

FUEL SYSTEM

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FUEL DELIVERY - GAS

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FUEL DELIVERY - GAS

DESCRIPTION

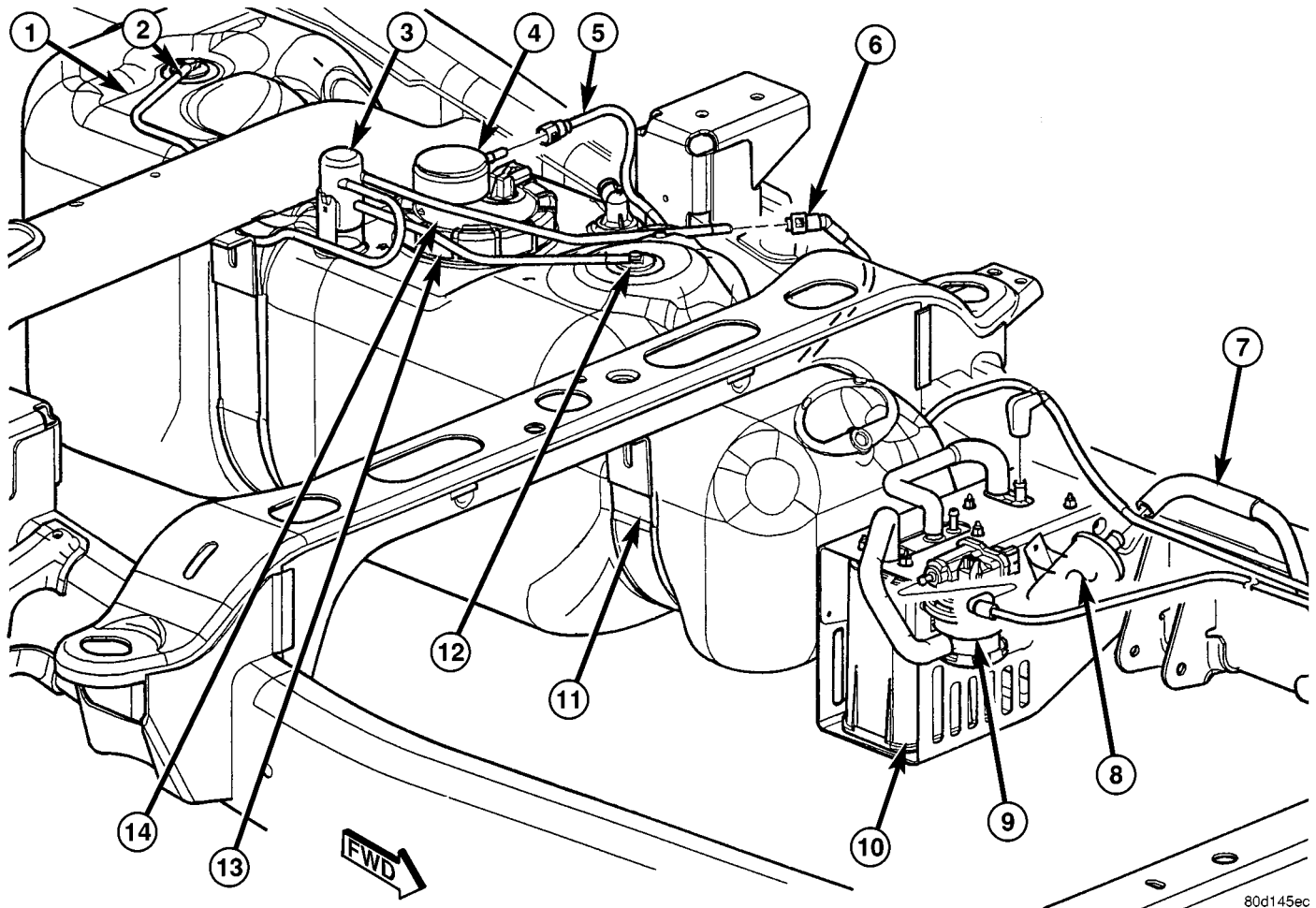
The fuel delivery system consists of:

- a fuel pump module containing the electric fuel pump, fuel filter/fuel pressure regulator, fuel gauge sending unit (fuel level sensor) and a secondary fuel filter located at the bottom of the pump module
- fuel tubes/lines/hoses
- a combination fuel filter/fuel pressure regulator

- quick-connect fittings
- fuel injector rail
- fuel tank
- fuel tank filler/vent tube assembly
- fuel tank filler tube cap
- accelerator pedal
- throttle cable

Certain fuel delivery components can be found in (Fig. 1).

FUEL DELIVERY - GAS (Continued)

**Fig. 1 FUEL DELIVERY COMPONENTS**

- 1 - FUEL TANK
- 2 - CHECK VALVE
- 3 - LIQUID EXPANSION CHAMBER
- 4 - FUEL FILTER / FUEL PRESSURE REGULATOR
- 5 - QUICK-CONNECT FITTING AND FUEL LINE (TO ENGINE)
- 6 - EVAP LINE CONNECTION
- 7 - LEAK DETECTION PUMP FRESH AIR LINE

- 8 - LDP FRESH AIR FILTER
- 9 - LEAK DETECTION PUMP
- 10 - EVAP CANISTERS (2)
- 11 - FUEL TANK STRAPS (2)
- 12 - CHECK VALVE
- 13 - FUEL PUMP MODULE LOCK RING
- 14 - FUEL PUMP MODULE

OPERATION

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

The fuel tank assembly consists of: the fuel tank, fuel pump module assembly, fuel pump module lock-nut/gasket, and fuel tank check valve (refer to Fuel Tank Check Valve for information).

A fuel filler/vent tube assembly using a pressure/vacuum, 1/4 turn fuel filler cap is used. The fuel filler tube contains a flap door located below the fuel fill cap.

Also to be considered part of the fuel system is the evaporation control system. This is designed to reduce the emission of fuel vapors into the atmo-

sphere. The description and function of the Evaporative Control System is found in Emission Control Systems.

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

STANDARD PROCEDURE - FUEL SYSTEM PRESSURE RELEASE

Use following procedure if the fuel injector rail is, or is not equipped with a fuel pressure test port.

- (1) Remove fuel fill cap.

FUEL DELIVERY - GAS (Continued)

(2) Remove fuel pump relay from Power Distribution Center (PDC). For location of relay, refer to label on underside of PDC cover.

(3) Start and run engine until it stalls.

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

(5) Turn ignition key to OFF position.

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

(6) Unplug connector from any fuel injector.

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

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

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

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

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

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

(12) Disconnect quick-connect fitting at fuel rail. Refer to Quick-Connect Fittings.

(13) Return fuel pump relay to PDC.

(14) One or more Diagnostic Trouble Codes (DTC's) may have been stored in PCM memory due to fuel pump relay removal. The DRB® scan tool must be used to erase a DTC.

SPECIFICATIONS**FUEL SYSTEM PRESSURE**

339 kPa +/- 34 kPa (49.2 psi +/- 2 psi).

TORQUE - FUEL SYSTEM

DESCRIPTION	N-m	Ft. Lbs.	In. Lbs.
Accelerator Pedal Bracket Mounting	12	-	105
Accelerator Pedal Position Sensor Bracket-to-Battery Tray Bolts	3	-	30
Crankshaft Position Sensor - 3.7L	28	21	-
Crankshaft Position Sensor - 4.7L	28	21	-
Crankshaft Position Sensor - 5.7L	12	-	105 (+/-20)
Crankshaft Position Sensor - 5.9L	8	-	70
Crankshaft Position Sensor - 8.0L	8	-	70
Camshaft Position Sensor - 3.7L	12	-	106
Camshaft Position Sensor - 4.7L	12	-	106
Camshaft Position Sensor - 5.7L	12	9	105 (+/-) 20
Camshaft Position Sensor - 8.0L	6	-	50

14 - 4 FUEL DELIVERY - GAS

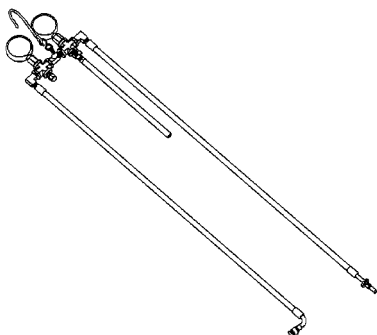
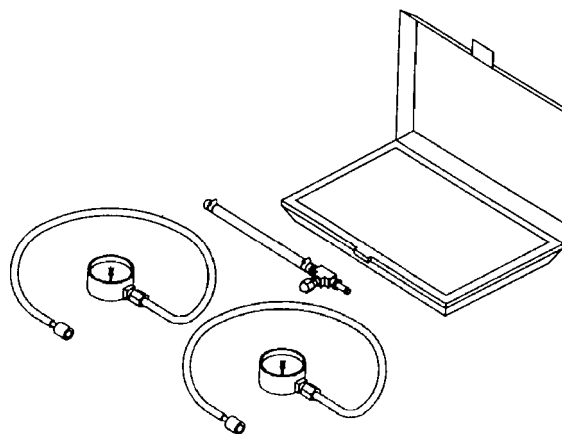
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FUEL DELIVERY - GAS (Continued)

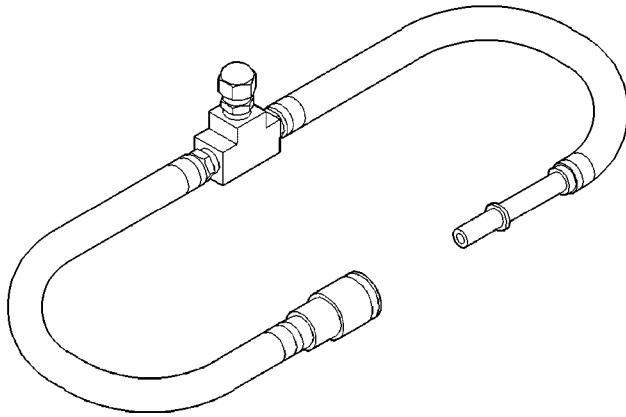
DESCRIPTION	N-m	Ft. Lbs.	In. Lbs.
Engine Coolant Temperature Sensor - 3.7L	11	-	96
Engine Coolant Temperature Sensor - 4.7L	11	-	96
Engine Coolant Temperature Sensor - 5.7L	11	-	96
Engine Coolant Temperature Sensor - 5.9L	11	-	96
Engine Coolant Temperature Sensor - 8.0L	11	-	96
EVAP Canister- to-Bracket Nuts	8.5	-	75
EVAP Canister-to-frame bolts	34	25	
Fuel Filler Hose Clamp at Tank	3	-	30
Fuel Filler Housing-to-Body Screws	2	-	17
Fuel Pump Module Lock Ring	54	40	-
Fuel Rail Mounting Bolts - 3.7L	11	-	100
Fuel Rail Mounting Bolts - 4.7L	11	-	100
Fuel Rail Mounting Bolts - 5.7L	11	-	100
Fuel Rail Mounting Bolts - 5.9L	23	-	200
Fuel Rail Mounting Bolts - 8.0L	15	-	136
Fuel Tank Mounting Straps	41	30	-
IAC Motor Mounting Screws - 3.7L	7	-	60
IAC Motor Mounting Screws - 4.7L	7	-	60
IAC Motor Mounting Screws - 5.9L	7	-	60
IAC Motor Mounting Screws - 8.0L	7	-	60
Leak Detection Pump Mounting Bolt	8.5	-	75
Map Sensor Mounting Screws - 3.7L	3	-	25

FUEL DELIVERY - GAS (Continued)

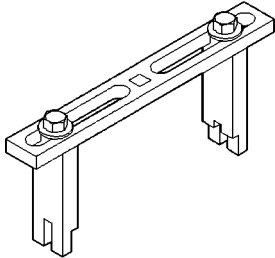
DESCRIPTION	N-m	Ft. Lbs.	In. Lbs.
Map Sensor Mounting Screws - 4.7L	3	-	25
Map Sensor Mounting Screws - 5.9L	3	-	25
Map Sensor Mounting Screws - 8.0L	2	-	20
PCM-to-Mounting Bracket Mounting Screws	4	-	35
Power Steering Pressure Switch - 3.7L	14-22	-	124-195
Power Steering Pressure Switch - 4.7L	14-22	-	124-195
TPS Mounting Screws - 3.7L	7	-	60
TPS Mounting Screws - 4.7L	7	-	60
TPS Mounting Screws - 5.9L	7	-	60
TPS Mounting Screws - 8.0L	7	-	60
Throttle Body Mounting Bolts - 3.7L	11	-	100
Throttle Body Mounting Bolts - 4.7L	12	-	105
Throttle Body Mounting Bolts - 5.7L	12	-	105
Throttle Body Mounting Bolts - 5.9L	23	-	200
Throttle Body Mounting Bolts - 8.0L	22	-	192
Oxygen Sensors	30	22	-

SPECIAL TOOLS
FUEL SYSTEM

FUEL PRESSURE TESTER - #8978

TEST KIT, FUEL PRESSURE, 8.0L ENGINE - #5069

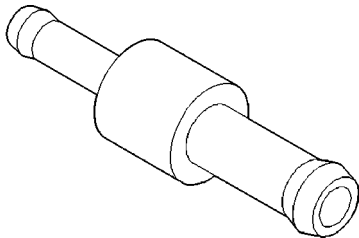
FUEL DELIVERY - GAS (Continued)



**ADAPTERS, FUEL PRESSURE TEST, 8.0L - #6539
AND/OR #6631**



SPANNER WRENCH - #6856



FITTING, AIR METERING - #6714



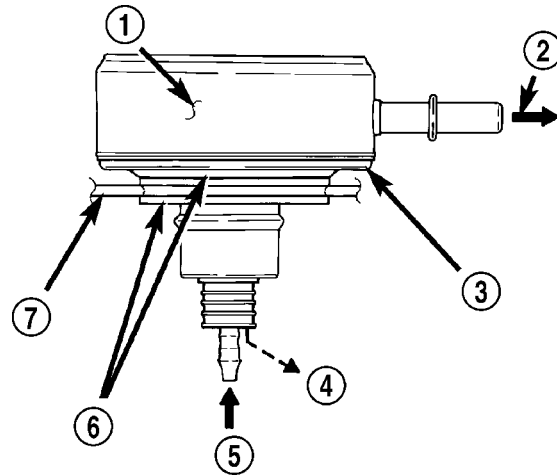
**O2S (OXYGEN SENSOR) REMOVER/INSTALLER -
#C-4907**

FUEL FILTER/PRESSURE REGULATOR

DESCRIPTION

A combination fuel filter and fuel pressure regulator (Fig. 2) is used on all engines. It is located on the top of the fuel pump module. A separate frame mounted fuel filter is not used with any engine.

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



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Fig. 2 SIDE VIEW - FILTER/REGULATOR

- 1 - INTERNAL FUEL FILTER
- 2 - FUEL FLOW TO FUEL INJECTORS
- 3 - FUEL FILTER/FUEL PRESSURE REGULATOR
- 4 - EXCESS FUEL BACK TO TANK
- 5 - FUEL INLET
- 6 - RUBBER GROMMET
- 7 - TOP OF PUMP MODULE

OPERATION

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

The regulator is calibrated to maintain fuel system operating pressure of approximately 339 kPa $\pm$ 34 kPa (49.2 psi $\pm$ 5 psi) at the fuel injectors. It contains a diaphragm, calibrated springs and a fuel return valve. The internal fuel filter (Fig. 2) is also part of the assembly.

Fuel is supplied to the filter/regulator by the electric fuel pump through an opening tube at the bottom of filter/regulator (Fig. 2).

The regulator acts as a check valve to maintain some fuel pressure when the engine is not operating. This will help to start the engine. A second check valve is located at the outlet end of the electric fuel

FUEL FILTER/PRESSURE REGULATOR (Continued)

pump. **Refer to Fuel Pump - Description and Operation for more information.**

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

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

FUEL LEVEL SENDING UNIT / SENSOR

DESCRIPTION

The fuel gauge sending unit (fuel level sensor) is attached to the side of the fuel pump module. The sending unit consists of a float, an arm, and a variable resistor track (card).

OPERATION

The fuel pump module has 4 different circuits (wires). Two of these circuits are used for the fuel gauge sending unit for fuel gauge operation, and for certain OBD II emission requirements. The other 2 wires are used for electric fuel pump operation.

For Fuel Gauge Operation: A constant current source is supplied to the resistor track on the fuel gauge sending unit. This is fed directly from the Powertrain Control Module (PCM). **NOTE: For diagnostic purposes, this 12V power source can only be verified with the circuit opened (fuel pump module electrical connector unplugged). With the connectors plugged, output voltages will vary from about 0.6 volts at FULL, to about 8.6 volts at EMPTY (about 8.6 volts at EMPTY for Jeep models, and about 7.0 volts at EMPTY for Dodge Truck models).** The resistor track is used to vary the voltage (resistance) depending on fuel tank float level. As fuel level increases, the float and arm move up, which decreases voltage. As fuel level decreases, the float and arm move down, which increases voltage. The varied voltage signal is returned back to the PCM through the sensor return circuit.

Both of the electrical circuits between the fuel gauge sending unit and the PCM are hard-wired (not multi-plexed). After the voltage signal is sent from the resistor track, and back to the PCM, the PCM will interpret the resistance (voltage) data and send a message across the multi-plex bus circuits to the instrument panel cluster. Here it is translated into the appropriate fuel gauge level reading. Refer to Instrument Panel for additional information.

For OBD II Emission Monitor Requirements:

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

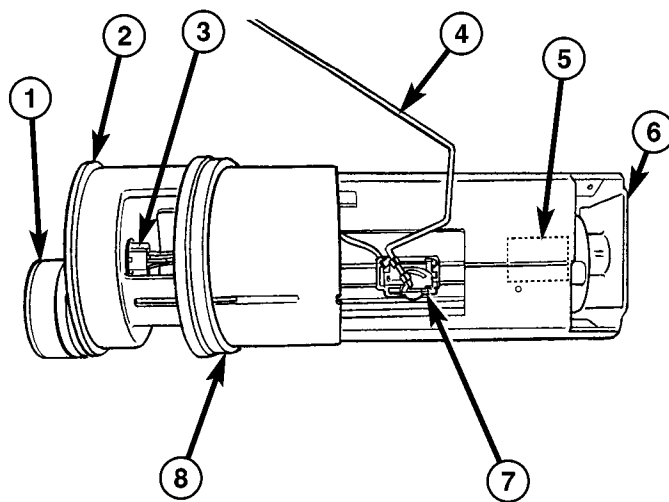
REMOVAL

The fuel level sending unit (fuel level sensor) and float assembly is located on the side of the fuel pump module (Fig. 3).

(1) Remove fuel pump module from fuel tank. Refer to Fuel Pump Module Removal/Installation.

(2) To remove sending unit from pump module, lift on plastic locking tab (Fig. 4) while sliding sending unit tracks.

(3) Disconnect 4-wire electrical connector (Fig. 3) from fuel pump module. Separate necessary sending unit wiring from connector using terminal pick / removal tool. Refer to Special Tools in 8W Wiring for tool part numbers.



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Fig. 3 LOCATION - FUEL GAUGE SENDING UNIT

- 1 - FUEL FILTER / FUEL PRESSURE REGULATOR
- 2 - FUEL PUMP MODULE ASSEMBLY
- 3 - 4-WAY ELEC. CONNECT.
- 4 - FLOAT ARM
- 5 - ELEC. FUEL PUMP
- 6 - INLET FILTER
- 7 - FUEL GAUGE SENDING UNIT
- 8 - GASKET (SEAL)

FUEL LEVEL SENDING UNIT / SENSOR (Continued)

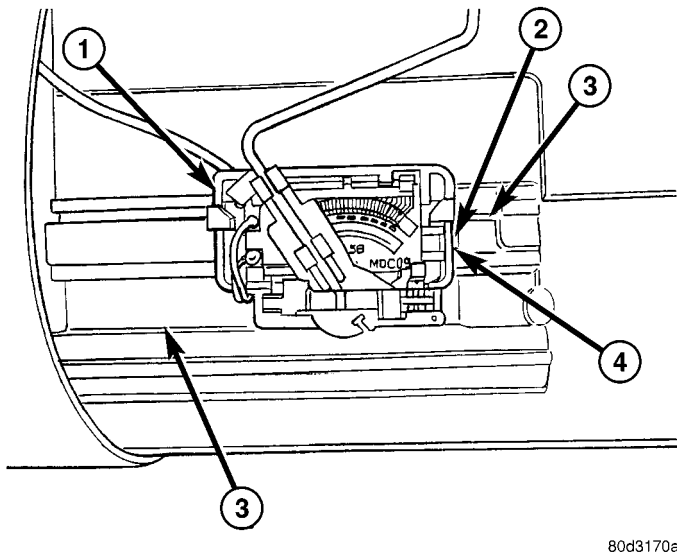


Fig. 4 FUEL GAUGE SENDING UNIT - R/I

- 1 - SENDING UNIT
- 2 - LOCK TAB
- 3 - TRACKS
- 4 - NOTCH

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INSTALLATION

- (1) Connect necessary wiring into electrical connectors. Connect 4-wire electrical connector to pump module.
- (2) Position sending unit to pump module. Slide and snap into place.
- (3) Install fuel pump module. Refer to Fuel Pump Module Removal/Installation.

FUEL LINES

DESCRIPTION

Also refer to Quick-Connect Fittings.

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

The lines/tubes/hoses used on fuel injected vehicles are of a special construction. This is due to the higher fuel pressures and the possibility of contaminated fuel in this system. If it is necessary to replace these lines/tubes/hoses, only those marked EFM/EFI may be used.

If equipped: The hose clamps used to secure rubber hoses on fuel injected vehicles are of a special rolled edge construction. This construction is used to

prevent the edge of the clamp from cutting into the hose. Only these rolled edge type clamps may be used in this system. All other types of clamps may cut into the hoses and cause high-pressure fuel leaks.

Use new original equipment type hose clamps.

QUICK CONNECT FITTING

DESCRIPTION

Different types of quick-connect fittings are used to attach various fuel system components, lines and tubes. These are: a single-tab type, a two-tab type or a plastic retainer ring type. Some are equipped with safety latch clips. Some may require the use of a special tool for disconnection and removal. Refer to Quick-Connect Fittings Removal/Installation for more information.

CAUTION: The interior components (o-rings, clips) of quick-connect fittings are not serviced separately, but new plastic spacers are available for some types. If service parts are not available, do not attempt to repair the damaged fitting or fuel line (tube). If repair is necessary, replace the complete fuel line (tube) assembly.

STANDARD PROCEDURE - QUICK-CONNECT FITTINGS

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

Different types of quick-connect fittings are used to attach various fuel system components, lines and tubes. These are: a single-tab type, a two-tab type or a plastic retainer ring type. Safety latch clips are used on certain components/lines. Certain fittings may require use of a special tool for disconnection.

DISCONNECTING

WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH ENGINE OFF). BEFORE SERVICING ANY FUEL SYSTEM HOSE, FITTING OR LINE, FUEL SYSTEM PRESSURE MUST BE RELEASED. REFER TO FUEL SYSTEM PRESSURE RELEASE PROCEDURE.

CAUTION: The interior components (o-rings, spacers) of some types of quick-connect fitting are not serviced separately. If service parts are not available, do not attempt to repair a damaged fitting or fuel line. If repair is necessary, replace complete fuel line assembly.

- (1) Perform fuel pressure release procedure. Refer to Fuel Pressure Release Procedure.

QUICK CONNECT FITTING (Continued)

(2) Disconnect negative battery cable from battery.

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

(4) **2-Button Type Fitting:** This type of fitting is equipped with a push-button located on each side of quick-connect fitting (Fig. 5). Press on both buttons simultaneously for removal. Special tools are not required for disconnection.

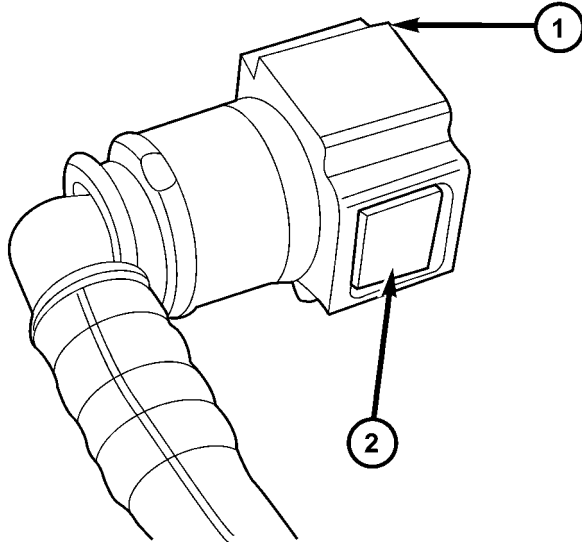


Fig. 5 2-BUTTON TYPE FITTING

1 - QUICK-CONNECT FITTING
2 - PUSH-BUTTONS (2)

(5) **Pinch-Type Fitting:** This fitting is equipped with two finger tabs. Pinch both tabs together while removing fitting (Fig. 6). Special tools are not required for disconnection.

(6) **Single-Tab Type Fitting:** This type of fitting is equipped with a single pull tab (Fig. 7). The tab is removable. After tab is removed, quick-connect fitting can be separated from fuel system component. Special tools are not required for disconnection.

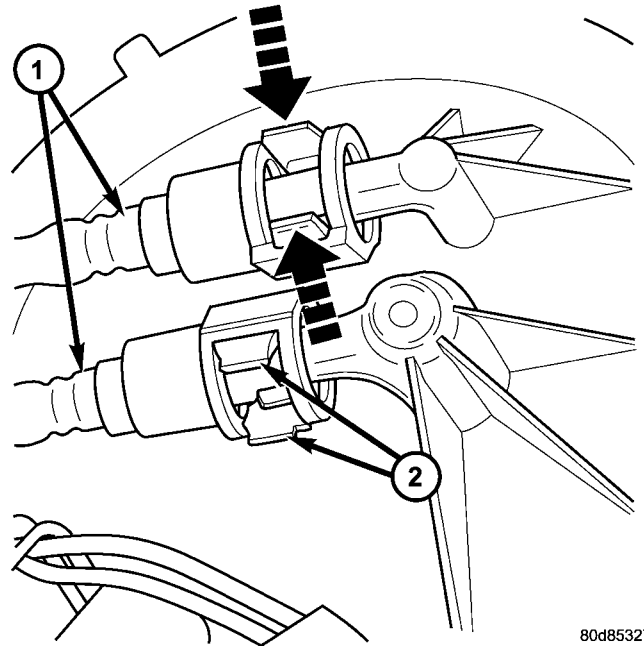
(a) Press release tab on side of fitting to release pull tab (Fig. 8). **If release tab is not pressed prior to releasing pull tab, pull tab will be damaged.**

(b) While pressing release tab on side of fitting, use screwdriver to pry up pull tab (Fig. 8).

(c) Raise pull tab until it separates from quick-connect fitting (Fig. 9).

(7) **Two-Tab Type Fitting:** This type of fitting is equipped with tabs located on both sides of fitting (Fig. 10). The tabs are supplied for disconnecting quick-connect fitting from component being serviced.

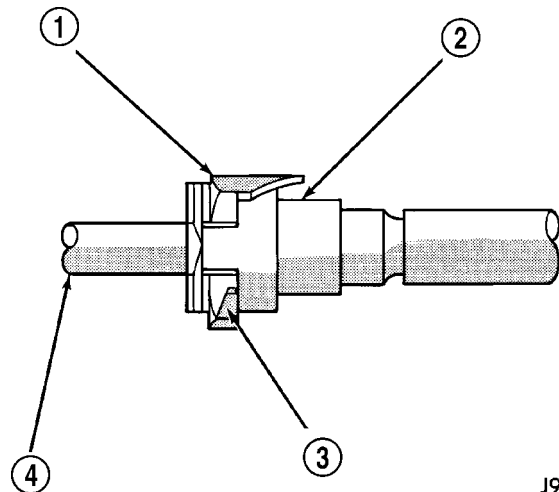
(a) To disconnect quick-connect fitting, squeeze plastic retainer tabs (Fig. 10) against sides of quick-connect fitting with your fingers. Tool use is



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Fig. 6 PINCH TYPE QUICK-CONNECT FITTING

1 - QUICK-CONNECT FITTINGS
2 - PINCH TABS



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Fig. 7 SINGLE-TAB TYPE FITTING

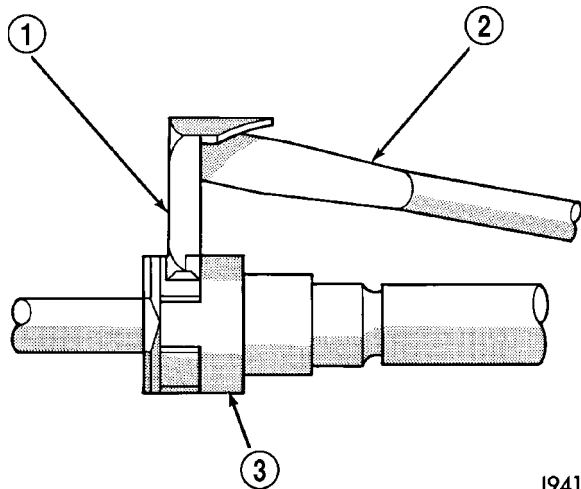
1 - PULL TAB
2 - QUICK-CONNECT FITTING
3 - PRESS HERE TO REMOVE PULL TAB
4 - INSERTED TUBE END

not required for removal and may damage plastic retainer.

(b) Pull fitting from fuel system component being serviced.

(c) The plastic retainer will remain on component being serviced after fitting is disconnected. The o-rings and spacer will remain in quick-connect fitting connector body.

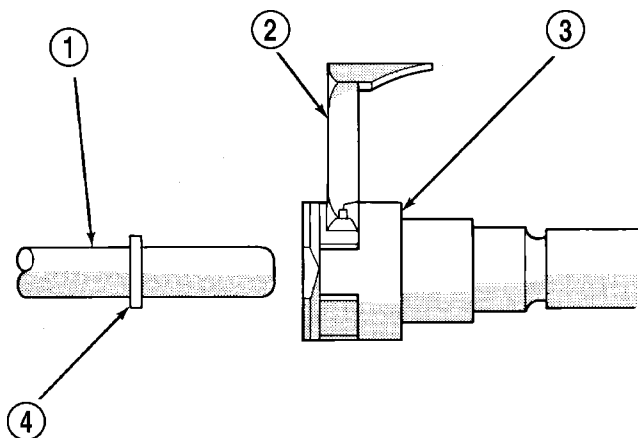
QUICK CONNECT FITTING (Continued)



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Fig. 8 DISCONNECTING SINGLE-TAB TYPE FITTING

- 1 - PULL TAB
- 2 - SCREWDRIVER
- 3 - QUICK-CONNECT FITTING



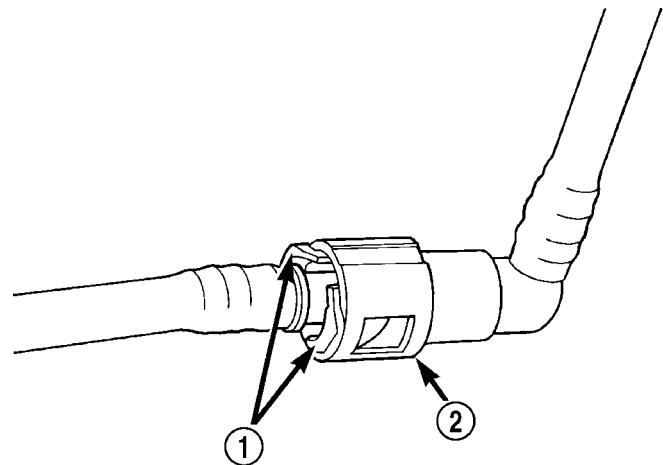
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Fig. 9 REMOVING PULL TAB

- 1 - FUEL TUBE OR FUEL SYSTEM COMPONENT
- 2 - PULL TAB
- 3 - QUICK-CONNECT FITTING
- 4 - FUEL TUBE STOP

(8) **Plastic Retainer Ring Type Fitting:** This type of fitting can be identified by the use of a full-round plastic retainer ring (Fig. 11) usually black in color.

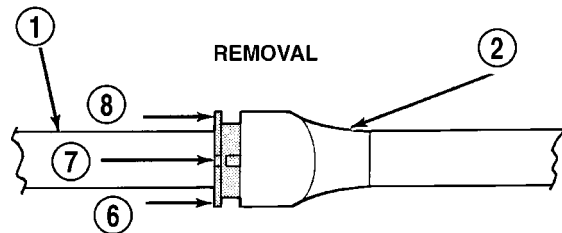
(a) To release fuel system component from quick-connect fitting, firmly push fitting towards component being serviced while firmly pushing plastic retainer ring into fitting (Fig. 11). With plastic ring depressed, pull fitting from component. **The plastic retainer ring must be pressed squarely into fitting body. If this retainer is cocked during removal, it may be difficult to disconnect fitting. Use an open-end wrench on shoulder of plastic retainer ring to aid in disconnection.**



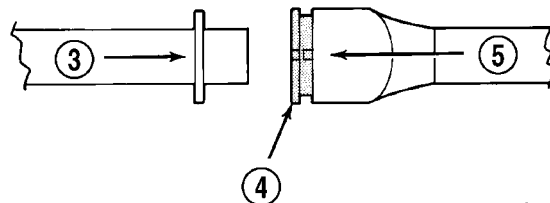
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Fig. 10 TYPICAL 2-TAB TYPE FITTING

- 1 - TAB(S)
- 2 - QUICK-CONNECT FITTING



INSTALLATION



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Fig. 11 PLASTIC RETAINER RING TYPE FITTING

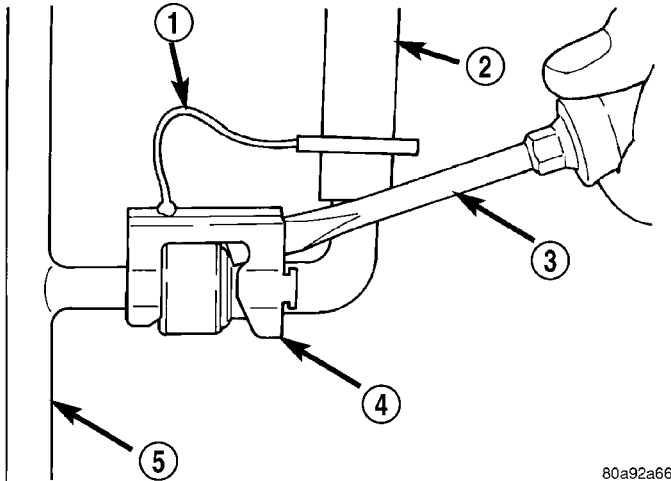
- 1 - FUEL TUBE
- 2 - QUICK CONNECT FITTING
- 3 - PUSH
- 4 - PLASTIC RETAINER
- 5 - PUSH
- 6 - PUSH
- 7 - PUSH
- 8 - PUSH

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

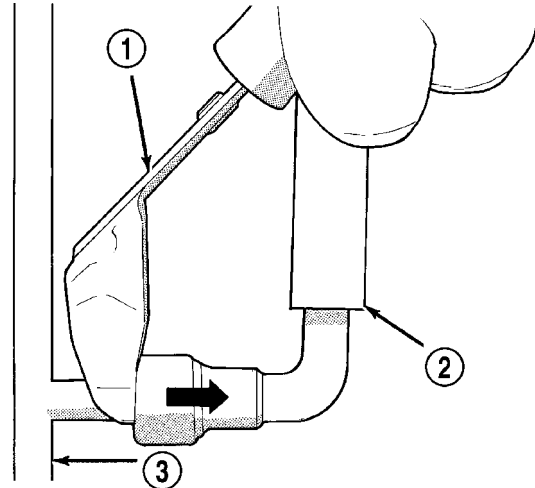
(c) Inspect fitting connector body, plastic retainer ring and fuel system component for damage. Replace as necessary.

(9) **Latch Clips:** Depending on vehicle model and engine, 2 different types of safety latch clips are used

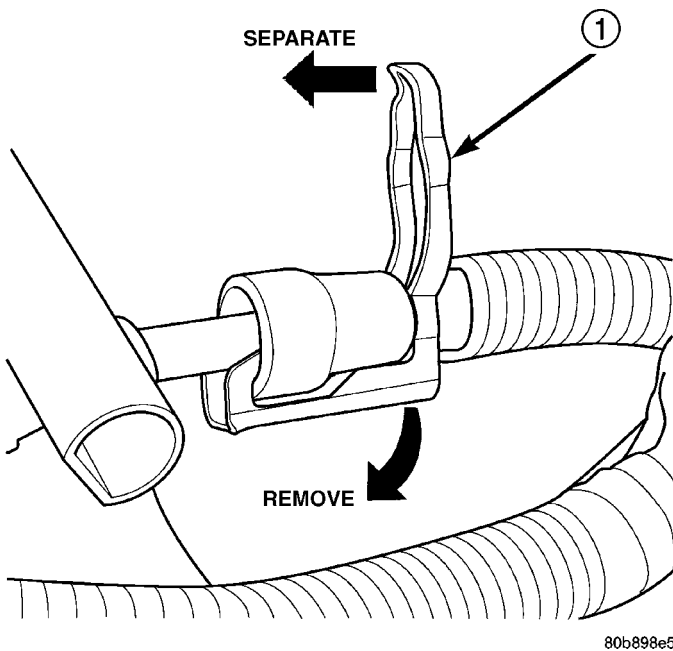
QUICK CONNECT FITTING (Continued)

**Fig. 12 LATCH CLIP-TYPE 1**

- 1 - TETHER STRAP
- 2 - FUEL LINE
- 3 - SCREWDRIVER
- 4 - LATCH CLIP
- 5 - FUEL RAIL

**Fig. 14 FUEL LINE DISCONNECTION USING SPECIAL TOOL**

- 1 - SPECIAL FUEL LINE TOOL
- 2 - FUEL LINE
- 3 - FUEL RAIL

**Fig. 13 LATCH CLIP-TYPE 2**

- 1 - LATCH CLIP

(Fig. 12) or (Fig. 13). Type-1 is tethered to fuel line and type-2 is not. A special tool will be necessary to disconnect fuel line after latch clip is removed. The latch clip may be used on certain fuel line/fuel rail connection, or to join fuel lines together.

(a) Type 1: Pry up on latch clip with a screwdriver (Fig. 12).

(b) Type 2: Separate and unlatch 2 small arms on end of clip (Fig. 13) and swing away from fuel line.

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

(d) Insert special fuel line removal tool (Snap-On number FIH 9055-1 or equivalent) into fuel line (Fig. 14). Use tool to release locking fingers in end of line.

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

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

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

CONNECTING

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

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

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

(4) Continue pushing until a click is felt.

(5) Single-tab type fitting: Push new tab down until it locks into place in quick-connect fitting.

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

(7) Latch Clip Equipped: Install latch clip (snaps into position). **If latch clip will not fit, this indicates fuel line is not properly installed to fuel rail (or other fuel line). Recheck fuel line connection.**

(8) Connect negative cable to battery.

(9) Start engine and check for leaks.

FUEL PUMP

DESCRIPTION

The electric fuel pump is located inside of the fuel pump module. A 12 volt, permanent magnet, electric motor powers the fuel pump. The electric fuel pump is not a separate, serviceable component.

OPERATION

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

Fuel is drawn in through a filter at the bottom of the module and pushed through the electric motor gearset to the pump outlet.

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

The electric fuel pump is not a separate, serviceable component.

FUEL PUMP MODULE

DESCRIPTION

The fuel pump module assembly is located on the top of the fuel tank (Fig. 1). The complete assembly contains the following components:

- A combination fuel filter/fuel pressure regulator
- A separate fuel pick-up, or inlet filter
- An electric fuel pump
- A lockring to retain pump module to tank
- A soft gasket between tank flange and module
- A fuel gauge sending unit (fuel level sensor)
- Fuel line connection

The fuel gauge sending unit may be serviced separately. If the electrical fuel pump, primary inlet filter, fuel filter or fuel pressure regulator require service, the fuel pump module must be replaced.

OPERATION

Refer to Fuel Pump, Inlet Filter, Fuel Filter / Fuel Pressure Regulator and Fuel Gauge Sending Unit.

REMOVAL

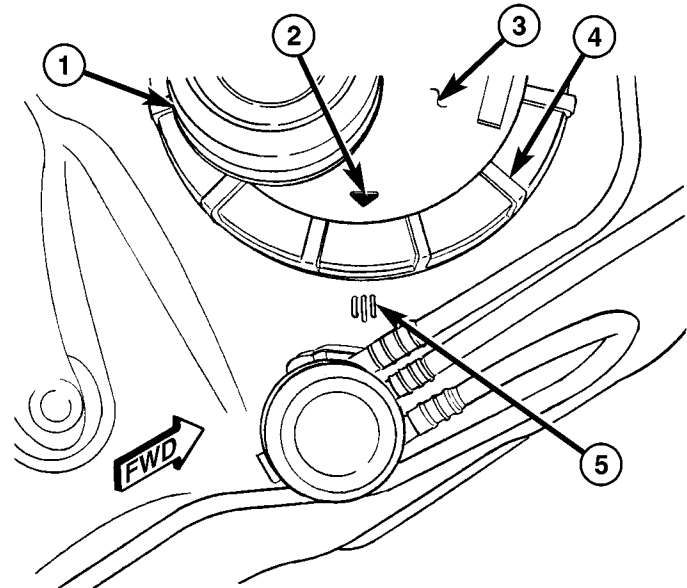
WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH THE ENGINE OFF).

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

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

(2) The plastic fuel pump module locknut (Fig. 15) is threaded onto fuel tank. Install Special Tool 6856 to locknut and remove locknut (Fig. 16). The fuel pump module will spring up slightly when locknut is removed.

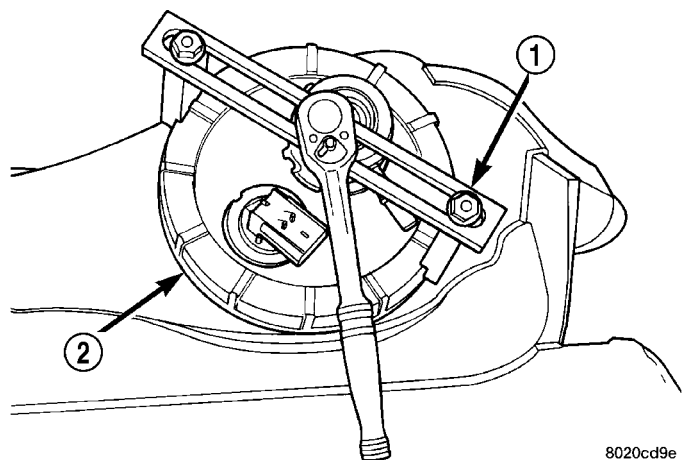
(3) Remove module from fuel tank.



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Fig. 15 FUEL PUMP MODULE (TOP)

- 1 - FUEL FILTER / FUEL PRESSURE REGULATOR
- 2 - ALIGNMENT ARROW
- 3 - TOP OF PUMP MODULE
- 4 - LOCKNUT
- 5 - ALIGNMENT MARKS



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Fig. 16 LOCKNUT REMOVAL/INSTALLATION - TYPICAL

- 1 - SPECIAL TOOL 6856
- 2 - LOCKNUT

FUEL PUMP MODULE (Continued)

INSTALLATION

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

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

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

(3) Rotate module until embossed alignment arrow (Fig. 15) points to center alignment mark. This step must be performed to prevent float from contacting side of fuel tank. Also be sure fitting on fuel filter/fuel pressure regulator is pointed to drivers side of vehicle.

(4) Install Special Tool 6856 (Fig. 16) to locknut.

(5) Tighten locknut. Refer to Torque Specifications.

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

FUEL RAIL

DESCRIPTION

The fuel injector rail is used to mount the fuel injectors to the engine.

OPERATION

High pressure from the fuel pump is routed to the fuel rail. The fuel rail then supplies the necessary fuel to each individual fuel injector.

A quick-connect fitting with a safety latch clip is used to attach the fuel line to the fuel rail.

The fuel rail is not repairable.

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

REMOVAL

3.7L V-6

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

CAUTION: The left and right fuel rails are replaced as an assembly. Do not attempt to separate rail halves at connector tubes (Fig. 18). Due to design of tubes, it does not use any clamps. Never attempt to install a clamping device of any kind to tubes. When removing fuel rail assembly for any reason, be careful not to bend or kink tubes.

(1) Remove fuel tank filler tube cap.

(2) Perform Fuel System Pressure Release Procedure.

(3) Remove negative battery cable at battery.

(4) Remove air duct at throttle body air box.

(5) Remove air box at throttle body.

(6) Remove air resonator mounting bracket at front of throttle body (2 bolts).

(7) Disconnect fuel line latch clip and fuel line at fuel rail. A special tool will be necessary for fuel line disconnection. Refer to Quick-Connect Fittings.

(8) Remove necessary vacuum lines at throttle body.

(9) Disconnect electrical connectors at all 6 fuel injectors. To remove connector refer to (Fig. 17). Push red colored slider away from injector (1). While pushing slider, depress tab (2) and remove connector (3) from injector. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification. If harness is not tagged, note wiring location before removal.

(10) Disconnect electrical connectors at all throttle body sensors.

(11) Remove 6 ignition coils. Refer to Ignition Coil Removal/Installation.

(12) Remove 4 fuel rail mounting bolts (Fig. 18).

(13) Gently rock and pull **left** side of fuel rail until fuel injectors just start to clear machined holes in cylinder head. Gently rock and pull **right** side of rail until injectors just start to clear cylinder head holes. Repeat this procedure (left/right) until all injectors have cleared cylinder head holes.

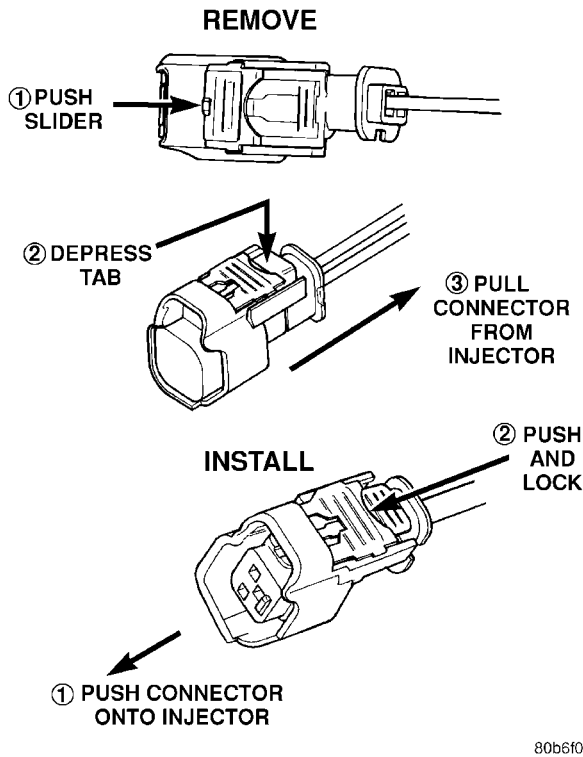
(14) Remove fuel rail (with injectors attached) from engine.

(15) If fuel injectors are to be removed, refer to Fuel Injector Removal/Installation.

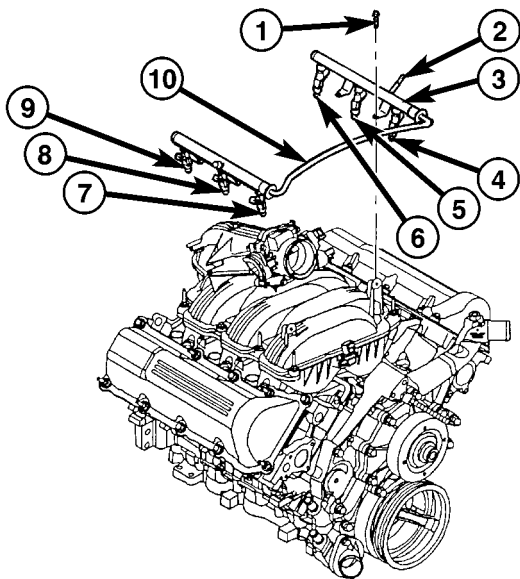
4.7L V-8

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

FUEL RAIL (Continued)



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Fig. 17 REMOVE/INSTALL INJECTOR CONNECTOR

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Fig. 18 FUEL RAIL REMOVE/INSTALL - 3.7L V-6

- 1 - MOUNTING BOLTS (4)
- 2 - QUICK-CONNECT FITTING
- 3 - FUEL RAIL
- 4 - INJ. #1
- 5 - INJ. #3
- 6 - INJ. #5
- 7 - INJ. #2
- 8 - INJ. #4
- 9 - INJ. #6
- 10 - CONNECTOR TUBE

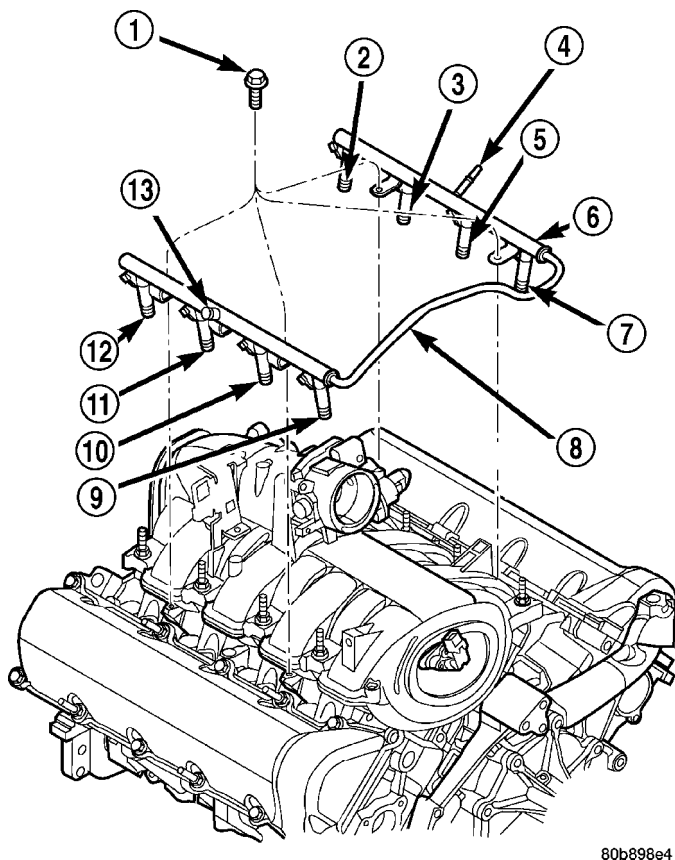
CAUTION: The left and right fuel rails are replaced as an assembly. Do not attempt to separate rail halves at connector tubes (Fig. 19). Due to design of tubes, it does not use any clamps. Never attempt to install a clamping device of any kind to tubes. When removing fuel rail assembly for any reason, be careful not to bend or kink tubes.

- (1) Remove fuel tank filler tube cap.
- (2) Perform Fuel System Pressure Release Procedure.
- (3) Remove negative battery cable at battery.
- (4) Remove air duct at throttle body air box.
- (5) Remove air box at throttle body.
- (6) Remove air resonator mounting bracket at front of throttle body (2 bolts).
- (7) Disconnect fuel line latch clip and fuel line at fuel rail. A special tool will be necessary for fuel line disconnection. Refer to Quick-Connect Fittings.
- (8) Remove necessary vacuum lines at throttle body.
- (9) Disconnect electrical connectors at all 8 fuel injectors. To remove connector refer to (Fig. 17). Push red colored slider away from injector (1). While pushing slider, depress tab (2) and remove connector (3) from injector. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification. If harness is not tagged, note wiring location before removal.
- (10) Disconnect electrical connectors at all throttle body sensors.
- (11) Remove 8 ignition coils. Refer to Ignition Coil Removal/Installation.
- (12) Remove 4 fuel rail mounting bolts (Fig. 19).
- (13) Gently rock and pull **left** side of fuel rail until fuel injectors just start to clear machined holes in cylinder head. Gently rock and pull **right** side of rail until injectors just start to clear cylinder head holes. Repeat this procedure (left/right) until all injectors have cleared cylinder head holes.
- (14) Remove fuel rail (with injectors attached) from engine.
- (15) If fuel injectors are to be removed, refer to Fuel Injector Removal/Installation.

5.7L V-8

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

FUEL RAIL (Continued)



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Fig. 19 FUEL RAIL REMOVE/INSTALL - 4.7L V-8

- 1 - MOUNTING BOLTS (4)
- 2 - INJ.#7
- 3 - INJ.#5
- 4 - QUICK-CONNECT FITTING
- 5 - INJ.#3
- 6 - FUEL INJECTOR RAIL
- 7 - INJ.#1
- 8 - CONNECTOR TUBE
- 9 - INJ.#2
- 10 - INJ.#4
- 11 - INJ.#6
- 12 - INJ.#8
- 13 - PRESSURE TEST PORT CAP

CAUTION: The left and right fuel rails are replaced as an assembly. Do not attempt to separate rail halves at connector tube (Fig. 20). Due to design of tube, it does not use any clamps. Never attempt to install a clamping device of any kind to tube. When removing fuel rail assembly for any reason, be careful not to bend or kink tube.

- (1) Remove fuel tank filler tube cap.
- (2) Perform Fuel System Pressure Release Procedure.
- (3) Remove negative battery cable at battery.
- (4) Remove flex tube (air cleaner housing to engine).
- (5) Remove air resonator box at throttle body.
- (6) Disconnect all spark plug cables from all spark plugs and ignition coils. Do not remove cables from

cable routing tray. Note original cable positions while removing (Fig. 22).

(7) Remove spark plug cable tray from engine by releasing 4 retaining clips (Fig. 21). Remove tray and cables from engine as an assembly.

(8) Disconnect electrical connectors at all 8 ignition coils. Refer to Ignition Coil Removal/Installation.

(9) Disconnect fuel line latch clip and fuel line at fuel rail. A special tool will be necessary for fuel line disconnection. Refer to Quick-Connect Fittings.

(10) Disconnect electrical connectors at all 8 fuel injectors. To remove connector refer to (Fig. 17). Push red colored slider away from injector (1). While pushing slider, depress tab (2) and remove connector (3) from injector. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification. If harness is not tagged, note wiring location before removal.

(11) Disconnect electrical connectors at all throttle body sensors.

(12) Remove 4 fuel rail mounting bolts and hold-down clamps (Fig. 20).

(13) Gently rock and pull **left** side of fuel rail until fuel injectors just start to clear machined holes in intake manifold. Gently rock and pull **right** side of rail until injectors just start to clear intake manifold head holes. Repeat this procedure (left/right) until all injectors have cleared machined holes.

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

(15) If fuel injectors are to be removed, refer to Fuel Injector Removal/Installation.

5.9L V-8

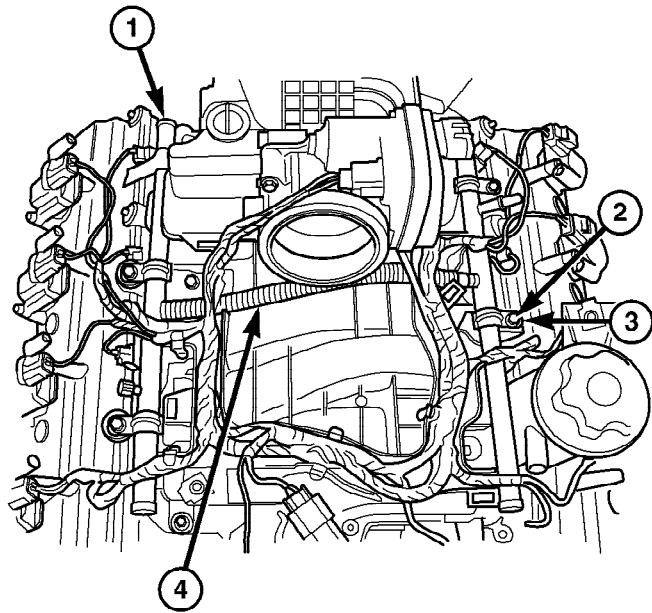
WARNING: THE FUEL SYSTEM IS UNDER A CONSTANT PRESSURE (EVEN WITH ENGINE TURNED OFF). BEFORE SERVICING FUEL RAIL ASSEMBLY, FUEL SYSTEM PRESSURE MUST BE RELEASED.

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

CAUTION: The left and right fuel rails are replaced as an assembly. Do not attempt to separate the rail halves at the connecting hose (Fig. 24). Due to the design of this connecting hose, it does use any clamps. Never attempt to install a clamping device of any kind to the hose. When removing the fuel rail assembly for any reason, be careful not to bend or kink the connecting hose.

- (1) Remove negative battery cable at battery.
- (2) Remove air cleaner.
- (3) Perform fuel pressure release procedure.
- (4) Remove throttle body from intake manifold. Refer to Throttle Body Removal/Installation.

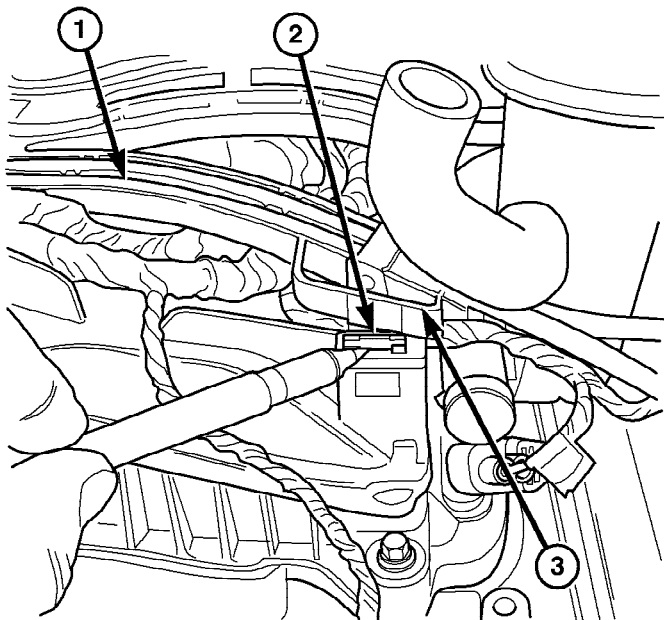
FUEL RAIL (Continued)



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Fig. 20 5.7L FUEL RAIL

- 1 - FUEL RAIL
- 2 - MOUNTING BOLT
- 3 - HOLDOWN CLAMPS
- 4 - CONNECTOR TUBE



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Fig. 21 5.7L SPARK PLUG CABLE ROUTING TRAY

- 1 - SPARK PLUG CABLES
- 2 - RETAINING CLIP
- 3 - SPARK PLUG CABLE ROUTING TRAY

(5) If equipped with air conditioning, remove the A-shaped A/C compressor-to-intake manifold support bracket (three bolts) (Fig. 23).

(6) Disconnect electrical connectors at all fuel injectors. To remove connector refer to (Fig. 17). Push red colored slider away from injector (1). While pushing slider, depress tab (2) and remove connector (3) from injector. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification. If harness is not tagged, note wiring location before removal.

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

(8) Remove the remaining fuel rail mounting bolts.

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

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

8.0L V-10

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

(1) Remove negative battery cable at battery.

(2) Remove air cleaner housing and tube.

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

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

(5) Remove ignition coil pack and bracket assembly (Fig. 25) at intake manifold and right engine valve cover (four bolts).

(6) Remove upper half of intake manifold. Refer to Engines for procedures.

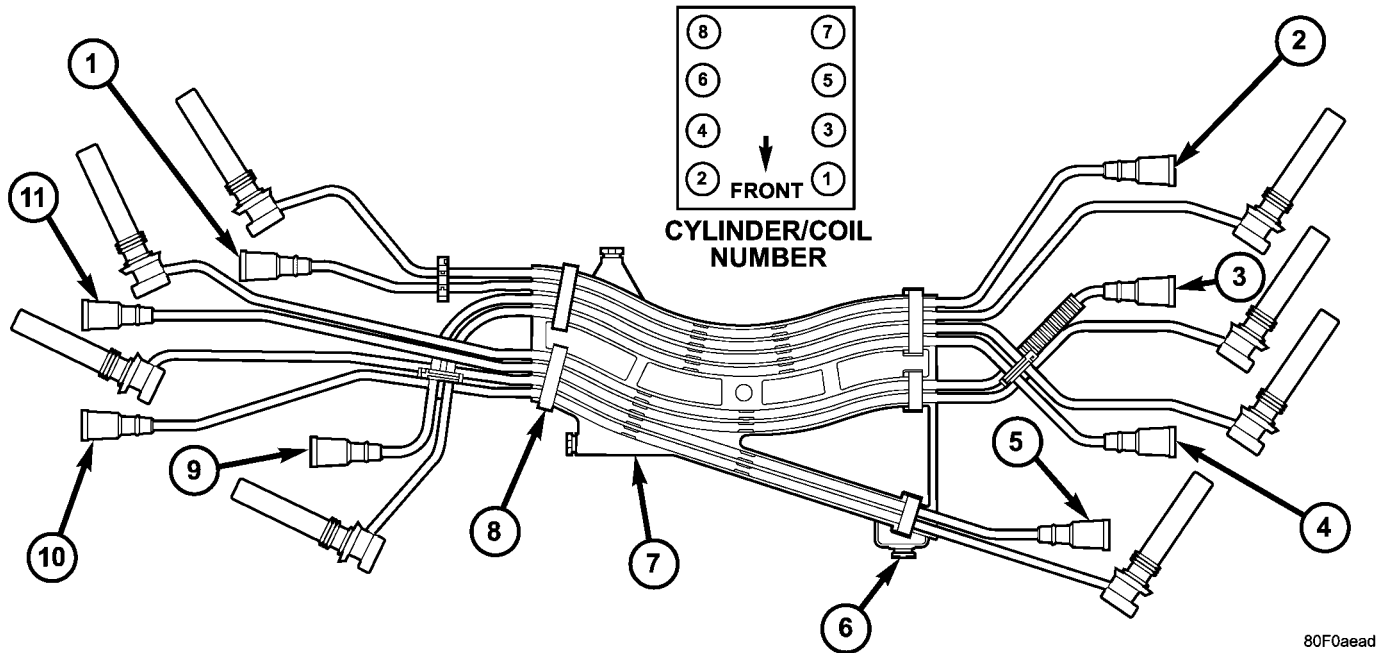
(7) Disconnect electrical connectors at all fuel injectors. To remove connector refer to (Fig. 26). Push red colored slider away from injector (1). While pushing slider, depress tab (2) and remove connector (3) from injector. The factory fuel injection wiring harness is numerically tagged (INJ 1, INJ 2, etc.) for injector position identification.

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

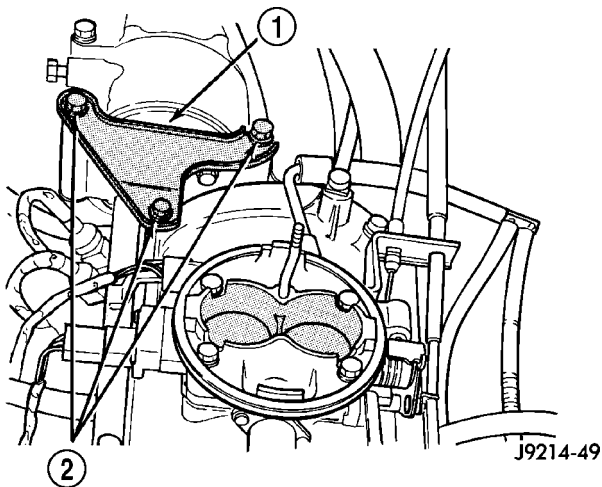
(9) Remove the six fuel rail mounting bolts from the lower half of intake manifold (Fig. 27).

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

FUEL RAIL (Continued)

**Fig. 22 5.7L SPARK PLUG CABLE ROUTING**

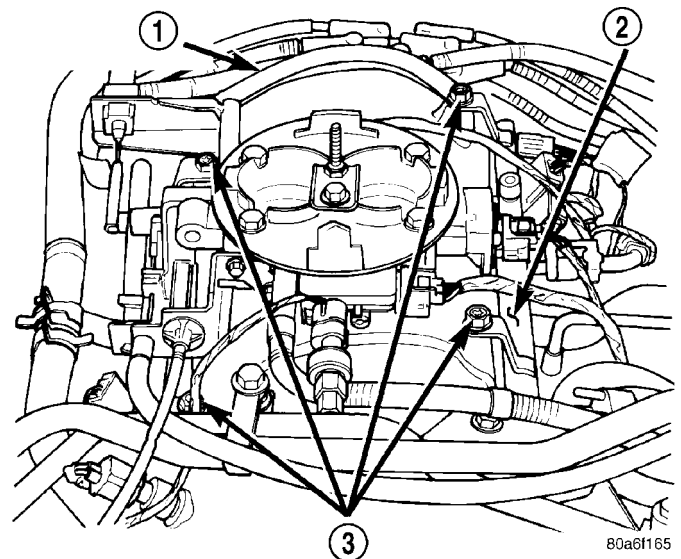
- | | |
|--|---|
| 1 - #8 COIL-TO- #5 SPARK PLUG (MARKED 5/8) | 7 - CABLE TRAY |
| 2 - #5 COIL-TO- #8 SPARK PLUG (MARKED 5/8) | 8 - CLIPS (SPARK PLUG CABLE-TO-TRAY- RETENTION) |
| 3 - #7 COIL-TO- #4 SPARK PLUG (MARKED 4/7) | 9 - #2 COIL-TO- #3 SPARK PLUG (MARKED 2/3) |
| 4 - #3 COIL-TO- #2 SPARK PLUG (MARKED 2/3) | 10 - #6 COIL-TO- #1 SPARK PLUG (MARKED 1/6) |
| 5 - #1 COIL-TO- #6 SPARK PLUG (MARKED 1/6) | 11 - #4 COIL-TO- #7 SPARK PLUG (MARKED 4/7) |
| 6 - CLIPS (TRAY-TO-MANIFOLD RETENTION) | |

**Fig. 23 A/C COMPRESSOR SUPPORT BRACKET - 5.9L V-8**

- 1 - AIR CONDITIONING COMPRESSOR SUPPORT BRACKET
2 - MOUNTING BOLTS

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

(12) If fuel injectors are to be removed, refer to Fuel Injector Removal/Installation.

**Fig. 24 FUEL RAIL REMOVE/INSTALL - 5.9L V-8**

- 1 - FUEL RAIL CONNECTING HOSE
2 - FUEL RAIL
3 - MOUNTING BOLTS (4)

FUEL RAIL (Continued)

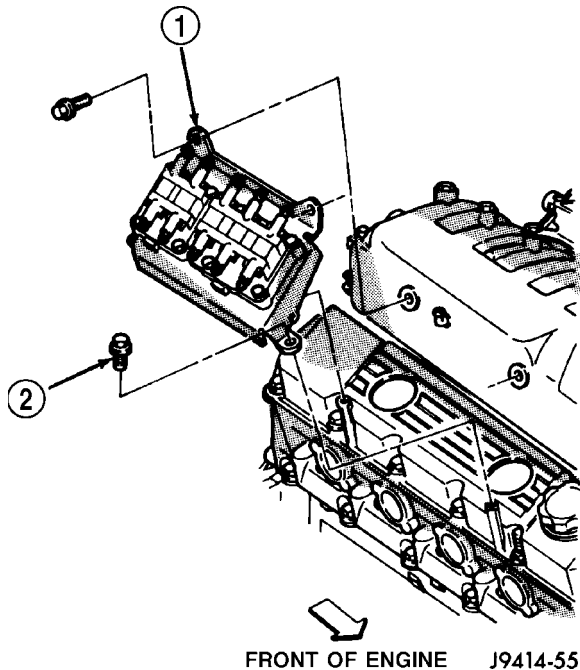
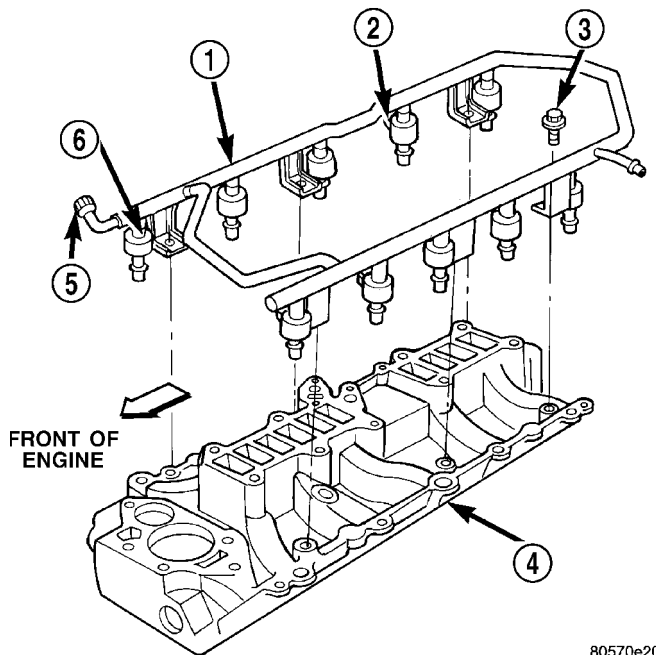


Fig. 25 IGNITION COIL PACK AND MOUNTING BRACKET - 8.0L V-10

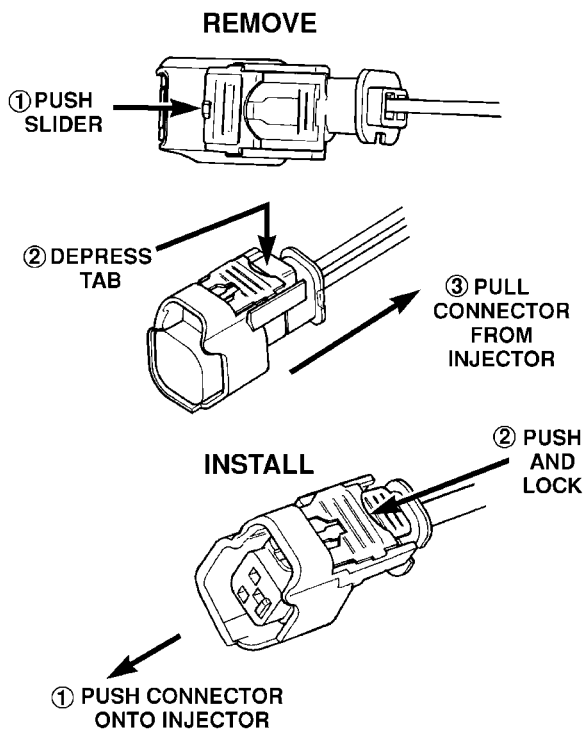
- 1 - COIL PACKS AND BRACKET
2 - MOUNTING BOLTS (4)



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Fig. 27 FUEL RAIL MOUNTING BOLTS - 8.0L V-10 - TYPICAL

- 1 - FUEL RAIL
2 - ELECTRICAL CONNECTOR
3 - MOUNTING BOLTS (6)
4 - INTAKE MANIFOLD LOWER HALF
5 - FUEL PRESSURE TEST PORT
6 - FUEL INJECTORS (10)



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Fig. 26 REMOVE/INSTALL FUEL INJECTOR CONNECTOR

INSTALLATION

3.7L V-6

- (1) If fuel injectors are to be installed, refer to Fuel Injector Removal/Installation.
- (2) Clean out fuel injector machined bores in intake manifold.
- (3) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.
- (4) Position fuel rail/fuel injector assembly to machined injector openings in cylinder head.
- (5) Guide each injector into cylinder head. Be careful not to tear injector o-rings.
- (6) Push **right** side of fuel rail down until fuel injectors have bottomed on cylinder head shoulder. Push **left** fuel rail down until injectors have bottomed on cylinder head shoulder.
- (7) Install 4 fuel rail mounting bolts and tighten. Refer to torque specifications.
- (8) Install 6 ignition coils. Refer to Ignition Coil Removal/Installation.
- (9) Connect electrical connectors to throttle body.
- (10) Connect electrical connectors at all fuel injectors. To install connector, refer to (Fig. 17). Push connector onto injector (1) and then push and lock red colored slider (2). Verify connector is locked to injector by lightly tugging on connector.

FUEL RAIL (Continued)

- (11) Connect necessary vacuum lines to throttle body.
- (12) Install air resonator mounting bracket near front of throttle body (2 bolts).
- (13) Connect fuel line latch clip and fuel line to fuel rail. Refer to Quick-Connect Fittings.
- (14) Install air box to throttle body.
- (15) Install air duct to air box.
- (16) Connect battery cable to battery.
- (17) Start engine and check for leaks.

4.7L V-8

- (1) If fuel injectors are to be installed, refer to Fuel Injector Removal/Installation.
- (2) Clean out fuel injector machined bores in intake manifold.
- (3) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.
- (4) Position fuel rail/fuel injector assembly to machined injector openings in cylinder head.
- (5) Guide each injector into cylinder head. Be careful not to tear injector o-rings.
- (6) Push **right** side of fuel rail down until fuel injectors have bottomed on cylinder head shoulder. Push **left** fuel rail down until injectors have bottomed on cylinder head shoulder.
- (7) Install 4 fuel rail mounting bolts and tighten. Refer to torque specifications.
- (8) Install 8 ignition coils. Refer to Ignition Coil Removal/Installation.
- (9) Connect electrical connectors to throttle body.
- (10) Connect electrical connectors at all fuel injectors. To install connector, refer to (Fig. 17). Push connector onto injector (1) and then push and lock red colored slider (2). Verify connector is locked to injector by lightly tugging on connector.
- (11) Connect necessary vacuum lines to throttle body.
- (12) Install air resonator mounting bracket near front of throttle body (2 bolts).
- (13) Connect fuel line latch clip and fuel line to fuel rail. Refer to Quick-Connect Fittings.
- (14) Install air box to throttle body.
- (15) Install air duct to air box.
- (16) Connect battery cable to battery.
- (17) Start engine and check for leaks.

5.7L V-8

- (1) If fuel injectors are to be installed, refer to Fuel Injector Removal/Installation.
- (2) Clean out fuel injector machined bores in intake manifold.
- (3) Apply a small amount of engine oil to each fuel injector o-ring. This will help in fuel rail installation.
- (4) Position fuel rail/fuel injector assembly to machined injector openings in intake manifold.

(5) Guide each injector into intake manifold. Be careful not to tear injector o-rings.

(6) Push **right** side of fuel rail down until fuel injectors have bottomed on shoulders. Push **left** fuel rail down until injectors have bottomed on shoulders.

(7) Install 4 fuel rail holdown clamps and 4 mounting bolts. Refer to Torque Specifications.

(8) Position spark plug cable tray and cable assembly to intake manifold. Snap 4 cable tray retaining clips into intake manifold.

(9) Install all cables to spark plugs and ignition coils.

(10) Connect electrical connector to throttle body.

(11) Install electrical connectors to all 8 ignition coils. Refer to Ignition Coil Removal/Installation.

(12) Connect electrical connector to throttle body.

(13) Connect electrical connectors at all fuel injectors. To install connector, refer to (Fig. 17). Push connector onto injector (1) and then push and lock red colored slider (2). Verify connector is locked to injector by lightly tugging on connector.

(14) Connect fuel line latch clip and fuel line to fuel rail. Refer to Quick-Connect Fittings.

(15) Install air resonator to throttle body (2 bolts).

(16) Install flexible air duct to air box.

(17) Connect battery cable to battery.

(18) Start engine and check for leaks.

5.9L V-8

(1) If fuel injectors are to be installed, refer to Fuel Injector Removal/Installation.

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

(3) Clean out fuel injector machined bores in intake manifold.

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

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

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

(7) Install fuel rail mounting bolts. Refer to Torque Specifications.

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

(9) Connect electrical connectors at all fuel injectors. To install connector, refer to (Fig. 17). Push connector onto injector (1) and then push and lock red colored slider (2). Verify connector is locked to injector by lightly tugging on connector.

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

(11) Install air cleaner resonator to throttle body.

(12) Connect battery cable to battery.

FUEL RAIL (Continued)

- (13) Start engine and check for leaks.

8.0L V-10

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

NOTE: The fuel injector electrical connectors on all 10 injectors should be facing to right (passenger) side of vehicle (Fig. 27).

- (3) Position fuel rail/fuel injector assembly to injector openings on intake manifold.
- (4) Guide each injector into intake manifold. Be careful not to tear injector o-ring.
- (5) Push the **right** fuel rail down until fuel injectors have bottomed on injector shoulder. Push the **left** fuel rail down until fuel injectors have bottomed on injector shoulder.
- (6) Install six fuel rail mounting bolts into lower half of intake manifold. Tighten bolts to 15 N·m (136 in. lbs.) torque.
- (7) Connect electrical connectors at all fuel injectors. To install connector, refer to (Fig. 26). Push connector onto injector (1) and then push and lock red colored slider (2). Verify connector is locked to injector by lightly tugging on connector. The injector wiring harness is numerically tagged.
- (8) Install upper half of intake manifold. Refer to Engines for procedures.
- (9) Connect main fuel line at fuel rail. Refer to Quick-Connect Fittings for procedures.
- (10) Install ignition coil pack and bracket assembly at intake manifold and right engine valve cover (four bolts).
- (11) Install throttle body to intake manifold. Refer to Throttle Body Removal / Installation.
- (12) Install throttle body linkage to throttle body.
- (13) Install air cleaner tube and housing.
- (14) Install negative battery cable at battery.
- (15) Start engine and check for leaks.

FUEL TANK

DESCRIPTION

The fuel tank is constructed of a plastic material. Its main functions are for fuel storage and for placement of the fuel pump module, and (if equipped) certain ORVR components.

OPERATION

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

Two check (control) valves are mounted into the top of the fuel tank. Refer to Fuel Tank Check Valve for additional information.

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

REMOVAL- EXCEPT DIESEL**Fuel Tank Draining**

WARNING: THE FUEL SYSTEM MAY BE UNDER CONSTANT FUEL PRESSURE EVEN WITH THE ENGINE OFF. THIS PRESSURE MUST BE RELEASED BEFORE SERVICING FUEL TANK.

Two different procedures may be used to drain fuel tank: through the fuel fill fitting on tank, or using the DRB® scan tool. Due to a one-way check valve installed into the fuel fill opening fitting at the tank, the tank cannot be drained conventionally at the fill cap.

The quickest draining procedure involves removing the rubber fuel fill hose.

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

If electric fuel pump is not operating, fuel must be drained through fuel fill fitting at tank. Refer to following procedures.

- (1) Release fuel system pressure.
- (2) Raise vehicle.
- (3) Thoroughly clean area around fuel fill fitting and rubber fuel fill hose at tank.
- (4) If vehicle is equipped with 4 doors and a 6 foot (short) box, remove left-rear tire/wheel.
- (5) Loosen clamp (Fig. 28) and disconnect rubber fuel fill hose at tank fitting. Using an approved gas holding tank, drain fuel tank through this fitting.

FUEL TANK (Continued)

Tank Removal

(1) Loosen clamp and disconnect rubber fuel vent hose (Fig. 28) at tank fitting.

(2) Support tank with a hydraulic jack.

(3) Remove 2 fuel tank strap nuts (Fig. 29) and remove both tank support straps.

(4) Carefully lower tank a few inches and disconnect fuel pump module electrical connector (Fig. 30) at top of tank. To disconnect electrical connector: Push upward on red colored tab to unlock. Push on black colored tab while removing connector.

(5) Disconnect fuel line at fuel filter / fuel pressure regulator (Fig. 30) by pressing on tabs at side of quick-connect fitting.

(6) Disconnect EVAP line at top of tank (Fig. 1).

(7) Continue to lower tank for removal.

(8) If fuel tank is to be replaced, remove fuel pump module from tank. Refer to Fuel Pump Module Removal/Installation procedures.

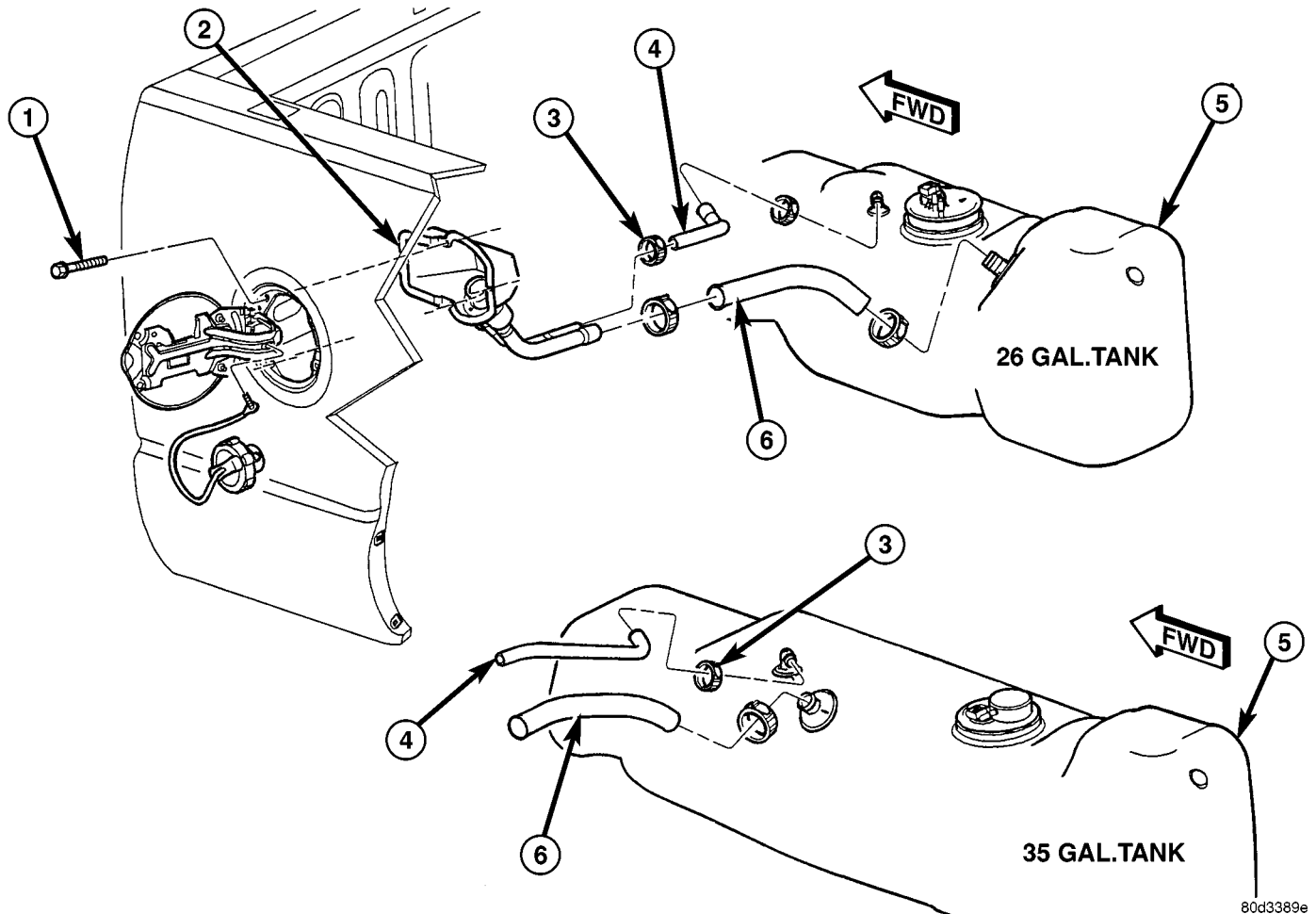


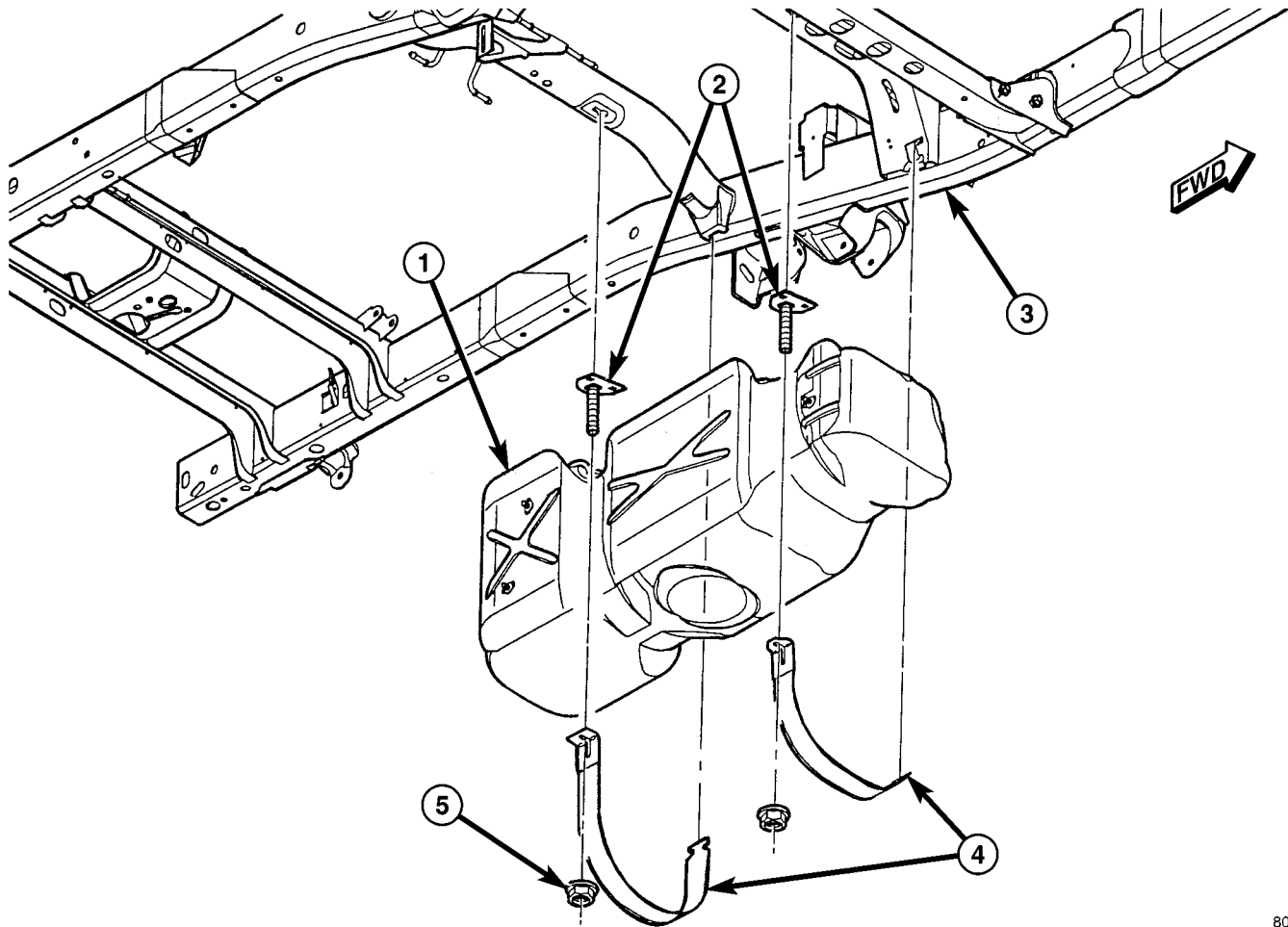
Fig. 28 FUEL TANK FILL / VENT HOSES

1 - BEZEL SCREWS
2 - FUEL FILL BEZEL
3 - HOSE CLAMPS

4 - VENT HOSE
5 - FUEL TANK
6 - FILL HOSE

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FUEL TANK (Continued)



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Fig. 29 FUEL TANK MOUNTING

- 1 - FUEL TANK
- 2 - STRAP MOUNTING STUDS
- 3 - VEHICLE FRAME

- 4 - MOUNTING STRAPS
- 5 - STRAP NUTS

INSTALLATION - EXCEPT DIESEL

(1) If fuel tank is to be replaced, install fuel pump module into tank. Refer to Fuel Pump Module Removal/Installation procedures.

(2) Disconnect clamps and remove rubber fuel fill hose and fuel vent hose at fuel fill tube. Install these 2 hoses to 2 fuel tank fittings. Rotate hoses until paint marks on hoses line up with alignment marks (Fig. 31). Tighten both clamps.

(3) Position fuel tank to hydraulic jack.

(4) Raise tank until positioned near body.

(5) Connect EVAP line at tank (Fig. 1).

(6) Connect fuel pump module electrical connector (Fig. 30) at top of tank.

(7) Connect fuel line quick-connect fitting to fuel filter / fuel pressure regulator (Fig. 1) or (Fig. 30).

(8) Continue raising tank until positioned snug to body.

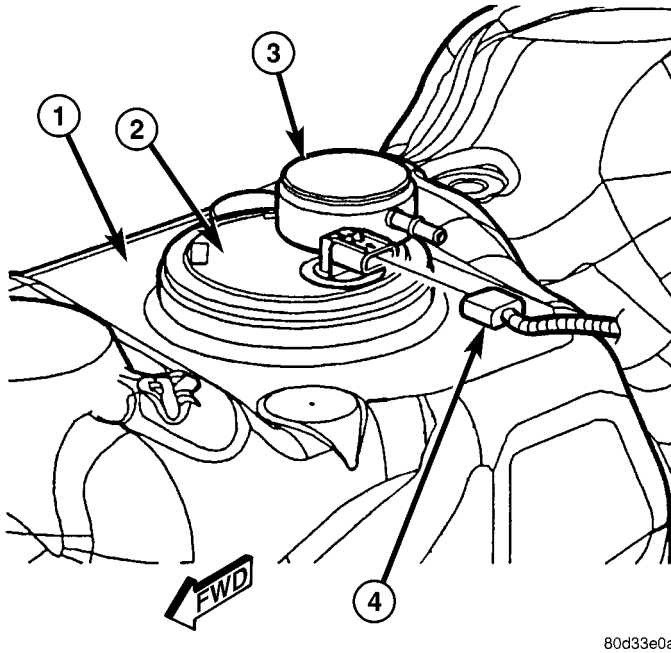
(9) Install and position both tank support straps. Install 2 fuel tank strap nuts (Fig. 29) and tighten. **Tighten rear strap nut first.** Refer to Torque Specifications.

(10) Connect rubber fill and vent hoses to fuel fill tube and tighten clamps.

(11) Lower vehicle.

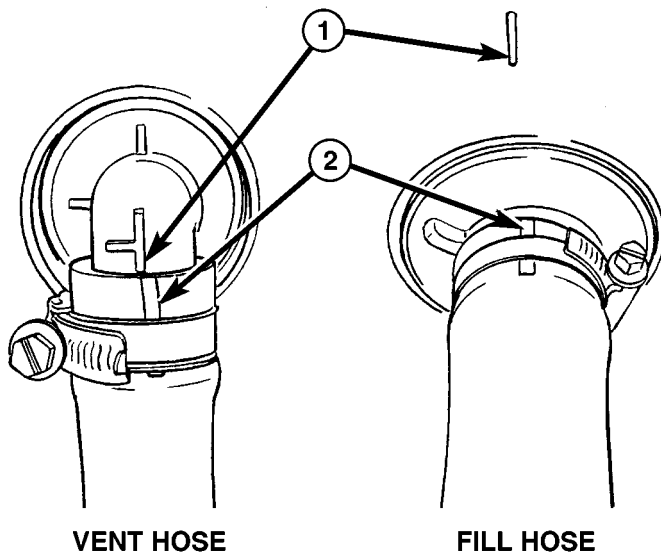
(12) Fill fuel tank with fuel.

FUEL TANK (Continued)

**Fig. 30 FUEL PUMP MODULE CONNECTIONS**

- 1 - TOP OF FUEL TANK
- 2 - FUEL PUMP MODULE
- 3 - FUEL FILTER / FUEL PRESSURE REGULATOR
- 4 - ELEC. CONNECT.

(13) Start engine and check for fuel leaks near top of module.

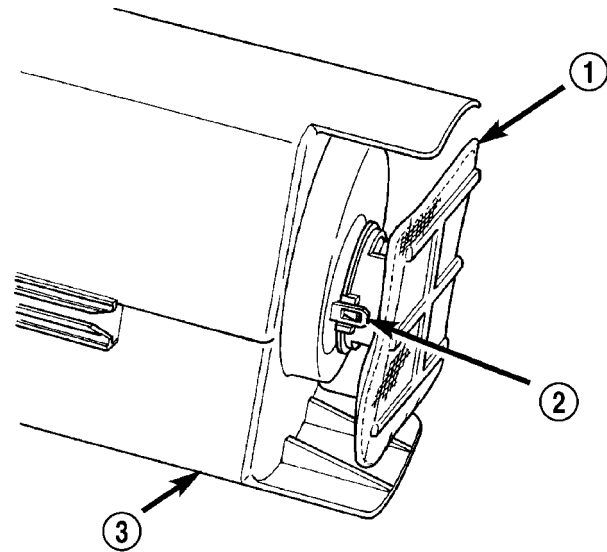
**Fig. 31 HOSE ALIGNMENT MARKS**

- 1 - ALIGNMENT MARKS (MARK FOR FILL HOSE IS LOCATED ON FUEL TANK - MARK FOR VENT HOSE IS LOCATED ON FITTING)
- 2 - PAINT MARKS ON RUBBER HOSES

INLET FILTER

REMOVAL

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

**Fig. 32 FUEL PUMP INLET FILTER**

- 1 - FUEL PUMP INLET FILTER
- 2 - LOCK TABS (2)
- 3 - FUEL PUMP MODULE (BOTTOM)

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

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

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

(4) Clean bottom of pump module.

INSTALLATION

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

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

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

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

FUEL INJECTION - GAS

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ACCELERATOR PEDAL

REMOVAL

The following procedure applies only to vehicles without the Adjustable Pedal Package (code XAP).

The accelerator pedal is serviced as a complete assembly including the bracket.

The accelerator cable is connected to the upper part of the accelerator pedal arm by a plastic retainer (clip) (Fig. 1). This plastic retainer snaps into the top of the accelerator pedal arm.

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

(2) Remove 2 accelerator pedal mounting bracket nuts. Remove accelerator pedal assembly.

INSTALLATION

(1) Place accelerator pedal assembly over 2 studs.

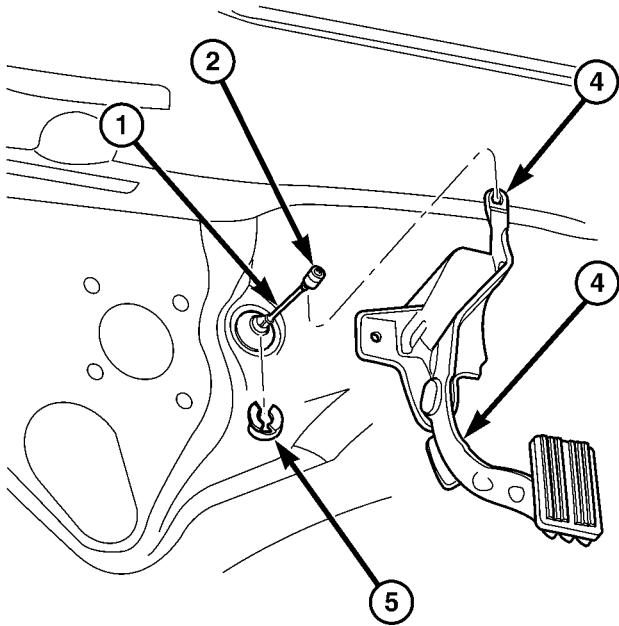
(2) Install and tighten 2 mounting nuts. Refer to Torque Specifications.

(3) Slide throttle cable into opening slot in top of pedal arm.

(4) Push plastic cable retainer (clip) into accelerator pedal arm opening until it snaps into place.

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

ACCELERATOR PEDAL (Continued)



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Fig. 1 ACCELERATOR PEDAL MOUNTING

- 1 - ACCELERATOR CABLE
- 2 - PLASTIC RETAINER (CLIP)
- 3 - THROTTLE PEDAL ARM
- 4 - PEDAL / BRACKET ASSEMBLY
- 5 - CABLE CLIP

ACCELERATOR PEDAL POSITION SENSOR

DESCRIPTION

The Accelerator Pedal Position Sensor (APPS) assembly is located under the vehicle battery tray. A cable connects the assembly to the accelerator pedal. A plastic cover with a movable door is used to cover the assembly.

The APPS is used only with the 5.7L V-8 engine.

OPERATION

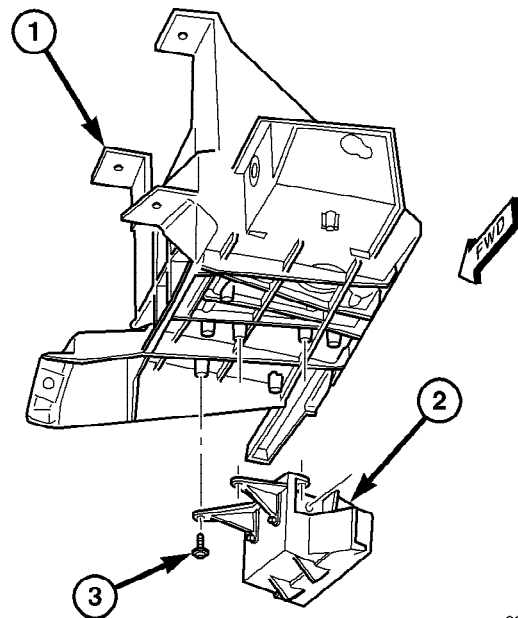
The Accelerator Pedal Position Sensor (APPS) is a linear potentiometer. It provides the Powertrain Control Module (PCM) with a DC voltage signal proportional to the angle, or position of the accelerator pedal. The APPS signal is translated (along with other sensors) to place the throttle plate (within the throttle body) to a pre-determined position.

A mechanical cable is used between the accelerator pedal and the APPS assembly. Although a cable is used between the pedal and APPS, a mechanical cable is not used at the throttle body. Throttle plate position is electrically determined.

REMOVAL

The APPS is serviced (replaced) as one assembly including the sensor, plastic housing and cable. The APPS assembly is located under the vehicle battery tray (Fig. 2). Access to APPS is gained from over top of left / front tire.

- (1) Disconnect negative battery cable at battery.
- (2) Disconnect APPS cable at accelerator pedal. Refer to Accelerator Pedal Removal / Installation.
- (3) Remove wheel house liner at left / front wheel. Refer to Body.
- (4) Gain access to APPS electrical connector by opening swing-down door (Fig. 3). Disconnect electrical connector.
- (5) Remove 3 mounting bolts (Fig. 3).
- (6) Remove APPS assembly from battery tray.
- (7) If cable is to be separated at APPS, unsnap cable clip from ball socket (Fig. 4). Release cable from plastic housing by pressing on small cable release tab (Fig. 3).



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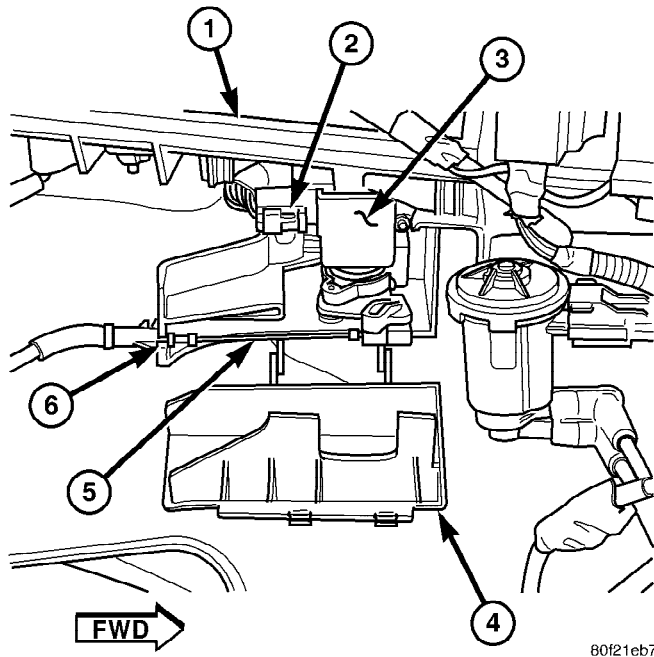
Fig. 2 APPS LOCATION

- 1 - BATTERY TRAY
- 2 - APPS LOCATION
- 3 - APPS MOUNTING BOLTS

INSTALLATION

- (1) Install Accelerator Pedal Position Sensor (APPS) cable to accelerator pedal. Refer to Accelerator Pedal Removal / Installation.
- (2) Connect electrical connector to APPS.
- (3) If necessary, connect cable to APPS lever ball socket (snaps on).
- (4) Snap APPS cable cover closed.

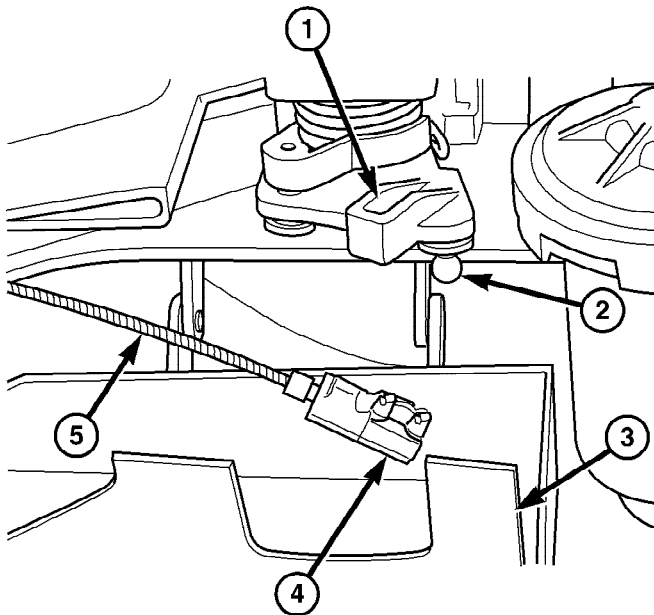
ACCELERATOR PEDAL POSITION SENSOR (Continued)



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Fig. 3 APPS REMOVE / INSTALL

- 1 - BOTTOM OF BATTERY TRAY
- 2 - ELECTRICAL CONNECTOR
- 3 - APPS
- 4 - SWING-DOWN DOOR
- 5 - CABLE (TO PEDAL)
- 6 - CABLE RELEASE TAB



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Fig. 4 APPS CABLE

- 1 - APPS LEVER
- 2 - BALL SOCKET
- 3 - SWING-DOWN DOOR
- 4 - CABLE CLIP
- 5 - CABLE

(5) Position APPS assembly to bottom of battery tray and install 3 bolts. Refer to Torque Specifications.

(6) Install wheelhouse liner. Refer to Body.

(7) Perform the following procedure:

(a) Connect negative battery cable to battery.

(b) Turn ignition switch ON, but do not crank engine.

(c) Leave ignition switch ON for a minimum of 10 seconds. This will allow PCM to learn electrical parameters.

(8) If the previous step is not performed, a Diagnostic Trouble Code (DTC) will be set.

(9) If necessary, use DRB III® Scan Tool to erase any Diagnostic Trouble Codes (DTC's) from PCM.

CRANKSHAFT POSITION SENSOR

DESCRIPTION

3.7L V-6

The Crankshaft Position (CKP) sensor is mounted into the right rear side of the cylinder block. It is positioned and bolted into a machined hole.

4.7L V-8

The Crankshaft Position (CKP) sensor is mounted into the right rear side of the cylinder block. It is positioned and bolted into a machined hole.

5.7L V-8

The Crankshaft Position (CKP) sensor is mounted into the right rear side of the cylinder block. It is positioned and bolted into a machined hole.

5.9L V-8 Gas

The Crankshaft Position (CKP) sensor is located near the outer edge of the flywheel (starter ringear). It is bolted to the rear of the engine.

8.0L V-10

The Crankshaft Position (CKP) sensor is located on the right-lower side of the cylinder block, forward of the right engine mount, just above the oil pan rail.

OPERATION

3.7L V-6

Engine speed and crankshaft position are provided through the CKP (Crankshaft Position) sensor. The sensor generates pulses that are the input sent to the Powertrain Control Module (PCM). The PCM interprets the sensor input to determine the crankshaft position. The PCM then uses this position, along with

CRANKSHAFT POSITION SENSOR (Continued)

other inputs, to determine injector sequence and ignition timing.

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

A tonewheel (targetwheel) is bolted to the engine crankshaft (Fig. 5). This tonewheel has sets of notches at its outer edge (Fig. 5).

The notches cause a pulse to be generated when they pass under the sensor. The pulses are the input to the PCM.

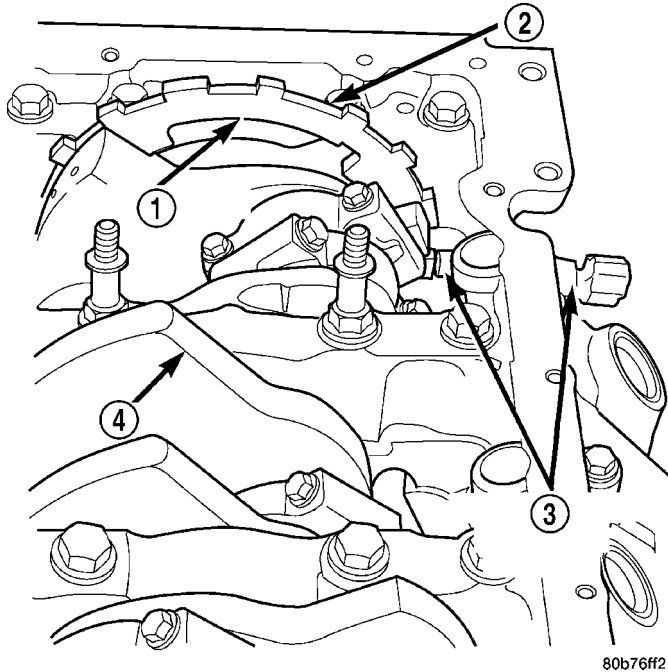


Fig. 5 CKP OPERATION - 3.7L V-6

- 1 - TONEWHEEL
- 2 - NOTCHES
- 3 - CRANKSHAFT POSITION SENSOR
- 4 - CRANKSHAFT

4.7L V-8

Engine speed and crankshaft position are provided through the crankshaft position sensor. The sensor generates pulses that are the input sent to the powertrain control module (PCM). The PCM interprets the sensor input to determine the crankshaft position. The PCM then uses this position, along with other inputs, to determine injector sequence and ignition timing.

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

On the 4.7L V-8 engine, a tonewheel is bolted to the engine crankshaft (Fig. 6). This tonewheel has sets of notches at its outer edge (Fig. 6).

The notches cause a pulse to be generated when they pass under the sensor. The pulses are the input to the PCM.

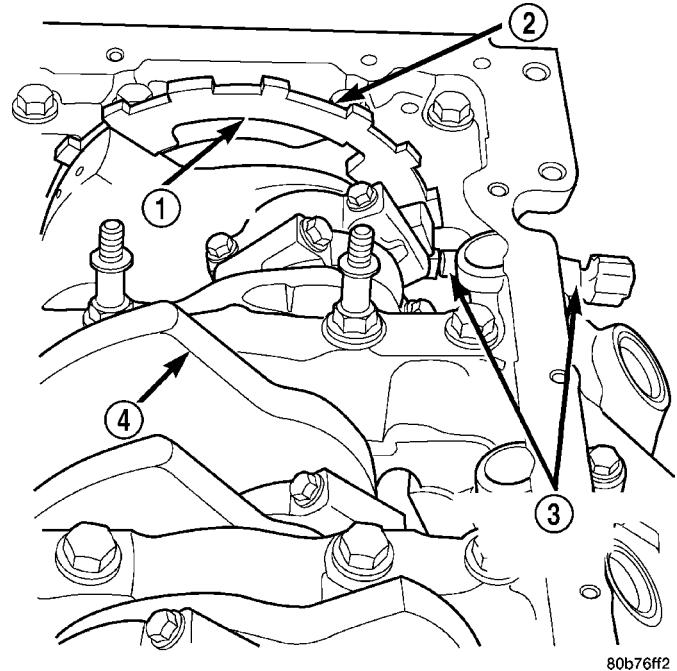


Fig. 6 CKP SENSOR OPERATION AND TONEWHEEL - 4.7L V-8

- 1 - TONEWHEEL
- 2 - NOTCHES
- 3 - CRANKSHAFT POSITION SENSOR
- 4 - CRANKSHAFT

5.7L V-8

Engine speed and crankshaft position are provided through the crankshaft position sensor. The sensor generates pulses that are the input sent to the powertrain control module (PCM). The PCM interprets the sensor input to determine the crankshaft position. The PCM then uses this position, along with other inputs, to determine injector sequence and ignition timing.

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

On the 5.7L V-8 engine, a tonewheel is bolted to the engine crankshaft. This tonewheel has sets of notches at its outer edge (Fig. 7).

The notches cause a pulse to be generated when they pass under the sensor. The pulses are the input to the PCM.

5.9L V-8 Gas

Engine speed and crankshaft position are provided through the CKP sensor. The sensor generates pulses that are the input sent to the Powertrain Control Module (PCM). The PCM interprets the sensor input to determine the crankshaft position. The PCM then uses this position, along with other inputs, to determine injector sequence and ignition timing.

CRANKSHAFT POSITION SENSOR (Continued)

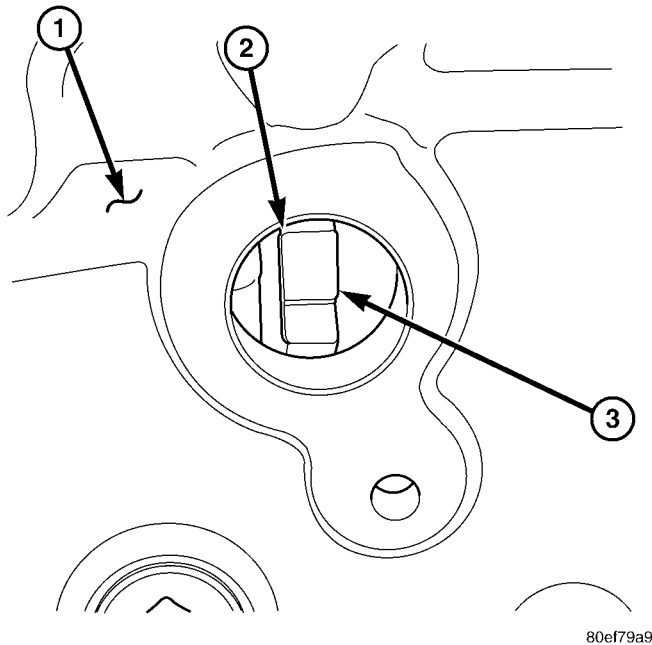


Fig. 7 CKP SENSOR OPERATION AND NOTCHES - 5.7L V-8

- 1 - RIGHT / REAR SIDE OF CYLINDER BLOCK
- 2 - MACHINED HOLE
- 3 - NOTCHES

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

On 5.9L V-8 engines, the flywheel/drive plate has 8 single notches, spaced every 45 degrees, at its outer edge (Fig. 8).

The notches cause a pulse to be generated when they pass under the sensor. The pulses are the input to the PCM. For each engine revolution, there are 8 pulses generated on V-8 engines.

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

8.0L V-10

The Crankshaft Position (CKP) sensor detects notches machined into the middle of the crankshaft (Fig. 9).

There are five sets of notches. Each set contains two notches. Basic ignition timing is determined by the position of the last notch in each set of notches. Once the Powertrain Control Module (PCM) senses the last notch, it will determine crankshaft position (which piston will next be at Top Dead Center). An input from the camshaft position sensor is also needed. It may take the module up to one complete engine revolution to determine crankshaft position during engine cranking.

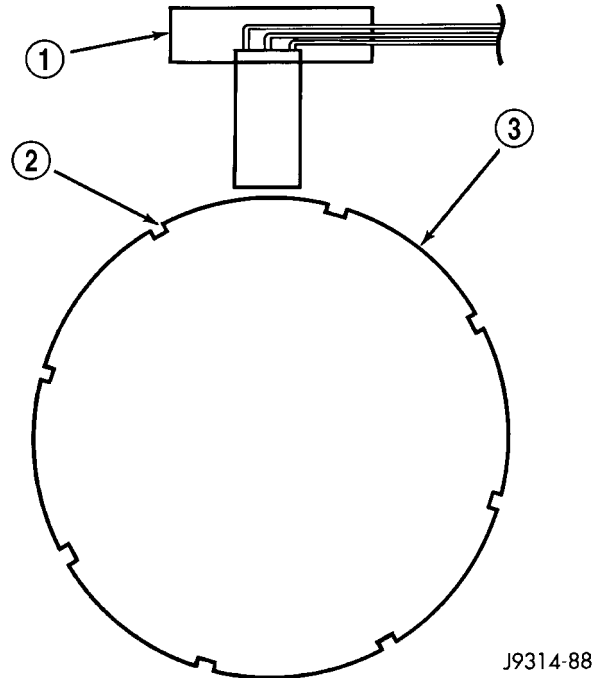


Fig. 8 CKP SENSOR OPERATION - 5.9L V-8

- 1 - CRANKSHAFT POSITION SENSOR
- 2 - NOTCHES
- 3 - FLYWHEEL

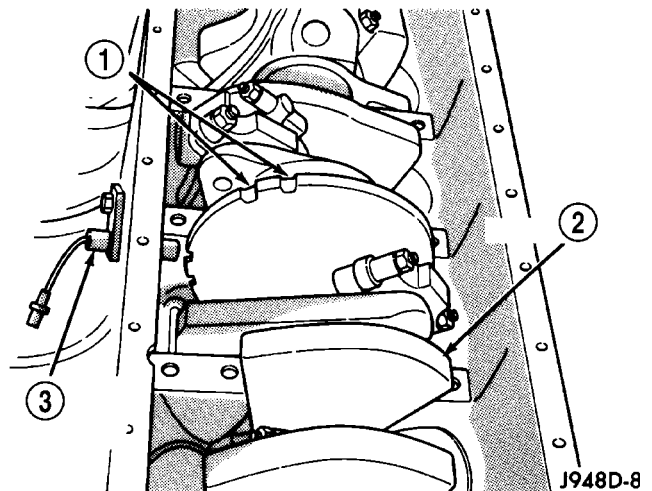


Fig. 9 CKP SENSOR OPERATION - 8.0L V-10 ENGINE

- 1 - CRANKSHAFT NOTCHES
- 2 - CRANKSHAFT
- 3 - CRANKSHAFT POSITION SENSOR

The PCM uses the signal from the camshaft position sensor to determine fuel injector sequence. Once crankshaft position has been determined, the PCM begins energizing a ground circuit to each fuel injector to provide injector operation.

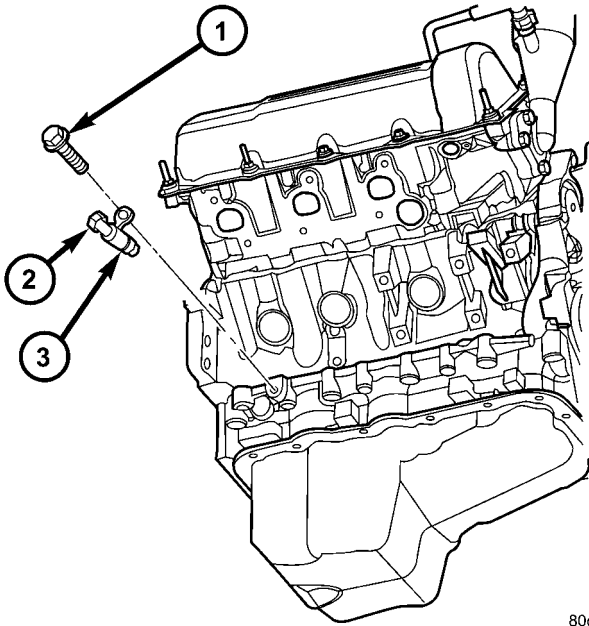
CRANKSHAFT POSITION SENSOR (Continued)

REMOVAL

3.7L V-6

The Crankshaft Position (CKP) sensor is mounted into the right rear side of the cylinder block (Fig. 10). It is positioned and bolted into a machined hole.

- (1) Raise vehicle.
- (2) Disconnect sensor electrical connector.
- (3) Remove sensor mounting bolt (Fig. 10).
- (4) Carefully twist sensor from cylinder block.
- (5) Check condition of sensor o-ring.



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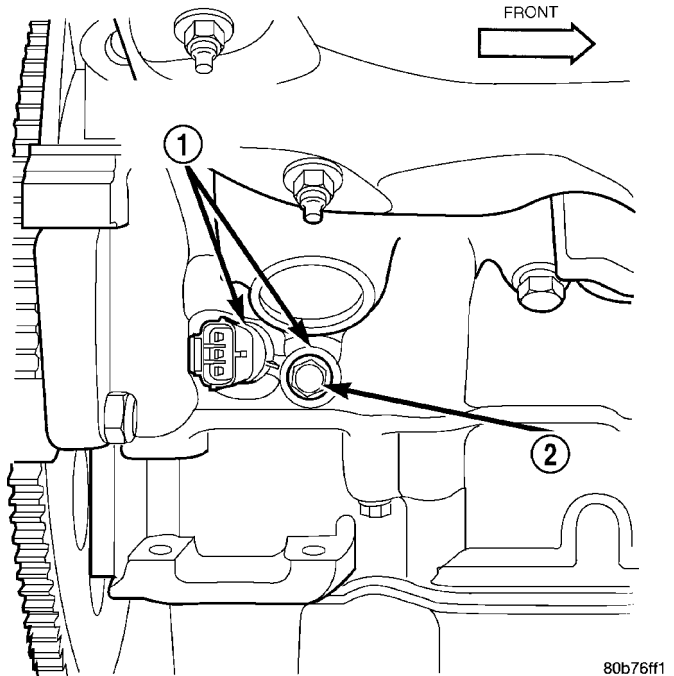
Fig. 10 CKP REMOVAL / INSTALLATION - 3.7L

- 1 - MOUNTING BOLT
- 2 - CKP SENSOR
- 3 - O-RING

4.7L V-8

The Crankshaft Position (CKP) sensor is located at the right-rear side of the engine cylinder block (Fig. 11). It is positioned and bolted into a machined hole in the engine block.

- (1) Raise vehicle.



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Fig. 11 CKP REMOVAL / INSTALLATION - 4.7L

- 1 - CRANKSHAFT POSITION SENSOR
- 2 - MOUNTING BOLT

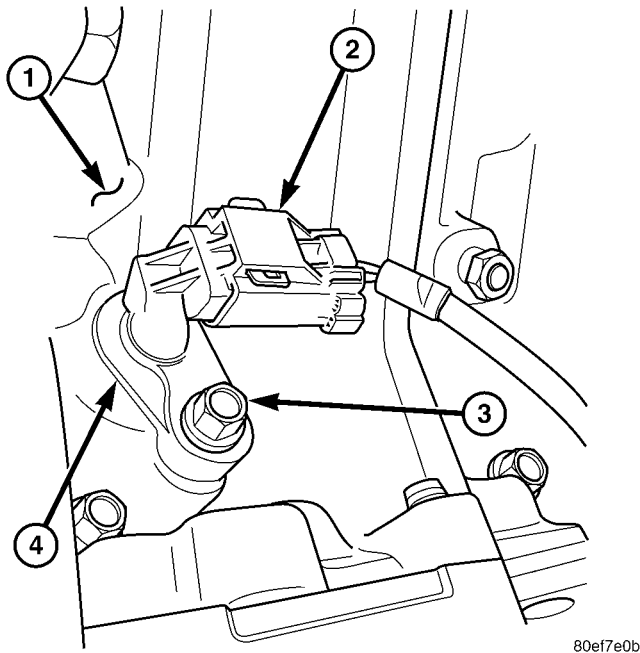
- (2) Disconnect CKP electrical connector at sensor.
- (3) Remove CKP mounting bolt (Fig. 11).
- (4) Carefully twist sensor from cylinder block.
- (5) Remove sensor from vehicle.
- (6) Check condition of sensor o-ring.

5.7L V-8

The Crankshaft Position (CKP) sensor is located at the right-rear side of the engine cylinder block (Fig. 12). It is positioned and bolted into a machined hole in the engine block.

- (1) Raise vehicle.
- (2) Disconnect CKP electrical connector at sensor (Fig. 12).
- (3) Remove CKP mounting bolt (Fig. 12).
- (4) Carefully twist sensor from cylinder block.
- (5) Remove sensor from vehicle.
- (6) Check condition of sensor o-ring.

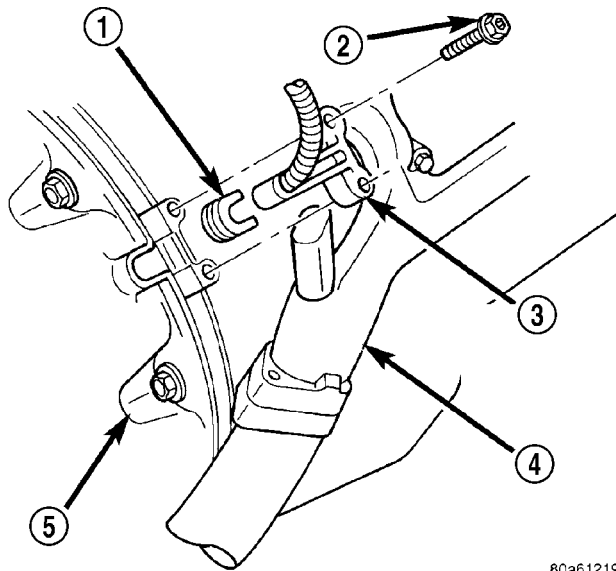
CRANKSHAFT POSITION SENSOR (Continued)

**Fig. 12 CKP REMOVAL / INSTALLATION - 5.7L V-8**

- 1 - CYLINDER BLOCK - RIGHT / REAR
- 2 - ELEC. CONNECTOR
- 3 - MOUNTING BOLT
- 4 - CKP SENSOR

5.9L Gas

The sensor is bolted to the top of the cylinder block near the rear of right cylinder head (Fig. 13).

**Fig. 13 CKP REMOVAL / INSTALLATION - 5.9L V-8**

- 1 - GROMMET
- 2 - MOUNTING BOLTS (2)
- 3 - CRANKSHAFT POSITION SENSOR
- 4 - RIGHT EXHAUST MANIFOLD
- 5 - TRANSMISSION BELL HOUSING

- (1) Raise vehicle.

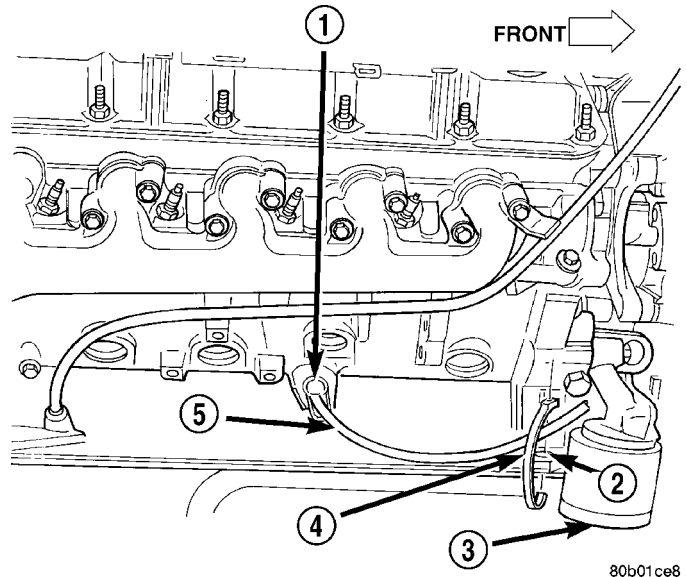
- (2) Disconnect crankshaft position sensor pigtail harness from main wiring harness.

- (3) Remove two sensor (recessed hex head) mounting bolts (Fig. 13).

- (4) Remove sensor from engine.

8.0L V-10

The crankshaft position sensor is located on the right-lower side of the cylinder block, forward of the right engine mount, just above the oil pan rail (Fig. 14).

**Fig. 14 CKP SENSOR LOCATION - 8.0L V-10**

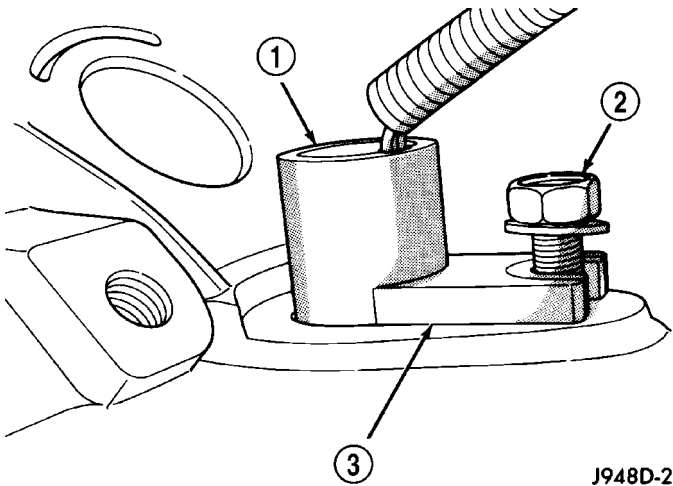
- 1 - CRANKSHAFT POSITION SENSOR
- 2 - HOLE
- 3 - OIL FILTER
- 4 - PLASTIC TIE STRAP
- 5 - PIGTAIL HARNESS

- (1) Raise and support vehicle.
- (2) Disconnect sensor pigtail harness from main engine wiring harness.
- (3) Remove sensor mounting bolt (Fig. 15).
- (4) Cut plastic tie strap (Fig. 14) securing sensor pigtail harness to side of engine block.
- (5) Carefully pry sensor from cylinder block in a rocking action with two small screwdrivers.
- (6) Remove sensor from vehicle.
- (7) Check condition of sensor o-ring (Fig. 16).

INSTALLATION**3.7L V-6**

- (1) Clean out machined hole in engine block.
- (2) Apply a small amount of engine oil to sensor o-ring.
- (3) Install sensor into engine block with a slight rocking and twisting action.

CRANKSHAFT POSITION SENSOR (Continued)



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Fig. 15 CKP SENSOR R/I – 8.0L V-10

- 1 - CRANKSHAFT POSITION SENSOR
 2 - MOUNTING BOLT
 3 - SENSOR POSITIONED FLUSH TO CYLINDER BLOCK

CAUTION: Before tightening sensor mounting bolt, be sure sensor is completely flush to cylinder block. If sensor is not flush, damage to sensor mounting tang may result.

- (4) Install mounting bolt and tighten to 28 N·m (21 ft. lbs.) torque.
 (5) Connect electrical connector to sensor.
 (6) Lower vehicle.

5.7L V-8

- (1) Clean out machined hole in engine block.
 (2) Apply a small amount of engine oil to sensor o-ring.
 (3) Install sensor into engine block with a slight rocking and twisting action.

CAUTION: Before tightening sensor mounting bolt, be sure sensor is completely flush to cylinder block. If sensor is not flush, damage to sensor mounting tang may result.

- (4) Install mounting bolt and tighten to 28 N·m (21 ft. lbs.) torque.
 (5) Connect electrical connector to sensor.
 (6) Lower vehicle.

5.9L V-8 Gas

- (1) Position crankshaft position sensor to engine.
 (2) Install mounting bolts and tighten to 8 N·m (70 in. lbs.) torque.
 (3) Connect main harness electrical connector to sensor.
 (4) Lower vehicle.

8.0L V-10

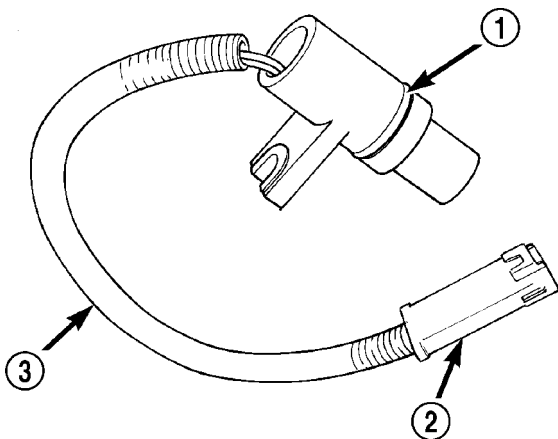
- (1) Apply a small amount of engine oil to sensor o-ring.
 (2) Install sensor into cylinder block with a slight rocking action. Do not twist sensor into position as damage to o-ring may result.

CAUTION: Before tightening sensor mounting bolt, be sure sensor is completely flush to cylinder block. If sensor is not flush, damage to sensor mounting tang may result.

- (3) Install mounting bolt and tighten to 8 N·m (70 in. lbs.) torque.

- (4) Connect sensor pigtail harness to main engine wiring harness

- (5) Install new plastic tie strap (Fig. 14) to secure sensor pigtail harness to side of engine block. Thread tie strap through casting hole on cylinder block.



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Fig. 16 SENSOR O-RING – 8.0L V-10

- 1 - CRANKSHAFT POSITION SENSOR O-RING
 2 - ELECTRICAL CONNECTOR
 3 - PIGTAIL HARNESS

CAUTION: Before tightening sensor mounting bolt, be sure sensor is completely flush to cylinder block. If sensor is not flush, damage to sensor mounting tang may result.

- (4) Install mounting bolt and tighten to 28 N·m (21 ft. lbs.) torque.
 (5) Connect electrical connector to sensor.
 (6) Lower vehicle.

4.7L V-8

- (1) Clean out machined hole in engine block.
 (2) Apply a small amount of engine oil to sensor o-ring.
 (3) Install sensor into engine block with a slight rocking and twisting action.

FUEL INJECTOR

DESCRIPTION

An individual fuel injector (Fig. 17) is used for each individual cylinder.

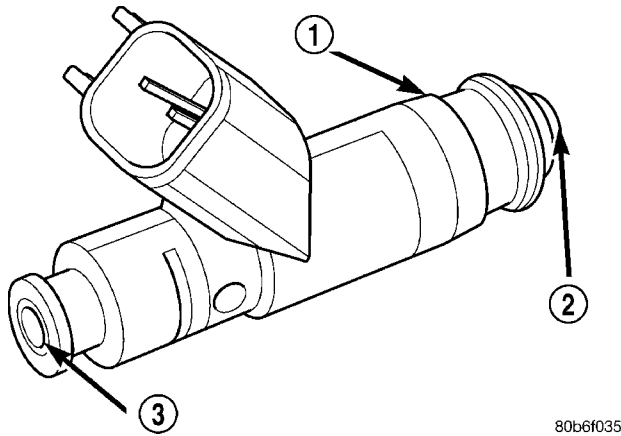


Fig. 17 FUEL INJECTOR

- 1 - FUEL INJECTOR
- 2 - NOZZLE
- 3 - TOP (FUEL ENTRY)

OPERATION

OPERATION - FUEL INJECTOR

The top (fuel entry) end of the injector (Fig. 17) is attached into an opening on the fuel rail.

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

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

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

Battery voltage is supplied to the injectors through the ASD relay.

The PCM determines injector pulse width based on various inputs.

OPERATION - PCM OUTPUT

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

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

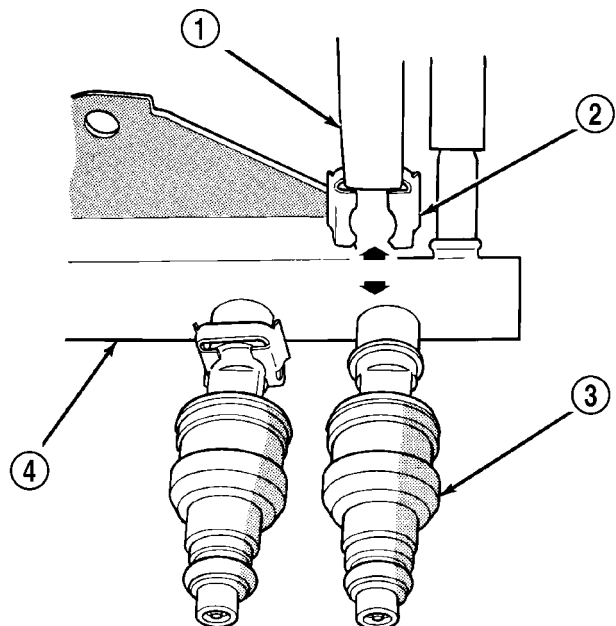
Battery voltage (12 volts +) is supplied to the injectors through the ASD relay. The ASD relay will shut-down the 12 volt power source to the fuel injectors if the PCM senses the ignition is on, but the engine is not running. This occurs after the engine has not been running for approximately 1.8 seconds.

The PCM determines injector on-time (pulse width) based on various inputs.

REMOVAL

(1) Remove fuel rail. Refer to Fuel Injector Rail Removal.

(2) Disconnect clip(s) that retain fuel injector(s) to fuel rail (Fig. 18).



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Fig. 18 INJECTOR RETAINING CLIP

- 1 - PLIERS
- 2 - INJECTOR CLIP
- 3 - FUEL INJECTOR - TYPICAL
- 4 - FUEL RAIL - TYPICAL

FUEL INJECTOR (Continued)

INSTALLATION

- (1) Install fuel injector(s) into fuel rail assembly and install retaining clip(s).
- (2) If same injector(s) is being reinstalled, install new o-ring(s).
- (3) Apply a small amount of clean engine oil to each injector o-ring. This will aid in installation.
- (4) Install fuel rail. Refer to Fuel Rail Installation.
- (5) Start engine and check for fuel leaks.

FUEL PUMP RELAY

DESCRIPTION

The 5-pin, 12-volt, fuel pump relay is located in the Power Distribution Center (PDC). Refer to the label on the PDC cover for relay location.

OPERATION

The Powertrain Control Module (PCM) energizes the electric fuel pump through the fuel pump relay. The fuel pump relay is energized by first applying battery voltage to it when the ignition key is turned ON, and then applying a ground signal to the relay from the PCM.

Whenever the ignition key is turned ON, the electric fuel pump will operate. But, the PCM will shut-down the ground circuit to the fuel pump relay in approximately 1–3 seconds unless the engine is operating or the starter motor is engaged.

REMOVAL

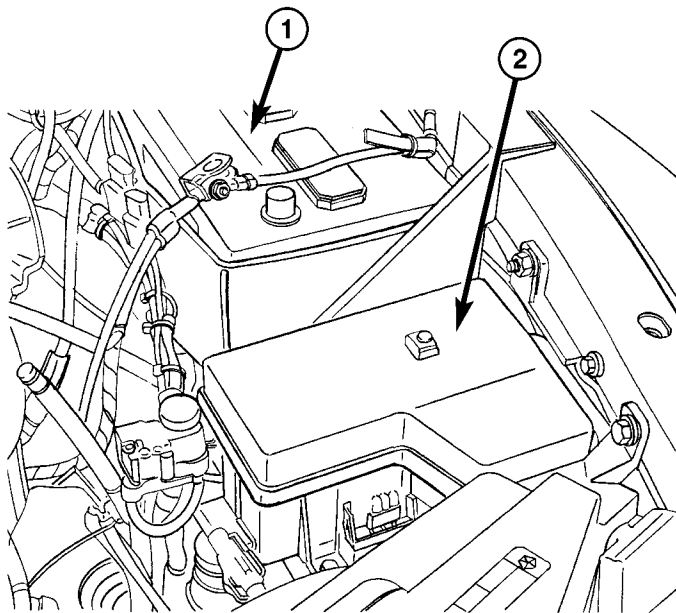
The fuel pump relay is located in the Power Distribution Center (PDC) (Fig. 19). Refer to label on PDC cover for relay location.

- (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

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

- (1) Install relay to PDC.
- (2) Install cover to PDC.



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Fig. 19 PDC LOCATION

- 1 - BATTERY
- 2 - PDC (POWER DISTRIBUTION CENTER)

IDLE AIR CONTROL MOTOR

DESCRIPTION

A separate IAC motor is not used with the 5.7L V-8 engine.

The IAC stepper motor is mounted to the throttle body, and regulates the amount of air bypassing the control of the throttle plate. As engine loads and ambient temperatures change, engine rpm changes. A pintle on the IAC stepper motor protrudes into a passage in the throttle body, controlling air flow through the passage. The IAC is controlled by the Powertrain Control Module (PCM) to maintain the target engine idle speed.

OPERATION

A separate IAC motor is not used with the 5.7L V-8 engine.

At idle, engine speed can be increased by retracting the IAC motor pintle and allowing more air to pass through the port, or it can be decreased by restricting the passage with the pintle and diminishing the amount of air bypassing the throttle plate.

The IAC is called a stepper motor because it is moved (rotated) in steps, or increments. Opening the IAC opens an air passage around the throttle blade which increases RPM.

The PCM uses the IAC motor to control idle speed (along with timing) and to reach a desired MAP during decel (keep engine from stalling).

IDLE AIR CONTROL MOTOR (Continued)

The IAC motor has 4 wires with 4 circuits. Two of the wires are for 12 volts and ground to supply electrical current to the motor windings to operate the stepper motor in one direction. The other 2 wires are also for 12 volts and ground to supply electrical current to operate the stepper motor in the opposite direction.

To make the IAC go in the opposite direction, the PCM just reverses polarity on both windings. If only 1 wire is open, the IAC can only be moved 1 step (increment) in either direction. To keep the IAC motor in position when no movement is needed, the PCM will energize both windings at the same time. This locks the IAC motor in place.

In the IAC motor system, the PCM will count every step that the motor is moved. This allows the PCM to determine the motor pintle position. If the memory is cleared, the PCM no longer knows the position of the pintle. So at the first key ON, the PCM drives the IAC motor closed, regardless of where it was before. This zeros the counter. From this point the PCM will back out the IAC motor and keep track of its position again.

When engine rpm is above idle speed, the IAC is used for the following:

- Off-idle dashpot (throttle blade will close quickly but idle speed will not stop quickly)
- Deceleration air flow control
- A/C compressor load control (also opens the passage slightly before the compressor is engaged so that the engine rpm does not dip down when the compressor engages)
- Power steering load control

The PCM can control polarity of the circuit to control direction of the stepper motor.

IAC Stepper Motor Program: The PCM is also equipped with a memory program that records the number of steps the IAC stepper motor most recently advanced to during a certain set of parameters. For example: The PCM was attempting to maintain a 1000 rpm target during a cold start-up cycle. The last recorded number of steps for that may have been 125. That value would be recorded in the memory cell so that the next time the PCM recognizes the identical conditions, the PCM recalls that 125 steps were required to maintain the target. This program allows for greater customer satisfaction due to greater control of engine idle.

Another function of the memory program, which occurs when the power steering switch (if equipped), or the A/C request circuit, requires that the IAC stepper motor control engine rpm, is the recording of the last targeted steps into the memory cell. The PCM can anticipate A/C compressor loads. This is accomplished by delaying compressor operation for approximately 0.5 seconds until the PCM moves the IAC

stepper motor to the recorded steps that were loaded into the memory cell. Using this program helps eliminate idle-quality changes as loads change. Finally, the PCM incorporates a "No-Load" engine speed limiter of approximately 1800 - 2000 rpm, when it recognizes that the TPS is indicating an idle signal and IAC motor cannot maintain engine idle.

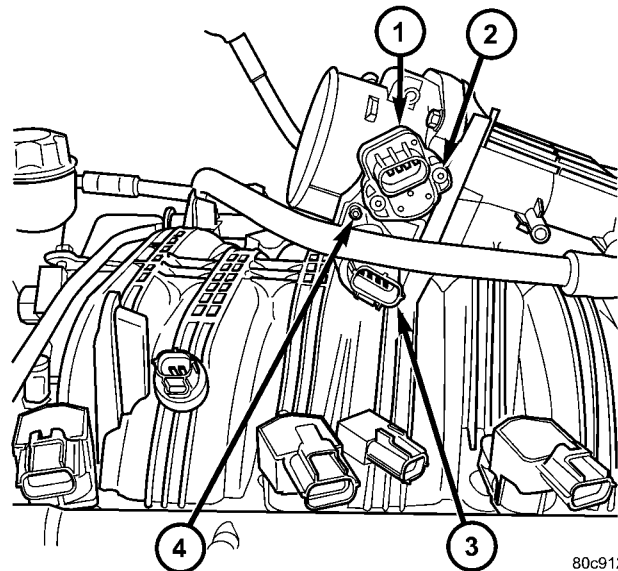
A (factory adjusted) set screw is used to mechanically limit the position of the throttle body throttle plate. **Never attempt to adjust the engine idle speed using this screw.** All idle speed functions are controlled by the IAC motor through the PCM.

REMOVAL

3.7L V-6

The Idle Air Control (IAC) motor is located on the side of the throttle body (Fig. 20).

- (1) Remove air resonator box at throttle body.
- (2) Disconnect electrical connector from IAC motor.
- (3) Remove two mounting bolts (screws).
- (4) Remove IAC motor from throttle body.



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Fig. 20 IDLE AIR CONTROL MOTOR - 3.7L V-6

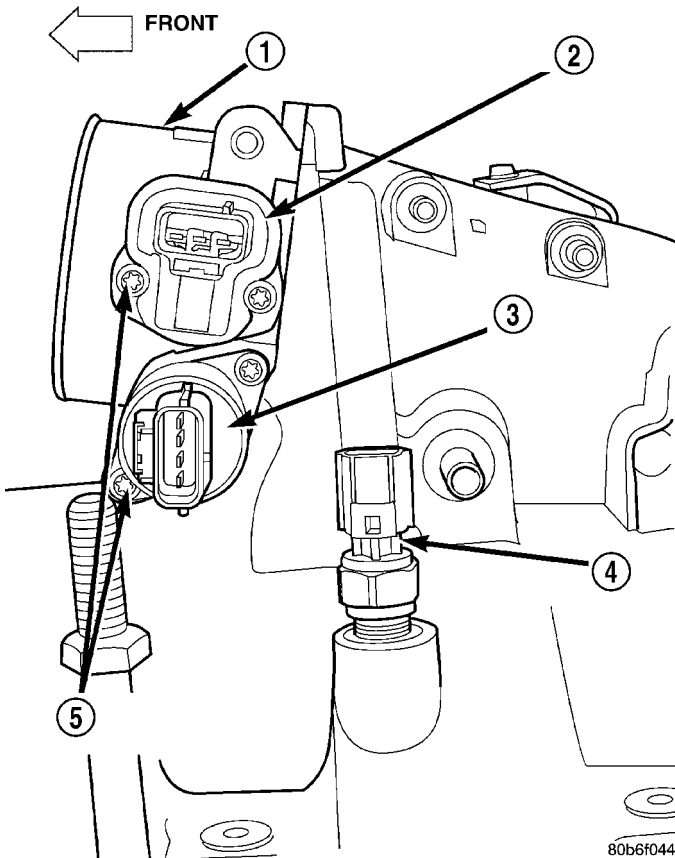
- 1 - THROTTLE POSITION SENSOR (TPS)
- 2 - MOUNTING SCREWS
- 3 - IDLE AIR CONTROL MOTOR (IAC)
- 4 - MOUNTING SCREWS

4.7L V-8

The Idle Air Control (IAC) motor is located on the side of the throttle body (Fig. 21).

- (1) Remove air resonator box at throttle body.
- (2) Disconnect electrical connector from IAC motor.
- (3) Remove two mounting bolts (screws).
- (4) Remove IAC motor from throttle body.

IDLE AIR CONTROL MOTOR (Continued)

**Fig. 21 IDLE AIR CONTROL MOTOR - 4.7L V-8**

- 1 - THROTTLE BODY
- 2 - TPS
- 3 - IAC MOTOR
- 4 - IAT SENSOR
- 5 - MOUNTING SCREWS

5.7L V-8

The IAC motor is not serviceable on the 5.7L V-8 engine.

5.9L V-8

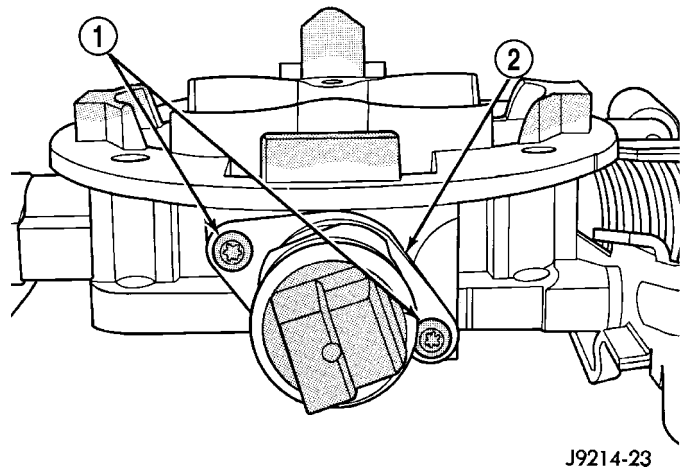
The IAC motor is located on the back of the throttle body (Fig. 22).

- (1) Remove air resonator box at throttle body.
- (2) Disconnect electrical connector from IAC motor.
- (3) Remove two mounting bolts (screws) (Fig. 22).
- (4) Remove IAC motor from throttle body.

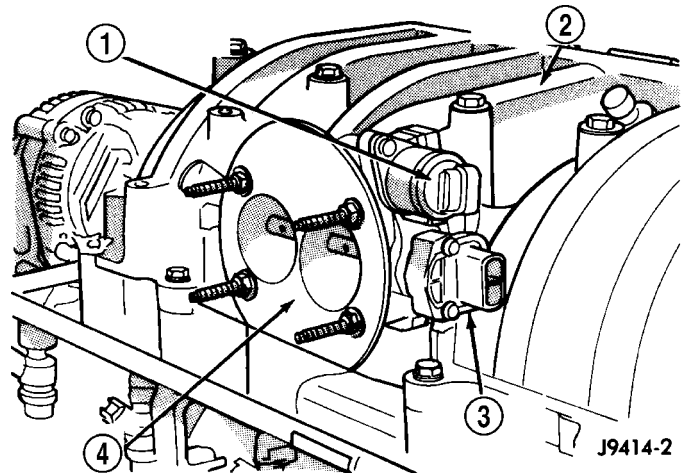
8.0L V-10

The IAC motor is located on the back of the throttle body (Fig. 23).

- (1) Remove the air cleaner cover.
- (2) Remove the 4 air cleaner housing mounting nuts and remove housing from throttle body.
- (3) Disconnect electrical connector from IAC motor.
- (4) Remove two mounting bolts (screw).
- (5) Remove IAC motor from throttle body.

**Fig. 22 IDLE AIR CONTROL MOTOR - 5.9L V-8**

- 1 - MOUNTING SCREWS
- 2 - IDLE AIR CONTROL MOTOR

**Fig. 23 IAC MOTOR - 8.0L V-10**

- 1 - IDLE AIR CONTROL MOTOR
- 2 - INTAKE MANIFOLD (UPPER HALF)
- 3 - THROTTLE POSITION SENSOR
- 4 - THROTTLE BODY

INSTALLATION**3.7L V-6**

The Idle Air Control (IAC) motor is located on the side of the throttle body (Fig. 20).

- (1) Install IAC motor to throttle body.
- (2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
- (3) Install electrical connector.
- (4) Install air resonator to throttle body.

4.7L V-8

The Idle Air Control (IAC) motor is located on the side of the throttle body (Fig. 21).

- (1) Install IAC motor to throttle body.

IDLE AIR CONTROL MOTOR (Continued)

- (2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
- (3) Install electrical connector.
- (4) Install air resonator to throttle body.

5.7L V-8

The IAC motor is not serviceable on the 5.7L V-8 engine.

5.9L V-8

The IAC motor is located on the back of the throttle body (Fig. 22).

- (1) Install IAC motor to throttle body.
- (2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
- (3) Install electrical connector.
- (4) Install air resonator to throttle body.

8.0L V-10

The IAC motor is located on the back of the throttle body (Fig. 23).

- (1) Install IAC motor to throttle body.
- (2) Install and tighten two mounting bolts (screws) to 7 N·m (60 in. lbs.) torque.
- (3) Install electrical connector.
- (4) Install air cleaner housing to throttle body.
- (5) Install 4 air cleaner housing mounting nuts. Tighten nuts to 11 N·m (96 in. lbs.) torque.
- (6) Install air cleaner housing cover.

INTAKE AIR TEMPERATURE SENSOR

DESCRIPTION

The 2-wire Intake Manifold Air Temperature (IAT) sensor is installed in the intake manifold with the sensor element extending into the air stream.

The IAT sensor is a two-wire Negative Thermal Coefficient (NTC) sensor. Meaning, as intake manifold temperature increases, resistance (voltage) in the sensor decreases. As temperature decreases, resistance (voltage) in the sensor increases.

OPERATION

The IAT sensor provides an input voltage to the Powertrain Control Module (PCM) indicating the density of the air entering the intake manifold based upon intake manifold temperature. At key-on, a 5-volt power circuit is supplied to the sensor from the PCM. The sensor is grounded at the PCM through a low-noise, sensor-return circuit.

The PCM uses this input to calculate the following:

- Injector pulse-width

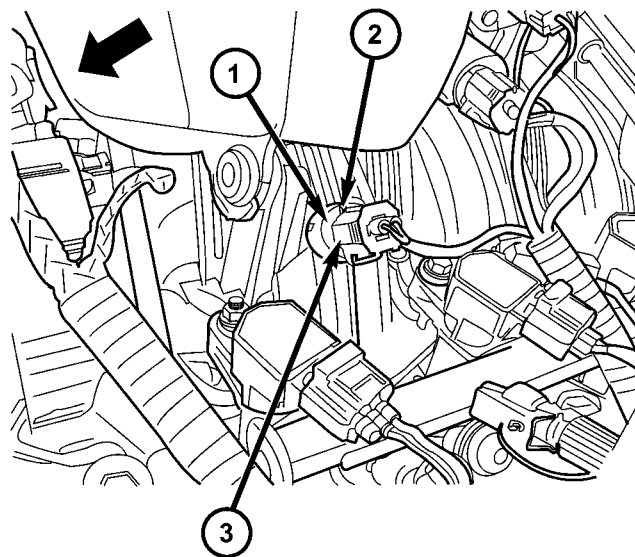
- Adjustment of spark timing (to help prevent spark knock with high intake manifold air-charge temperatures)

The resistance values of the IAT sensor is the same as for the Engine Coolant Temperature (ECT) sensor.

REMOVAL**3.7L V-6**

The intake manifold air temperature (IAT) sensor is installed into the left side of intake manifold plenum (Fig. 24).

- (1) Disconnect electrical connector from IAT sensor.
- (2) Clean dirt from intake manifold at sensor base.
- (3) Gently lift on small plastic release tab (Fig. 24) or (Fig. 25) and rotate sensor about 1/4 turn counter-clockwise for removal.
- (4) Check condition of sensor o-ring.



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Fig. 24 IAT SENSOR LOCATION - 3.7L V-6

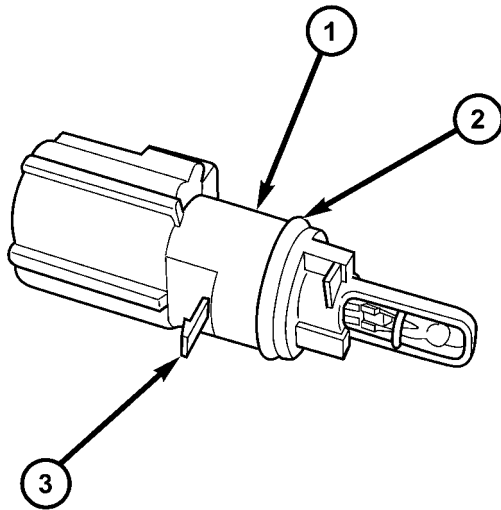
- 1 - IAT SENSOR
- 2 - RELEASE TAB
- 3 - ELECTRICAL CONNECTOR

4.7L V-8

The intake manifold air temperature (IAT) sensor is installed into the left side of intake manifold plenum (Fig. 26).

- (1) Disconnect electrical connector from IAT sensor.
- (2) Clean dirt from intake manifold at sensor base.
- (3) Gently lift on small plastic release tab (Fig. 25) or (Fig. 26) and rotate sensor about 1/4 turn counter-clockwise for removal.

INTAKE AIR TEMPERATURE SENSOR (Continued)

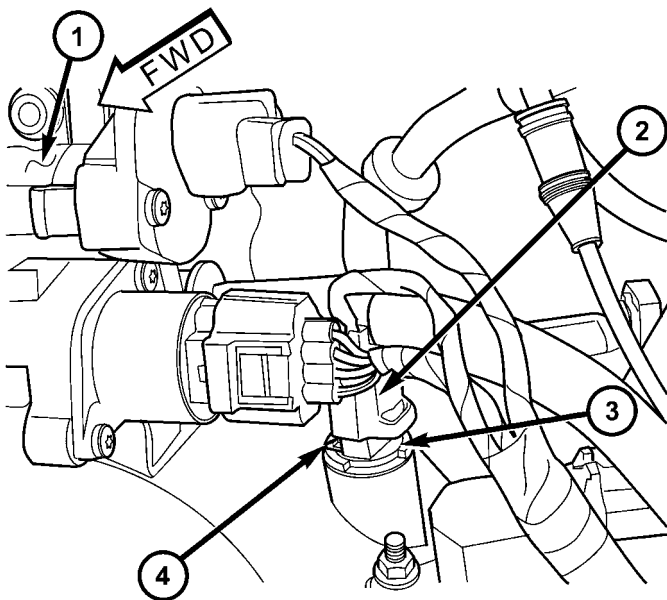


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Fig. 25 IAT SENSOR TAB / O-RING - 3.7L V-6/4.7L V-8/5.7L V-8

- 1 - IAT SENSOR
- 2 - SENSOR O-RING
- 3 - RELEASE TAB

(4) Check condition of sensor o-ring.



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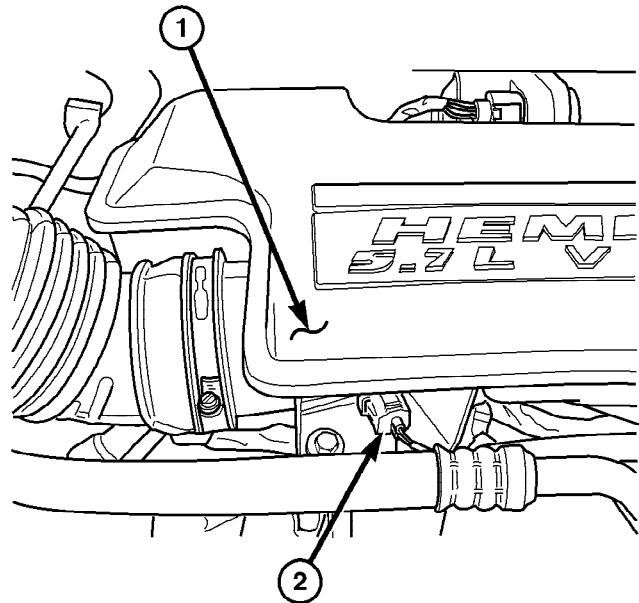
Fig. 26 IAT SENSOR - 4.7L V-8

- 1 - LEFT SIDE OF THROTTLE BODY
- 2 - ELEC. CONNECT.
- 3 - IAT SENSOR
- 4 - RELEASE TAB

5.7L V-8

The intake manifold air temperature (IAT) sensor is installed into the front of the intake manifold air box plenum (Fig. 27).

- (1) Disconnect electrical connector from IAT sensor (Fig. 27).
- (2) Clean dirt from intake manifold at sensor base.
- (3) Gently lift on small plastic release tab (Fig. 25) or (Fig. 28) and rotate sensor about 1/4 turn counter-clockwise for removal.
- (4) Check condition of sensor o-ring.



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Fig. 27 5.7L IAT SENSOR LOCATION

- 1 - FRONT OF INTAKE MANIFOLD PLENUM
- 2 - IAT ELECTRICAL CONNECTOR

5.9L

The intake manifold air temperature sensor is located in the front/side of the intake manifold (Fig. 29).

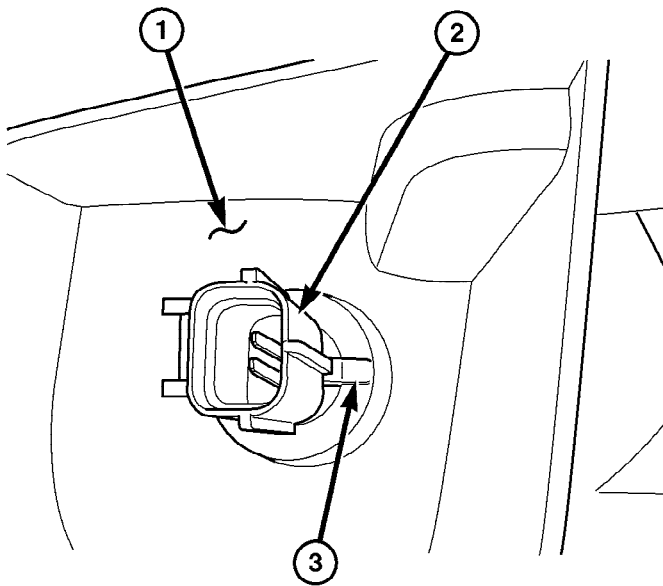
- (1) Clean dirt from intake manifold at sensor base.
- (2) Disconnect electrical connector at sensor (Fig. 29).
- (3) Remove sensor from intake manifold.

8.0L V-10

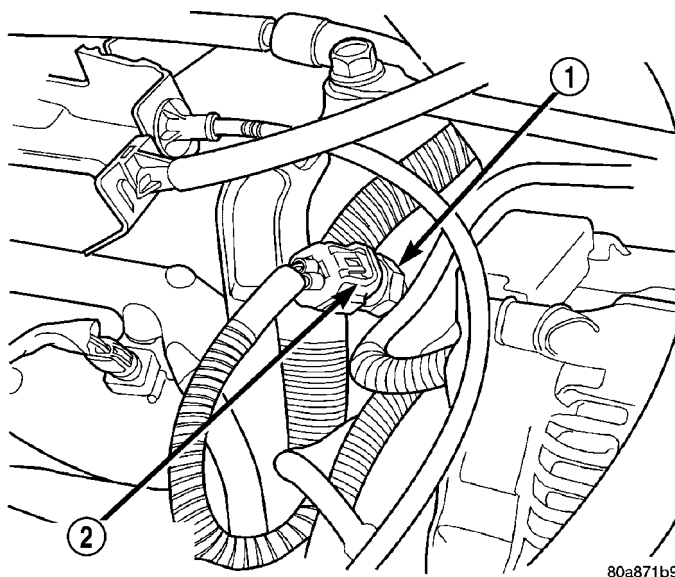
The intake manifold air temperature sensor is located in the side of the intake manifold near the front of throttle body (Fig. 30).

- (1) Disconnect electrical connector at sensor.
- (2) Remove sensor from intake manifold.

INTAKE AIR TEMPERATURE SENSOR (Continued)

**Fig. 28 5.7L IAT SENSOR R/I**

- 1 - FRONT OF INTAKE MANIFOLD PLENUM
- 2 - IAT SENSOR
- 3 - RELEASE TAB

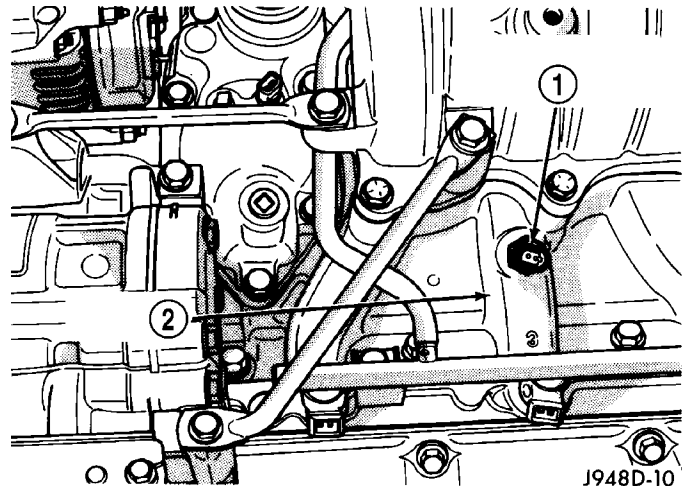
**Fig. 29 IAT SENSOR LOCATION - 5.9L**

- 1 - INTAKE MANIFOLD AIR TEMPERATURE SENSOR
- 2 - ELECTRICAL CONNECTOR

INSTALLATION**3.7L V-6**

The intake manifold air temperature (IAT) sensor is installed into the left side of intake manifold plenum (Fig. 24).

- (1) Check condition of sensor o-ring.

**Fig. 30 AIR TEMPERATURE SENSOR - 8.0L V-10**

- 1 - INTAKE MANIFOLD AIR TEMP. SENSOR
- 2 - INTAKE MANIFOLD

- (2) Clean sensor mounting hole in intake manifold.
- (3) Position sensor into intake manifold and rotate clockwise until past release tab (Fig. 24).
- (4) Install electrical connector.

4.7L V-8

The intake manifold air temperature (IAT) sensor is installed into the left side of intake manifold plenum (Fig. 26).

- (1) Check condition of sensor o-ring.
- (2) Clean sensor mounting hole in intake manifold.
- (3) Position sensor into intake manifold and rotate clockwise until past release tab.
- (4) Install electrical connector.

5.7L V-8

The intake manifold air temperature (IAT) sensor is installed into the front of the intake manifold air box plenum (Fig. 27).

- (1) Check condition of sensor o-ring.
- (2) Clean sensor mounting hole in intake manifold.
- (3) Position sensor into intake manifold and rotate clockwise until past release tab.
- (4) Install electrical connector.

5.9L V-8

The intake manifold air temperature sensor is located in the front/side of the intake manifold (Fig. 29).

- (1) Install sensor to intake manifold. Tighten to 12–15 N·m (110–130 in. lbs.) torque.
- (2) Install electrical connector.

8.0L V-10

The intake manifold air temperature sensor is located in the side of the intake manifold near the front of throttle body (Fig. 30).

INTAKE AIR TEMPERATURE SENSOR (Continued)

- (1) Install sensor to intake manifold. Tighten to 12–15 N·m (110–130 in. lbs.) torque.
- (2) Install electrical connector.

MAP SENSOR**DESCRIPTION****3.7L V-6**

The Manifold Absolute Pressure (MAP) sensor is mounted into the front of the intake manifold with 2 screws.

4.7L V-8

The Manifold Absolute Pressure (MAP) sensor is mounted into the front of the intake manifold with 2 screws.

5.7L V-8

The Manifold Absolute Pressure (MAP) sensor is mounted to the front of the intake manifold air plenum box.

5.9L V-8

The Manifold Absolute Pressure (MAP) sensor is mounted to the front of the throttle body with 2 screws.

8.0L V-10

The Manifold Absolute Pressure (MAP) sensor is mounted into the right side of the intake manifold.

OPERATION

The MAP sensor is used as an input to the Powertrain Control Module (PCM). It contains a silicon based sensing unit to provide data on the manifold vacuum that draws the air/fuel mixture into the combustion chamber. The PCM requires this information to determine injector pulse width and spark advance. When manifold absolute pressure (MAP) equals Barometric pressure, the pulse width will be at maximum.

A 5 volt reference is supplied from the PCM and returns a voltage signal to the PCM that reflects manifold pressure. The zero pressure reading is 0.5V and full scale is 4.5V. For a pressure swing of 0–15 psi, the voltage changes 4.0V. To operate the sensor, it is supplied a regulated 4.8 to 5.1 volts. Ground is provided through the low-noise, sensor return circuit at the PCM.

The MAP sensor input is the number one contributor to fuel injector pulse width. The most important function of the MAP sensor is to determine barometric pressure. The PCM needs to know if the vehicle is at sea level or at a higher altitude, because the air

density changes with altitude. It will also help to correct for varying barometric pressure. Barometric pressure and altitude have a direct inverse correlation; as altitude goes up, barometric goes down. At key-on, the PCM powers up and looks at MAP voltage, and based upon the voltage it sees, it knows the current barometric pressure (relative to altitude). Once the engine starts, the PCM looks at the voltage again, continuously every 12 milliseconds, and compares the current voltage to what it was at key-on. The difference between current voltage and what it was at key-on, is manifold vacuum.

During key-on (engine not running) the sensor reads (updates) barometric pressure. A normal range can be obtained by monitoring a known good sensor.

As the altitude increases, the air becomes thinner (less oxygen). If a vehicle is started and driven to a very different altitude than where it was at key-on, the barometric pressure needs to be updated. Any time the PCM sees Wide Open Throttle (WOT), based upon Throttle Position Sensor (TPS) angle and RPM, it will update barometric pressure in the MAP memory cell. With periodic updates, the PCM can make its calculations more effectively.

The PCM uses the MAP sensor input to aid in calculating the following:

- Manifold pressure
- Barometric pressure
- Engine load
- Injector pulse-width
- Spark-advance programs
- Shift-point strategies (certain automatic transmissions only)
- Idle speed
- Decel fuel shutoff

The MAP sensor signal is provided from a single piezoresistive element located in the center of a diaphragm. The element and diaphragm are both made of silicone. As manifold pressure changes, the diaphragm moves causing the element to deflect, which stresses the silicone. When silicone is exposed to stress, its resistance changes. As manifold vacuum increases, the MAP sensor input voltage decreases proportionally. The sensor also contains electronics that condition the signal and provide temperature compensation.

The PCM recognizes a decrease in manifold pressure by monitoring a decrease in voltage from the reading stored in the barometric pressure memory cell. The MAP sensor is a linear sensor; meaning as pressure changes, voltage changes proportionately. The range of voltage output from the sensor is usually between 4.6 volts at sea level to as low as 0.3 volts at 26 in. of Hg. Barometric pressure is the pressure exerted by the atmosphere upon an object. At sea level on a standard day, no storm, barometric

MAP SENSOR (Continued)

pressure is approximately 29.92 in Hg. For every 100 feet of altitude, barometric pressure drops 0.10 in. Hg. If a storm goes through, it can change barometric pressure from what should be present for that altitude. You should know what the average pressure and corresponding barometric pressure is for your area.

REMOVAL

3.7L V-6

The Manifold Absolute Pressure (MAP) sensor is mounted into the front of the intake manifold (Fig. 31). An o-ring is used to seal the sensor to the intake manifold (Fig. 32).

- (1) Disconnect electrical connector at sensor.
- (2) Clean area around MAP sensor.
- (3) Remove 2 sensor mounting screws.
- (4) Remove MAP sensor from intake manifold.
- (5) Check condition of sensor o-ring (Fig. 32).

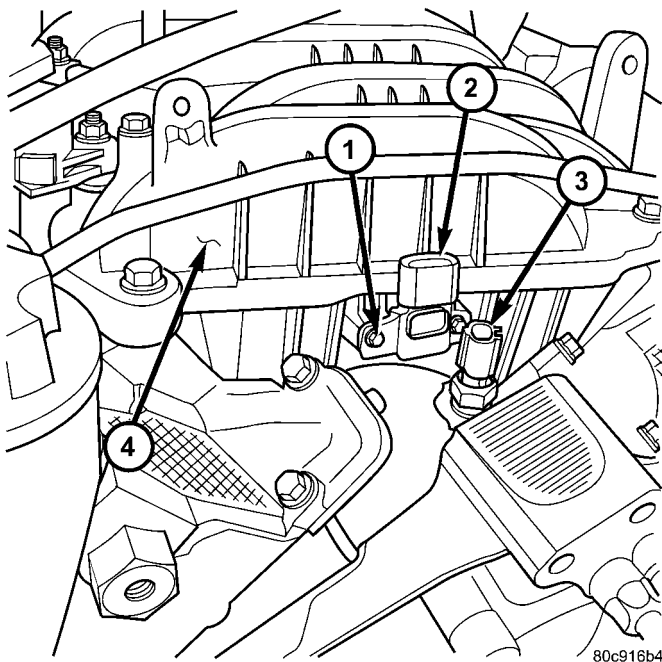


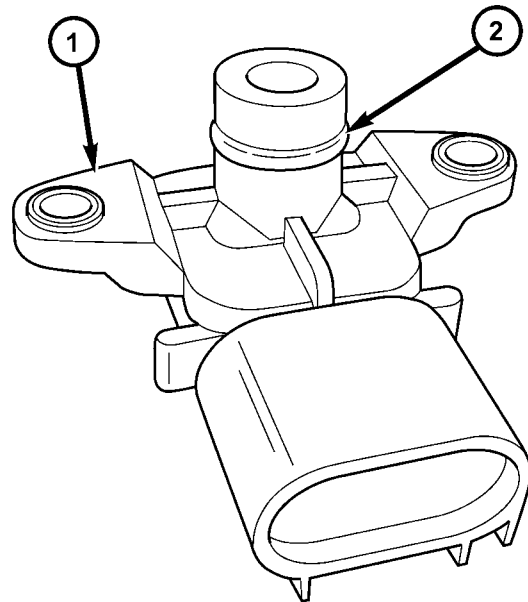
Fig. 31 MAP SENSOR - 3.7L V-6

- 1 - MOUNTING SCREWS
- 2 - MAP SENSOR
- 3 - ECT SENSOR
- 4 - FRONT OF INTAKE MANIFOLD

4.7L V-8

The MAP sensor is located on the front of the intake manifold (Fig. 33). An o-ring seals the sensor to the intake manifold.

- (1) Disconnect electrical connector at sensor.
- (2) Clean area around MAP sensor.
- (3) Remove 2 sensor mounting bolts (Fig. 33).
- (4) Remove MAP sensor from intake manifold.

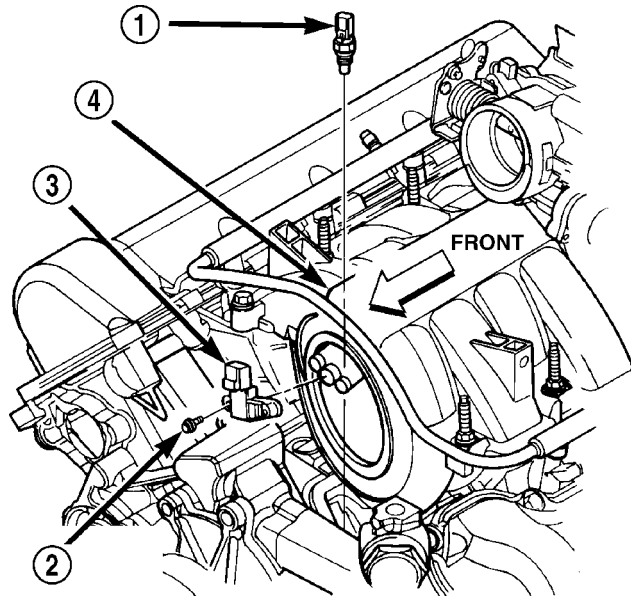


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Fig. 32 MAP SENSOR O-RING 3.7L / 4.7L

- 1 - MAP SENSOR
- 2 - O-RING

- (5) Check condition of sensor o-ring (Fig. 32).



80b898f8

Fig. 33 MAP SENSOR - 4.7L V-8

- 1 - ECT SENSOR
- 2 - MOUNTING BOLTS (2)
- 3 - MAP SENSOR
- 4 - INTAKE MANIFOLD

MAP SENSOR (Continued)

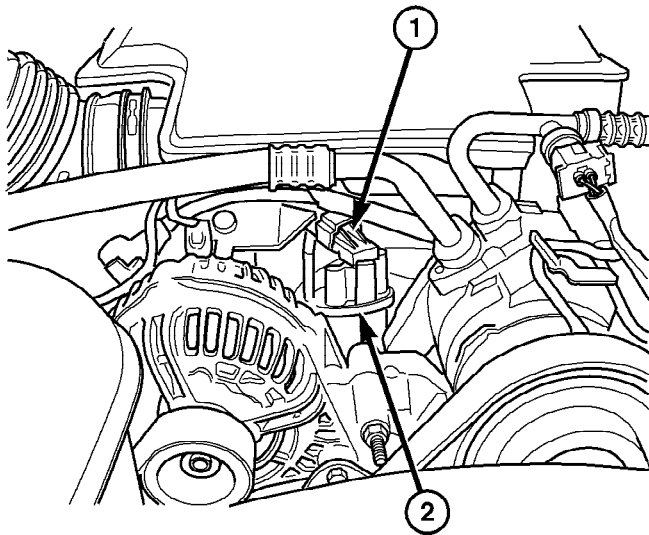
5.7L V-8

The Manifold Absolute Pressure (MAP) sensor is mounted to the front of the intake manifold air plenum box (Fig. 34).

(1) Disconnect electrical connector at sensor by sliding release lock out (Fig. 35). Press down on lock tab for removal.

(2) Rotate sensor 1/4 turn counter-clockwise for removal.

(3) Check condition of sensor o-ring.



80125908

Fig. 34 5.7L MAP SENSOR LOCATION

- 1 - MAP SENSOR
2 - FRONT OF INTAKE MANIFOLD

5.9L V-8

The MAP sensor is located on the front of the throttle body (Fig. 36). An L-shaped rubber fitting is used to connect the MAP sensor to throttle body (Fig. 37).

(1) Clean area around MAP sensor.

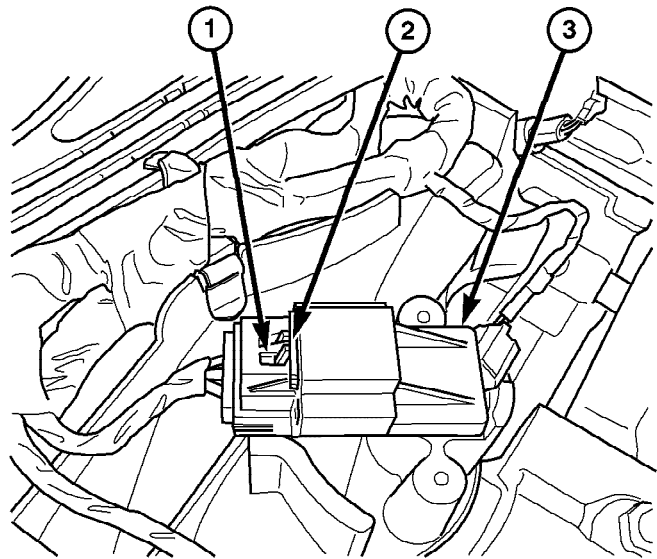
(2) Remove two MAP sensor mounting bolts (screws) (Fig. 36).

(3) While removing MAP sensor, slide the vacuum rubber L-shaped fitting (Fig. 37) from the throttle body.

(4) Remove rubber L-shaped fitting from MAP sensor.

8.0L V-10

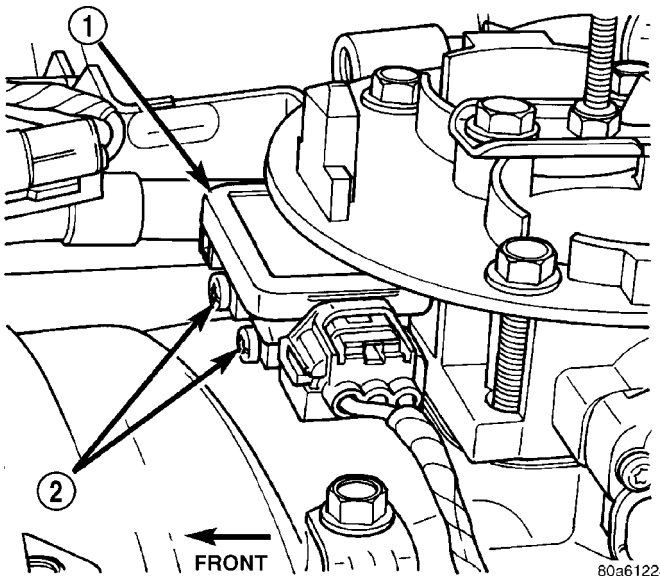
The MAP sensor is mounted into the right upper side of intake manifold (Fig. 38). A rubber gasket is used to seal sensor to intake manifold. The rubber gasket is part of sensor and is not serviced separately.



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Fig. 35 5.7L MAP SENSOR R/I

- 1 - PRESS DOWN
2 - SLIDE RELEASE LOCK
3 - MAP SENSOR



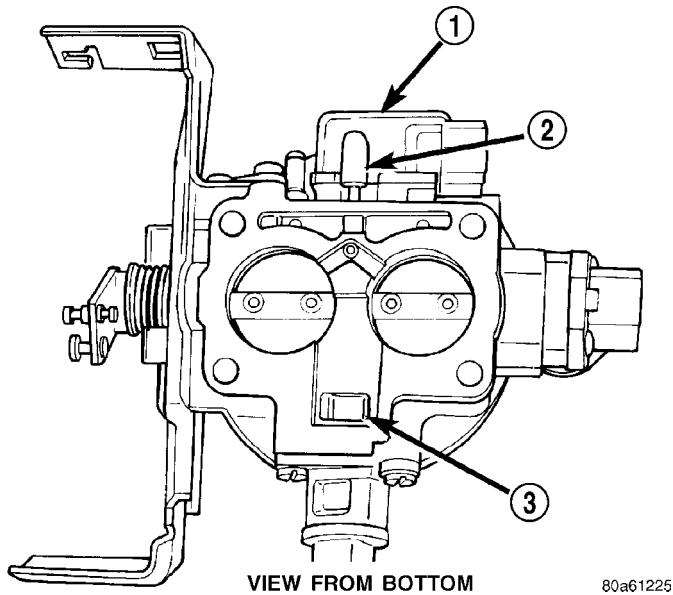
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Fig. 36 MAP SENSOR - 5.9L V-8

- 1 - MAP SENSOR
2 - MOUNTING SCREWS (2)

- (1) Remove electrical connector at sensor.
(2) Clean area around sensor before removal.
(3) Remove two sensor mounting bolts.
(4) Remove sensor from intake manifold.

MAP SENSOR (Continued)



**Fig. 37 MAP SENSOR L-SHAPED RUBBER FITTING
- 5.9L V-8**

- 1 - MAP SENSOR
- 2 - RUBBER FITTING
- 3 - IDLE AIR PASSAGE

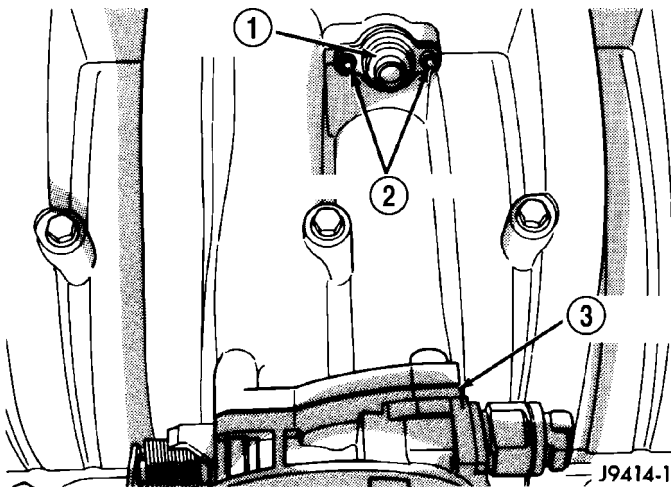


Fig. 38 MAP SENSOR LOCATION - 8.0L V-10

- 1 - MAP SENSOR
- 2 - MOUNTING BOLTS
- 3 - THROTTLE BODY

INSTALLATION

3.7L V-6

The Manifold Absolute Pressure (MAP) sensor is mounted into the front of the intake manifold (Fig. 31). An o-ring is used to seal the sensor to the intake manifold (Fig. 32).

- (1) Clean MAP sensor mounting hole at intake manifold.
- (2) Check MAP sensor o-ring seal for cuts or tears.
- (3) Position sensor into manifold.

- (4) Install MAP sensor mounting bolts (screws). Refer to Torque Specifications.
- (5) Connect electrical connector.

4.7L V-8

The MAP sensor is located on the front of the intake manifold (Fig. 33). An o-ring seals the sensor to the intake manifold (Fig. 32).

- (1) Clean MAP sensor mounting hole at intake manifold.
- (2) Check MAP sensor o-ring seal for cuts or tears.
- (3) Position sensor into manifold.
- (4) Install MAP sensor mounting bolts (screws). Refer to Torque Specifications.
- (5) Connect electrical connector.

5.7L V-8

The Manifold Absolute Pressure (MAP) sensor is mounted to the front of the intake manifold air plenum box (Fig. 34).

- (1) Clean MAP sensor mounting hole at intake manifold.
- (2) Check MAP sensor o-ring seal for cuts or tears.
- (3) Position sensor into manifold.
- (4) Rotate sensor 1/4 turn clockwise for installation.
- (5) Connect electrical connector.

5.9L V-8

The MAP sensor is located on the front of the throttle body (Fig. 36). An L-shaped rubber fitting is used to connect the MAP sensor to throttle body (Fig. 37).

- (1) Install rubber L-shaped fitting to MAP sensor.
- (2) Position sensor to throttle body while guiding rubber fitting over throttle body vacuum nipple.
- (3) Install MAP sensor mounting bolts (screws). Refer to Torque Specifications.
- (4) Install air resonator box.

8.0L V-10

The MAP sensor is mounted into the right upper side of intake manifold (Fig. 38). A rubber gasket is used to seal sensor to intake manifold. The rubber gasket is part of sensor and is not serviced separately.

- (1) Check condition of sensor seal. Clean sensor and lubricate rubber gasket with clean engine oil.
- (2) Clean sensor opening in intake manifold.
- (3) Install sensor into intake manifold.
- (4) Install sensor mounting bolts. Refer to Torque Specifications.
- (5) Install electrical connector to sensor.

OXYGEN SENSOR

DESCRIPTION

The Oxygen Sensors (O2S) are attached to, and protrude into the vehicle exhaust system. Depending on the engine or emission package, the vehicle may use a total of either 2 or 4 sensors.

Federal Emission Packages : Two sensors are used: upstream (referred to as 1/1) and downstream (referred to as 1/2). With this emission package, the upstream sensor (1/1) is located just before the main catalytic convertor. The downstream sensor (1/2) is located just after the main catalytic convertor.

California Emission Packages: On this emissions package, 4 sensors are used: 2 upstream (referred to as 1/1 and 2/1) and 2 downstream (referred to as 1/2 and 2/2). With this emission package, the right upstream sensor (2/1) is located in the right exhaust downpipe just before the mini-catalytic convertor. The left upstream sensor (1/1) is located in the left exhaust downpipe just before the mini-catalytic convertor. The right downstream sensor (2/2) is located in the right exhaust downpipe just after the mini-catalytic convertor, and before the main catalytic convertor. The left downstream sensor (1/2) is located in the left exhaust downpipe just after the mini-catalytic convertor, and before the main catalytic convertor.

OPERATION

An O2 sensor is a galvanic battery that provides the PCM with a voltage signal (0-1 volt) inversely proportional to the amount of oxygen in the exhaust. In other words, if the oxygen content is low, the voltage output is high; if the oxygen content is high the output voltage is low. The PCM uses this information to adjust injector pulse-width to achieve the 14.7-to-1 air/fuel ratio necessary for proper engine operation and to control emissions.

The O2 sensor must have a source of oxygen from outside of the exhaust stream for comparison. Current O2 sensors receive their fresh oxygen (outside air) supply through the O2 sensor case housing.

Four wires (circuits) are used on each O2 sensor: a 12-volt feed circuit for the sensor heating element; a ground circuit for the heater element; a low-noise sensor return circuit to the PCM, and an input circuit from the sensor back to the PCM to detect sensor operation.

Oxygen Sensor Heater Relay - 5.9L/8.0L: If 4 oxygen sensors are used, a separate heater relay is used to supply voltage to the sensors heating elements for only the 1/2 and 2/2 downstream sensors. Voltage for the other 2 sensor heating elements is supplied directly from the Powertrain Control Mod-

ule (PCM) through a Pulse Width Module (PWM) method.

Pulse Width Module (PWM) - 5.9L/8.0L: Voltage to the O2 sensor heating elements is supplied directly from the Powertrain Control Module (PCM) through two separate Pulse Width Module (PWM) low side drivers. PWM is used on both the upstream and downstream O2 sensors if equipped with a Federal Emissions Package, and only on the 2 upstream sensors (1/1 and 2/1) if equipped with a California Emissions Package. The main objective for a PWM driver is to avoid overheating of the O2 sensor heater element. With exhaust temperatures increasing with time and engine speed, it's not required to have a full-voltage duty-cycle on the O2 heater elements.

To avoid the large simultaneous current surge needed to operate all 4 sensors, power is delayed to the 2 downstream heater elements by the PCM for approximately 2 seconds.

Oxygen Sensor Heater Elements:

The O2 sensor uses a Positive Thermal Co-efficient (PTC) heater element. As temperature increases, resistance increases. At ambient temperatures around 70°F, the resistance of the heating element is approximately 13 ohms. As the sensor's temperature increases, resistance in the heater element increases. This allows the heater to maintain the optimum operating temperature of approximately 930°-1100°F (500°-600° C). Although the sensors operate the same, there are physical differences, due to the environment that they operate in, that keep them from being interchangeable.

Maintaining correct sensor temperature at all times allows the system to enter into closed loop operation sooner. Also, it allows the system to remain in closed loop operation during periods of extended idle.

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

Upstream Sensor - Federal Emissions Package : The upstream sensor (1/1) provides an input voltage to the PCM. The input tells the PCM the oxygen content of the exhaust gas. The PCM uses this information to fine tune fuel delivery to maintain the correct oxygen content at the downstream oxygen sensor. The PCM will change the air/fuel ratio until the upstream sensor inputs a voltage that the PCM has determined will make the downstream sensor output (oxygen content) correct.

The upstream oxygen sensor also provides an input to determine catalytic convertor efficiency.

OXYGEN SENSOR (Continued)

Downstream Sensor - Federal Emissions

Package : The downstream oxygen sensor (1/2) is also used to determine the correct air-fuel ratio. As the oxygen content changes at the downstream sensor, the PCM calculates how much air-fuel ratio change is required. The PCM then looks at the upstream oxygen sensor voltage and changes fuel delivery until the upstream sensor voltage changes enough to correct the downstream sensor voltage (oxygen content).

The downstream oxygen sensor also provides an input to determine catalytic convertor efficiency.

Upstream Sensors - California Emissions

Package : Two upstream sensors are used (1/1 and 2/1). The 1/1 sensor is the first sensor to receive exhaust gases from the #1 cylinder. They provide an input voltage to the PCM. The input tells the PCM the oxygen content of the exhaust gas. The PCM uses this information to fine tune fuel delivery to maintain the correct oxygen content at the downstream oxygen sensors. The PCM will change the air/fuel ratio until the upstream sensors input a voltage that the PCM has determined will make the downstream sensors output (oxygen content) correct.

The upstream oxygen sensors also provide an input to determine mini-catalyst efficiency. Main catalytic convertor efficiency is not calculated with this package.

Downstream Sensors - California Emissions

Package : Two downstream sensors are used (1/2 and 2/2). The downstream sensors are used to determine the correct air-fuel ratio. As the oxygen content changes at the downstream sensor, the PCM calculates how much air-fuel ratio change is required. The PCM then looks at the upstream oxygen sensor voltage, and changes fuel delivery until the upstream sensor voltage changes enough to correct the downstream sensor voltage (oxygen content).

The downstream oxygen sensors also provide an input to determine mini-catalyst efficiency. Main catalytic convertor efficiency is not calculated with this package.

Engines equipped with either a downstream sensor(s), or a post-catalytic sensor, will monitor catalytic convertor efficiency. If efficiency is below emission standards, the Malfunction Indicator Lamp (MIL) will be illuminated and a Diagnostic Trouble Code (DTC) will be set. Refer to Monitored Systems in Emission Control Systems for additional information.

REMOVAL

CAUTION: Never apply any type of grease to the oxygen sensor electrical connector, or attempt any soldering of the sensor wiring harness.

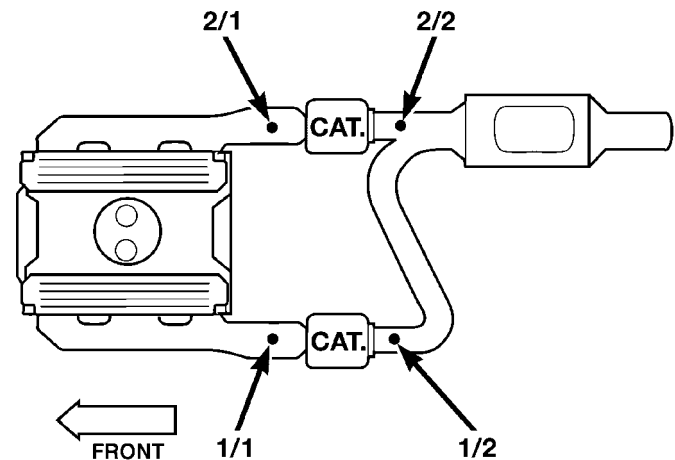
Refer to (Fig. 39) or (Fig. 40) for typical O2S (oxygen sensor) locations.

WARNING: THE EXHAUST MANIFOLD, EXHAUST PIPES AND CATALYTIC CONVERTER BECOME VERY HOT DURING ENGINE OPERATION. ALLOW ENGINE TO COOL BEFORE REMOVING OXYGEN SENSOR.

- (1) Raise and support vehicle.
- (2) Disconnect wire connector from O2S sensor.

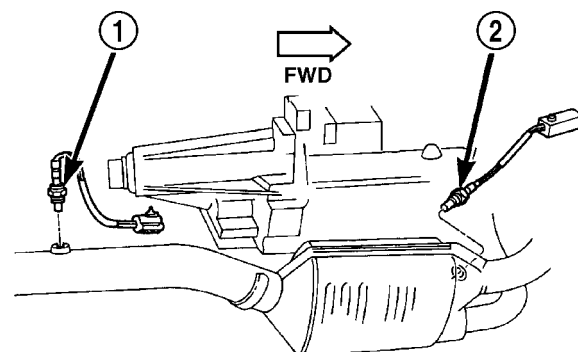
CAUTION: When disconnecting sensor electrical connector, do not pull directly on wire going into sensor.

- (3) Remove O2S sensor with an oxygen sensor removal and installation tool.
- (4) Clean threads in exhaust pipe using appropriate tap.



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Fig. 39 O2 SENSOR SYSTEM - WITH 4 SENSORS



80bfe0e6

Fig. 40 O2 SENSOR SYSTEM - WITH 2 SENSORS

- 1 - POST CATALYST OXYGEN SENSOR (1/3)
- 2 - PRE-CATALYST OXYGEN SENSOR (1/2)

OXYGEN SENSOR (Continued)

INSTALLATION

Threads of new oxygen sensors are factory coated with anti-seize compound to aid in removal. **DO NOT add any additional anti-seize compound to threads of a new oxygen sensor.**

- (1) Install O2S sensor. Tighten to 30 N·m (22 ft. lbs.) torque.
- (2) Connect O2S sensor wire connector.
- (3) Lower vehicle.

THROTTLE BODY

DESCRIPTION

The throttle body is located on the intake manifold. Fuel does not enter the intake manifold through the throttle body. Fuel is sprayed into the manifold by the fuel injectors.

OPERATION

Filtered air from the air cleaner enters the intake manifold through the throttle body. The throttle body contains an air control passage controlled by an Idle Air Control (IAC) motor. The air control passage is used to supply air for idle conditions. A throttle valve (plate) is used to supply air for above idle conditions.

5.7L V-8 Engine:

The throttle body on the 5.7L engine is an electrically controlled unit. A mechanical cable is not used to connect the throttle body to the accelerator pedal. The Accelerator Pedal Position Sensor (APPS) along with inputs from other sensors sets the throttle blade to pre-determined positions.

Except 5.7L V-8 Engine:

Certain sensors are attached to the throttle body. The accelerator pedal cable, speed control cable and transmission control cable (when equipped) are connected to the throttle body linkage arm.

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

REMOVAL

3.7L V-6

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

- (1) Remove air cleaner tube at throttle body.
- (2) Disconnect throttle body electrical connectors at IAC motor and TPS.

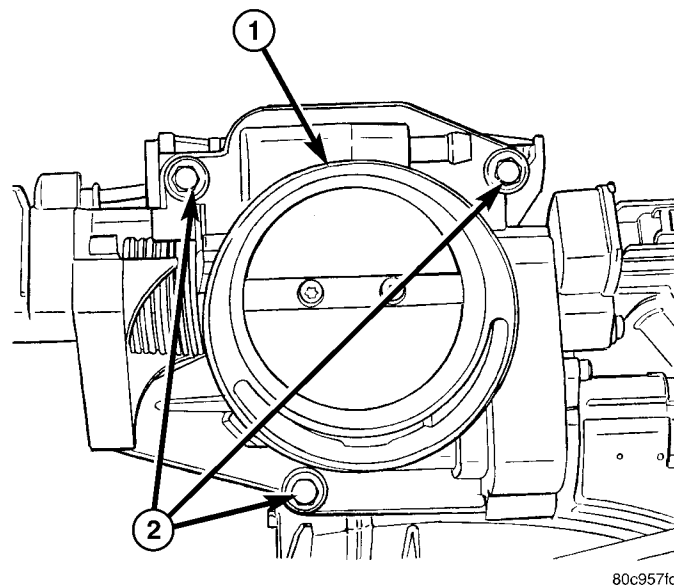
(3) Remove all control cables from throttle body (lever) arm. Refer to the Accelerator Pedal and Throttle Cable section for removal/installation procedures.

(4) Disconnect necessary vacuum lines at throttle body.

(5) Remove 3 throttle body mounting bolts (Fig. 41).

(6) Remove throttle body from intake manifold.

(7) Check condition of old throttle body-to-intake manifold o-ring (Fig. 42).



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Fig. 41 THROTTLE BODY MOUNTING BOLTS - 3.7L V-6

- 1 - THROTTLE BODY
2 - MOUNTING BOLTS (3)

4.7L V-8

(1) Remove air duct and air resonator box at throttle body.

(2) Disconnect throttle body electrical connectors at IAC motor and TPS (Fig. 43).

(3) Remove vacuum line at throttle body.

(4) Remove all control cables from throttle body (lever) arm. Refer to Accelerator Pedal and Throttle Cable.

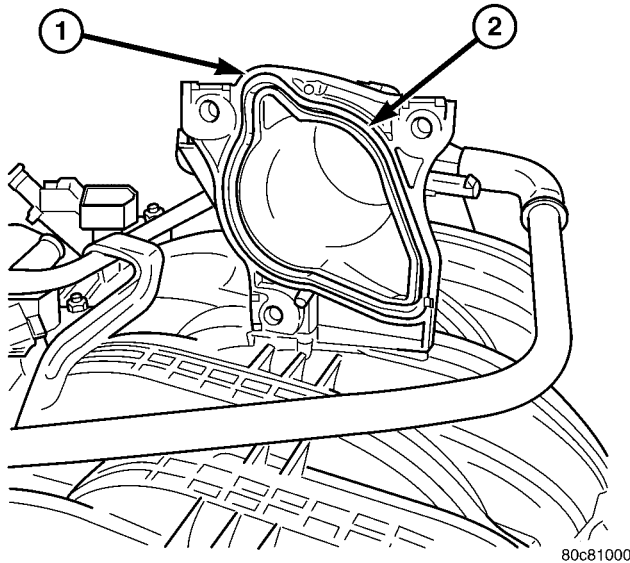
(5) Remove three throttle body mounting bolts (Fig. 43).

(6) Remove throttle body from intake manifold.

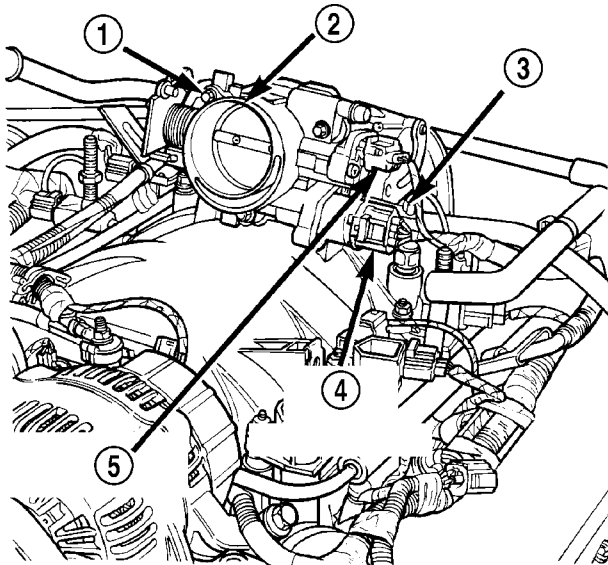
5.7L V-8

CAUTION: Do not use spray (carb) cleaners on any part of the throttle body. Do not apply silicone lubricants to any part of the throttle body.

THROTTLE BODY (Continued)

**Fig. 42 THROTTLE BODY O-RING - 3.7L V-6**

- 1 - INTAKE MANIFOLD
2 - THROTTLE BODY O-RING

**Fig. 43 THROTTLE BODY MOUNTING BOLTS - 4.7L V-8**

- 1 - MOUNTING BOLTS (3)
2 - THROTTLE BODY
3 - IAT SENSOR CONNECTOR
4 - IAC MOTOR CONNECTOR
5 - TPS CONNECTOR

- (1) Remove air duct and air resonator box at throttle body.
- (2) Disconnect electrical connector at throttle body (Fig. 44).
- (3) Remove 4 throttle body mounting bolts (Fig. 44).
- (4) Remove throttle body from intake manifold.

(5) Check condition of throttle body o-ring (Fig. 45).

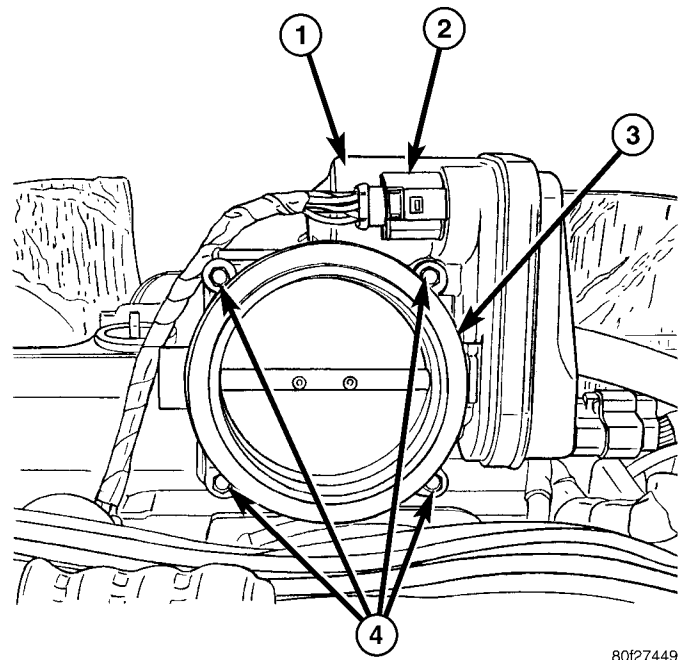
(6) If the throttle body has been changed, the following procedure must be performed:

(a) Disconnect negative battery cable from battery. Leave cable disconnected for approximately 90 seconds.

(b) Reconnect cable to battery.

(c) Turn ignition switch ON, but do not crank engine.

(d) Leave ignition switch ON for a minimum of 10 seconds. This will allow PCM to learn throttle body electrical parameters.

**Fig. 44 5.7L V-8 THROTTLE BODY**

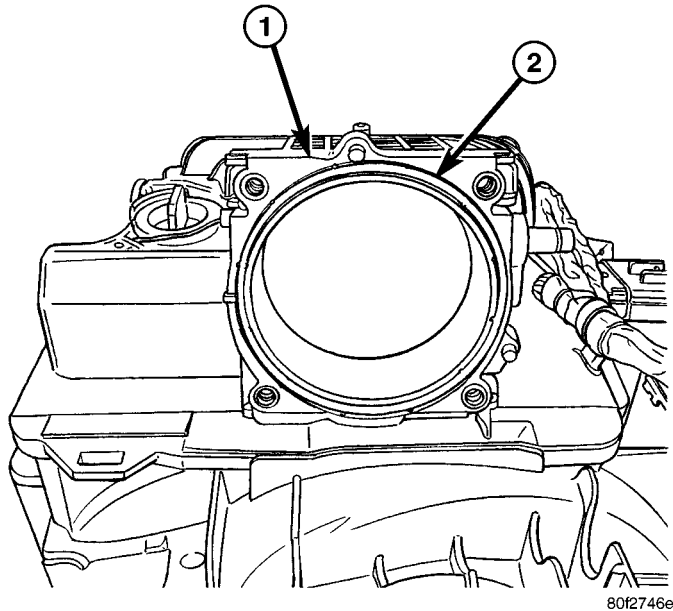
- 1 - THROTTLE BODY
2 - ELECTRICAL CONNECTOR
3 - SILICONE SEAL
4 - MOUNTING BOLTS (4)

5.9L V-8

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

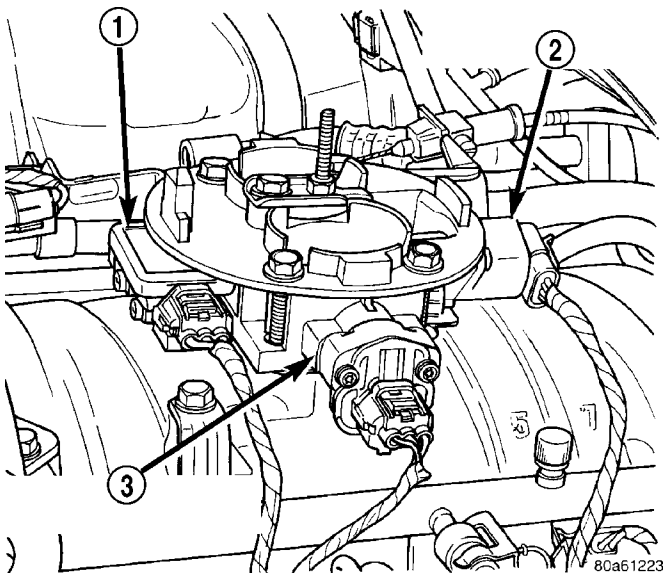
- (1) Remove the air cleaner resonator tube.
- (2) Disconnect throttle body electrical connectors at MAP sensor, IAC motor and TPS (Fig. 46).
- (3) Remove vacuum line at throttle body.
- (4) Remove all control cables from throttle body (lever) arm. Refer to the Accelerator Pedal and Throttle Cable section of this group for additional information.

THROTTLE BODY (Continued)

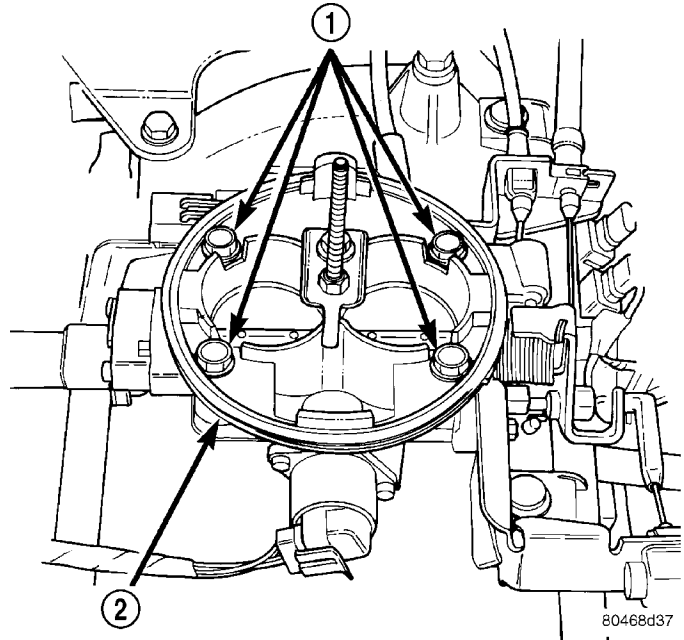
**Fig. 45 5.7L V-8 THROTTLE BODY O-RING**

- 1 - INTAKE MANIFOLD
2 - THROTTLE BODY O-RING

- (5) Remove four throttle body mounting bolts (Fig. 47).
(6) Remove throttle body from intake manifold.
(7) Discard old throttle body-to-intake manifold gasket.

**Fig. 46 SENSOR ELECTRICAL CONNECTORS - 5.9L V-8**

- 1 - MAP SENSOR
2 - IDLE AIR CONTROL MOTOR
3 - THROTTLE POSITION SENSOR

**Fig. 47 THROTTLE BODY MOUNTING BOLTS - 5.9L V-8**

- 1 - THROTTLE BODY MOUNTING BOLTS (4)
2 - THROTTLE BODY

8.0L V-10

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

- (1) Remove air plenum resonator.
- (2) Disconnect throttle body electrical connectors at the IAC motor and TPS.
- (3) Remove all control cables from throttle body (lever) arm. Refer to the Accelerator Pedal and Throttle Cable section of this group for additional information.
- (4) Remove four throttle body mounting nuts (Fig. 48).
- (5) Remove throttle body from intake manifold.
- (6) Discard old throttle body-to-intake manifold gasket.

INSTALLATION**3.7L V-6**

- (1) Check condition of throttle body-to-intake manifold o-ring. Replace as necessary.
- (2) Clean mating surfaces of throttle body and intake manifold.
- (3) Install throttle body-to-intake manifold o-ring.
- (4) Install throttle body to intake manifold.
- (5) Install 3 mounting bolts. Tighten bolts to 12 N·m (105 in. lbs.) torque.

THROTTLE BODY (Continued)

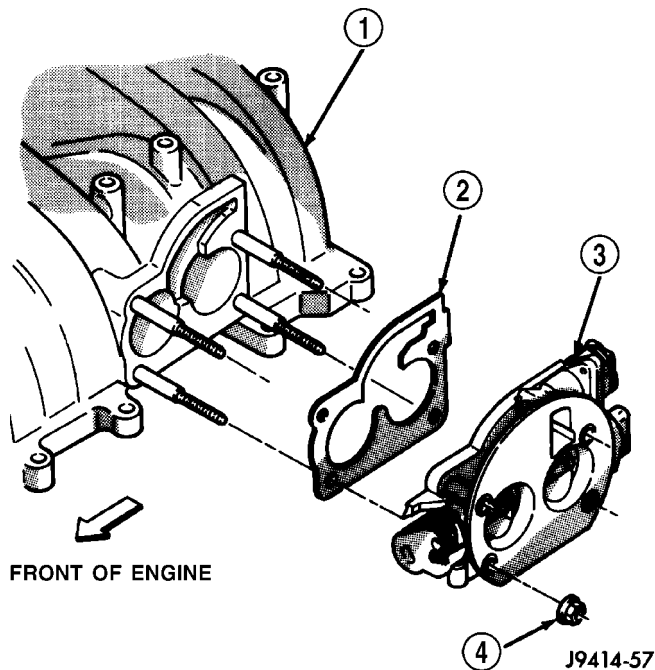


Fig. 48 THROTTLE BODY MOUNTING NUTS - 8.0L V-10

- 1 - INTAKE MANIFOLD UPPER HALF
 2 - GASKET
 3 - THROTTLE BODY
 4 - MOUNTING NUTS (4)

- (6) Install control cables.
- (7) Install electrical connectors.
- (8) Install necessary vacuum lines.
- (9) Install air plenum.

4.7L V-8

- (1) Clean throttle body-to-intake manifold o-ring.
- (2) Clean mating surfaces of throttle body and intake manifold.
- (3) Install throttle body to intake manifold by positioning throttle body to manifold alignment pins.
- (4) Install three mounting bolts. Tighten bolts to 12 N·m (105 in. lbs.) torque.
- (5) Install control cables.
- (6) Install vacuum line to throttle body.
- (7) Install electrical connectors.
- (8) Install air plenum.

5.7L V-8

CAUTION: Do not use spray (carb) cleaners on any part of the throttle body. Do not apply silicone lubricants to any part of the throttle body.

- (1) Clean and check condition of throttle body-to-intake manifold o-ring.
- (2) Clean mating surfaces of throttle body and intake manifold.

(3) Install throttle body to intake manifold by positioning throttle body to manifold alignment pins.

(4) Install 4 mounting bolts. Refer to Torque Specifications.

(5) Install electrical connector.

(6) Install air plenum.

(7) **If the throttle body has been changed, the following procedure must be performed:**

(a) Disconnect negative battery cable from battery. Leave cable disconnected for approximately 90 seconds.

(b) Reconnect cable to battery.

(c) Turn ignition switch ON, but do not crank engine.

(d) Leave ignition switch ON for a minimum of 10 seconds. This will allow PCM to learn throttle body electrical parameters.

5.9L V-8

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

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

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

(3) Install throttle body to intake manifold.

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

(5) Install control cables.

(6) Install vacuum line to throttle body.

(7) Install electrical connectors.

(8) Install air plenum.

8.0L V-10

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

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

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

(3) Install throttle body to intake manifold.

(4) Install four mounting nuts (Fig. 48). Refer to Torque Specifications.

(5) Install control cables.

(6) Install electrical connectors.

(7) Install air plenum and hoses.

THROTTLE CONTROL CABLE

REMOVAL

3.7L V-6

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

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

(2) Remove cable core wire at pedal arm.

(3) From inside vehicle, remove metal clip holding cable to dashpanel (Fig. 1).

(4) Remove air resonator box at throttle body.

(5) Unsnap cable from dashpanel routing clip.

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

(7) Hold throttle in wide open position. While held in this position, slide throttle cable pin (Fig. 49) from throttle body bellcrank.

(8) Using a pick or small screwdriver, press release tab (Fig. 50) to release plastic cable mount from bracket. **Press on tab only enough to release cable from bracket. If tab is pressed too much, it will be broken.** Slide plastic mount (Fig. 50) towards right side of vehicle to remove throttle cable from throttle body bracket.

(9) Remove throttle cable from vehicle.

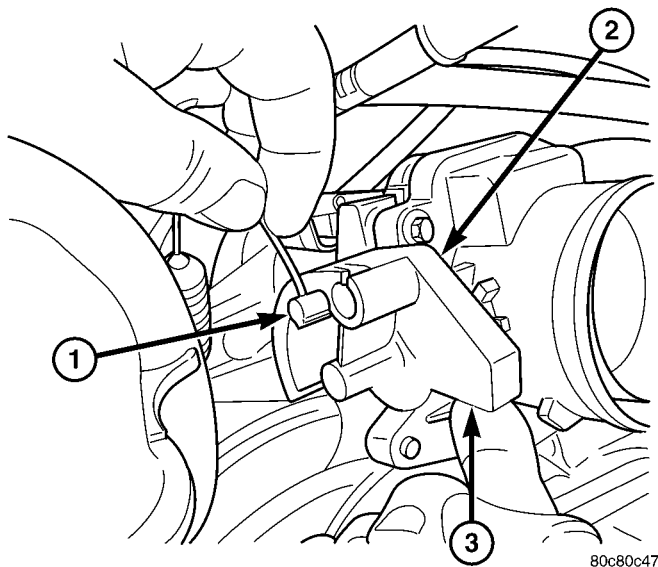


Fig. 49 THROTTLE CABLE PIN - 3.7L V-6

- 1 - THROTTLE CABLE PIN
- 2 - THROTTLE BODY BELLCRANK
- 3 - PUSH UP HERE

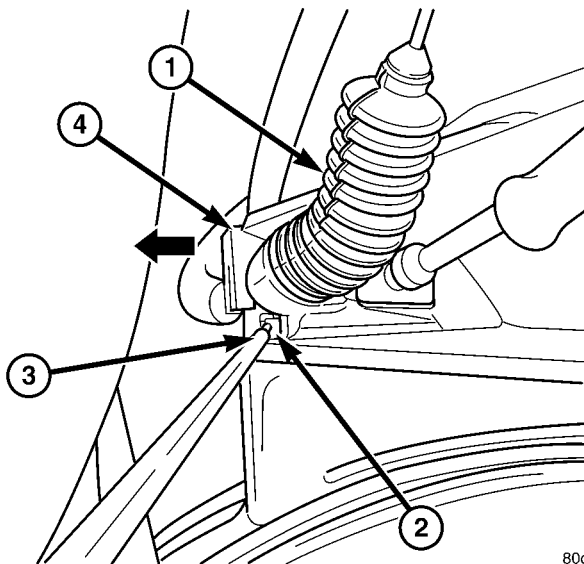


Fig. 50 THROTTLE CABLE RELEASE TAB - 3.7L V-6

- 1 - THROTTLE CABLE
- 2 - RELEASE TAB
- 3 - PICK OR SCREWDRIVER
- 4 - PLASTIC CABLE MOUNT

4.7L V-8

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

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

(2) Remove cable core wire at pedal arm.

(3) From inside vehicle, remove cable clip holding cable to dashpanel (Fig. 1).

(4) Remove air box at throttle body.

(5) Unsnap cable from dashpanel routing clip.

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

(7) Using finger pressure only, disconnect accelerator cable connector at throttle body bellcrank pin by pushing connector off bellcrank pin towards front of vehicle (Fig. 51). **DO NOT try to pull connector off perpendicular to bellcrank pin. Connector will be broken.**

(8) Lift accelerator cable from top of cable cam (Fig. 51).

(9) Press tab (Fig. 52) to release plastic cable mount from bracket. **Press on tab only enough to release cable from bracket. If tab is pressed too much, it will be broken.** Slide plastic mount (Fig. 52) towards passenger side of vehicle to remove cable from bracket.

(10) Remove throttle cable from vehicle.

THROTTLE CONTROL CABLE (Continued)

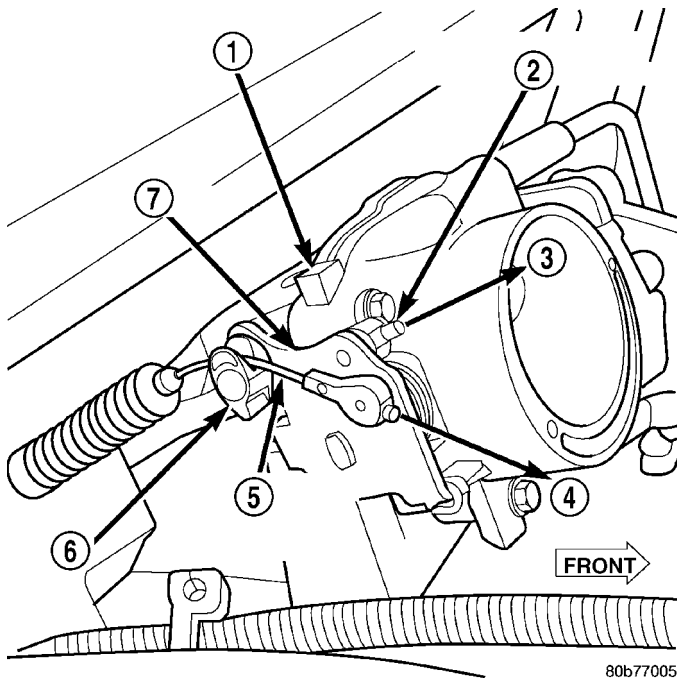


Fig. 51 ACCELERATOR CABLE AT BELL CRANK - 4.7L V-8

- 1 - THROTTLE BODY
- 2 - SPEED CONTROL CABLE CONNECTOR
- 3 - OFF
- 4 - OFF
- 5 - ACCELERATOR CABLE CONNECTOR
- 6 - CABLE CAM
- 7 - BELLCRANK

5.7L V-8

The Throttle Control Cable on the 5.7L V-8 engine connects the accelerator pedal to the Accelerator Pedal Position Sensor (APPS). A separate mechanical cable is not routed to the throttle body.

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

- (1) From inside vehicle, hold up accelerator pedal. Remove plastic cable retainer and throttle cable core wire from upper end of pedal arm (Fig. 1). The plastic cable retainer snaps into pedal arm.
- (2) Remove cable core wire at pedal arm.
- (3) Remove APPS. Refer to Accelerator Pedal Position Sensor (APPS) Removal / Installation.
- (4) From inside vehicle, remove cable clip (Fig. 1).
- (5) Remove cable housing from dash panel and pull cable into engine compartment.
- (6) Remove cable housing at APPS bracket by pressing on release tab with a small screwdriver. **To prevent cable housing breakage, press on tab only enough to release cable from APPS bracket.**

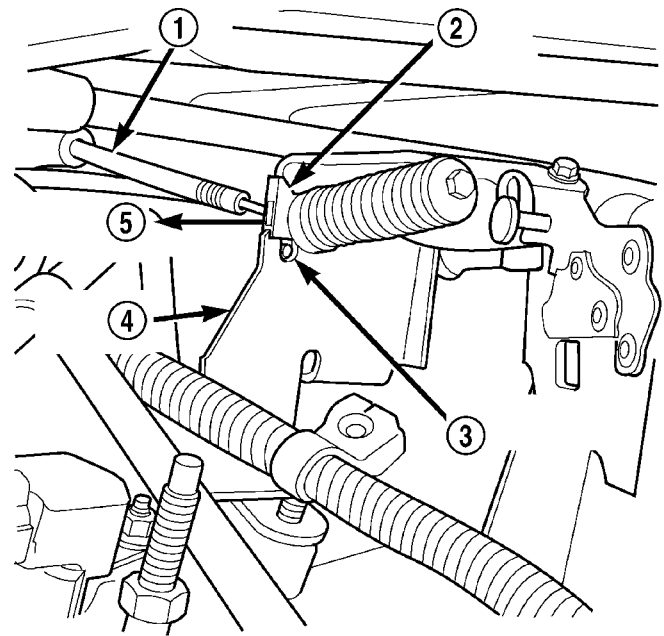


Fig. 52 ACCELERATOR CABLE RELEASE TAB - 4.7L V-8

- 1 - ACCELERATOR CABLE
- 2 - PLASTIC CABLE MOUNT
- 3 - PRESS TAB FOR REMOVAL
- 4 - CABLE BRACKET
- 5 - SLIDE FOR REMOVAL

5.9L V-8

CAUTION: Be careful not to damage or kink cable core wire (within 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. 1). The plastic cable retainer snaps into pedal arm.
- (2) Remove cable core wire at pedal arm.
- (3) Remove air resonator at throttle body.
- (4) From inside vehicle, remove cable clip (Fig. 1).
- (5) Remove cable housing from dash panel and pull cable into engine compartment.
- (6) Disconnect cable from routing/holddown clip.
- (7) Slip cable end rearward from pin on throttle body (Fig. 53).
- (8) Remove cable housing at throttle body mounting bracket by pressing on release tab with a small screwdriver (Fig. 54). **To prevent cable housing breakage, press on tab only enough to release cable from bracket.** Lift cable housing straight up from bracket while pressing on release tab. Remove throttle cable from vehicle.

THROTTLE CONTROL CABLE (Continued)

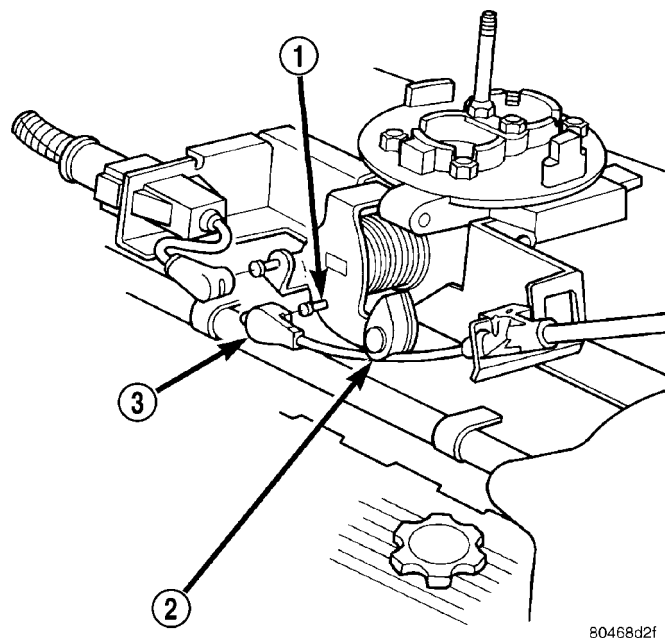


Fig. 53 THROTTLE CABLE AT THROTTLE BODY - 5.9L

- 1 - THROTTLE LEVER PIN
- 2 - CAM (V-8 ENGINE ONLY)
- 3 - THROTTLE CABLE END

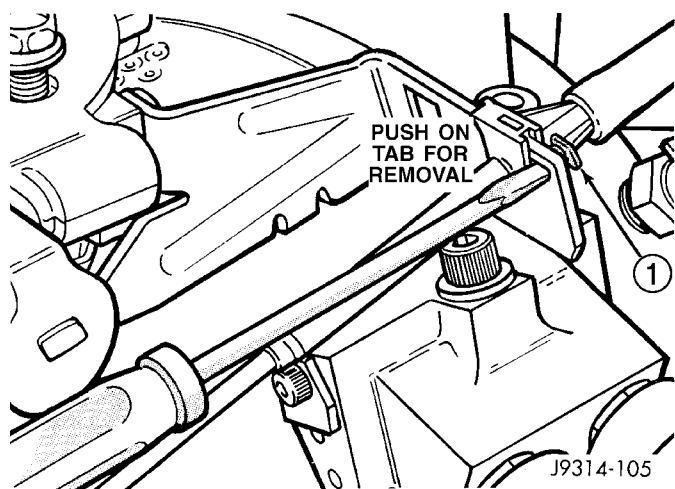


Fig. 54 CABLE RELEASE - 5.9L V-8

- 1 - TAB

8.0L V-10

CAUTION: Be careful not to damage or kink cable core wire (within 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. 1). The plastic cable retainer snaps into pedal arm.

(2) Remove cable core wire at pedal arm.

(3) Remove necessary air intake tubes and resonator housing.

(4) From inside vehicle, pinch both sides of plastic cable housing retainer tabs at dash panel (Fig. 1).

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

(6) Remove throttle cable socket at throttle lever ball (Fig. 55) (snaps off).

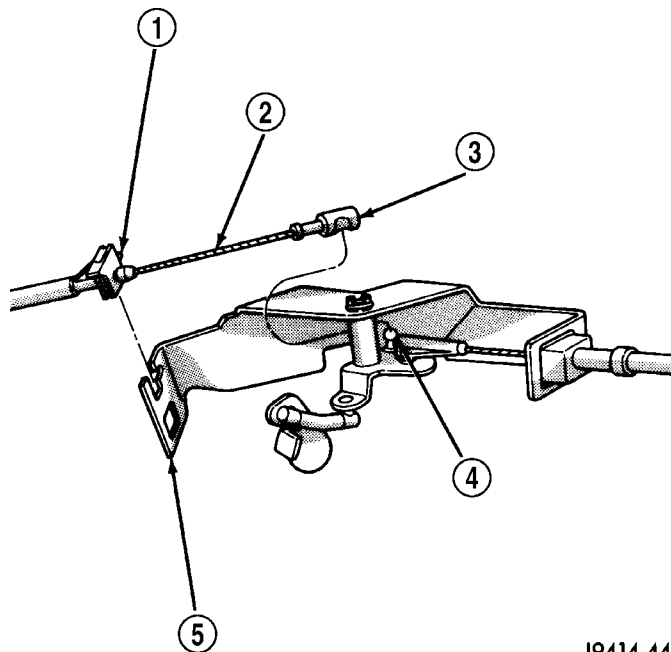


Fig. 55 THROTTLE CABLE AT THROTTLE BODY - 8.0L V-10

- 1 - PRESS TAB FOR CABLE REMOVAL
- 2 - THROTTLE CABLE
- 3 - CABLE SOCKET
- 4 - LEVER BALL
- 5 - MOUNTING BRACKET

(7) Remove cable housing at throttle body mounting bracket by pressing on release tab with a small screwdriver (Fig. 55). **To prevent cable housing breakage, press on tab only enough to release cable from bracket.** Lift cable housing straight up from bracket while pressing on release tab. Remove throttle cable from vehicle.

INSTALLATION

3.7L V-6

(1) Slide accelerator cable plastic mount into throttle body mounting bracket. Continue sliding until release tab (Fig. 50) is aligned to hole in mounting bracket.

(2) Hold throttle in wide open position. While held in this position, slide throttle cable pin (Fig. 49) into throttle body bellcrank.

(3) Push cable housing into rubber grommet and through opening in dash panel.

THROTTLE CONTROL CABLE (Continued)

- (4) From inside vehicle, install metal clip holding cable to dashpanel (Fig. 1).
- (5) From inside vehicle, slide throttle cable core wire into opening (slot) in top of pedal arm.
- (6) Push plastic cable retainer (clip) into pedal arm opening until it snaps in place.
- (7) Install air resonator tube to throttle body.
- (8) Before starting engine, operate accelerator pedal to check for any binding.

4.7L V-8

- (1) Slide accelerator cable plastic mount into bracket. Continue sliding until tab (Fig. 52) is aligned to hole in mounting bracket.
- (2) Route accelerator cable over top of cable cam.
- (3) Connect cable end to throttle body bellcrank pin (snaps on rearward).
- (4) Slide rubber grommet away from plastic cable housing.
- (5) Install rubber grommet into dash panel until seated.
- (6) Push cable housing into rubber grommet and through opening in dash panel.
- (7) From inside vehicle, install clip holding cable to dashpanel (Fig. 1).
- (8) From inside vehicle, slide throttle cable core wire into opening in top of pedal arm.
- (9) Push cable retainer (clip) into pedal arm opening until it snaps in place.
- (10) Snap cable into dashpanel routing clip.
- (11) Install air resonator tube to throttle body.
- (12) Before starting engine, operate accelerator pedal to check for any binding.

5.7L V-8

- (1) Attach cable to Accelerator Pedal Position Sensor (APPS). Refer to APPS Removal / Installation.
- (2) Push cable housing into rubber grommet and through opening in dash panel.
- (3) From inside vehicle, install clip holding cable to dashpanel (Fig. 1).
- (4) From inside vehicle, slide throttle cable core wire into opening in top of pedal arm.
- (5) Push cable retainer (clip) into pedal arm opening until it snaps in place.
- (6) Before starting engine, operate accelerator pedal to check for any binding.
- (7) If necessary, use DRB III® Scan Tool to erase any APPS Diagnostic Trouble Codes (DTC's) from PCM.

5.9L V-8

- (1) Slide accelerator cable plastic mount into throttle body mounting bracket. Continue sliding until release tab (Fig. 54) is aligned to hole in mounting bracket.

- (2) Hold throttle in wide open position. While held in this position, slide throttle cable pin into throttle body bellcrank.

- (3) Push cable housing into rubber grommet and through opening in dash panel.

- (4) From inside vehicle, install metal clip holding cable to dashpanel (Fig. 1).

- (5) From inside vehicle, slide throttle cable core wire into opening (slot) in top of pedal arm.

- (6) Push plastic cable retainer (clip) into pedal arm opening until it snaps in place.

- (7) Install air resonator tube to throttle body.

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

8.0L V-10

- (1) Connect cable end socket to throttle body lever ball (snaps on) (Fig. 55).

- (2) Connect cable to throttle body mounting bracket (push down and lock)

- (3) Install the remaining cable housing end into and through the dash panel opening (snaps into position). The two plastic pinch tabs (Fig. 1) should lock the cable to dash panel.

- (4) From inside the vehicle, hold up the accelerator pedal. Install the throttle cable core wire and plastic cable retainer into and through the upper end of the pedal arm (the plastic retainer is snapped into the pedal arm). When installing the plastic retainer to the accelerator pedal arm, note the index tab on the pedal arm (Fig. 1). Align the index slot on the plastic cable retainer to this index tab.

- (5) Install air resonator tube to throttle body.

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

THROTTLE POSITION SENSOR

DESCRIPTION

The 3-wire Throttle Position Sensor (TPS) is mounted on the throttle body and is connected to the throttle blade shaft.

The 5.7L V-8 engine does not use a separate TPS on the throttle body.

OPERATION

The 5.7L V-8 engine does not use a separate Throttle Position Sensor (TPS) on the throttle body.

The 3-wire TPS provides the Powertrain Control Module (PCM) with an input signal (voltage) that represents the throttle blade position of the throttle body. The sensor is connected to the throttle blade shaft. As the position of the throttle blade changes, the output voltage of the TPS changes.

THROTTLE POSITION SENSOR (Continued)

The PCM supplies approximately 5 volts to the TPS. The TPS output voltage (input signal to the PCM) represents the throttle blade position. The PCM receives an input signal voltage from the TPS. This will vary in an approximate range of from .26 volts at minimum throttle opening (idle), to 4.49 volts at wide open throttle. Along with inputs from other sensors, the PCM uses the TPS input to determine current engine operating conditions. In response to engine operating conditions, the PCM will adjust fuel injector pulse width and ignition timing.

The PCM needs to identify the actions and position of the throttle blade at all times. This information is needed to assist in performing the following calculations:

- Ignition timing advance
- Fuel injection pulse-width
- Idle (learned value or minimum TPS)
- Off-idle (0.06 volt)
- Wide Open Throttle (WOT) open loop (2.608 volts above learned idle voltage)
- Deceleration fuel lean out
- Fuel cutoff during cranking at WOT (2.608 volts above learned idle voltage)
- A/C WOT cutoff (certain automatic transmissions only)

REMOVAL

3.7L V6

The Throttle Position Sensor (TPS) is mounted to the throttle body (Fig. 56), or (Fig. 57).

- (1) Remove air resonator tube at throttle body.
- (2) Disconnect TPS electrical connector.
- (3) Remove 2 TPS mounting screws.
- (4) Remove TPS.

4.7L V-8

The TPS is located on the throttle body (Fig. 58).

- (1) Remove air duct and tube at throttle body.
- (2) Disconnect TPS electrical connector.
- (3) Remove two TPS mounting bolts (screws) (Fig. 58).
- (4) Remove TPS from throttle body.

5.7L V-8

The 5.7L V-8 engine does not use a separate Throttle Position Sensor (TPS) on the throttle body.

5.9L V-8

The TPS is located on the side of the throttle body (Fig. 59).

- (1) Remove air intake tube at throttle body.
- (2) Disconnect TPS electrical connector.
- (3) Remove two TPS mounting bolts (Fig. 59).
- (4) Remove TPS from throttle body.

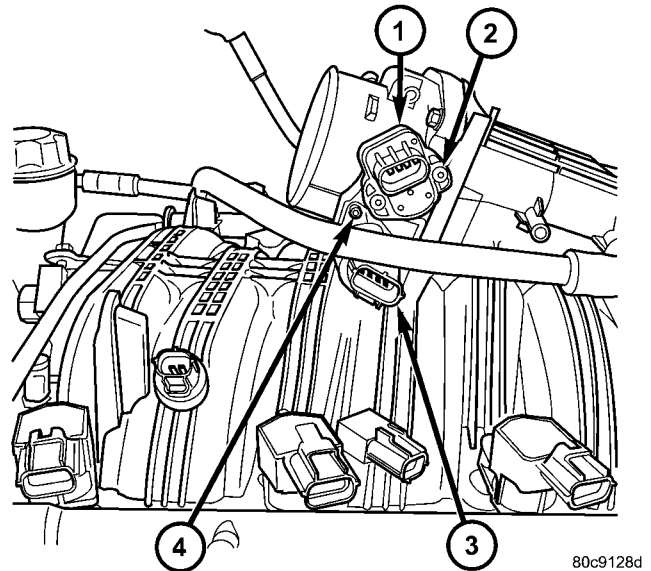


Fig. 56 TPS LOCATION - 3.7L V-6

- 1 - THROTTLE POSITION SENSOR (TPS)
- 2 - MOUNTING SCREWS
- 3 - IDLE AIR CONTROL MOTOR (IAC)
- 4 - MOUNTING SCREWS

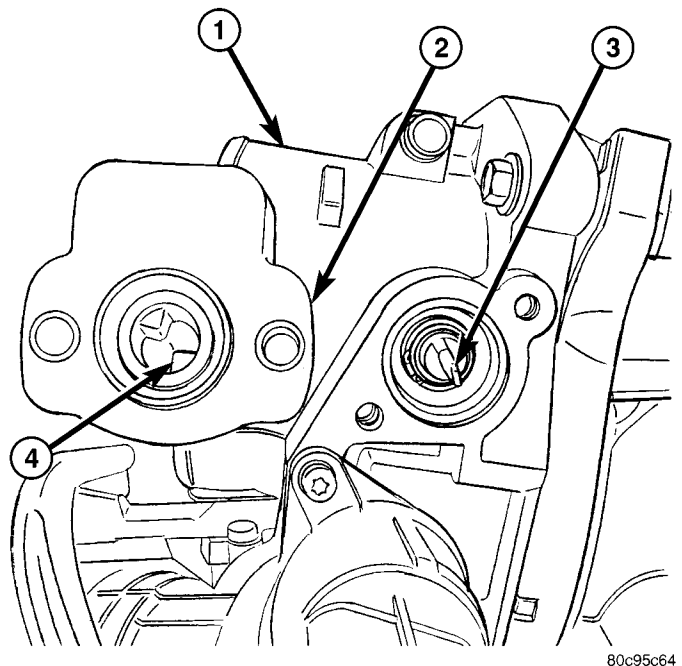


Fig. 57 TPS INSTALLATION - 3.7 V-6

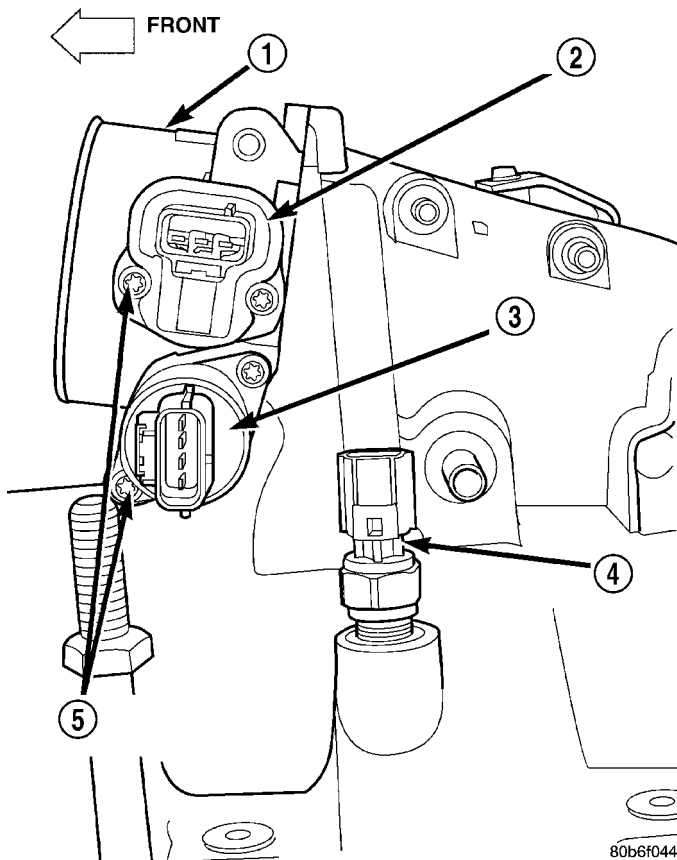
- 1 - THROTTLE BODY
- 2 - TPS
- 3 - THROTTLE BODY SHAFT
- 4 - SOCKET LOCATING TANGS

8.0L V-10

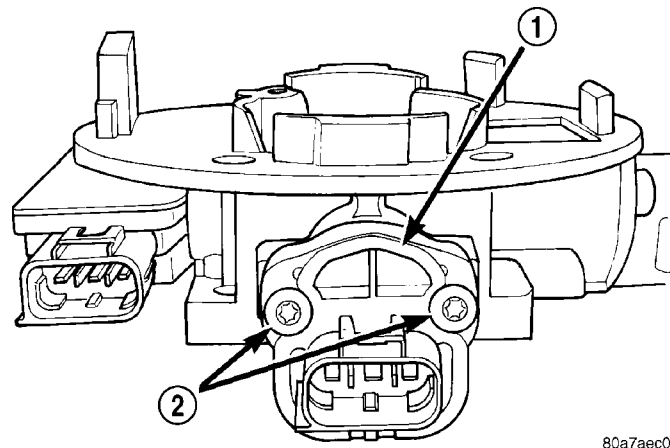
The TPS is located on the side of the throttle body (Fig. 60).

- (1) Remove air plenum.
- (2) Disconnect TPS electrical connector.

THROTTLE POSITION SENSOR (Continued)

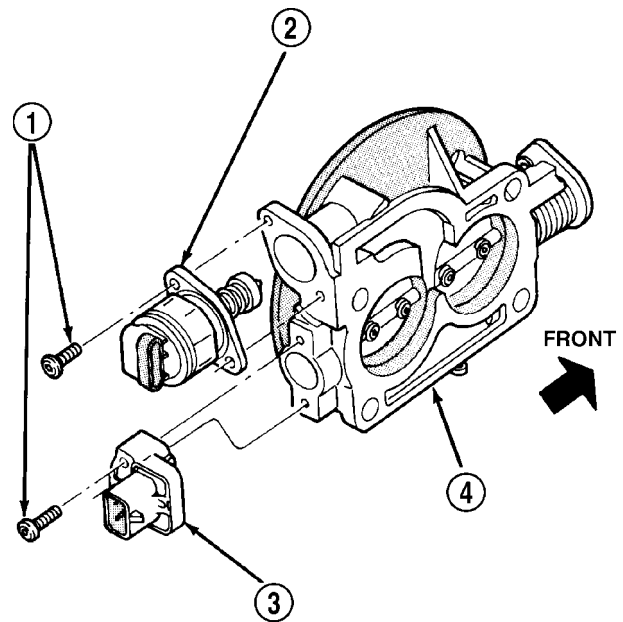
**Fig. 58 TPS LOCATION - 4.7L**

- 1 - THROTTLE BODY
- 2 - TPS
- 3 - IAC MOTOR
- 4 - IAT SENSOR
- 5 - MOUNTING SCREWS

**Fig. 59 TPS LOCATION - 5.9L V-8**

- 1 - THROTTLE POSITION SENSOR
- 2 - MOUNTING SCREWS

- (3) Remove two TPS mounting bolts (Fig. 60).
- (4) Remove TPS from throttle body.



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Fig. 60 TPS MOUNTING BOLTS - 8.0L V-10

- 1 - MOUNTING BOLTS (2)
- 2 - IDLE AIR CONTROL MOTOR
- 3 - THROTTLE POSITION SENSOR
- 4 - THROTTLE BODY

INSTALLATION**3.7L V-6**

The Throttle Position Sensor (TPS) is mounted to the throttle body (Fig. 56).

The throttle shaft end of throttle body slides into a socket in TPS (Fig. 61). The TPS must be installed so that it can be rotated a few degrees. (If sensor will not rotate, install sensor with throttle shaft on other side of socket tangs). The TPS will be under slight tension when rotated.

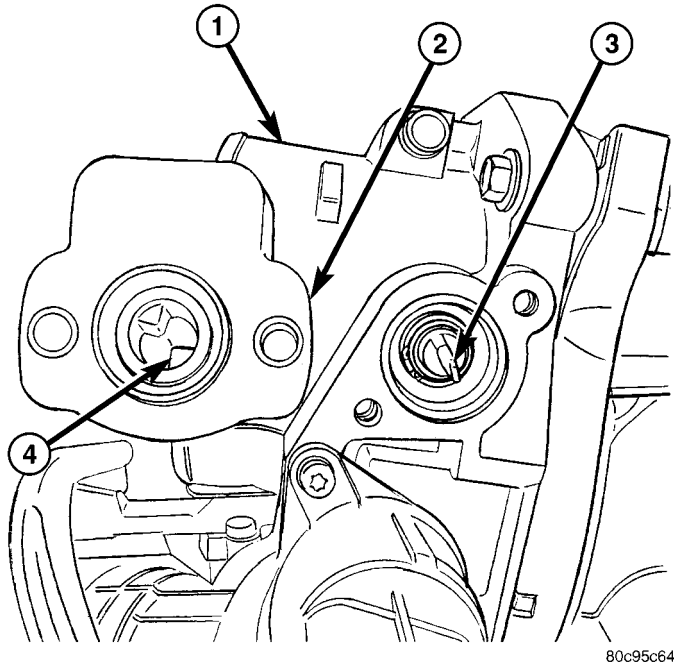
- (1) Install TPS and retaining screws.
- (2) Tighten screws to 7 N·m (60 in. lbs.) torque.
- (3) Connect TPS electrical connector to TPS.
- (4) Manually operate throttle (by hand) to check for any TPS binding before starting engine.
- (5) Install air cleaner tube to throttle body.

4.7L V-8

The throttle shaft end of throttle body slides into a socket in TPS (Fig. 62). The TPS must be installed so that it can be rotated a few degrees. If sensor will not rotate, install sensor with throttle shaft on other side of socket tangs. The TPS will be under slight tension when rotated.

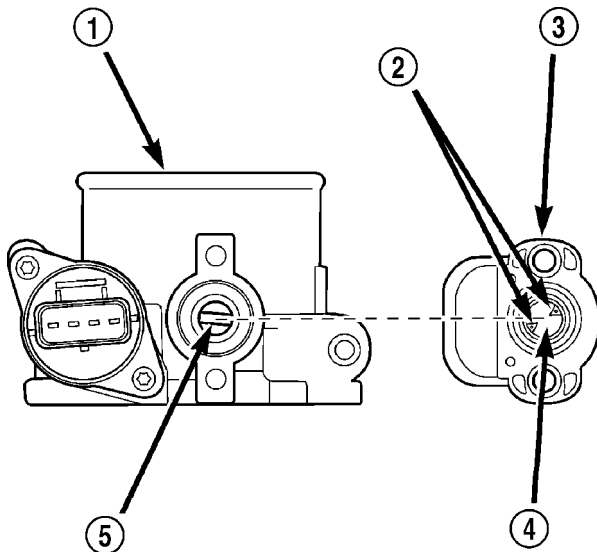
- (1) Install TPS and two retaining bolts.
- (2) Tighten bolts to 7 N·m (60 in. lbs.) torque.
- (3) Manually operate throttle control lever by hand to check for any binding of TPS.
- (4) Connect TPS electrical connector to TPS.

THROTTLE POSITION SENSOR (Continued)

**Fig. 61 TPS INSTALLATION - 3.7L**

- 1 - THROTTLE BODY
- 2 - TPS
- 3 - THROTTLE BODY SHAFT
- 4 - SOCKET LOCATING TANGS

(5) Install air duct/air box to throttle body.

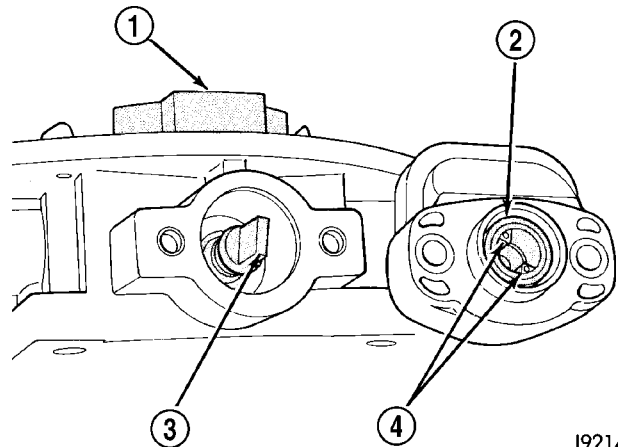
**Fig. 62 TPS INSTALLATION - 4.7L**

- 1 - THROTTLE BODY
- 2 - LOCATING TANGS
- 3 - THROTTLE POSITION SENSOR
- 4 - SOCKET
- 5 - THROTTLE SHAFT

5.9L V-8

The throttle shaft end of the throttle body slides into a socket in the TPS (Fig. 63). The TPS must be installed so that it can be rotated a few degrees. If sensor will not rotate, install sensor with throttle shaft on other side of socket tangs. The TPS will be under slight tension when rotated.

- (1) Install TPS and two retaining bolts.
- (2) Tighten bolts to 7 N·m (60 in. lbs.) torque.
- (3) Manually operate throttle control lever by hand to check for any binding of TPS.
- (4) Connect TPS electrical connector to TPS.
- (5) Install air intake tube.



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Fig. 63 TPS INSTALLATION - 5.9L V-8 AND 8.0L V-10

- 1 - THROTTLE BODY
- 2 - THROTTLE POSITION SENSOR
- 3 - THROTTLE SHAFT
- 4 - SOCKET LOCATING TANGS

8.0L V-10

The throttle shaft end of the throttle body slides into a socket in the TPS (Fig. 63). The TPS must be installed so that it can be rotated a few degrees. If sensor will not rotate, install sensor with throttle shaft on other side of socket tangs. The TPS will be under slight tension when rotated.

- (1) Install TPS and two retaining bolts. Refer to Torque Specifications.
- (2) Manually operate throttle control lever by hand to check for any binding of TPS.
- (3) Connect TPS electrical connector to TPS.
- (4) Install air plenum.

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FUEL DELIVERY - DIESEL

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FUEL DELIVERY - DIESEL

DESCRIPTION - DIESEL FUEL SYSTEM

The fuel system used on the Cummins engine is an electronically controlled, Bosch HPCR (High-Pressure Common Rail) system. The HPCR system consists of five main components:

- Electric Fuel Transfer (lift) Pump
- Fuel Pump/Gear Pump (attached to fuel injection pump)
- High-Pressure Fuel Injection Pump
- Fuel Injection Rail
- Fuel Injectors

Also to be considered as part of the overall fuel system are:

- Accelerator Pedal
- Air Cleaner Housing/Element
- Fuel Drain Manifold (passage)
- Fuel Drain Valve (at filter)
- Fuel Filter/Water Separator
- Fuel Heater
- Fuel Heater Relay
- Fuel Level (gauge) Sending Unit
- Fuel Tank
- Fuel Tank Module (containing fuel gauge sending unit and separate fuel filter located at bottom of tank module)
- Fuel Tank Filler/Vent Tube Assembly
- Fuel Tank Filler Tube Cap
- 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 Fuel Line Fittings
- Throttle Cable
- Water Draining (maintenance)
- Water-In-Fuel (WIF) Sensor

The fuel injection pump supplies high pressure to the fuel rail independent of engine speed. This high pressure is then accumulated in the fuel rail. High pressure fuel is constantly supplied to the injectors by the fuel rail. The Engine Control Module (ECM) controls the fueling and timing of the engine by actuating the injectors.

Fuel enters the system from the electric fuel transfer (lift) pump, which is attached to the fuel filter assembly. Fuel is forced through the fuel filter element and then enters the Fuel Pump/Gear Pump, which is attached to the rear of the fuel injection pump. The Fuel Pump/Gear Pump is a low-pressure pump and produce pressures ranging from 551.5 kpa (80 psi) to 1241 kpa (180) psi. Fuel then enters the fuel injection pump. Low pressure fuel is then supplied to the FCA (Fuel Control Actuator).

The FCA is an electronically controlled solenoid valve. The ECM controls the amount of fuel that enters the high-pressure pumping chambers by opening and closing the FCA based on a demanded fuel pressure. The FPS (Fuel Pressure Sensor) on the fuel rail provides the actual fuel pressure. When the actuator is opened, the maximum amount of fuel is being supplied to the fuel injection pump. Any fuel that does not enter the injection pump is directed to the overflow valve. The overflow valve regulates how much excess fuel is used for lubrication of the pump and how much is returned to the tank through the drain manifold.

Fuel entering the injection pump is pressurized to between 300 - 1600 bar by three radial pumping chambers. The pressurized fuel is then supplied to the fuel rail.

Some fuel system components are shown in.

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 160,000 KPA (23,206 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.

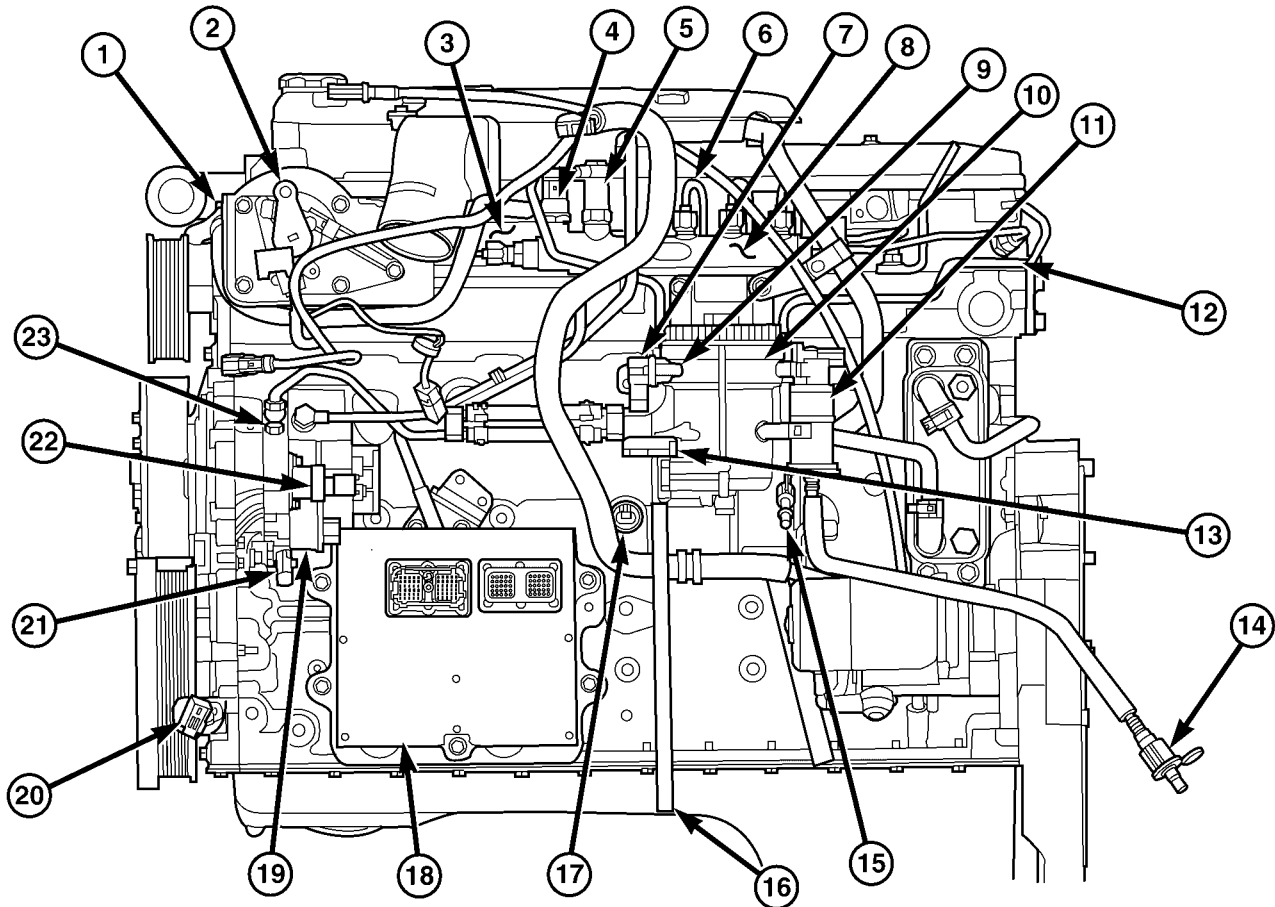
Certain fuel system components can be found in (Fig. 1), or (Fig. 2).

STANDARD PROCEDURE

STANDARD PROCEDURES - WATER DRAINING AT FUEL FILTER

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

FUEL DELIVERY - DIESEL (Continued)



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Fig. 1 DIESEL FUEL SYSTEM COMPONENTS

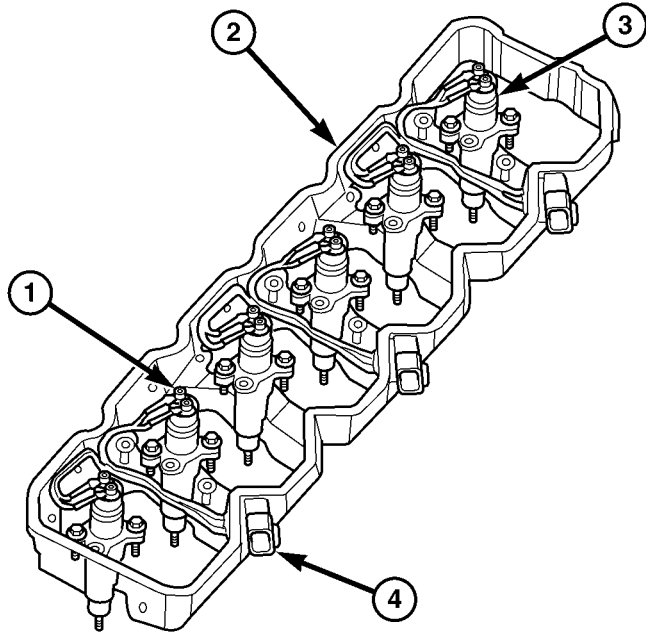
- | | |
|---|---|
| 1 - ENGINE COOLANT TEMPERATURE (ECT) SENSOR | 14 - FUEL SUPPLY LINE (LOW-PRESSURE, TO ENGINE) |
| 2 - THROTTLE LEVER BELLCRANK AND APPS (ACCELERATOR PEDAL POSITION SENSOR) | 15 - FUEL RETURN LINE CONNECTION (TO FUEL TANK) |
| 3 - INTAKE MANIFOLD AIR HEATER/ELEMENTS | 16 - FUEL DRAIN TUBE |
| 4 - FUEL PRESSURE SENSOR | 17 - OIL PRESSURE SENSOR |
| 5 - FUEL LIMITING VALVE | 18 - ENGINE CONTROL MODULE (ECM) |
| 6 - HIGH-PRESSURE FUEL LINES | 19 - FUEL INJECTION PUMP |
| 7 - FUEL HEATER | 20 - CRANKSHAFT POSITION (ENGINE SPEED) SENSOR |
| 8 - HIGH-PRESSURE FUEL INJECTOR RAIL | 21 - CAMSHAFT POSITION SENSOR (CMP) |
| 9 - FUEL HEATER TEMPERATURE SENSOR (THERMOSTAT) | 22 - FUEL CONTROL ACTUATOR (FCA) |
| 10 - FUEL FILTER/WATER SEPARATOR | 23 - CASCADE OVERFLOW VALVE |
| 11 - FUEL TRANSFER (LIFT) PUMP | |
| 12 - FUEL DRAIN MANIFOLD | |
| 13 - DRAIN VALVE | |

STANDARD 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.

FUEL DELIVERY - DIESEL (Continued)



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Fig. 2 FUEL INJECTORS

- 1 - SOLENOID CONNECTIONS
- 2 - ROCKER HOUSING
- 3 - FUEL INJECTOR
- 4 - PASSTHROUGH CONNECTOR

STANDARD PROCEDURE - FUEL SYSTEM PRIMING

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. Fuel system priming is accomplished using the electric fuel transfer (lift) pump.

Servicing or replacing fuel system components usually will not require fuel system priming.

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 quickly engaged, and then disengaged without allowing the engine to start. The pump shuts off immediately if the key is on and the engine stops running.

(1) 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.

(2) If the engine does not start after 25 seconds, turn key OFF. Repeat previous step until engine starts.

(3) Fuel system priming is now completed.

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

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

(5) Perform previous fuel priming procedure steps using fuel transfer pump. Be sure fuel is present at fuel tank.

(6) Crank the engine for 30 seconds at a time to allow fuel system to prime.

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. DO NOT LOOSEN FUEL FITTINGS WHILE ENGINE IS RUNNING.

WARNING: ENGINE MAY START WHILE CRANKING STARTER MOTOR.

FUEL DELIVERY - DIESEL (Continued)

SPECIFICATIONS

FUEL SYSTEM PRESSURE - DIESEL

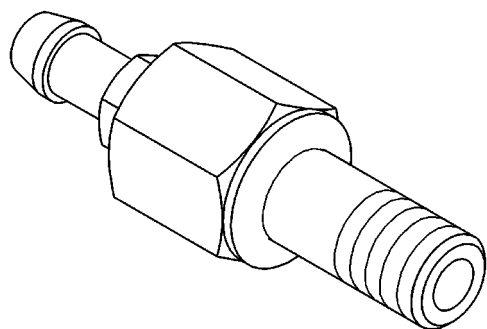
DESCRIPTION	PRESSURE
Fuel Transfer (Lift) Pump Pressure	Minimum 9.5 psi

FUEL INJECTOR FIRING ORDER - DIESEL

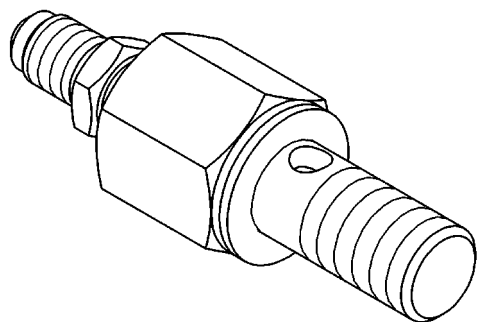
1-5-3-6-2-4

SPECIAL TOOLS

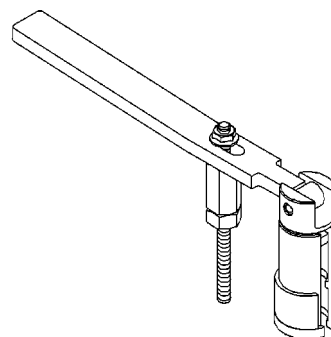
DIESEL FUEL SYSTEM



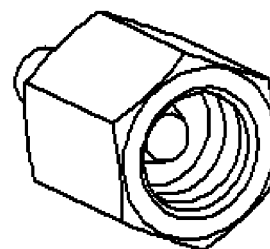
FUEL PRESSURE TEST ADAPTER - # 9012



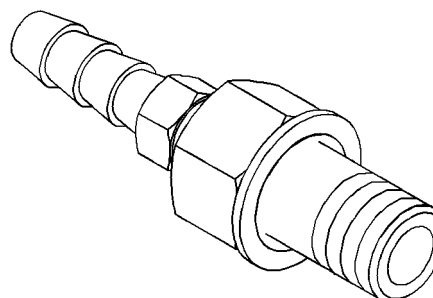
FUEL PRESSURE TEST ADAPTER - #9014



FUEL INJECTOR REMOVER - #9010

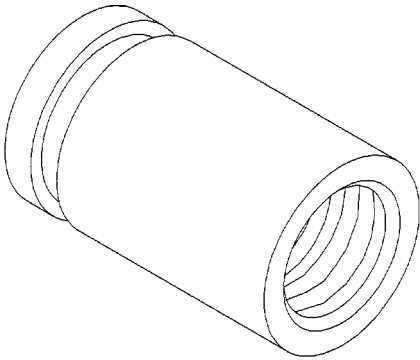


PRESSURE CAP - #9011

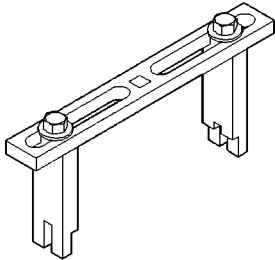


FUEL PRESSURE TEST ADAPTER - #9013

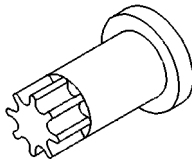
FUEL DELIVERY - DIESEL (Continued)



FUEL INJECTOR TUBE (CONNECTOR) REMOVER - #9015



SPANNER WRENCH (FUEL TANK MODULE REMOVAL/INSTALLATION) - #6856



**ENGINE ROTATING (BARRING) TOOL - #7471B
(ALSO PART OF KIT #6860)**

FUEL FILTER / WATER SEPARATOR

DESCRIPTION

The fuel filter/water separator assembly is located on left side of engine above starter motor. The assembly also includes the fuel heater and Water-In-Fuel (WIF) sensor, and fuel transfer pump.

OPERATION

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.

Refer to the maintenance schedules 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.

REMOVAL

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

Draining water from fuel filter/water separator housing:

The housing drain valve (Fig. 3) or (Fig. 4) serves two purposes. One is to **partially** drain filter housing of excess water. The other is to **completely** drain housing for fuel filter, drain valve, heater element, , water-in-fuel sensor replacement or transfer pump replacement.

The filter housing should be partially 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 (Fig. 3) or (Fig. 4) is located at bottom of drain valve. Place drain pan under drain.

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

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

(4) After draining operation, push valve handle forward to CLOSE position.

(5) **Fuel Filter Replacement:** The fuel filter is located inside of the fuel filter housing.

(a) Clean all debris from around canister.

(b) Remove filter lid (Fig. 5) using a socket. Attach socket to large hex on top of lid (Fig. 5). Rotate counter-clockwise for removal. Remove o-ring.

(c) Remove filter element by twisting element sideways from filter lid.

(6) **Water-In-Fuel (WIF) Sensor Replacement:** The WIF sensor is located on the side of the fuel filter housing (Fig. 3) or (Fig. 4).

(a) Disconnect electrical connector at sensor.

(b) Clean area around sensor.

(c) Remove sensor by rotating counter-clockwise.

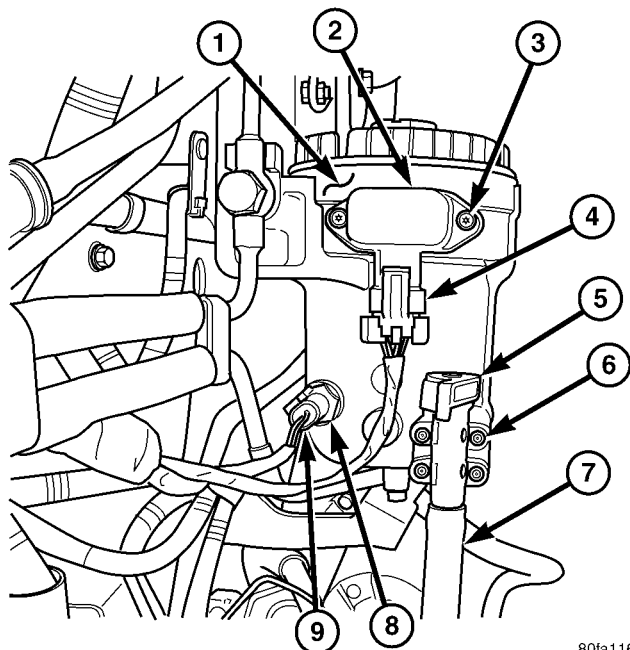
(d) Check condition of sensor o-ring. Replace if damaged.

(7) **Fuel Heater Element Replacement:** The heater element is located in the fuel filter housing (Fig. 3) or (Fig. 4).

(a) Remove fuel filter. See previous steps.

FUEL FILTER / WATER SEPARATOR (Continued)

- (b) Disconnect electrical connector.
- (c) Remove two T-15 Torx head mounting screws from fuel heater element.
- (d) Remove fuel filter cover and filter element.
- (e) Remove fuel heater.
- (8) **Drain Valve Replacement:** The drain valve assembly is located on the side of the fuel filter housing (Fig. 3) or (Fig. 4).
- (a) Disconnect drain hose from the fuel drain valve.
- (b) Remove 4 drain valve mounting screws (T-15 Torx head).
- (c) Remove drain valve from filter housing.



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Fig. 3 FILTER HOUSING (EARLY)

- 1 - FILTER HOUSING
- 2 - FUEL HEATER AND THERMOSTAT
- 3 - FUEL HEATER MOUNTING SCREWS
- 4 - FUEL HEATER ELEC. CONNECTOR
- 5 - DRAIN VALVE
- 6 - DRAIN VALVE MOUNTING SCREWS
- 7 - DRAIN HOSE
- 8 - WIF SENSOR
- 9 - WIF SENSOR ELEC. CONNECTOR

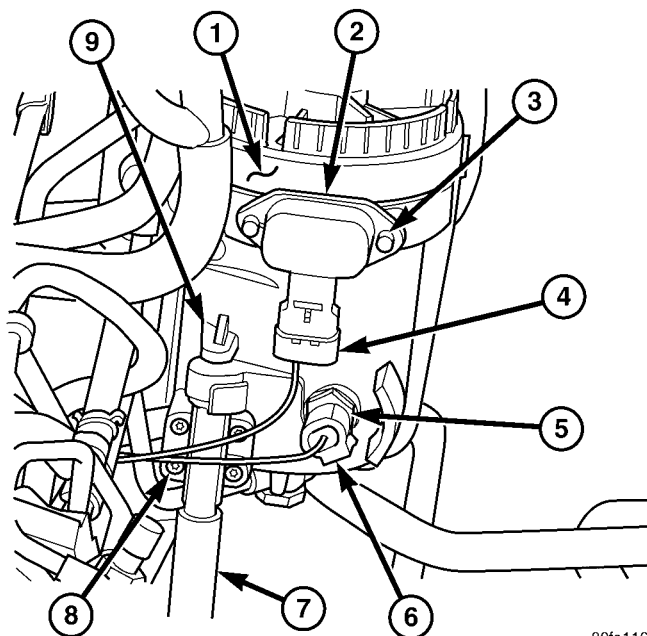
INSTALLATION

Refer to maintenance schedules for recommended fuel filter replacement intervals.

- (1) Thoroughly clean inside of filter housing, filter cap and all related components.

(2) Fuel Filter:

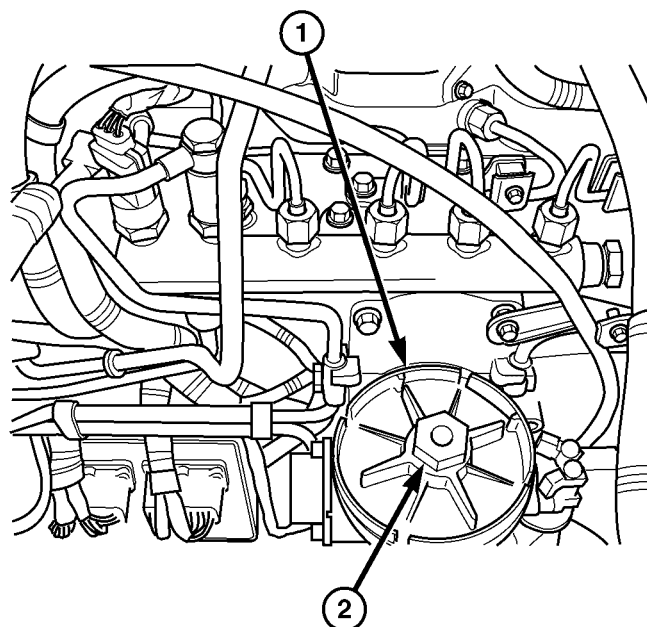
- (a) **The engine has a self-priming low-pressure fuel system. Refer to Standard Procedures-Fuel System Priming.**
- (b) Install new o-ring to canister lid and lubricate o-ring with 30W oil.



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Fig. 4 FILTER HOUSING (LATE)

- 1 - FILTER HOUSING
- 2 - FUEL HEATER AND THERMOSTAT
- 3 - FUEL HEATER MOUNTING SCREWS
- 4 - FUEL HEATER ELEC. CONNECTOR
- 5 - WIF SENSOR
- 6 - WIF SENSOR ELEC. CONNECTOR
- 7 - DRAIN HOSE
- 8 - DRAIN VALVE MOUNTING SCREWS
- 9 - DRAIN VALVE



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Fig. 5 FILTER COVER (LID)

- 1 - FILTER COVER
- 2 - ATTACH SOCKET HERE

FUEL FILTER / WATER SEPARATOR (Continued)

(c) Position new element to canister lid. Place this assembly into canister by rotating clockwise.

(d) Tighten cap to 34 N·m (25 ft. lbs.) torque. Do not overtighten cap.

(3) Water-In-Fuel (WIF) Sensor:

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

(b) Apply a light film of clean diesel oil to o-ring seal.

(c) Install sensor into housing.

(d) Tighten sensor to 4.5 N·m (39 in. lbs.) torque.

(e) Connect electrical connector to WIF sensor.

(4) Fuel Heater Element:

(a) Install fuel heater into fuel filter housing.

(b) Install fuel heater thermostat into fuel filter housing.

(c) Install fuel heater mounting screws and tighten to 1-1.5 N·m torque.

(d) Connect electrical connector to fuel heater thermostat.

(e) Install new filter cover O-ring onto fuel filter housing cover and lubricate with 30W oil.

(f) Tighten fuel filter housing cover (lid) to 34 N·m (25 ft. lbs.).

(5) Drain Valve:

(a) Install 2 new o-rings to valve and filter housing.

(b) Lubricate with silicon grease.

(c) Install fuel drain valve.

(d) Install 4 mounting screws and tighten to 1-1.5 N·m (8-13 in. lbs.) torque.

(e) Connect drain hose to drain valve.

(6) Start engine and check for leaks.

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.

DIAGNOSIS AND TESTING - FUEL HEATER

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 Engine Control Module (ECM), or 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 on the side of fuel filter housing.

The heater assembly is equipped with a built-in fuel temperature sensor (thermostat) that senses fuel temperature. When fuel temperature drops below 45 degrees $\pm$ 8 degrees F, the sensor allows current to flow to built-in heater element to warm fuel. When fuel temperature rises above 75 degrees $\pm$ 8 degrees F, the sensor stops current flow to heater element (circuit is open).

Voltage to operate fuel heater element is supplied from ignition switch, through fuel heater relay (also refer to Fuel Heater Relay), to fuel temperature sensor and on to 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 fuel heater. The resistance value of heater element is less than 1 ohm (cold) and up to 1000 ohms warm.

TESTING

(1) Disconnect electrical connector from thermostat (Fig. 3) or (Fig. 4).

Ambient temperature must be below circuit close temperature. If necessary, induce this ambient temperature by placing ice packs on thermostat to produce an effective ambient temperature below circuit close temperature. For first check of thermostat you can hear click of thermostat when circuit closes.

Measure resistance across two pins. Operating range is 0.3 — 0.45 Ohms.

(2) If resistance is out of range, remove thermostat and check resistance across terminal connections of

FUEL HEATER**DESCRIPTION**

The fuel heater assembly is located on the side of the fuel filter housing (Fig. 3) or (Fig. 4).

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.

OPERATION

The fuel heater is used to prevent diesel fuel from waxing during cold weather operation.

When the temperature is below 45 $\pm$ 8 degrees F, the temperature sensor allows current to flow to the heater element warming the fuel. When the temperature is above 75 $\pm$ 8 degrees F, the sensor stops current flow to the heater element.

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.

FUEL HEATER (Continued)

heater. The heater can be check at room temperature. Operating range is 0.3 — 0.45 Ohms.

(3) Replace heater if resistance is not within operating range.

(4) If heater is within operating range, replace heater thermostat.

REMOVAL

REMOVAL/INSTALLATION

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

DESCRIPTION

The fuel heater relay is located in Power Distribution Center (PDC) (Fig. 6). Refer to label on inside of PDC cover for relay location.

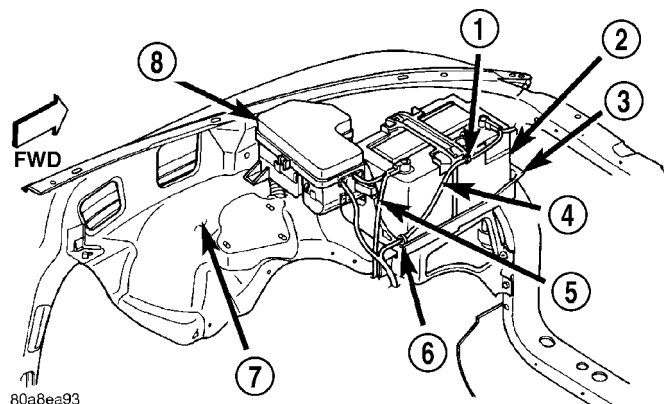


Fig. 6 POWER DISTRIBUTION CENTER LOCATION

- 1 - CLIP
- 2 - BATTERY
- 3 - TRAY
- 4 - NEGATIVE CABLE
- 5 - POSITIVE CABLE
- 6 - CLIP
- 7 - FENDER INNER SHIELD
- 8 - POWER DISTRIBUTION CENTER

OPERATION

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.**

REMOVAL

The fuel heater relay is located in the Power Distribution Center (PDC) (Fig. 7). Refer to label under PDC cover for relay location.

- (1) Remove PDC cover.
- (2) Remove relay from PDC.

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

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

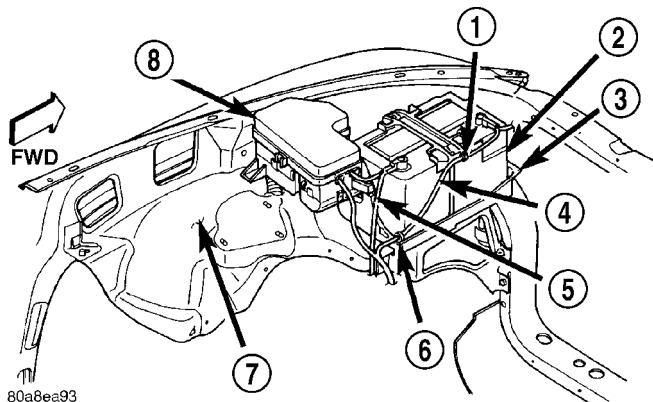


Fig. 7 POWER DISTRIBUTION CENTER LOCATION

- 1 - CLIP
- 2 - BATTERY
- 3 - TRAY
- 4 - NEGATIVE CABLE
- 5 - POSITIVE CABLE
- 6 - CLIP
- 7 - FENDER INNER SHIELD
- 8 - POWER DISTRIBUTION CENTER

INSTALLATION

The fuel heater relay is located in the Power Distribution Center (PDC) (Fig. 7). Refer to label under PDC cover for relay location.

- (1) Install relay to PDC.
- (2) Install cover to PDC.

FUEL INJECTION PUMP

DESCRIPTION

A Robert Bosch high-pressure fuel injection pump is used. The pump is attached to the back of the timing gear cover at the left / rear side of the engine.

OPERATION

The fuel injection pump supplies high pressure to the fuel rail independent of engine speed. This high pressure is then accumulated in the fuel rail. High pressure fuel is constantly supplied to the injectors by the fuel rail. The Engine Control Module (ECM) controls the fueling and timing of the engine by actuating the injectors.

Fuel enters the system from the electric fuel transfer (lift) pump, which is attached to the fuel filter assembly. Fuel is forced through the fuel filter element and then enters the Fuel Pump/Gear Pump, which is attached to the rear of the fuel injection

FUEL INJECTION PUMP (Continued)

pump. The Fuel Pump/Gear Pump is a low-pressure pump and produce pressures ranging from 551.5 kpa (80 psi) to 1241 kpa (180) psi. Fuel then enters the fuel injection pump. Low pressure fuel is then supplied to the FAC (Fuel Control Actuator).

The FAC is an electronically controlled solenoid valve. The ECM controls the amount of fuel that enters the high-pressure pumping chambers by opening and closing the FAC based on a demanded fuel pressure. The FPS (Fuel Pressure Sensor) on the fuel rail provides the actual fuel pressure. When the actuator is opened, the maximum amount of fuel is being supplied to the fuel injection pump. Any fuel that does not enter the injection pump is directed to the overflow valve. The overflow valve regulates how much excess fuel is used for lubrication of the pump and how much is returned to the tank through the drain manifold.

Fuel entering the injection pump is pressurized to between 300 - 1600 bar by three radial pumping chambers. The pressurized fuel is then supplied to the fuel rail.

DIAGNOSIS AND TESTING - FUEL INJECTION PUMP TIMING

With the Bosch injection pump, there are no mechanical adjustments needed or necessary to accomplish fuel injection timing. All timing and fuel adjustments are electrically made by the engine mounted Engine Control Module (ECM).

REMOVAL

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.

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

(2) Remove intake manifold air intake tube (above injection pump) and its rubber connector hose (Fig. 8).

(3) The Engine Control Module (ECM) is mounted to left side of engine (Fig. 9). Remove 5 ECM mount-

ing bolts and position ECM for injection pump removal. **Do not disconnect wiring connectors from ECM.**

(4) Remove cooling fan shroud.

(5) Remove cooling fan assembly.

(6) Remove accessory drive belt.

(7) Thoroughly clean the rear of injection pump, and attachment points for its 3 fuel lines (Fig. 10). Also clean the opposite ends of these same 3 lines at their attachment points.

(8) Disconnect Fuel Control Actuator (FCA) electrical connector at rear of injection pump (Fig. 11).

(9) Remove fuel line (injection pump-to-overflow valve).

(10) Remove fuel line (injection pump-to-fuel rail).

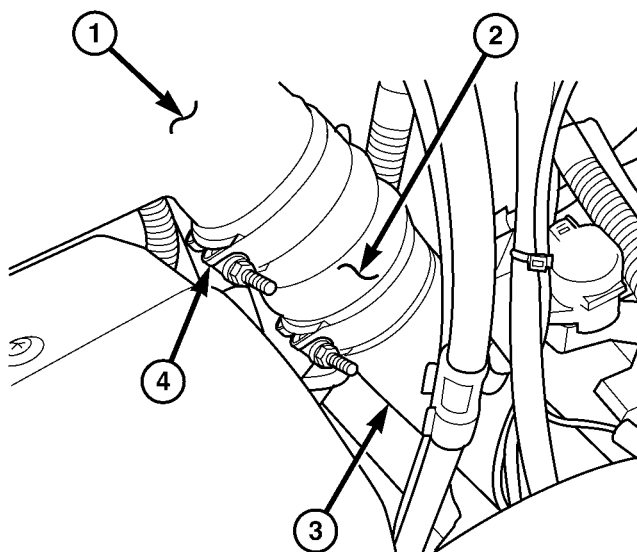
(11) Remove fuel line (injection pump-to-fuel filter housing).

(12) Remove fuel pump drive gear access cover (plate) with a 1/2 inch drive ratchet. Plate is threaded to timing gear cover (Fig. 12).

(13) Remove fuel pump drive gear mounting nut and washer.

(14) Attach C3428B, or L4407A (or equivalent) gear puller (Fig. 13) to pump drive gear with 2 bolts, and separate gear from pump (a keyway is not used on this particular injection pump). Leave drive gear hanging loose within timing gear cover.

(15) Remove 3 injection pump mounting nuts (Fig. 14), and remove pump from engine.

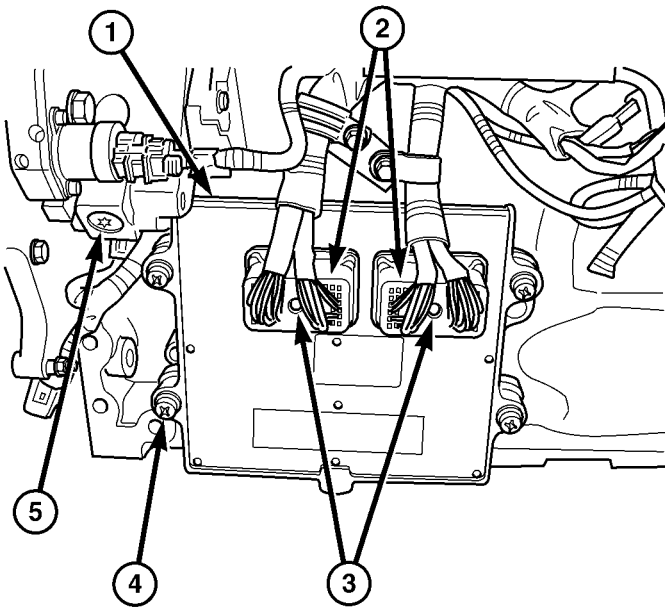


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Fig. 8 INTAKE TUBE AND CONNECTING HOSE

- 1 - MANIFOLD ABOVE HEATERS
- 2 - RUBBER CONNECTING HOSE
- 3 - METAL INTAKE TUBE
- 4 - CLAMPS (2)

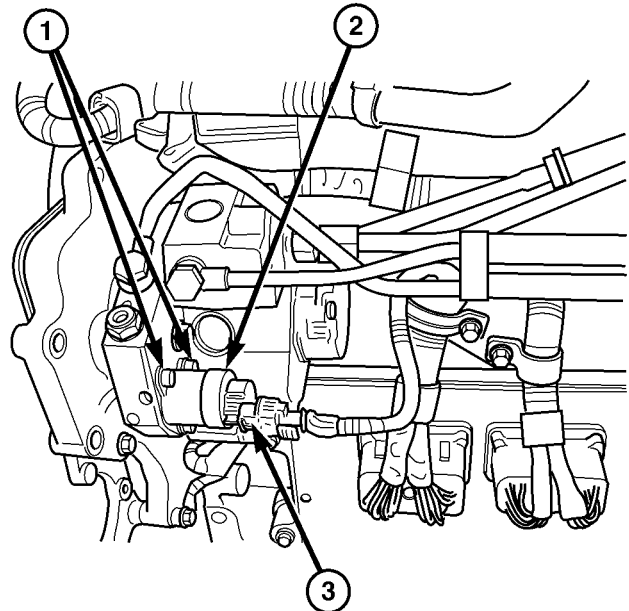
FUEL INJECTION PUMP (Continued)



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Fig. 9 ECM REMOVAL/INSTALLATION

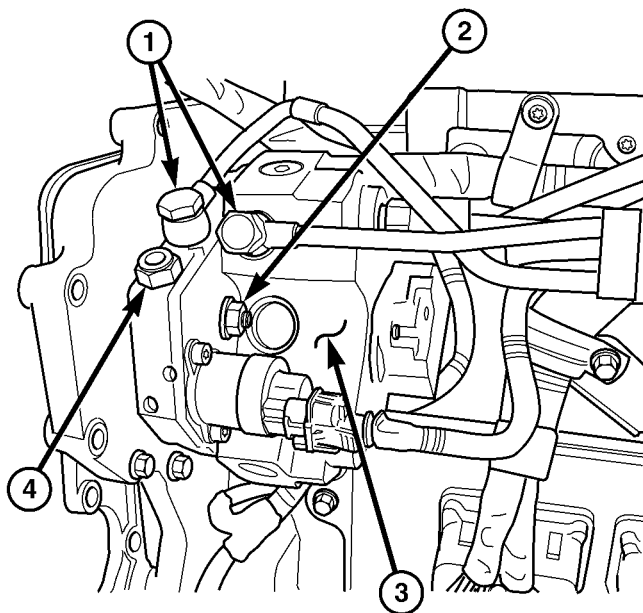
- 1 - ECM LOCATION
- 2 - ELECTRICAL CONNECTORS (2)
- 3 - CONNECTOR BOLTS
- 4 - ECM MOUNTING BOLTS (5)
- 5 - BOTTOM OF INJECTION PUMP



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Fig. 11 FUEL CONTROL ACTUATOR

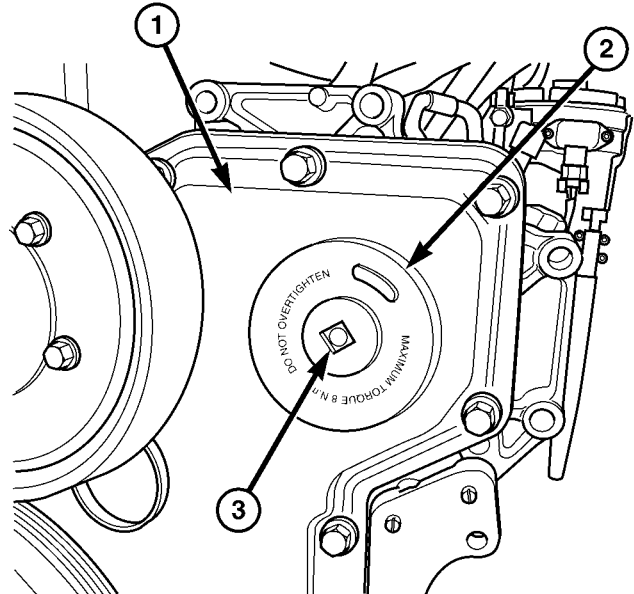
- 1 - ACTUATOR MOUNTING BOLTS
- 2 - FCA (FUEL CONTROL ACTUATOR)
- 3 - ACTUATOR ELECTRICAL CONNECTOR



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Fig. 10 OVERFLOW VALVE

- 1 - BANJO BOLTS
- 2 - PUMP MOUNTING NUTS (3)
- 3 - FUEL INJECTION PUMP
- 4 - CASCADE OVERFLOW VALVE

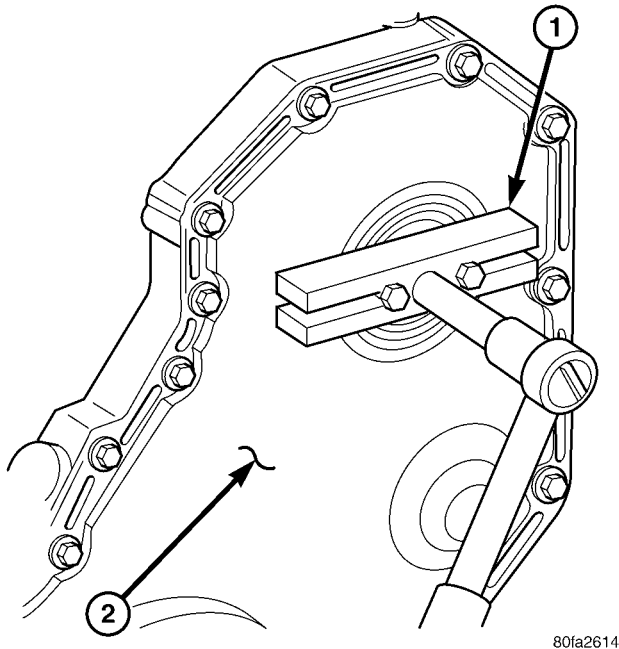


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Fig. 12 PUMP DRIVE GEAR ACCESS COVER

- 1 - FRONT TIMING GEAR COVER
- 2 - GEAR ACCESS PLATE (COVER)
- 3 - HEX DRIVE (FOR COVER REMOVAL/INSTALLATION)

FUEL INJECTION PUMP (Continued)



80fa2614

Fig. 13 DRIVE GEAR REMOVAL

- 1 - FRONT TIMING GEAR COVER
2 - GEAR PULLER TOOL

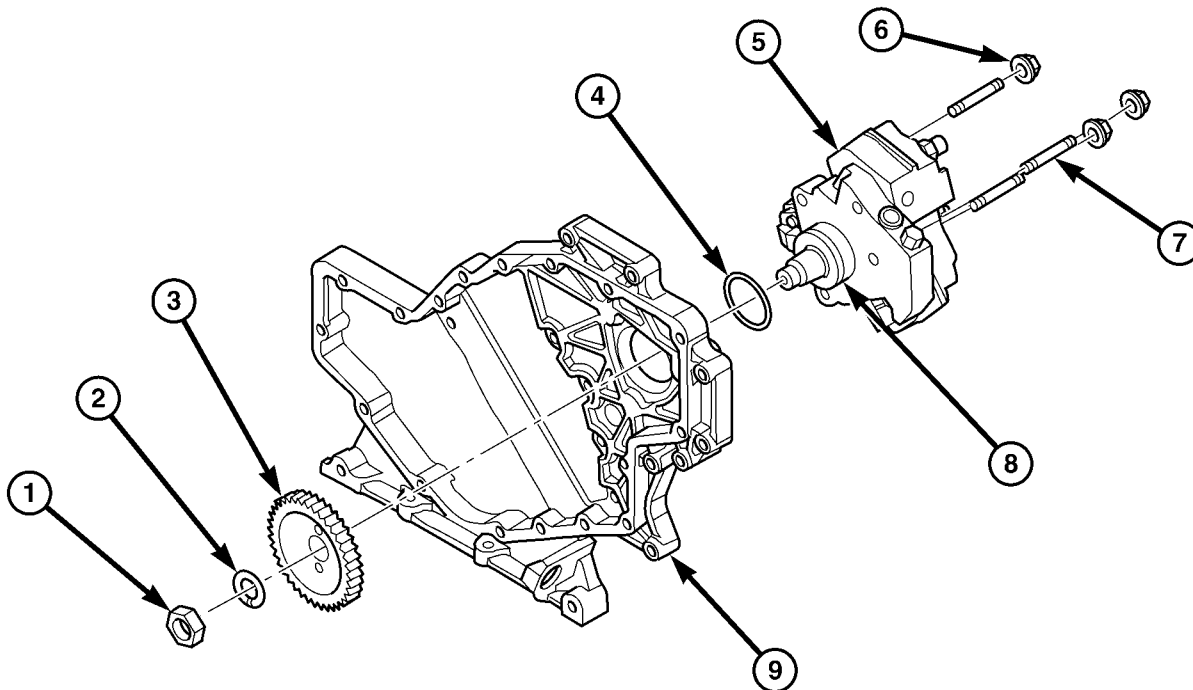
INSTALLATION

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.

(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 at gear housing. Also clean front of injection pump.

(3) Install new rubber o-ring into machined groove (Fig. 14) at pump mounting area.



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Fig. 14 FUEL INJECTION PUMP REMOVAL/INSTALLATION

- 1 - PUMP DRIVE GEAR NUT
2 - WASHER
3 - PUMP DRIVE GEAR
4 - RUBBER O-RING
5 - FUEL INJECTION PUMP

- 6 - PUMP MOUNTING NUTS (3)
7 - PUMP MOUNTING STUDS (3)
8 - O-RING MACHINED GROOVE
9 - FRONT TIMING GEAR COVER

FUEL INJECTION PUMP (Continued)

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

The machined tapers on both injection pump shaft and injection pump gear 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 with an evaporative type cleaner such as brake cleaner.

(6) Position injection pump to mounting flange on gear cover while aligning injection pump shaft through back of injection pump gear.

(7) After pump is positioned flat to mounting flange, install 3 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 3 mounting nuts.**

(8) To prevent damage or cracking of components, install and tighten nuts in the following sequence:

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

(b) Do preliminary (light) tightening of injection pump shaft nut.

(c) Tighten 3 injection pump mounting nuts to 8 N·m (70.8 in. lbs.).

(d) Do a final tightening of pump shaft nut to 105 N·m (77 ft. lbs.).

(9) Install drive gear access cover (plate) using a 1/2 inch drive ratchet. Plate is threaded to timing gear cover.

(10) Install Engine Control Module (ECM) to left side of engine.

(11) Install fuel line (injection pump-to-overflow valve). Tighten bolts to 24 N·m (17 ft. lbs.) torque.

(12) Install fuel line (injection pump-to-fuel rail). Tighten to 24 N·m (17 ft. lbs.) torque.

(13) Install fuel line (injection pump-to-fuel filter housing). Tighten to 24 N·m (17 ft. lbs.) torque.

(14) Connect Fuel Control Actuator (FCA) electrical connector to rear of injection pump.

(15) Install intake manifold air intake tube (above injection pump). Tighten clamps.

(16) Install accessory drive belt.

(17) Install cooling fan shroud.

(18) Install cooling fan assembly.

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

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

FUEL LEVEL SENDING UNIT / SENSOR

DESCRIPTION

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 (card).

OPERATION

The fuel tank module on diesel powered models has 3 different circuits (wires). Two of these circuits are used at the fuel gauge sending unit for fuel gauge operation. The other wire is used for a ground. The diesel engine does not have a fuel tank module mounted electric fuel pump. The electric fuel pump (fuel transfer pump) is mounted to the engine.

For Fuel Gauge Operation: A constant input voltage source of about 12 volts (battery voltage) is supplied to the resistor track on the fuel gauge sending unit. This is fed directly from the Powertrain Control Module (PCM). **NOTE: For diagnostic purposes, this 12V power source can only be verified with the circuit opened (fuel tank module electrical connector unplugged). With the connectors plugged, output voltages will vary from about .6 volts at FULL, to about 7.0 volts at EMPTY.** The resistor track is used to vary the voltage (resistance) depending on fuel tank float level. As fuel level increases, the float and arm move up, which decreases voltage. As fuel level decreases, the float and arm move down, which increases voltage. The varied voltage signal is returned back to the ECM through the sensor return circuit.

Both of the electrical circuits between the fuel gauge sending unit and the ECM are hard-wired (not multi-plexed). After the voltage signal is sent from the resistor track, and back to the ECM, the ECM will interpret the resistance (voltage) data and send a message across the multi-plex bus circuits to the instrument panel cluster. Here it is translated into the appropriate fuel gauge level reading. Refer to Instrument Panel for additional information.

REMOVAL

REMOVAL/INSTALLATION

For diesel removal and installation procedures, refer to the gas section of Fuel System/Fuel Delivery. See Fuel Level Sending Unit/Sensor Removal/Installation.

FUEL LINES

DESCRIPTION

Low-Pressure Lines

- the fuel supply line from fuel tank to fuel transfer (lift) pump.
- the fuel return line back to fuel tank.
- the fuel drain manifold line at rear of cylinder head.
- the fuel supply line from fuel filter to fuel injection pump.

High-Pressure Lines

- the fuel line from fuel injection pump to overflow valve.
- the fuel line from fuel injection pump to fuel rail.
- the 6 fuel lines from fuel rail up to injector connector tubes

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 160,000 KPa (23,206 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.

OPERATION

High-Pressure 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 160,000 kPa (23,206 PSI) from the injection pump to the fuel injectors. The lines expand and contract from the high-pressure fuel pulses generated during the injection process. All high-pressure fuel lines are of the same length and inside diameter. Correct high-pressure fuel line usage and installation is critical to smooth engine operation.

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

DIAGNOSIS AND TESTING - HIGH-PRESSURE FUEL LINE LEAKS

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

WARNING: DUE TO EXTREME FUEL PRESSURES OF UP TO 160,000 kPa (23,206 PSI), USE EXTREME CAUTION WHEN INSPECTING FOR HIGH-PRESSURE FUEL LEAKS. DO NOT GET YOUR HAND OR A FINGER NEAR A SUSPECTED LEAK. INSPECT FOR HIGH-PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. HIGH FUEL INJECTION PRESSURE CAN CAUSE PERSONAL INJURY IF CONTACT IS MADE WITH THE SKIN.

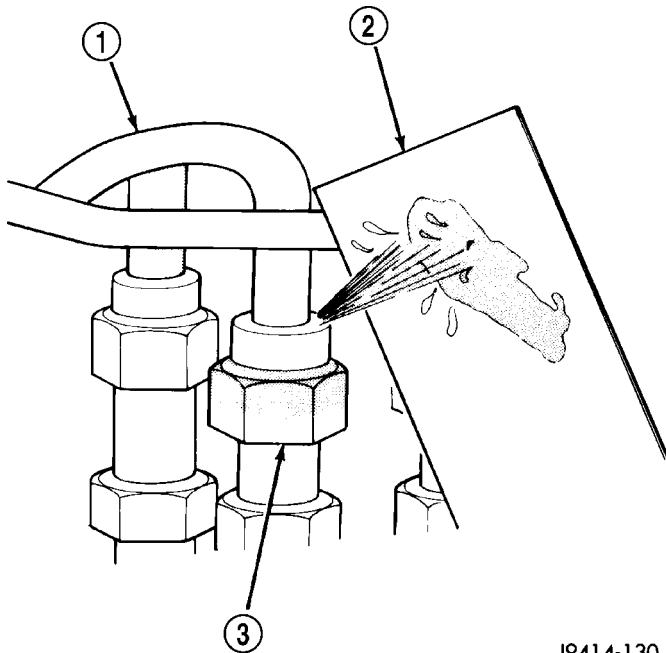
Start the engine. Move the cardboard (Fig. 15) over the suspected high-pressure fuel line leak, and check for fuel spray onto the cardboard. If line is leaking, retorque line. Replace damaged, restricted or leaking high-pressure fuel lines with the correct replacement line.

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

REMOVAL

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.

FUEL LINES (Continued)



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Fig. 15 TYPICAL TEST FOR LEAKS USING CARDBOARD

- 1 - HIGH-PRESSURE LINE
- 2 - CARDBOARD
- 3 - TYPICAL HIGH-PRESSURE FITTING

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

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

(3) If removing fuel line at either #1 or #2 cylinder, the intake manifold air heater elements must first be removed from top of intake manifold. Refer to Intake Air Heater Removal / Installation for procedures.

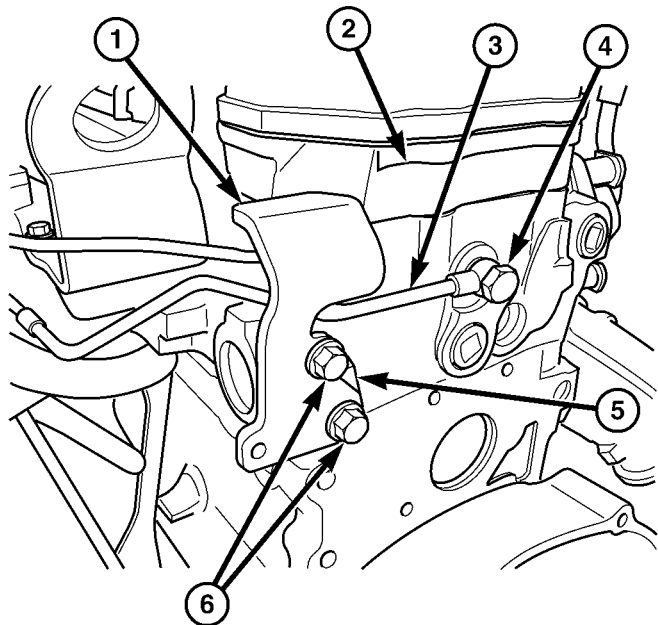
(4) If removing fuel line at #6 cylinder, a bracket (Fig. 16) is located above fuel line connection at cylinder head. Two bolts secure this bracket to rear of cylinder head. The upper bolt hole is slotted. Loosen (but do not remove) these 2 bracket bolts. Tilt bracket down to gain access to #6 fuel line connection.

(5) Remove necessary insulated fuel line support clamps (Fig. 17) and bracket bolts at intake manifold.

(6) Place shop towels around fuel lines at fuel rail and injectors. If possible, do not allow fuel to drip down side of engine.

CAUTION: WHEN LOOSENING OR TIGHTENING HIGH-PRESSURE LINES ATTACHED TO A SEPARATE FITTING (Fig. 18) , USE A BACK-UP WRENCH ON FITTING. DO NOT ALLOW FITTING TO ROTATE. DAMAGE TO BOTH FUEL LINE AND FITTING WILL RESULT.

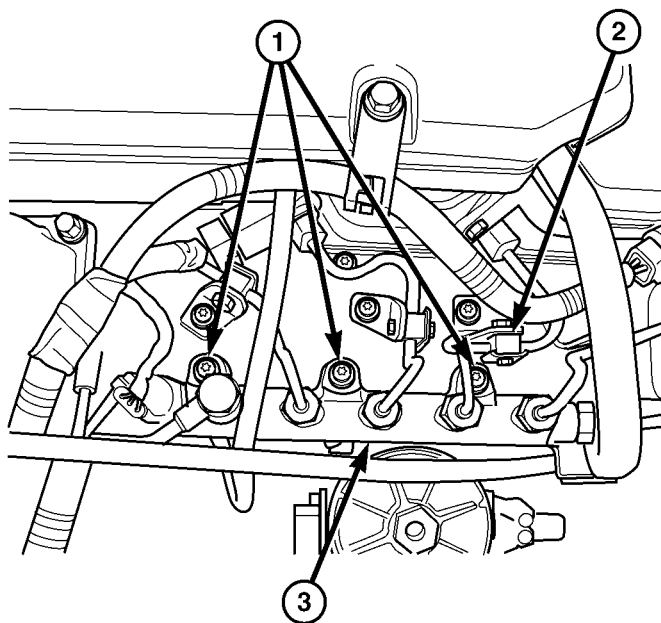
(7) Carefully remove each fuel line from engine. Note position of each while removing. **Do not bend lines while removing.**



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Fig. 16 BRACKET - #6 INJECTOR

- 1 - BRACKET
- 2 - REAR OF CYLINDER HEAD
- 3 - FUEL DRAIN MANIFOLD LINE (TO FUEL TANK)
- 4 - BANJO BOLT
- 5 - SLOTTED HOLE
- 6 - BRACKET BOLTS (2)

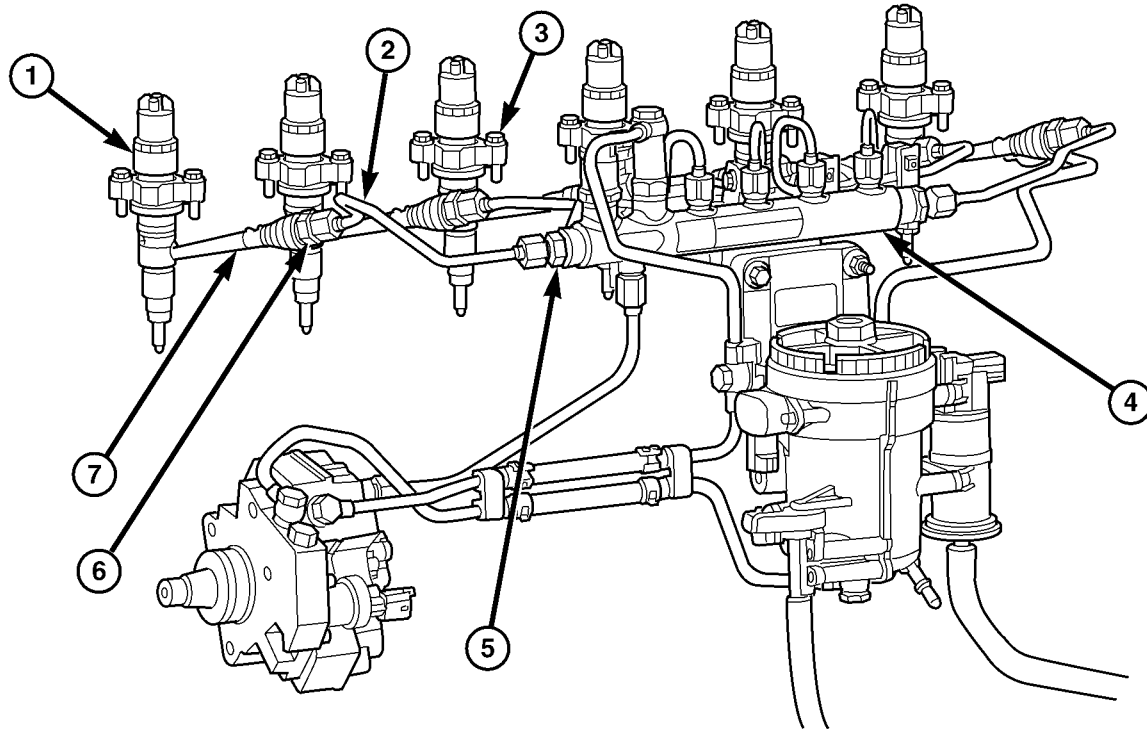


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Fig. 17 FUEL INJECTOR RAIL

- 1 - FUEL RAIL MOUNTING BOLTS (3)
- 2 - INSULATED CLAMPS
- 3 - FUEL INJECTOR RAIL

FUEL LINES (Continued)



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Fig. 18 HIGH PRESSURE FUEL LINES

- 1 - FUEL INJECTOR
- 2 - HIGH-PRESSURE LINE
- 3 - INJECTOR MOUNTING BOLTS
- 4 - FUEL INJECTOR RAIL

- 5 - SEPARATE FITTING (TYPICAL)
- 6 - CONNECTOR TUBE RETAINER (FITTING)
- 7 - CONNECTOR TUBE

INSTALLATION

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.

(1) Position fuel line support clamp to fuel line. Install clamp nuts/bolts and tighten finger tight.

(2) Position proper fuel line to proper injector on engine. Tighten fittings hand tight at both ends of line.

(3) Tighten fuel lines at high pressure injector connector to 30 N·m (22 lb. ft.).

(4) Tighten fuel lines at fuel rail to 30 N·m (22 lb. ft.).

(5) Tighten clamp/support nuts and bolts.

(6) Install engine lifting bracket and bolt. Tighten bolt to 77 N·m (56 lb.ft.).

(7) If fuel line at either #1 or #2 cylinder has been replaced, install intake manifold air heater elements to top of intake manifold. Refer to Intake Air Heater Removal / Installation for procedures.

(8) If fuel line at #6 cylinder has been replaced, tilt metal bracket upward and tighten 2 bolts at rear of cylinder head.

(9) Install remaining fuel line support clamps and bracket bolts at intake manifold.

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

(11) Prime fuel system. Refer to Fuel System Priming.

(12) Check lines/fittings for leaks.

FUEL PRESSURE SENSOR

DESCRIPTION

The fuel pressure sensor is mounted vertically near the top/center of the fuel rail.

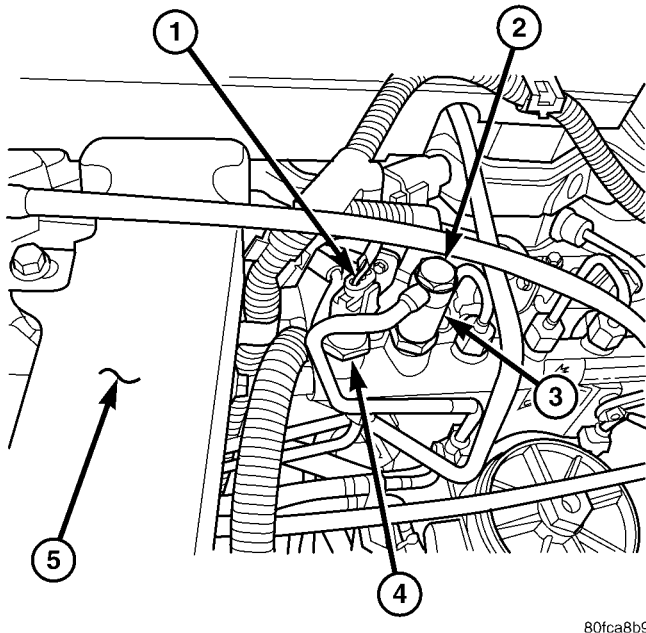
OPERATION

The fuel pressure sensor monitors actual high-pressure within the fuel rail. An output signal from this sensor (relating to fuel pressure) is sent to the Engine Control Module (ECM).

REMOVAL

The fuel pressure sensor is mounted vertically near the top/center of the fuel rail (Fig. 19).

- (1) Disconnect electrical connector at sensor.
- (2) Remove sensor from fuel rail.
- (3) Inspect sensor o-ring.



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Fig. 19 FUEL PRESSURE SENSOR/FUEL PRES. LIMIT. VALVE

- 1 - ELEC. CONNECTOR
- 2 - BANJO BOLT
- 3 - FUEL PRESSURE LIMITING VALVE
- 4 - FUEL PRESSURE SENSOR
- 5 - TOP OF INTAKE HEATER MANIFOLD

INSTALLATION

- (1) Inspect fuel pressure sensor o-ring.
- (2) Lubricate sensor o-ring with clean diesel fuel.
- (3) Install sensor into fuel rail.
- (4) To prevent leaks, sensor **must** be tightened to prescribed torque. Tighten sensor to 101 N·m (75 ft. lbs.) torque.
- (5) Connect electrical connector to sensor.
- (6) Start engine and check for fuel leaks.

FUEL PRESSURE LIMITING VALVE

DESCRIPTION

The fuel pressure limiting valve is located on the top of the fuel rail.

OPERATION

Fuel pressure at the fuel rail is monitored by the fuel rail pressure sensor. If fuel pressure becomes excessive, the pressure limiting valve opens and vents excess pressure into the fuel drain circuit.

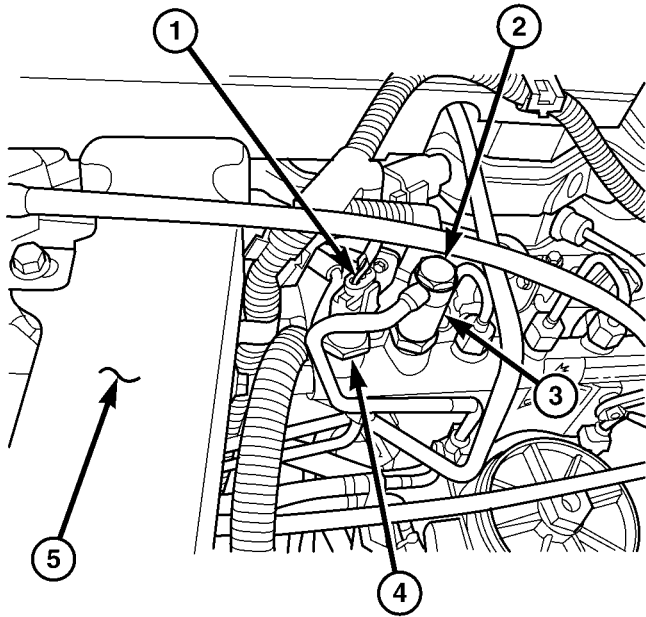
REMOVAL

The fuel pressure limiting valve is located on the top of the fuel rail (Fig. 20).

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.

- (1) Thoroughly clean area at pressure limiting valve.
- (2) Remove banjo bolt (Fig. 20) at banjo fitting.
- (3) Remove pressure limiting valve from intake manifold.

FUEL PRESSURE LIMITING VALVE (Continued)



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Fig. 20 FUEL PRESSURE SENSOR/FUEL PRESSURE LIMITING VALVE

- 1 - ELEC. CONNECTOR
- 2 - BANJO BOLT
- 3 - FUEL PRESSURE LIMITING VALVE
- 4 - FUEL PRESSURE SENSOR
- 5 - TOP OF INTAKE HEATER MANIFOLD

INSTALLATION

- (1) Be sure both top of manifold and limiting valve are clean.
- (2) Assemble banjo bolt and new sealing washers to limiting valve.
- (3) Tighten banjo bolt to 24 N·M (17 ft. lbs.) torque.

FUEL TANK

DESCRIPTION - DIESEL

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.

REMOVAL - DIESEL

Fuel Tank Draining

Due to a one-way check valve installed into the fuel fill opening fitting at the tank, the tank cannot be drained conventionally at the fill cap.

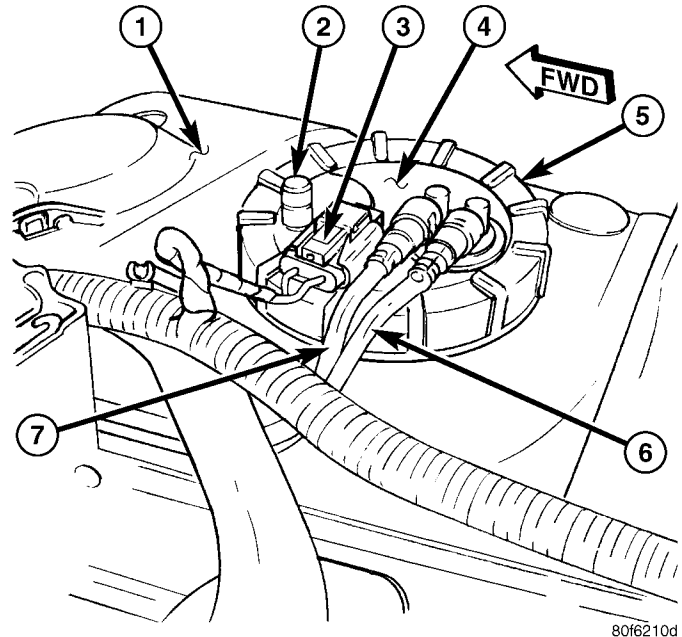
- (1) Raise vehicle.

(2) If vehicle is equipped with 4 doors and a 6 foot (short) box, remove left-rear tire/wheel.

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

(4) Remove rubber cap from auxiliary fitting on top of tank module (Fig. 21).

(5) Drain fuel tank by attaching drain hose from an approved draining station to auxiliary fitting on top of tank module (Fig. 21).



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Fig. 21 FUEL TANK MODULE - DIESEL

- 1 - TOP OF FUEL TANK
- 2 - AUX. FITTING
- 3 - ELEC. CONNECTOR
- 4 - FUEL TANK MODULE (TOP)
- 5 - LOCKNUT
- 6 - FUEL SUPPLY LINE
- 7 - FUEL RETURN LINE

Tank Removal

(1) Loosen clamp and disconnect rubber fuel fill hose at tank.

(2) Support tank with a hydraulic jack.

(3) Remove 2 fuel tank strap nuts (Fig. 22) and remove both tank support straps.

(4) Carefully lower tank a few inches and disconnect fuel pump module electrical connector (Fig. 21) at top of tank. To disconnect electrical connector: Push upward on red colored tab to unlock. Push on black colored tab while removing connector.

(5) Disconnect fuel supply and return lines at fuel tank module (Fig. 21). Refer to Quick-Connect Fittings for procedures.

(6) Continue to lower tank for removal.

FUEL TANK (Continued)

(7) If fuel tank is to be replaced, remove fuel tank module from tank. Refer to Fuel Tank Module Removal/Installation procedures.

INSTALLATION - DIESEL

(1) If fuel tank is to be replaced, install fuel tank module into tank. Refer to Fuel Tank Module Removal/Installation procedures.

(2) Position fuel tank to hydraulic jack.

(3) Raise tank until positioned near body.

(4) Connect fuel tank module electrical connector at top of tank.

(5) Connect fuel supply and return lines to tank module.

(6) Continue raising tank until positioned snug to body.

(7) Install and position both tank support straps. Install 2 fuel tank strap nuts and tighten. **Tighten rear strap nut first.** Refer to Torque Specifications.

(8) Remove hydraulic jack.

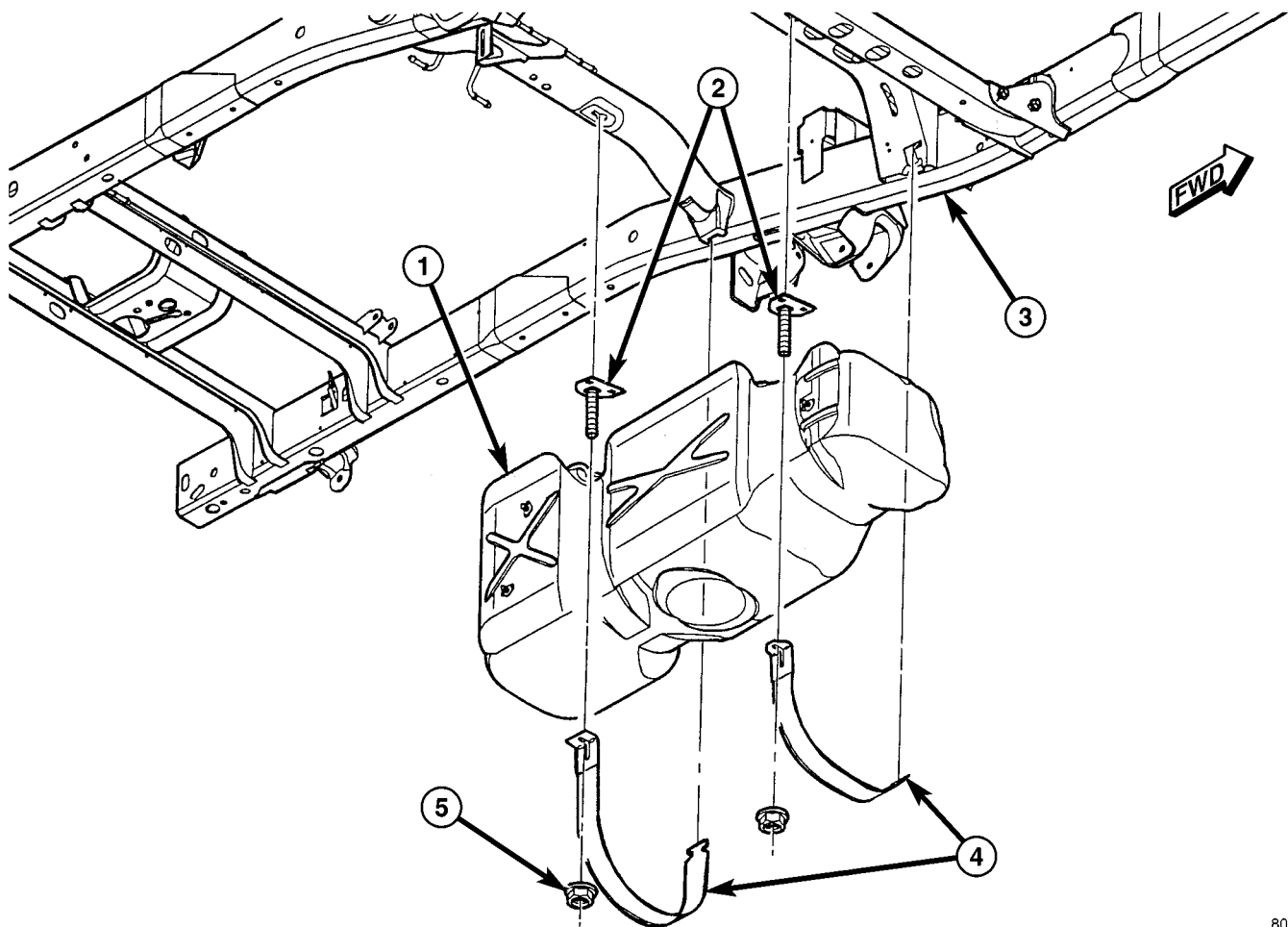
(9) Connect rubber fill hose to fuel fill tube and tighten clamp.

(10) Install tire / wheel (if necessary).

(11) Lower vehicle.

(12) Fill fuel tank with fuel.

(13) Start engine and check for fuel leaks near top of module.



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Fig. 22 FUEL TANK MOUNTING

1 - FUEL TANK
2 - STRAP MOUNTING STUDS
3 - VEHICLE FRAME

4 - MOUNTING STRAPS
5 - STRAP NUTS

FUEL TANK MODULE

DESCRIPTION

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 (lift) pump.

The fuel tank module is installed in the top of the fuel tank (Fig. 23). The fuel tank module contains the following components:

- Fuel reservoir
- A separate in-tank fuel filter
- Fuel gauge sending unit (fuel level sensor)
- Fuel supply line connection
- Fuel return line connection
- Auxiliary non-pressurized fitting

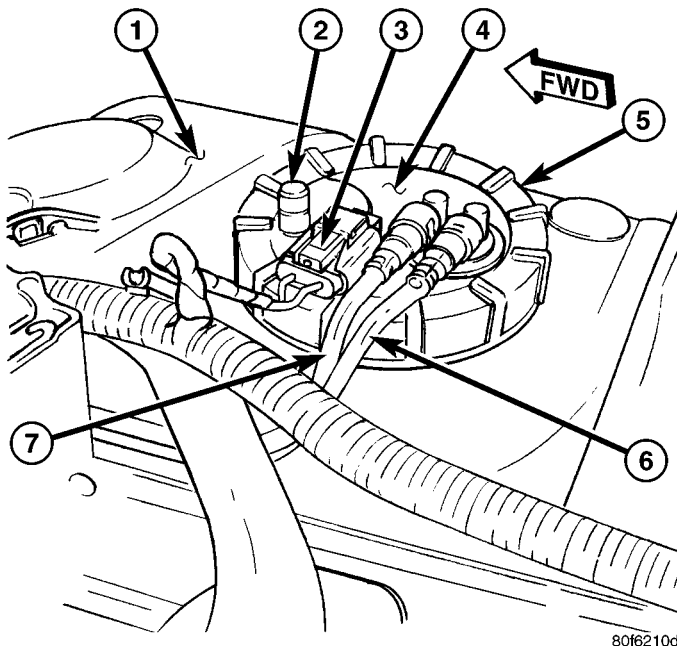


Fig. 23 FUEL TANK MODULE - DIESEL

- 1 - TOP OF FUEL TANK
- 2 - AUX. FITTING
- 3 - ELEC. CONNECTOR
- 4 - FUEL TANK MODULE (TOP)
- 5 - LOCKNUT
- 6 - FUEL SUPPLY LINE
- 7 - FUEL RETURN LINE

OPERATION

Refer to Fuel Gauge Sending Unit.

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. Install Special Tool 6856 to

locknut and remove locknut (Fig. 24). The fuel tank module will spring up when locknut is removed.

- (4) Remove module from fuel tank.

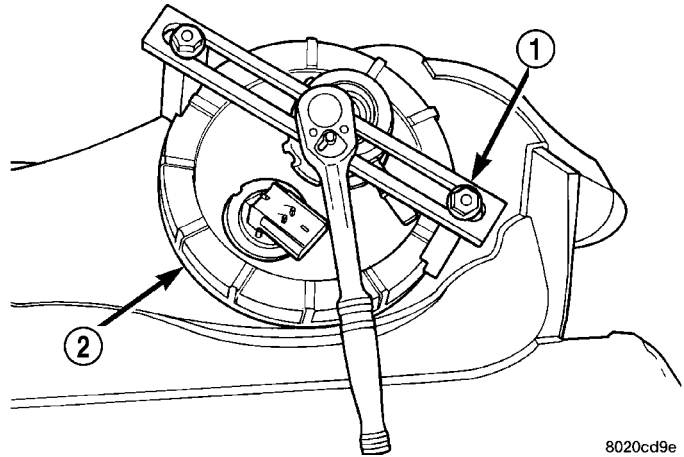


Fig. 24 LOCKNUT REMOVAL/INSTALLATION - TYPICAL MODULE

- 1 - SPECIAL TOOL 6856
- 2 - LOCKNUT

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 fuel line connectors and fuel gauge electrical connector should all be pointed to drivers side of vehicle. Rotate and align 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 TRANSFER PUMP

DESCRIPTION

The fuel transfer pump (fuel lift pump) is attached to the rear of the fuel filter/water separator housing. The 12-volt electric pump is operated and controlled by the Engine Control Module (ECM).

FUEL TRANSFER PUMP (Continued)

OPERATION

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.

Maximum current flow to the pump is 5 amperes.

With the engine running, the pump has a 100 percent duty-cycle with a minimum pressure of 11.5 psi.

The transfer pump is self-priming: When the key is first turned on (without cranking engine), the pump will operate for approximately 1/2 second 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.

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, and then back to the fuel tank.

REMOVAL

The fuel transfer pump (fuel lift pump) is attached to the rear of the fuel filter/water separator housing (Fig. 25).

(1) Drain fuel from fuel filter housing. Refer to Fuel Filter/Water Separator - Removal. See Draining.

(2) Disconnect electrical connector (Fig. 25) from fuel transfer pump.

(3) Disconnect fuel tank supply line from fuel transfer pump extension line. Do this at disconnection point at inside of left inner frame rail (Fig. 26). Refer to quick-connect fittings for procedures. **The fuel line extension is permanently attached to the transfer pump. Do not attempt to disconnect fuel line at transfer pump.**

(4) Remove 4 pump mounting bolts (hex-allen), and remove pump from fuel filter housing.

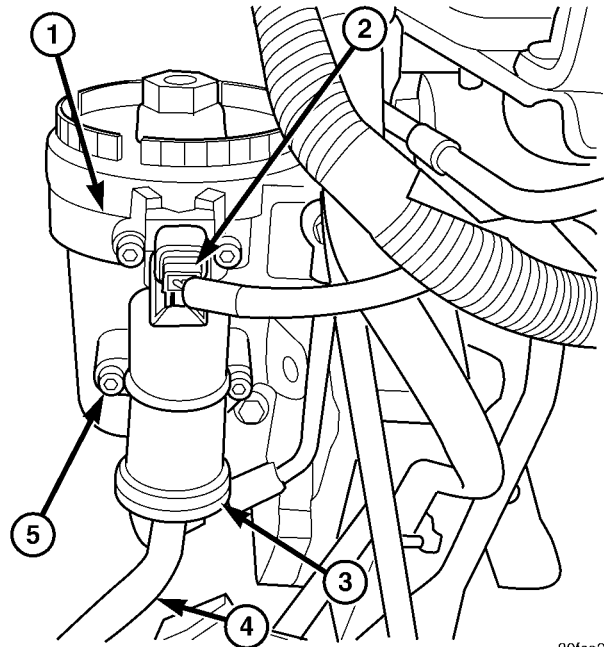
(5) Confirm that transfer pump o-ring is also removed from fuel filter housing.

INSTALLATION

(1) Install a new o-ring to fuel transfer pump.

(2) Lubricate o-ring and OD of transfer pump inlet connector.

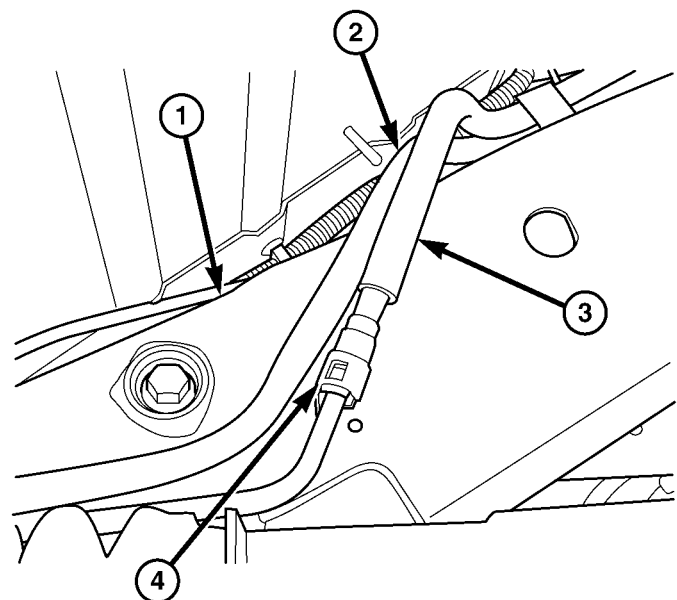
(3) Position fuel transfer pump onto fuel filter housing. **Do not use mounting bolts to draw transfer pump to filter housing.**



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Fig. 25 FUEL TRANSFER (LIFT) PUMP

- 1 - FILTER HOUSING
- 2 - ELEC. CONNECTOR
- 3 - FUEL TRANSFER (LIFT) PUMP
- 4 - FUEL LINE EXTENTION
- 5 - MOUNTING BOLTS (4)



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Fig. 26 TRANSFER PUMP FUEL LINE CONNECT

- 1 - LEFT INNER FRAME RAIL
- 2 - FUEL RETURN LINE
- 3 - FUEL SUPPLY LINE
- 4 - QUICK-CONNECT FITTING

FUEL TRANSFER PUMP (Continued)

(4) Be sure pump is positioned flat to fuel filter housing. Install mounting bolts and evenly tighten to 7 N·m (61 in. lbs.).

(5) Connect fuel line extension at fuel supply line.
(6) Connect electrical connector to pump.

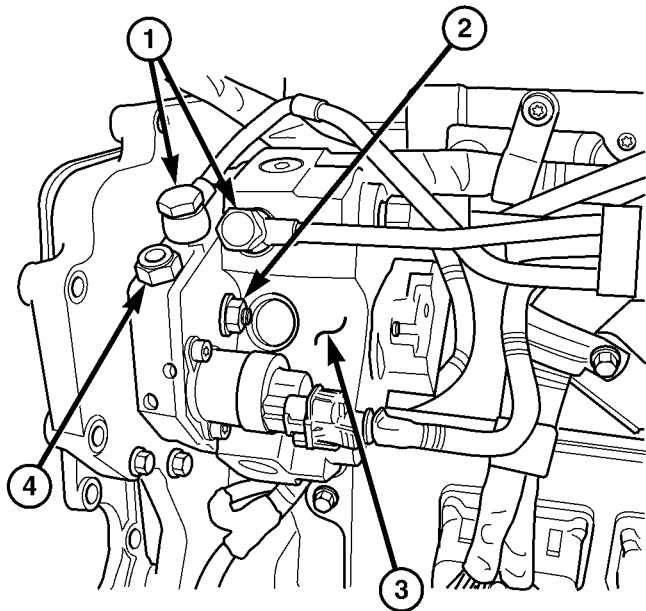
(7) **Prime System:** Cycle key to actuate transfer pump or use DRB II Scan Tool to actuate transfer pump. Check for leaks.

(8) Operate engine and check for fuel leaks.

CASCADE OVERFLOW VALVE

DESCRIPTION

The cascade overflow valve is located on the top/rear side of the fuel injection pump (Fig. 27).



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Fig. 27 OVERFLOW VALVE

- 1 - BANJO BOLTS
- 2 - PUMP MOUNTING NUTS (3)
- 3 - FUEL INJECTION PUMP
- 4 - CASCADE OVERFLOW VALVE

OPERATION

When the fuel control actuator (FCA) is opened, the maximum amount of fuel is being delivered to the fuel injection pump. Any fuel that does not enter the injection pump is directed to the cascade overflow valve. The cascade valve regulates how much excess fuel is used for lubrication of the injection pump, and is also used to route excess fuel through the drain circuit and back into the fuel tank.

REMOVAL

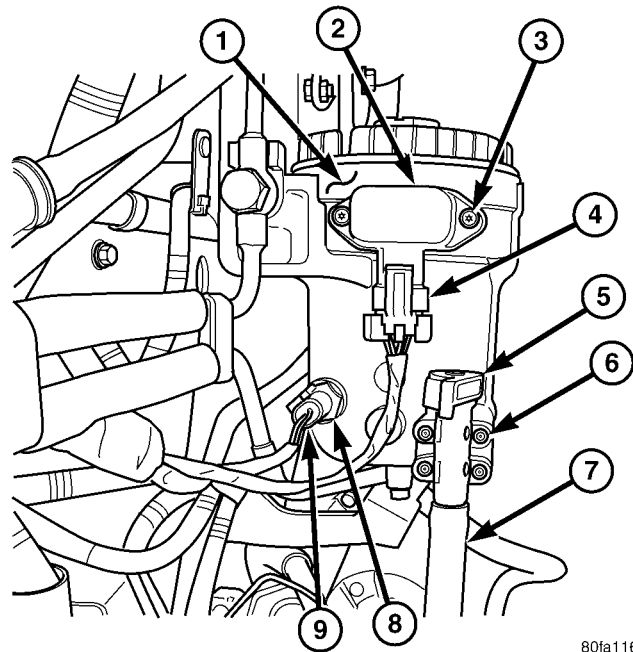
REMOVAL/INSTALLATION

The cascade overflow valve is not serviced separately.

WATER IN FUEL SENSOR

DESCRIPTION

The Water-In-Fuel (WIF) sensor is located on the side of the fuel filter/water separator canister (Fig. 28), or (Fig. 29).

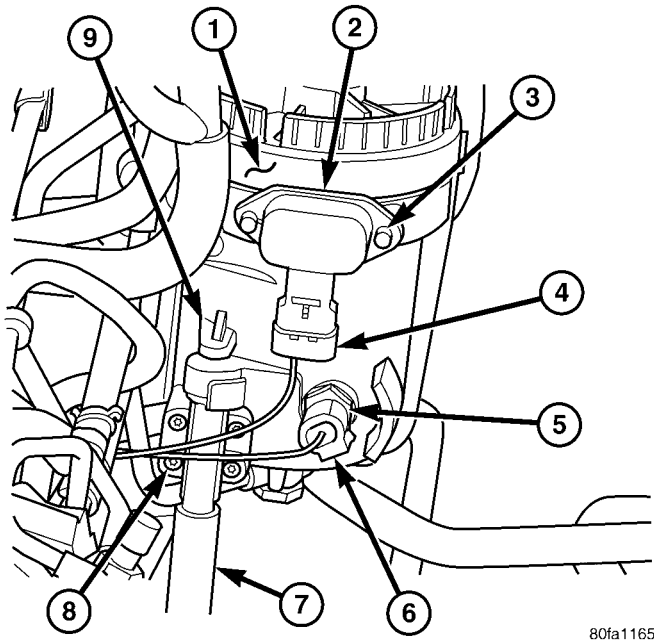


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Fig. 28 FILTER HOUSING (EARLY)

- 1 - FILTER HOUSING
- 2 - FUEL HEATER AND THERMOSTAT
- 3 - FUEL HEATER MOUNTING SCREWS
- 4 - FUEL HEATER ELEC. CONNECTOR
- 5 - DRAIN VALVE
- 6 - DRAIN VALVE MOUNTING SCREWS
- 7 - DRAIN HOSE
- 8 - WIF SENSOR
- 9 - WIF SENSOR ELEC. CONNECTOR

WATER IN FUEL SENSOR (Continued)



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Fig. 29 FILTER HOUSING (LATE)

- 1 - FILTER HOUSING
- 2 - FUEL HEATER AND THERMOSTAT
- 3 - FUEL HEATER MOUNTING SCREWS
- 4 - FUEL HEATER ELEC. CONNECTOR
- 5 - WIF SENSOR
- 6 - WIF SENSOR ELEC. CONNECTOR
- 7 - DRAIN HOSE
- 8 - DRAIN VALVE MOUNTING SCREWS
- 9 - DRAIN VALVE

OPERATION

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.

REMOVAL

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.

FUEL DRAIN CIRCUIT**OPERATION**

The Fuel Drain Circuit incorporates several sources of fuel return. Fuel travels from the fuel tank to the fuel transfer pump and is forced through the fuel filter. A portion of that fuel travels through the fuel filter and into the fuel injection pump, while the rest of the fuel flows through a passage in the fuel filter housing. It then goes to a fuel drain line and returns back to the fuel tank.

The fuel that flows to the fuel pump is pressurized and sent into a passage in the fuel pump. At this point the fuel is channeled into two passages. One passage sends fuel to the FCA (Fuel Control Actuator). The other passage sends fuel to the cascade overflow valve. The overflow valve sends some fuel to a lubrication passage. The rest of the fuel is sent to a drain passage which connects to an external fuel line. This fuel line is connected to the same fuel filter housing passage that the fuel transfer pump is connected to.

Fuel that travels through the FCA is pressurized by the fuel injection pump and sent through an external high pressure fuel line to the fuel rail. At the fuel rail, fuel is sent to the fuel injectors. If fuel pressure in the fuel rail becomes excessive, the pressure limiting valve opens and sends fuel through an external fuel line. This line is connected to the fuel filter housing at the fuel pump drain.

At the fuel injector, fuel that is not injected is used for lubrication of the fuel injectors. This fuel then travels through an internal passage in the rear of the cylinder head, and then into an external fuel line. This line is connected to the vehicles fuel return line, and returns excess fuel back to the fuel tank.

FUEL INJECTION - DIESEL

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ACCELERATOR PEDAL POSITION SENSOR

DESCRIPTION

DESCRIPTION (EARLY)

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

DESCRIPTION (LATE)

The Accelerator Pedal Position Sensor (APPS) assembly is located under the vehicle battery tray. A cable connects the assembly to the accelerator pedal.

A plastic cover with a movable door is used to cover the assembly.

OPERATION

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.

REMOVAL

Early Diesel Engines

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. 1).

ACCELERATOR PEDAL POSITION SENSOR (Continued)

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. 3) are used to position lever. Do not attempt to alter positions of these set screws as electronic calibration will be destroyed.

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

(2) Remove cable cover (Fig. 1). Cable cover is attached with 2 Phillips screws, 2 plastic retention clips and 2 push tabs (Fig. 1). 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. 2). **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. 2). **Be very careful not to bend throttle lever arm.**

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

(6) Squeeze pinch tabs on speed control cable (Fig. 2) and pull cable rearward to remove from cable mounting bracket.

(7) Squeeze pinch tabs on throttle cable (Fig. 2) and pull cable rearward to remove from cable mounting bracket.

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

(9) Disconnect wiring harness clip (Fig. 3) at bottom of bracket.

(10) Remove 6 mounting bolts (Fig. 3) 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. 4).

(11) Remove APPS assembly from engine.

Late Diesel Engines

The APPS is serviced (replaced) as one assembly including the sensor, plastic housing and cable. The APPS assembly is located under the left vehicle battery tray (Fig. 5). Access to APPS is gained from over top of left / front tire.

(1) Disconnect negative battery cable at battery.

(2) Disconnect APPS cable at accelerator pedal. Refer to Accelerator Pedal Removal / Installation.

(3) Remove wheel house liner at left / front wheel. Refer to Body.

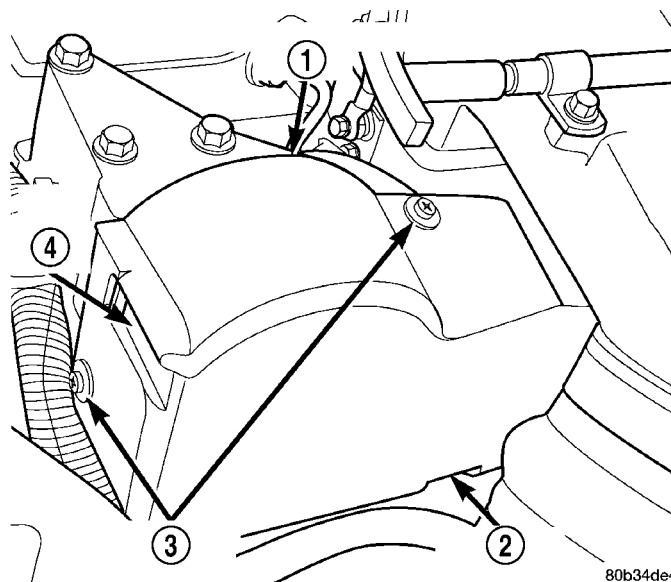


Fig. 1 CABLE/LEVER/THROTTLE LINKAGE COVER

- 1 - CABLE/LEVER/LINKAGE COVER
- 2 - PUSH UP LOWER TAB
- 3 - SCREWS/CLIPS (2)
- 4 - TAB PUSH HERE

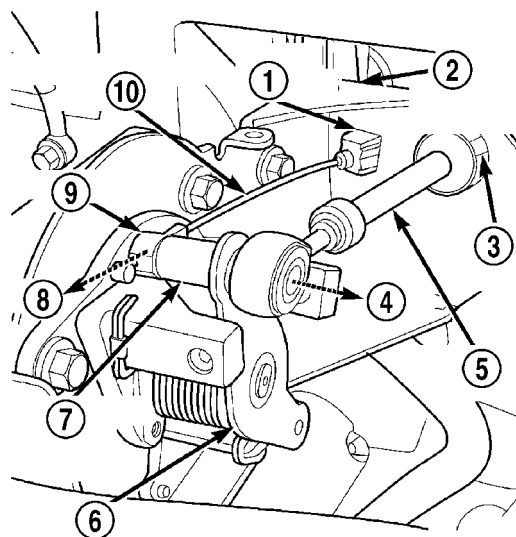


Fig. 2 SERVO CABLE AT THROTTLE LEVER

- 1 - PINCH (2) TABS
- 2 - CABLE MOUNTING BRACKET
- 3 - PINCH TABS (2)
- 4 - OFF
- 5 - THROTTLE CABLE
- 6 - THROTTLE LEVER
- 7 - THROTTLE LEVER PIN
- 8 - OFF
- 9 - CONNECTOR
- 10 - SPEED CONTROL CABLE

(4) Gain access to APPS electrical connector by opening swing-down door (Fig. 6). Disconnect electrical connector.

(5) Remove 3 mounting bolts (Fig. 6).

(6) Remove APPS assembly from battery tray.

ACCELERATOR PEDAL POSITION SENSOR (Continued)

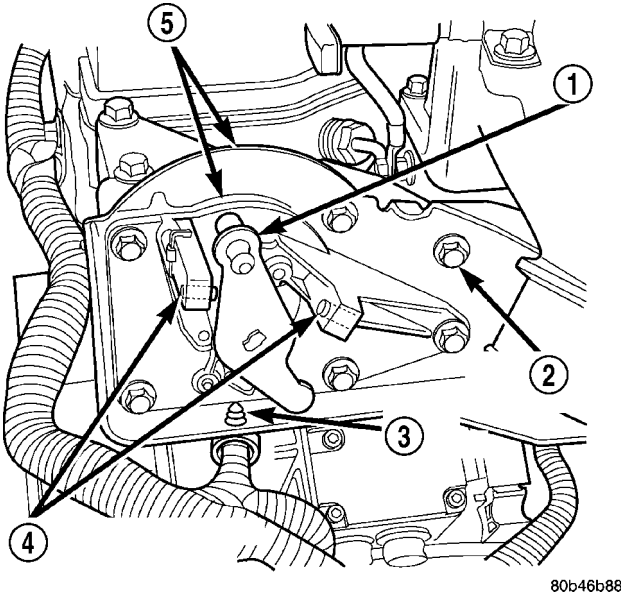


Fig. 3 APPS ASSEMBLY

- 1 - LEVER
- 2 - MOUNTING BOLTS (6)
- 3 - WIRE HARNESS CLIP
- 4 - CALIBRATION SCREWS (NO ADJUSTMENT)
- 5 - APPS ASSEMBLY

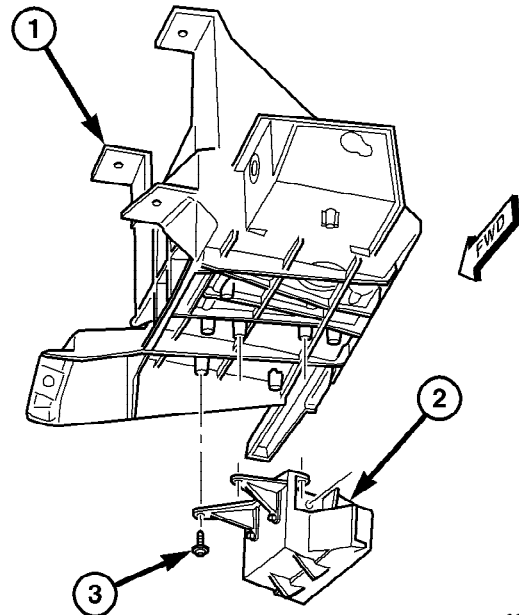


Fig. 5 APPS LOCATION (LATE)

- 1 - BATTERY TRAY
- 2 - APPS LOCATION
- 3 - APPS MOUNTING BOLTS

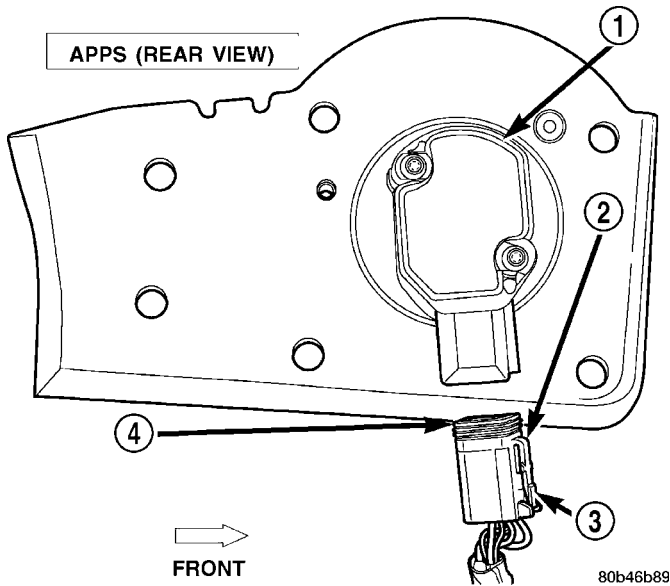


Fig. 4 APPS CONNECTOR

- 1 - APPS
- 2 - TAB
- 3 - PUSH FOR REMOVAL
- 4 - APPS CONNECTOR

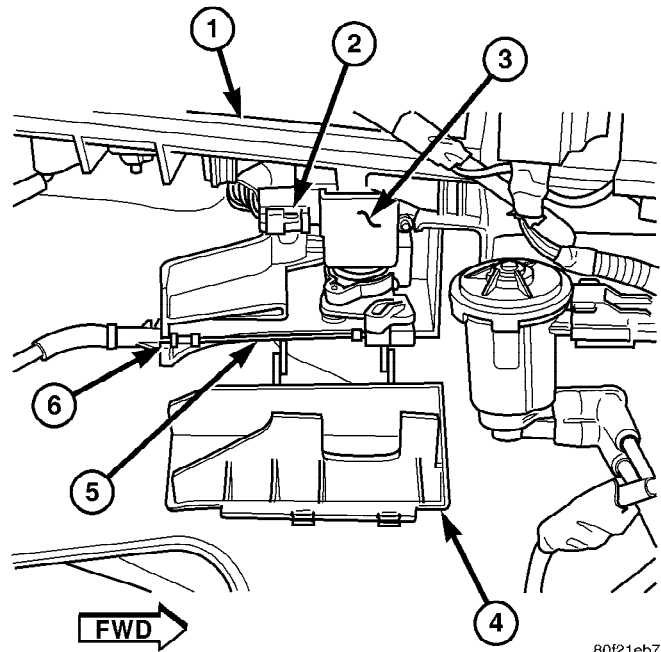
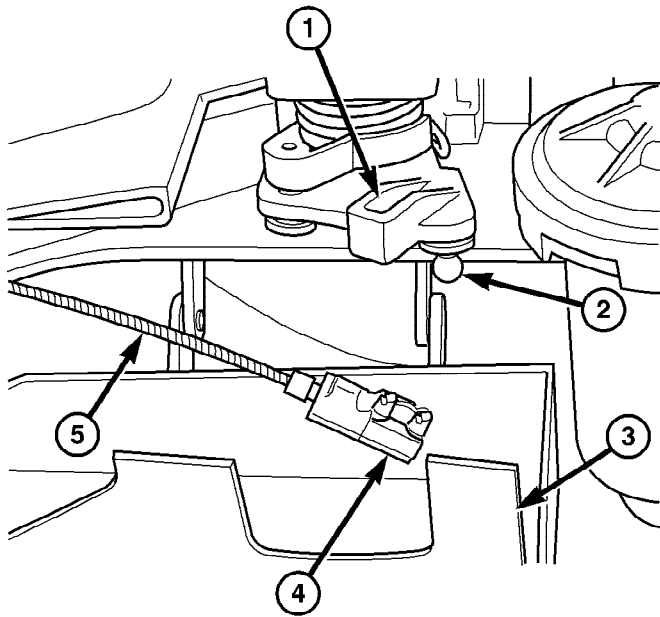


Fig. 6 APPS REMOVE / INSTALL (LATE)

- 1 - BOTTOM OF BATTERY TRAY
- 2 - ELECTRICAL CONNECTOR
- 3 - APPS
- 4 - SWING-DOWN DOOR
- 5 - CABLE (TO PEDAL)
- 6 - CABLE RELEASE TAB

(7) If cable is to be separated at APPS, unsnap cable clip from ball socket (Fig. 7). Release cable from plastic housing by pressing on small cable release tab (Fig. 6).

ACCELERATOR PEDAL POSITION SENSOR (Continued)



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Fig. 7 APPS CABLE (LATE)

- 1 - APPS LEVER
- 2 - BALL SOCKET
- 3 - SWING-DOWN DOOR
- 4 - CABLE CLIP
- 5 - CABLE

INSTALLATION**Early Diesel Engines**

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

- (1) Snap electrical connector into bottom of sensor.
- (2) Position APPS assembly to engine and install 6 bolts. Tighten bolts to 24 N·m (18 ft. lbs.) torque.
- (3) Connect wiring harness clip 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 have secured cable.
- (6) Install throttle cable into mounting bracket. Be sure pinch tabs 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 III scan tool to erase any DTC's from ECM.

Late Diesel Engines

(1) Install Accelerator Pedal Position Sensor (APPS) cable to accelerator pedal. Refer to Accelerator Pedal Removal / Installation.

(2) Connect electrical connector to APPS.

(3) If necessary, connect cable to APPS lever ball socket (snaps on).

(4) Snap APPS cable cover closed.

(5) Position APPS assembly to bottom of battery tray and install 3 bolts. Refer to Torque Specifications.

(6) Install wheelhouse liner. Refer to Body.

(7) Perform the following procedure:

(a) Connect negative battery cables to both batteries.

(b) Turn key switch ON, but do not crank engine.

(c) Leave key switch ON for a minimum of 10 seconds. This will allow ECM to learn electrical parameters.

(8) If necessary, use DRB III® Scan Tool to erase any Diagnostic Trouble Codes (DTC's) from PCM.

CAMSHAFT POSITION SENSOR**DESCRIPTION**

The Camshaft Position Sensor (CMP) on the 5.9L diesel engine is located below the fuel injection pump. It is bolted to the back of the timing gear cover.

OPERATION

The diesel Camshaft Position Sensor (CMP) contains a hall effect device. A rotating target wheel (tonewheel) for the CMP is located on the front timing gear. This hall effect device detects notches located on the tonewheel. As the tonewheel rotates, the notches pass the tip of the CMP.

When the leading edge of the tonewheel notch passes the tip of the CMP, the following occurs: 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 tonewheel notch passes the tip of the CMP, the following occurs: The change of the magnetic field causes the signal voltage to switch low to 0 volts.

CAMSHAFT POSITION SENSOR (Continued)

The CMP (Fig. 8) provides a signal to the Engine Control Module (ECM) at all times when the engine is running. The ECM uses the CMP information primarily on engine start-up. Once the engine is running, the ECM uses the CMP as a backup sensor for engine speed. The Crankshaft Position Sensor (CKP) is the primary engine speed indicator for the engine after the engine is running.

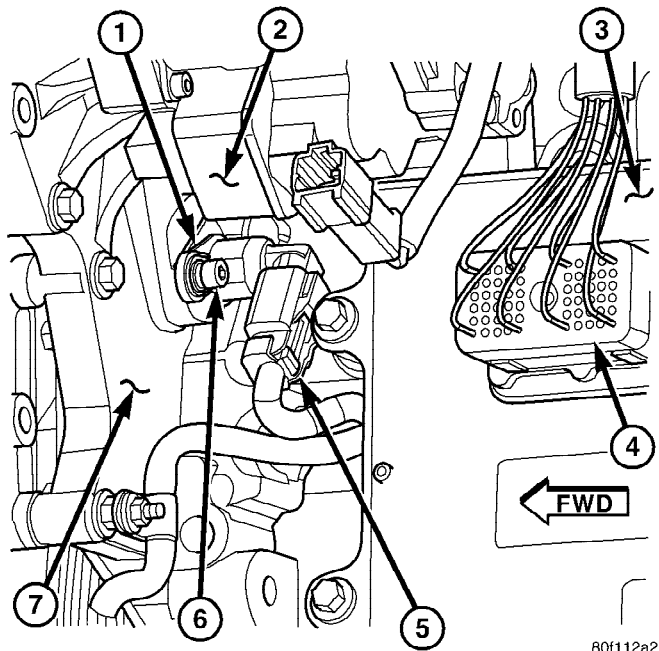


Fig. 8 5.9L DIESEL CMP

- 1 - CMP
- 2 - FUEL INJECTION PUMP (BOTTOM)
- 3 - ELECTRONIC CONTROL MODULE (ECM)
- 4 - ECM ELEC. CONNECTOR
- 5 - CMP ELEC. CONNECTOR
- 6 - CMP MOUNTING BOLT
- 7 - BACK OF TIMING GEAR COVER

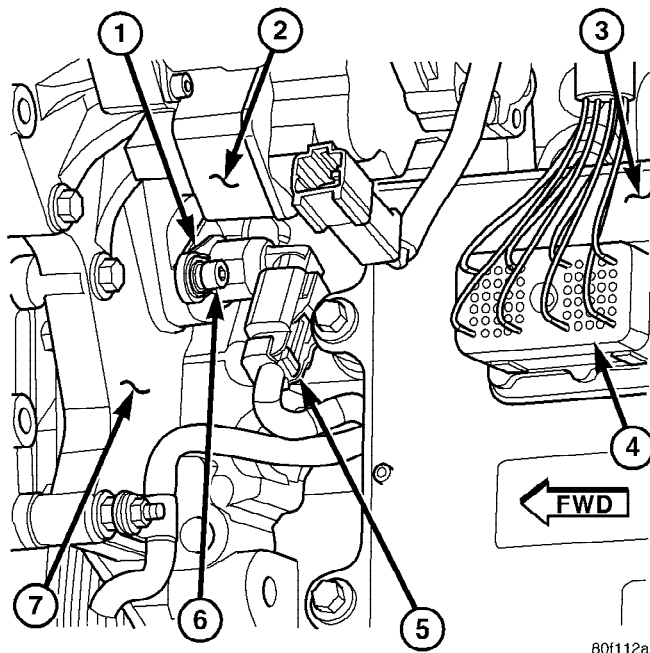
REMOVAL

The Camshaft Position Sensor (CMP) on the 5.9L diesel engine is located below the fuel injection pump. It is bolted to the back of the timing gear cover (Fig. 9).

- (1) Disconnect electrical connector at CMP sensor (Fig. 9).
- (2) Remove sensor mounting bolt.
- (3) Carefully twist sensor from timing gear cover.
- (4) Check condition of sensor o-ring.

INSTALLATION

- (1) Clean out machined hole in back of timing gear cover.
- (2) Apply a small amount of engine oil to sensor o-ring.
- (3) Install sensor into timing gear cover with a slight rocking action. Do not twist sensor into position as damage to o-ring may result.



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Fig. 9 5.9L DIESEL CMP

- 1 - CMP
- 2 - FUEL INJECTION PUMP (BOTTOM)
- 3 - ELECTRONIC CONTROL MODULE (ECM)
- 4 - ECM ELEC. CONNECTOR
- 5 - CMP ELEC. CONNECTOR
- 6 - CMP MOUNTING BOLT
- 7 - BACK OF TIMING GEAR COVER

CAUTION: Before tightening sensor mounting bolt, be sure sensor is completely flush to back of timing chain cover. If sensor is not flush, damage to sensor mounting tang may result.

(4) Install mounting bolt and tighten. Refer to Torque Specifications.

(5) Connect electrical connector to sensor.

CRANKSHAFT POSITION SENSOR

DESCRIPTION

The Crankshaft Position Sensor (CKP) on the diesel engine is attached at the front / left side of the engine next to the engine harmonic balancer.

OPERATION

The Crankshaft Position Sensor (CKP) is the primary engine speed indicator for the engine after the engine is running (Fig. 10). The CKP contains a hall effect device. A rotating, notched target wheel (tone-wheel) for the CMP is located on the engine harmonic balancer (Fig. 11). This hall effect device detects notches located on the tonewheel. As the

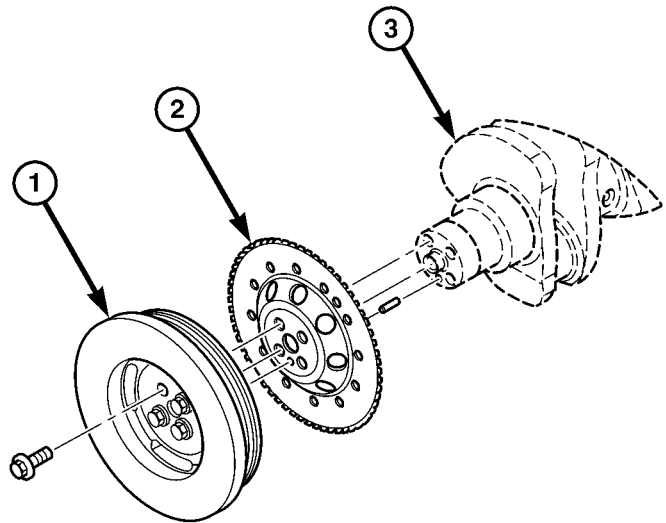
CRANKSHAFT POSITION SENSOR (Continued)

tonewheel rotates, the notches pass the tip of the CKP.

When the leading edge of the tonewheel notch passes the tip of the CKP, the following occurs: 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 tonewheel notch passes the tip of the CKP, the following occurs: The change of the magnetic field causes the signal voltage to switch low to 0 volts.

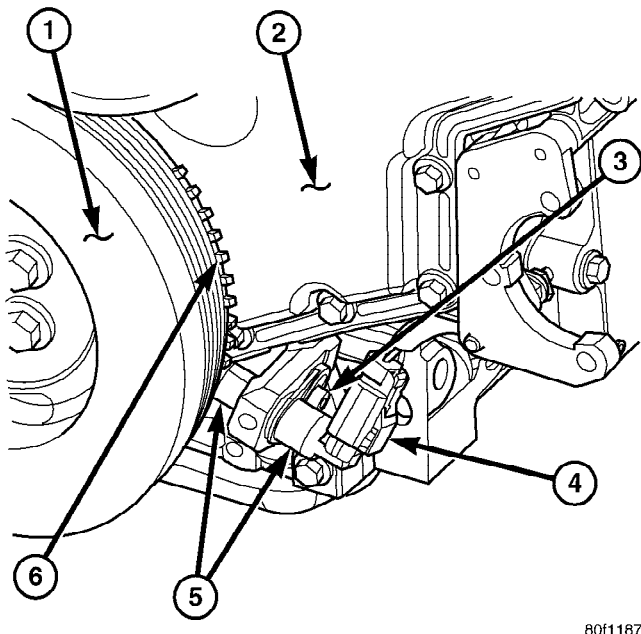
The Camshaft Position Sensor (CMP) also provides a signal to the Engine Control Module (ECM) at all times when the engine is running. The ECM uses this CMP information primarily on engine start-up. Once the engine is running, the ECM uses the CMP as a backup sensor for engine speed.



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Fig. 11 CKP NOTCHED TONEWHEEL

- 1 - ENGINE HARMONIC BALANCER
- 2 - NOTCHED TONEWHEEL
- 3 - FRONT OF CRANKSHAFT



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Fig. 10 5.9L DIESEL CKP

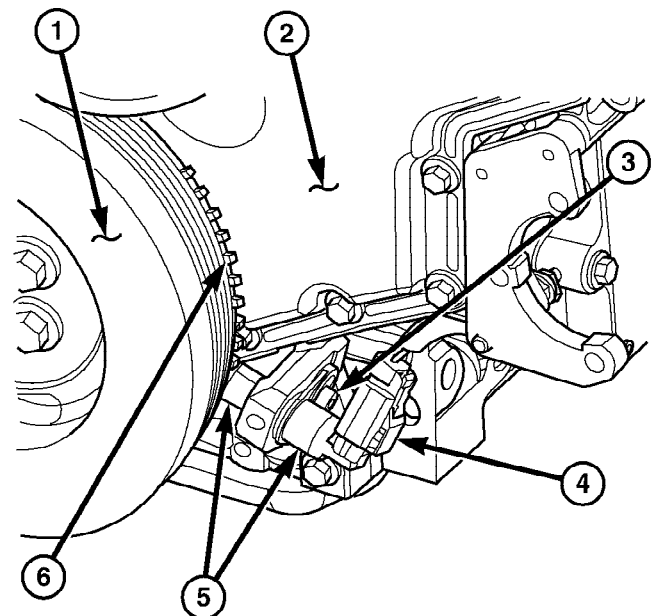
- 1 - ENGINE HARMONIC BALANCER
- 2 - FRONT OF TIMING GEAR COVER
- 3 - CKP MOUNTING BOLT
- 4 - ELEC. CONNECTOR
- 5 - CKP SENSOR
- 6 - NOTCHES

REMOVAL

- (1) Raise and support vehicle
- (2) Disconnect electrical connector at CKP sensor (Fig. 12).
- (3) Remove 1 sensor mounting bolt.
- (4) Remove CKP sensor.

INSTALLATION

- (1) Position and install CKP sensor to engine.
- (2) Install 1 sensor mounting bolt. Refer to Torque Specifications.



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Fig. 12 5.9L DIESEL CKP

- 1 - ENGINE HARMONIC BALANCER
- 2 - FRONT OF TIMING GEAR COVER
- 3 - CKP MOUNTING BOLT
- 4 - ELEC. CONNECTOR
- 5 - CKP SENSOR
- 6 - NOTCHES

- (3) Install electrical connector to CKP sensor (Fig. 12).

FUEL CONTROL ACTUATOR

DESCRIPTION

The Fuel Control Actuator (FCA) is located at the rear of the high-pressure, fuel injection pump.

OPERATION

The Fuel Control Actuator (FCA) is an electronically controlled solenoid valve. The ECM controls the amount of fuel that enters the high-pressure pumping chambers by opening and closing the FCA based on a demanded fuel pressure. When the FCA is opened, the maximum amount of fuel is being supplied to the fuel injection pump. Any fuel that does not enter the injection pump is directed to the overflow valve. The overflow valve regulates how much excess fuel is used for lubrication of the pump and how much is returned to the fuel tank through the drain manifold.

An audible click from the FCA is normal when operating the key to either the ON or OFF positions.

REMOVAL

The Fuel Control Actuator (FCA) is located at the rear of the high-pressure, fuel injection pump (Fig. 13).

- (1) Clean FCA mounting area at rear of fuel injection pump with an evaporative-type cleaner.
- (2) Disconnect electrical connector at FCA.
- (3) Remove 2 FCA mounting bolts.
- (4) Remove FCA from injection pump.
- (5) After removal, inspect FCA for corrosion or damage. Shake the FCA and listen for a rattle. If FCA does not rattle, replace it.

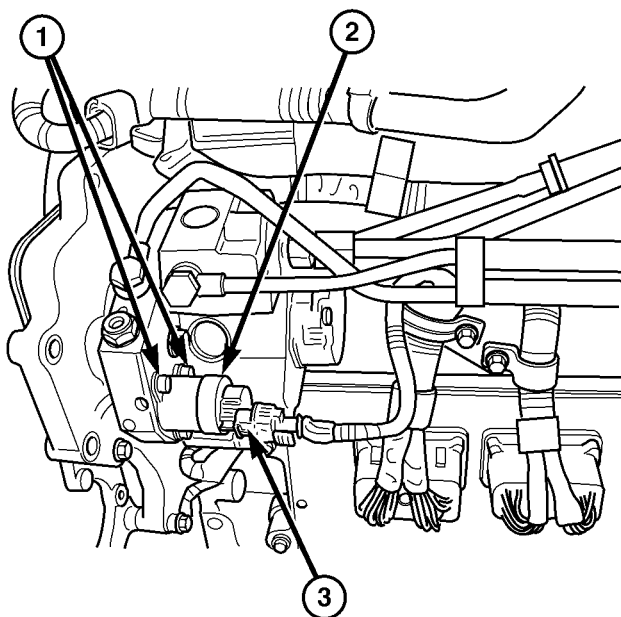


Fig. 13 FUEL CONTROL ACTUATOR

- 1 - ACTUATOR MOUNTING BOLTS
- 2 - FCA (FUEL CONTROL ACTUATOR)
- 3 - ACTUATOR ELECTRICAL CONNECTOR

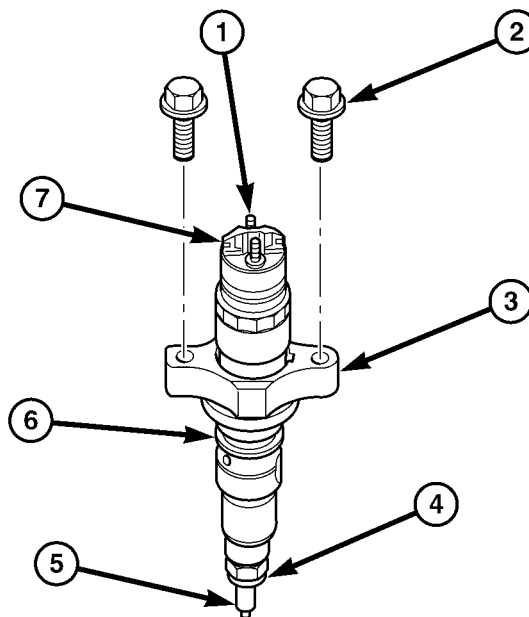
INSTALLATION

- (1) Install new o-rings to the Fuel Control Actuator (FCA).
- (2) Lubricate o-rings with clean, light grease.
- (3) Using new mounting bolts, install FCA into injection pump. Tighten the micro-encapsulated bolts in two stages. First to 3 N·m (27 in. lbs.), and then to 7 N·m (62 in. lbs.) torque. Do not pause more than two minutes between tightening stages as bolts may lose their ability to retain torque.
- (4) Ensure FCA is mounted flush to injection pump.
- (5) Connect electrical connector to FCA.
- (6) Start engine and observe for leaks.

FUEL INJECTOR

DESCRIPTION

Six individual, solenoid actuated high-pressure fuel injectors are used (Fig. 14). The injectors are vertically mounted into a bored hole in the top of the cylinder head. This bored hole is located between the intake/exhaust valves. High-pressure connectors (Fig. 15), mounted into the side of the cylinder head, connect each fuel injector to each high-pressure fuel line.

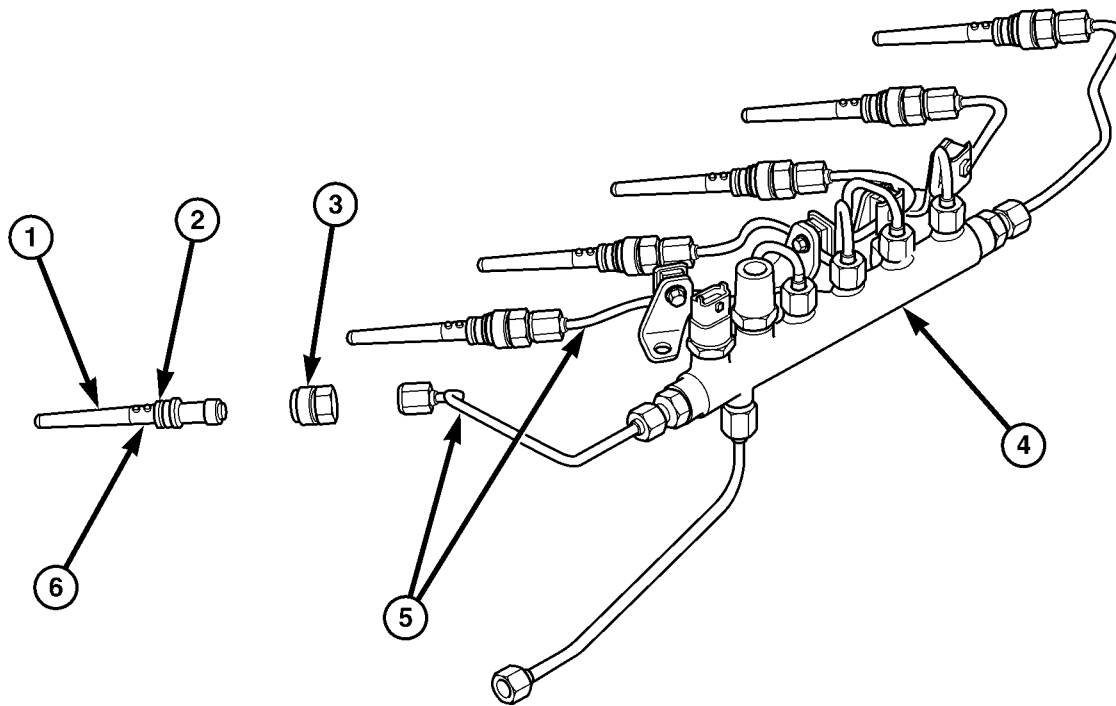


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Fig. 14 FUEL INJECTOR - DIESEL

- 1 - SOLENOID ELECTRICAL CONNECTOR STUDS
- 2 - MOUNTING BOLTS
- 3 - MOUNTING PLATES
- 4 - COPPER SEALING WASHER
- 5 - INJECTOR TIP
- 6 - INJECTOR O-RING
- 7 - INJECTOR ELECTRICAL SOLENOID

FUEL INJECTOR (Continued)



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Fig. 15 HIGH-PRESSURE CONNECTOR

1 - HIGH-PRESSURE CONNECTOR (TO FUEL INJECTOR)
 2 - O-RING
 3 - CONNECTOR RETAINER

4 - FUEL RAIL
 5 - HIGH-PRESSURE FUEL LINES
 6 - LOCATING PINS

OPERATION

High-pressure fuel is supplied from the injection pump, through a high-pressure fuel line, through a fuel pressure limiting valve, into a fuel rail, through high-pressure lines, through steel connectors and into the solenoid actuated fuel injector. The ECM actuates the solenoid causing the needle valve to rise and fuel flows through the spray holes in the nozzle tip into the combustion chamber.

Each fuel injector is connected to the fuel rail by a high-pressure fuel line with a steel connector. 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. The ferrule 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.

The fuel injectors use hole type nozzles. High-pressure flows into the side of the injector, the ECM activates the solenoid causing the injector needle to lift and fuel to be injected. The clearances in the nozzle bore 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.

Each fuel injector connector tube contains an edge filter 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). 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

FUEL INJECTOR (Continued)

closed and fuel flow into the combustion chamber is stopped. Exhaust gases are prevented from entering the injector nozzle by the needle valve.

REMOVAL

CAUTION: Refer to Cleaning Fuel System Parts.

Six individual, solenoid actuated high-pressure fuel injectors are used (Fig. 14). The injectors are vertically mounted into a bored hole in the top of the cylinder head. This bored hole is located between the intake/exhaust valves. High-pressure connectors (Fig. 15), mounted into the side of the cylinder head, connect each fuel injector to each high-pressure fuel line.

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

(2) Remove breather assembly.

(3) Remove valve cover. Refer to Engines for procedures.

(4) Remove necessary high pressure fuel line connecting necessary fuel injector rail to high pressure connector. Refer to Fuel Line Removal for procedures.

(5) A connector retainer (nut) (Fig. 15) is used on each connector tube. Remove this nut(s) by unthreading from cylinder head.

(6) Using special high-pressure connector removal tool #9015 (Fig. 16), or (Fig. 17) remove necessary high-pressure connector(s) from cylinder head. Tool #9015 threads onto connector tube. Use tool to pry connector tube(s) from cylinder head.

(7) Remove necessary exhaust rocker arm assembly(s).

(8) Disconnect injector solenoid wire nuts at top of injectors (Fig. 18).

(9) Remove 2 fuel injector hold-down clamp bolts at each injector being removed.

(10) USING TOOL #9010:

(a) Special Tool #9010 (Fig. 19) is equipped with 2 clamshell clamps, a sliding retainer sleeve to retain the clamshell clamps, a 2-piece mounting stud, and a pivoting handle. **Do not attempt to remove the fuel injector with any other device. Damage to injector will occur.**

(b) The rocker housing (Fig. 18) is bolted to the top of cylinder head. The mounting stud from tool #9010 was meant to temporarily replace a rocker housing mounting bolt. Remove the necessary rocker housing mounting bolt. These mounting bolts are located at the center of each of the 3 rocker housing support bridges.

(c) Install and tighten 2-piece mounting stud to rocker housing. If removing the #6 fuel injector, separate the 2-piece mounting stud. Install lower half of mounting stud to center of rocker housing bridge. Install upper half of mounting stud to lower half.

(d) Position tool handle to mounting stud and install handle nut. Leave handle nut loose to allow a pivoting action.

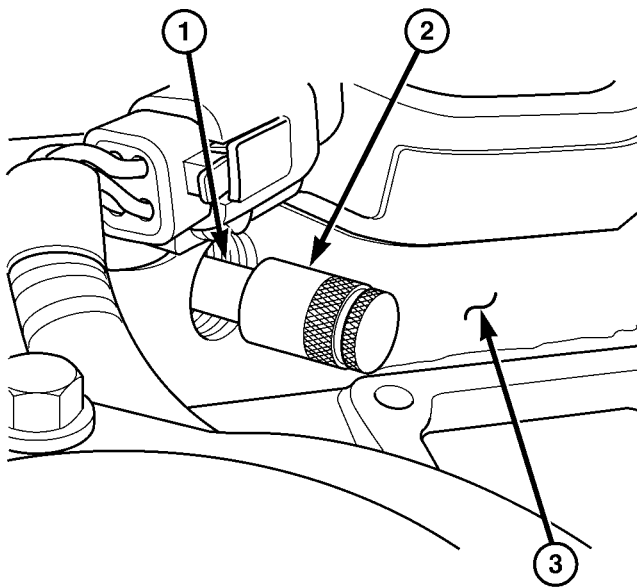
(e) Position lower part of clamshell halves to sides of fuel injector (wider shoulder to bottom). The upper part of clamshell halves should also be positioned into machined shoulder on the handles pivoting head.

(f) Slide the retainer sleeve over pivoting handle head to lock clamshell halves together.

(g) Be sure handle pivot nut is loose.

(h) Depress handle downward to remove fuel injector straight up from cylinder head bore.

(11) Remove and discard injector sealing washer. This should be located on tip of injector (Fig. 20) or (Fig. 21).



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Fig. 16 CONNECTOR TUBE REMOVAL

- 1 - CONNECTOR TUBE
- 2 - TOOL #9015
- 3 - CYLINDER HEAD (LEFT SIDE)

INSTALLATION

(1) Inspect fuel injector.

(a) Look for burrs on injector inlet.

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

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

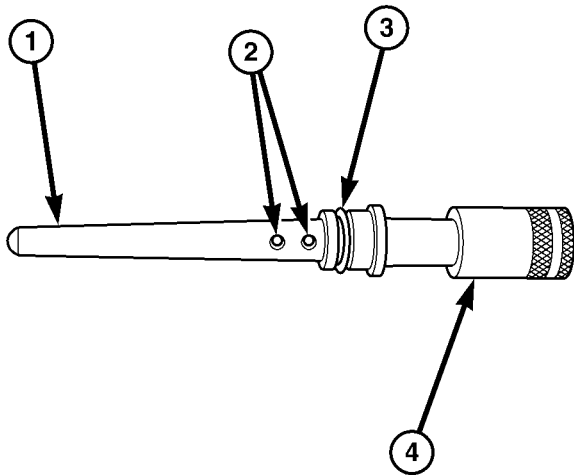
(d) Look for cracks at nozzle end.

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

(f) 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. 22). Blow out bore hole with compressed air.

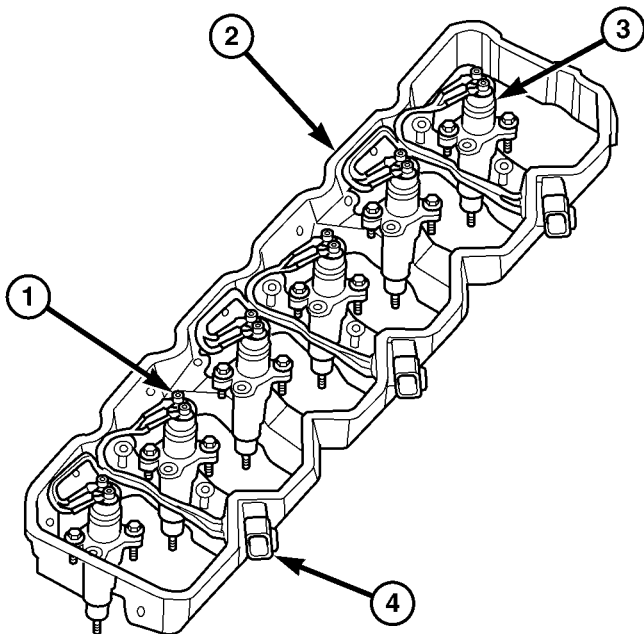
FUEL INJECTOR (Continued)



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Fig. 17 TOOL #9015 AND CONNECTOR TUBE

- 1 - CONNECTOR TUBE
- 2 - LOCATING PINS
- 3 - RUBBER O-RING
- 4 - TOOL #9015

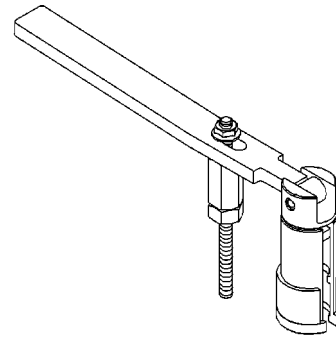
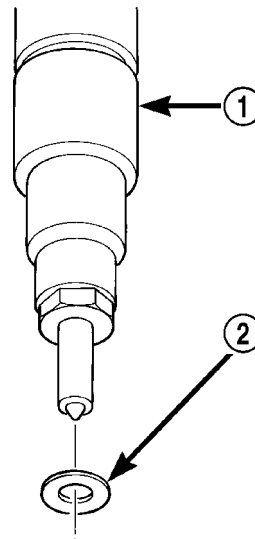


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Fig. 18 FUEL INJECTORS

- 1 - SOLENOID CONNECTIONS
- 2 - ROCKER HOUSING
- 3 - FUEL INJECTOR
- 4 - PASSTHROUGH CONNECTOR

(3) The bottom of fuel injector is sealed to cylinder head bore with a copper sealing washer (shim) of a

**Fig. 19 FUEL INJECTOR REMOVER - #9010**

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Fig. 20 FUEL INJECTOR SEALING WASHER (SHIM) LOCATION

- 1 - FUEL INJECTOR
- 2 - COPPER SEALING WASHER (SHIM)

certain thickness (Fig. 20). A new shim with correct thickness must always be re-installed after removing injector. Measure thickness of injector shim (Fig. 21). **Shim Thickness: 1.5 mm (.060")**

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

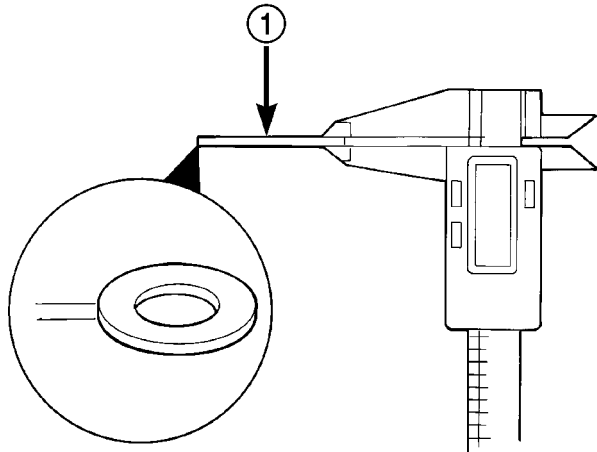
(5) Install new o-ring to fuel injector. Apply small amount of clean engine oil to o-ring.

(6) Note fuel inlet port on high pressure connector. This must be positioned towards intake manifold. 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.

(7) Install fuel injector hold down clamp and hold down bolts. Alternately tighten clamp bolts to 10 N·m (89 in. lbs.) torque.

(8) Connect injector solenoid wires and nuts to top of injectors (Fig. 18). Tighten connector nuts to 1.5

FUEL INJECTOR (Continued)



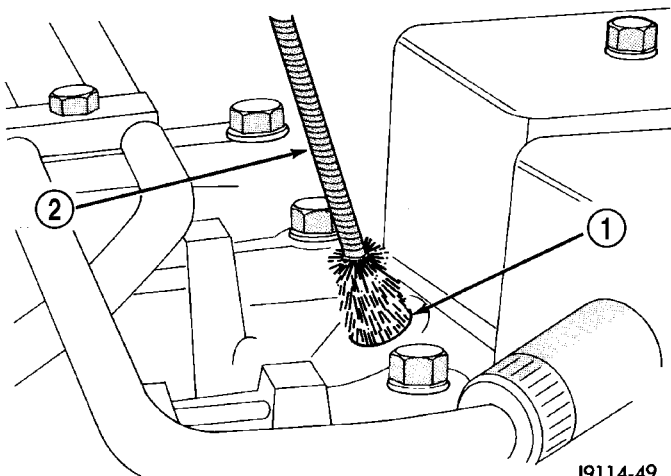
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Fig. 21 MEASURING INJECTOR SEALING WASHER (SHIM)

1 - SHIM

N·m (14 in. lbs.). **Be very careful not to over-tighten these nuts as damage to fuel injector will occur.**

- (9) Install exhaust rocker arm assembly.
- (10) Set exhaust valve lash. Refer to Engine.
- (11) Install high pressure connector and its retainer nut. Tighten nut to 50 N·m (37 ft. lbs.) torque.
- (12) Install high pressure fuel line. Refer to Fuel Line Installation.
- (13) Install valve cover. Refer to Engine.
- (14) Install breather assembly.
- (15) Connect negative battery cables to both batteries.



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Fig. 22 CLEANING CYLINDER HEAD INJECTOR BORE - TYPICAL BORE

1 - TYPICAL INJECTOR BORE
2 - WIRE BRUSH

FUEL INJECTOR RAIL

DESCRIPTION

The fuel injector rail is bolted to the top of the intake manifold.

OPERATION

The fuel rail is used as a distribution device to supply high-pressure fuel to the high-pressure fuel lines.

REMOVAL

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.

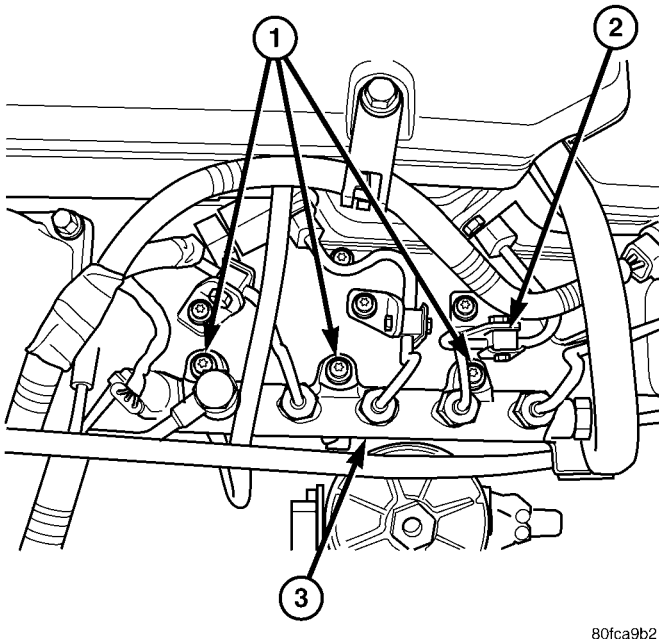
- (1) Disconnect both negative battery cables at both batteries. Isolate ends of both cables.
- (2) Disconnect electrical connector at fuel pressure sensor.
- (3) Remove banjo bolt at fuel limiting valve and remove fuel limiting valve.
- (4) Disconnect necessary wiring harness retention clips from intake manifold.
- (5) Lift 2 rubber covers to gain access to positive (+), intake heater cable nuts. Remove 2 nuts and remove 2 cables from studs.
- (6) Carefully remove 4 high-pressure fuel lines from top of injector rail engine. Note position of each line while removing. **Do not bend lines while removing.**

CAUTION: WHEN LOOSENING OR TIGHTENING HIGH-PRESSURE LINES ATTACHED TO A SEPARATE FITTING, USE A BACK-UP WRENCH ON FITTING. DO NOT ALLOW FITTING TO ROTATE. DAMAGE TO BOTH FUEL LINE AND FITTING WILL RESULT.

- (7) Carefully remove 2 high-pressure fuel lines at each end of injector rail. Note position of each line while removing. **Do not bend lines while removing.**

FUEL INJECTOR RAIL (Continued)

- (8) Remove 3 injector rail mounting bolts (Fig. 23).
- (9) Remove rail from top of intake manifold.



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Fig. 23 FUEL INJECTOR RAIL

- 1 - FUEL RAIL MOUNTING BOLTS (3)
- 2 - INSULATED CLAMPS
- 3 - FUEL INJECTOR RAIL

INSTALLATION

- (1) Clean any dirt/debris from top of intake manifold and bottom of fuel rail.
- (2) Position fuel rail to top of manifold and install 3 mounting bolts. Tighten 3 bolts to 24 N·m (18 ft. lbs.) torque.
- (3) Install all high-pressure lines to rail. Refer to Fuel Lines for procedures.
- (4) Reposition wiring harness to intake manifold and install new tie wraps.
- (5) Position fuel limiting valve and install banjo bolt. Tighten bolt to 30 N·m (22 ft. lbs.) torque.
- (6) Connect electrical connector to fuel pressure sensor.
- (7) Position 2 positive (+) cables to intake heater studs. Install 2 nuts.
- (8) Connect battery cables to both batteries.
- (9) Start engine and check for leaks.

INLET AIR TEMPERATURE SENSOR/PRESSURE SENSOR**DESCRIPTION**

The combination, dual function Inlet Air Temperature/Pressure Sensor is located on the air cleaner (filter) cover.

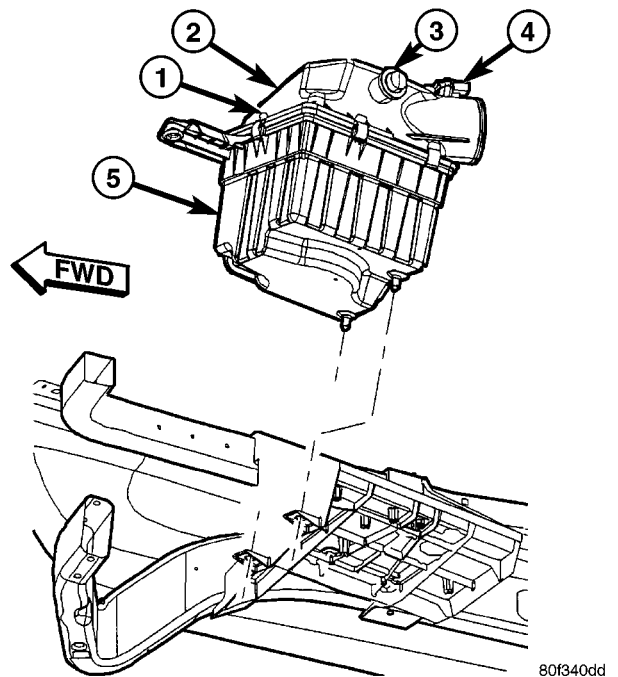
OPERATION

The Inlet Air Temperature/Pressure Sensor is a combination dual-function sensor. The sensor element extends into the intake air stream at the top of the air filter housing. Ambient air temperature as well as barometric pressure is monitored by this sensor. The Engine Control Module (ECM) monitors signals from this sensor.

REMOVAL

The Inlet Air Temperature/Pressure Sensor is located on the air cleaner cover (Fig. 24).

- (1) Disconnect electrical connector at sensor (Fig. 25).
- (2) Remove two Torx-type mounting screws.
- (3) Remove sensor from air cleaner cover.
- (4) Check condition of sensor o-ring (Fig. 26).



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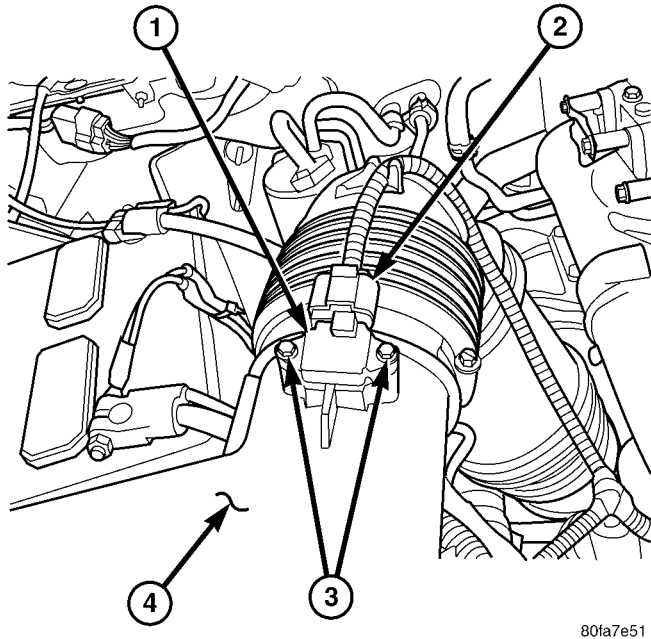
Fig. 24 IAT/PRESSURE SENSOR LOCATION - 5.9L DIESEL

- 1 - CLIPS
- 2 - FILTER COVER
- 3 - FILTER MINDER™
- 4 - INLET AIR TEMPERATURE/ PRESSURE SENSOR
- 5 - FILTER HOUSING

INSTALLATION

- (1) Check condition of sensor o-ring.
- (2) Position sensor into top of air cleaner cover with a slight twisting action.
- (3) Install 2 mounting screws.
- (4) Install electrical connector.

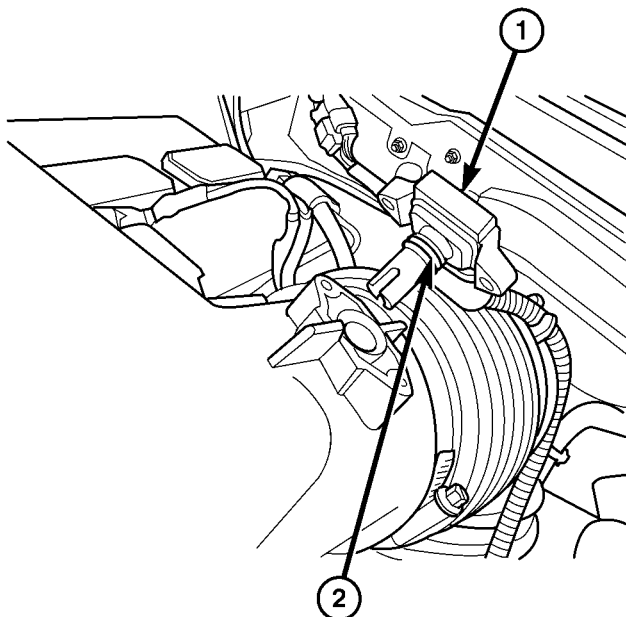
INLET AIR TEMPERATURE SENSOR/PRESSURE SENSOR (Continued)



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Fig. 25 INLET/PRESSURE SENSOR REMOVAL/INSTALLATION

- 1 - INLET/PRESSURE SENSOR
- 2 - ELEC. CONNECTOR
- 3 - SENSOR MOUNTING SCREWS (2)
- 4 - TOP OF AIR FILTER COVER



80fa7e55

Fig. 26 SENSOR O-RING

- 1 - IAT/PRESSURE SENSOR
- 2 - O-RING

INTAKE AIR HEATER

DESCRIPTION

The intake manifold air heater element assembly is located in the top of the intake manifold.

OPERATION

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.

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.

REMOVAL

If servicing either of the heater elements, the entire block/element assembly must be replaced.

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

(2) Remove both the intake manifold air intake tube (above injection pump), and its rubber connector hose (Fig. 27).

(3) Lift 2 rubber covers (Fig. 28) to gain access to 2 positive (+) cable nuts. Remove these 2 nuts (Fig. 29) and remove 2 cables from studs.

(4) Disconnect ground strap (Fig. 28) at heater element stud.

(5) Remove wiring harness clips.

(6) Remove engine oil dipstick tube bracket from air inlet connection and fuel filter housing.

(7) Remove 4 housing mounting bolts (Fig. 28) and remove heater element assembly.

INSTALLATION

If servicing either of the heater elements, the entire block/element assembly must be replaced.

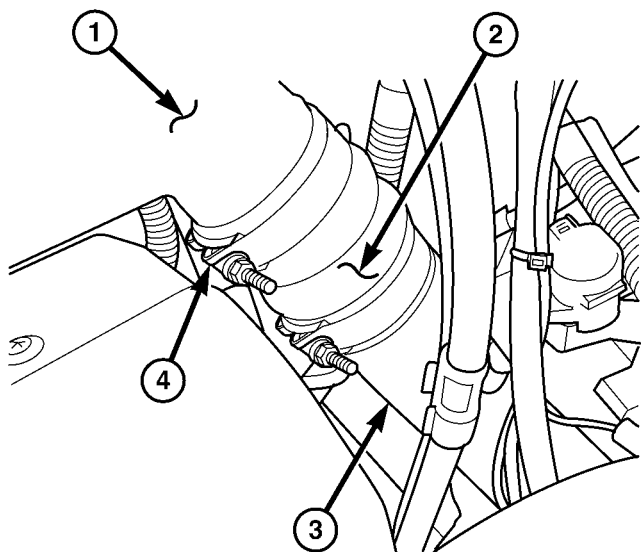
(1) Using 2 new gaskets, position element assembly and air housing to intake manifold.

(2) Position ground cable to air housing.

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

(4) Connect 2 positive (+) heater cables at cable mounting studs. **Do not allow either of the cable eyelets to contact any other metal source other than the cable nuts/studs.**

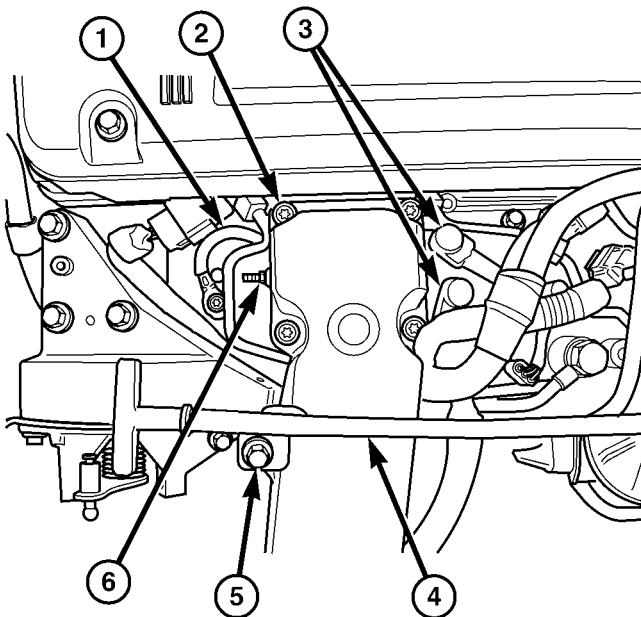
INTAKE AIR HEATER (Continued)



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Fig. 27 INTAKE TUBE AND CONNECTING HOSE

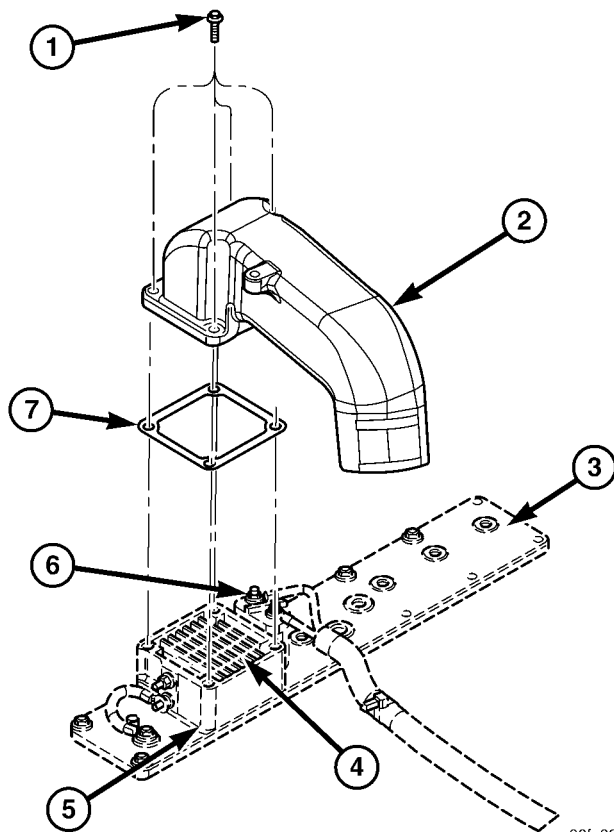
- 1 - MANIFOLD ABOVE HEATERS
- 2 - RUBBER CONNECTING HOSE
- 3 - METAL INTAKE TUBE
- 4 - CLAMPS (2)



80fa829b

Fig. 28 AIR HEATER MANIFOLD

- 1 - GROUND CABLE
- 2 - MOUNTING BOLTS (4)
- 3 - RUBBER COVERS
- 4 - OIL DIPSTICK TUBE
- 5 - DIPSTICK MOUNTING BOLT
- 6 - NUT (GROUND CABLE)



80fa82a3

Fig. 29 AIR HEATER ELEMENTS

- 1 - MOUNTING BOLTS (4)
- 2 - AIR HEATER MANIFOLD
- 3 - INTAKE MANIFOLD
- 4 - HEATER ELEMENTS
- 5 - LOWER GASKET
- 6 - NUTS (2) POSITIVE CABLES
- 7 - UPER GASKET

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

(6) Connect rubber connector hose and intake tube to air intake housing.

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

INTAKE AIR HEATER RELAY

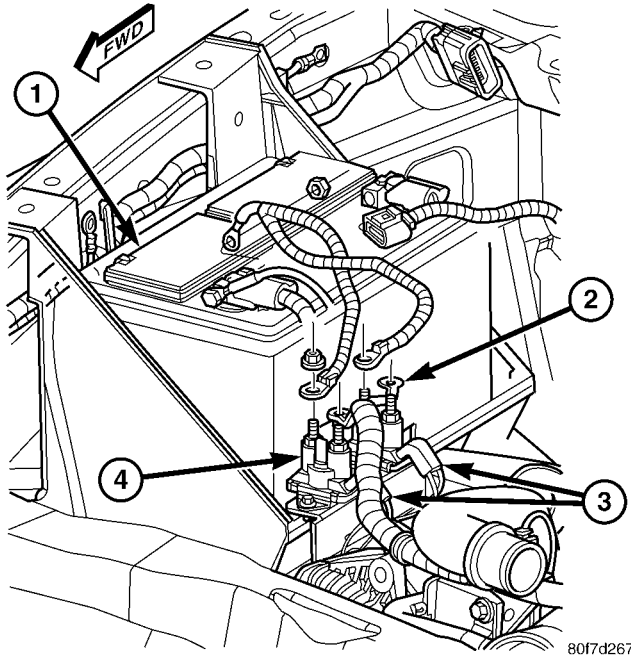
DESCRIPTION

The 2 intake manifold air heater relays are located in the engine compartment. They are attached to a common bracket. This bracket is attached to the right battery tray (Fig. 30).

OPERATION

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

INTAKE AIR HEATER RELAY (Continued)

**Fig. 30 INTAKE MANIFOLD AIR HEATER RELAYS**

- 1 - BATTERY
- 2 - CABLES TO INTAKE HEATERS
- 3 - RELAY TRIGGER WIRES
- 4 - INTAKE AIR HEATER RELAYS (2)

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

REMOVAL

The 2 intake manifold air heater relays are located in the engine compartment. They are attached to a common bracket. This bracket is attached to the right battery tray (Fig. 30).

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. Note position of wiring before removing.

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

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

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

INSTALLATION

(1) Install relay assembly to battery tray. 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.

INTAKE AIR TEMPERATURE SENSOR/MAP SENSOR**DESCRIPTION**

The combination, dual function Intake Manifold Air Temperature Sensor/MAP Sensor is installed into the top of the intake manifold.

OPERATION

The combination, dual function Intake Manifold Air Temperature Sensor/MAP Sensor is installed into the top of the intake manifold with the sensor element extending into the air stream.

The IAT portion of the sensor provides an input voltage to the Engine Control Module (ECM) indicating intake manifold air temperature. The MAP portion of the sensor provides an input voltage to the ECM indicating turbocharger boost pressure.

REMOVAL

The combination, dual function Intake Manifold Air Temperature Sensor/MAP (IAT/MAP) sensor is installed into the top of the intake manifold (Fig. 31).

(1) Clean area around sensor.

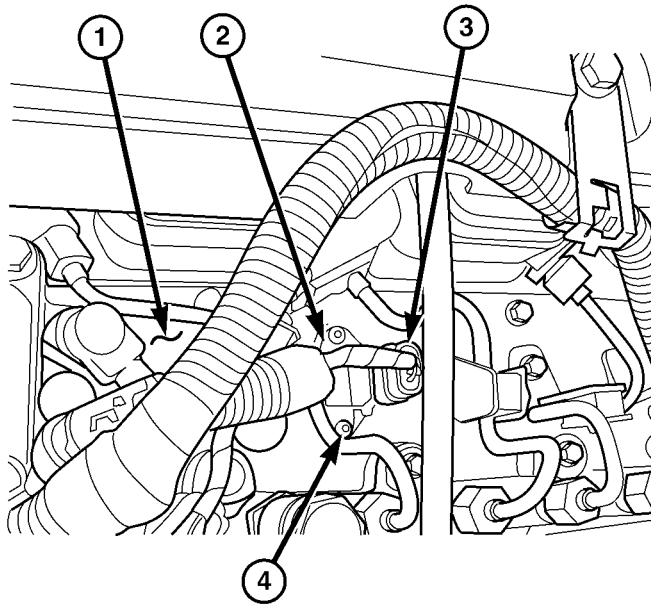
(2) Disconnect electrical connector from IAT/MAP sensor.

(3) Remove two T-15 Torx headed screws.

(4) Remove sensor from intake manifold.

(5) Check condition of sensor o-ring (Fig. 32).

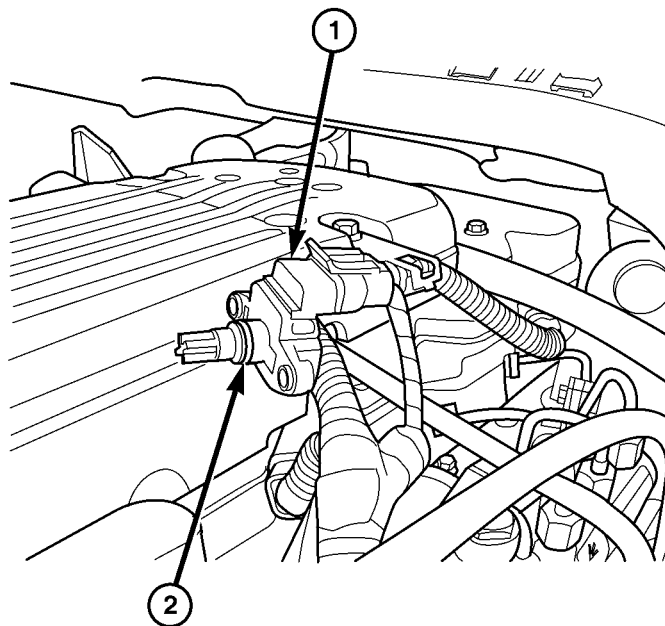
INTAKE AIR TEMPERATURE SENSOR/MAP SENSOR (Continued)



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Fig. 31 INTAKE/MAP SENSOR

- 1 - TOP OF INTAKE MANIFOLD
- 2 - IAT/MAP SENSOR
- 3 - ELEC. CONNECTOR
- 4 - MOUNTING BOLTS (2)



80fa8731

Fig. 32 SENSOR O-RING

- 1 - IAT/MAP SENSOR
- 2 - O-RING

INSTALLATION

- (1) Check condition of sensor o-ring.
- (2) Clean sensor mounting area at intake manifold.
- (3) Position sensor into intake manifold.
- (4) Install and tighten 2 screws.
- (5) Connect electrical connector to sensor.

MAP SENSOR**DESCRIPTION**

A combination, dual function Intake Manifold Air Temperature Sensor/MAP Sensor is used. Refer to Intake Air Temperature Sensor/MAP Sensor for information.

THROTTLE CONTROL CABLE**REMOVAL****Early Diesel Engine**

(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. 33). The plastic cable retainer snaps into pedal arm.

(3) From inside vehicle, remove cable clip (Fig. 33).

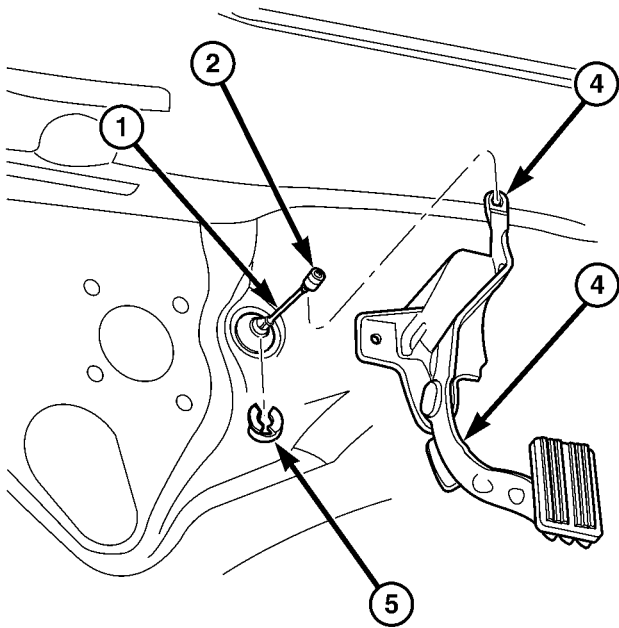
(4) Remove cable core wire at pedal arm.

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

(6) Remove cable cover (Fig. 34). Cable cover is attached with 2 Phillips screws, 2 plastic retention clips and 2 push tabs (Fig. 34). 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. 35). **Be very careful not to bend throttle lever arm.**

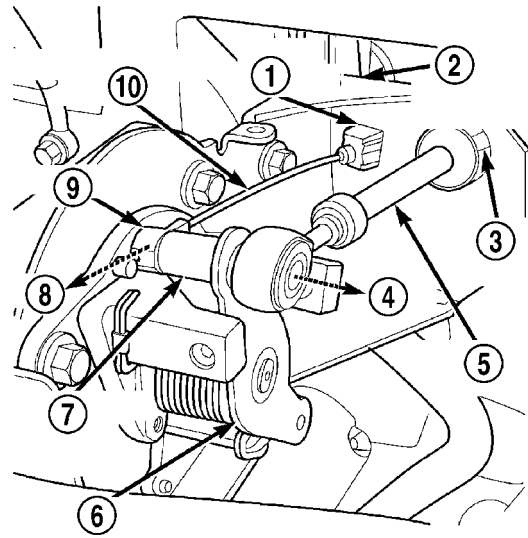
THROTTLE CONTROL CABLE (Continued)



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Fig. 33 ACCELERATOR PEDAL MOUNTING

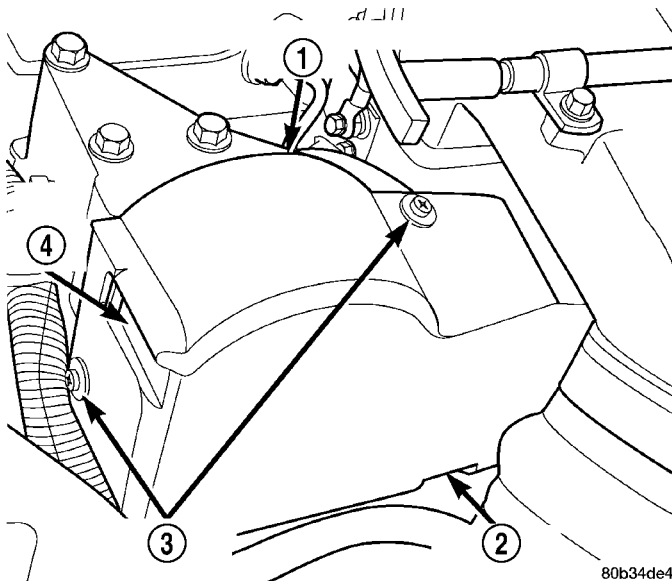
- 1 - ACCELERATOR CABLE
- 2 - PLASTIC RETAINER (CLIP)
- 3 - THROTTLE PEDAL ARM
- 4 - PEDAL / BRACKET ASSEMBLY
- 5 - CABLE CLIP



80b34de5

Fig. 35 SERVO CABLE AT THROTTLE LEVER

- 1 - PINCH (2) TABS
- 2 - CABLE MOUNTING BRACKET
- 3 - PINCH TABS (2)
- 4 - OFF
- 5 - THROTTLE CABLE
- 6 - THROTTLE LEVER
- 7 - THROTTLE LEVER PIN
- 8 - OFF
- 9 - CONNECTOR
- 10 - SPEED CONTROL CABLE



80b34de4

Fig. 34 CABLE/LEVER/THROTTLE LINKAGE COVER

- 1 - CABLE/LEVER/LINKAGE COVER
- 2 - PUSH UP LOWER TAB
- 3 - SCREWS/CLIPS (2)
- 4 - TAB PUSH HERE

Late Diesel Engine

The Throttle Control Cable on the late diesel engine connects the accelerator pedal to the Accelerator Pedal Position Sensor (APPS). A separate mechanical cable is not routed to the throttle body.

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

(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. 36). The plastic cable retainer snaps into pedal arm.

(3) Remove cable core wire at pedal arm.

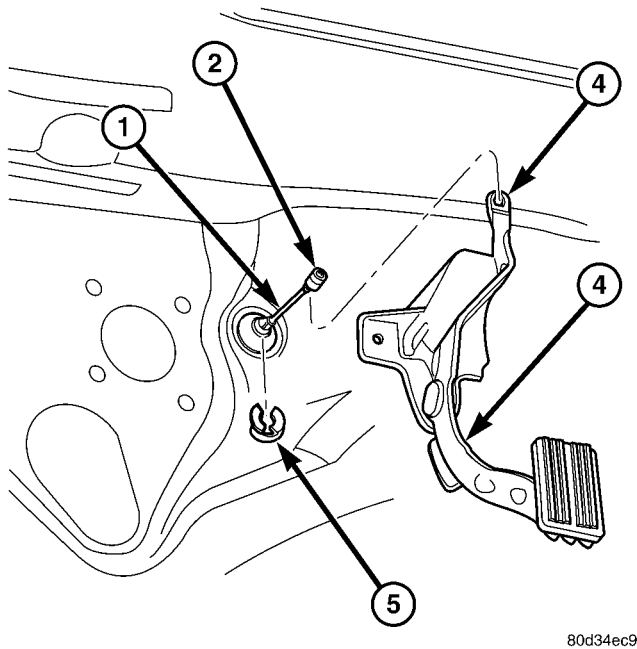
(4) Remove APPS. Refer to (Diesel) Accelerator Pedal Position Sensor (APPS) Removal / Installation.

(5) From inside vehicle, remove cable clip (Fig. 36).

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

(7) Remove cable housing at APPS bracket by pressing on release tab with a small screwdriver. **To prevent cable housing breakage, press on tab only enough to release cable from APPS bracket.**

THROTTLE CONTROL CABLE (Continued)



80d34ec9

Fig. 36 ACCELERATOR PEDAL MOUNTING

- 1 - ACCELERATOR CABLE
- 2 - PLASTIC RETAINER (CLIP)
- 3 - THROTTLE PEDAL ARM
- 4 - PEDAL / BRACKET ASSEMBLY
- 5 - CABLE CLIP

INSTALLATION**Early Diesel Engine**

(1) Install cable through mounting hole on cable mounting bracket (Fig. 35). 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 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. 33). 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.

Late Diesel Engine

(1) Attach cable to Accelerator Pedal Position Sensor (APPS). Refer to APPS (Diesel) Removal / Installation.

(2) Push cable housing into rubber grommet and through opening in dash panel.

(3) From inside vehicle, install clip holding cable to dashpanel (Fig. 36).

(4) From inside vehicle, slide throttle cable core wire into opening in top of pedal arm.

(5) Push cable retainer (clip) into pedal arm opening until it snaps in place.

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

(7) If necessary, use DRB III® Scan Tool to erase any APPS Diagnostic Trouble Codes (DTC's) from PCM.