainer into and through upper end of pedal arm (the plastic retainer is snapped into pedal arm). When installing plastic retainer to accelerator pedal arm, note index tab on pedal arm (Fig. 39). Align index slot on plastic cable retainer to this index tab.

(5) Connect negative battery cables to both batteries.

(6) Before starting engine, operate accelerator pedal to check for any binding.

(7) Install cable/lever cover.

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. 43). This air flow restriction gauge will determine when the air cleaner element is restricted and should be replaced.

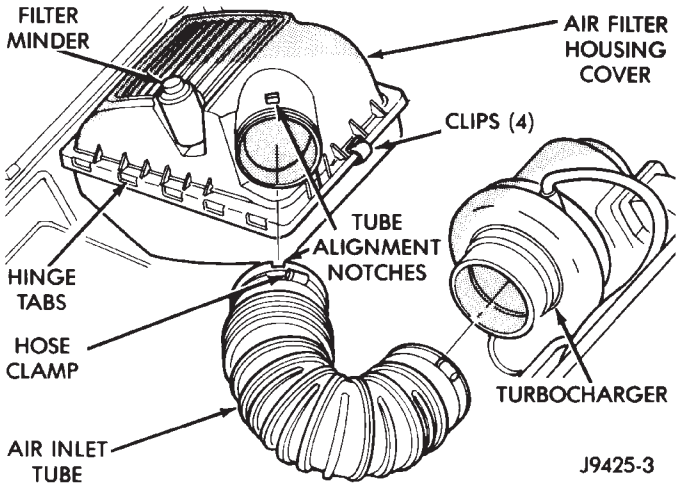


Fig. 43 Filter Minder™—Location—Diesel Engine

REMOVAL AND INSTALLATION (Continued)

The Filter Minder™ consists of a diaphragm and calibrated spring sealed inside of a plastic housing (Fig. 44). 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.

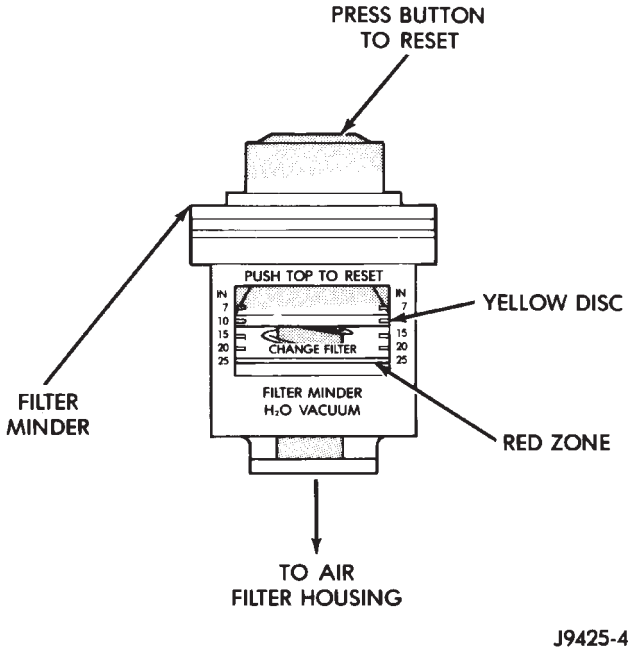


Fig. 44 Filter Minder™—Diesel Engine

To test, turn the engine off. If the yellow disc (Fig. 44) 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. 44). 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

(1) Loosen air inlet tube clamp at air cleaner housing inlet (Fig. 43). Remove this tube at air cleaner housing cover.

(2) The housing cover is equipped with four (4) spring clips (Fig. 43) and is hinged at front with plastic tabs. Unlatch clips from top of air cleaner housing and tilt housing cover up and forward for cover removal.

(3) Remove air cleaner element from air cleaner housing.

INSTALLATION

(1) Before installing a new air cleaner element, clean inside of air cleaner housing.

(2) Position air cleaner cover to tabs on front of air cleaner housing. Latch four spring clips to seal cover to housing.

(3) Install air inlet tube at air cleaner housing inlet. Note hose alignment notches at both inlet hose and air cleaner cover (Fig. 43).

(4) Position tube clamp to inlet tube and tighten to 3 N·m (25 in. lbs.) torque.

FUEL DRAIN MANIFOLD

The fuel drain manifold (line) connects a fuel return passage within the cylinder head to a “T” fitting on the fuel return line. It is located at the rear of the cylinder head.

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Remove starter motor. Refer to Group 8B for procedures.

(3) Disconnect fitting at “T” (Fig. 45).

(4) Remove banjo bolt at rear of cylinder head. Discard old sealing washers.

(5) Remove fuel line from vehicle.

(6) Clean connection at rear of cylinder head before line installation.

INSTALLATION

Servicing fuel return components will not require air bleeding.

(1) Using new sealing washers, assemble banjo bolt to fuel line.

(2) Position line to engine and loosely tighten fasteners.

(3) Tighten banjo bolt to 24 N·m (18 ft. lbs.) torque.

REMOVAL AND INSTALLATION (Continued)

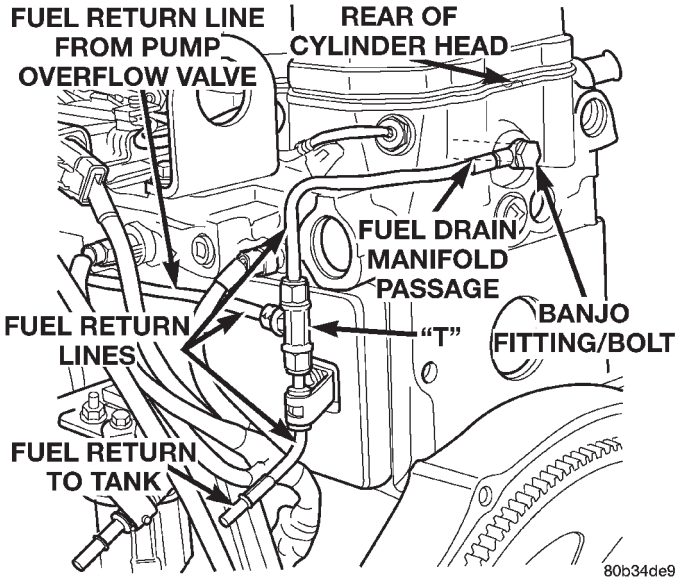


Fig. 45 Fuel Return Line at Rear of Cylinder Head

(4) Tighten fitting at "T" to 12 N·m (106 in. lbs.) torque.

(5) Install starter motor. Refer to Group 8B for procedures.

(6) Connect both negative battery cables at both batteries.

FUEL FILTER/WATER SEPARATOR

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

The fuel filter/water separator assembly is located on left/rear side of engine above starter motor (Fig. 46). The assembly contains the fuel filter cartridge, Water-In-Fuel (WIF) sensor, and fuel heater.

REMOVAL

Draining water from filter canister:

The canister drain valve (Fig. 47) serves two purposes. One is to **partially** drain filter canister of excess water. The other is to **completely** drain canister for filter, heater or water-in-fuel sensor replacement.

The filter should be drained whenever water-in-fuel warning lamp remains illuminated. (Note that lamp will be illuminated for approximately two seconds when ignition key is initially placed in ON position for a bulb check).

(1) A drain hose is located at bottom of drain valve (Fig. 48). Place drain pan under drain hose.

(2) **With engine not running,** rotate drain valve handle forward to OPEN (DRAIN) position (Fig. 47). Hold drain valve open until all water and contaminants have been removed and clean fuel exits drain hose.

(3) If fuel filter, fuel heater or Water-In-Fuel (WIF) sensor is being replaced, drain canister completely. Dispose of mixture in drain pan according to applicable regulations.

(4) After draining operation, rotate valve handle rearward to CLOSE position (Fig. 47). **If fuel filter, fuel heater or WIF sensor is being replaced, proceed to next step.**

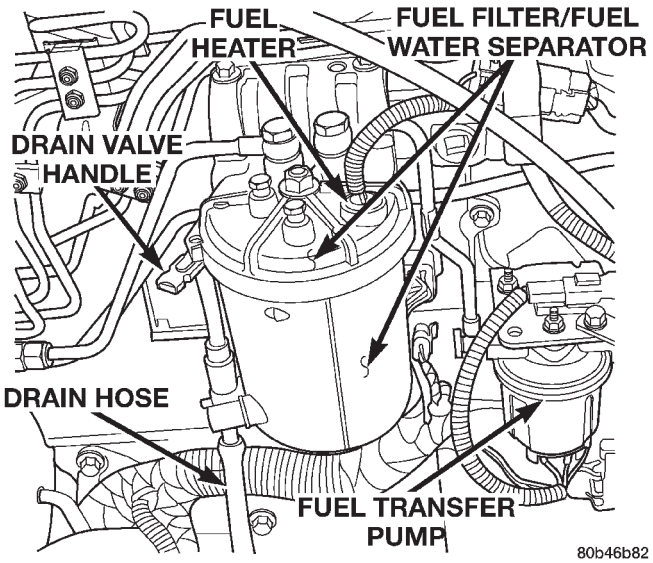


Fig. 46 Fuel Filter/Water Separator/Drain Hose Location

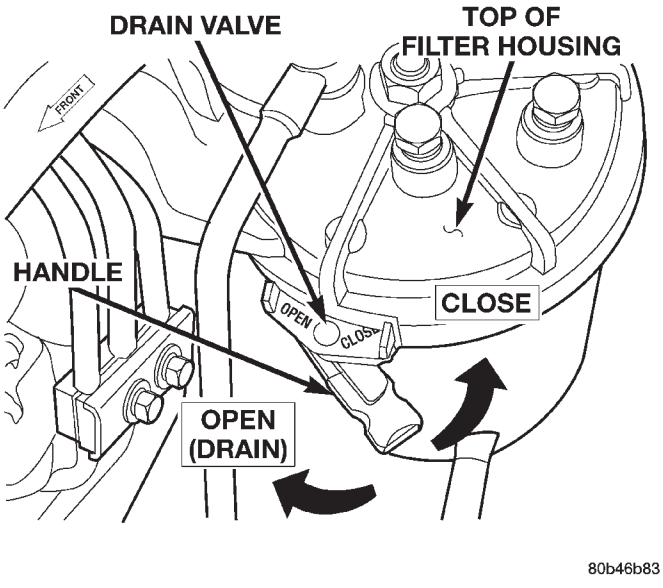


Fig. 47 Drain Valve at Fuel Filter/Water Separator

(5) Remove drain hose at drain valve (Fig. 46).

(6) Disconnect Water-In-Fuel (WIF) sensor electrical connector at sensor. The WIF sensor is located at side of filter canister (Fig. 48).

REMOVAL AND INSTALLATION (Continued)

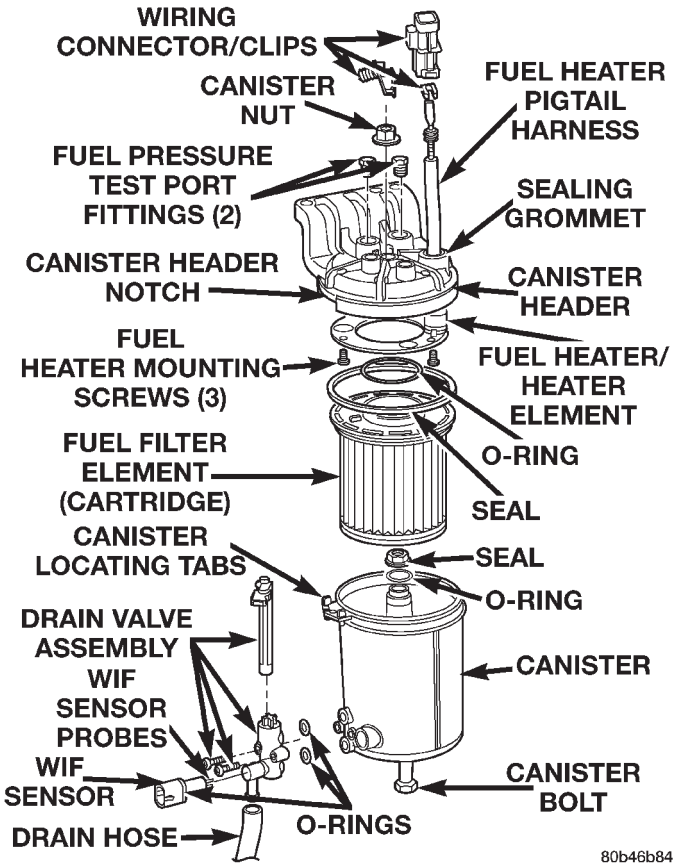


Fig. 48 Fuel Filter/Water Separator Components

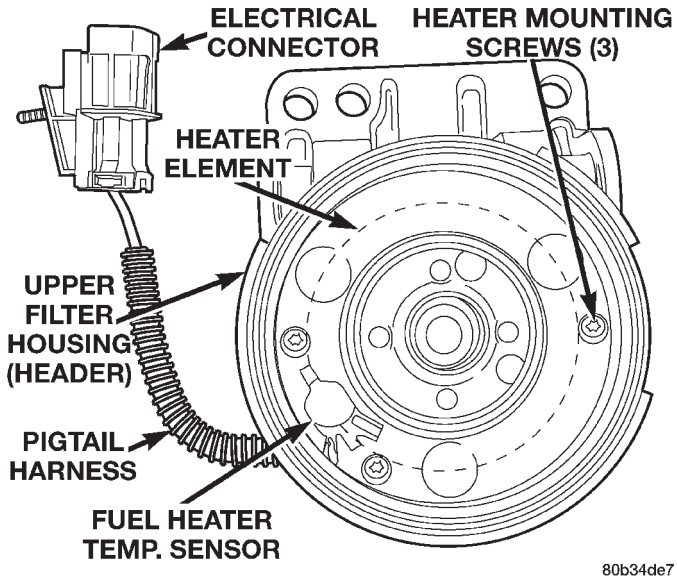


Fig. 49 Fuel Heater Mounting Screws (Bottom View)

(7) Loosen filter canister nut at top of header (Fig. 48) while lowering canister assembly from header.

(8) Remove and discard seals and center o-rings (Fig. 48).

(9) Remove filter element (cartridge) from canister.

(10) Remove WIF sensor and its o-ring seal from canister (Fig. 48).

(11) Inspect WIF sensor probes (Fig. 48). Carefully clean contaminants from sensor probes with a cloth if necessary. Replace sensor if probes are covered with contaminants and will not clean up.

(12) **Fuel Heater:** The fuel heater is located inside fuel filter housing (header) (Fig. 46), (Fig. 48) or (Fig. 49). The heater mounting plate, heating element, temperature sensor and wiring harness are serviced as one assembly.

(a) Disconnect heater pigtail harness electrical connector (Fig. 49) from main engine wiring harness near upper/rear of filter.

(b) The plastic electrical connector (Fig. 49) at end of 2–wire pigtail harness will have to be removed from wiring harness before attempting to pass harness through filter header.

(c) Note locations (colors) of wires in connector before removing connector.

(d) Remove clip (Fig. 48) retaining wires to connector.

(e) Remove wires from connector.

(f) Remove 3 fuel heater mounting screws (Fig. 48) or (Fig. 49).

(g) Press down on heater sealing grommet (Fig. 48) to remove heater from filter canister header.

(h) Pass wire harness through hole in filter header while removing heater from header.

INSTALLATION

(1) Clean inside of canister and canister header.

(2) **Fuel Heater:**

(a) Lift fuel heater assembly into filter header while passing wire harness upward through hole in header. Heater sealing grommet should protrude at top of filter header.

(b) Install 3 fuel heater mounting screws (Fig. 49) or (Fig. 48) and tighten to 2–3 N·m (15–20 in. lbs.) torque.

(c) Install 2 wires into electrical connector and install connector clip.

(d) Connect heater pigtail harness electrical connector (Fig. 49) to main engine wiring harness.

(3) Install new o-ring seal to WIF sensor.

(4) Install WIF sensor to canister. Tighten to 2–3 N·m (15–20 in. lbs.) torque.

(5) If drain valve assembly is being replaced, tighten mounting screws to 3–5 N·m (30–40 in. lbs.) torque.

(6) Install new o-rings.

(7) Install new seal between canister and canister header.

If filter canister is not filled with clean diesel fuel before installation, manual air bleeding of fuel system may be necessary (temporary rough engine running may occur). If necessary, refer to Air Bleed Procedures.

REMOVAL AND INSTALLATION (Continued)

(8) Load filter into canister.
(9) Fill filter canister with clean diesel fuel.
(10) Apply a light film of clean diesel oil to all seals.
(11) Position canister assembly to canister header. Note locating tabs on canister should align into notch on canister header (Fig. 48).
(12) Install canister nut and tighten to 14 N·m (10 ft. lbs.) torque.
(13) Connect electrical connector to WIF sensor.
(14) Connect drain hose to bottom of drain valve.
(15) Start engine and check for leaks.

FUEL TANK

Depending on body style, tank may have to be lowered for fuel draining. Refer to following procedures.

REMOVAL

(1) Remove fuel tank filler tube cap.
(2) Disconnect both negative battery cables at both batteries.
(3) Raise vehicle on hoist.
(4) Open fuel fill door and remove screws mounting fuel filler tube assembly to body (some body styles only). Do not disconnect rubber fuel fill or vent hoses from tank at this time.
(5) Place a transmission jack under center of fuel tank. Apply a slight amount of pressure to fuel tank with transmission jack.
(6) Remove fuel tank mounting strap nuts from mounting strap studs (Fig. 50). If equipped, remove fuel tank shield bolts.
(7) 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 DIESEL FUEL SPILLAGE.

(8) While working over left rear tire/wheel, disconnect rubber fuel vent hose at fuel vent fitting (Fig. 51) (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 diesel fuel safety container.
(9) Disconnect rubber fuel fill hose at fuel tank (Fig. 50).
(10) While working over left rear tire/wheel, disconnect wiring harness connector from electrical connector at top of fuel tank module (Fig. 51).
(11) Disconnect fuel supply and fuel return lines at fuel tank module fittings (Fig. 51). Refer to Quick-Connect Fittings for procedures.
(12) Continue lowering fuel tank for removal.
(13) If fuel tank module removal is necessary, refer to Fuel Tank Module Removal/Installation in this group.

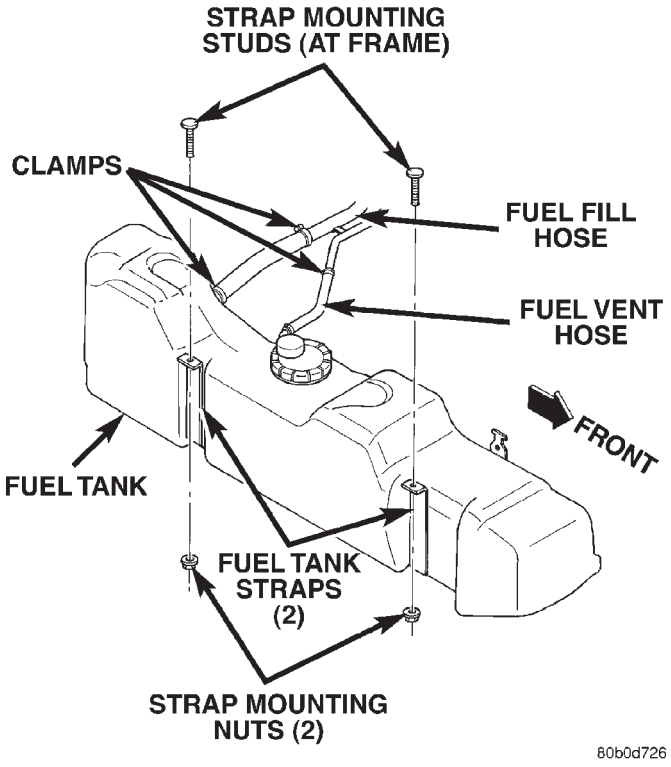


Fig. 50 Fuel Tank Mounting—Typical

INSTALLATION

(1) 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) Connect electrical connector to fuel tank module.

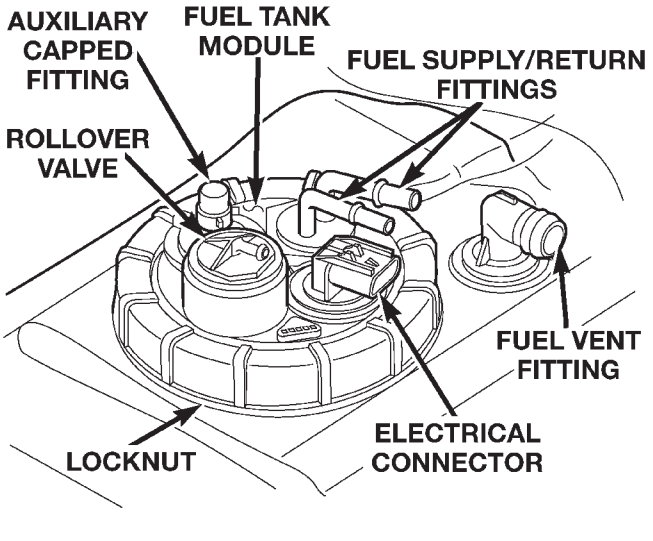


Fig. 51 Fuel Tank Module Location

REMOVAL AND INSTALLATION (Continued)

(6) 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.

(10) Connect fuel filler tube assembly to body.

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

(12) Connect both negative battery cables to both batteries.

FUEL TANK MODULE

REMOVAL

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

(2) Thoroughly clean area around tank module at top of tank.

(3) The plastic fuel tank module locknut is threaded onto fuel tank (Fig. 51). Install Special Tool 6856 to locknut and remove locknut (Fig. 52). The fuel tank module will spring up when locknut is removed.

(4) Remove module from fuel tank.

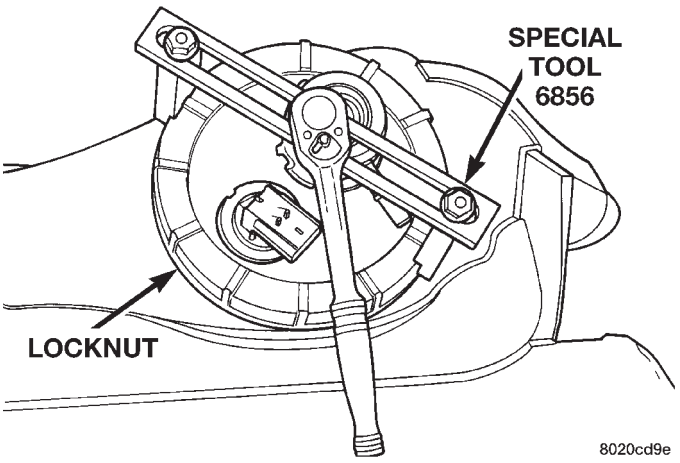


Fig. 52 Locknut Removal/Installation—TYPICAL MODULE

INSTALLATION

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

(1) Thoroughly clean locknut and locknut threads at top of tank.

(2) Using new gasket, carefully position fuel tank module into opening in fuel tank.

(3) Position locknut over top of fuel tank module. Install locknut finger tight.

(4) When looking down at tank from drivers side of tank, the arrow at top of module should be aligned between two marks stamped into tank (approximately 2 o'clock position). The fuel line connectors, roll over valve and fuel gauge electrical connector should all be pointed to drivers side of vehicle. Rotate and align module/tank marks if necessary before tightening locknut. **This step must be performed to prevent the module's float from contacting side of fuel tank.**

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

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

FUEL HEATER

The fuel heater/element/sensor assembly is located inside of the fuel filter housing. Refer to Fuel Filter/Water Separator Removal/Installation for procedures.

FUEL HEATER RELAY

The fuel heater relay is located in the Power Distribution Center (PDC) (Fig. 53). Refer to label under PDC cover for relay location.

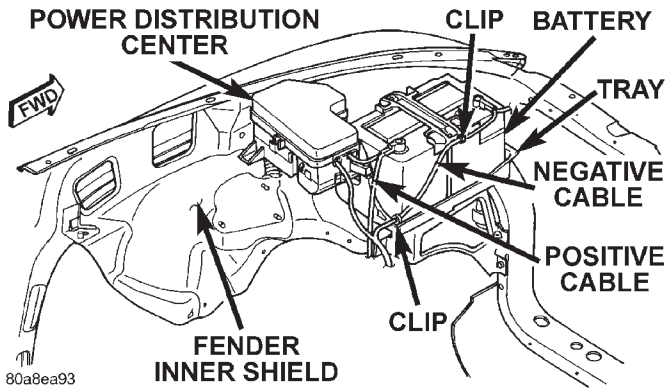


Fig. 53 Power Distribution Center (PDC) Location

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.

REMOVAL AND INSTALLATION (Continued)

HIGH-PRESSURE FUEL LINES

High-pressure lines are used between the fuel injection pump and the fuel injectors only. 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.

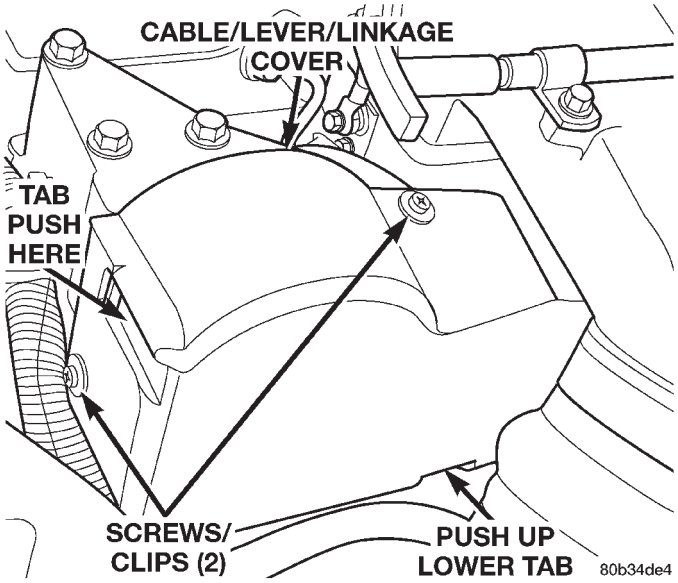


Fig. 54 Cable/Lever/Throttle Linkage Cover

REMOVAL

CAUTION: Refer to Cleaning Fuel System Parts.

(1) Disconnect both negative battery cables from both batteries. Cover and isolate ends of cables.

(2) Thoroughly clean fuel lines at cylinder head and injection pump ends.

(3) Remove cable cover (Fig. 54). Cable cover is attached with 2 Phillips screws, 2 plastic retention clips and 2 push tabs (Fig. 54). Remove 2 Phillips screws and carefully pry out 2 retention clips. After clip removal, push rearward on front tab, and upward on lower tab for cover removal. **Do not remove any cables at lever.**

(4) Disconnect wiring harness (clip) at bottom of Accelerator Pedal Position Sensor (APPS) mounting bracket (Fig. 55).

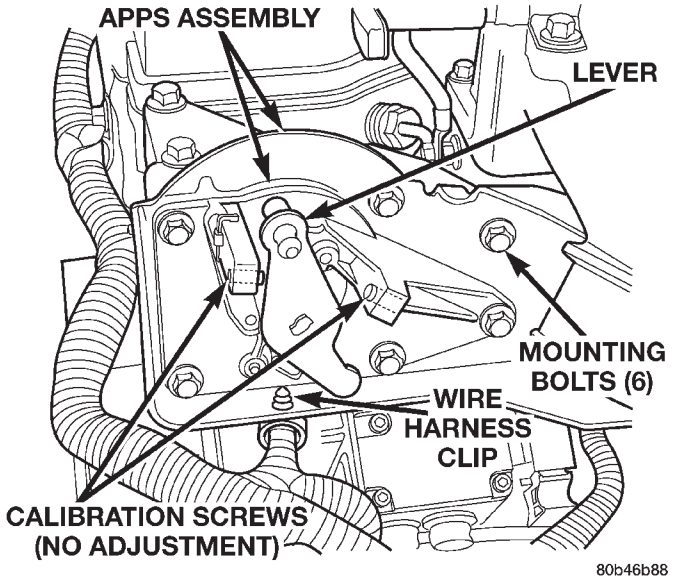


Fig. 55 Wiring Clip at APPS

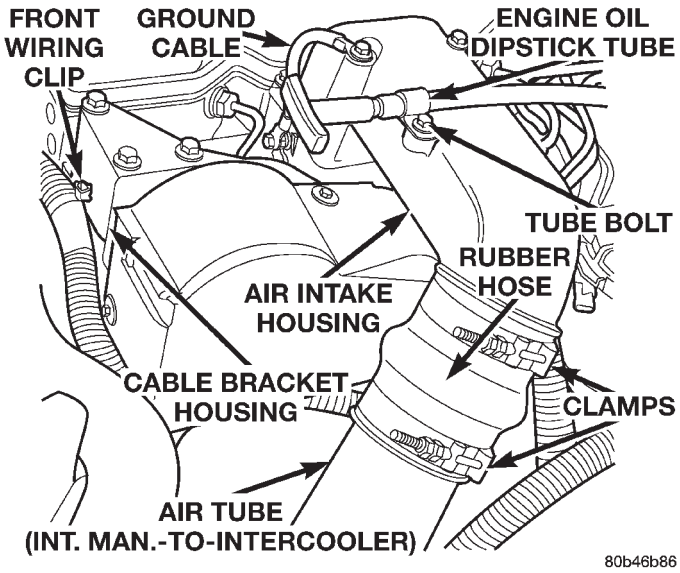


Fig. 56 Air Tube

(5) Using 2 small screwdrivers, pry front wiring clip (Fig. 56) from cable bracket housing. Position wiring harness towards front of engine.

(6) Remove electrical connector from APPS by pushing connector tab rearward while pulling down on connector (Fig. 57).

(7) Disconnect 2 electrical cables from cable mounting studs (Fig. 58) at intake air heater on top of intake manifold.

(8) Remove engine oil dipstick from engine.

(9) Remove engine oil dipstick tube support mounting bolt (Fig. 56) and position tube to side.

(10) Disconnect clamps and remove air tube (intake manifold-to-intercooler) (Fig. 56).

REMOVAL AND INSTALLATION (Continued)

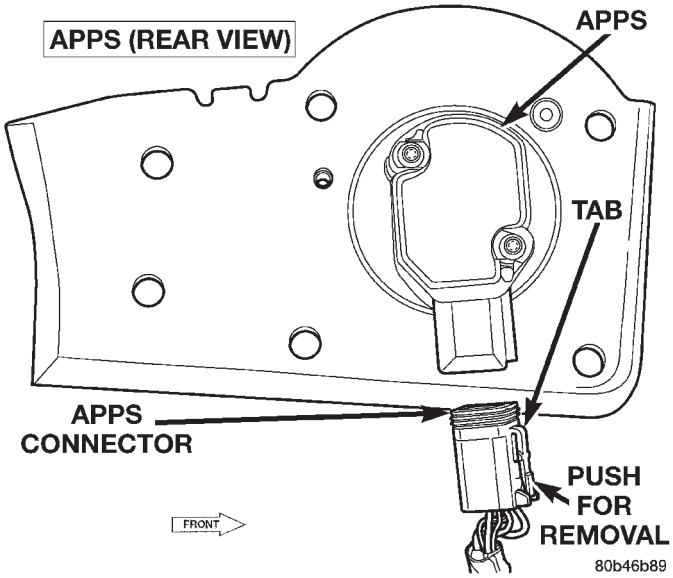


Fig. 57 Rear View of APPS

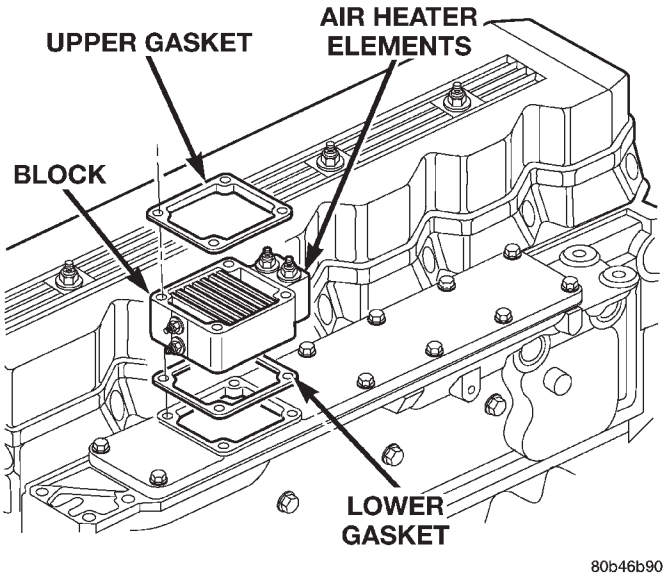


Fig. 59 Intake Manifold Air Heater (Elements)

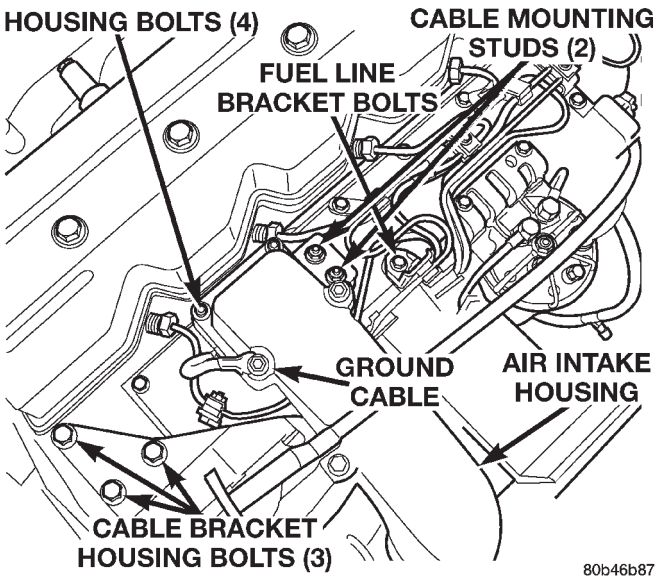


Fig. 58 Air Intake Housing

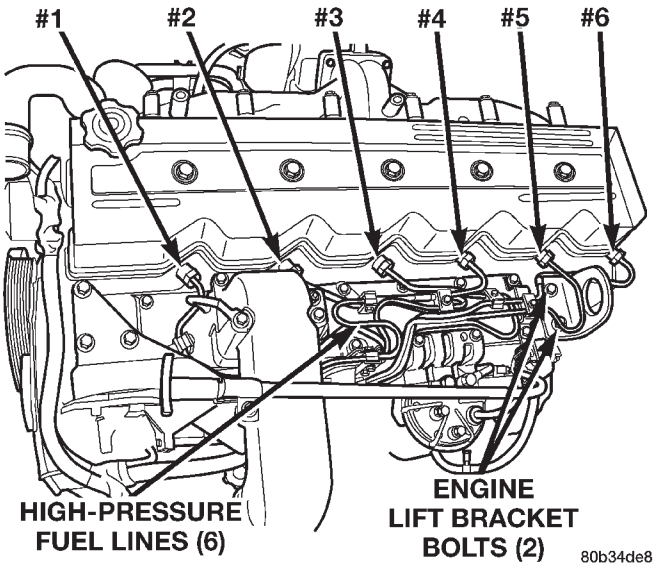


Fig. 60 High-Pressure Lines at Cylinder Head

(11) Remove 4 air intake housing mounting bolts and remove housing (Fig. 58). Position ground cable at top of air intake housing to front of engine.

(12) Remove intake manifold air heater element block from engine (Fig. 59). Discard old upper and lower gaskets

(13) Remove 3 cable bracket housing mounting bolts (Fig. 58). Carefully position cable bracket and cable assembly to side of engine. **Leave cables connected to lever.**

(14) Remove engine lifting bracket at rear of intake manifold (2 bolts) (Fig. 60).

(15) Remove bolts from all fuel injection line support brackets at intake manifold (Fig. 58).

(16) Place shop towels around fuel lines at fuel injectors. Do not allow fuel to drip down side of engine.

CAUTION: WHEN LOOSENING OR TIGHTENING HIGH-PRESSURE FITTINGS AT INJECTION PUMP, USE A BACK-UP WRENCH ON DELIVERY VALVE AT PUMP. DO NOT ALLOW DELIVERY VALVE TO ROTATE.

(17) Loosen high-pressure lines at injection pump (Fig. 61) beginning with cylinders 1, 2 and 4.

(18) Loosen high-pressure lines at cylinder head for cylinders 1, 2 and 4 (Fig. 60).

REMOVAL AND INSTALLATION (Continued)

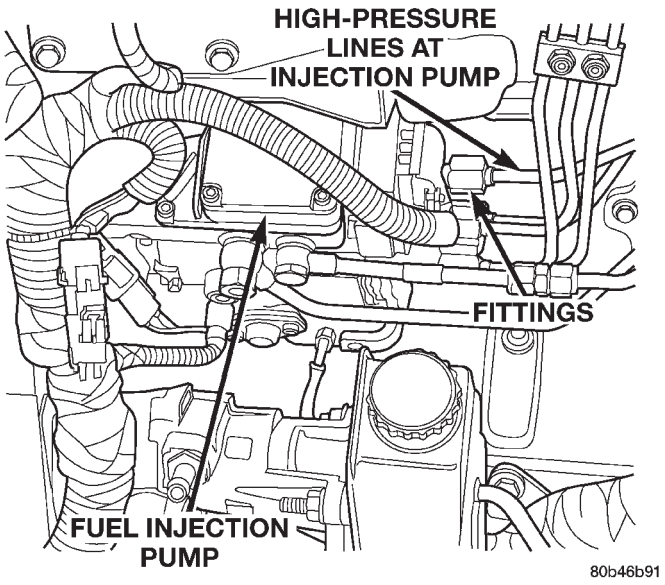


Fig. 61 High-Pressure Lines at Fuel Injection Pump

(19) Carefully remove front line bundle from engine. **Do not bend lines while removing.** While removing front line bundle, note line position.

(20) Loosen high-pressure lines at injection pump beginning with cylinders 3, 5 and 6.

(21) Loosen high-pressure lines at cylinder head for cylinders 3, 5 and 6 (Fig. 60).

(22) Carefully remove rear line bundle from engine. **Do not bend lines while removing.** While removing rear line bundle, note line position.

INSTALLATION

CAUTION: Be sure that the high-pressure fuel lines are installed in the same order that they were removed.

(1) Lubricate threads of injector line fittings with clean engine oil.

(2) Loosen, but do not remove, all fuel line support bracket bolts.

(3) Install **rear** injection line bundle beginning with cylinder head (fuel injector) connections, followed by injection pump connections. Tighten all fittings finger tight.

(4) Tighten fittings at fuel injector ends for cylinders number 6 and 5 to 40 N·m (30 ft. lbs.) torque. **Do not tighten number 3 line at this time. It will be tightened during bleeding procedure.**

(5) Tighten 3 fittings at fuel injection pump ends to 24 N·m (18 ft. lbs.) torque.

(6) Install **front** injection line bundle beginning with cylinder head (fuel injector) connections, followed by injection pump connections. Tighten all fittings finger tight.

(7) Tighten fitting at fuel injector end for cylinder number 2 to 40 N·m (30 ft. lbs.) torque. **Do not tighten lines number 1 or 4 at this time. They will be tightened during bleeding procedure.**

(8) Tighten remaining 3 fittings at fuel injection pump ends to 24 N·m (18 ft. lbs.) torque.

(9) Install fuel line support bracket bolts to intake manifold and tighten to 24 N·m (18 ft. lbs.) torque.

CAUTION: Be sure fuel lines are not contacting each other or any other component. Noise will result.

(10) Install engine lifting bracket at rear of intake manifold. Tighten 2 bolts to 77 N·m (57 ft. lbs.) torque.

(11) Install cable bracket housing/cable assembly and tighten 3 mounting bolts to 24 N·m (18 ft. lbs.) torque.

(12) Clean any old gasket material below and above intake manifold air heater element block. Also clean mating areas at intake manifold and air intake housing.

(13) Using new gaskets, position intake manifold air heater element block to engine.

(14) Install air intake housing and position ground cable. Install 4 mounting bolts (Fig. 58) and tighten to 24 N·m (18 ft. lbs.) torque.

(15) Install air tube (intake manifold-to-intercooler) (Fig. 56). Tighten clamps to 8 N·m (72 in. lbs.) torque.

(16) Install engine oil dipstick tube support mounting bolt (Fig. 56) and tighten to 24 N·m (18 ft. lbs.) torque.

(17) Install engine oil dipstick to engine.

(18) Connect 2 electrical cables to cable mounting studs (Fig. 58).

(19) Connect electrical connector to bottom of APPS by pushing connector upward until it snaps into position.

(20) Connect wiring harness (clip) at bottom of Accelerator Pedal Position Sensor (APPS) mounting bracket (Fig. 55).

(21) Connect front wiring clip (Fig. 56) to cable bracket housing.

(22) Install cable cover (Fig. 54).

(23) Connect both negative battery cables to both batteries.

(24) Bleed air from fuel system. Do this at fuel injector ends of lines. Use cylinders numbers 1, 3 and 4 for bleeding . Refer to Air Bleed Procedure section of this group. After bleeding, tighten fittings to 40 N·m (30 ft. lbs.) torque.

(25) Check lines/fittings for leaks.

REMOVAL AND INSTALLATION (Continued)

OVERFLOW VALVE

The overflow valve (pressure relief valve) is located at the outside of fuel injection pump (Fig. 62). 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.

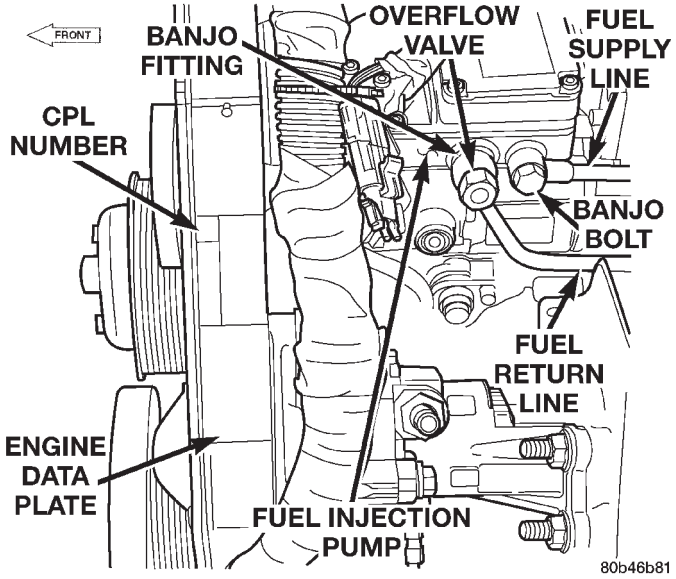


Fig. 62 Overflow Valve Location

REMOVAL

(1) Clean area around overflow valve and fuel return line at injection pump before removal.

(2) Remove valve from pump and banjo fitting.

(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.

FUEL INJECTION 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 injection pump.**.

CAUTION: Whenever the fuel injection pump is removed from the engine, the pump drive gear is laying loose on the camshaft drive gear. Never attempt to crank or rotate the engine with the pump removed from the engine. Serious damage will occur.

REMOVAL

CAUTION: Refer to Cleaning Fuel System Parts.

(1) Disconnect both negative battery cables at both batteries. Cover and isolate ends of cables.

(2) Thoroughly clean fuel lines at cylinder head and injection pump ends. Thoroughly clean fuel injection pump and supply/return lines at side of pump.

(3) Disconnect 9–way electrical connector at Fuel Pump Control Module (FPCM) (Fig. 63).

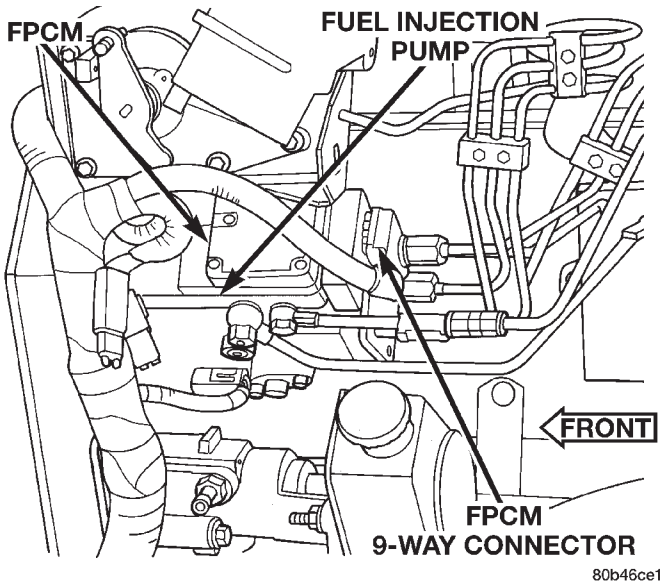


Fig. 63 FPCM 9–Way Connector

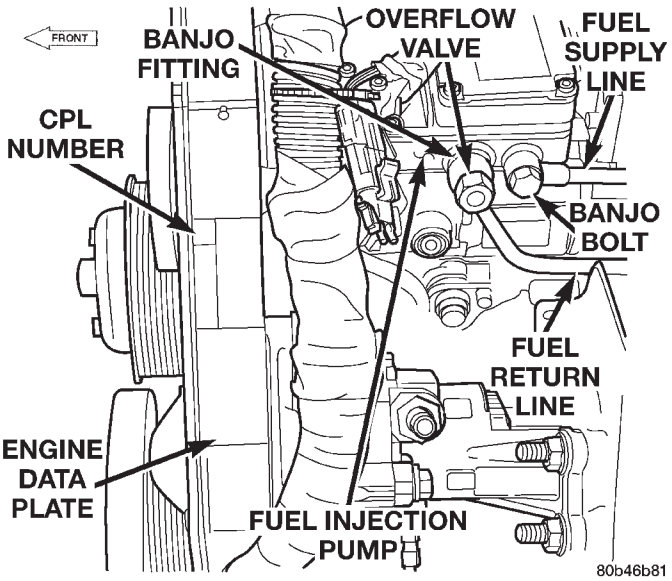


Fig. 64 Fuel Supply and Return Lines at Pump

(4) Remove fuel return line at side of injection pump by removing overflow valve (Fig. 64). Place rag beneath overflow valve to catch excess fuel.

REMOVAL AND INSTALLATION (Continued)

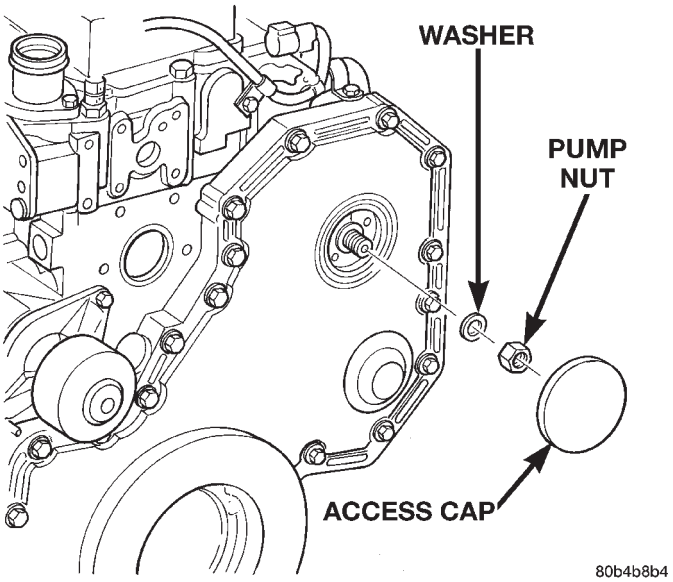


Fig. 65 Access Cap at Front Gear Cover

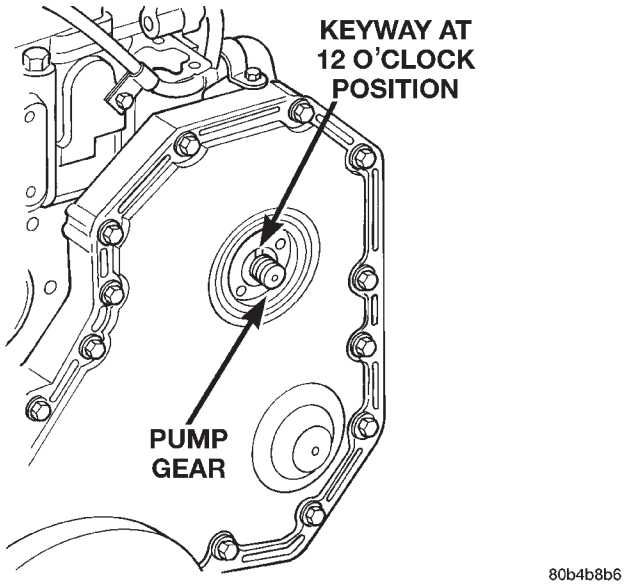


Fig. 67 Placing Keyway at 12 O'clock Position

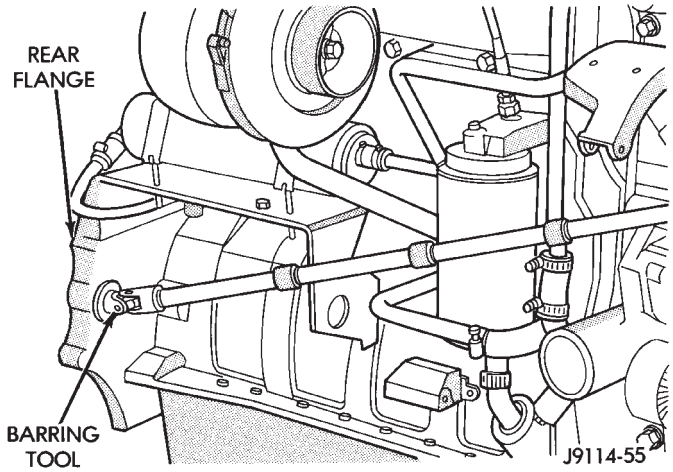


Fig. 66 Rotating Engine with Barring Tool

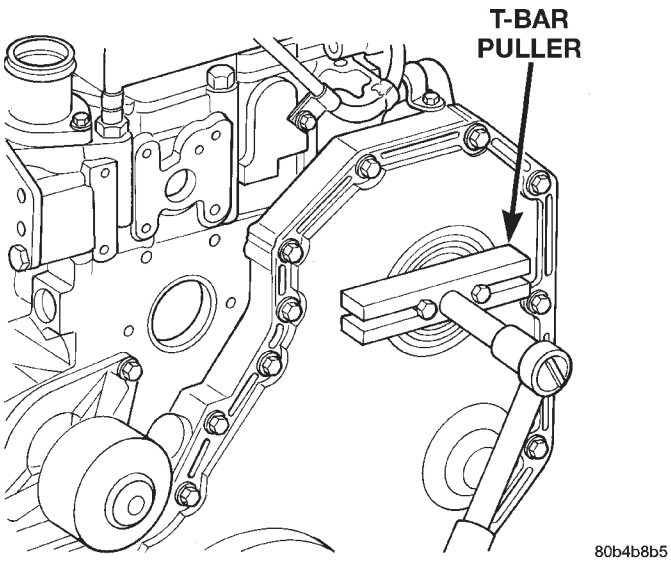


Fig. 68 Separating Injection Pump Gear from Pump Shaft

(5) Remove fuel supply line at side of injection pump by removing banjo bolt (Fig. 64). Also remove same line at top of fuel filter housing (banjo bolt).

(6) Remove all high-pressure fuel lines, intake air tube, accelerator pedal position sensor, air intake housing, engine oil dipstick tube, wiring clips, electrical cables at intake heaters and engine lifting bracket. Refer to High-Pressure Fuel Line Removal/ Installation. All of these items are covered in this procedure.

(7) Unscrew plastic access cap (Fig. 65) at front gear cover.

CAUTION: To prevent pump/gear keyway from falling into gear housing, engine must be rotated until keyway is at 12 o'clock position (Fig. 67). If gear retainer nut, washer or key drops into gear housing, cover may have to be removed to retrieve them before engine is started.

(8) Remove nut and washer retaining injection pump gear to injection pump shaft (Fig. 65).

(9) The engine can be rotated with a barring tool such as Snap-On No. SP371, MTE No. 3377371 (Cummins Tool Division), or an equivalent. The opening for barring tool is located in rear flange of engine on exhaust manifold side (Fig. 66). Remove rubber access plug covering this opening.

(10) Insert barring tool into flywheel housing opening (Fig. 66).

(11) Rotate engine until keyway is at 12 o'clock position (Fig. 67).

(12) Use T-bar type puller (Fig. 68) to separate injection pump gear from injection pump shaft. Attach two M8 X 1.24 MM (metric) screws through

REMOVAL AND INSTALLATION (Continued)

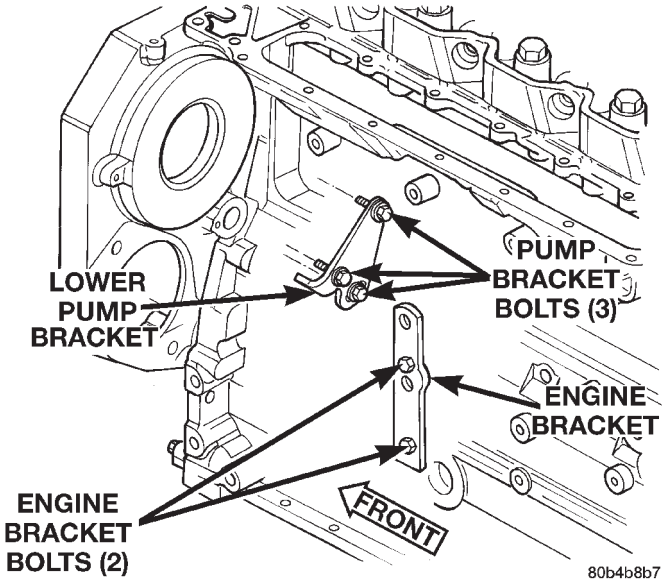


Fig. 69 Lower Pump Bracket and Mounting Bolts

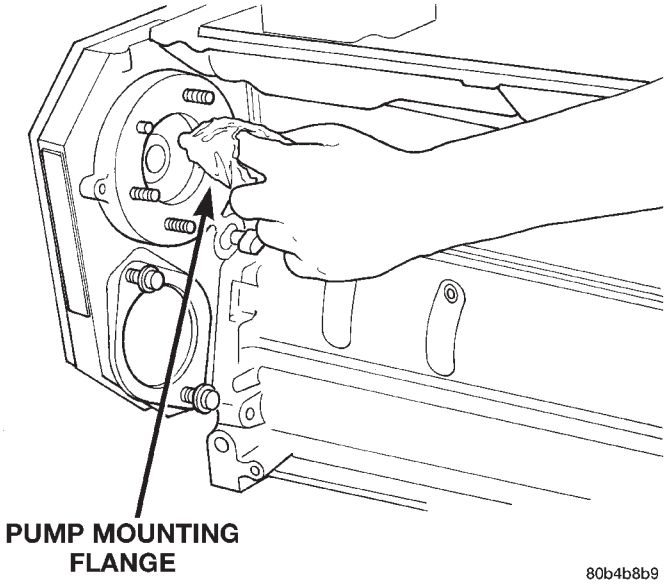


Fig. 71 Cleaning Pump Mounting Flange

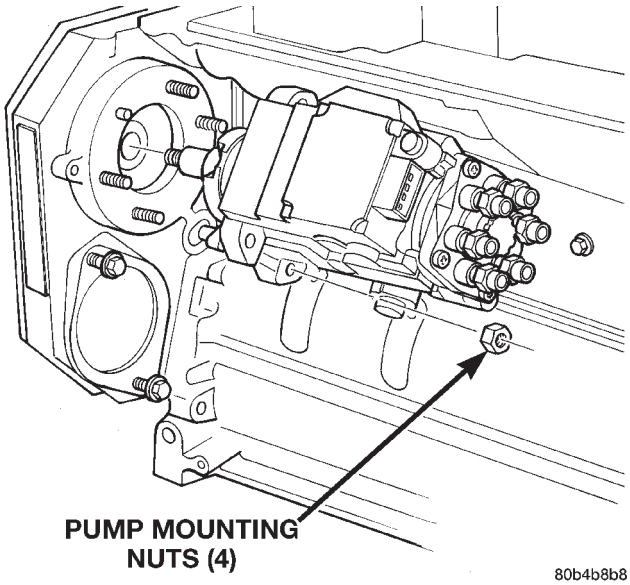


Fig. 70 Injection Pump Mounting Nuts

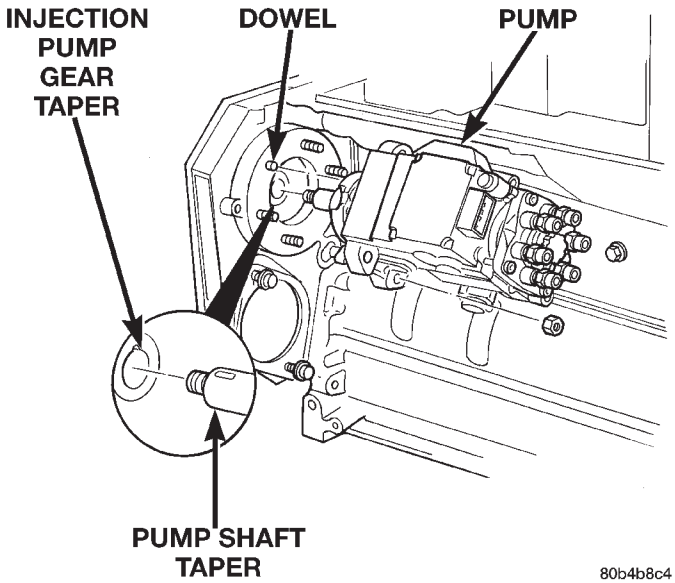


Fig. 72 Injection Pump Installation

puller and into 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.**

(13) Remove 3 lower pump bracket bolts (Fig. 69) and remove lower pump bracket. Loosen, but do not remove 2 engine bracket bolts (Fig. 69).

(14) Remove 4 injection pump-to-gear housing mounting nuts (Fig. 70).

(15) Remove injection pump from gear housing. **Take care not to nick injection pump shaft on aluminum gear housing when removing pump. Also be very careful not to drop pump keyway (Fig. 73) into gear housing.**

CAUTION: Whenever the fuel injection pump is removed from the engine, the pump drive gear is laying loose on the camshaft drive gear. Never attempt to crank or rotate the engine with the pump removed from the engine. Serious damage will occur.

INSTALLATION

(1) Inspect pump mounting surfaces at pump and mounting flange for nicks, cuts or damage. Inspect o-ring surfaces for nicks, cuts or damage.

(2) Clean injection pump mounting flange (Fig. 71) at gear housing. Also clean front of injection pump.

(3) Install new rubber o-ring (Fig. 73) at pump mounting area.

REMOVAL AND INSTALLATION (Continued)

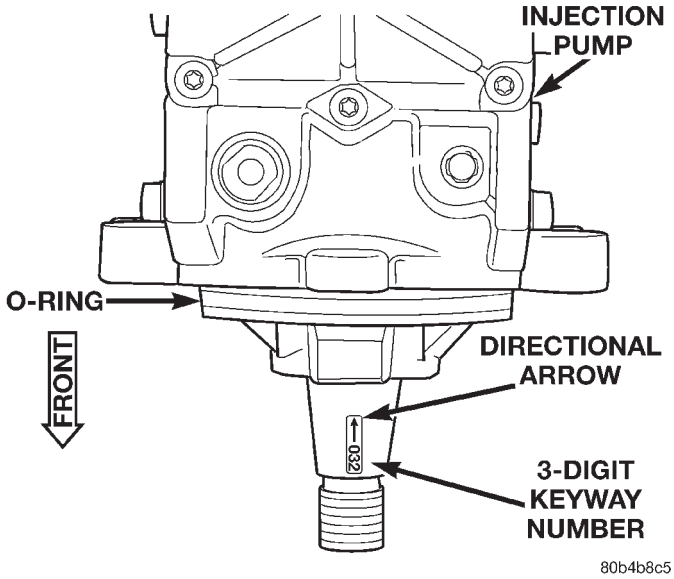


Fig. 73 Keyway, Keyway Arrow and Keyway Number

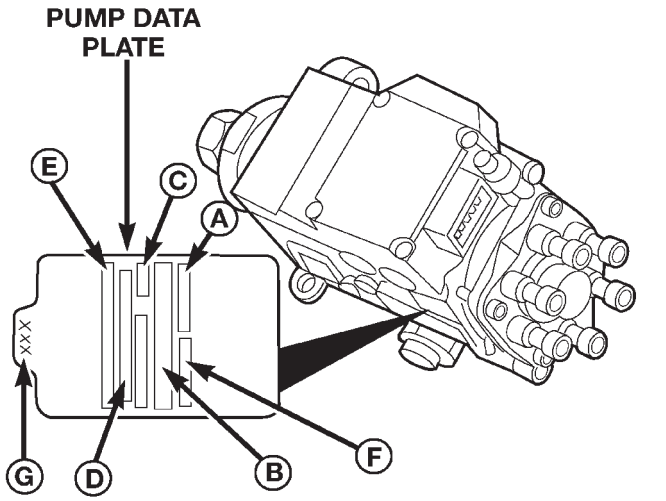


Fig. 74 Injection Pump Data Plate Location

(4) Apply clean engine oil **to injection pump o-ring only.**

The machined tapers on both injection pump shaft and injection pump gear (Fig. 72) must be absolutely dry, clean and free of any dirt or oil film. This will ensure proper gear-to-shaft tightening.

(5) Clean pump gear and pump shaft at machined tapers (Fig. 72) with an evaporative type cleaner such as brake cleaner.

Keyway Installation:

(6) The pump/gear keyway has an arrow and a 3–digit number stamped at top edge (Fig. 73). Position keyway into pump shaft with **arrow pointed to rear of pump.** Also be sure 3–digit number stamped to top of keyway is same as 3–digit number stamped to injection pump data plate (Fig. 74). If wrong keyway is installed, a diagnostic trouble code may be set.

(7) Position pump assembly to mounting flange on gear cover while aligning injection pump shaft through back of injection pump gear. When installing pump, dowel (Fig. 72) on mounting flange must align to hole in front of pump.

(8) After pump is positioned flat to mounting flange, install four pump mounting nuts and tighten finger tight only. Do not attempt a final tightening at this time. **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.**

(9) To prevent damage or cracking of components, tighten nuts/bolts in the following sequence:

(a) Install injection pump shaft washer and nut to pump shaft. Tighten nut **finger tight only.**

(b) Position lower pump bracket and install 3 bolts **finger tight only.**

(c) Do preliminary tightening of injection pump shaft nut to 30 N·m (15–22 ft. lbs.) torque. **This is not the final torque.**

(d) Tighten 4 pump mounting nuts to 43 N·m (32 ft. lbs.) torque.

(e) Tighten 3 lower pump bracket-to-pump bolts 24 N·m (18 ft. lbs.) torque.

(f) Tighten 2 engine bracket-to-engine bolts 24 N·m (18 ft. lbs.) torque.

(g) Do final tightening of injection pump shaft nut to 170 N·m (125 ft. lbs.) torque. Use barring tool to prevent engine from rotating when tightening gear.

(10) Install plastic access cap (Fig. 65) to front gear cover.

(11) Using new gaskets, install fuel return line and overflow valve to side of injection pump (Fig. 64). Tighten overflow valve to 24 N·m (18 ft. lbs.) torque.

(12) Using new gaskets, install fuel supply line to side of injection pump and top of fuel filter housing (Fig. 64). Tighten banjo bolts to 24 N·m (18 ft. lbs.) torque.

(13) Install all high-pressure fuel lines, intake air tube, accelerator pedal position sensor, air intake housing, engine oil dipstick tube, wiring clips, electrical cables at intake heaters and engine lifting

REMOVAL AND INSTALLATION (Continued)

bracket. Refer to High-Pressure Fuel Line Removal/ Installation. All of these items are covered in this procedure.

(14) Connect 9–way electrical connector to Fuel Pump Control Module (FPCM) (Fig. 63).

(15) Connect both negative battery cables to both batteries.

(16) Bleed air from fuel system. Refer to Air Bleed Procedure.

(17) Check system for fuel or engine oil leaks.

FUEL INJECTORS

The fuel injectors are located in the top of the cylinder head between the intake/exhaust valves (Fig. 75).

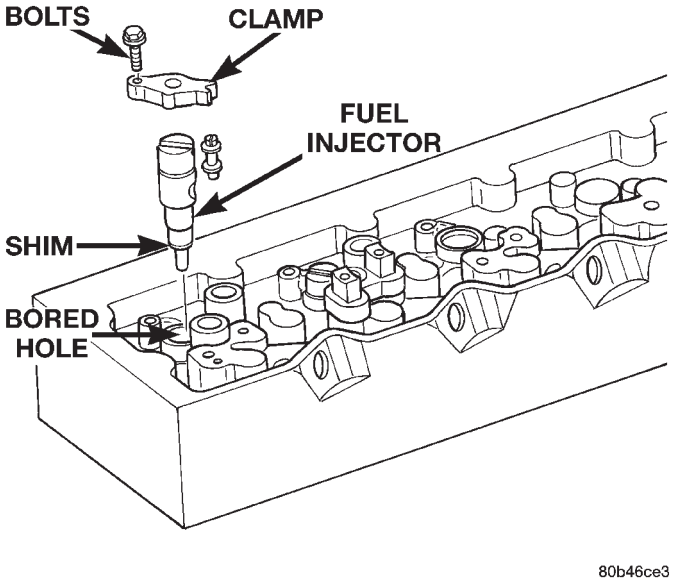


Fig. 75 Fuel Injector Location

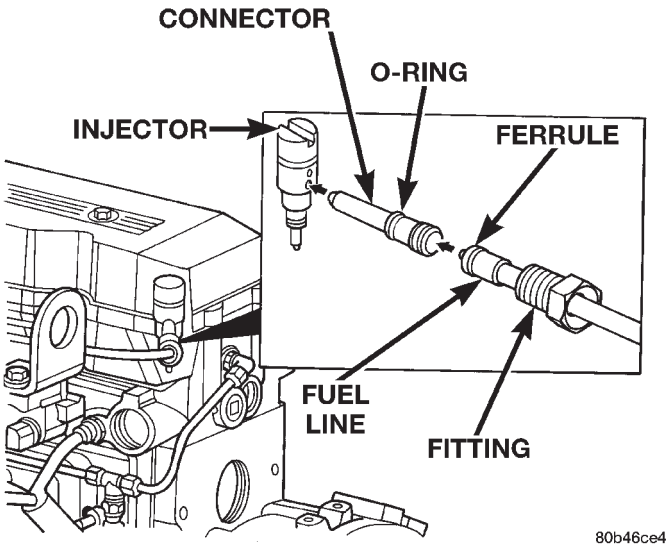


Fig. 76 Fuel Injector Connections

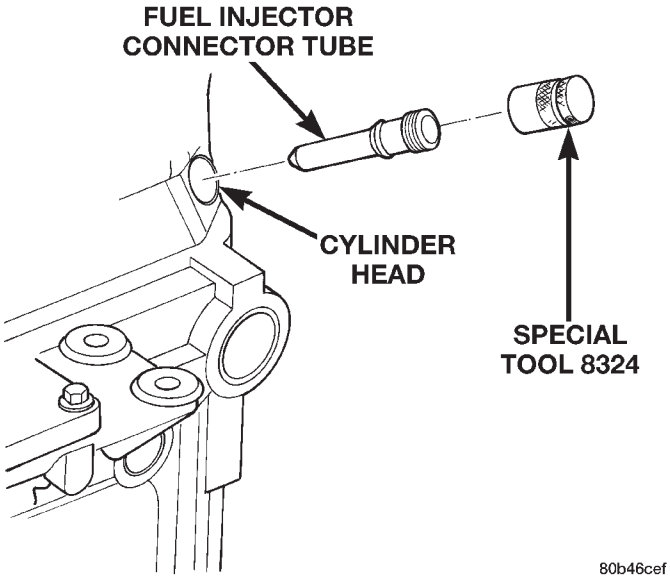


Fig. 77 Fuel Injector Connector Tube Removal

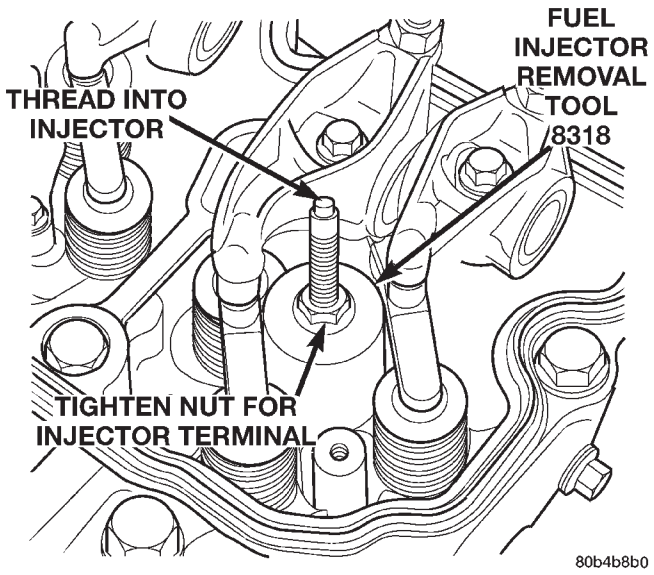


Fig. 78 Fuel Injector Removal

REMOVAL

CAUTION: Refer to Cleaning Fuel System Parts.

(1) Disconnect both negative battery cables from both batteries. Cover and isolate ends of cables.

Each fuel injector is connected to each high-pressure fuel line with a steel connector tube (Fig. 76). This steel connector is positioned into cylinder head and sealed with an o-ring. The connectors are connected to high-pressure fuel lines with fittings (Fig. 76).

(2) If injector at #1 or #2 cylinder is being removed, intake manifold air heater assembly must be removed. Refer to Intake Manifold Air Heater Removal/Installation.

REMOVAL AND INSTALLATION (Continued)

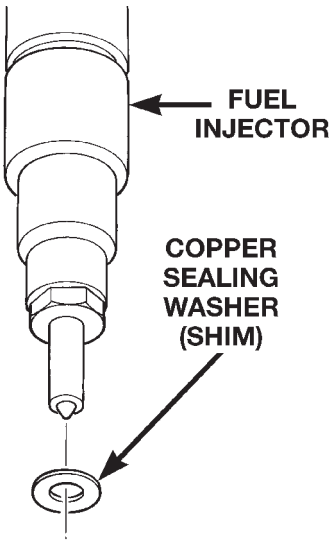


Fig. 79 Fuel Injector Sealing Washer (Shim) Location

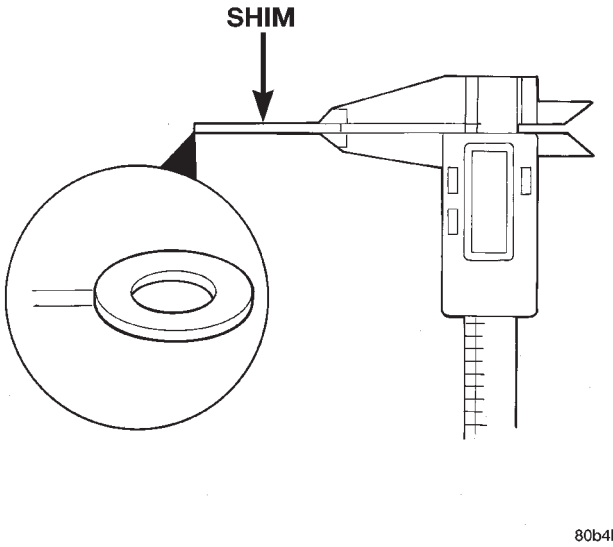


Fig. 80 Measuring Injector Sealing Washer (Shim)

(3) If injector at #5 cylinder is being removed, remove engine lifting bracket (2 bolts).

(4) Thoroughly clean area around injector and injector high-pressure lines before removal.

(5) Remove necessary high-pressure fuel lines. Refer to High-Pressure Fuel Lines Removal/Installation. **Do not bend any high-pressure fuel line to gain access to fuel injector.** Cover or cap any open fuel connections.

(6) Remove valve cover. Refer to Group 9, Engines.

(7) Thread Special Tool 8324 (Fuel Injector Connector Tube Remover) onto end of injector connector tube (Fig. 77).

(8) Pull injector connector tube from cylinder head. **The injector connector tube must be removed before attempting to remove fuel injector or serious damage to fuel injector and tube will result.**

(9) Remove and discard old o-ring (Fig. 76) from injector connector tube.

(10) Remove fuel injector hold down clamp bolt at front end of clamp (Fig. 75). **Do not loosen or remove special (2 shouldered) bolt at rear end of clamp.** Remove injector clamp by sliding it from shoulders on rear clamp bolt.

(11) Thread rod from Special Tool number 8318 (Fuel Injector Remover) into top of fuel injector (Fig. 78).

(12) Tighten nut on 8318 tool to pull (remove) fuel injector from cylinder head.

(13) Remove and discard old o-ring from fuel injector.

(14) Remove and discard copper sealing washer (shim) (Fig. 79) from bottom of injector. **If copper sealing washer has remained in cylinder head, it must be removed.**

INSTALLATION

(1) Inspect fuel injector.

(a) If necessary, perform pressure test of injector. Refer to Fuel Injector Testing.

(b) Look for burrs on injector inlet.

(c) Check nozzle holes for hole erosion or plugging.

(d) Inspect end of nozzle for burrs or rough machine marks.

(e) Look for cracks at nozzle end.

(f) Check nozzle color for signs of overheating. Overheating will cause nozzle to turn a dark yellow/tan or blue (depending on overheating temperature).

(g) If any of these conditions occur, replace injector.

(2) Thoroughly clean fuel injector cylinder head bore with special Cummins wire brush tool or equivalent (Fig. 81). Blow out bore hole with compressed air.

(3) The bottom of fuel injector is sealed to cylinder head bore with a copper sealing washer (shim) of a certain thickness. A new shim with correct thickness must always be re-installed after removing injector. Measure thickness of injector shim (Fig. 80). **Shim Thickness: 1.5 mm (.060”)**

(4) Install new shim (washer) to bottom of injector (Fig. 79). Apply light coating of clean engine oil to washer. This will keep washer in place during installation.

(5) Install new o-ring to fuel injector. Apply small amount of clean engine oil to o-ring.

REMOVAL AND INSTALLATION (Continued)

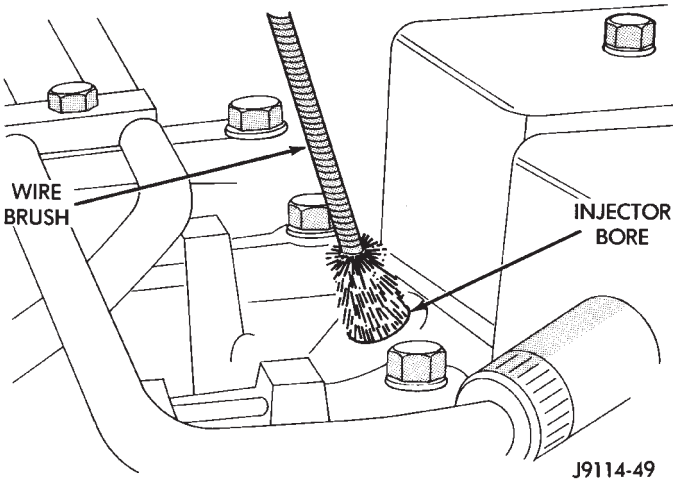


Fig. 81 Cleaning Cylinder Head Injector Bore—TYPICAL BORE

(6) Note fuel inlet hole on side of fuel injector. This hole must be positioned towards injector connector tube. Position injector into cylinder head bore being extremely careful not to allow injector tip to touch sides of bore. Press fuel injector into cylinder head with finger pressure only. **Do not use any tools to press fuel injector into position. Damage to machined surfaces may result.**

(7) Position fuel injector hold down clamp into shouldered bolt while aligning slot in top of injector into groove in bottom of clamp. Tighten opposite clamp bolt (Fig. 75) to 10 N·m (89 in. lbs.) torque.

(8) Install new o-ring to fuel injector connector tube. Apply small amount of clean engine oil to o-ring.

(9) Press injector connector tube into cylinder head with finger pressure only. **Do not use any tools to press tube into position. Damage to machined surfaces may result.**

(10) Connect high-pressure fuel lines. Refer to High-Pressure Fuel Lines Removal/Installation. **The fuel line fitting torque is very critical.** If fitting is under torqued, the mating surfaces will not seal and a high-pressure fuel leak will result. If fitting is over torqued, the connector and injector will deform and also cause a high-pressure fuel leak. This leak will be inside cylinder head and will not be visible resulting in a possible fuel injector miss and low power.

(11) Install valve cover. Refer to Group 9, Engines.

(12) (If necessary) install intake manifold air heater assembly. Refer to Intake Manifold Air Heater Removal/Installation.

(13) (If necessary) install engine lifting bracket. Tighten 2 bolts to 77 N·m (57 ft. lbs.) torque.

(14) Connect negative battery cables to both batteries.

(15) Bleed air from high-pressure lines. Refer to Air Bleed Procedure.

FUEL TRANSFER PUMP

The fuel transfer pump (fuel lift pump) is located on left side of engine, below and rearward of fuel filter (Fig. 82).

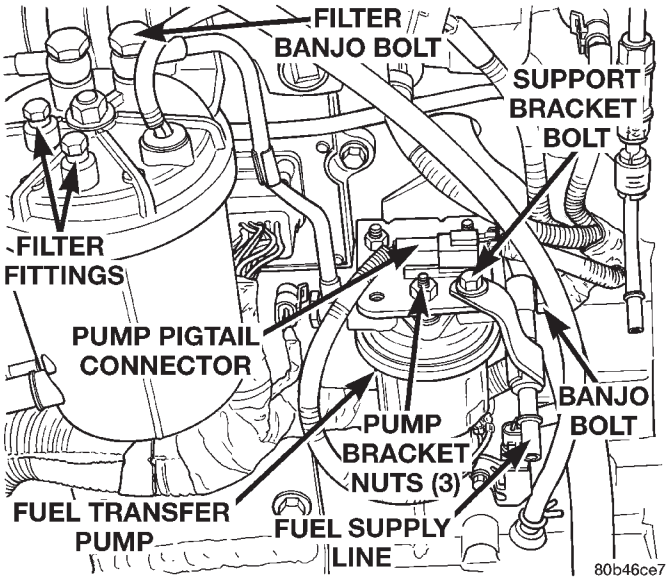


Fig. 82 Fuel Transfer Pump Location

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Thoroughly clean 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) Disconnect fuel line quick-connect fitting at fuel supply line (Fig. 82) at rear of pump.

(6) Remove support bracket bolt at top of pump (Fig. 82).

(7) Remove banjo bolts at front and rear of pump (Fig. 82).

(8) Disconnect pigtail harness electrical connector from main engine wiring harness (Fig. 82).

(9) Remove three pump bracket nuts (Fig. 82) and remove pump from vehicle.

INSTALLATION

(1) Install new gaskets to fuel supply line/support bracket and banjo bolt at rear of pump. Install line and banjo bolt to pump. **Do not** tighten banjo bolt at this time.

(2) Install new gaskets to fuel line and banjo bolt at front of pump.

(3) Position 3 pump studs into pump mounting bracket and install 3 nuts. **Do not** tighten nuts at this time.

(4) Install support bracket bolt (Fig. 82). **Do not** tighten bolt at this time.

REMOVAL AND INSTALLATION (Continued)

(5) Tighten 3 pump nuts to 12 N·m (9 ft. lbs.) torque.

(6) Tighten both banjo bolts to 24 N·m (18 ft. lbs.) torque.

(7) Tighten support bracket bolt 12 N·m (9 ft. lbs.) torque.

(8) Connect pigtail harness electrical connector to main engine wiring harness (Fig. 82).

(9) Connect fuel line quick-connect fitting to fuel supply line at rear of pump.

(10) Install starter motor. Refer to Starter Removal/Installation in Group 8B for procedures.

(11) Connect both negative battery cables at both batteries.

(12) Bleed air at fuel supply line at side of fuel injection pump. Refer to the Air Bleed Procedure.

(13) Start engine and check for leaks.

SPECIFICATIONS

ENGINE DATA PLATE

The engine data plate contains:

- Advertised horsepower
- Cubic inch/liter of engine
- Engine model number
- Fuel rate at advertised horsepower
- Idle speed specification
- Injection pump CPL number
- Injection pump timing (in degrees)
- Injector firing order
- Valve lash specification

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 permanently riveted to the side of the engine timing gear cover located on the drivers side of engine (Fig. 83).

FUEL INJECTION PUMP DATA PLATE

Pertinent information about the fuel injection pump is machined into a boss on the drivers side of the fuel injection pump (Fig. 84).

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.		

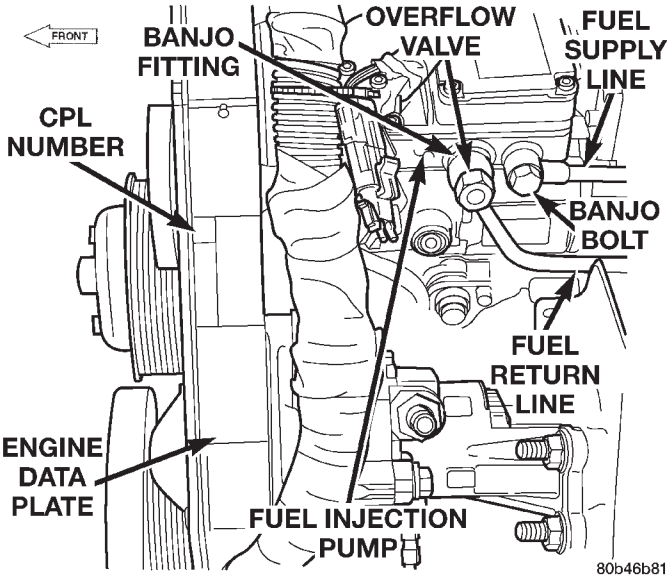


Fig. 83 Engine Data Plate Location

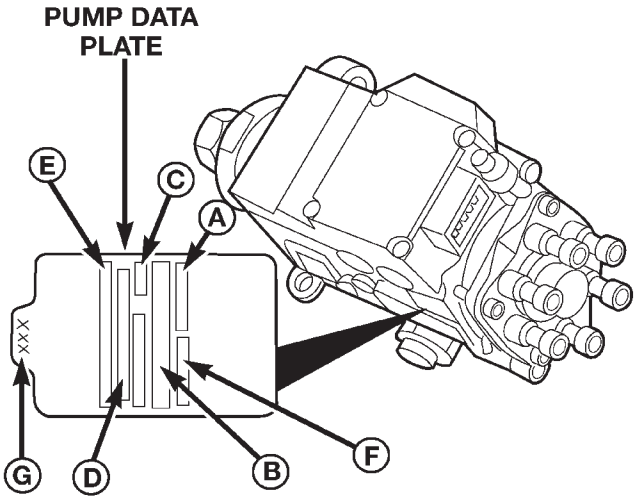


Fig. 84 Fuel Injection Pump Data Plate Location

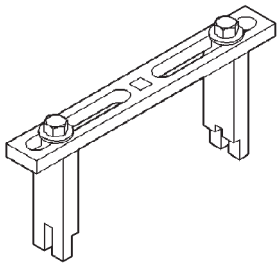
SPECIFICATIONS (Continued)

FUEL SYSTEM PRESSURES—DIESEL ENGINES

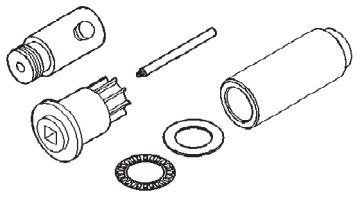
DESCRIPTION	PRESSURE
Fuel Transfer (Lift) Pump Pressure With Engine Running	minimum 69 kPa (10 psi)
Fuel Transfer (Lift) Pump Pressure With Engine Cranking	minimum 48 kPa (7 psi)
Fuel Injector "Pop Off" Pressure	31,026 kPa (310 bars) or (4500 psi ± 250 psi)
Fuel Injector Leak-Down Pressure	approximately 20 bars (291 psi) lower than pop pressure.
Fuel Pressure Drop Across Fuel Filter Test Ports	34 kPa max. (5 psi. max.) at 2500 rpm (rated rpm)
Overflow Valve Release Pressure	97 kPa max. (14 psi.) at 2500 rpm (rated rpm)

SPECIAL TOOLS

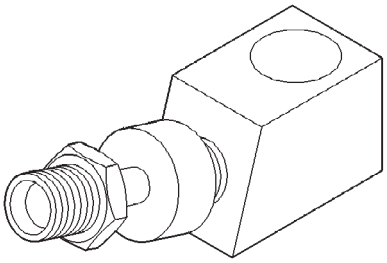
DIESEL FUEL SYSTEM



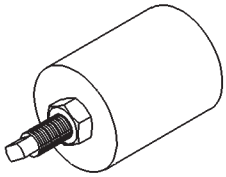
Spanner Wrench (Fuel Tank Module Removal/ Installation)—6856



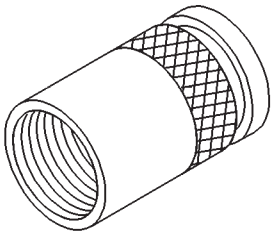
Engine Barring (Rotating) Tool—7471B or 7471C (part of Kit 6714)



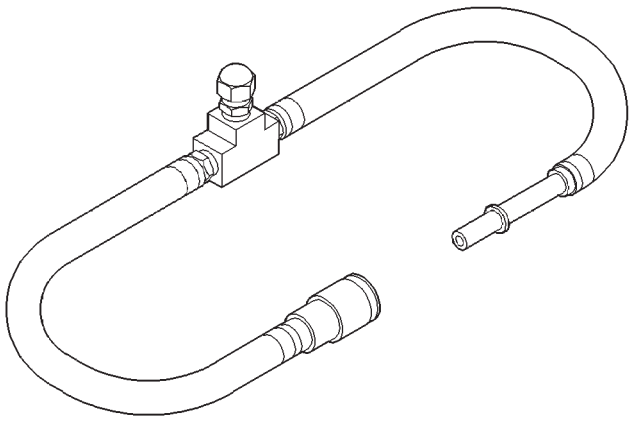
Fuel Injector Pop Pressure Adaptor—8301



Fuel Injector Remover—8318

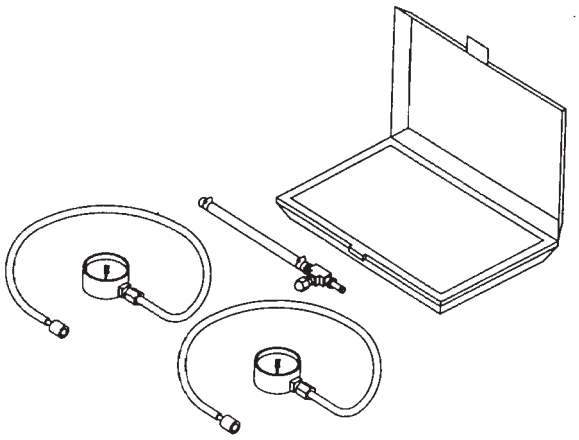


Fuel Injector Tube (Connector) Remover—8324



Fuel Pressure Hose Adapters—6631 and/or 6539

SPECIAL TOOLS (Continued)



Fuel Pressure Test Gauge Kit —5069 (or gauge 6828)

Fuel Line Removal Tool—6782

FUEL INJECTION SYSTEM-DIESEL ENGINE

INDEX

DESCRIPTION AND OPERATION

FUEL INJECTION SYSTEM—DIESEL ENGINE

Two different fuel systems (early and late) are used for the diesel engine in this model year. The **early** fuel system, using the two-valve-per-cylinder engine, will retain the mechanical fuel injection pump as used in previous model years. The **late** fuel system, using the four-valve-per-cylinder engine, will use an **electronic** fuel injection system with three different control modules. This book will include information for the **late** fuel system only.

The Engine Control Module (ECM) and Fuel Injection Pump Control Module (FPCM) are used primarily for fuel system control. The ECM is a separate replaceable component, while the FPCM is internal to the fuel injection pump and is a non-serviceable part. The ECM and FPCM are interconnected (wired together) for fuel injection control.

The Powertrain Control Module (PCM) is used to regulate or control the A/C, charging and speed control systems. It is also used to partially control certain electronic automatic transmission components. The PCM also has control over certain instrument panel components.

Refer to either Powertrain Control Module (PCM) or Engine Control Module (ECM) for additional information. Refer to (Fig. 1) for a partial list of fuel system components.

ENGINE CONTROL MODULE (ECM)

The Engine Control Module (ECM) and Fuel Injection Pump Control Module (FPCM) are used to electrically control the fuel system. The Powertrain Control Module (PCM) **does not control** the fuel system.

The ECM is bolted to the left side of the engine behind the fuel filter (Fig. 2). It is a separate component and can be serviced. The FPCM is internal to the fuel injection pump (Fig. 3) and cannot be serviced.

The main function of the ECM and the FPCM is to control the fuel injection system.

The ECM can adapt its programming to meet changing operating conditions. **If the ECM has been replaced, flashed or re-calibrated, the ECM must learn the Accelerator Pedal Position Sensor (APPS) idle voltage. Failure to learn this voltage may result in unnecessary diagnostic trouble codes. Refer to ECM Removal/Installation for learning procedures.**

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

NOTE: ECM Inputs:

- Accelerator Pedal Position Sensor (APPS)
- Battery voltage
- Camshaft Position Sensor (CMP)
- CCD bus (+) circuits
- CCD bus (-) circuits
- Crankshaft Position Sensor (CKP)
- Data link connection for DRB scan tool
- (FPCM) Fuel Injection Pump Control Module
- Engine Coolant Temperature (ECT) sensor
- Ground circuits
- Intake manifold Air Temperature (IAT) sensor
- Manifold Air Pressure (MAP) Sensor
- Oil pressure sensor output
- PCM
- Power Take Off (PTO)
- Power ground
- Sensor return
- Signal ground
- Water-In-Fuel (WIF) sensor

NOTE: ECM Outputs:

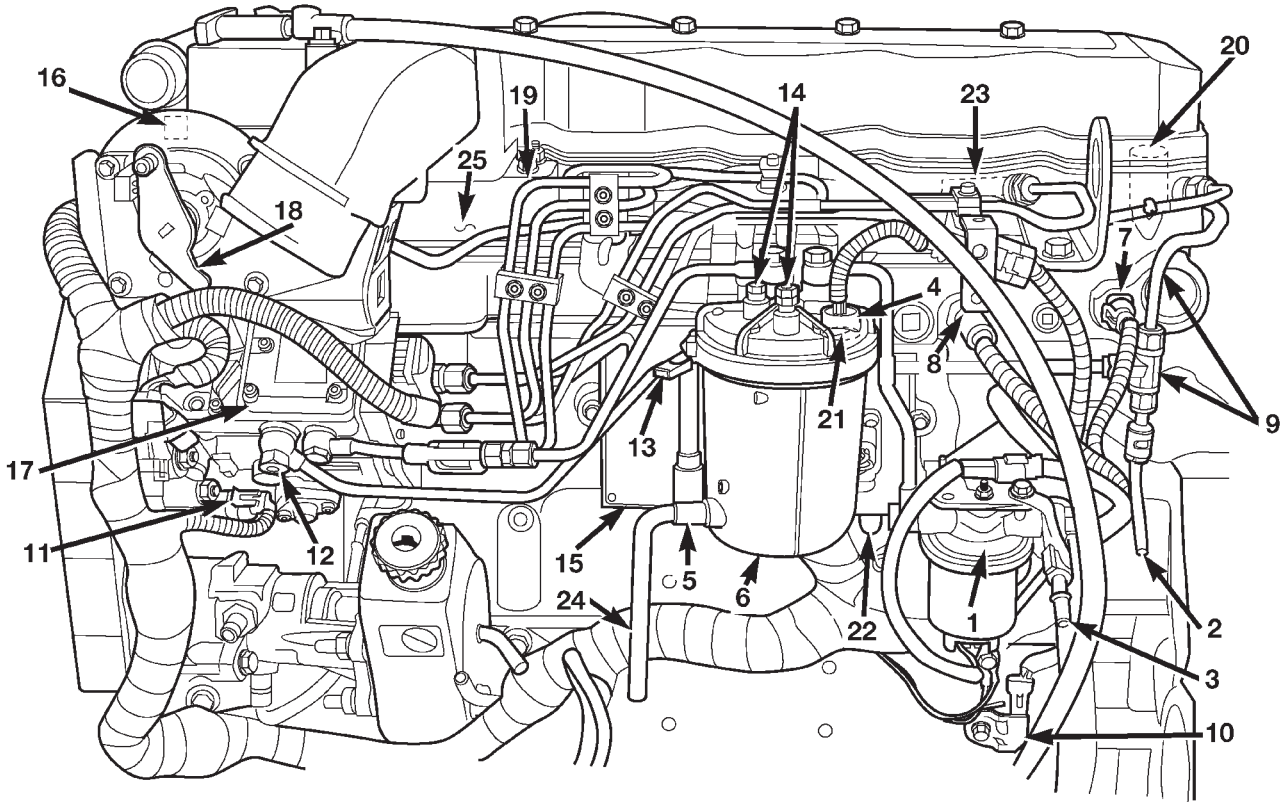
After inputs are received by the ECM, certain sensors, switches and components are controlled or regulated by the ECM. These are considered **ECM Outputs.** These outputs are for:

- CCD bus (+) circuits
- CCD bus (-) circuits
- CKP and APPS outputs to the PCM
- Data link connection for DRB scan tool
- Five volt sensor supply
- Fuel injection pump
- Fuel injection pump relay
- (FPCM) Fuel Pump Control Module
- Fuel transfer (lift) pump
- Intake manifold air heater elements #1 and #2
- Intake manifold air heater relays #1 and #2
- Malfunction indicator lamp (Check engine lamp)
- Oil pressure gauge/warning lamp
- PCM
- Wait-to-start warning lamp
- Water-In-Fuel (WIF) warning lamp

ACCELERATOR PEDAL POSITION SENSOR (APPS)—ECM INPUT

The Accelerator Pedal Position Sensor (APPS) is a linear potentiometer. It provides the Engine Control Module (ECM) with a DC voltage signal proportional to the angle, or position of the accelerator pedal. In previous model years, this part was known as the Throttle Position Sensor (TPS).

DESCRIPTION AND OPERATION (Continued)



1. FUEL TRANSFER (LIFT) PUMP
2. FUEL RETURN LINE (TO FUEL TANK)
3. FUEL SUPPLY LINE (LOW-PRESSURE, TO ENGINE)
4. FUEL HEATER
5. WATER-IN-FUEL (WIF) SENSOR
6. FUEL FILTER/WATER SEPARATOR
7. IAT SENSOR
8. MAP (BOOST) SENSOR
9. FUEL DRAIN MANIFOLD
10. CKP SENSOR
11. CMP SENSOR
12. OVERFLOW VALVE
13. DRAIN VALVE
14. FUEL PRESSURE TEST PORTS
15. ECM
16. ECT SENSOR
17. FUEL INJECTION PUMP
18. THROTTLE LEVER BELLCRANK AND APPS
19. HIGH-PRESSURE FUEL LINES
20. FUEL INJECTORS
21. FUEL HEATER TEMPERATURE SENSOR (THERMOSTAT)
22. OIL PRESSURE SENSOR
23. FUEL INJECTOR CONNECTOR
24. DRAIN TUBE
25. INTAKE MANIFOLD AIR HEATER/ELEMENTS

80b34ea4

Fig. 1 Fuel System Components—Diesel Engine

DESCRIPTION AND OPERATION (Continued)

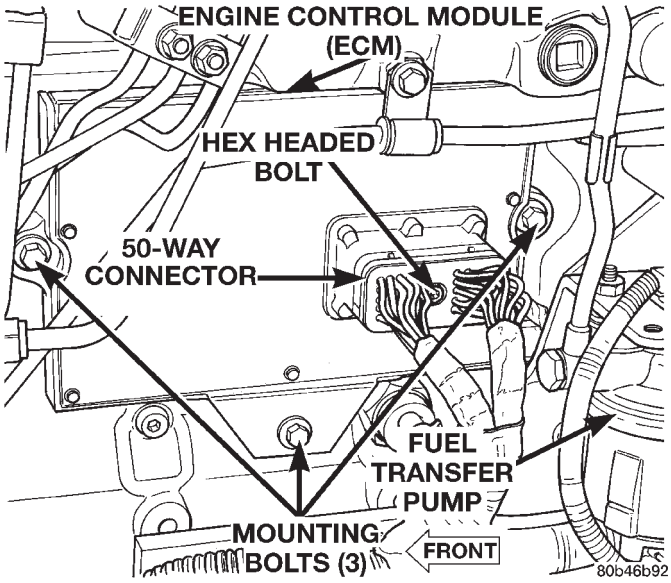


Fig. 2 Engine Control Module (ECM) Location

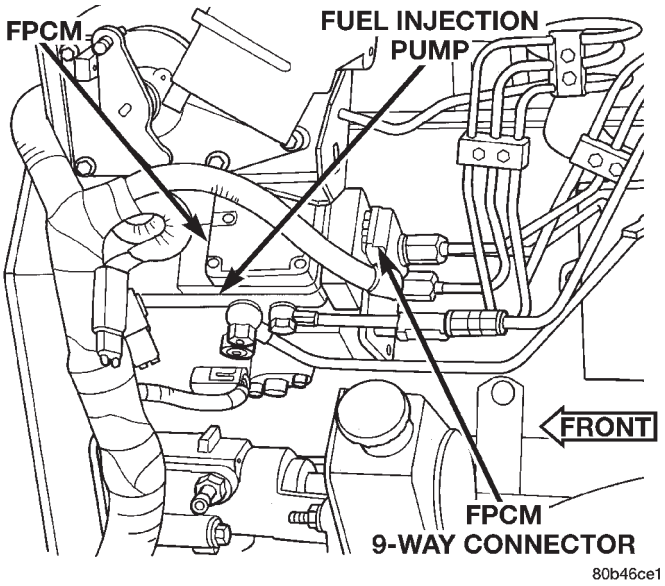


Fig. 3 Fuel Injection Pump Control Module (FPCM) Location

Diesel engines used in previous model years used a mechanical cable between the accelerator pedal and the TPS lever. Linkage and bellcranks between the TPS cable lever and the fuel injection pump were also used. Although the cable has been retained with the APPS, the linkage and bellcranks between the cable lever and the fuel injection pump are no longer used.

The APPS assembly is located at the top-left-front of the engine (Fig. 4). A plastic cover is used to cover the assembly. The actual sensor is located behind its mounting bracket (Fig. 5).

The APPS is serviced (replaced) as one assembly including the lever, brackets and sensor. The APPS is calibrated and permanently positioned to its mounting bracket.

CAUTION: Do not attempt to remove sensor from its mounting bracket as electronic calibration will be destroyed (sensor-to-bracket mounting screws are permanently attached). Two accelerator lever set screws (Fig. 4) are used to position lever. Do not attempt to alter positions of these set screws as electronic calibration will be destroyed.

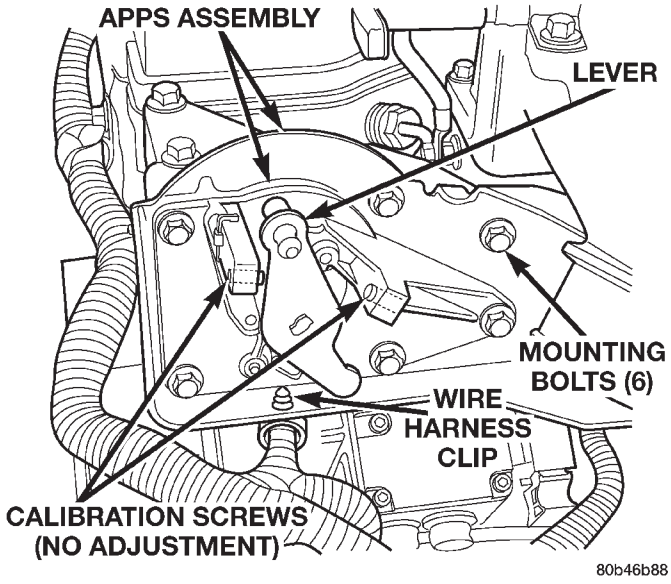


Fig. 4 APPS Assembly Location

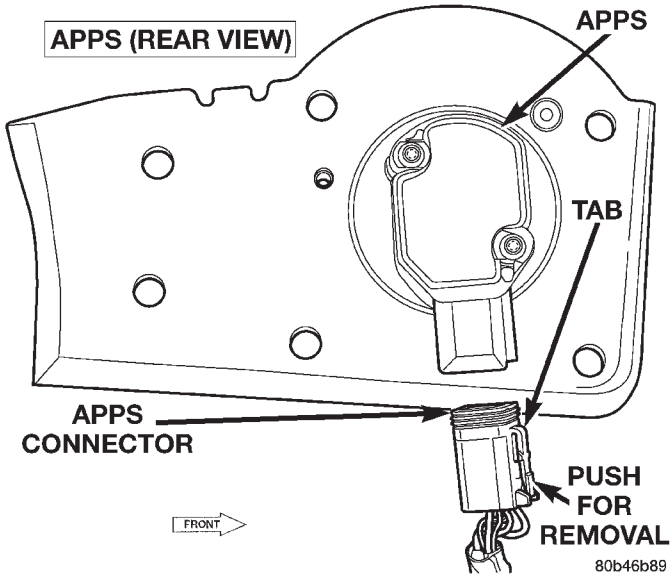


Fig. 5 APPS Sensor Location (Rear View)

BATTERY VOLTAGE—ECM INPUT

The battery voltage input provides power to the Engine Control Module (ECM). It also informs the ECM 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 ECM memory alive. The memory stores Diagnostic Trouble Code (DTC) messages.

DESCRIPTION AND OPERATION (Continued)

CAMSHAFT POSITION SENSOR (CMP)—ECM INPUT

The Camshaft Position Sensor (CMP) (Fig. 6) contains a hall effect device called a sync signal generator to generate a sync signal.

The sync signal generator detects a machined hole on the rear face of the camshaft drive gear. The signal is used to verify the position of the #1 cylinder during engine operation.

When the leading edge of the machined hole enters the tip of the CMP, the interruption of magnetic field causes the voltage to switch high resulting in a signal of approximately 5 volts.

When the trailing edge of the machined hole leaves the tip of the CMP, the change of the magnetic field causes the voltage to switch low to 0 volts.

The CMP is located below the fuel injection pump (Fig. 7). It is attached to the back of the timing gear cover housing.

The CMP is **not used** for any control of fuel system. It is used only for diagnostic purposes.

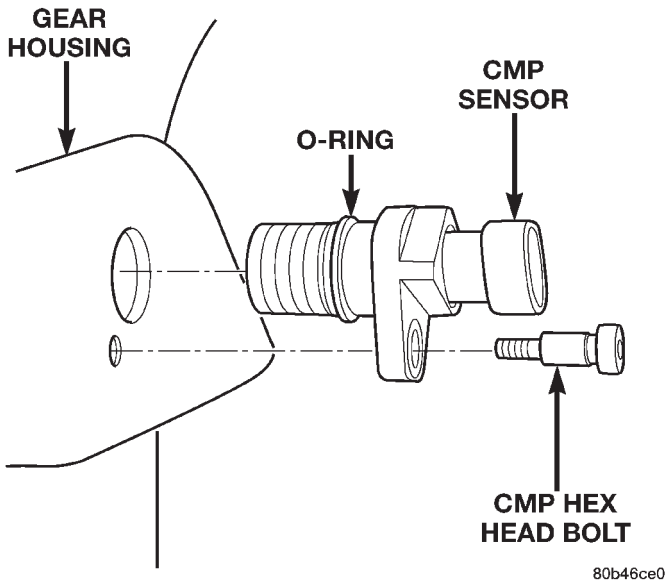


Fig. 6 Camshaft Position Sensor (CMP)

CCD BUS (+/-) CIRCUITS—ECM/PCM INPUTS/OUTPUTS

The Engine Control Module (ECM) and the Powertrain Control Module (PCM) send certain signals through the CCD bus circuits. Some of these signals are parallel circuited between the two control modules (ECM and PCM). 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.

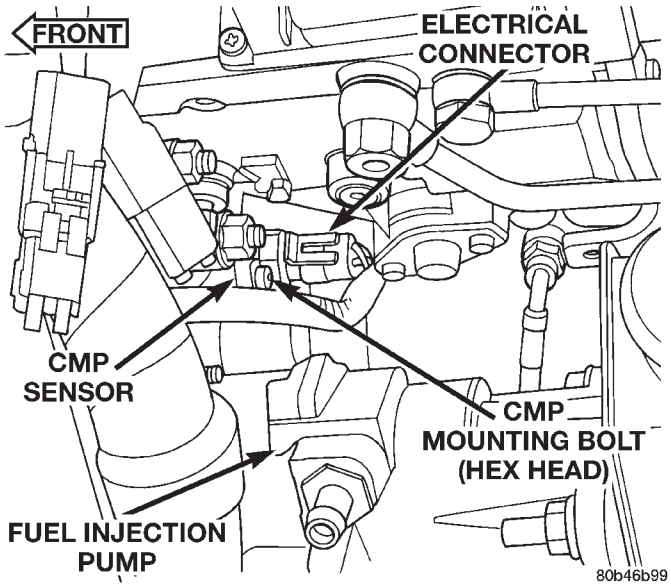


Fig. 7 Camshaft Position Sensor (CMP) Location

CRANKSHAFT POSITION SENSOR (CKP)—ECM INPUT

The Crankshaft Position Sensor (CKP) is located on the lower left-rear side of the engine behind the starter motor (Fig. 8).

Engine speed and crankshaft position are provided through the CKP. The sensor generates pulses that are the input sent to the Engine Control Module (ECM). The ECM interprets the sensor input to determine the crankshaft position. The ECM then uses this position, along with other inputs, to determine injector firing sequence and fuel timing. The sensor must be powered up by 5 volts to operate.

The sensor is a hall effect device combined with an internal magnet. It is also sensitive to steel within a certain distance from it.

The engine crankshaft is equipped with a bolt-on tone wheel (Fig. 9). The tone wheel is equipped with 35 teeth and a gap where the 36th tooth should be placed (Fig. 9). This missing tooth indicates to the ECM the relative position of cylinder #1 to the Top Dead Center (TDC) position. This does not mean that cylinder #1 is at TDC. When the CKP is aligned with the missing tooth, the missing tooth is 60 degrees away from cylinder #1 TDC position. The teeth cause pulses to be generated when they pass under the sensor. The pulses are the input to the ECM.

DESCRIPTION AND OPERATION (Continued)

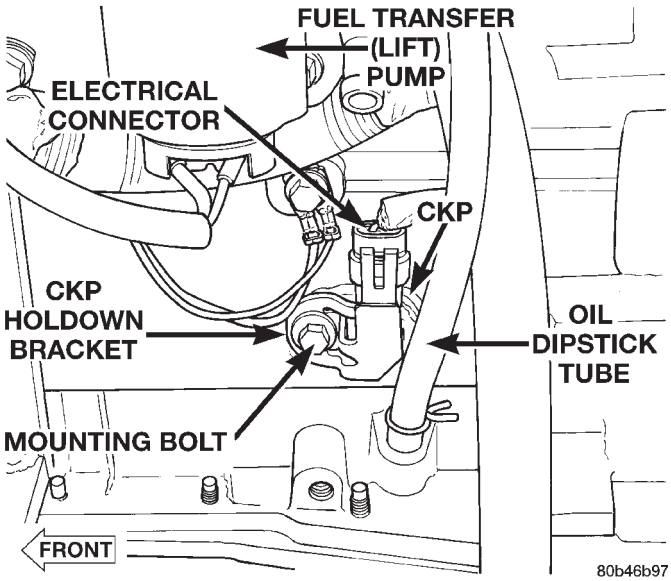


Fig. 8 Crankshaft Position Sensor (CKP) Location

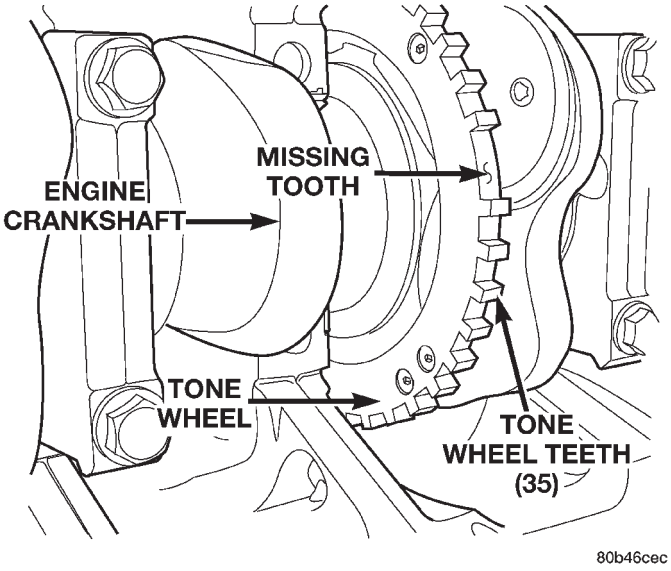


Fig. 9 Crankshaft Tone Wheel

ENGINE COOLANT TEMPERATURE (ECT) SENSOR—ECM INPUT

The engine coolant temperature sensor is installed into the front of the cylinder head near to the thermostat housing (Fig. 10) and protrudes into a water jacket. The sensor provides an input voltage to the Engine Control Module (ECM) to monitor coolant temperature. The ECM uses this input along with inputs from other sensors for engine protection, fuel timing and fuel control. As coolant temperature varies, the coolant temperature sensor resistance will change. This change in resistance results in a different input voltage to the ECM.

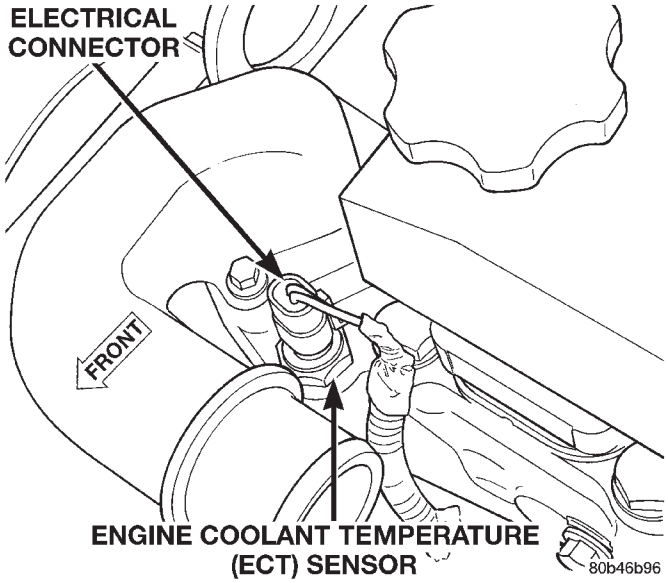


Fig. 10 Engine Coolant Temperature Sensor

FUEL TEMPERATURE SENSOR

Two different fuel temperature sensors are used. One of the sensors is located inside of the Bosch VP44 fuel injection pump and is a non-serviceable part. It is used to check fuel temperature within the injection pump and to set a Diagnostic Trouble Code (DTC) if a specific high fuel temperature has been reached. If high temperature has been reached, engine power will be de-rated by the Engine Control Module (ECM).

The other fuel temperature sensor is located in the top of the fuel filter housing and is serviceable. It is used to control the fuel heater element. Refer to Fuel Heater Description and Operation for additional information.

INTAKE MANIFOLD AIR TEMPERATURE (IAT) SENSOR—ECM INPUT

The IAT provides an input voltage to the Engine Control Module (ECM) indicating intake manifold air temperature. The input is used along with inputs from other sensors for engine protection, fuel timing and fuel control. 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 ECM.

The intake manifold air temperature sensor is installed into the rear of the intake manifold (Fig. 11) with the sensor element extending into the air stream.

DESCRIPTION AND OPERATION (Continued)

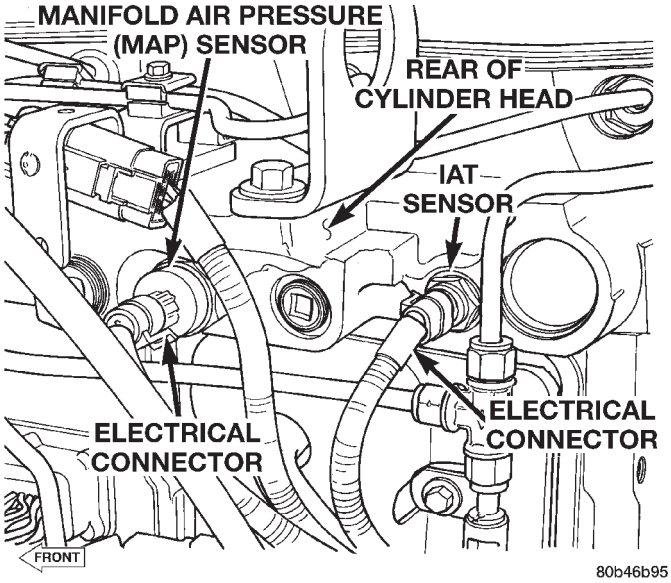


Fig. 11 Intake Manifold Air Temperature (IAT) Sensor Location

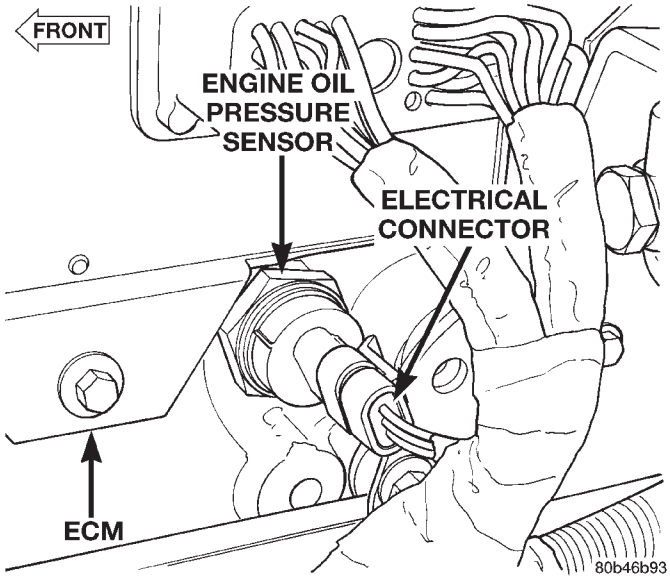


Fig. 12 Oil Pressure Sensor (Engine) Location

MANIFOLD AIR PRESSURE (MAP) SENSOR—ECM INPUT

The MAP sensor reacts to air pressure changes in the intake manifold. It provides an input voltage to the Engine Control Module (ECM). As pressure changes, MAP sensor voltage will change. The change in MAP sensor voltage results in a different input voltage to the ECM. The ECM uses this input, along with inputs from other sensors to provide fuel timing, fuel control and engine protection. Engine protection is used to derate (drop power off) the engine if turbocharger pressure becomes to high.

The MAP sensor is installed into the rear of the intake manifold (Fig. 11).

OIL PRESSURE SENSOR (ENGINE)—ECM INPUT

A signal is sent from the engine oil pressure sensor (sending unit) to the Engine Control Module (ECM) relating to engine oil pressure. The ECM monitors this signal and converts it to a pressure value. This value is used by the ECM for the engine protection system.

The pressure signal from the ECM is bussed to the instrument panel oil gauge/lamp via the CCD circuits.

The oil pressure sensor is installed into the oil pressure galley on the engine block. It is located below and to the rear of the ECM (Fig. 12).

PTO SWITCH SENSE—ECM INPUT

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

The input is used to tell the ECM that the PTO has been engaged. When engaged, the ECM will disable certain OBD II functions until the PTO has been turned off.

WATER-IN-FUEL (WIF) SENSOR—ECM INPUT

The sensor sends an input to the Engine Control Module (ECM) 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 ECM and compared to a high water standard value. Once the value reaches 30 to 40 kilohms, the ECM will activate the water-in-fuel warning lamp through CCD bus circuits. This all takes place when the ignition key is initially put in the ON position. The ECM continues to monitor the input at the end of the intake manifold air heater post-heat cycle.

The WIF sensor is located at the bottom of the fuel filter/water separator canister (Fig. 13).

FUEL INJECTION PUMP RELAY—ECM OUTPUT

The Engine Control Module (ECM) energizes the electric fuel injection pump through the fuel injection pump relay. Battery voltage is applied to the fuel injection pump relay at all times. When the key is turned ON, the relay is energized when a 12–volt signal is provided by the ECM. When energized, 12–volts is supplied to the Fuel Pump Control Module. The Fuel Pump Control Module is located on the top of the fuel injection pump and is non-servicable.

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

DESCRIPTION AND OPERATION (Continued)

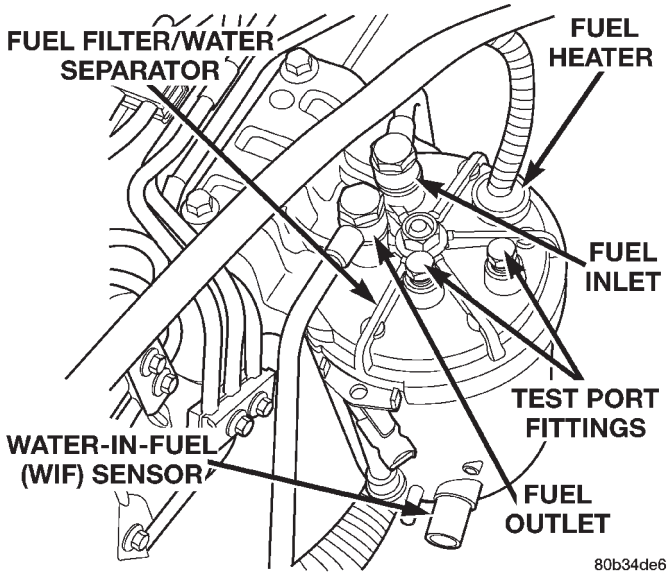


Fig. 13 Water-in-Fuel Sensor Location

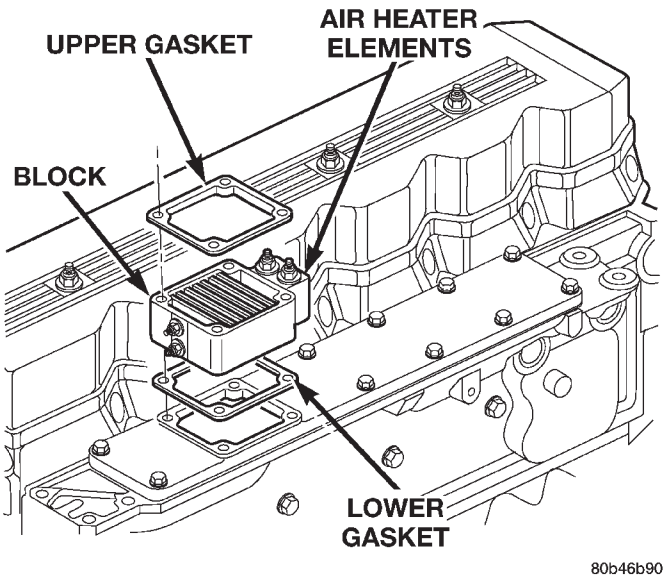


Fig. 14 Air Heater Elements Location

INTAKE MANIFOLD AIR HEATER ELEMENTS

The air heater elements are used to heat incoming air to the intake manifold. This is done to help engine starting and improve driveability with cool or cold outside temperatures.

Electrical supply for the 2 air heater elements is controlled by the Engine Control Module (ECM) through the 2 air heater relays. Refer to Intake Manifold Air Heater Relays for more information.

Two heavy-duty cables 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.

The intake manifold air heater element assembly is located in the top of the intake manifold (Fig. 14).

Refer to the Powertrain Diagnostic Procedures manual for an electrical operation and complete description of the intake heaters, including pre-heat and post-heat cycles.

INTAKE MANIFOLD AIR HEATER RELAYS—ECM OUTPUT

The Engine Control Module (ECM) operates the 2 heating elements through the 2 intake manifold air heater relays.

The 2 relays are located in the engine compartment, attached to the left inner fender below the left battery (Fig. 15).

Refer to the Powertrain Diagnostic Procedures manual for an electrical operation and complete description of the intake heaters, including pre-heat and post-heat cycles.

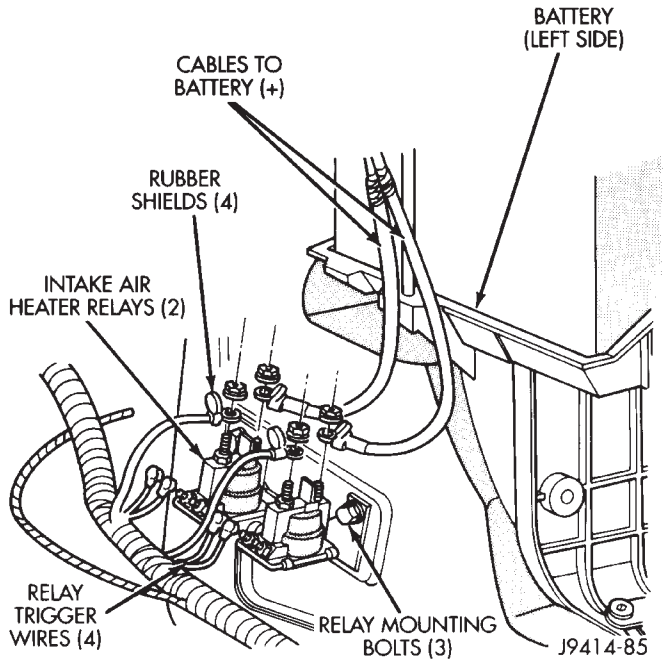


Fig. 15 Intake Manifold Air Heater Relays Location

WAIT-TO-START WARNING LAMP—ECM OUTPUT

The wait-to-start warning lamp is turned on and off by the Engine Control Module (ECM) based on the intake manifold air temperature sensor input. The lamp is located on the instrument panel.

The lamp is turned on when the key is first activated. If the ECM reads intake manifold air temperature below 19°C (66°F), it will turn the wait-to-start warning lamp on for the air heater pre-heat cycle. The lamp stays on until the pre-heat cycle is over.

DESCRIPTION AND OPERATION (Continued)

Refer to the Powertrain Diagnostic Procedures manual for electrical operation and complete description of the intake heaters, including pre-heat and post-heat cycles.

WATER-IN-FUEL WARNING LAMP—ECM INPUT

The Engine Control Module (ECM) turns on the water-in-fuel warning lamp if water is detected in the diesel fuel. The water-in-fuel warning lamp is located in the instrument panel. The lamp will illuminate for about two seconds each time the key is initially turned to the ON position as a bulb check.

If the lamp continues to be illuminated, it signals an immediate need for service. Refer to Fuel Filter/Water Separator Removal/Installation for water draining procedures.

Also refer to Water-In-Fuel Sensor—ECM Input for additional information.

POWERTRAIN CONTROL MODULE (PCM)—DIESEL

Two different control modules are used: The Powertrain Control Module (PCM), and the Engine Control Module (ECM). The ECM **controls** the fuel system. The PCM **does not control** the fuel system.

The PCM is located in the right-rear side of the engine compartment (Fig. 16).

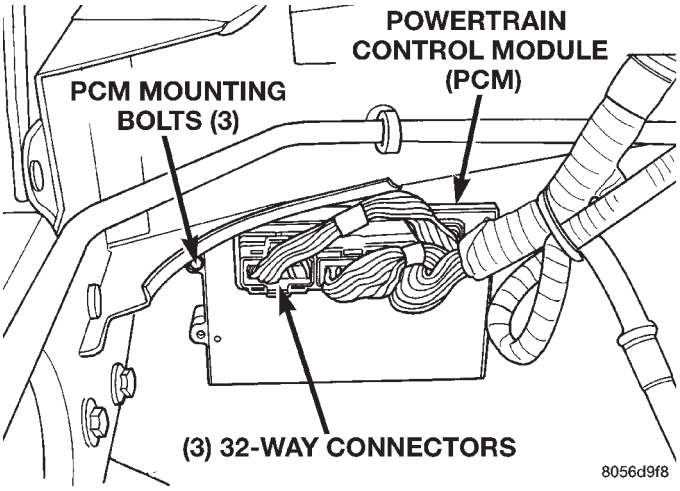


Fig. 16 PCM Location

The PCM's main function is to control: the vehicle charging system, speed control system, transmission, air conditioning system and certain bussed messages.

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)
- Accelerator Pedal Position Sensor (APPS) output from ECM
- Auto shutdown (ASD) relay sense
- Battery temperature sensor
- Battery voltage
- Brake switch
- CCD bus (+) circuits
- CCD bus (-) circuits
- Crankshaft Position Sensor (CKP) output from ECM
- Data link connection for DRB scan tool
- Fuel level sensor
- Generator (battery voltage) output
- Ignition sense
- 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
- Transmission governor pressure sensor
- Transmission temperature 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 and A/C clutch
- Auto shutdown (ASD) relay
- CCD bus (+) circuits
- CCD bus (-) circuits
- Data link connection for DRB scan tool
- Five volt sensor supply
- 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.)

DESCRIPTION AND OPERATION (Continued)

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 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.

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. A signal is then sent out from the PCM to the CCD bus circuits for fuel gauge operation.

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.

TRANSMISSION TEMPERATURE SENSOR—PCM INPUT

The transmission temperature sensor is a variable, thermistor type. It reacts to temperature changes. At 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.

DESCRIPTION AND OPERATION (Continued)

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.

AIR CONDITIONING CLUTCH RELAY—PCM OUTPUT

The A/C relay is located in the Power Distribution Center (PDC). Refer to label under 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).

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. Refer to Groups 8A and 8C for charging system information.

DATA LINK CONNECTOR—PCM/ECM 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 both the Powertrain Control Module (PCM) and the Engine Control Module (ECM). The data link connector (Fig. 17) 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.

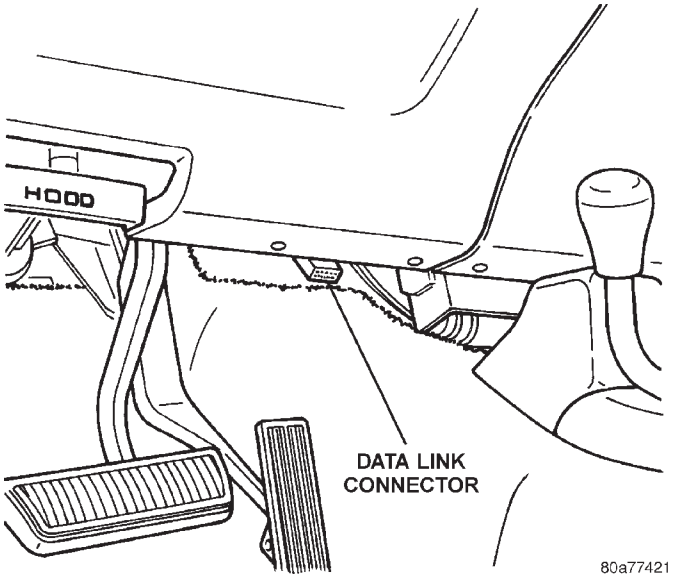


Fig. 17 16–Way Data Link Connector

MALFUNCTION INDICATOR LAMP—ECM/PCM OUTPUT

Refer to Group 25, Emission Control System for information.

DESCRIPTION AND OPERATION (Continued)

OVERDRIVE LAMP—PCM OUTPUT

Automatic Transmission Only: This circuit controls a signal for operation of the overdrive warning lamp. When the lamp is illuminated, overdrive is disengaged. When the lamp is off, overdrive is engaged.

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 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 tachometer through the CCD circuits, after an engine speed (rpm) signal is sent from the Engine Control Module (ECM). Refer to Group 8E, Instrument Panel 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 Accelerator Pedal Position Sensor (APPS). The APPS signal is sent from the Engine Control Module (ECM). Also needed are various inputs from:

- Transmission temperature sensor
- Output shaft speed sensor
- Module timer
- Engine rpm signal from ECM
- 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.

DIAGNOSIS AND TESTING

BOOST PRESSURE TEST

Two pressure gauges attached at two different points are required for this test.

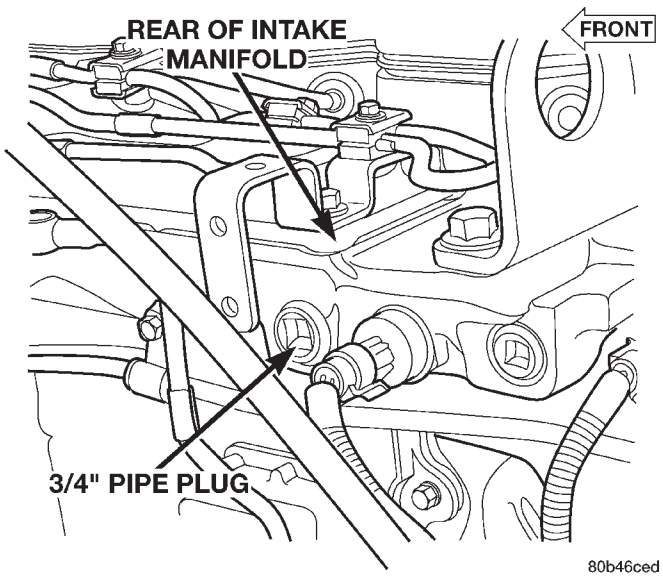


Fig. 18 Boost Pressure Test at Intake Manifold

(1) Obtain two 6828 fuel pressure test gauges (equivalent gauges are OK). **Gauge Consistency Test:** Connect the gauges together to a common pressure source and verify pressure consistency of both gauges. Do this consistency test at approximately 206 kPa (30 psi). If pressures are different, they can still be used for test. Note and record differences in pressures before testing. Make adjustments as necessary.

DIAGNOSIS AND TESTING (Continued)

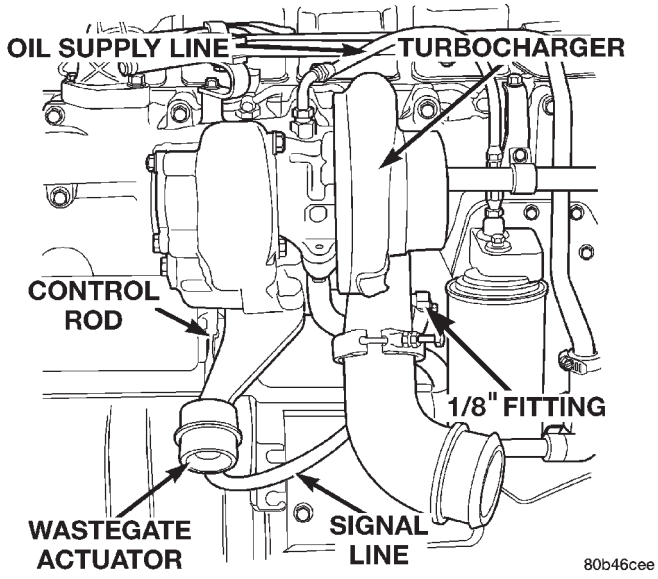


Fig. 19 Boost Pressure Test at Turbocharger

(2) Remove 3/4" pipe plug fitting at rear of intake manifold (Fig. 18). Temporarily replace this fitting with fitting reducer to adapt to pressure gauge. **Note: This pipe plug is located to front of MAP sensor. Do not remove plug to rear of MAP sensor. This is a COOLANT passage plug.**

(3) Loosen hose clamp and disconnect rubber signal line (Fig. 19) from 1/8" brass fitting at front of turbocharger.

(4) Remove 1/8" brass fitting (Fig. 19) from turbocharger. Temporarily replace this fitting with a 1/8" "T" fitting to adapt to pressure gauge.

(5) Reattach signal line to temporary "T".

(6) Attach first pressure gauge to intake manifold fitting.

(7) Attach second pressure gauge to "T" fitting at turbocharger.

Engine must be at rated RPM and full load for the test.

If gauge pressure differential is greater than 3 psi (6 in. Hg), check intercooler and associated piping for restrictions, plugging or damage.

Maximum pressure at intake manifold (rated rpm and load) is 36–37 in/hg ± 3 in/hg (17.7–18.2 psi ± 1.5 psi).

Wastegate should open at no higher than 38.7 in/hg (19 psi) at wide open throttle, full load. If wastegate is out of adjustment, a DTC may have been set. Refer to Wastegate Adjustment in Group 11, Exhaust System and Turbocharger for adjustment procedures.

REMOVAL AND INSTALLATION

ACCELERATOR PEDAL POSITION SENSOR (APPS)

The APPS is serviced (replaced) as one assembly including the lever, brackets and sensor. The APPS is calibrated to its mounting bracket. The APPS assembly is located at left-front of engine below plastic cable/lever/linkage cover (Fig. 20).

CAUTION: Do not attempt to remove sensor from its mounting bracket as electronic calibration will be destroyed (sensor-to-bracket mounting screws are permanently attached). Two accelerator lever set screws (Fig. 22) are used to position lever. Do not attempt to alter positions of these set screws as electronic calibration will be destroyed.

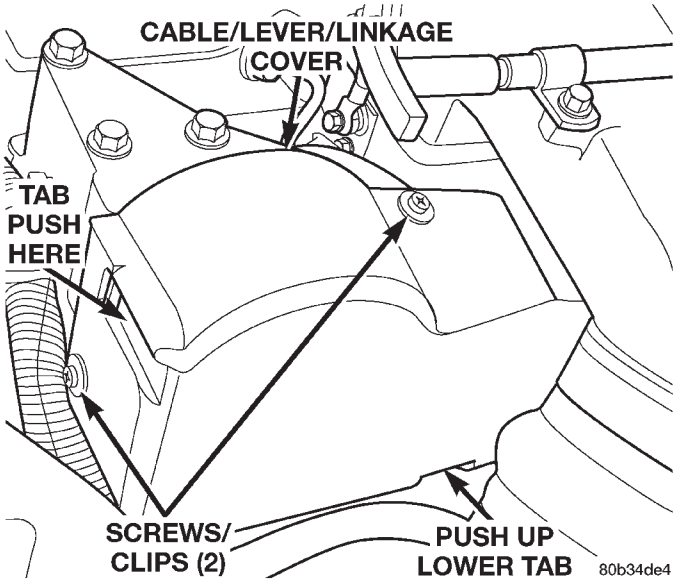


Fig. 20 Cable/Lever/Linkage/Cover

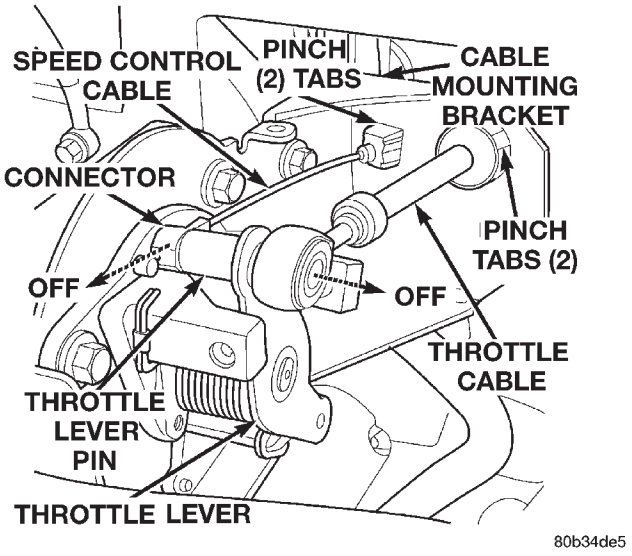


Fig. 21 Cables at Throttle Lever

REMOVAL AND INSTALLATION (Continued)

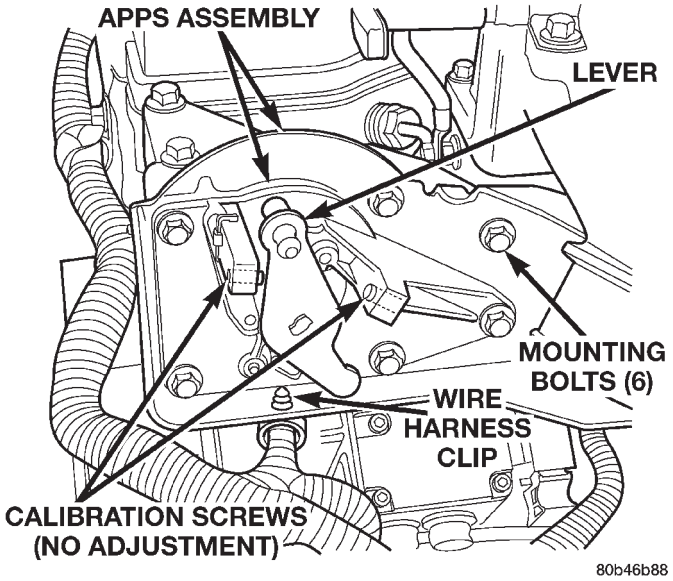


Fig. 22 APPS Assembly

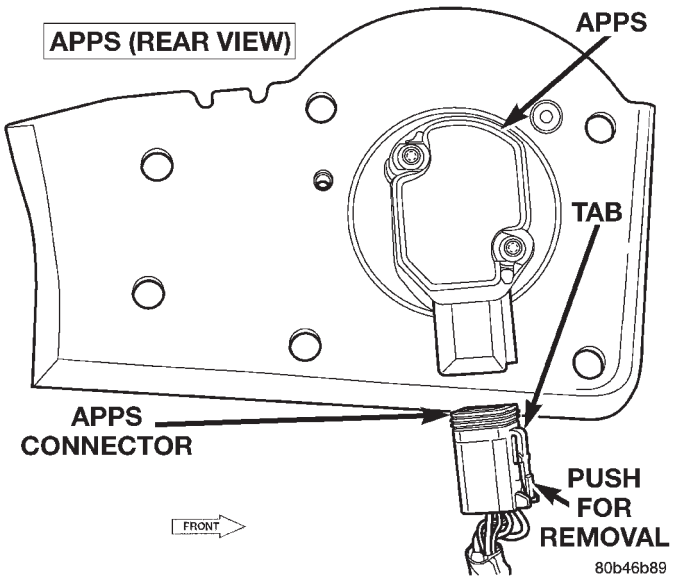


Fig. 23 Electrical Connector at Bottom of APPS

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Remove cable cover (Fig. 20). Cable cover is attached with 2 Phillips screws, 2 plastic retention clips and 2 push tabs (Fig. 20). Remove 2 Phillips screws and carefully pry out 2 retention clips. After clip removal, push rearward on front tab, and upward on lower tab for cover removal.

(3) Using finger pressure only, disconnect end of speed control servo cable from throttle lever pin by pulling forward on connector while holding lever rearward (Fig. 21).**DO NOT try to pull connector off perpendicular to lever pin. Connector will be broken.**

(4) Using two small screwdrivers, pry throttle cable connector socket from throttle lever ball (Fig. 21). **Be very careful not to bend throttle lever arm.**

(5) Disconnect transmission control cable at lever arm (if equipped). Refer to Group 21, Transmission.

(6) Squeeze pinch tabs on speed control cable (Fig. 21) and pull cable rearward to remove from cable mounting bracket.

(7) Squeeze pinch tabs on throttle cable (Fig. 21) and pull cable rearward to remove from cable mounting bracket.

(8) If equipped with an automatic transmission, refer to Group 21, Transmission for transmission control cable removal procedures.

(9) Disconnect wiring harness clip (Fig. 22) at bottom of bracket.

(10) Remove 6 mounting bolts (Fig. 22) and partially remove APPS assembly from engine. After assembly is partially removed, disconnect electrical connector from bottom of sensor by pushing on connector tab (Fig. 23).

(11) Remove APPS assembly from engine.

INSTALLATION

(1) Snap electrical connector into bottom of sensor.

(2) Position APPS assembly to engine and install 6 bolts. Tighten bolts to 12 N·m (105 in. lbs.) torque.

(3) Connect wiring harness clip (Fig. 22) at bottom of bracket.

(4) If equipped with an automatic transmission, refer to Group 21, Transmission for transmission control cable installation procedures.

(5) Install speed control cable into mounting bracket. Be sure pinch tabs (Fig. 21) have secured cable.

(6) Install throttle cable into mounting bracket. Be sure pinch tabs (Fig. 21) have secured cable.

(7) Connect throttle cable at lever (snaps on).

(8) Connect speed control cable to lever by pushing cable connector rearward onto lever pin while holding lever forward.

(9) Install cable cover.

(10) Connect both negative battery cables to both batteries.

(11) **ECM Calibration:** Turn key to ON position. Without starting engine, slowly press throttle pedal to floor and then slowly release. This step must be done (one time) to ensure accelerator pedal position sensor calibration has been learned by ECM. If not done, possible DTC's may be set.

(12) Use DRB scan tool to erase any DTC's from ECM/PCM.

REMOVAL AND INSTALLATION (Continued)

CAMSHAFT POSITION SENSOR (CMP)

The camshaft position sensor (CMP) is located below the fuel injection pump (Fig. 24). It is attached to the back of the timing gear cover housing.

REMOVAL

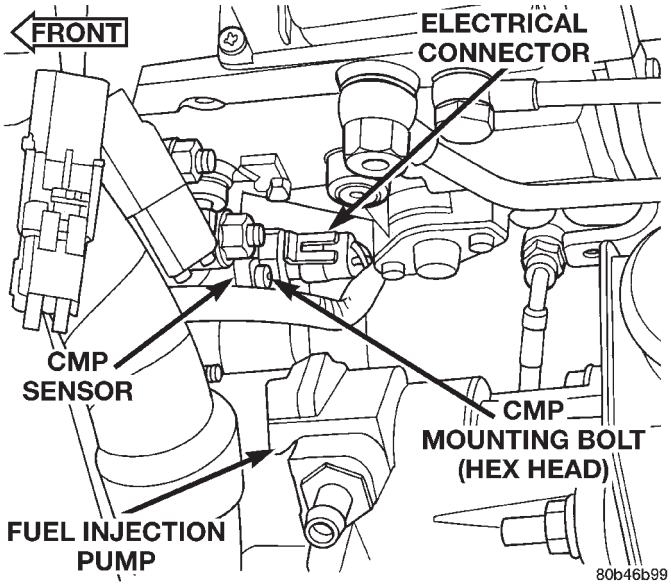


Fig. 24 Camshaft Position Sensor (CMP) Location

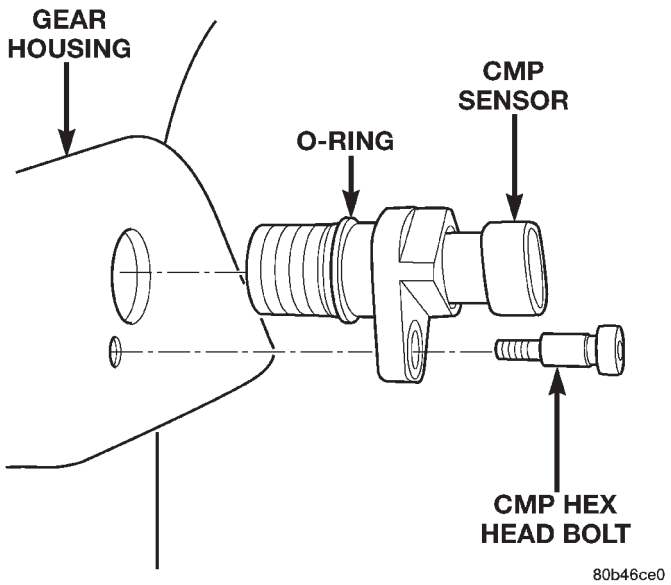


Fig. 25 Camshaft Position Sensor Removal/ Installation

(1) Disconnect both negative cables from both batteries.
(2) Clean area around CMP.
(3) Disconnect electrical at CMP (Fig. 24).
(4) Remove CMP mounting bolt. Bolt head is female-hex (Fig. 25).
(5) Remove CMP from engine by twisting and pulling straight back.
(6) Discard CMP o-ring (Fig. 25).

INSTALLATION

(1) Install new o-ring to CMP. Apply clean engine oil to o-ring.
(2) Clean area around CMP mounting hole.
(3) To prevent tearing o-ring, install CMP into gear housing using a twisting action.
(4) Install mounting bolt and tighten to 20 Nm (15 ft. lbs.) torque.
(5) Install electrical connector to CMP.
(6) Connect both negative cables to both batteries.

CRANKSHAFT POSITION SENSOR (CKP)

REMOVAL

The CKP is located on the left/rear side of engine block near the starter motor (Fig. 26).

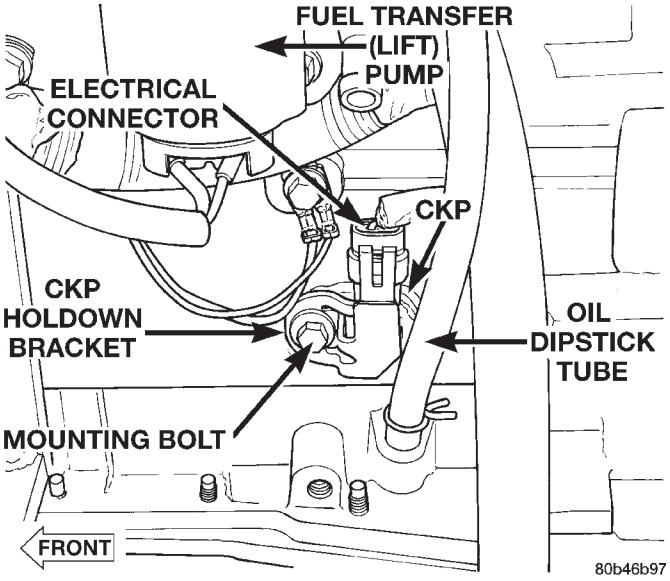


Fig. 26 Crankshaft Position Sensor (CKP) Location

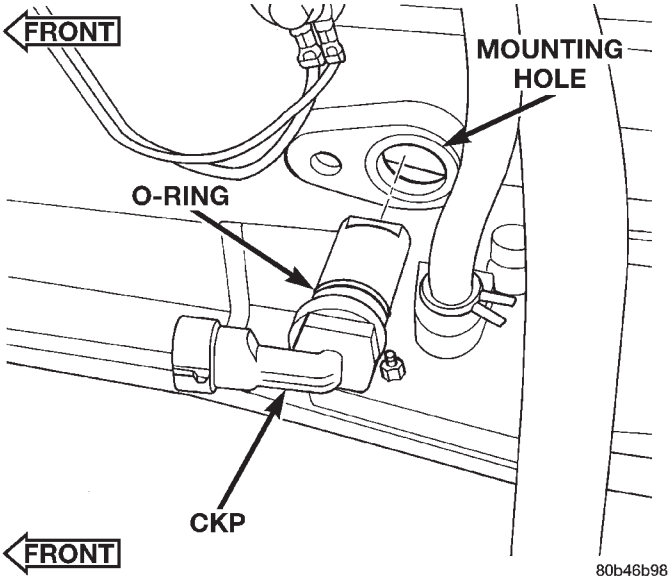


Fig. 27 CKP Removal/Installation

REMOVAL AND INSTALLATION (Continued)

(1) Disconnect both negative battery cables at both batteries.
(2) Remove starter motor. Refer to Group 8B, Starter.
(3) Disconnect electrical connector at CKP (Fig. 26).
(4) Remove CKP mounting bolt and hold down bracket (Fig. 26).
(5) Pull CKP from engine block with a slight twisting action.
(6) Discard old CKP o-ring (Fig. 27).

INSTALLATION

(1) Install new o-ring to CKP. Apply clean engine oil to o-ring.
(2) Clean area around CKP mounting hole.
(3) To prevent tearing o-ring, install CKP into engine block using a twisting action.
(4) Position hold down bracket and install mounting bolt.
(5) Tighten bolt to 24 N·m (18 ft. lbs.) torque.
(6) Install starter motor. Refer to Group 8B, Starter.
(7) Connect both negative battery cables at both batteries.

ENGINE CONTROL MODULE (ECM)

The ECM is bolted to the engine block behind the fuel filter (Fig. 28).

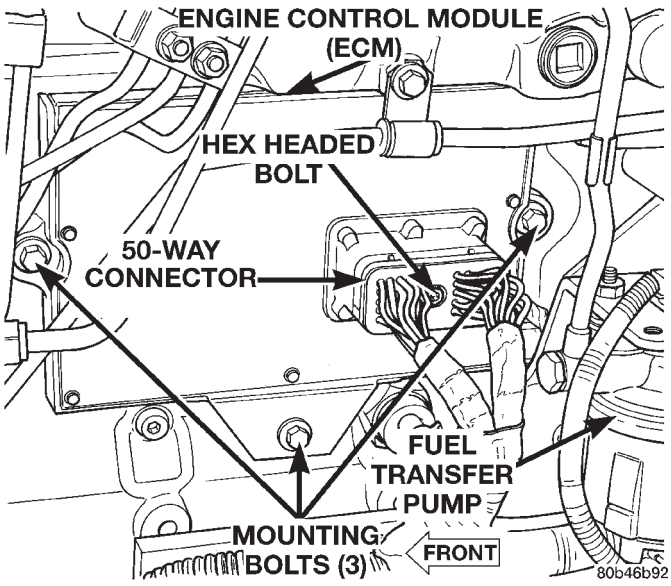


Fig. 28 Engine Control Module (ECM) Location and Mounting

REMOVAL

(1) Record any Diagnostic Trouble Codes (DTC's) found in the PCM or ECM.

To avoid possible voltage spike damage to either the Powertrain Control Module (PCM) or ECM, ignition key must be off, and negative battery cables must be disconnected before unplugging ECM connectors.

(2) Disconnect both negative battery cables at both batteries.
(3) Remove 50–way electrical connector bolt at ECM (Fig. 28). Note: Connector bolt is female 4mm hex head. To remove bolt, use a ball-hex bit or ball-hex screwdriver such as Snap-On ® 4mm SDABM4. As bolt is being removed, very carefully remove connector from ECM.
(4) Remove three ECM mounting bolts and remove ECM from vehicle.

INSTALLATION

Do not apply paint to back of ECM. Poor ground will result.

(1) Clean ECM mounting points at engine block.
(2) Position ECM to engine block and install 3 mounting bolts. Tighten bolts to 24 N·m (18 ft. lbs.).
(3) Check pin connectors in ECM and 50–way connector for corrosion or damage. Repair as necessary.
(4) Clean pins in 50–way electrical connector with a quick-dry electrical contact cleaner.
(5) Very carefully install 50–way connector to ECM. Tighten connector hex bolt.
(6) Install battery cables.
(7) **Turn key to ON position. Without starting engine, slowly press throttle pedal to floor and then slowly release. This step must be done (one time) to ensure accelerator pedal position sensor calibration has been learned by ECM. If not done, possible DTC's may be set.**
(8) Use DRB scan tool to erase any stored companion DTC's from PCM.

ENGINE COOLANT TEMPERATURE (ECT) SENSOR

The Engine Coolant Temperature (ECT) sensor is located at the front of the cylinder head near the thermostat (Fig. 29).

REMOVAL

WARNING: THE COOLING SYSTEM MAY BE UNDER PRESSURE. HOT COOLANT CAN CAUSE BURNS. OBSERVE THE WARNINGS IN GROUP 7, COOLING SYSTEM BEFORE PROCEEDING.

(1) Partially drain cooling system until coolant level is below cylinder head.
(2) Disconnect ECT sensor electrical connector from sensor (Fig. 29).
(3) Remove ECT sensor from cylinder head (Fig. 30).
(4) Discard sensor o-ring (Fig. 30).

REMOVAL AND INSTALLATION (Continued)

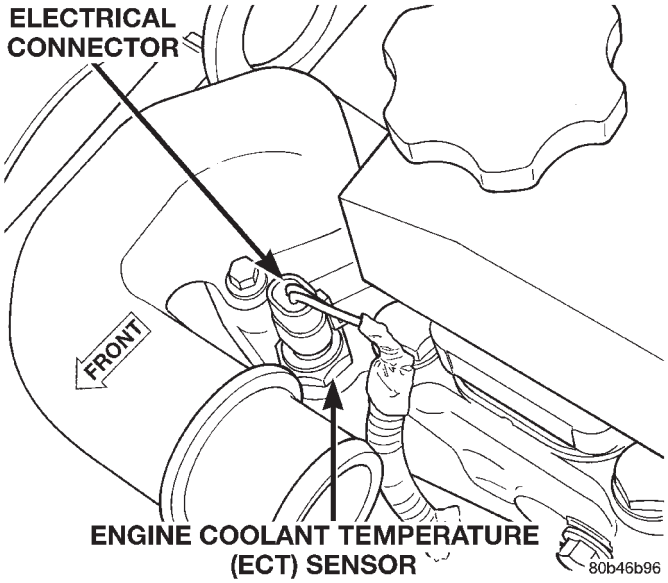


Fig. 29 ECT Sensor Location

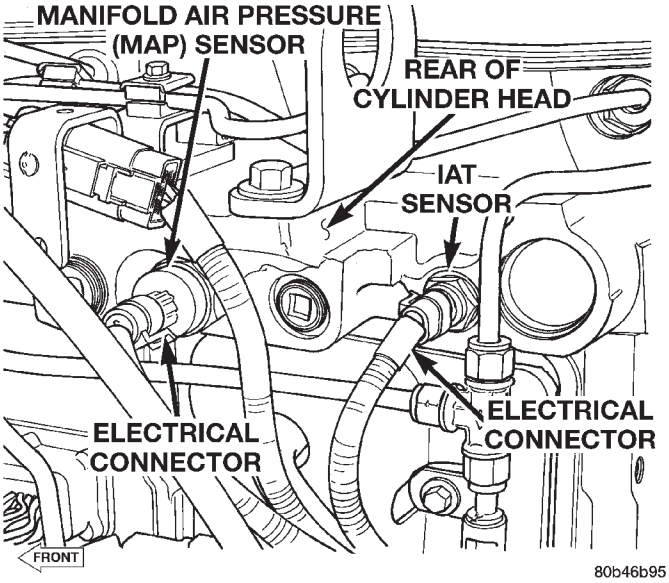


Fig. 31 IAT Sensor Location

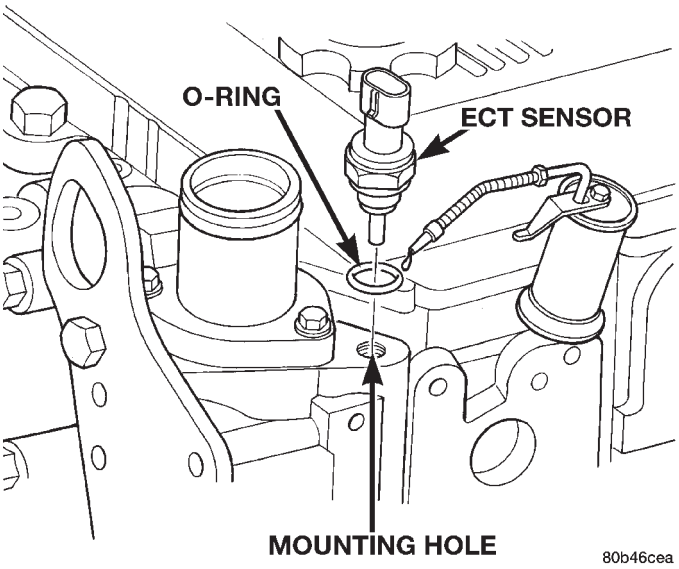


Fig. 30 ECT Sensor Removal/Installation

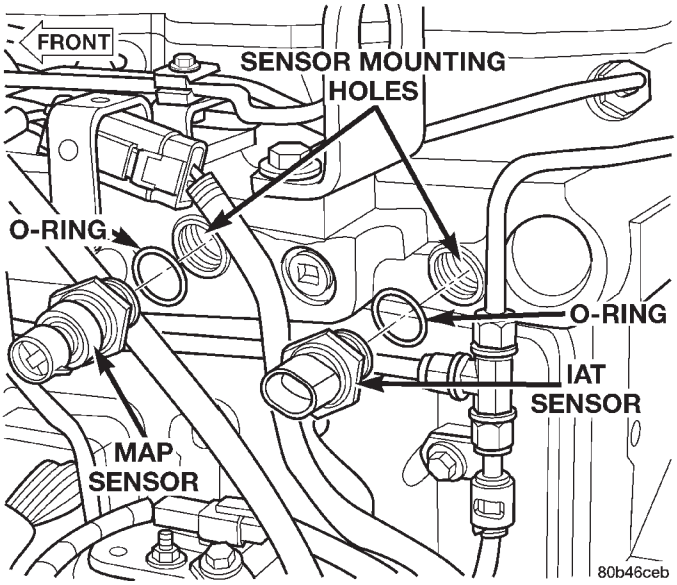


Fig. 32 IAT Sensor Removal/Installation

INSTALLATION

(1) Clean sensor mounting hole (Fig. 30) of rust or contaminants.

(2) Install new o-ring to sensor. Apply clean engine oil to sensor o-ring and sensor threads.

(3) Install ECT sensor into cylinder head. Tighten to 14 N·m (10 ft. lbs.) torque.

(4) Connect sensor electrical connector.

(5) Fill cooling system and check for coolant leaks. Refer to Group 7, Cooling System for procedures.

INTAKE MANIFOLD AIR TEMPERATURE (IAT) SENSOR

The IAT sensor is located in the left/rear side of the intake manifold (Fig. 31).

REMOVAL

(1) Disconnect electrical connector from IAT sensor (Fig. 31).

(2) Remove IAT sensor from intake manifold (Fig. 32).

(3) Discard sensor o-ring (Fig. 32).

INSTALLATION

(1) Clean sensor mounting hole (Fig. 32) of rust or contaminants.

(2) Install new o-ring to sensor. Apply clean engine oil to sensor o-ring and sensor threads.

(3) Install IAT sensor into intake manifold. Tighten to 14 N·m (10 ft. lbs.) torque.

(4) Connect sensor electrical connector.

REMOVAL AND INSTALLATION (Continued)

INTAKE MANIFOLD AIR HEATERS

The 2 intake manifold air heater elements are attached to a metal block located at the top of the intake manifold (Fig. 33). If servicing either of the heater elements, the entire block/element assembly must be replaced.

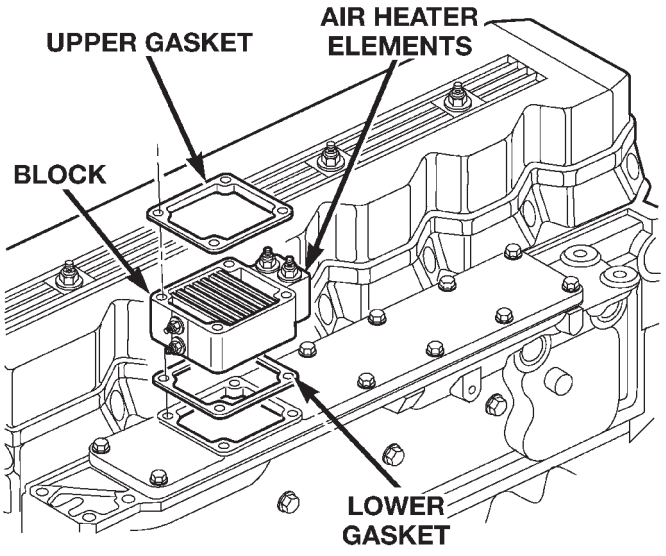


Fig. 33 Intake Manifold Air Heater Element Location

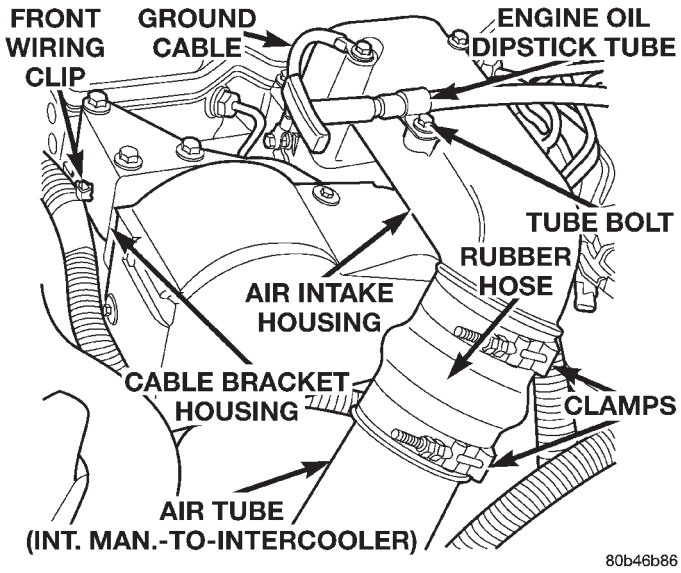


Fig. 34 Air Tube (Intercooler-to-Air Intake Housing)

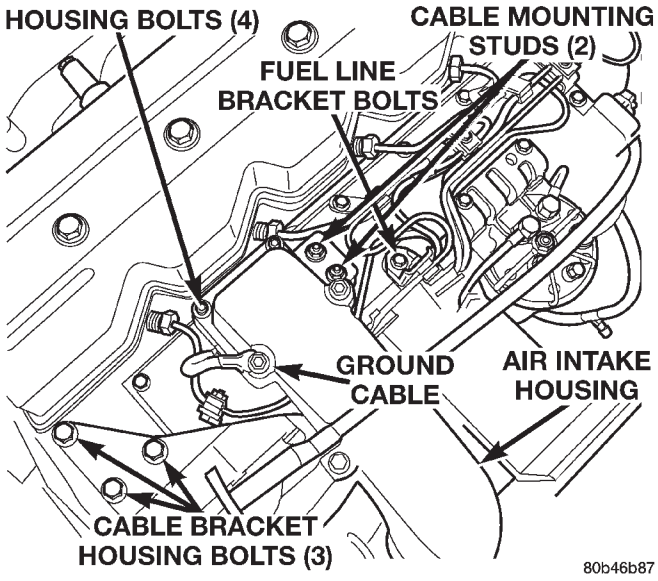


Fig. 35 Air Intake Housing

REMOVAL

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect clamp from rubber hose at air intake housing (Fig. 34).

(3) Disconnect rubber hose at air intake housing (Fig. 34).

(4) Remove engine oil dipstick tube mounting bolt (Fig. 34). Position dipstick tube to the side.

(5) Disconnect heater electrical cables at cable mounting studs (Fig. 35).

(6) Remove 4 housing bolts (Fig. 35).

(7) Remove air intake housing from top of heater elements.

(8) Remove heater element assembly from intake manifold.

(9) Clean old gasket material from air intake housing and intake manifold.

(10) Clean old gasket material from both ends of heater block (Fig. 33).

INSTALLATION

(1) Using 2 new gaskets, position element assembly and air housing to intake manifold.

(2) Position ground cable (Fig. 35) to air housing.

(3) Install 4 housing bolts and tighten to 24 N·m (18 ft. lbs.) torque.

(4) Connect heater cables at cable mounting studs (Fig. 35).

(5) Install engine oil dipstick tube and mounting bolt.

(6) Connect rubber hose to air intake housing.

(7) Connect clamp to rubber hose at air intake housing.

(8) Connect both negative battery cables at both batteries.

REMOVAL AND INSTALLATION (Continued)

INTAKE MANIFOLD AIR HEATER RELAYS

The relays are located in engine compartment, bolted to left inner fender below left battery (Fig. 36).

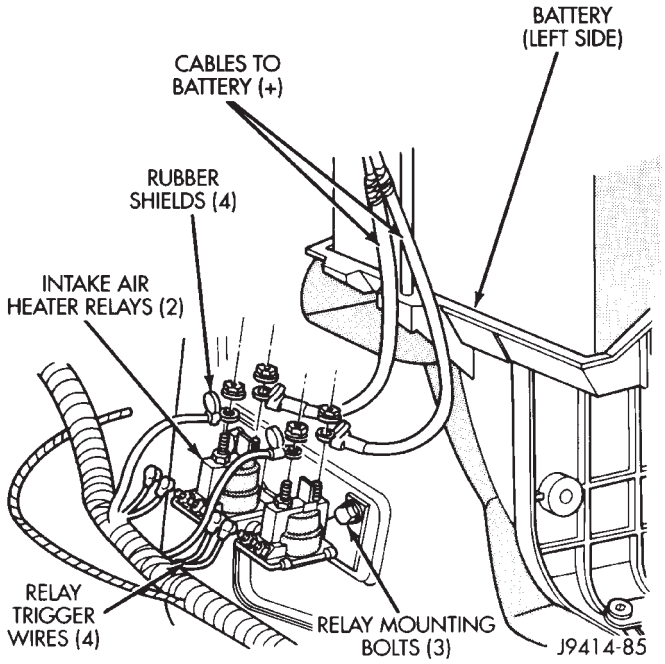


Fig. 36 Intake Manifold Air Heater Relays

REMOVAL

The mounting bracket and both relays are replaced as an assembly.

(1) Disconnect both negative battery cables at both batteries.

(2) Disconnect four relay trigger wires at both relays (Fig. 36). Note position of wiring before removing.

(3) Lift four rubber shields from all 4 cables (Fig. 36).

(4) Remove four nuts at cable connectors (Fig. 36). Note position of wiring before removing.

(5) Remove three relay mounting bracket bolts (Fig. 36) and remove relay assembly.

INSTALLATION

(1) Install relay assembly to inner fender. Tighten mounting bolts to 4.5 N·m (40 in. lbs.) torque.

(2) Connect eight electrical connectors to relays.

(3) Connect battery cables to both batteries.

MANIFOLD AIR PRESSURE (MAP) SENSOR

The MAP sensor is located in the left/rear side of the intake manifold (Fig. 37).

REMOVAL

(1) Disconnect electrical connector from MAP sensor (Fig. 37).

(2) Remove MAP sensor from intake manifold (Fig. 38).

(3) Discard sensor o-ring (Fig. 38).

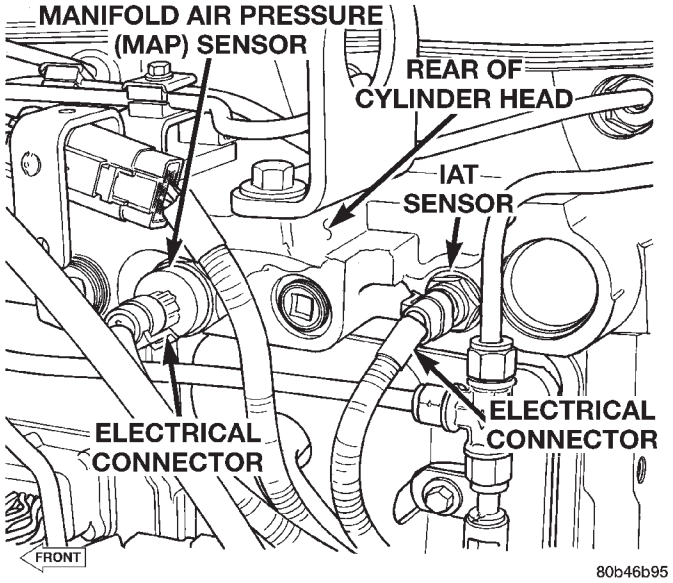


Fig. 37 MAP Sensor Location

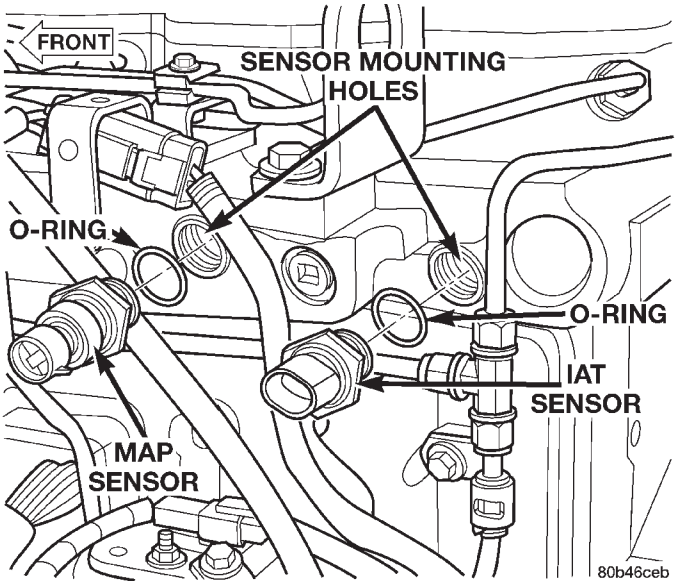


Fig. 38 MAP Sensor Removal/Installation

INSTALLATION

(1) Clean sensor mounting hole (Fig. 38) of rust or contaminants.

(2) Install new o-ring to sensor. Apply clean engine oil to sensor o-ring and sensor threads.

(3) Install MAP sensor into intake manifold. Tighten to 14 N·m (10 ft. lbs.) torque.

(4) Connect sensor electrical connector.

REMOVAL AND INSTALLATION (Continued)

POWERTRAIN CONTROL MODULE (PCM)

The PCM is located in the engine compartment (Fig. 39) to the rear of the air cleaner assembly.

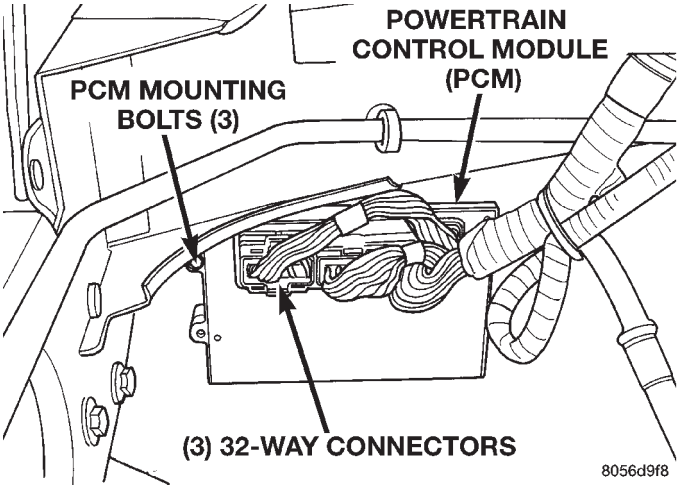


Fig. 39 PCM Location and Mounting

REMOVAL

To avoid possible voltage spike damage to either the PCM or the ECM, ignition key must be off, and both negative battery cables must be disconnected before unplugging PCM connectors.

(1) Disconnect negative battery cables at both batteries.

(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 cables.

(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.

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
Accelerator Pedal Position Sensor Bracket Bolts	12 N·m (105 in. lbs.)
Air Intake Housing Bolts	24 N·m (18 ft. lbs.)
Banjo Fittings at top of Filter/Separator	24 N·m (18 ft. lbs.)
Banjo Fittings at Fuel Return Lines	24 N·m (18 ft. lbs.)
Banjo Fitting At Fuel Supply Line (Injector Pump)	24 N·m (18 ft. lbs.)
Camshaft Position Sensor (CMP) Bolt	20 N·m (15 ft. lbs.)
Crankshaft Position Sensor (CKP) Bolt	24 N·m (18 ft. lbs.)
ECM Mounting Bolts	24 N·m (18 ft. lbs.)
Engine Coolant Temperature (ECT) Sensor	14 N·m (10 ft. lbs.)
Engine Lifting Bracket Bolts	77 N·m (57 ft. lbs.)
Fuel Drain Manifold “T” Fitting	12 N·m (106 in. lbs.)
Fuel Filter Canister Bracket Bolts	24 N·m (18 ft. lbs.)
Fuel Filter Canister Mounting Nut	14 N·m (10 ft. lbs.)
Fuel Filter Drain Valve Mounting Screws	3–5 N·m (30–40 in. lbs.)
Fuel Heater Screws	2–3 N·m (15–20 in. lbs.)
Fuel Injector Clamp Bolts	10 N·m (89 in. 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 Nuts	12 N·m (9 ft. lbs.)
High-Pressure Fuel Line Fittings (at Injectors)	40 N·m (30 ft. lbs.)
High-Pressure Fuel Line Fittings (at Pump)	24 N·m (18 ft. lbs.)
High-Pressure Fuel Line Clamps-to-Intake Manifold	24 N·m (18 ft. lbs.)
Hose Clamps at Intercooler Tube	8 N·m (72 in. lbs.)
Injection Pump-to-Injection Pump Gear Nut	170 N·m (125 ft. lbs.)
Injection Pump Mounting Nuts	43 N·m (32 ft. lbs.)
Intake Manifold Air Temperature (IAT) Sensor	14 N·m (10 ft. lbs.)
Intake Manifold Air Heater Relay Bolts	4.5 N·m (40 in. lbs.)
Manifold Air Pressure (MAP) Sensor	14 N·m (10 ft. lbs.)
PCM Mounting Bolts	4 N·m (35 in. lbs.)
Overflow Valve-to-Fuel Injection Pump	24 N·m (18 ft. lbs.)
Water-In-Fuel (WIF) Sensor	2–3 N·m (15–20 in. lbs.)