

# FUEL SYSTEM

## TABLE OF CONTENTS

| page                                                                                                                                                                                                                                                                                                                                                                                                                                                   | page |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------|
| <b>FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL</b>                                                                                                                                                                                                                                                                                                                                                                                                            |      |
| DESCRIPTION - DIESEL FUEL DELIVERY                                                                                                                                                                                                                                                                                                                                                                                                                     |      |
| SYSTEM .....                                                                                                                                                                                                                                                                                                                                                                                                                                           | 1    |
| WARNING - HIGH FUEL SYSTEM PRESSURE .....                                                                                                                                                                                                                                                                                                                                                                                                              | 1    |
| DIAGNOSIS AND TESTING                                                                                                                                                                                                                                                                                                                                                                                                                                  |      |
| DIAGNOSIS AND TESTING - AIR IN FUEL                                                                                                                                                                                                                                                                                                                                                                                                                    |      |
| SYSTEM .....                                                                                                                                                                                                                                                                                                                                                                                                                                           | 3    |
| DIAGNOSIS AND TESTING - FUEL SUPPLY                                                                                                                                                                                                                                                                                                                                                                                                                    |      |
| RESTRICTIONS.....                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3    |
| DIAGNOSIS AND TESTING - FUEL                                                                                                                                                                                                                                                                                                                                                                                                                           |      |
| DELIVERY SYSTEM .....                                                                                                                                                                                                                                                                                                                                                                                                                                  | 3    |
| STANDARD PROCEDURE                                                                                                                                                                                                                                                                                                                                                                                                                                     |      |
| STANDARD PROCEDURE - FUEL                                                                                                                                                                                                                                                                                                                                                                                                                              |      |
| TRANSFER PUMP PRESSURE TEST .....                                                                                                                                                                                                                                                                                                                                                                                                                      | 4    |
| <b>FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL</b>                                                                                                                                                                                                                                                                                                                                                                                                            |      |
| DESCRIPTION - DIESEL FUEL DELIVERY                                                                                                                                                                                                                                                                                                                                                                                                                     |      |
| SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                                                 |      |
| 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 1600 BAR (23,200 PSI). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH - PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT FOR HIGH - PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM. |      |
| The fuel system on the 2.5L OR 2.8L Common Rail Diesel (CRD) Engine uses a high pressure pump and an Electronic Control Module (ECM). (Fig. 1)                                                                                                                                                                                                                                                                                                         |      |
| The fuel delivery system consists of the:                                                                                                                                                                                                                                                                                                                                                                                                              |      |
| <ul style="list-style-type: none"> <li>• Accelerator pedal</li> <li>• Air cleaner housing/element</li> <li>• Fuel filter/water separator</li> <li>• Fuel heater</li> <li>• Fuel heater relay</li> <li>• Fuel/Lift pump</li> <li>• High Pressure Fuel injection pump</li> <li>• Fuel injectors</li> <li>• Fuel tank</li> <li>• Fuel tank filler/vent tube assembly</li> </ul>                                                                           |      |
| STANDARD PROCEDURES - DRAINING                                                                                                                                                                                                                                                                                                                                                                                                                         |      |
| WATER FROM FUEL FILTER .....                                                                                                                                                                                                                                                                                                                                                                                                                           | 4    |
| STANDARD PROCEDURE - FUEL SYSTEM                                                                                                                                                                                                                                                                                                                                                                                                                       |      |
| AIR PURGE .....                                                                                                                                                                                                                                                                                                                                                                                                                                        | 4    |
| STANDARD PROCEDURES - CLEANING                                                                                                                                                                                                                                                                                                                                                                                                                         |      |
| FUEL SYSTEM COMPONENTS .....                                                                                                                                                                                                                                                                                                                                                                                                                           | 5    |
| SPECIFICATIONS - TORQUE .....                                                                                                                                                                                                                                                                                                                                                                                                                          |      |
| FUEL DELIVERY .....                                                                                                                                                                                                                                                                                                                                                                                                                                    | 6    |
| FUEL INJECTION .....                                                                                                                                                                                                                                                                                                                                                                                                                                   | 17   |

## FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL

### DESCRIPTION - DIESEL FUEL DELIVERY

#### SYSTEM

**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 1600 BAR (23,200 PSI). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH - PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT FOR HIGH - PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

The fuel system on the 2.5L OR 2.8L Common Rail Diesel (CRD) Engine uses a high pressure pump and an Electronic Control Module (ECM). (Fig. 1)

The fuel delivery system consists of the:

- Accelerator pedal
- Air cleaner housing/element
- Fuel filter/water separator
- Fuel heater
- Fuel heater relay
- Fuel/Lift pump
- High Pressure Fuel injection pump
- Fuel injectors
- Fuel tank
- Fuel tank filler/vent tube assembly

- Fuel tank filler tube cap
- Fuel tank module containing fuel tank vent valves and a fuel gauge sending unit (fuel level sensor).
- Fuel tubes/lines/hoses
- High-pressure fuel injector lines
- Low-pressure fuel supply lines
- Low-pressure fuel return line
- Overflow valve
- Quick-connect fittings
- Water draining

### WARNING - HIGH FUEL SYSTEM PRESSURE

**WARNING: HIGH-PRESSURE FUEL LINES DELIVER FUEL UNDER EXTREME PRESSURE FROM THE INJECTION PUMP TO THE INJECTORS. THIS MAYBE AS HIGH AS 1600BAR (23,200PSI). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH-PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT HIGH-PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

## FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL (Continued)

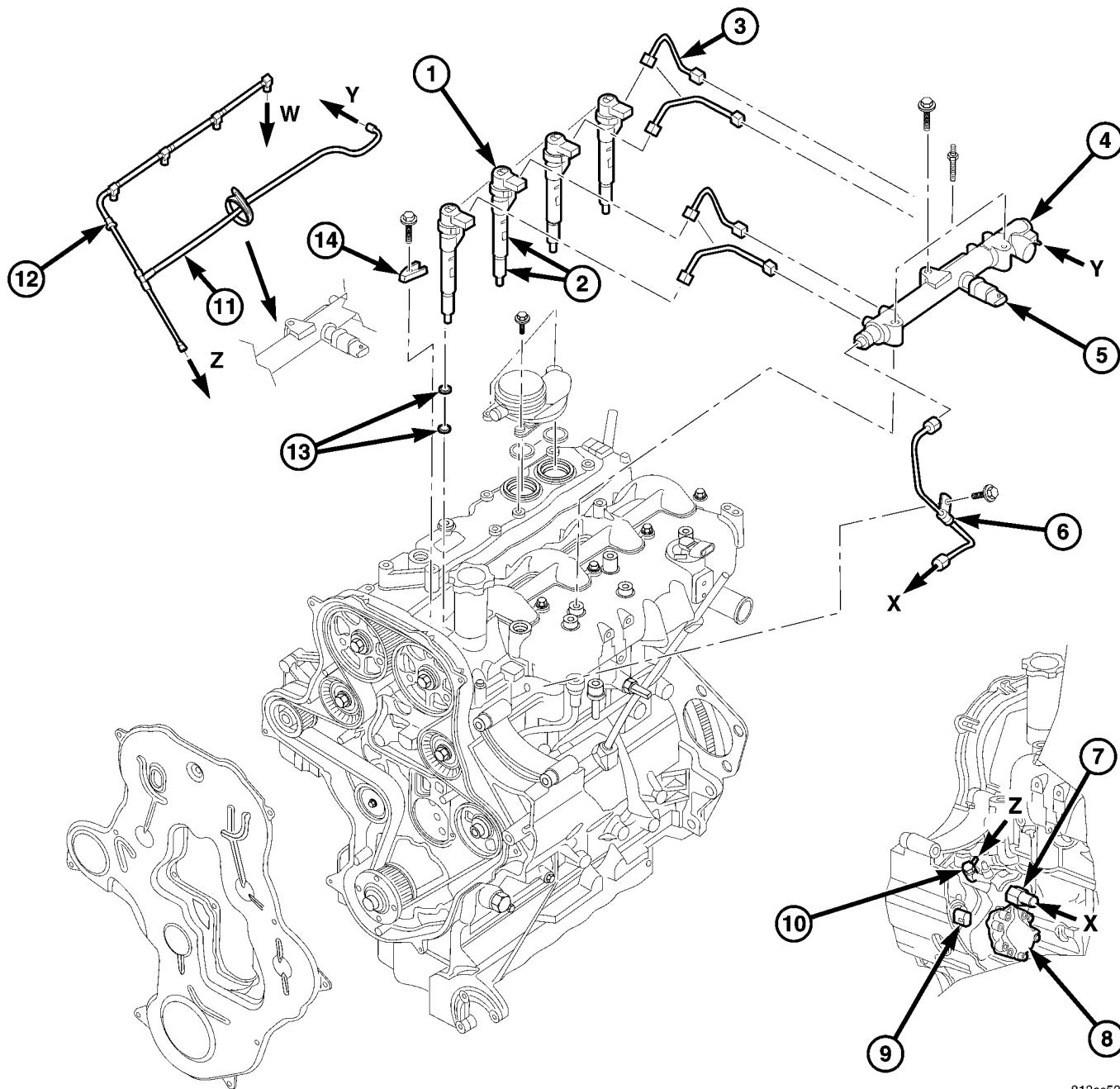


Fig. 1 CRD FUEL SYSTEM

- 1 - FUEL INJECTOR
- 2 - INJECTOR LUBRICATION POINT
- 3 - HIGH PRESSURE FUEL LINE
- 4 - FUEL RAIL
- 5 - FUEL RAIL PRESSURE SENSOR
- 6 - FUEL RAIL SUPPLY LINE
- 7 - INJECTION PUMP HIGH PRESSURE OUTLET

- 8 - HIGH PRESSURE INJECTION PUMP
- 9 - FUEL PRESSURE SOLENOID
- 10 - INJECTION PUMP FUEL RETURN FITTING
- 11 - FUEL INJECTOR FUEL RETURN HOSE
- 12 - FUEL FLOW BACK VALVE
- 13 - WASHER AND O-RING
- 14 - FUEL INJECTOR HOLD DOWN

## FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL (Continued)

## DIAGNOSIS AND TESTING

## DIAGNOSIS AND TESTING - AIR IN FUEL SYSTEM

Air will enter the fuel system whenever fuel supply lines, separator filters, injection pump, high-pressure lines or injectors are removed or disconnected. Air trapped in the fuel system can result in hard starting, a rough running engine, engine misfire, low power, excessive smoke and fuel knock.

Inspect the fuel system from the fuel tank to the injectors for loose connections (Refer to 14 - FUEL SYSTEM - WARNING). Leaking fuel is an indicator of loose connections or defective seals. Air can also enter the fuel system between the fuel tank and the injectors because the lift pump only runs to prime the system. It does not run while the engine is running. Inspect the fuel tank and fuel lines for damage or loose connections that might allow air into the system.

With the DRBIII® connected to the vehicle, select Engine and the select Sensor Display. Page down to view Fuel Pressure Set Point and Actual Fuel Pressure. Start the engine and observe the Fuel Pressure Set Point and the Actual Fuel Pressure. If the Actual Fuel Pressure Oscillates above and below the Fuel Pressure Set Point in a regular cycle, perform the Fuel System Air Purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

If the Actual Fuel Pressure gradually drops below the Fuel Pressure Set Point then spikes well above the Fuel Pressure Set Point, replace the fuel pressure solenoid (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL PRESSURE SOLENOID - REMOVAL), then perform the Fuel System Air Purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

## DIAGNOSIS AND TESTING - FUEL SUPPLY RESTRICTIONS

## LOW-PRESSURE LINES

Fuel supply line restrictions or a defective fuel/lift pump can cause starting problems and prevent engine from accelerating.

Test all fuel supply lines for restrictions or blockage. Flush or replace as necessary. Purge fuel system of air once a fuel supply line has been replaced (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

## HIGH-PRESSURE LINES

**CAUTION:** High pressure lines cannot contact each other or other components. Do not attempt to weld high-pressure fuel lines or to repair lines that are damaged. High pressure lines must be replaced at each disassembly. Use only recommended lines when replacement of high-pressure fuel line is necessary.

Restricted (kinked or bent) high-pressure lines can cause starting problems, poor engine performance, engine mis-fire and white smoke from exhaust (Refer to 14 - FUEL SYSTEM - WARNING).

## DIAGNOSIS AND TESTING - FUEL DELIVERY SYSTEM

**NOTE:** Air Intrusion is the most common failure of a fuel system. If air intrusion is suspect, perform the Fuel System Air Purge procedure first.(Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

| CONDITION                           | POSSIBLE CAUSES                                                                                                                                                                                                        | CORRECTION                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| No Start/Hard Start/Start and Stall | Contaminated Fuel<br>Low Fuel Pressure<br><br>Restricted Fuel Filter<br>Fuel/Lift Pump Relay Inoperative<br><br>Fuel Heater Inoperative<br><br>Restricted or Leaking Fuel Lines<br><br>Stored Diagnostic Trouble Codes | Drain, Flush and Refill Fuel System<br>Check Fuel/Lift Pump Pressure. Refer to Fuel Pump Pressure Test in this section<br>Replace Fuel Filter<br>Test Fuel/Lift Pump Relay, refer to Fuel/Lift Pump Relay in this section.<br>Test Fuel Heater and circuitry. Refer to Fuel Heater in this section.<br>Inspect/ Replace necessary fuel line(s), perform Fuel System Air Purge<br>Refer to the appropriate Diagnostic Service Manual |

## FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL (Continued)

| CONDITION                                                                    | POSSIBLE CAUSES                                                                                                                                      | CORRECTION                                                                                                                                                               |
|------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Stalls Under Aggressive Maneuvers/Loss Of Fuel Pressure                      | Restricted or Damaged Fuel Tank Siphon Filter<br>Contaminated Fuel<br>Damaged Fuel Tank<br>Restricted Fuel Filter<br>Stored Diagnostic Trouble Codes | Replace Fuel Tank Siphon Filter<br>Drain, Flush and Refill Fuel System<br>Replace Fuel Tank<br>Replace Fuel Filter<br>Refer to the appropriate Diagnostic Service Manual |
| Cannot Refill Fuel Tank/ Excessive Pressure in Fuel Tank When Cap Is Removed | Sticking or Damaged Fuel Tank Fill/Vent Valve, Hose or Lines                                                                                         | Inspect, Repair Vent Hose and Lines, Replace Fuel Tank                                                                                                                   |

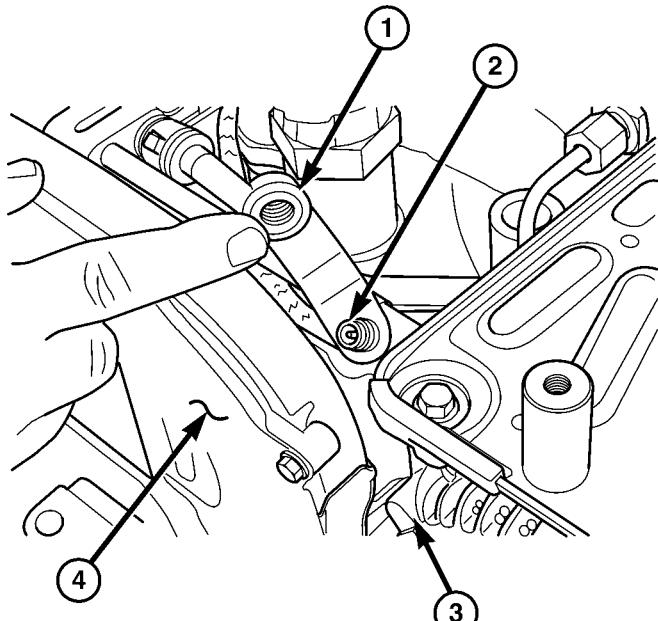
## STANDARD PROCEDURE

STANDARD PROCEDURE - FUEL TRANSFER  
PUMP PRESSURE TEST

**NOTE:** Use a shop towel to capture any fuel spillage.

(1) Remove engine cover (Refer to 9 - ENGINE - REMOVAL).

(2) Connect a fuel pump pressure gauge to the air purge valve (Fig. 2).



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**Fig. 2 AIR PURGE VALVE**

1 - AIR PURGE VALVE CAP

2 - AIR PURGE VALVE

3 - ALTERNATOR

4 - ENGINE FRONT COVER

(3) Turn ON the ignition (fuel/lift pump should run for approximately 5 seconds).

(4) Observe the fuel pressure gauge, fuel pressure should read between 0.8 - 1.2 bar (12 - 17 psi.).

If fuel pressure is outside of specification, review the following list of possible causes:

- Restricted fuel filter.
- Stored DTC's.
- Defective fuel/lift pump relay.
- Defective fuel/lift pump. (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL TRANSFER PUMP - DIAGNOSIS AND TESTING).
- Open fuel/lift pump relay Ignition positive circuit.
- Open fuel/lift pump ignition positive circuit.
- High resistance, fuel/lift pump ground.

## STANDARD PROCEDURES - DRAINING WATER FROM FUEL FILTER

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

## STANDARD PROCEDURE - FUEL SYSTEM AIR PURGE

(1) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).

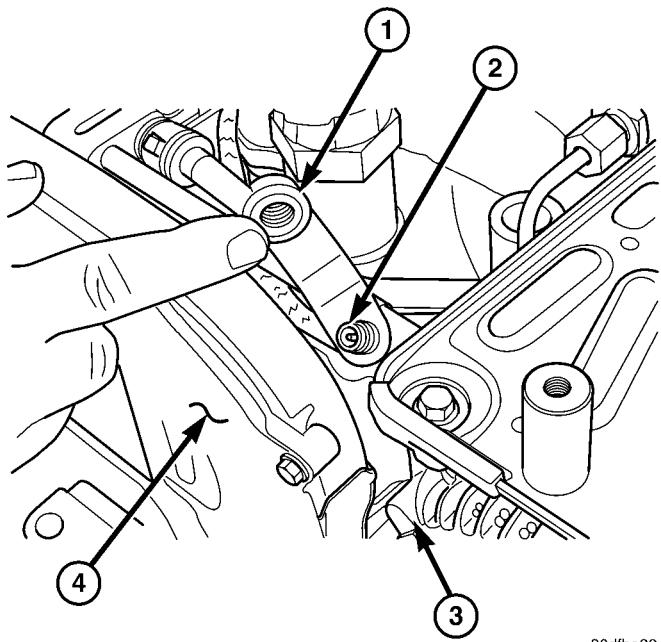
(2) Remove cap from air purge fitting on the fuel supply line. This fitting is located just behind the alternator next to the engine oil fill tube. (Fig. 3).

(3) Attach a hose of about 1 or 2 meters to this fitting using an appropriate connector to open the valve.

(4) Direct the end of the hose into an appropriate fuel container.

(5) Turn the ignition to the "ON" position, **Do not crank the engine**. Keep key on until about 1 liter of fuel has been pumped into the container. **Make sure the hose remains below the level of fuel in the container while the key is in the ON position.**

## FUEL SYSTEM 2.5L / 2.8L TURBO DIESEL (Continued)



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**Fig. 3 AIR PURGE VALVE**

- 1 - AIR PURGE VALVE CAP  
 2 - AIR PURGE VALVE  
 3 - ALTERNATOR  
 4 - ENGINE FRONT COVER

**NOTE:** The fuel pump will only run for 5 seconds. It will be necessary to cycle the key to the OFF then

ON position several times to pump approximately 1 liter of fuel.

(6) While keeping end of hose below fuel level in container, turn the ignition "OFF".

(7) Remove hose from air purge fitting and replace cap.

(8) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

**STANDARD PROCEDURES - CLEANING FUEL SYSTEM COMPONENTS**

**CAUTION:** Cleanliness cannot be overemphasized when handling or replacing diesel fuel system components. This especially includes the fuel injectors, high-pressure fuel lines, fuel rail, 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. DO NOT wire brush injector nozzles when cleaning. 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.

**SPECIFICATIONS - TORQUE****2.5L / 2.8L DIESEL - TORQUE SPECIFICATIONS**

| DESCRIPTION                                          | N·m  | Ft. Lbs. | In. Lbs. |
|------------------------------------------------------|------|----------|----------|
| Crankshaft Position Sensor Bolt                      | 10.8 | 8        | 96       |
| Boost Pressure / Intake Air Temperature Sensor Bolts | 5.4  | —        | 48       |
| Fuel Pump Nuts                                       | 27.5 | 21       | —        |
| Fuel Line Fittings at Pump                           | 27.5 | 21       | —        |
| Fuel Pump Sprocket Nut                               | 88.3 | 65       | —        |
| Fuel Injector Retaining Bolts                        | 32.4 | 24       | —        |
| High Pressure Fuel Lines                             | 28   | 20       | 310      |
| Fuel Rail Bolts                                      | 35   | 26       | —        |
| Fuel Rail Pressure Sensor                            | 35   | 26       | —        |

# FUEL DELIVERY

## TABLE OF CONTENTS

|                                            | page |                                              | page |
|--------------------------------------------|------|----------------------------------------------|------|
| <b>FUEL RAIL</b>                           |      | <b>FUEL/LIFT PUMP RELAY</b>                  |      |
| DESCRIPTION .....                          | 6    | DESCRIPTION .....                            | 13   |
| OPERATION .....                            | 6    | OPERATION .....                              | 13   |
| REMOVAL - FUEL RAIL .....                  | 6    | <b>FUEL/LIFT PUMP</b>                        |      |
| INSTALLATION - FUEL RAIL .....             | 7    | DESCRIPTION .....                            | 13   |
| <b>FUEL FILTER / WATER SEPARATOR</b>       |      | OPERATION .....                              | 14   |
| DESCRIPTION .....                          | 7    | DIAGNOSIS AND TESTING - FUEL/LIFT PUMP ..... | 14   |
| OPERATION .....                            | 7    | REMOVAL .....                                | 14   |
| REMOVAL                                    |      | INSTALLATION .....                           | 14   |
| REMOVAL - FUEL FILTER .....                | 8    | <b>WATER IN FUEL SENSOR</b>                  |      |
| REMOVAL .....                              | 8    | DESCRIPTION .....                            | 15   |
| INSTALLATION                               |      | OPERATION .....                              | 15   |
| INSTALLATION - FUEL FILTER .....           | 9    | REMOVAL .....                                | 15   |
| INSTALLATION .....                         | 9    | INSTALLATION .....                           | 15   |
| <b>FUEL INJECTION PUMP</b>                 |      | <b>FUEL HEATER RELAY</b>                     |      |
| DESCRIPTION .....                          | 9    | DESCRIPTION .....                            | 15   |
| REMOVAL .....                              | 9    | OPERATION .....                              | 15   |
| INSTALLATION .....                         | 10   | <b>FUEL HEATER</b>                           |      |
| <b>FUEL LINES</b>                          |      | DESCRIPTION .....                            | 15   |
| DESCRIPTION                                |      | OPERATION .....                              | 15   |
| DESCRIPTION .....                          | 12   | DIAGNOSIS AND TESTING - FUEL HEATER .....    | 16   |
| DESCRIPTION - HIGH PRESSURE FUEL           |      | REMOVAL .....                                | 16   |
| LINES .....                                | 12   | INSTALLATION .....                           | 16   |
| OPERATION - HIGH PRESSURE FUEL LINES ..... | 12   |                                              |      |
| DIAGNOSIS AND TESTING - HIGH               |      |                                              |      |
| PRESSURE FUEL LINES .....                  | 12   |                                              |      |

## FUEL RAIL

### DESCRIPTION

The fuel rail is mounted to the cylinder head cover/intake manifold (Refer to 14 - FUEL SYSTEM - WARNING) (Fig. 1).

### OPERATION

**WARNING: HIGH - PRESSURE LINES DELIVER DIESEL FUEL UNDER EXTREME PRESSURE FROM THE INJECTION PUMP TO THE FUEL INJECTORS. THIS MAY BE AS HIGH AS 1600BAR (23,200 PSI.). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH - PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT FOR HIGH — PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY**

### GOOGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.

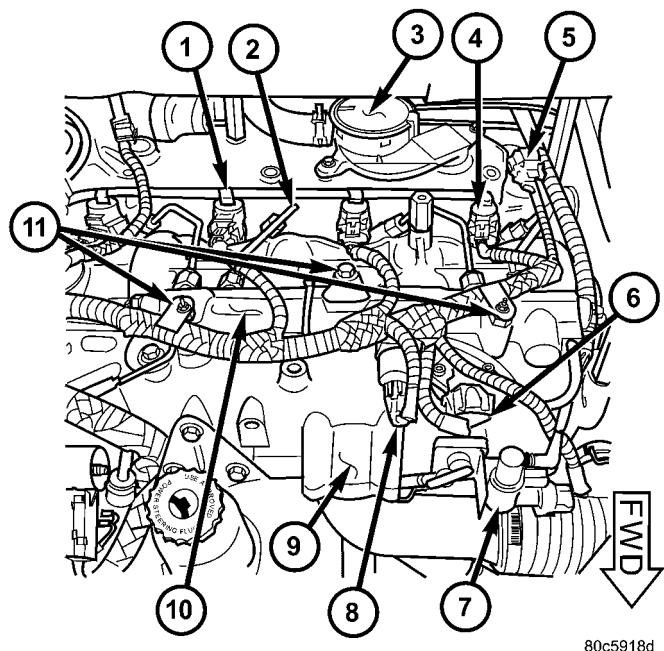
The fuel rail stores the fuel for the injectors at high pressure. At the same time, the pressure oscillations which are generated due to the high-pressure pump delivery and the injection of fuel are damped by the rail volume.

The fuel rail is common to all cylinders, hence it's name "common rail". Even when large quantities of fuel are extracted, the fuel rail maintains a constant inner pressure. This ensures that the injection pressure remains constant from the moment the injector opens.

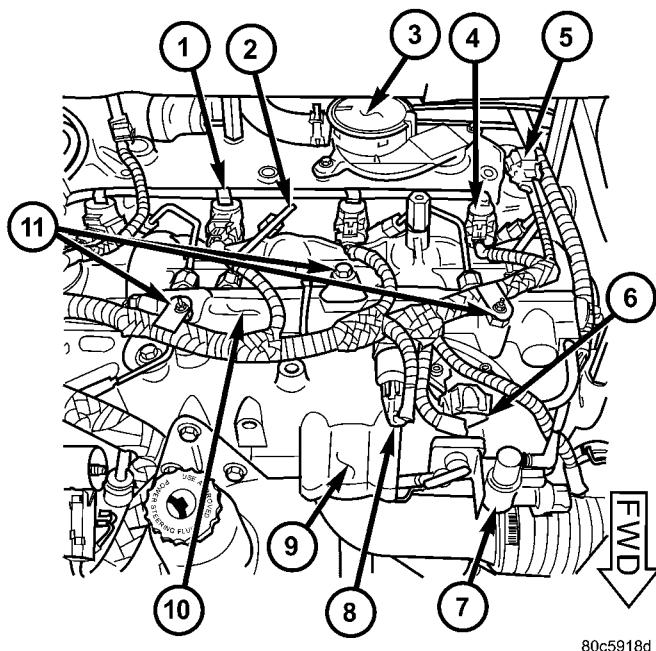
### REMOVAL - FUEL RAIL

- (1) Disconnect negative battery cable.
- (2) Remove engine cover (Refer to 9 - ENGINE - REMOVAL).
- (3) Disconnect fuel injector high pressure lines (Refer to 14 - FUEL SYSTEM - WARNING).

## FUEL RAIL (Continued)

**Fig. 1 ENGINE COMPONENT LOCATIONS**

- 1 - FUEL INJECTOR RETURN LINE
- 2 - FUEL INJECTOR HIGH PRESSURE LINE
- 3 - OIL SEPARATOR
- 4 - FUEL INJECTOR
- 5 - CAMSHAFT POSITION SENSOR
- 6 - BOOST PRESSURE/INTAKE AIR TEMPERATURE SENSOR
- 7 - EGR SOLENOID
- 8 - FUEL PRESSURE SENSOR
- 9 - CYLINDER HEAD COVER/INTAKE MANIFOLD
- 10 - FUEL RAIL
- 11 - FUEL INJECTOR WIRING HARNESS RETAINER(S)

**Fig. 2 FUEL RAIL COMPONENTS**

- 1 - FUEL INJECTOR RETURN LINE
- 2 - FUEL INJECTOR HIGH PRESSURE LINE
- 3 - OIL SEPARATOR
- 4 - FUEL INJECTOR
- 5 - CAMSHAFT POSITION SENSOR
- 6 - BOOST PRESSURE/INTAKE AIR TEMPERATURE SENSOR
- 7 - EGR SOLENOID
- 8 - FUEL PRESSURE SENSOR
- 9 - CYLINDER HEAD COVER/INTAKE MANIFOLD
- 10 - FUEL RAIL
- 11 - FUEL INJECTOR WIRING HARNESS RETAINER(S)

- (4) Disconnect fuel rail supply line. (Fig. 2)
- (5) Disconnect fuel rail return line. (Fig. 2)
- (6) Disconnect fuel rail high pressure sensor connector. (Fig. 2)
- (7) Remove engine electrical harness retainers from the fuel rail retaining bolts/studs. (Fig. 2)
- (8) Remove fuel rail retaining bolts and remove fuel rail (Fig. 2).

**INSTALLATION - FUEL RAIL**

- (1) (Refer to 14 - FUEL SYSTEM - WARNING) Install fuel rail to intake manifold/cylinder head cover (Fig. 2). Torque retaining bolts to 27.5N·m.
- (2) Install engine electrical harness retainers from the fuel rail retaining bolts/studs. (Fig. 2)
- (3) Connect fuel rail high pressure sensor electrical connector. (Fig. 2)
- (4) Connect fuel rail return line. (Fig. 2)
- (5) Connect fuel rail supply line. (Fig. 2)
- (6) Connect fuel injector high pressure lines. (Fig. 2)
- (7) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).
- (8) Connect negative battery cable.

**FUEL FILTER / WATER SEPARATOR****DESCRIPTION**

The fuel filter/water separator assembly is located under the vehicle in front of the rear axle assembly (Fig. 3). The assembly also includes the Fuel Heater and Water-In-Fuel (WIF) sensor.

**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.

The recommended fuel filter replacement interval is 20,000 km.

For draining of water from canister, refer to Fuel Filter/Water Separator Removal/Installation section.

A Water-In-Fuel (WIF) sensor is part of the fuel filter bowl assembly. Refer to Water-In-Fuel Sensor Description/Operation.

## FUEL FILTER / WATER SEPARATOR (Continued)

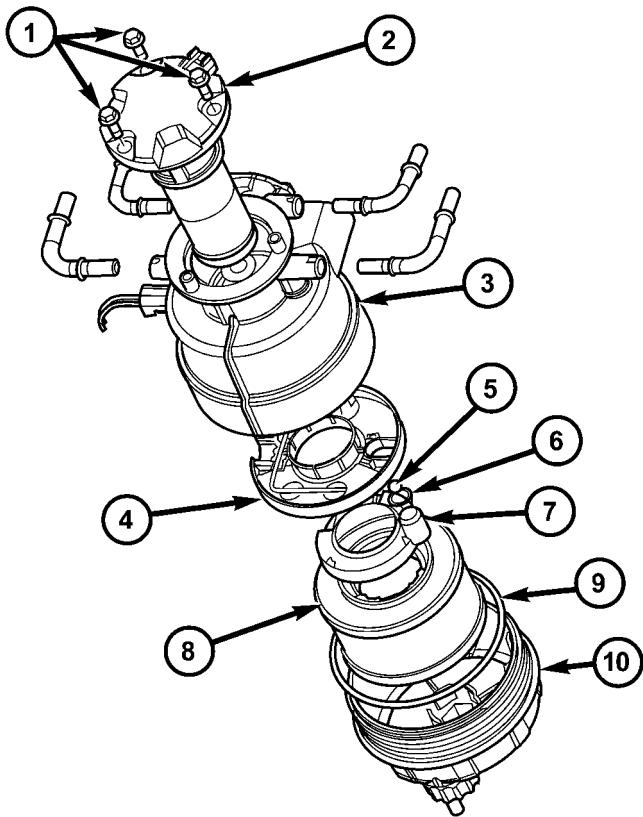


Fig. 3 FUEL FILTER/WATER SEPARATOR

- 1 - LIFT PUMP RETAINING BOLTS  
 2 - LIFT PUMP  
 3 - FUEL FILTER/WATER SEPARATOR HOUSING  
 4 - FUEL HEATER  
 5 - CHECK BALL  
 6 - O-RING  
 7 - FLOW DIVERTER  
 8 - FUEL FILTER  
 9 - O-RING  
 10 - FUEL FILTER BOWL ASSEMBLY

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

## REMOVAL

## REMOVAL - FUEL FILTER

**WARNING: NO SPARKS, OPEN FLAMES, OR SMOKING. RISK OF POISONING FROM INHALING AND SWALLOWING FUEL. RISK OF INJURY TO EYES AND SKIN FROM CONTACT WITH FUEL. POUR FUELS ONLY INTO SUITABLE AND APPROPRIATELY MARKED CONTAINERS. WEAR PROTECTIVE CLOTHING.**

- (1) Disconnect negative battery cable.
- (2) Raise and support the vehicle.

(3) Clean the fuel filter/water separator housing and dry with compressed air.

(4) Connect a drain hose to the fuel filter/water separator drain port and place the other end in a suitable container.

(5) Twist the fuel filter/water separator drain port counterclockwise and completely drain the housing.

(6) Close the draincock.

(7) Disconnect the water in fuel electrical connector.

(8) Turning counterclockwise, remove the fuel filter and bowl assembly (Fig. 3).

## REMOVAL

**WARNING: NO SPARKS, OPEN FLAMES OR SMOKING. RISK OF POISONING FROM INHALING AND SWALLOWING FUEL. RISK OF INJURY TO EYES AND SKIN FROM CONTACT WITH FUEL. POUR FUELS ONLY INTO SUITABLE AND APPROPRIATELY MARKED CONTAINERS. WEAR PROTECTIVE CLOTHING.**

(1) Disconnect negative battery cable.

(2) Raise and support vehicle.

(3) Insert a suitable hose onto the fuel drain port of the fuel filter bowl assembly, turn drain port counterclockwise and drain fuel into a suitable and appropriately marked container (Fig. 4).

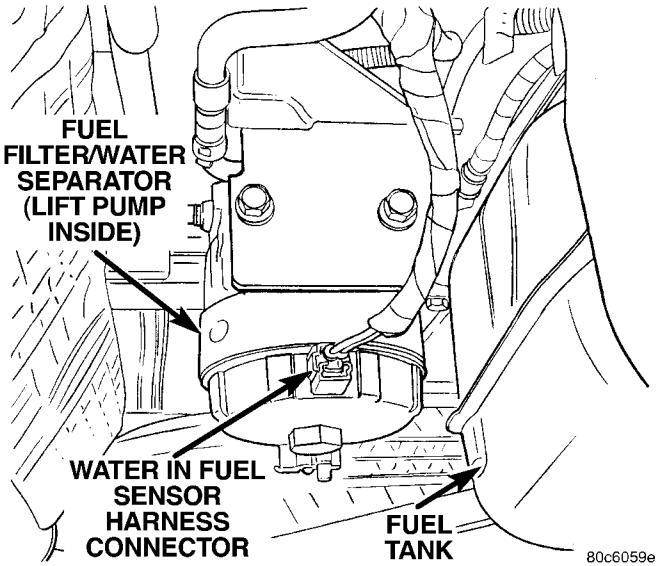


Fig. 4 LIFT PUMP LOCATION

(4) Disconnect fuel supply and return lines at fuel filter/water separator and set aside.

(5) Disconnect fuel filter/water separator electrical connector at bracket.

(6) Remove fuel filter/water separator retaining bracket bolts and remove assembly.

## FUEL FILTER / WATER SEPARATOR (Continued)

## INSTALLATION

## INSTALLATION - FUEL FILTER

**WARNING: NO SPARKS, OPEN FLAMES, OR SMOKING. RISK OF POISONING FROM INHALING AND SWALLOWING FUEL. RISK OF INJURY TO EYES AND SKIN FROM CONTACT WITH FUEL. POUR FUELS ONLY INTO SUITABLE AND APPROPRIATELY MARKED CONTAINERS. WEAR PROTECTIVE CLOTHING.**

(1) Inspect the new fuel filter bowl assembly O-ring seal for proper positioning and deformities, replace as necessary.

(2) Lubricate the O-ring seal with clean engine oil or diesel fuel.

(3) Position the fuel filter bowl assembly to the fuel filter/water separator (Fig. 3).

(4) Turning clockwise, hand tighten the bowl assembly until both mating surfaces meet, then tighten the bowl assembly to 35N·m (26 lbs. ft.).

(5) Connect the water in fuel electrical connector.

(6) Reconnect negative battery cable.

(7) Perform the fuel system air purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

(8) Start engine and inspect for fuel leaks.

## INSTALLATION

**WARNING: NO SPARKS, OPEN FLAMES OR SMOKING. RISK OF POISONING FROM INHALING AND SWALLOWING FUEL. RISK OF INJURY TO EYES AND SKIN FROM CONTACT WITH FUEL. POUR FUELS ONLY INTO SUITABLE AND APPROPRIATELY MARKED CONTAINERS. WEAR PROTECTIVE CLOTHING.**

**NOTE: Assure fuel filter drain port is closed.**

(1) Position fuel filter/water separator bracket and tighten retaining bolts (Fig. 4).

(2) Connect fuel filter/water separator electrical connector.

(3) Connect fuel feed and return lines.

(4) Connect negative battery cable.

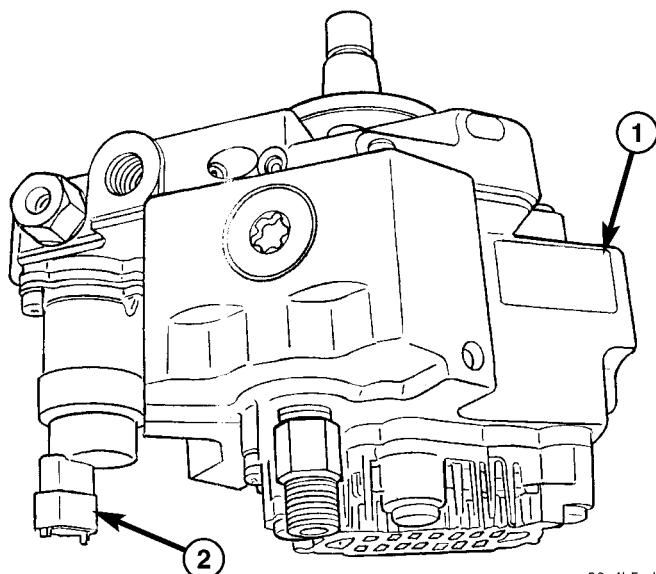
(5) Perform the fuel system air purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

(6) Start engine and inspect for leaks.

## FUEL INJECTION PUMP

## DESCRIPTION

A radial-piston pump is used as the high pressure pump for fuel pressure generation (Refer to 14 - FUEL SYSTEM - WARNING) (Fig. 5).



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**Fig. 5 FUEL INJECTION PUMP**

1 - FUEL INJECTION PUMP

2 - INJECTION PUMP PRESSURE SOLENOID

## REMOVAL

(1) Disconnect negative battery cable (Refer to 14 - FUEL SYSTEM - WARNING).

(2) Remove engine cover (Refer to 9 - ENGINE - REMOVAL)

(3) Remove air cleaner housing assembly.

(4) Remove power steering belt (Refer to 7 - COOLING/ACCESSORY DRIVE/DRIVE BELTS - REMOVAL).

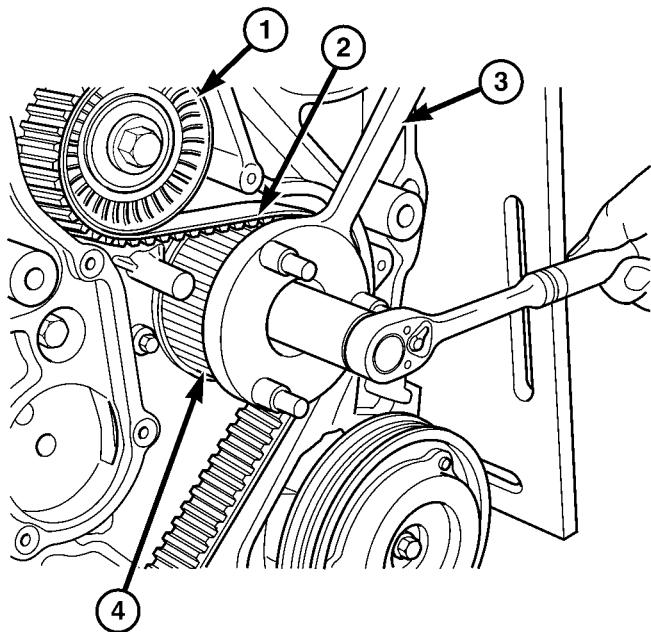
(5) Remove accessory drive belt (Refer to 7 - COOLING/ACCESSORY DRIVE/DRIVE BELTS - REMOVAL).

(6) Support engine and remove right engine mount assembly.

(7) Remove outer timing belt cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - REMOVAL).

## FUEL INJECTION PUMP (Continued)

(8) Using special tool VM.1055, remove injection pump sprocket retaining nut (Fig. 6).



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**Fig. 6 INJECTION PUMP SPROCKET RETAINING NUT REMOVAL/INSTALLATION**

- 1 - IDLER PULLEY
- 2 - TIMING BELT
- 3 - VM.1055
- 4 - INJECTION PUMP SPROCKET

**NOTE:** The use of special tool VM.1067 will allow you to remove the injection pump without removing the timing belt from the engine. This will allow you to remove and install the injection pump without altering injection pump timing.

(9) Install feet from VM.1067 in injection pump sprocket as shown (Fig. 7).

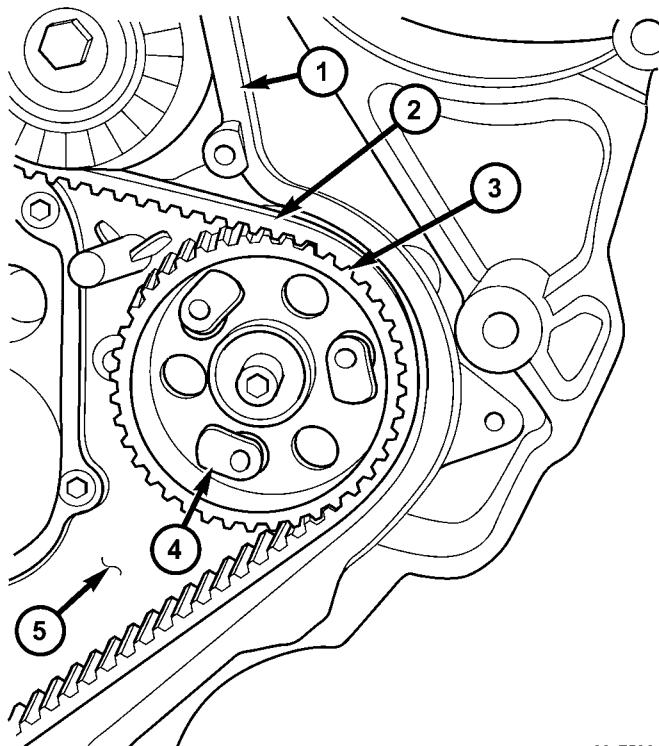
(10) Install inner flange of special tool VM.1067 on injection pump sprocket as shown (Fig. 8). Secure flange to feet in injection pump sprocket with allen bolts supplied with tool.

(11) Screw injection pump sprocket holding plate assembly into flange of VM.1067 (Fig. 9) Using LHD threaded bolt supplied, secure holding plate assembly to timing belt inner cover.

(12) Remove generator (Refer to 8 - ELECTRICAL/CHARGING/GENERATOR - REMOVAL)

(13) Disconnect fuel supply and return lines at injection pump.

(14) Disconnect fuel pressure solenoid electrical connector at injection pump (Fig. 10).



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**Fig. 7 VM.1067 FEET INSTALLATION**

- 1 - OUTER TIMING BELT SEALING SURFACE
- 2 - TIMING BELT
- 3 - TIMING BELT SPROCKET
- 4 - FEET FOR SPECIAL TOOL VM.1067
- 5 - INNER TIMING BELT COVER

(15) Remove injection pump retaining nuts (Fig. 10).

(16) While holding injection pump, tighten bolt in center of injection pump holding plate (Fig. 9). This will push the injection pump out of the injection pump sprocket.

## INSTALLATION

(1) Loosen bolt in center of injection pump holding plate and slide injection pump through the accessory bracket into the injection pump sprocket (Refer to 14 - FUEL SYSTEM - WARNING).

(2) Install injection pump retaining nuts. Torque nuts to 27.5N·m (Fig. 10).

(3) Unscrew injection pump holding plate (part of VM.1067) from inner timing belt cover and remove (Fig. 9).

(4) Install injection pump sprocket retaining nut to hold sprocket in place.

(5) Remove flange and feet (both part of VM.1067) from injection pump sprocket (Fig. 8) (Fig. 7).

## FUEL INJECTION PUMP (Continued)

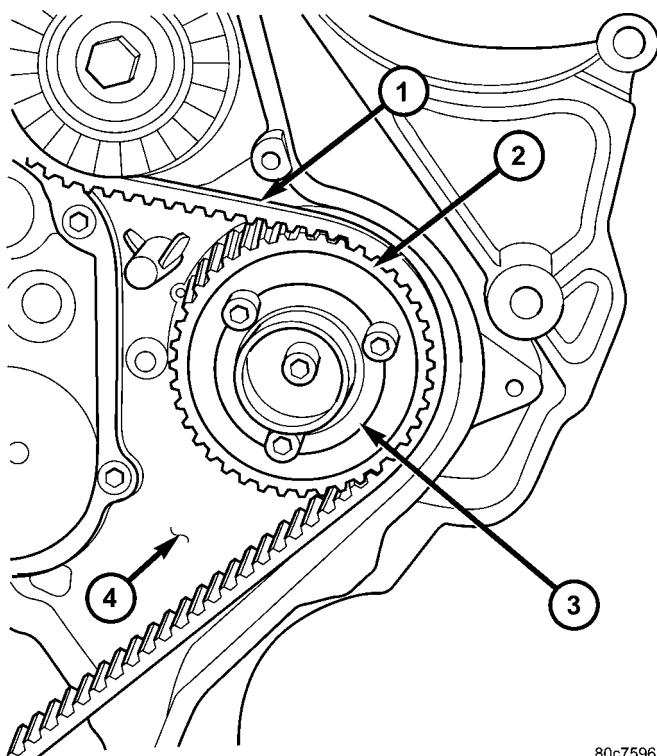
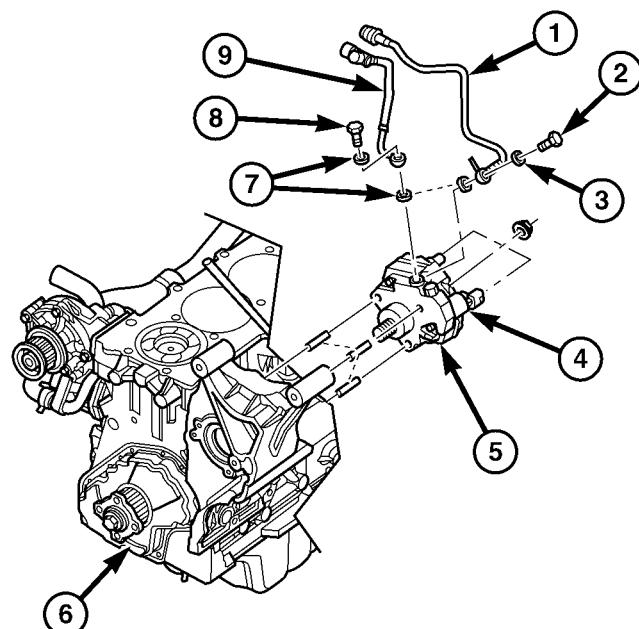


Fig. 8 VM.1067 INSTALLATION

- 1 - TIMING BELT  
 2 - INJECTION PUMP SPROCKET  
 3 - FLANGE OF VM.1067  
 4 - INNER TIMING BELT COVER

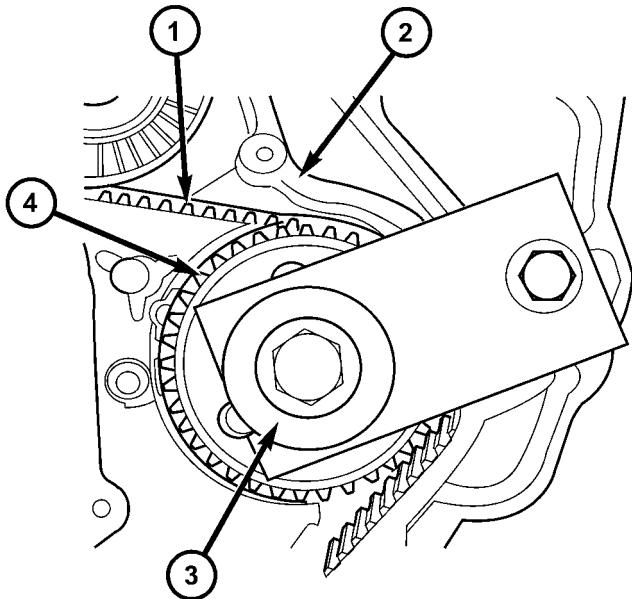
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Fig. 10 INJECTION PUMP REMOVAL

- 1 - FUEL SUPPLY HOSE  
 2 - BANJO BOLT  
 3 - WASHER  
 4 - FUEL PRESSURE SOLENOID  
 5 - HIGH PRESSURE INJECTION PUMP  
 6 - INJECTION PUMP GEAR  
 7 - WASHERS  
 8 - BANJO BOLT  
 9 - FUEL RETURN HOSE



80c7594c

Fig. 9 INJECTION PUMP/GEAR REMOVAL USING VM.1067

- 1 - TIMING BELT  
 2 - INNER TIMING BELT COVER  
 3 - INJECTION PUMP SPROCKET HOLDING PLATE ASSEMBLY PART OF VM.1067  
 4 - INJECTION PUMP SPROCKET

(6) Using special tool VM.1055 (Fig. 6), torque injection pump sprocket retaining nut to 88.3N·m.

(7) Connect fuel pressure solenoid electrical connector (Fig. 10).

(8) Connect fuel supply and return lines at injection pump. Tighten bolts to 27.5N·m (20 lbs. ft.). (Fig. 10).

(9) Install generator (Refer to 8 - ELECTRICAL/CHARGING/GENERATOR - INSTALLATION).

(10) Install outer timing belt cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - INSTALLATION).

(11) Install right engine mount assembly.

(12) Install accessory drive belt (Refer to 7 - COOLING/ACCESSORY DRIVE/DRIVE BELTS - INSTALLATION).

(13) Install power steering belt (Refer to 7 - COOLING/ACCESSORY DRIVE/DRIVE BELTS - INSTALLATION).

(14) Install air cleaner housing assembly.

(15) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).

(16) Connect negative battery cable (Refer to 14 - FUEL SYSTEM - WARNING).

## FUEL LINES

### DESCRIPTION

#### DESCRIPTION

**NOTE: High pressure fuel lines must be replaced once disassembled.**

All fuel lines up to the high pressure pump are considered low-pressure. This includes the fuel lines from the fuel tank to the fuel/lift pump, and the fuel/lift pump to the high pressure pump. The fuel return lines and the fuel drain lines are also considered low-pressure lines. High-pressure lines are used between the high pressure pump and the fuel rail and then from the rail to the fuel injectors (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL LINES - DESCRIPTION).

### DESCRIPTION - HIGH PRESSURE FUEL LINES

**NOTE: High pressure fuel lines must be replaced once disassembled.**

(Refer to 14 - FUEL SYSTEM - WARNING). The high-pressure fuel lines are used between the fuel injection pump and the fuel rail, and between the fuel rail and fuel injectors.

### OPERATION - HIGH PRESSURE FUEL LINES

**WARNING:: HIGH - PRESSURE LINES DELIVER DIESEL FUEL UNDER EXTREME PRESSURE FROM THE INJECTION PUMP TO THE FUEL INJECTORS. THIS MAY BE AS HIGH AS 1600BAR (23,200 PSI.). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH - PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT FOR HIGH — PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

**CAUTION: The high-pressure fuel 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 extremely high pressure from the high pressure pump to the fuel injectors (Refer to 14 - FUEL SYSTEM - WARNING). 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.

### DIAGNOSIS AND TESTING - HIGH PRESSURE FUEL LINES

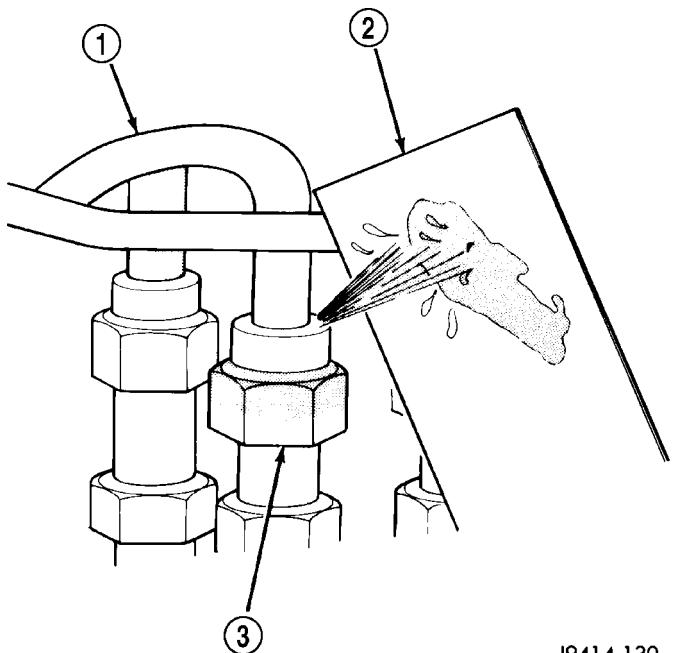
Review the high pressure fuel system warning before beginning service.(Refer to 14 - FUEL SYSTEM - WARNING). High-pressure fuel line leaks can cause starting problems and poor engine performance.

**WARNING: DUE TO EXTREME FUEL PRESSURES, USE EXTREME CAUTION WHEN INSPECTING FOR HIGH-PRESSURE FUEL LEAKS. DO NOT GET YOUR HAND NEAR A SUSPECTED LEAK. INSPECT FOR HIGH-PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD. HIGH FUEL INJECTION PRESSURE CAN CAUSE PERSONAL INJURY IF CONTACT IS MADE WITH THE SKIN.**

**NOTE: Fuel Injector high pressure fuel lines must be replaced when ever they are removed for service.**

Place the cardboard over the suspected high-pressure fuel line(s). Move your hands away from the area. Start the engine. TURN THE ENGINE OFF. Inspect the cardboard for fuel spray (Fig. 11). If a high-pressure line connection is leaking, counterhold and tighten the connection to specification. Re-test as indicated in the previous steps. Replace damaged, restricted or leaking high-pressure fuel lines with the correct replacement line and perform the Fuel System Air Purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

## FUEL LINES (Continued)



J9414-130

**Fig. 11 Typical Test for Leaks with Cardboard**

- 1 - HIGH-PRESSURE LINE  
 2 - CARDBOARD  
 3 - FITTING

**CAUTION:** The high-pressure fuel 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 replacing high-pressure fuel line(s).

## FUEL/LIFT PUMP RELAY

## DESCRIPTION

The fuel/lift pump relay is located in the Integrated Power Module (IPM). This micro-relay operates the same as a conventional relay except the terminal orientation and current capacity is different, and the relay case is smaller.

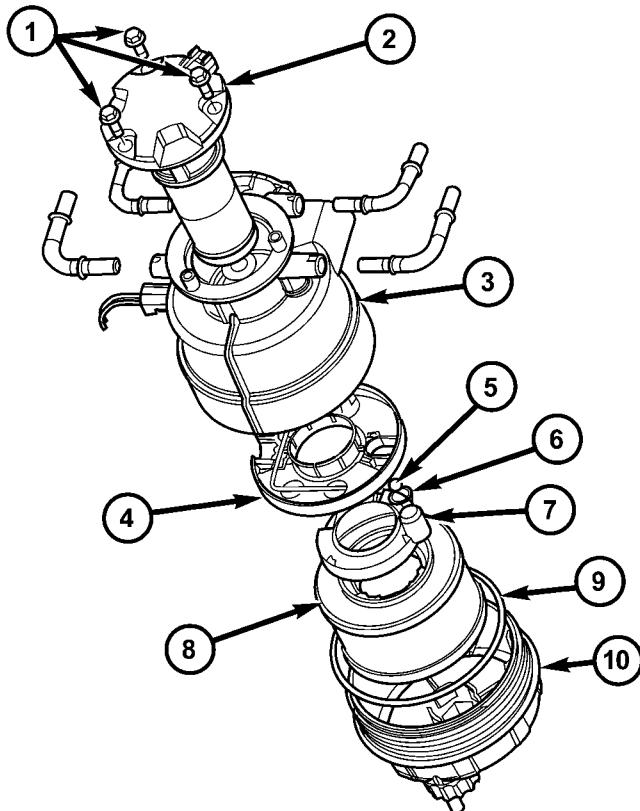
## OPERATION

Fused battery positive voltage is supplied to the fuel/lift pump relay at all times through the Integrated Power Module (IPM). Fused ignition positive voltage is supplied to the fuel/lift pump relay through the IPM. The fuel/lift pump is grounded to the chassis. When the ignition switch is in the Run or Start position, the ECM grounds the lift pump relay control circuit for 5 seconds. This closes the relay contacts and supplies power to the fuel/lift pump motor. The fuel/lift pump will only operate on initial key On.

## FUEL/LIFT PUMP

## DESCRIPTION

The fuel/lift pump is located under the vehicle in front of the rear axle assembly (Fig. 12). The 12-volt electric vane-type pump is operated and controlled by the Engine Control Module (ECM).



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**Fig. 12 FUEL TRANSFER(LIFT) PUMP LOCATION**

- 1 - LIFT PUMP RETAINING BOLTS  
 2 - LIFT PUMP  
 3 - FUEL FILTER/WATER SEPARATOR HOUSING  
 4 - FUEL HEATER  
 5 - CHECK BALL  
 6 - O-RING  
 7 - FLOW DIVERTER  
 8 - FUEL FILTER  
 9 - O-RING  
 10 - FUEL FILTER BOWL ASSEMBLY

## FUEL/LIFT PUMP (Continued)

## OPERATION

The purpose of the fuel/lift pump is to supply low-pressure fuel: **from** the fuel tank, **through** the fuel filter/water separator and **to** the high pressure pump.

Fused battery positive voltage is supplied to the fuel/lift pump relay at all times through the Integrated Control Module. Fused ignition positive volt-

age is supplied to the fuel/lift pump relay by the ECM. When the ignition key is turned to the Run or Start position, the ECM grounds the relay control circuit for 5 seconds, which closes the relay contacts and allows fuel pump operation.

With the ignition "ON" and fuel transfer pump running, the low-pressure fuel pressure should be 12-17 psi.

## DIAGNOSIS AND TESTING - FUEL/LIFT PUMP

| CONDITION                  | POSSIBLE CAUSES                                                                                                                                                                                                                                                                                                                          | CORRECTION                                                                                                                                                                                                                                                                         |
|----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fuel/Lift Pump Inoperative | Stored DTC's<br><br>Open or shorted fused ignition switch output circuit.<br>Open or shorted fused battery voltage circuit to fuel/lift pump relay.<br>Open or shorted fuel/lift pump relay output circuit.<br>Open or high resistance, fuel/lift pump ground circuit.<br>Defective fuel/lift pump relay<br><br>Defective fuel/lift pump | Refer to the appropriate diagnostic manual<br><br>Test and repair circuit as required<br>Test and repair circuit as required.<br>Test and repair circuit as required.<br>Test and repair circuit as required.<br>Test and replace relay as required.<br><br>Replace fuel/lift pump |

## REMOVAL

(1) The fuel pump is serviced as part of the fuel filter/water separator assembly. Refer to (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - REMOVAL).

## INSTALLATION

(1) The fuel pump is serviced as an assembly along with the fuel filter/water separator. Refer to (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - INSTALLATION).

## WATER IN FUEL SENSOR

### DESCRIPTION

The WIF sensor is located in the bowl assembly of the fuel filter/water separator.

### 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. This all takes place when the ignition key is initially put in the ON position.

### REMOVAL

The Water in Fuel Sensor is part of the fuel filter bowl assembly. Refer to fuel filter replacement for removal procedure (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - REMOVAL)

### INSTALLATION

The Water in Fuel Sensor is part of the fuel filter bowl assembly. Refer to fuel filter installation for procedure (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - INSTALLATION).

## FUEL HEATER RELAY

### DESCRIPTION

The fuel heater relay is located in the Integrated Power Module (IPM). This micro-relay operates the same as a conventional relay except the terminal orientation and current capacity is different, and the relay case is smaller.

### OPERATION

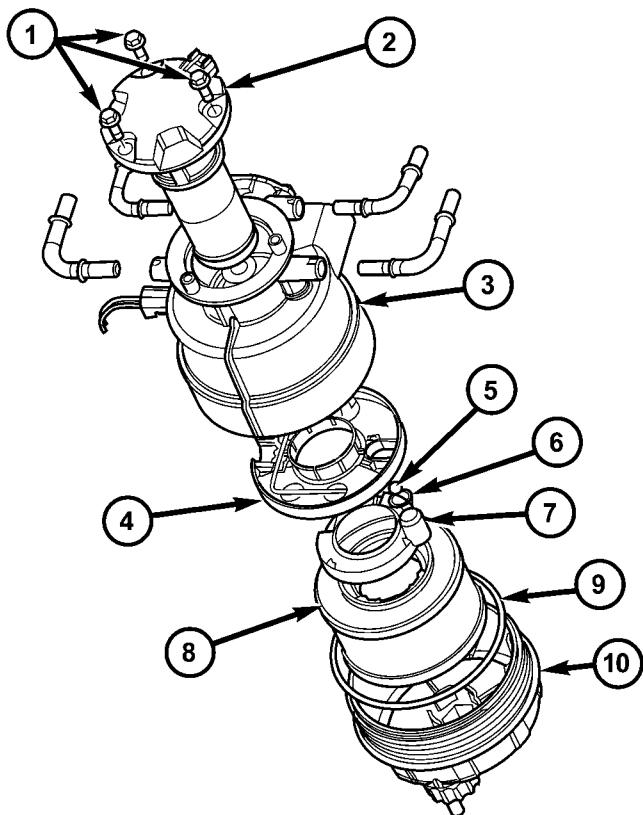
The fuel heater relay is a electromechanical devise that switches battery voltage to the fuel heater when the ECM grounds the relay coil. The fuel heater relay can not be repaired, and if faulty or damaged, must be replaced.

## FUEL HEATER

### DESCRIPTION

The fuel heater is incorporated within the Fuel Filter/Water Separator, which is located under the vehicle in front of the rear axle assembly. It's purpose is

to keep the fuel at a suitable temperature range to improve cold starting, cold driveability and cold exhaust emissions.



80c75f72

**Fig. 13 FUEL FILTER/WATER SEPARATOR**

- 1 - FUEL/LIFT PUMP RETAINING BOLTS
- 2 - FUEL/LIFT PUMP
- 3 - FUEL FILTER/WATER SEPARATOR HOUSING
- 4 - FUEL HEATER
- 5 - CHECK BALL
- 6 - O-RING
- 7 - FLOW DIVERTER
- 8 - FUEL FILTER
- 9 - O-RING
- 10 - FUEL FILTER BOWL ASSEMBLY

### OPERATION

Fused battery positive voltage is supplied to the fuel heater relay at all times through the Integrated Power Module (IPM). Fused ignition positive voltage is supplied to the fuel heater relay through the IPM. The fuel heater is grounded through the ECM. When the ignition switch is in Run or Start position, the fuel heater relay contacts close and supply power to the fuel heater. The fuel heater acts as a thermister (resistance varies with temperature). If the fuel temperature is 8°C (46°F) or below the heater turns on until the temperature of the fuel reaches 25°C (76°F) at which time the heater turns off. (Fig. 13).

## FUEL HEATER (Continued)

## DIAGNOSIS AND TESTING - FUEL HEATER

The fuel heater element only operates between 8°C (46°F) and 24°C (76°F).

| CONDITION               | POSSIBLE CAUSES                                                                                                                                                                                                                                                                                                                                    | CORRECTION                                                                                                                                                                                                                                                                                        |
|-------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fuel Heater Inoperative | <p>Open or shorted battery positive circuit to fuel heater relay.</p> <p>Open or shorted ignition positive voltage circuit to fuel heater relay.</p> <p>Open or shorted fuel heater relay ground circuit.</p> <p>Open or shorted fuel heater relay output circuit.</p> <p>Faulty fuel heater relay</p> <p>Faulty fuel heater</p> <p>Faulty ECM</p> | <p>Test and repair circuit as required.</p> <p>Test and replace as necessary.</p> <p>Test and replace as necessary.</p> <p>Test and replace as necessary.</p> |

## REMOVAL

(1) The Fuel Heater is part of the Fuel Filter/Water Separator. Refer to the Fuel Filter/Water Separator Replacement Procedure (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - REMOVAL).

## INSTALLATION

(1) The Fuel Heater is part of the Fuel Filter/Water Separator. Refer to the Fuel Filter/Water Separator Installation Procedure (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL FILTER / WATER SEPARATOR - INSTALLATION).

# FUEL INJECTION

## TABLE OF CONTENTS

| page                                     | page |
|------------------------------------------|------|
| <b>FUEL INJECTION</b>                    |      |
| STANDARD PROCEDURE - TESTING FUEL        |      |
| INJECTORS .....                          | 17   |
| <b>FUEL PRESSURE SOLENOID</b>            |      |
| DESCRIPTION .....                        | 18   |
| REMOVAL .....                            | 18   |
| INSTALLATION .....                       | 19   |
| <b>FUEL INJECTOR</b>                     |      |
| DESCRIPTION                              |      |
| FUEL INJECTOR .....                      | 19   |
| OPERATION .....                          | 19   |
| STANDARD PROCEDURE - INJECTOR BORE       |      |
| CLEANING .....                           | 21   |
| REMOVAL .....                            | 22   |
| INSTALLATION .....                       | 22   |
| <b>ACCELERATOR PEDAL POSITION SENSOR</b> |      |
| DESCRIPTION .....                        | 23   |
| OPERATION .....                          | 23   |
| REMOVAL - PEDAL POSITION SENSOR (LHD) .. | 23   |
| INSTALLATION - PEDAL POSITION SENSOR     |      |
| (LHD) .....                              | 23   |
| <b>BOOST PRESSURE SENSOR</b>             |      |
| DESCRIPTION .....                        | 24   |
| OPERATION .....                          | 24   |
| DIAGNOSIS AND TESTING - BOOST            |      |
| PRESSURE/INTAKE AIR TEMPERATURE          |      |
| SENSOR .....                             | 24   |
| <b>INTAKE AIR TEMPERATURE SENSOR</b>     |      |
| DESCRIPTION .....                        | 24   |
| OPERATION .....                          | 24   |
| REMOVAL .....                            | 25   |
| INSTALLATION .....                       | 25   |
| <b>CRANKSHAFT POSITION SENSOR</b>        |      |
| DESCRIPTION .....                        | 25   |
| OPERATION .....                          | 25   |
| <b>MASS AIR FLOW (MAF) SENSOR</b>        |      |
| DESCRIPTION .....                        | 25   |
| OPERATION .....                          | 25   |
| REMOVAL .....                            | 25   |
| INSTALLATION .....                       | 26   |

## FUEL INJECTION

### STANDARD PROCEDURE - TESTING FUEL INJECTORS

**NOTE:** The fuel pump pressure must be between 0.8 and 1.2 bar (13–17 psi), and engine must be at operating temperature, engine coolant 88°C (190°F).

(1) (Refer to 14 - FUEL SYSTEM - WARNING). Run engine until operating temperature is obtained.

(2) Turn Off the ignition.

(3) Disconnect the fuel injector fuel return hose at the return hose tee directly behind the generator, next to the air purge fitting, leaving the return hose to the high pressure injection pump connected to the pump (Fig. 1).

(4) Block off fuel return line to high pressure injection pump.

(5) Connect a hose to the return hose tee and place it in a suitable container.

(6) Start the engine and measure the return fuel for 1 minute at idle.

**NOTE:** If the quantity of fuel is above 100ml. it means one or more of the fuel injectors has a problem.

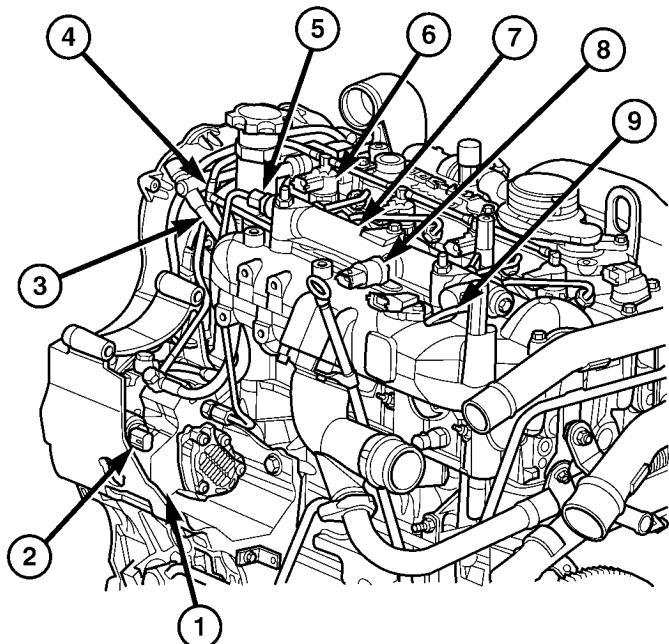
(7) If the measured quantity is above 100ml, disconnect each individual injector and measure the quantity of return fuel into the container.

**NOTE:** Make sure to block off the fuel return hose at each individual fuel injector before taking a measurement.

(8) Replace the fuel injector that has a return rate above 25ml. for one minute at idle(Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - REMOVAL).

(9) If the test does not give a positive result, disconnect the fuel return line at the fuel rail. If fuel is present, replace the fuel rail (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL RAIL - REMOVAL).

## FUEL INJECTION (Continued)



8122fb03

**Fig. 1 DIESEL FUEL SYSTEM COMPONENTS**

- 1 - HIGH PRESSURE FUEL INJECTION PUMP
- 2 - FUEL PRESSURE SOLENOID
- 3 - AIR PURGE FITTING
- 4 - FUEL INJECTOR FUEL RETURN HOSE TEE
- 5 - HIGH PRESSURE FUEL SUPPLY LINE
- 6 - FUEL INJECTOR
- 7 - FUEL RAIL
- 8 - FUEL RAIL PRESSURE SENSOR
- 9 - FUEL RAIL RETURN LINE

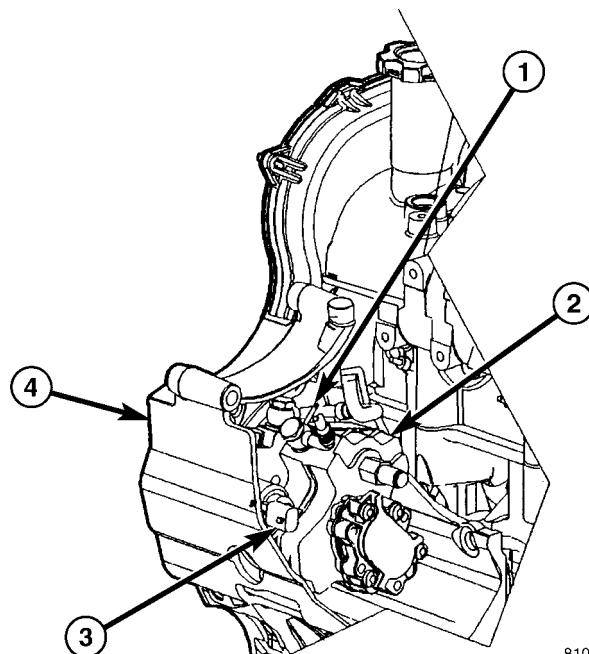
(10) Perform the fuel system air purge procedure after replacing any components (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

**FUEL PRESSURE SOLENOID****DESCRIPTION**

The fuel pressure solenoid controls the low pressure fuel supply to the high pressure injection pump. The readings along with the Fuel Pressure Sensor readings are used by the ECM to determine and maintain the appropriate fuel system pressure under all driving conditions (Fig. 2).

**REMOVAL**

- (1) Disconnect negative battery cable.
- (2) Remove engine cover (Refer to 9 - ENGINE - REMOVAL).
- (3) Lift up on the power steering pump reservoir, and remove it from its mounting. Place the reservoir aside.



8100995a

**Fig. 2 FUEL PRESSURE SOLENOID**

- 1 - FUEL RETURN LINE
- 2 - HIGH PRESSURE FUEL INJECTION PUMP
- 3 - FUEL PRESSURE SOLENOID
- 4 - ACCESSORY BRACKET

(4) (Refer to 14 - FUEL SYSTEM - WARNING). Thoroughly clean the high pressure fuel injection pump around the area of the fuel pressure solenoid and use compressed air to dry (Fig. 2).

(5) Disconnect the fuel pressure solenoid electrical connector (Refer to 14 - FUEL SYSTEM - WARNING).

(6) Remove the screw attaching the solenoid to the pump (Refer to 14 - FUEL SYSTEM - WARNING).

(7) Grab the fuel pressure solenoid, twist, and pull back to remove the solenoid from the pump (Refer to 14 - FUEL SYSTEM - WARNING).

**NOTE: DO NOT use mechanical implements to remove dirt and debris from the injection pump bores or mating surfaces.**

(8) Use a clean, lint free cloth to remove any debris from the bores and mating surfaces of the injection pump.

## FUEL PRESSURE SOLENOID (Continued)

## INSTALLATION

(1) Inspect O-rings on the new pressure solenoid for any damage and ensure that the O-rings are seated properly (Refer to 14 - FUEL SYSTEM - WARNING).

(2) Coat both O-rings with clean engine oil or diesel fuel.

**NOTE:** If pressure solenoid is pressed in at an angle, the O-rings may be damaged, resulting in fuel leakage or high pressure injection pump malfunction.

(3) Position the new pressure solenoid horizontally into the high pressure injection pump, twist slightly while pressing into pump. Ensure the mating surfaces of both components are flush (Fig. 2).

(4) Install the pressure solenoid retaining screws by hand and tighten in 2 phases. 3 - 4Nm (27 - 35lbs.in.) then 6 - 7Nm (53 - 62 lbs.in.).

(5) Connect the pressure solenoid electrical connector.

(6) Install the power steering reservoir into it's mounting bracket.

(7) Connect the negative battery cable.

(8) Perform the Fuel System Air Purge procedure (Refer to 14 - FUEL SYSTEM - STANDARD PROCEDURE).

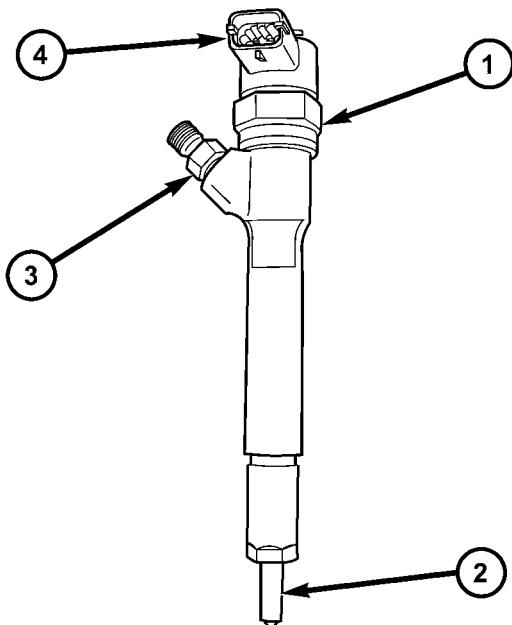
## FUEL INJECTOR

## DESCRIPTION

## FUEL INJECTOR

**WARNING: HIGH - PRESSURE FUEL LINE DELIVER DIESEL FUEL UNDER EXTREME PRESSURE FROM THE INJECTION PUMP TO THE FUEL INJECTORS. THIS MAY BE AS HIGH AS 1600BAR (23,200PSI). USE EXTREME CAUTION WHEN INSPECTING FOR HIGH - PRESSURE FUEL LEAKS. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN CAUSING PERSONAL INJURY OR DEATH. INSPECT FOR HIGH - PRESSURE LEAKS WITH A SHEET OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

(Refer to 14 - FUEL SYSTEM - WARNING) There are individual fuel injectors for all four cylinders. These fuel injectors are used to spray fuel into the combustion chamber (Fig. 3).



**Fig. 3 FUEL INJECTOR**

- 1 - FUEL INJECTOR
- 2 - NOZZLE
- 3 - FUEL INLET FITTING
- 4 - ELECTRICAL CONNECTION

## OPERATION

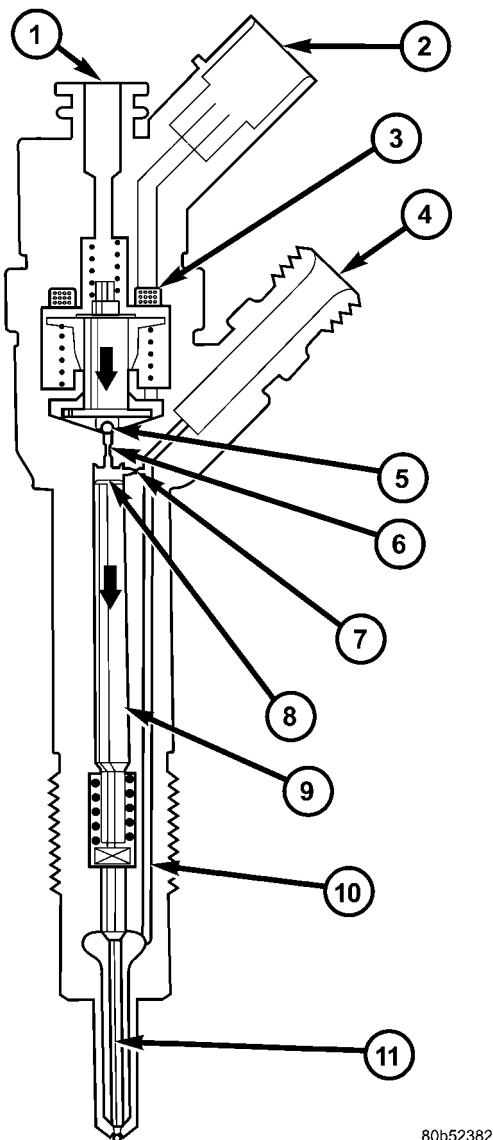
(Refer to 14 - FUEL SYSTEM - WARNING) The injector operation can be subdivided into four operating states with the engine running and the high-pressure pump generating pressure:

- Injector closed (with high pressure applied)
- Injector opens (start of injection)
- Injector opened fully
- Injector closes (end of injection)

**Injector closed (with high pressure applied)**

With the injector closed (at-rest state), the solenoid valve is not energized and is therefore closed. With the bleed orifice closed, the valve spring forces the armature's ball onto the bleed-orifice seat. The rail's high pressure build up in the valve control chamber, and the same pressure is also present in the nozzle's chamber volume. The rail pressure applied at the control plunger's end face, together with the force of the nozzle spring, maintain the nozzle in the closed position against the opening forces applied to its pressure stage (Fig. 4).

## FUEL INJECTOR (Continued)

**Fig. 4 INJECTOR COMPONENTS**

- 1 - INJECTOR CLOSED (AT-REST STATUS)
- 2 - ELECTRICAL CONNECTION
- 3 - TRIGGERING ELEMENT (SOLENOID VALVE)
- 4 - FUEL INLET (HIGH PRESSURE) FROM THE RAIL
- 5 - VALVE BALL
- 6 - BLEED ORIFICE
- 7 - FEED ORIFICE
- 8 - VALVE CONTROL CHAMBER
- 9 - VALVE CONTROL PLUNGER
- 10 - FEED PASSAGE TO THE NOZZLE
- 11 - NOZZLE NEEDLE

**Injector opens (start of injection)**

The solenoid valve is energized with the pickup current which serves to ensure that it opens quickly. The force exerted by the triggered solenoid now exceeds that of the valve spring and the armature opens the bleed orifice. Almost immediately, the high-level pick-up current is reduced to the lower holding current required for the electromagnet. This is possible due to the magnetic circuit's air gap now being smaller. When the bleed orifice opens, fuel can flow from the valve control chamber into the cavity situated above it, and from there via the fuel return to the tank. The bleed orifice prevents complete pressure balance, and the pressure in the valve control chamber sinks as a result. This leads to the pressure in the valve-control chamber being lower than that in the nozzle's chamber volume which is still at the same pressure level as the rail. The reduced pressure in the valve-control chamber causes a reduction in the force exerted on the control plunger, the nozzle needle opens as a result, and injection starts (Fig. 4).

**Injector opens fully**

The control plunger reaches its upper stop where it remains supported by a cushion of fuel which is generated by the flow of fuel between the bleed and feed orifices. The injector nozzle has now opened fully, and the fuel is injected into the combustion chamber at a pressure almost equal to that in the fuel rail (Fig. 4).

**Injector closes (end of injection)**

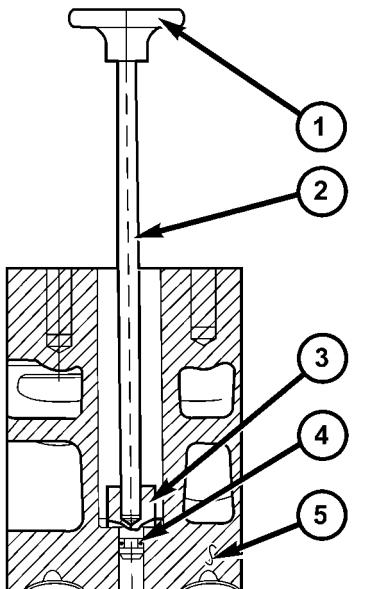
As soon as the solenoid valve is no longer triggered, the valve spring forces the armature downwards and the ball closes the bleed orifice. The armature is a 2-piece design. Here, although the armature plate is guided by a driver shoulder in its downward movement, it can "overspring" with the return spring so that it exerts no downwards-acting forces on the armature and the ball. The closing of the bleed orifice lead to pressure build up in the control chamber via the input from the feed orifice. This pressure is the same as that in the rail and exerts an increased force on the control plunger through its end face. This force, together with that of the spring, now exceeds the force exerted by the chamber volume and the nozzle needle closes. Injection ceases as soon as the nozzle needle comes up against its bottom stop again (Fig. 4).

## FUEL INJECTOR (Continued)

## STANDARD PROCEDURE - INJECTOR BORE CLEANING

(1) Screw the injector nozzle bore plug onto the threaded extention.

(2) Seat the plug into the injector nozzle bore and remove threaded extention (Fig. 5).



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**Fig. 5 FUEL INJECTOR PLUG AND EXTENTION**

- 1 - HANDLE
- 2 - THREADED EXTENTION
- 3 - PLUG
- 4 - O-RING
- 5 - CYLINDER HEAD

(3) Using the abrasive blade roller, clean the injector bore (Fig. 6).

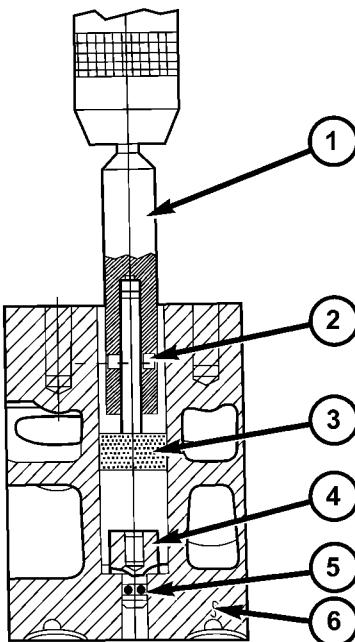
**NOTE:** Before blowing the debris out of the bore, insert the threaded extention onto the the plug and press down to prevent debris from entering the combustion chamber.

(4) Install the threaded extention onto the bore plug and press down while blowing the material away from the injector seat (Fig. 5).

**NOTE:** Do Not apply antiseize compound near the fuel injector nozzle.

**NOTE:** Repeated mounting of the return fuel hose retaining ring is not permitted

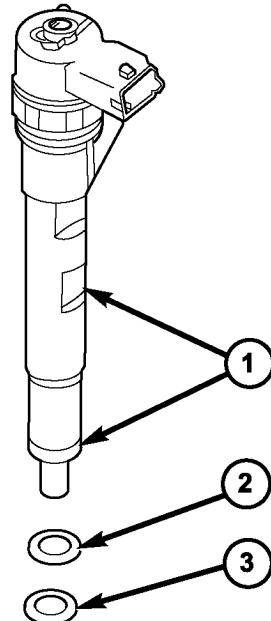
(5) Carefully clean and lubricate the injector body with antiseize compound before installation (Fig. 7).



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**Fig. 6 CYLINDER HEAD INJECTOR BORE CLEANING**

- 1 - EXTENTION
- 2 - DOWEL
- 3 - ABRASIVE BLADE ROLLER
- 4 - PLUG
- 5 - O-RING
- 6 - CYLINDER HEAD



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**Fig. 7 FUEL INJECTOR**

- 1 - LUBRICATION POINTS
- 2 - WASHER
- 3 - SEAL

## FUEL INJECTOR (Continued)

## REMOVAL

**NOTE:** Repeated mounting of the fuel return line and retaining clip is not permitted.

(1) Disconnect negative battery cable (Refer to 14 - FUEL SYSTEM - WARNING).

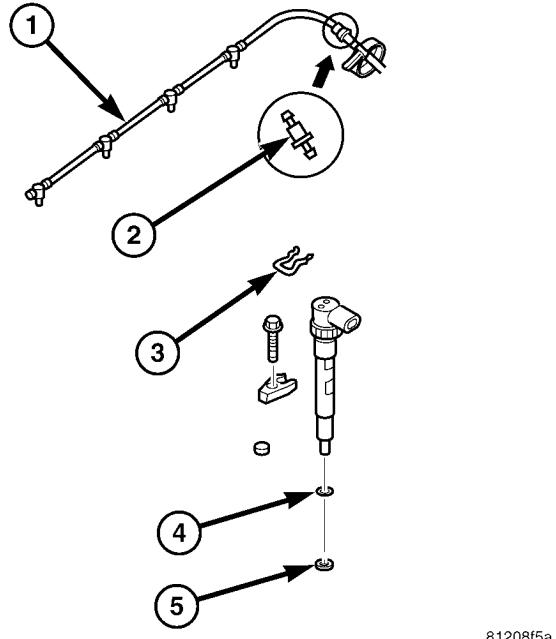
(2) Remove engine cover (Refer to 9 - ENGINE - REMOVAL) (Refer to 9 - ENGINE COVER - REMOVAL).

(3) Disconnect injector electrical connector.

**NOTE:** DO NOT use a brush to clean around injector nozzle. The Injector may become restricted with debris.

(4) Remove fuel return line from injector (Fig. 8).

(5) Counterhold and remove fuel injector high pressure line from the injector.



**Fig. 8 FUEL INJECTOR AND COMPONENTS**

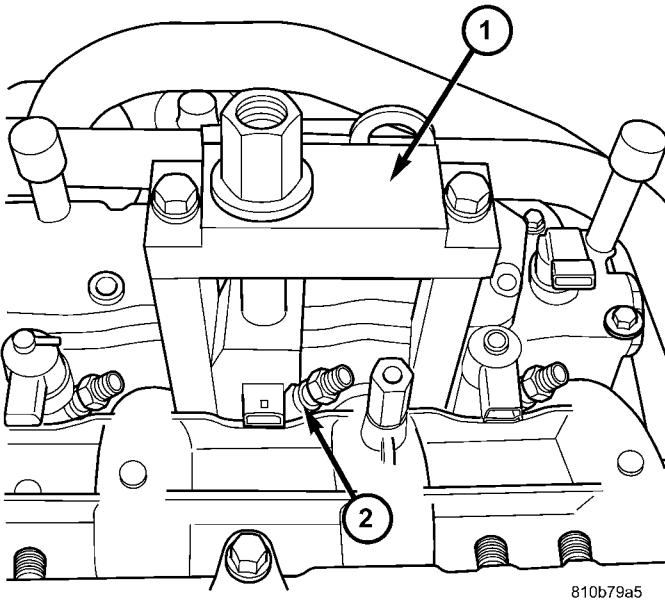
- 1 - FUEL RETURN LINE
- 2 - ONE WAY VALVE
- 3 - RETAINING RING
- 4 - WASHER
- 5 - O-RING

(6) Remove fuel injector retaining bolt and retainer (Fig. 8).

(7) Remove fuel injector from cylinder head (Fig. 8).

**CAUTION:** If the fuel injectors will not come out of the cylinder head perform the following steps to prevent damaging other components.

(8) Assemble and install Injector extractor special tool VM9075 on to injector and cylinder head (Fig. 9).



**Fig. 9 FUEL INJECTOR EXTRACTOR**

- 1 - VM9075
- 2 - FUEL INJECTOR

(9) Tighten injector extractor center nut until fuel injector is extracted (Fig. 10).

**NOTE:** If the injector is still hard to remove, leave the tool in place with tension on the injector and liberally spray the injector seat with antiseize lubricant.

(10) Thoroughly clean cylinder head fuel injector bore (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - STANDARD PROCEDURE).

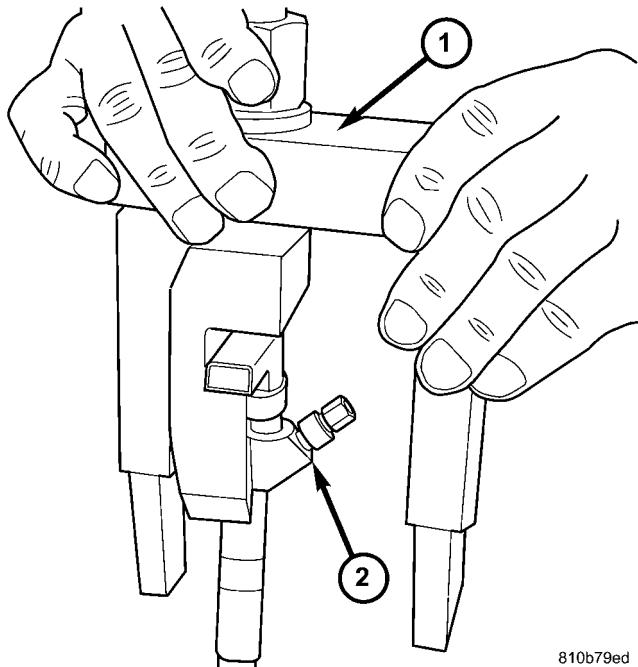
## INSTALLATION

**WARNING:** (Refer to 14 - FUEL SYSTEM - WARNING).

**NOTE:** Lightly lubricate injector body with antiseize compound and install fuel injector in cylinder head. Be sure the copper washer is installed on end of injector before installing in cylinder head.

**NOTE:** DO NOT use a brush to clean around injector nozzle. DO NOT lubricate area around injector nozzle. The Injector may become restricted with debris.

## FUEL INJECTOR (Continued)

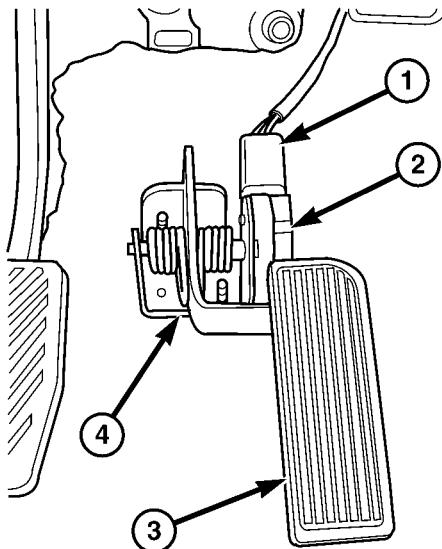


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**Fig. 10 SPECIAL TOOL VM9075**

1 - VM9075

2 - FUEL INJECTOR



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**Fig. 11 ACCELERATOR PEDAL POSITION SENSOR LOCATION (TYPICAL)**

1 - ACCELERATOR PEDAL POSITION SENSOR ELECTRICAL CONNECTOR

2 - ACCELERATOR PEDAL POSITION SENSOR

3 - ACCELERATOR PEDAL

4 - ACCELERATOR PEDAL MOUNTING BRACKET

- (1) Install fuel injector with new seals.
- (2) Install fuel injector retainer and bolt (Fig. 8). Torque bolt to 32.4 N·m.
- (3) Install fuel injector high pressure line, counterhold and tighten to 20 N·m (177 lbs. in.)..

**NOTE: Repeated mounting of the return line and clip is not permitted.**

- (4) Install fuel return line to injector (Fig. 8).
- (5) Connect fuel injector electrical connector.
- (6) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).
- (7) Connect negative battery cable (Refer to 14 - FUEL SYSTEM - WARNING).

## ACCELERATOR PEDAL POSITION SENSOR

### DESCRIPTION

The accelerator pedal position sensor mounts to the accelerator pedal bracket (Fig. 11).

### OPERATION

The accelerator pedal position sensor contains a low idle switch and a potentiometer that are operated by the accelerator pedal. As the accelerator pedal is depressed, the low idle switch opens and the potentiometer provides a variable voltage signal to the engine control module directly proportional to accelerator pedal position. When the pedal is fully depressed, the voltage signal is high.

### REMOVAL - PEDAL POSITION SENSOR (LHD)

- (1) Disconnect negative battery cable.
- (2) Disconnect pedal position sensor electrical connector (Fig. 11).
- (3) Remove 2 pedal position sensor retaining nuts (Fig. 11).
- (4) Remove pedal position sensor from vehicle.

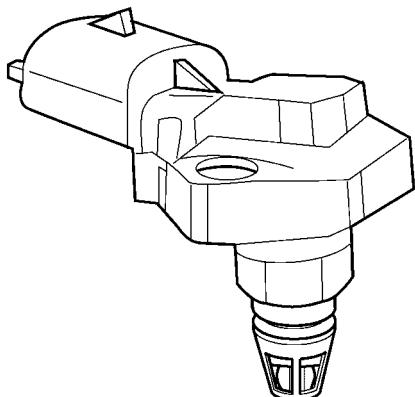
### INSTALLATION - PEDAL POSITION SENSOR (LHD)

- (1) Position pedal position sensor in vehicle.
- (2) Install pedal position sensor retaining nuts (Fig. 11).
- (3) Connect pedal position sensor electrical connector (Fig. 11).
- (4) Connect negative battery cable.

## BOOST PRESSURE SENSOR

### DESCRIPTION

The boost pressure/ intake air temperature sensor is mounted to the top of the intake manifold. The sensor allows the ECM to monitor air pressure within the intake manifold. This sensor is also used to monitor the intake air temperature (Fig. 12).



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**Fig. 12 BOOST PRESSURE SENSOR / INTAKE AIR TEMPERATURE SENSOR**

### OPERATION

When the intake manifold pressure is low sensor voltage output is 0.25-1.8 volts at the ECM. When the intake manifold pressure is high due to turbo boost, sensor voltage output is 2.0-4.7 volts. The sensor receives a 5-volts reference from the ECM. Sensor ground is also provided by the ECM. The ECM uses boost pressure combined with intake air temperature to determine the volume of air entering the engine.

### DIAGNOSIS AND TESTING - BOOST PRESSURE/INTAKE AIR TEMPERATURE SENSOR

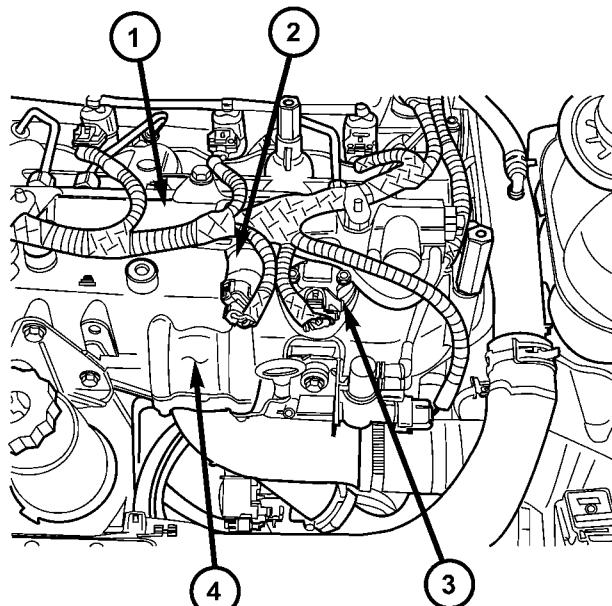
If the boost pressure sensor fails, the ECM records a DTC into memory and continues to operate the engine in one of the three limp-in modes. When the ECM is operating in this mode, a loss of power will be present, as if the turbocharger was not operating. The best method for diagnosing faults with the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

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

## INTAKE AIR TEMPERATURE SENSOR

### DESCRIPTION

The boost pressure sensor/intake air temperature sensor is located in the top of the intake manifold (Fig. 13). The intake air temperature sensor is used to measure the intake air temperature. The intake air temperature sensor is a dual purpose sensor. It is also used as a boost pressure sensor.



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**Fig. 13 BOOST PRESSURE SENSOR/INTAKE AIR TEMPERATURE SENSOR LOCATION**

- 1 - FUEL RAIL
- 2 - FUEL PRESSURE SENSOR
- 3 - BOOST PRESSURE/INTAKE AIR TEMPERATURE SENSOR
- 4 - CYLINDER HEAD COVER/INTAKE MANIFOLD

### OPERATION

The intake air temperature sensor is a negative temperature coefficient (NTC) thermistor (resistance varies inversely with temperature). This means at cold air temperature its resistance is high, so the voltage signal will be high. As intake air temperature increases, sensor resistance decreases and the signal voltage will be low. This allows the sensor to provide an analog voltage signal (0.2-4.8 volts) to the ECM.

## INTAKE AIR TEMPERATURE SENSOR (Continued)

### REMOVAL

- (1) Disconnect negative battery cable.
- (2) Remove engine cover retaining bolts and cover (Refer to 9 - ENGINE - REMOVAL).
- (3) Disconnect intake air temperature electrical connector.
- (4) Remove intake air temperature sensor retaining screws and sensor (Fig. 13).

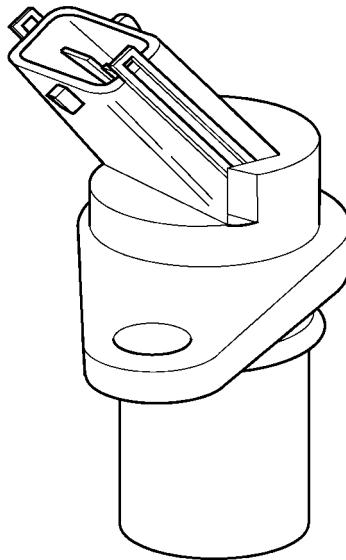
### INSTALLATION

- (1) Install intake air temperature sensor and retaining bolts (Fig. 13). Torque to 5.4 N·m.
- (2) Connect intake air temperature sensor.
- (3) Install engine cover and retaining bolts (Refer to 9 - ENGINE - INSTALLATION).

## CRANKSHAFT POSITION SENSOR

### DESCRIPTION

The crankshaft position sensor is mounted in the right rear of the engine block below the turbocharger (Fig. 14). This sensor is used to detect engine speed.



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Fig. 14 CRANKSHAFT POSITION SENSOR

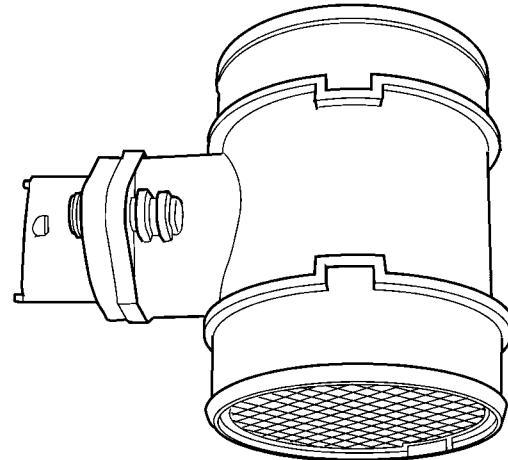
### OPERATION

The crankshaft position sensor is a magnetic pickup type sensor that generates an A/C signal. The sensor contains a permanent magnet and a coil of wire. The sensor generates an A/C signal each time a notch in the reluctor wheel on the crankshaft passes across the permanent magnet. The ECM calculates engine speed based on the frequency of the A/C signal.

## MASS AIR FLOW (MAF) SENSOR

### DESCRIPTION

The Mass Air Flow (MAF) Sensor is mounted inline in the air intake between the air filter and the turbocharger (Fig. 15).



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Fig. 15 MASS AIR FLOW (MAF) SENSOR

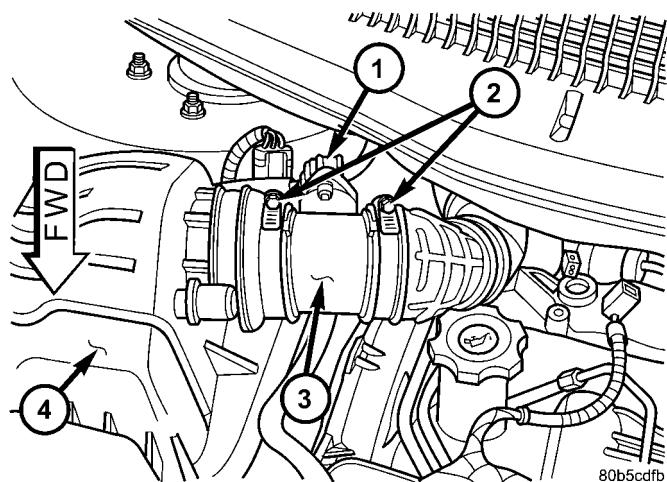
### OPERATION

The ECM uses the mass air flow (MAF) sensor to measure air density. The MAF sensor contains a ceramic element. A signal voltage is provided to the element. As engine speed increases, airflow across the ceramic element increases. Changes in air flow and air density cause the temperature of the ceramic element to fluctuate. The ceramic element changes resistance respectively to changes in temperature. The change in resistance varies the signal voltage output to the ECM. The ECM/PCM relay supplies battery power to the MAF sensor. Ground is provided by the ECM. The MAF sensor signal is provided to the ECM.

### REMOVAL

- (1) Disconnect negative battery cable.
- (2) Disconnect MAF sensor electrical connector (Fig. 16).
- (3) Loosen MAF sensor retaining clamps (Fig. 16).
- (4) Remove MAF sensor from airduct (Fig. 16).

## MASS AIR FLOW (MAF) SENSOR (Continued)



**Fig. 16 MASS AIR FLOW (MAF) SENSOR LOCATION**

1 - MAF SENSOR ELECTRICAL CONNECTOR

2 - RETAINING CLAMPS

3 - MASS AIR FLOW (MAF) SENSOR

4 - AIR CLEANER HOUSING

### INSTALLATION

- (1) Install MAF sensor in airduct (Fig. 16).
- (2) Tighten retaining clamps (Fig. 16).
- (3) Connect MAF sensor electrical connector (Fig. 16).
- (4) Connect negative battery cable.