# GROUP TAB LOCATOR


9 **Engine**

14 **Fuel System**

25 **Emissions Control**

**Service Manual Comment Forms (Rear of Manual)**

# ENGINE

## TABLE OF CONTENTS

page

**ENGINE - 2.2L DIESEL**
DESCRIPTION . . . . . 2
STANDARD PROCEDURE
COMPRESSION TESTING ENGINE . . . . . 2
CYLINDER LEAK DOWN TEST . . . . . 3
CHECKING OIL PRESSURE . . . . . 3
REMOVAL
ENGINE COVER . . . . . 4
ENGINE . . . . . 4
INSTALLATION
ENGINE COVER . . . . . 5
ENGINE . . . . . 5
SPECIFICATIONS
TORQUE . . . . . 7
SPECIAL TOOLS . . . . . 13
**CYLINDER HEAD**
STANDARD PROCEDURE
CYLINDER HEAD BOLT INSPECTION . . . . . 17
MEASURE CYLINDER HEAD SURFACE . . . . 17
REMOVAL
CYLINDER HEAD . . . . . 18
CYLINDER HEAD FRONT COVER . . . . . 20
CYLINDER HEAD GUIDE RAIL . . . . . 21
INSTALLATION
CYLINDER HEAD . . . . . 21
CYLINDER HEAD FRONT COVER . . . . . 23
CYLINDER HEAD GUIDE RAIL . . . . . 23
**CYLINDER HEAD COVER**
REMOVAL . . . . . 24
INSTALLATION . . . . . 24
**VALVE SPRINGS**
REMOVAL
VALVE SPRINGS . . . . . 25
VALVES . . . . . 25
INSTALLATION
VALVE SPRINGS . . . . . 26
VALVES . . . . . 26
**CAMSHAFT(S)**
STANDARD PROCEDURE
CHECKING CAMSHAFT POSITION . . . . . 27
REMOVAL . . . . . 28
INSTALLATION . . . . . 28
**ENGINE BLOCK**
STANDARD PROCEDURE
REPLACING ENGINE CORE AND OIL GALLERY PLUGS . . . . . 30
MEASURING CYLINDER BORES . . . . . 30

page

**CRANKSHAFT**
STANDARD PROCEDURE
MEASURE CRANKSHAFT AND BLOCK JOURNALS . . . . . 31
REMOVAL . . . . . 31
INSTALLATION . . . . . 32
**CRANKSHAFT OIL SEAL - REAR**
REMOVAL . . . . . 33
INSTALLATION . . . . . 33
**VACUUM PUMP**
DESCRIPTION . . . . . 34
REMOVAL . . . . . 34
INSTALLATION . . . . . 34
**OIL PRESSURE SENSOR/SWITCH**
DESCRIPTION . . . . . 35
OPERATION . . . . . 35
**OIL PAN**
REMOVAL . . . . . 35
INSTALLATION . . . . . 36
**OIL PUMP**
REMOVAL . . . . . 36
INSTALLATION . . . . . 37
**OIL JET**
DESCRIPTION . . . . . 37
REMOVAL . . . . . 37
INSTALLATION . . . . . 37
**BALANCE SHAFT**
DESCRIPTION . . . . . 37
OPERATION . . . . . 37
REMOVAL . . . . . 38
INSTALLATION . . . . . 38
**TIMING CHAIN COVER**
REMOVAL . . . . . 40
INSTALLATION . . . . . 40
**TIMING CHAIN**
REMOVAL
BOTTOM GUIDE RAIL . . . . . 42
INTERMEDIATE GEAR . . . . . 42
TIMING CHAIN TENSIONING RAIL . . . . . 43
TIMING CHAIN . . . . . 44
INSTALLATION
BOTTOM GUIDE RAIL . . . . . 46
INTERMEDIATE GEAR . . . . . 46
TIMING CHAIN TENSIONING RAIL . . . . . 46
ADJUSTMENTS
TIMING CHAIN . . . . . 47
**TIMING CHAIN TENSIONER**
REMOVAL
TIMING CHAIN TENSIONER . . . . . 50

INSTALLATION
TIMING CHAIN TENSIONER . . . . . 51
**INTAKE MANIFOLD**
DESCRIPTION . . . . . 51
REMOVAL . . . . . 51
CLEANING . . . . . 52
INSPECTION . . . . . 52
INSTALLATION . . . . . 52
**AIR CLEANER ELEMENT**
REMOVAL . . . . . 53
INSTALLATION . . . . . 53
**AIR CLEANER HOUSING**
DESCRIPTION . . . . . 53
REMOVAL
AIR CLEANER HOUSING . . . . . 53
REMOVAL . . . . . 54
INSTALLATION
AIR CLEANER HOUSING . . . . . 54
INSTALLATION . . . . . 54
**ENGINE MOUNTING**
DESCRIPTION . . . . . 54
OPERATION . . . . . 55
**TORQUE STRUT**
REMOVAL
REMOVAL - UPPER . . . . . 55
REMOVAL - LOWER . . . . . 55
INSTALLATION
UPPER . . . . . 55
LOWER . . . . . 55
ADJUSTMENTS
ENGINE TORQUE STRUT ADJUSTMENT . . . 56
**RIGHT MOUNT**
REMOVAL . . . . . 57
INSTALLATION . . . . . 57
**LEFT MOUNT**
REMOVAL . . . . . 58
INSTALLATION . . . . . 58

# ENGINE - 2.2L DIESEL

## DESCRIPTION

This 2.2 Liter four-cylinder Common Rail Diesel Injection (CDI) engine is an in-line overhead valve diesel engine (Fig. 1). This engine utilizes a cast iron cylinder block and an aluminum cylinder head. The engine is turbocharged and intercooled. This engine also has four valve per cylinder and dual overhead camshafts (Fig. 1).

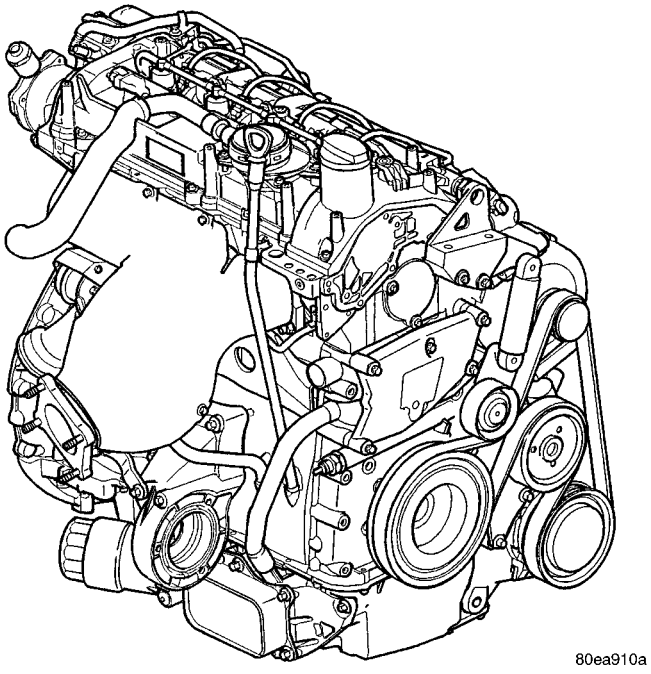



***Fig. 1 2.2L Diesel Engine***

| DESCRIPTION | SPECIFICATION |
|---|---|
| Engine | 2.2L CDI |
| Engine Description | 4 Cylinder In-Line Engine With 4-Valve Technology |
| Fuel Injection System | Common Rail Diesel Injection (CDI) |
| Fuel | Diesel |
| Rated Output | 85/4200 kW at RPM |
| Torque | 250/1400-2600 Nm at RPM |
| Maximum Speed | 4600 RPM |
| Compression Ratio | 18:0 |
| Bore/Stroke | 88.0/88.3 mm |
| Eff. Displacement | 2148 cm3 |

# STANDARD PROCEDURE

## COMPRESSION TESTING ENGINE

(1) Warm up engine to operating temperature (approximately 80 °C, 176°F).

(2) Shut off engine.

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

(4) Remove glow plugs (Refer to 8 - ELECTRICAL/ IGNITION CONTROL/GLOW PLUG - REMOVAL).

(5) Crank engine several times with the starter to eliminate combustion residues in the cylinders.

(6) Insert compression tester adapter with check valve installed into glow plug hole of cylinder to be tested.

(7) Test compression pressure by cranking engine with starter for at least 8 revolutions.

ENGINE - 2.2L DIESEL (Continued)

(8) Carry out test procedure at the remaining cylinders in the same way.

(9) Compare pressure readings obtained with the specified pressures. If the pressure reading is below the minimum compression pressure or if the permissible difference between the individual cylinders is exceeded. Refer to (Refer to 9 - ENGINE - STANDARD PROCEDURE).

*2.2L*

| COMPRESSION SPECIFICATION | |
|---|---|
| Minimum Allowable | 18 bar (261 psi.) |
| Maximum Allowable Difference Between Cylinders | 3 bar (44 psi.) |
| Average Compression Ratio | 24 - 30 bar (348 - 435 psi) |

(10) Remove compression tester and adapter from cylinder head.

(11) Install glow plugs (Refer to 8 - ELECTRICAL/ IGNITION CONTROL/GLOW PLUG - INSTALLATION).

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

## CYLINDER LEAK DOWN TEST

(1) Warm engine to operating temperature.

**WARNING: DO NOT OPEN COOLING SYSTEM UNLESS COOLANT TEMPERATURE IS BELOW 90C (194°F). RISK OF INJURY TO SKIN AND EYES AS A RESULT OF SCALDING WITH HOT COOLANT WHICH SPLASHES OUT. RISK OF POISONING FROM SWALLOWING COOLANT. OPEN CAP SLOWLY AND RELEASE PRESSURE. STORE COOLANT IN PROPER CONTAINERS ONLY. WEAR PROTECTIVE GLOVES, CLOTHING AND EYE PROTECTION.**

**NOTE: Turn cap carefully as far as first detent, release pressure, then unscrew cap.**

(2) Open cooling system cap at coolant recover pressure container.

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

(4) Unscrew oil filler cap.

(5) Remove glow plugs (Refer to 8 - ELECTRICAL/ IGNITION CONTROL/GLOW PLUG - REMOVAL).

**NOTE: Crank engine at crankshaft in direction of rotation of the engine (clockwise).**

(6) Position cylinder to be tested to ignition Top Dead Center (DTC).

**NOTE: Calibrate cylinder leak down tester and remove check valve in screw-in fitting.**

(7) Connect cylinder leak down tester and follow INSPECTING Instruction.

### INSPECTING

**NOTE: If crankshaft rotates, install retaining lock for crankshaft/ring gear.**

(1) Pressurize cylinder with compressed air and read off pressure loss at cylinder leak tester. If excessive pressure loss exists, determine cause by viewing the paragraph below.

**NOTE: If the retaining lock is installed, remove it, rotate engine and install lock once again.**

(2) Carry out test of other cylinders in the firing order of engine.

### DETERMINING PRESSURE LOSS

If a great pressure loss was detected, listen using a stethoscope around suspected areas, such as the cylinder head gasket through the air suction area, the exhaust system, the oil filler neck, the pre-chamber, the bore wholes of the cylinder effected or neighboring cylinders. Observe the coolant in the expansion tank, looking for traces of bubbles.

The possible causes of pressure loss are:

- If air leak is detected through the prechamber, cylinder bore hole, from a neighboring cylinder or air bubbles in the coolant expansion tank, pressure loss may be caused by the cylinder head gasket.
- If the air leak occurs in the air suction area, the pressure loss may be caused by the intake valve(s).
- Air leak through the exhaust system, may be caused by the exhaust valve(s).
- Air leak through the oil filler neck, may be caused by piston, ring, or cylinder sleeve.

If none of the above evidence supports a failure, the engine may be assembled and run until operating temperature is reached. Reconnect engine leak down tester on a warm engine with a few drops of clean engine oil in the cylinder being tested. Engine oil seals the clearance between the piston and cylinder for a short length of time. If under this condition a smaller pressure loss occurs for a shorter length of time, it is possible that the cause is piston, ring or cylinder sleeve related.

## CHECKING OIL PRESSURE

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

(2) Remove oil galley plug together with seal at timing case cover.

ENGINE - 2.2L DIESEL (Continued)

(3) Screw oil pressure gauge adaptor fitting together with seal onto timing case cover.
(4) Connect oil pressure gauge to adaptor fitting.
(5) Check oil level, adjust with correct engine oil if necessary.
(6) Insert temperature of remote thermometer into oil level indicator tube.

**WARNING: USE EXTREME CAUTION WHEN ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH FAN. DO NOT PUT YOUR HANDS NEAR PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

**CAUTION: Ensure that fan and accessory drive belt DO NOT damage oil pressure gauge hose.**

(7) Start engine and bring to operating temperature 90°C (194°F).
(8) Record engine oil pressure at idle.
(9) Raise engine speed to 3000 rpm and record oil pressure.
(10) At normal operating temperature the oil pressure must not drop below 3 bar (44 psi.). When engine speed is raised, oil pressure must rise with out delay and be no less than 3 bar (44 psi.) at 3000 rpm.
(11) If oil pressure is out of range, determine cause.

## REMOVAL

### ENGINE COVER

(1) Remove engine cover retaining nuts (Fig. 2).
(2) Unclip engine cover from retainers and remove engine cover from engine (Fig. 2).

### ENGINE

**CAUTION: WHEN REMOVING ANCILLARY COMPONENTS, PLUG ALL INLET/OUTLET AND FLUID LINES TO PREVENT RESIDUAL LEAKAGE AND CONTAMINATION.**

(1) Disconnect negative battery cable located under the front passenger seat.
(2) Discharge air conditioning (Refer to 24 - HEATING & AIR CONDITIONING - STANDARD PROCEDURE).
(3) Drain cooling system (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).
(4) Remove engine cover (Refer to 9 - ENGINE REMOVAL/ENGINE COVER - REMOVAL).
(5) Remove front grille assembly (Refer to 23 - BODY/EXTERIOR/GRILLE - REMOVAL).

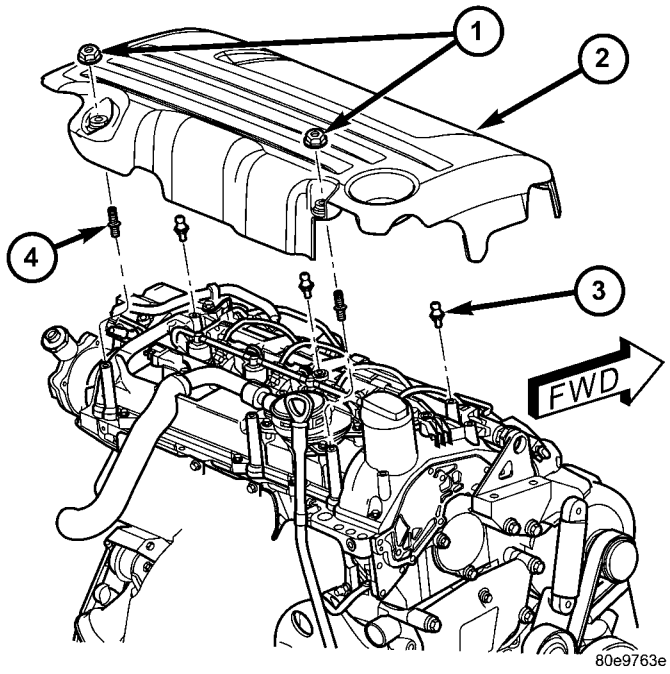



*Fig. 2 Engine Cover Mounts*

1 - ENGINE COVER RETAINING NUTS
2 - ENGINE COVER
3 - ENGINE COVER MOUNTS
4 - ENGINE COVER MOUNTING STUDS

(6) Remove upper radiator closure panel (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - REMOVAL).
(7) Remove air cleaner housing and air inlet hose assembly (Refer to 9 - ENGINE/AIR CLEANER HOUSING - REMOVAL).
(8) Remove radiator and A/C condensor (Refer to 7 - COOLING/ENGINE/RADIATOR - REMOVAL).
(9) Remove engine compartment lower silencer and accessory drive belt splash shield.
(10) Remove power distribution center bracket.
(11) Disconnect shift cables at transaxle.
(12) Disconnect clutch hydraulic line at transaxle.
(13) Disconnect reverse light switch harness connector at transaxle.
(14) Disconnect speed sensor harness connector at transaxle.
(15) Disconnect wiring at starter and alternator, position wiring harness aside.
(16) Disconnect three wiring harness connectors and two ECM harness connectors, position wiring harnesses aside.
(17) Disconnect engine coolant heater harness connector.
(18) Disconnect harness connector at fuel filter/fuel heater.
(19) Disconnect fuel lines at fuel filter/water separator.
(20) Disconnect heater hoses at heater core.

ENGINE - 2.2L DIESEL (Continued)

(21) Disconnect power brake booster vacuum hose at engine.
(22) Disconnect coolant recovery hose at engine.
(23) Disconnect coolant recovery hose at coolant pressure recovery container.
(24) Disconnect supply hose at power steering fluid reservoir and set aside.
(25) Disconnect vacuum hose at turbocharger.
(26) Disconnect suction line at A/C compressor and position aside.
(27) Remove fastener retaining ground strap to engine.
(28) Remove two fasteners from upper torque strut.
(29) Disconnect swirl valve actuator hose at actuator.
(30) Raise support vehicle.
(31) Remove front wheels.
(32) Remove two fasteners retaining left strut to steering knuckle.
(33) Separate front strut from steering knuckle.
(34) Disengage left half shaft tripod joint from output shaft.

**NOTE: When removing tripod joint, DO NOT let spline or snap ring drag across transaxle oil seal lip.**

(35) Remove left half shaft tripod joint from transaxle while pulling outward on top of the steering knuckle.
(36) Support half shaft to prevent damage to seal boot and clamp.
(37) Perform steps 34 through 38 to remove right side tripod.
(38) Remove inner splash shield.
(39) Disconnect engine oil pressure sensor harness connector and remove sensor from engine.
(40) Disconnect power steering pressure hose at steering gear, position aside.
(41) Remove exhaust manifold.
(42) Remove pencil strut and lower torque strut.
(43) Remove inner cooler tube.
(44) Position the engine cradle dolly with the cradle and support posts (special Tools #6710) underneath the engine.
(45) Carefully lower the vehicle enough to position the engine above the support posts.
(46) Align three support posts with three engine mounting sockets.
(47) Position the fourth support post and adaptor underneath engine oil cooler flange.
(48) Adjust the height of each support post as necessary and tighten the support posts and cradle fasteners.
(49) Carefully lower vehicle enough to seat engine onto support posts.

**WARNING: SAFETY STRAPS MUST BE USE TO SECURE ENGINE TO THE DOLLY FIXTURE.**

(50) Install, tighten and lock safety straps around engine and attach them to the cradle.
(51) Raise vehicle enough to verify safety straps retain dolly fixture to engine.
(52) Lower vehicle so that only the weight of the engine and transmission assembly is on dolly fixture.
(53) Remove right mount through bolt.
(54) Remove two left mount through bolts.

**CAUTION: IT MAY BE NECESSARY TO ADJUST THE ENGINE AND TRANSMISSION ASSEMBLY, WITH THE DOLLY FIXTURE ATTACHED, TO SUCCESSFULLY CLEAR THE ENGINE COMPARTMENT.**

(55) While watching for obstructions, slowly raise the vehicle until the engine and transmission assembly clear the engine compartment.

## INSTALLATION

### ENGINE COVER

(1) Align engine cover with mounting studs (Fig. 2).
(2) Firmly press cover onto mounting studs (Fig. 2).
(3) Install retaining nuts at rear of engine cover (Fig. 2).

### ENGINE

**WARNING: SAFETY STRAPS MUST BE USED TO SECURE ENGINE TO THE DOLLY FIXTURE.**

(1) Seat engine onto fixture support posts then install, tighten and lock safety straps around engine, securing it to the cradle.
(2) Position the engine and transmission assemblies below vehicle engine compartment.

**CAUTION: IT MAY BE NECESSARY TO ADJUST THE ENGINE AND TRANSMISSION ASSEMBLY, WITH THE DOLLY FIXTURE ATTACHED, TO SUCCESSFULLY CLEAR THE ENGINE COMPARTMENT.**

(3) While watching for obstructions, slowly lower the vehicle until the engine and transmission assembly clearly fit the engine compartment.
(4) Install two left mount through bolts.(Refer to 9 - ENGINE/ENGINE MOUNTING/LEFT MOUNT - INSTALLATION).
(5) Install right mount through bolt (Refer to 9 - ENGINE/ENGINE MOUNTING/RIGHT MOUNT - INSTALLATION).

ENGINE - 2.2L DIESEL (Continued)

(6) Carefully raise the vehicle enough to clear the cradle and support post.
(7) Install charge air cooler pipe.
(8) Install pencil strut and lower torque strut (Refer to 9 - ENGINE/ENGINE MOUNTING/ TORQUE STRUT - INSTALLATION).
(9) Install exhaust manifold downpipe.
(10) Connect power steering pressure hose at steering gear.
(11) Connect oil pressure switch electrical connector.

**NOTE: When installing tripod joint, DO NOT let spline or snap ring drag across transaxle oil seal lip.**

(12) Pull outward on the right steering knuckle and position the right half shaft tripod joint to the transaxle.
(13) Engage right half shaft tripod joint to output shaft.
(14) Connect steering knuckle to strut.
(15) Install two fasteners retaining strut to knuckle.
(16) Perform steps 13 through 16 to install left side tripod joint.
(17) Install front wheels.
(18) Remove cradle assembly from beneath vehicle and lower vehicle.
(19) Connect swirl actuator line at engine.
(20) Install two fasteners for the upper torque strut.
(21) Install ground strap.
(22) Connect suction line to A/C compressor (Refer to 24 - HEATING & AIR CONDITIONING/PLUMBING/A/C COMPRESSOR - INSTALLATION). (408)
(23) Connect vacuum hose at turbocharger.
(24) Connect power steering fluid resevoir supply hose.
(25) Connect coolant recovery hose to recovery container.
(26) Connect coolant recovery hose to engine.
(27) Connect power brake booster vacuum hose to engine.
(28) Connect heater hoses to heater core (Refer to 24 - HEATING & AIR CONDITIONING/PLUMBING/ HEATER INLET HOSE - INSTALLATION). (400)
(29) Connect fuel lines to fuel filter/water separator.
(30) Connect harness connector to fuel filter/fuel heater.
(31) Connect engine coolant heater harness connector.
(32) Connect three wiring harness connectors and two Engine Control Module harness connectors.
(33) Connect wiring at starter and alternator.
(34) Connect speed sensor harness connector to transaxle.
(35) Connect reverse light switch harness connector to transaxle.
(36) Connect clutch hydraulic line at transaxle.
(37) Install power distribution center bracket.
(38) Install lower engine compartmet silencer and accessory drive belt splash shield..
(39) Install coolant module assembly and connect radiator fan electrical connector (Refer to 7 - COOLING/ENGINE/RADIATOR - INSTALLATION).
(40) Install air cleaner inlet housing and air inlet hose.
(41) Install upper radiator closure pane (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - INSTALLATION).
(42) Install front grille assembly(Refer to 23 - BODY/EXTERIOR/GRILLE - INSTALLATION).
(43) Refill cooling system with the appropriate coolant mixture to the proper level (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).
(44) Be sure all oil and fluid levels are adjust to specification.
(45) Connect negative battery cable.

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

(46) Start engine and inspect for leaks
(47) Check all fluid levels in accordance with owners guide and adjust levels as necessary.
(48) Recharge air conditioning (Refer to 24 - HEATING & AIR CONDITIONING - STANDARD PROCEDURE).
(49) Install engine cover (Refer to 9 - ENGINE INSTALLATION - ENGINE COVER - INSTALLATION).

ENGINE - 2.2L DIESEL (Continued)

## SPECIFICATIONS

### TORQUE

*2.2L DIESEL*

| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Crankcase Ventilation | | | |
| Screw-Air Charge Distribution Pipe to Air Charge Distribution Panel | 11 | - | 97 |
| Cylinder Head | | | |
| 8m-Bolt- Cylinder Head to Timing Case Cover | 20 | 15 | - |
| Bolt-Front Cover to Cylinder Head | 14 | - | 124 |
| 12m-Bolt-Cylinder Head to Crankcase (3 stages, torque, torque angle, torque angle) | 60, 90°, 90° | 44, 90°, 90° | - |
| Crankcase, Timing Case Cover, End Cover | | | |
| Bolt-Crankshaft Bearing Cap to Crankcase (2 stages, torque, torque angle) | 55, 90° | 40, 90° | - |
| Bolt-End Cover to Crankcase | 9 | - | 80 |
| Bolt-Timing Case Cover to Crankcase | 20 | 15 | - |
| Plug-Coolant Drain to Crankcase | 30 | 22 | - |
| Oil Pan | | | |
| 6m-Bolt-Oil Pan to Crankcase | 9 | - | 80 |
| 8m-Bolt-Oil Pan to Crankcase | 20 | 15 | - |
| Bolt-Oil Pan to End Cover | 9 | - | 80 |
| Bolt-Oil Pan to Timing Case Cover | 9 | - | 80 |
| Bolt-Oil Pan to Transmission Bell Housing | 40 | 30 | - |
| Plug-Pil Pan to Oil Drain | 47 | 35 | - |
| Connecting Rod | | | |
| Bolt-Connecting Rod Cap to Connecting Rod (3 stage, 1&2 torque, 3 torque angle) | 5,25,90° | - | 44,221, 90° |

ENGINE - 2.2L DIESEL (Continued)

| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Crankshaft | | | |
| Bolt-Crankshaft Bearing Cap (2 stage, 1 torque, 2 torque angle | 55,90° | 40.5, 90° | - |
| Flywheel, Driven Plate, Vibration Damper, Starter Ring Gear | | | |
| 8.8m-Bolt-Central Bolt of Vibration Damper (2 stage, 1 torque, 2 torque angle) | 200,90° | 147.5, 90° | - |
| 10.9m-Bolt-Central Bolt of Vibration Damper (2 stage, 1 torque, 2 torque angle) | 325,90° | 240, 90° | - |
| Bolt-Stretch Shank for Flywheel or 2 Mass Flywheel to Crankshaft (2 stage, 1 torque, 2 torque angle) | 45,90° | 33, 90° | |
| Turbo Charger | | | |
| Bolt-Oil Feed Line to Cylinder Head | 9/22 | - | 80-194 |
| Bolt-Oil Feed Line to Turbo Charger | 30 | 22 | - |
| Bolt-Turbo Charger Support | 30 | 22 | - |
| Bolt-Turbo Charger Support to Crankcase | 20 | - | 177 |
| Bolt-Oil Outlet Line to Turbo Charger | 9 | - | 80 |
| Connection-Flange of Exhaust Manifold to Turbo Charger | 30 | 22 | - |
| Connection-Turbo Charger to Front Catalytic Converter | 30 | 22 | - |
| Charge Air Pipe/Charge Air Cooling | | | |
| Bolt-Charge Air Distribution Pipe | 16 | - | 141 |
| Bolt-Inlet Port Shut Off Positioning Motor to Air Charge Distribution Pipe | 9 | - | 80 |
| Bolt-Support to Charge Air Distribution Pipe | 20 | - | 177 |
| Bolt-Support to Engine Bracket | 40 | 30 | - |
| Clamp-Charge Air Pipes/Hoses | 3 | - | 27 |

ENGINE - 2.2L DIESEL (Continued)

| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Belt Tensioning Device | | | |
| Bolt-Guide Pully to Coolant Pump | 35 | 26 | - |
| Bolt-Guide Pully to Timimg Case Cover | 35 | 26 | - |
| Bolt-V-Belt Tensioning Device to Tensioning Pully | 36 | 26.5 | - |
| Bolt-V-Belt Tensioning Device to Timing Case Cover | 30 | 22 | - |
| Exhaust Manifold | | | |
| Nut-Exhaust Manifold at Cylinder Head | 30 | 22 | - |
| Position Sensor | | | |
| Nut/Bolt-Camshaft Position Sensor to Cylinder Head Cover | 11 | - | 97 |
| Nut/Bolt-Crankshaft Position Sensor to Engine Block | 8 | - | 70 |
| Pre-Glow System | | | |
| Cylinder Head to Glow Plug | 12 | - | 106 |
| Starter | | | |
| Bolt-Starter to Crankcase | 42 | 31 | - |
| Nut-Connection of Circuit 30 | 14 | - | 124 |
| Nut-Connection of Circuit 50 | 6 | - | 53 |
| Alternator | | | |
| Bolt-Generator to Timing Case Cover | 20 | 15 | - |
| Bolt-Generator to Cooler Housing | 6 | - | 53 |
| Bolt-Cooler Housing of Generator to Crankcase | 20 | - | 177 |
| Nut-B+ Circuit to Generator | 13-18 | - | 115-159 |
| Nut-D+ Circuit to Generator | 5 | - | 44 |
| Nut-Collar to V-Belt Pully | 80 | 59 | - |
| Oil Pump | | | |
| Bolt-Oil Pump to Crankcase | 18 | - | 133 |
| Bolt-Oil Pipe to Crankshaft Bearing Cap | 8 | - | 70 |

ENGINE - 2.2L DIESEL (Continued)

| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Oil Filter | | | |
| Screw Cap to Oil Filter | 25 | 18.5 | - |
| Oil Cooling System | | | |
| Bolt-Oil-Water Heat Exchanger to Timing Cover Case | 15 | - | 133 |
| Oil Level Pressure | | | |
| Bolt-Dip Stick Guide Tube to Cylinder Head | 14 | - | 123 |
| Bolt-Oil Level Sensor to Oil Pan | 14 | - | 123 |
| Coolant Pre- Heater | | | |
| Coolant Pre-Heater in Engine Block | 35 | 26 | - |
| Engine Cooling General | | | |
| Bolt-Belt Pully to Coolant Pump | 8-35 | 6-26 | - |
| Bolt-Coolant Pump to Timing Case Cover 6m/8m | 14/20 | 10-15 | - |
| Bolt-Thremostat Housing to Cylinder Head | 9 | - | 80 |
| Coolant Drain Plug to Crankcase | 30 | 22 | - |
| Engine Suspension, Engine Mount, Engine Bracket | | | |
| Bolt-Engine Bracket to Crankcase (2 stage, torque, torque angle) | 20, 90° | 15, 90° | - |
| Bolt-Engine Mount to Engine Bracket | 55 | 40.5 | - |
| Bolt-Front Engine Mount to Front Axle Carrier | 35 | 26 | - |
| Bolt-Rear Engine Cross Member to Body | 40 | 30 | - |
| Bolt-Rear Engine Mount to Rear Engine Cross Member | 35 | 26 | - |
| Bolt/Nut- Rear Engine Mount to Transmission | 40 | 26 | - |
| Bolt-Shrowd to Engine Bracket | 10 | - | 88.5 |
| Nut-Front Engine Mount to Engine Bracket | 65 | 48 | - |
| Nut-Engine Mount to Vehicle Frame | 35 | 26 | - |

ENGINE - 2.2L DIESEL (Continued)

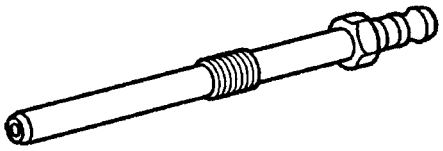
| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Fuel Filter | | | |
| Bolt-Clip to Fuel Filter | 8 | - | 70 |
| Bolt- Fuel Filter to Charge Air Distribution Pipe | 14 | - | 124 |
| Exhaust System | | | |
| Bolt- Catalytic Converter Bracket to Crankcase | 20 | - | 177 |
| Clamp-Connection Between Front Exhaust Pipe and Rear Exhaust System | 55 | 41 | - |
| Clip-Front Catalytic Converter to Engine Mount | 20 | - | 177 |
| Nut-Bracket to Tail Pipe | 55 | 40.5 | - |
| Nut-Exhaust Bracket to Threaded Plate of Center Exhaust Pipe | 20 | - | 177 |
| Support-Exhaust Bracket on Transmission | 20 | - | 177 |
| Refrigerant Compressor | | | |
| Bolt-Refrigerant Compressor to Timing Case Cover | 20 | - | 177 |
| Bolt-Refrigerant Compressor to Bracket | 20 | - | 177 |
| Bolt-Refrigerant Lines to Refrigerant Compressor | 20 | - | 177 |
| Timing Chain, Chain Tensioner | | | |
| Bolt-Camshaft Sprocket to Exhaust Camshaft | 18 | - | 159 |
| Bolt-Intermediate Gear of High Pressure Pump to Cylinder Head | 40 | 29.5 | - |
| Timing Chain Tensioner to Timing Case Cover | 80 | 59 | - |
| Camshaft | | | |
| Bolt-Camshaft Bearing Cap to Cylinder Head | 9 | - | 80 |
| Bolt-Driver to Inlet Camshaft | 50 | 37 | - |

ENGINE - 2.2L DIESEL (Continued)

| DESCRIPTION | N·m | Ft. Lbs. | In. Lbs. |
|---|---|---|---|
| Common Rail Diesel Injection | | | |
| Bolt-Bango Bolt of Leak Oil Line to Rail | 20 | - | 177 |
| Bolt-Bracket to High Pressure Pump | 9 | - | 80 |
| Bolt-High Pressure Pump to Cylinder Head | 14 | - | 124 |
| Bolt-Pre-delivery Pump to Top Cover of Cylinder Head | 9 | - | 80 |
| Bolt-Pressure Control Valve to Rail (2 stage, torque) | 3, 5 | - | 26, 44 |
| Bolt-Rail to Cylinder Head | 14 | - | 124 |
| Bolt-Shutoff Valve to Cylinder Head | 8 | - | 70 |
| Nut-Pressure Line to Rail/Injector (New,Reused) | 22/25 | 16/18.5 | - |
| Nut-Pressure Line to High Pressure Pump/Rail | 22 | 16 | - |
| Screw-Tensioning Claw to Injector (2 stage, 1 torque, 2 torque angle) | 7, 90° | - | 62, 90° |
| Rail- Pressure Sensor to Rail | 22 | 16 | - |
| Pressure Pipe Connection to Injector | 42 | 31 | - |
| Threaded Rail to Rail | 22 | 16 | - |
| Fuel Cooling System | | | |
| Bolt-Fuel Cooler to Charge Air Distribution Pipe | 14 | - | 124 |
| Heater Booster, Heater Unit | | | |
| Bolt- Temperature Controlled Cut Out to Heater Booster control Module | 12 | - | 106 |
| Nut-Threaded Stud to Electronic Heater Booster | 18 | - | 159 |

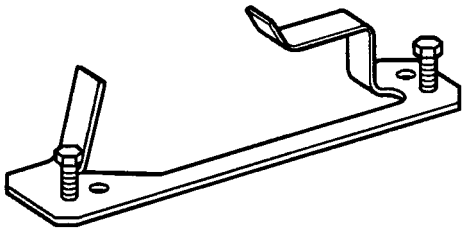
ENGINE - 2.2L DIESEL (Continued)

## SPECIAL TOOLS



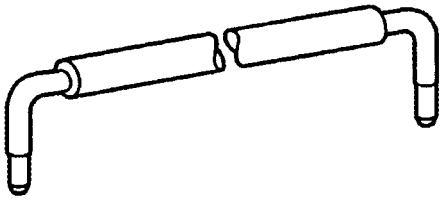
80e492e9

***#8927 COMPRESSION TESTER ADAPTER***



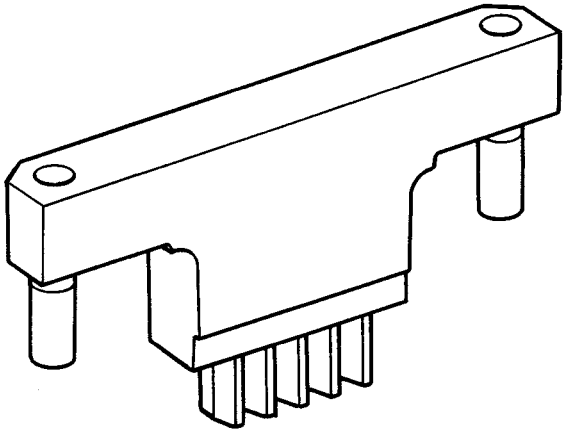
80e492c2

***#8931 TIMING CHAIN RETAINER***



80e492c7

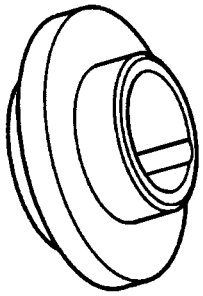
***#8929 CAMSHAFT LOCKING PIN***



80ea91fc

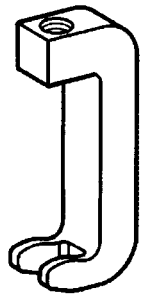
***#8933 CRANKSHAFT LOCK***

ENGINE - 2.2L DIESEL (Continued)



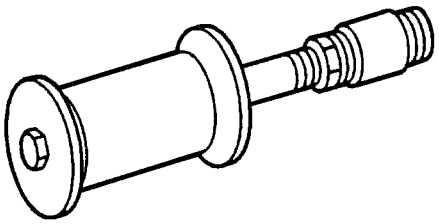
80e49185

***#8936 FRONT CRANKSHAFT SEAL INSTALLER***



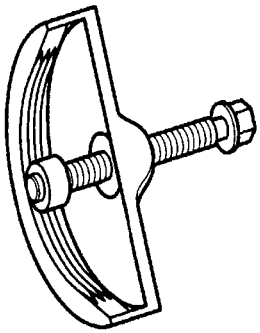
80e492ee

***#8938A EXTRACTION CLAW***



80e492f2

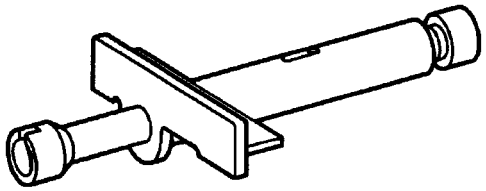
***#8937 SLIDE HAMMER***



80e492e4

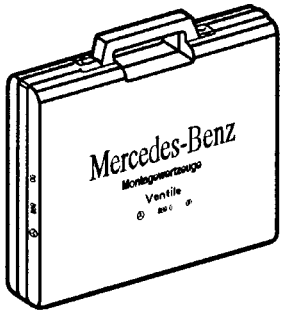
***#8940 VIBRATION DAMPER REMOVER***

ENGINE - 2.2L DIESEL (Continued)



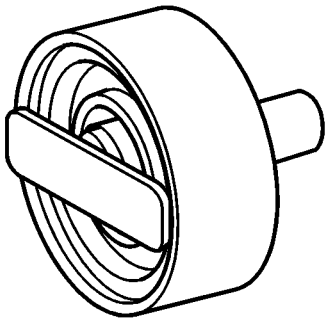
80e492e0

***#8942 OIL JET INSTALLER***



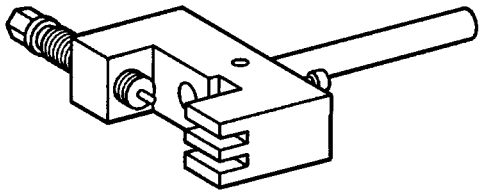

80e4922a

***#9307 VALVE SERVICE TOOLS***



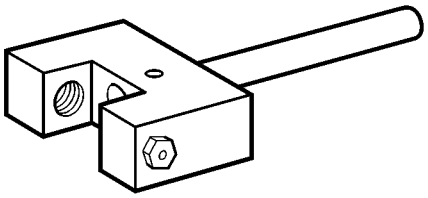
80e49274

***#8944 REAR MAIN SEAL INSTALLER***



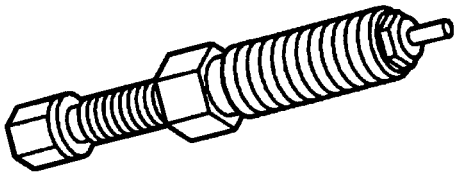
80e4922e

***#8947 RIVET OPENER***



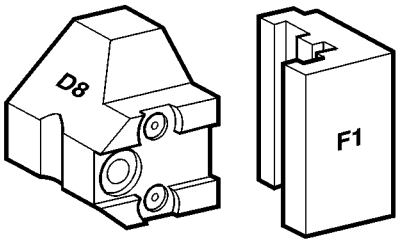
80e49289

***#8948 CHAIN SEPARATOR TOOL***



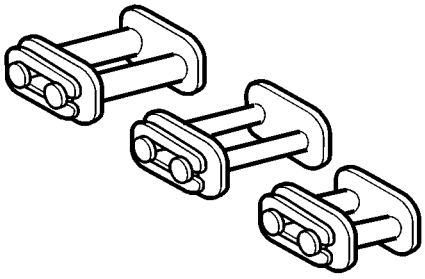
80e492b0

***#8950 PRESSING SCREW***



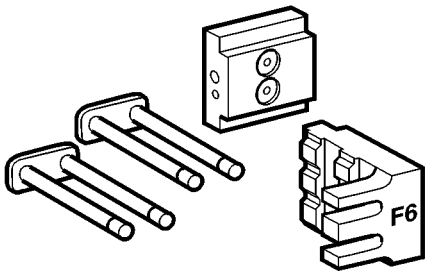

80e492bd

***#8949 THRUST PIECE***



80e492a7

***#8951 ASSEMBLY LINKS***




80e4929e

***#8952 ASSEMBLY INSERTS***

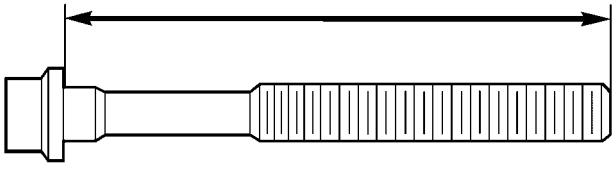
# CYLINDER HEAD

## STANDARD PROCEDURE

### CYLINDER HEAD BOLT INSPECTION

(1) Measure cylinder head bolts between points shown (Fig. 3).

| | | |
|---|---|---|
| Cylinder Head Bolts | Thread Diameter | 12 M |
| | Length When New | 102 mm |
| | Maximum Length | 104 mm |



80e214d0

***Fig. 3 Measuring Cylinder Head Bolts***

(2) If the cylinder head bolt length is greater than the maximum allowable measurement, replace the cylinder head bolts.

### MEASURE CYLINDER HEAD SURFACE

**NOTE: Only resurface cylinder head contact surface if porous or damaged. IT IS NOT necessary to rework minor variations in flatness in the longitudinal direction.**

(1) Disconnect negative battery cable.
(2) Remove cylinder head (Refer to 9 - ENGINE/ CYLINDER HEAD - REMOVAL).
(3) Remove valves.
(4) Inspect cylinder head contact surface for flatness, porous and damage.
(5) Using a straight edge, measure cylinder head and cylinder block flatness.
(6) Measure cylinder head height at point (1) indicated and retain reading (Fig. 4).

**NOTE: The camshaft housing Must Not be machined. Basic bore of the camshaft bearings will be altered.**

(7) Machine cylinder head contact surface, if necessary.
(8) Measure cylinder head height (1) at point indicated, record stock removal (Fig. 4).
(9) Measure valve setback at points (2) indicated (Fig. 4).

**NOTE: If measurement is less than dimension “2” no further correct valve clearance compensation is possible; replace valve seat ring or cylinder head if measurement is greater than specification.**

*CYLINDER HEAD SPECIFICATIONS*

| Description | Specification |
|---|---|
| Height of Cylinder Head (1), With Out Camshaft Housing | 126.85mm to 127.15mm |
| Valve Set Back (2) With New Valves and New Valve Seat Rings | Exhaust Valve: 1.0mm - 1.4mm<br><br>Intake Valve: 1.1mm - 1.5mm |

CYLINDER HEAD (Continued)

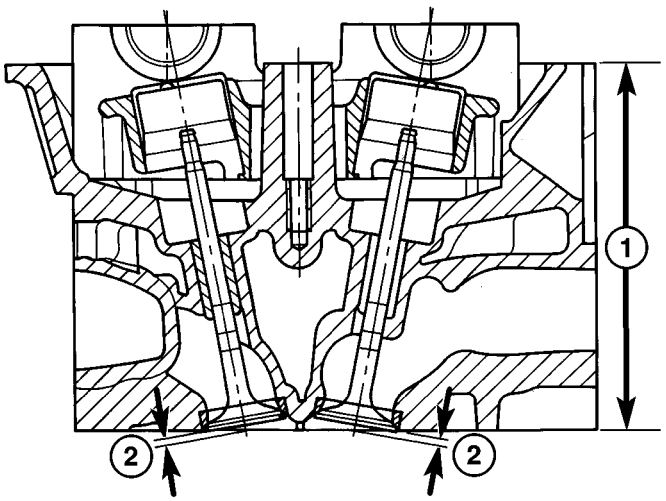



***Fig. 4 Cylinder Head Measurments***

1 - CYLINDER HEAD HEIGHT
2 - VALVE SETBACK

## REMOVAL

### CYLINDER HEAD

(1) Disconnect negative battery cable located under passenger seat (Fig. 5).

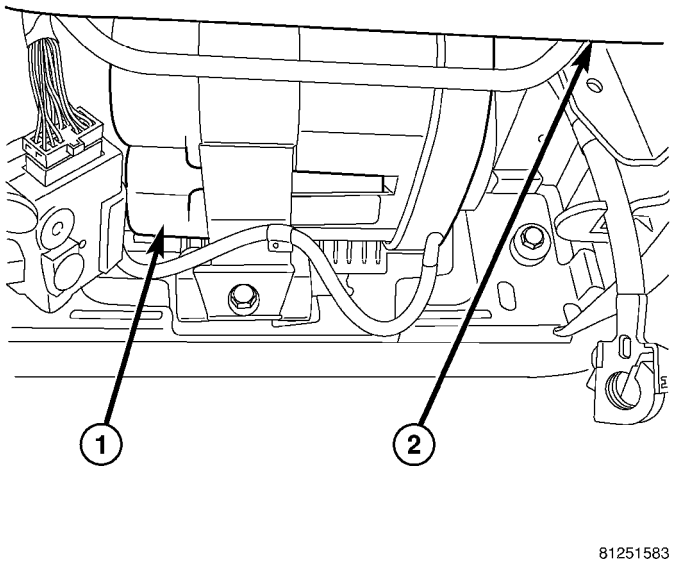



***Fig. 5 Battery Location***

1 - BATTERY
2 - PASSENGER SEAT

(2) Raise and support vehicle.

(3) Remove engine compartment lower silencer and drive belt splash shield (Fig. 6).

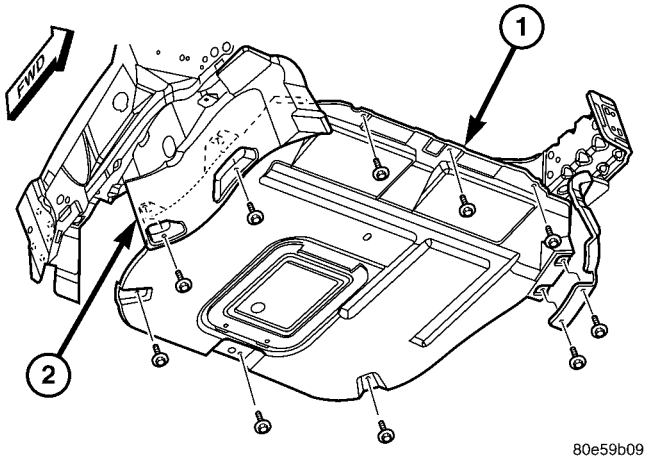



***Fig. 6 Engine Compartment Lower Silencer***

1 - ENGINE COMPARTMENT SILENCER
2 - ACCESSORY DRIVE BELT SPLASH SHIELD

**WARNING: RISK OF INJURY TO SKIN AND EYES FROM SCALDING COOLANT. DO NOT OPEN COOLING SYSTEM UNLESS TEMPERATURE IS BELOW 90°C (194°F). OPEN CAP SLOWLY TO RELEASE PRESSURE. STORE COOLANT IN APPROVED CONTAINER ONLY. WEAR PROTECTIVE GLOVES, CLOTHING AND EYE WEAR.**

(4) Drain cooling system (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).

(5) Disconnect exhaust pipe from turbocharger downpipe.

(6) Remove exhaust manifold support bracket (Fig. 7).

(7) Remove turbocharger support bracket (Fig. 7).

(8) Disconnect charge air cooler pipe from turbocharger.

(9) Disconnect oil return line from turbocharger.

(10) Remove starter and position out of the way.

(11) Remove accessory drive belt.

(12) Lower vehicle.

(13) Remove front grille assembly (Refer to 23 - BODY/EXTERIOR/GRILLE - REMOVAL).

(14) Remove radiator closure panel (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - REMOVAL).

(15) Disconnect upper radiator hose from thermostat housing.

(16) Pull cooling module forward to gain access to the intake manifold inlet hose. Disconnect inlet hose at manifold (Fig. 8).

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

CYLINDER HEAD (Continued)

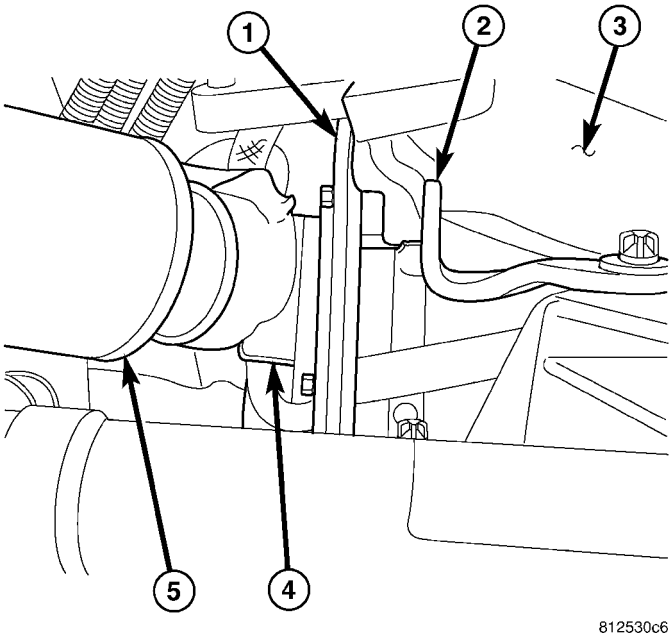



***Fig. 7 Turbo Support Bracket***

1 - TURBO SUPPORT BRACKET
2 - EXHAUST MANIFOLD SUPPORT BRACKET
3 - EXHAUST MANIFOLD
4 - TURBOCHARGER
5 - TURBO OUTLET PIPE

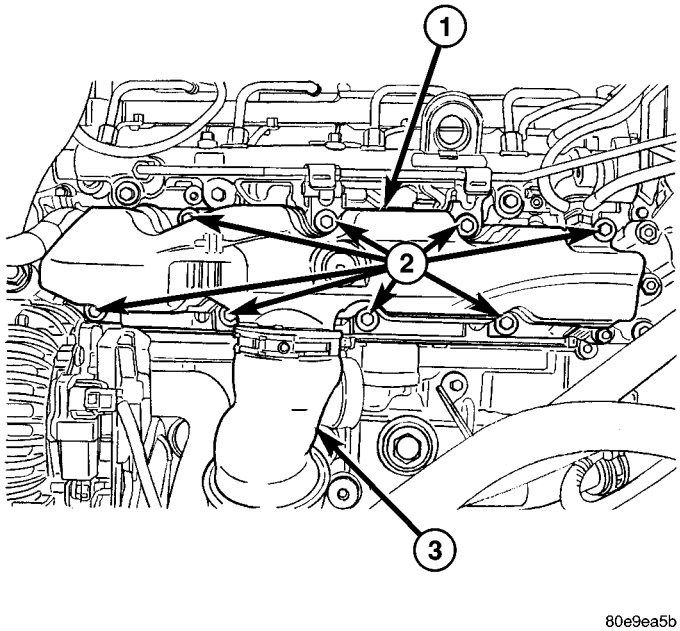



***Fig. 8 IntakeManifold***

1 - INTAKE MANIFOLD
2 - INTAKE MANIFOLD RETAINING BOLTS
3 - INTAKE INLET HOSE

(18) Remove air cleaner housing and turbocharger inlet hose (Fig. 9)(Refer to 9 - ENGINE/AIR INTAKE SYSTEM/AIR CLEANER HOUSING - REMOVAL).

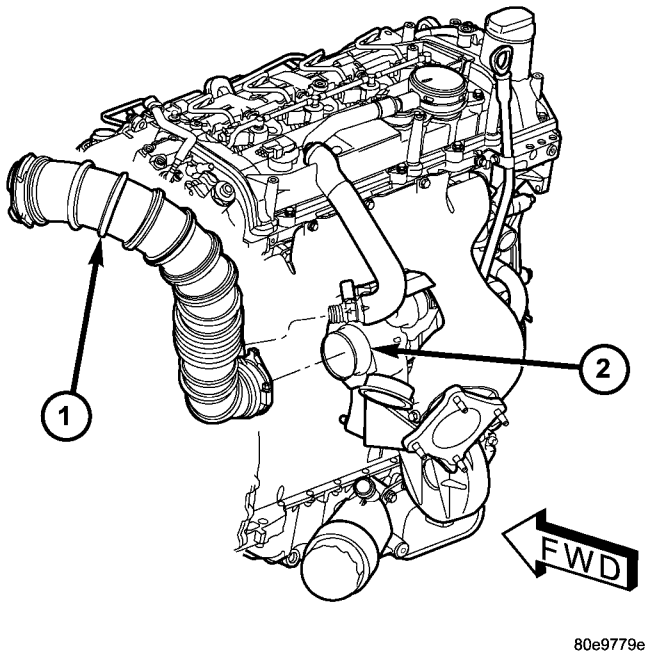



***Fig. 9 Turbocharger Inlet Hose***

1 - TURBOCHARGER INLET HOSE
2 - TURBOCHARGER

(19) Remove coolant recovery pressure container-.(Refer to 7 - COOLING/ENGINE/COOLANT RECOVERY PRESS CONTAINER - REMOVAL)

(20) Disconnect vacuum hose at turbocharger waste gate actuator.

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

(21) Disconnect fuel injector, glow plug, and camshaft position sensor electrical connectors

(22) Remove fuel high pressure lines, return lines, injectors, and fuel rail(Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - REMOVAL).

(23) Reposition wiring harness out of way.

(24) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

(25) Position piston of cylinder #1 to ignition TDC.

CYLINDER HEAD (Continued)

(26) Install special tool 8933, crankshaft lock, into block (Fig. 10).

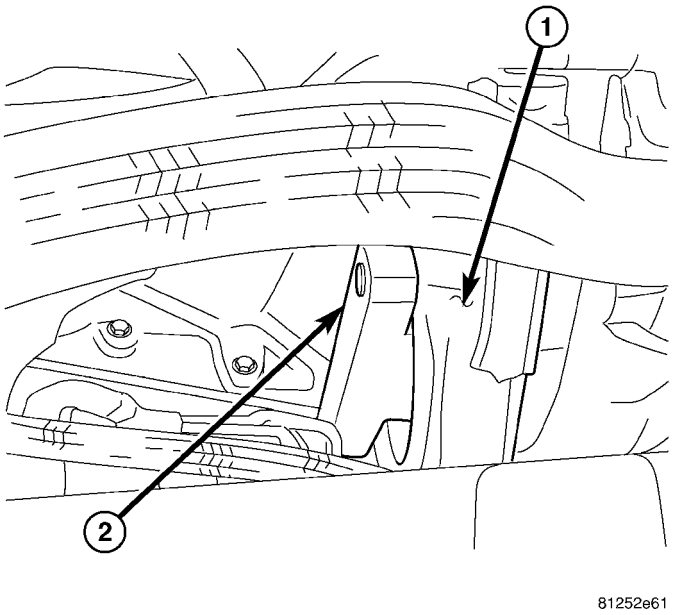



***Fig. 10 Special Tool #8933***

1 - ENGINE BLOCK
2 - SPECIAL TOOL #8933

(27) Install special tool 8929, camshaft locking pin, into cylinder head (Fig. 11).

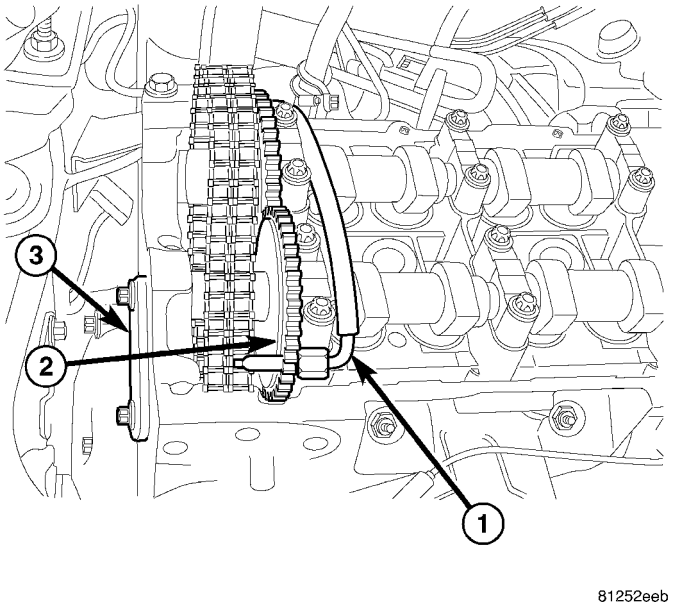



***Fig. 11 Special Tool #8929***

1 - SPECIAL TOOL #8929
2 - INTAKE CAM SPROCKET
3 - INTERMEDIATE GEAR COVER

(28) Remove right upper engine mount.
(29) Remove right engine mount bracket from cylinder head.
(30) Mark timing chain and sprockets with paint.
(31) Remove timing chain tensioner(Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).
(32) Remove cylinder head front cover(Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).
(33) Remove top guide rail (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).
(34) Remove high pressure pump (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL INJECTION PUMP - REMOVAL).
(35) Remove vacuum pump (Refer to 9 - ENGINE/ENGINE BLOCK/INTERNAL VACUUM PUMP - REMOVAL).
(36) Remove camshafts(Refer to 9 - ENGINE/CYLINDER HEAD/CAMSHAFT(S) - REMOVAL).
(37) Remove intermediate gearÜRefer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).
(38) Unbolt oil dip stick tube, ground, and electrical connectors from cylinder head.
(39) Disconnect EGR valve to mixing chamber pipe at EGR valve (Refer to 25 - EMISSIONS CONTROL/EXHAUST GAS RECIRCULATION/VALVE - REMOVAL) .
(40) Remove upper timing case to cylinder head bolts.

**NOTE: Loosen cylinder head bolts in the reverse order of the tightening sequence (Fig. 14).**

(41) Remove cylinder head bolts and inspect (Refer to 9 - ENGINE/CYLINDER HEAD - STANDARD PROCEDURE).
(42) Remove cylinder head assembly from engine.
(43) Disassemble cylinder head assembly as necessary for service.

## CYLINDER HEAD FRONT COVER

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE - REMOVAL).
(3) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD COVER(S) - REMOVAL).
(4) Remove timing chain tensioner (Refer to 9 - ENGINE/TIMING CHAIN TENSIONER - REMOVAL).
(5) Remove bolts attaching front cover.

**NOTE: Lower portion of front cover is sealed with RTV sealant. Carefully tug at front cover until it loosens from cylinder head.**

CYLINDER HEAD (Continued)

(6) Raise locking pawl of top guide rail and remove cylinder head front cover (Fig. 12).

**NOTE: Dowel pins are use as a guide during assembly and must remain in the proper position to assure a good sealing surface.**

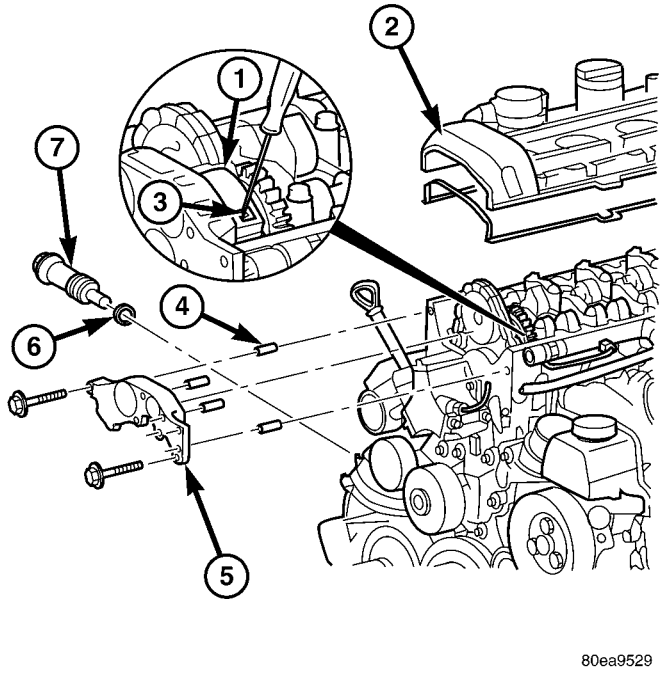



*Fig. 12 Cylinder Head Front Cover - Typical*

1 - TOP GUIDE RAIL
2 - CYLINDER HEAD COVER
3 - LOCKING PAWL
4 - DOWEL PIN
5 - CYLINDER HEAD FRONT COVER
6 - SEAL
7 - TIMING CHAIN TENSIONER

## CYLINDER HEAD GUIDE RAIL

(1) Disconnect negative battery cable.

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

**CAUTION: Rotate engine at crankshaft only. DO NOT rotate the engine with the bolt of the camshaft sprocket. DO NOT rotate the engine back.**

**NOTE: Markings on the camshaft and camshaft bearing cap must be aligned.**

(3) Remove cylinder head cover. (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

(4) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).

(5) Carefully raise locking pawl of top slide rail and remove cylinder head front cover (Fig. 13)(Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

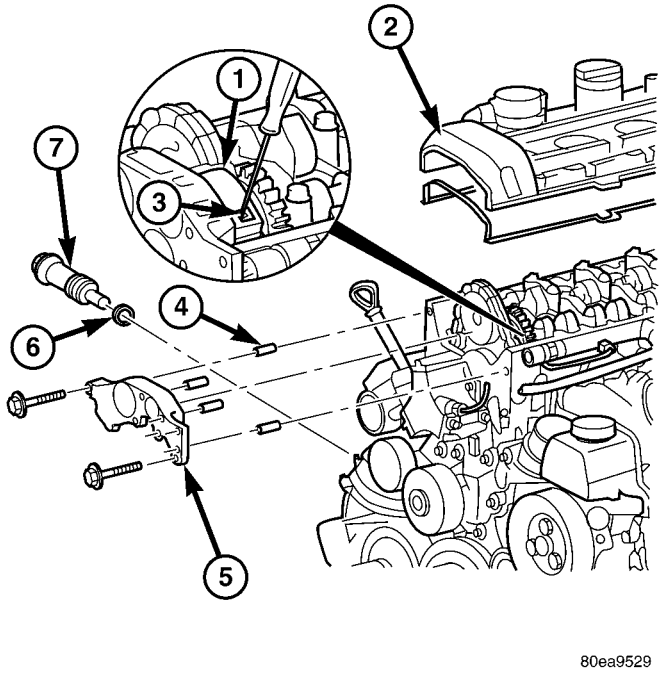



*Fig. 13 Cylinder Head Front Cover - Typical*

1 - TOP GUIDE RAIL
2 - CYLINDER HEAD COVER
3 - LOCKING PAWL
4 - DOWEL PIN
5 - CYLINDER HEAD FRONT COVER
6 - SEAL
7 - TIMING CHAIN TENSIONER

(6) Insert a locking pin through 1st camshaft bearing cap into the hole in the inlet camshaft sprocket.

(7) Counter hold the camshaft with an open end wrench to avoid damage and unbolt driver of inlet camshaft sprocket.

(8) Remove top guide rail.

# INSTALLATION

## CYLINDER HEAD

**WARNING: NO FIRE, OPEN FLAMES OR SMOKING. SERVICE VEHICLES IN WELL VENTILATED AREAS. RISK OF POISONING FROM INHALING OR SWALLOWING FUEL. RISK OF INJURY FROM SKIN AND EYE CONTACT WITH FUEL. WEAR PROTECTIVE CLOTHING.**

CYLINDER HEAD (Continued)

**NOTE: Thoroughly clean all mating surfaces with appropriate solvents and blow out bolt holes, to assure that no grease or oil is present during reassembly.**

**NOTE: If piston or connecting rods have been replaced, measure piston projection.**

**NOTE: Check facing cylinder head contact surface.**

(1) Position the cylinder head and gasket properly on engine using the dowel pins as guide.

**NOTE: Inspect all cylinder head bolts for defects and stretching before installation (Refer to 9 - ENGINE/CYLINDER HEAD - STANDARD PROCEDURE).**

(2) Reassemble cylinder head assembly as necessary.

(3) Install cylinder head assembly on engine block.

## CYLINDER HEAD BOLT TORQUE SEQUENCE

**The M12 cylinder head bolts must be torqued in 3 stages.**

(1) Install M12 cylinder head bolts finger tight.

(2) Torque bolts in numeric order starting with number 1 to 60 N·m (44 lbs.in.) (Fig. 14).

(3) Install M8 timing chain cover to cylinder head bolts (1A) (Fig. 14). Tighten to 20N·m (177 lbs.in.).

(4) Tighten M12 cylinder head bolts in numeric order starting with number 1 an additional 90° (Fig. 14).

(5) Tighten M12 cylinder head bolts in numeric order starting with number 1 an additional 90° (Fig. 14).

(4) Connect vacuum hose at turbocharger waste gate solenoid.

(5) Connect intake manifold inlet tube at intake manifold.

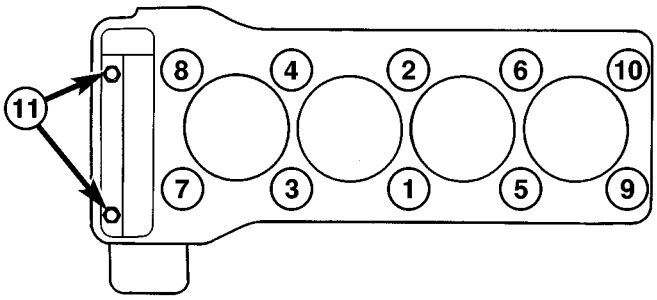
(6) Connect EGR valve to mixing chamber pipe at EGR valve (Refer to 25 - EMISSIONS CONTROL/ EXHAUST GAS RECIRCULATION/VALVE - INSTALLATION) .

(7) Connect oil dip stick tube. Tighten to 14 N·m (124 lbs. in.).

(8) Install intermediate timing chain gear (Refer to 9 - ENGINE/TIMING CHAIN INSTALLATION/INTERMEDIATE GEAR - INSTALLATION).

(9) Install camshafts (Refer to 9 - ENGINE/CAMSHAFT(S) - INSTALLATION).

(10) Install vacuum pump (Refer to 9 - ENGINE/ ENGINE BLOCK/INTERNAL VACUUM PUMP - INSTALLATION).




80ea9349

*Fig. 14 Cylinder Head Bolt Torque Sequence*

(11) Install fuel injection pump (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL INJECTION PUMP - INSTALLATION).

(12) Install cylinder head front cover and top guide rail (Refer to 9 - ENGINE/CYLINDER HEAD COVER- INSTALLATION).

(13) Install timing chain tensioner with new gasket. (Refer to 9 - ENGINE/TIMING CHAIN TENSIONER - INSTALLATION) Tighten to 80N·m (59 lbs.ft.).

(14) Remove special tool 8929, camshaft locking pin.

(15) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD COVER(S) - INSTALLATION).

(16) Reposition engine electrical harness and connect the fuel injector, glow plug, camshaft position sensor, and coolant tempertaure electrical connectors.

(17) Install fuel high pressure pipes and injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/ FUEL INJECTOR - INSTALLATION).

(18) Raise vehicle on hoist.

(19) Install turbocharger support bracket. Tighten bolts to 30N·m (22 lbs.ft.).

(20) Install oil return flow line at turbocharger.

(21) Remove special tool 8933, crankshaft lock.

(22) Install starter.

(23) Install charge air distribution pipe (Refer to 11 - EXHAUST SYSTEM/TURBOCHARGER SYSTEM - INSTALLATION).

(24) Install engine compartment lower silencer and accessory drive belt splash shield.

(25) Lower vehicle.

(26) Install air cleaner housing and turbocharger air intake tube.

CYLINDER HEAD (Continued)

(27) Install coolant recovery pressure container (Refer to 7 - COOLING/ENGINE/COOLANT RECOVERY PRESS CONTAINER - INSTALLATION).

(28) Connect upper radiator hose to thermostat housing.

(29) Install radiator closure panel (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - INSTALLATION).

(30) Install front grille assembly (Refer to 23 - BODY/EXTERIOR/GRILLE - INSTALLATION).

(31) Refill cooling system with proper coolant mixture to proper level (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).

(32) Connect negative battery cable.

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

(33) Start engine and inspect for leaks.

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

## CYLINDER HEAD FRONT COVER

**NOTE: Thoroughly clean all mating surfaces with appropriate solvents to assure that no grease or oil is present during reassembly.**

**NOTE: Dowel pins are used as a guide during assembly and must remain in the proper position to assure a good sealing surface.**

(1) Apply sealant to the marked surfaces with a bead thickness of 1.5 ± 0.5 mm (Fig. 15).

**NOTE: Install front cover of cylinder head within 10 minutes after applying sealant. Do not spread sealing bead.**

(2) Raise locking pawl of top guide rail and guide front cover onto guide pins.

(3) Install bolts attaching front cover (Fig. 12) Tighten bolts to 14N·m (124 lbs. in.).

**NOTE: Timing chain tensioner must be installed with a new gasket.**

(4) Install timing chain tensioner (Refer to 9 - ENGINE/TIMING CHAIN TENSIONER - INSTALLATION).

(5) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

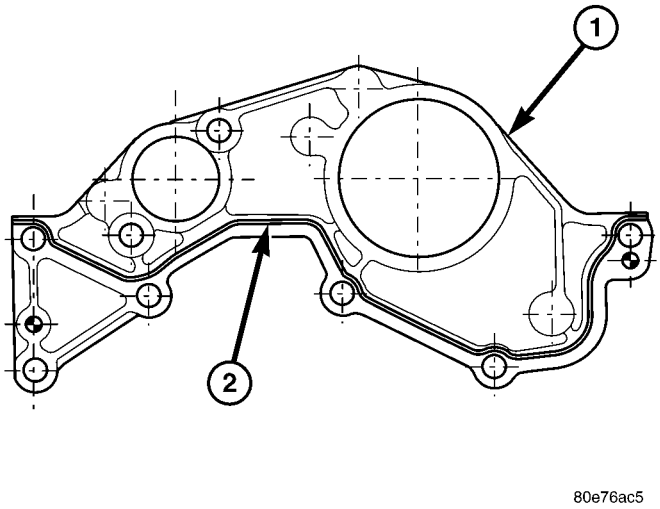



***Fig. 15 Cylinder Head Cover Sealing Surface***

1 - CYLINDER HEAD FRONT COVER
2 - SEALANT BEAD

(6) Start the engine and inspect for leaks.

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

## CYLINDER HEAD GUIDE RAIL

(1) Carefully position the top guide rail onto the guide pins.

(2) Counter hold the camshaft with an open end wrench and install driver of inlet camshaft sprocket. Tight bolt to 50N·m (37 lbs. ft.).

(3) Carefully raise locking pawl of top guide rail and install front cover at cylinder head (Fig. 13)(Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).

(4) Install timing chain tensioner with new gasket (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).

(5) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).

(6) Reconnect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(7) Start engine and inspect for leaks.

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

# CYLINDER HEAD COVER

## REMOVAL

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Remove high pressure fuel lines to injectors (Fig. 16).

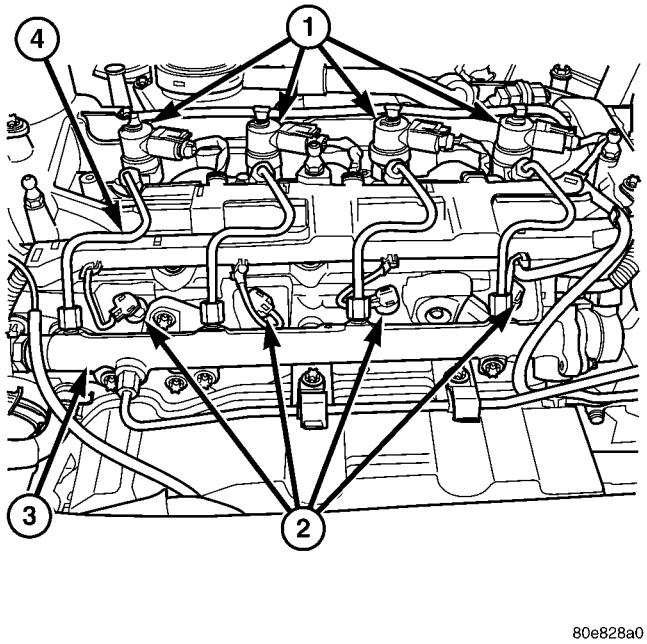



***Fig. 16 Fuel Injector and Glow Plug Locations***

1 - FUEL INJECTORS
2 - GLOW PLUGS
3 - FUEL RAIL
4 - HIGH PRESSURE FUEL LINE

(4) Disconnect fuel injector, camshaft position sensor, fuel pressor sensor, fuel pressure solenoid, and glow plug electrical connectors.
(5) Disconnect injector drain tubes at injectors.
(6) Disconnect fuel rail return line to pump at rail.
(7) Remove engine harness retaining bolts and reposition harness out of way.
(8) Remove fuel injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - REMOVAL).
(9) Detach hose from oil separator.
(10) Remove cylinder head cover retaining bolts and remove cover (Fig. 17).

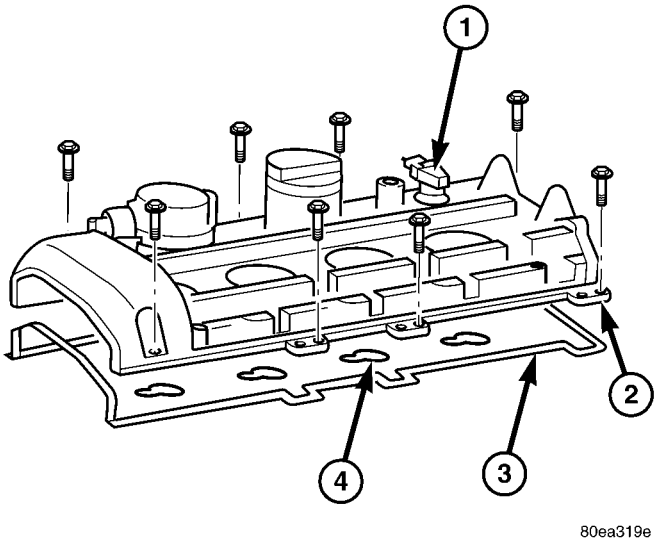



***Fig. 17 Cylinder Head Cover - Typical***

1 - CAMSHAFT POSITION (CMP) SENSOR
2 - CYLINDER HEAD COVER
3 - CYLINDER HEAD COVER GASKET
4 - INJECTOR BORE SEALS

## INSTALLATION

(1) Install new gasket and injector bore seals on cylinder head cover (Fig. 18).

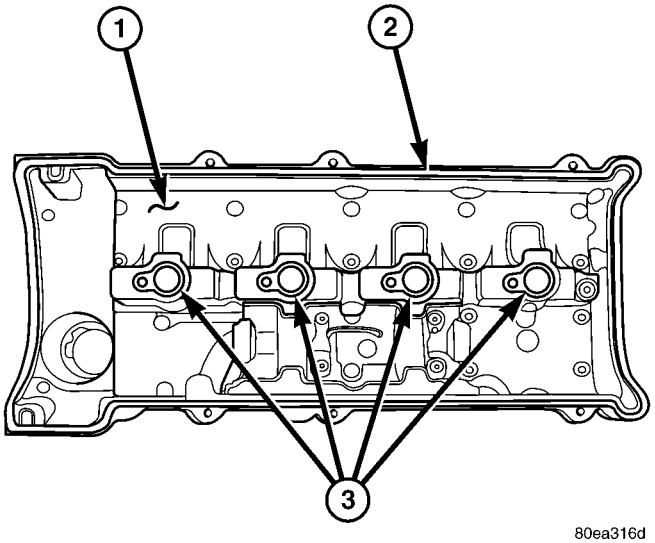



***Fig. 18 Cylinder Head Cover Gasket and Seal Location***

1 - CYLINDER HEAD COVER
2 - CYLINDER HEAD COVER GASKET
3 - INJECTOR BORE SEALS

**NOTE: Do not tighten cylinder head cover bolts until injectors are installed.**

CYLINDER HEAD COVER (Continued)

(2) Position cylinder head cover with new gasket and seals. Tighten bolts only finger tight.
(3) Install injectors into cylinder head (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - INSTALLATION).
(4) Torque cylinder head cover bolts to 9N·m (80 lbs. in.).
(5) Reroute engine harness and install retaining bolts.
(6) Install injector high pressure fuel lines.
(7) Torque injector retaining bolts to 7N·m (62 lbs. in.) + 90°.
(8) Connect fuel injector, camshaft position sensor, fuel pressure sensor, fuel pressure solenoid, and glow plug electrical connectors.
(9) Connect fuel drain tubes at injectors.
(10) Attach oil seperator hose.
(11) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH FAN. DO NOT PUT YOUR HANDS NEAR PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(12) Start engine and inspect for leaks.
(13) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

# VALVE SPRINGS

## REMOVAL

### VALVE SPRINGS

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Remove glow plugs (Refer to 8 - ELECTRICAL/IGNITION CONTROL/GLOW PLUG - REMOVAL).
(4) Remove injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - REMOVAL).
(5) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).
(6) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).
(7) Remove front cover at cylinder head (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).
(8) Remove top guide rail (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).
(9) Remove camshafts (Refer to 9 - ENGINE/CYLINDER HEAD/CAMSHAFT(S) - REMOVAL).

**NOTE: The timing chain must be held in up position so as not to jam during procedure.**

(10) Position piston of cylinder to be processed to DTC by rotating the crankshaft clockwise. **DO NOT crank engine. DO NOT rotate engine backward.**
(11) Install crankshaft lock, special tool #8933.
(12) Seal injector hole with connection piece and retain with orginal tensioning claw.
(13) Connect cylinder leak tester with adaptors and pressurize the cylinder to 5 bar (73 psi.).

**WARNING: Valve springs and retainers must be kept in order of the cylinder they were removed.**

**NOTE: Using tool, screw retaining fork into threaded edge of cylinder head and position thrust piece vertically at top of valve spring retainer.**

(14) Compress valve spring.
(15) Remove valve keepers.
(16) Remove top valve spring retainer and valve spring.
(17) Remove valve stem seals.
(18) Remove bottom valve spring retainer.

**NOTE: Inspect all cylinder head components for wear or damage.**

(19) Repeat procedure for each cylinder as necessary.

### VALVES

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Remove cylinder head (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

**WARNING: Suitably mark the valve and the position in the cylinder head before removal. Failure to do so will result in improperly seated valves and possible engine damage after reassembly.**

**NOTE: Using tool, screw retaining fork into threaded edge of cylinder head and position thrust piece vertically at top of valve spring retainer.**

(4) Using a suitable valve spring compressor, compress valve spring.
(5) Remove valve keepers.
(6) Remove top valve spring retainer and valve spring.
(7) Remove valve stem seals.
(8) Repeat steps 5 through 9 for each valve as necessary.

VALVE SPRINGS (Continued)

(9) Remove cylinder head from assembly board.

**WARNING: Valves, springs and retainers must be kept in order of the cylinder they were removed.**

(10) Remove valves.

## INSTALLATION

### VALVE SPRINGS

**NOTE: Inspect all valve springs and retainers for wear or damage. Replace as necessary.**

(1) Position piston of cylinder to be processed to TDC by rotating the crankshaft clockwise. **DO NOT crank engine or rotate engine counter clockwise.**
(2) Connect cylinder leak tester with adaptors and pressurize the cylinder to 5 bar (73 psi).
(3) Install lower valve spring retainer.
(4) Install valve stem seal.
(5) Install valve spring.
(6) Install valve spring retainer.

**NOTE: Using tool, screw retaining fork into threaded edge of cylinder head and position thrust piece vertically at the top of each valve spring retainer.**

**NOTE: Ensure that the valve keepers are seated properly.**

(7) Compress valve and install valve keepers.
(8) Repeat procedure for each cylinder as necessary.
(9) Remove special tooling from cylinder head.
(10) Position piston of #1 cylinder to ignition TDC.
(11) Install camshafts and check basic position (Refer to 9 - ENGINE/CYLINDER HEAD/CAMSHAFT(S) - INSTALLATION).
(12) Install top guide rail (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(13) Install front cover at cylinder head (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(14) Install timing chain tensioner with new gasket (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION)
(15) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).
(16) Install glow plugs (Refer to 8 - ELECTRICAL/IGNITION CONTROL/GLOW PLUG - INSTALLATION).

**WARNING: SERVICE VEHICLES IN A WELL VENTILATED AREA AND AVOID IGNITION SORCES. RISK OF INJURY TO SKIN AND EYES FROM FUEL JET FLOWING OUT.**

(17) Install injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - INSTALLATION).
(18) Reconnect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.**

(19) Start the engine and inspect for leaks.
(20) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

### VALVES

**WARNING: Valves must be kept in their original positions in cylinder head. Failure to do so will result in engine damage.**

**NOTE: Inspect all valves, springs and retainers for wear or damage. Replace as necessary.**

(1) Install valves in their original position in the cylinder head.
(2) Install lower valve spring retainer.
(3) Install valve stem seal.
(4) Install valve spring.
(5) Install valve spring retainer.

**NOTE: Using tool, screw retaining fork into threaded edge of cylinder head and position thrust piece vertically at the top of each valve spring retainer.**

**NOTE: Ensure that the valve keepers are seated properly.**

(6) Using a suitable valve spring compressor, compress valve spring and install valve keepers.
(7) Repeat steps 3 through 7 for each valve as necessary.
(8) Remove valve assembly from cylinder head.
(9) Install cylinder head on engine block (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(10) Install glow plugs (Refer to 8 - ELECTRICAL/IGNITION CONTROL/GLOW PLUG - INSTALLATION).
(11) Connect negative battery cable.

VALVE SPRINGS (Continued)

**WARNING: US EXTREME CAUTION WHEN THE ENGINE IS IN OPERATION. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.**

(12) Start engine and check for leaks.
(13) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

# CAMSHAFT(S)

## STANDARD PROCEDURE

### CHECKING CAMSHAFT POSITION

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).

**WARNING: NO FIRE, SPARKS, OR SMOKING. RISK OF POISONING FROM INHALING AND SWALLOWING FUEL AS WELL AS RISK OF INJURY TO EYES AND SKIN FROM CONTACT WITH FUEL. POUR FUEL ONLY INTO SUITABLE AND MARKED CONTAINERS. WEAR PROTECTIVE CLOTHING WHEN HANDLING FUEL.**

(3) Remove injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - REMOVAL).
(4) Clean injectors and recesses(Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - STANDARD PROCEDURE).
(5) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

**NOTE: Rotate engine at crankshaft only. DO NOT crank engine at the camshaft and DO NOT rotate the engine backward.**

(6) Position piston of cylinder #1 to ignition TDC.
(7) Insert the locking pin (special tool #8929) through first camshaft bearing cap into the hole in the left inlet camshaft sprocket (Fig. 19).

**NOTE: The two markings in the inlet camshaft sprockets must be positioned opposite and markings of camshaft and camshaft bearing cap must be aligned. If not, perform basic position of camshafts.**

(8) Remove locking pin from camshaft bearing cap hole.
(9) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).

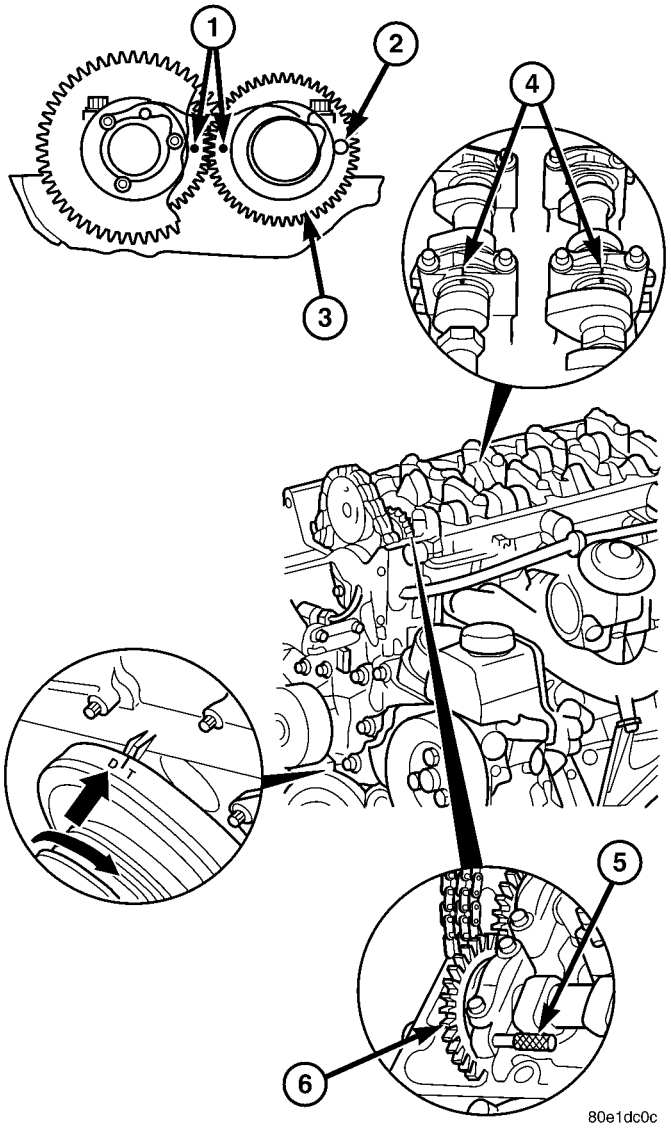



***Fig. 19 Checking Camshaft Position - Typical***

1 - CAMSHAFT SPROCKET ALIGNMENT DOTS
2 - CAMSHAFT LOCK POSITION
3 - INTAKE CAMSHAFT SPROCKET
4 - CAMSHAFT AND BEARING CAP ALIGNMENT MARKS
5 - CAMSHAFT LOCKING PIN (SPECIAL TOOL #8929)
6 - INTAKE CAMSHAFT SPROCKET

(10) Install injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - INSTALLATION).

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NO WEAR LOOSE CLOTHING.**

(11) Start the engine and inspect for leaks.

CAMSHAFT(S) (Continued)

## REMOVAL

(1) Disconnect negative battery cable located under the passenger seat.

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

**WARNING: NO FIRE, OPEN FLAMES OR SMOKING. RISK OF POISONING FROM INHALING OR SWALLOWING FUEL. RISK OF INJURY FROM SKIN AND EYE CONTACT WITH FUEL. WEAR PROTECTIVE CLOTHING. STORE FUEL ONLY IN SUITABLE AND APPROPRIATELY MARKED CONTAINERS.**

(3) Remove high pressure lines and injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/ FUEL INJECTOR - REMOVAL).

(4) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

(5) Position piston of cylinder #1 to ignition TDC (Fig. 20).

(6) Install special tool #8929, camshaft locking pin (Fig. 21).

(7) Remove starter and position out of the way.

(8) Install special tool #8933 crankshaft lock.

(9) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).

**NOTE: The lower portain of the cylinder head front cover is sealed with RTV sealant. Carefully tug front cover after bolt removal to loosen from cylinder head.**

(10) Remove cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

(11) Remove top side rail (Refer to 9 - ENGINE/ CYLINDER HEAD - REMOVAL).

**CAUTION: For all work in which the crankshaft should not rotate, secure camshaft gear to timing chain.**

(12) Mark camshaft sprocket relative to timing chain.

(13) Unbolt camshaft sprocket from exhaust camshaft.

**NOTE: Note the position of dowel pin for camshaft sprocket alignment during reassembly.**

(14) Remove camshaft sprocket.

**CAUTION: Camshaft bearing caps must remain in proper order and position.**

(15) Mark and remove camshaft bearing caps.

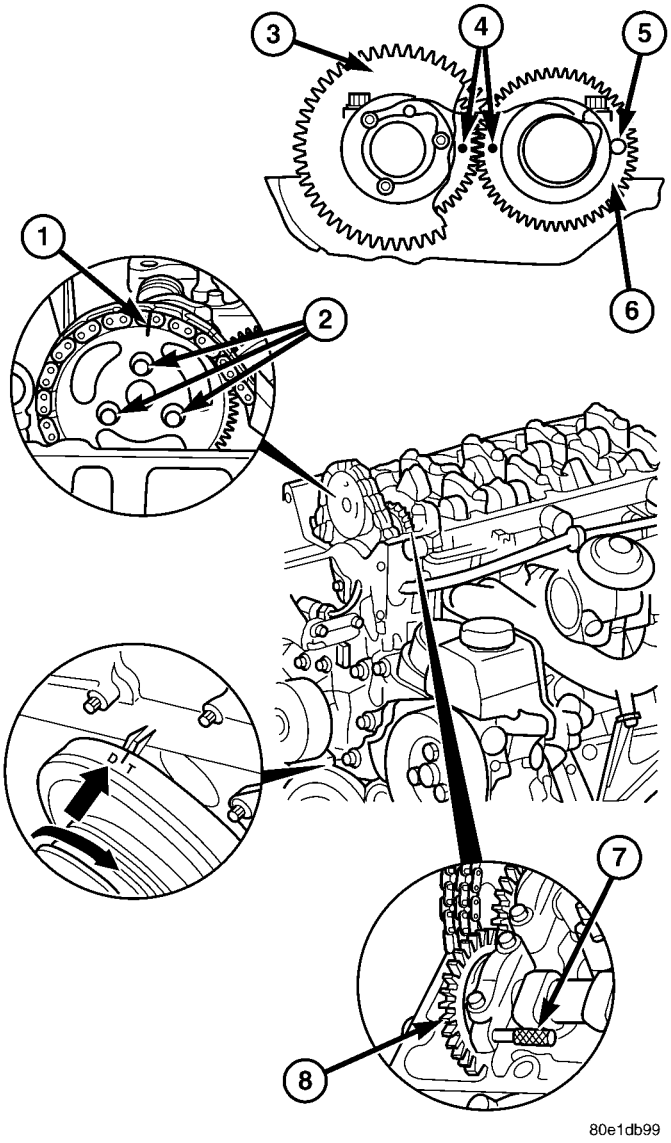



***Fig. 20 Camshaft Alignment - Typical***

1 - EXHAUST CAMSHAFT SPROCKET AND CHAIN MARKING
2 - EXHAUST CAMSHAFT SPROCKET BOLTS
3 - EXHAUST CAMSHAFT SPROCKET
4 - CAMSHAFT ALIGNMENT DOTS
5 - INTAKE CAMSHAFT LOCK POSITION
6 - INTAKE CAMSHAFT SPROCKET
7 - SPECIAL TOOL 8929
8 - INTAKE CAMSHAFT SPROCKET

(16) Remove the inlet and exhaust camshafts (Fig. 22).

## INSTALLATION

**CAUTION: The camshafts are sensitive to fracturing. Ensure they are installed free of stress.**

**CAUTION: Pay attention to assignment of camshafts. Camshaft code numbers are visible on the thrust collar of the axial bearing.**

CAMSHAFT(S) (Continued)

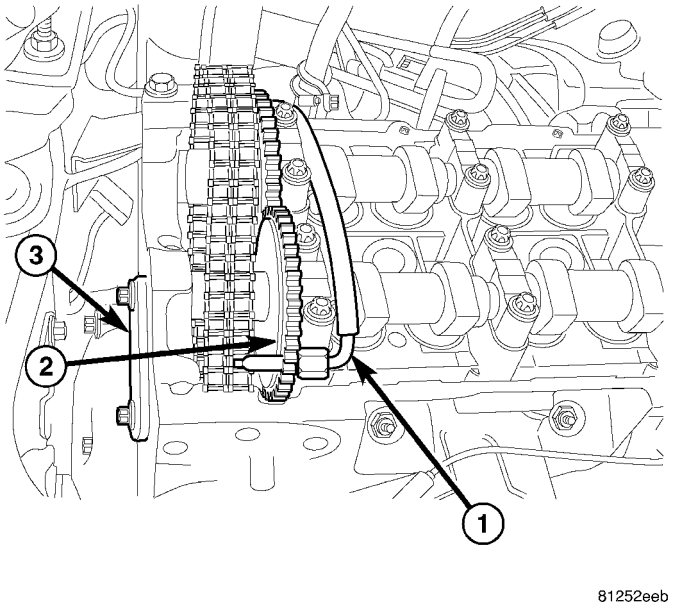



***Fig. 21 Special Tool 8929-Camshaft Locking Pin***

1 - SPECIAL TOOL 8929
2 - INTAKE CAMSHAFT SPROCKET
3 - ITERMEDIATE GEAR COVER

**CAUTION: Oil bucket tappets and camshaft bearing points. Inspect ease of operation of bucket tappets.**

(1) Install inlet and exhaust camshafts.

**CAUTION: Install camshafts so that the two holes in camshaft sprockets are positioned opposite and the markings of the camshaft and camshaft bearing cap are aligned.**

(2) Align inlet and exhaust camshafts at axial bearing (Refer to 9 - ENGINE/CYLINDER HEAD/ CAMSHAFT(S) - STANDARD PROCEDURE).

(3) Position piston of cylinder #1 to 30° TDC.

**NOTE: Pay attention to markings on camshaft bearing caps.**

(4) Install camshaft bearing caps in the proper order. Tighten bolts to 9N·m (80 lbs. in.).

**CAUTION: Do not rotate engine counter clockwise.**

(5) Position the piston of cylinder #1 to ignition TDC.

**NOTE: Pay attention to markings on camshaft bearing caps.**

(6) Install the bearing caps in reverse order at the same point. Tighten bearing cap bolts evenly in steps each of 1 turn.

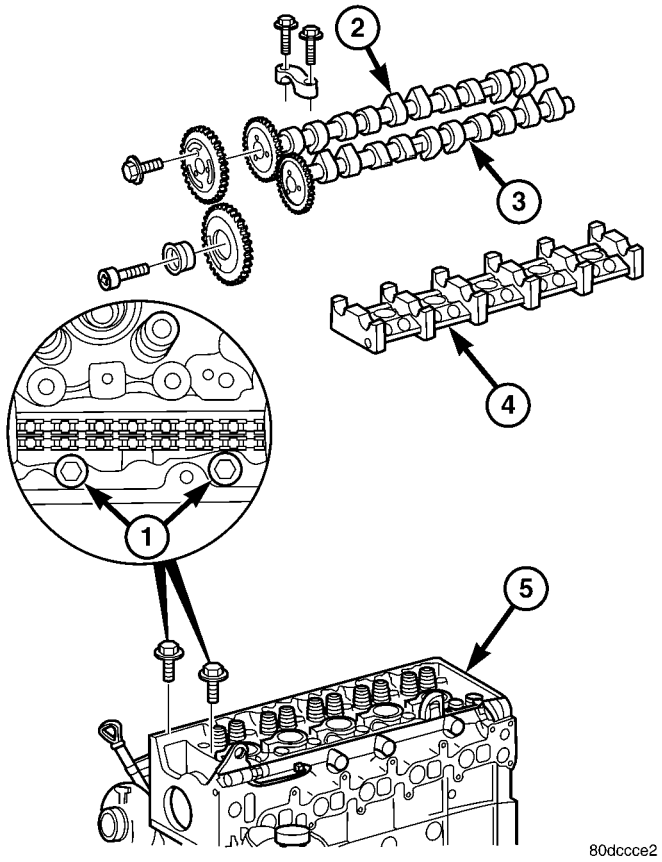



***Fig. 22 Camshafts and Housing Assembly - Typical***

1 - CYLINDER HEAD BOLTS
2 - EXHAUST CAMSHAFT
3 - INTAKE CAMSHAFT
4 - CAMSHAFT HOUSING
5 - CYLINDER HEAD

**NOTE: The piston of cylinder #1 must be positioned at ignition TDC when the inlet camshaft is locked.**

(7) Insert locking pin through the first camshaft bearing cap into the whole in the camshaft sprocket.

**NOTE: Do Not use old camshaft sprocket bolts.**

(8) Fit camshaft sprocket with timing chain fitted on, onto exhaust camshaft paying attention to position of dowel pin. Tighten bolt to 18N·m (159 lbs.in.).

(9) Install timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).

(10) Inspect/Set basic position of camshafts (Refer to 9 - ENGINE/CYLINDER HEAD/CAMSHAFT(S) - STANDARD PROCEDURE).

(11) Remove special tool #8933, crankshaft lock.

(12) Install starter.

(13) Remove special tool #8929, camshaft locking pin.

CAMSHAFT(S) (Continued)

(14) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).

**NOTE: Refer to the appropriate injector servicing procedures for cleaning of injectors and recesses.**

(15) Clean and install injectors (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - STANDARD PROCEDURE), (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - INSTALLATION).

(16) Reconnect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.**

(17) Start engine and inspect for leaks.

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

# ENGINE BLOCK

## STANDARD PROCEDURE

### REPLACING ENGINE CORE AND OIL GALLERY PLUGS

Using a blunt tool such as a drift and a hammer, strike the bottom edge of the cup plug. With the cup plug rotated, grasp firmly with pliers or other suitable tool and remove plug (Fig. 23).

**CAUTION: Do not drive cup plug into the casting as restricted cooling can result and cause serious engine problems.**

Thoroughly clean inside of cup plug hole in cylinder block or head. Be sure to remove old sealer. Lightly coat inside of cup plug hole with Mopar® Stud and Bearing Mount. Make certain the new plug is cleaned of all oil or grease. Using proper drive plug, drive plug into hole so that the sharp edge of the plug is at least 0.5 mm (0.020 in.) inside the lead-in chamfer.

It is not necessary to wait for curing of the sealant. The cooling system can be refilled and the vehicle placed in service immediately.

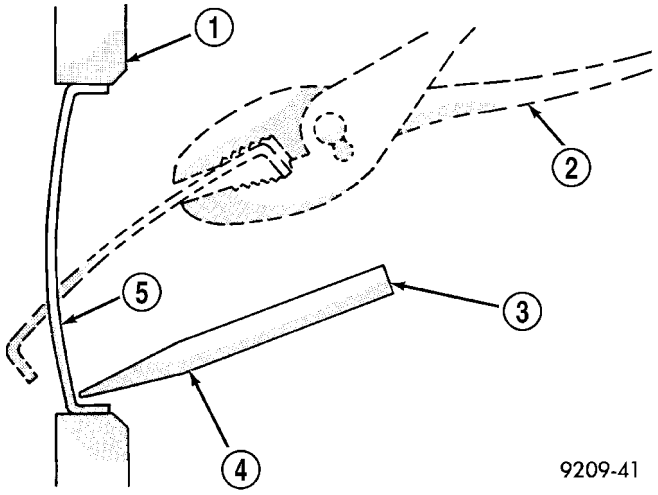



*Fig. 23 Core Hole Plug Removal*

1 - CYLINDER BLOCK
2 - REMOVE PLUG WITH PLIERS
3 - STRIKE HERE WITH HAMMER
4 - DRIFT PUNCH
5 - CUP PLUG

### MEASURING CYLINDER BORES

**NOTE: This must be done with engine completely disassembled.**

(1) Thoroughly clean all cylinder bores with appropriate cleaning solvent.

(2) Measure each cylinder at the three measuring points shown (Fig. 24).

(3) Using the three measurment point, measure cylinder in the longitudinal and in the transverse direction (Fig. 24).

(4) Use the measurment and table below to group cylinder bores:

| | |
|---|---|
| Standard size | 88.0 mm |
| Group code letter A | 88.000-88.006 mm |
| Group code letter X | 88.006-88.012 mm |
| Group code letter B | 88.012-88.018 mm |
| Wear limit in longitudinal in transverse direction | 0.020 mm |
| Permissible variation of cylinder shape (when new) | 0.000-0.014 mm |

ENGINE BLOCK (Continued)

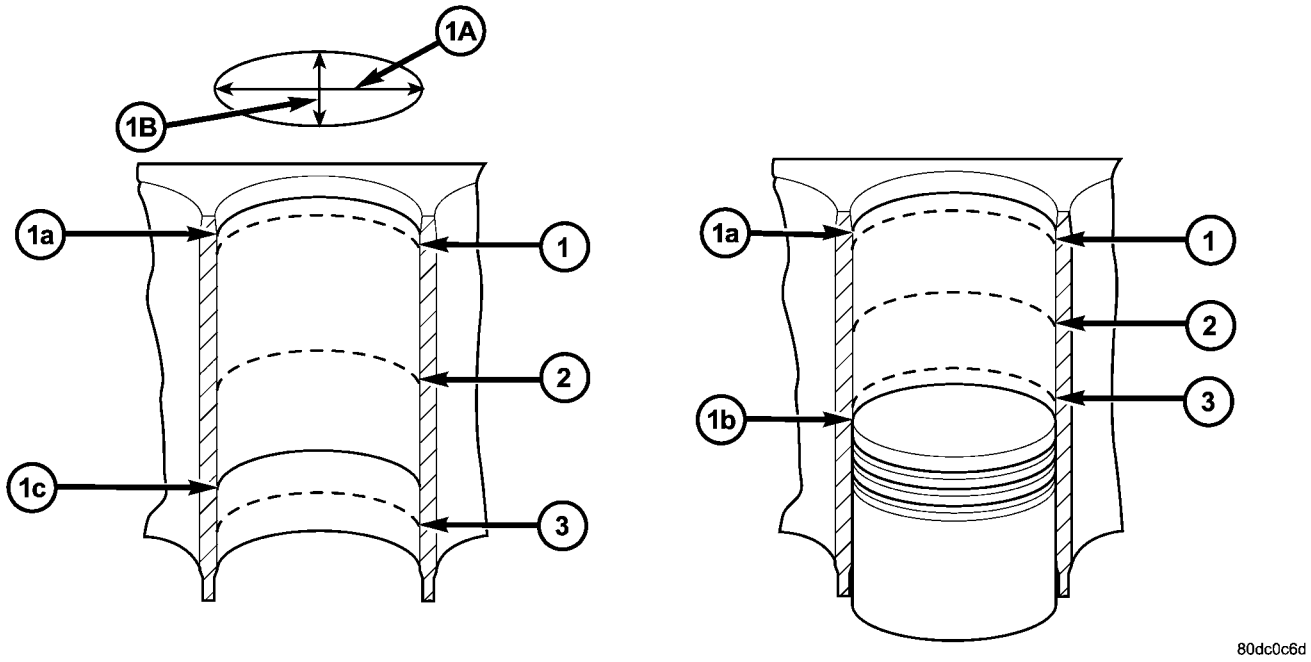



***Fig. 24 Measuring Cylinder Bores***

1 - MEASURING POINT OF CYLINDER BORE
2 - MEASURING POINT OF CYLINDER BORE
3 - MEASURING POINT OF CYLINDER BORE
1a - UPPER REVERSAL POINT OF #1 PISTON RING
1b - BOTTOM DEAD CENTER OF PISTON
1c - BOTTOM REVERSAL POINT OF OIL SCRAPER RING
1A - LONGITUDINAL DIRECTION
1B - TRANSVERSE DIRECTION

# CRANKSHAFT

## STANDARD PROCEDURE

### MEASURE CRANKSHAFT AND BLOCK JOURNALS

**NOTE: After any bearing damage occurred, remove all debris which is present in the main oil gallery, connecting rod bores, and in the crankshaft and oil galleries. Include removal of the inserting steel ball of the main oil gallery before cleaning.**

(1) Remove crankshaft (Refer to 9 - ENGINE/ENGINE BLOCK/CRANKSHAFT - REMOVAL).
(2) Clean all engine parts thoroughly.

**CAUTION: After bearing has damage has occurred, replace connecting rods which have suffered overheating because of bearing damage. The connecting rod must not have any cross scores and notches.**

(3) Inspect connecting rod. If damage is present, inspect crankshaft, replace as necessary.
(4) Inspect crankcase.
(5) Inspect standard size of crankshaft bearing shells.
(6) Inspect crankshaft bearing cap.
(7) Mount crankshaft radially.
(8) Inspect crankshaft bearing play.

**NOTE: Radial mounting of the main bearings of standard size crankshaft is possible by assigning the color-coded bearing shells.**

### ASSIGN CRANKSHAFT BEARING SHELLS

The oil pan rail of the cylinder block is marked with chisel punches indicating what bearing shell are used.
(9) Assign crankshaft bearing shells.
(10) Mount crankshaft axially.
(11) Inspect crankshaft bearing play.

### REMOVAL

**NOTE: The engine must be removed from the vehicle to service crankshaft.**

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Remove engine (Refer to 9 - ENGINE - REMOVAL).

CRANKSHAFT (Continued)

(4) Remove timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - REMOVAL)

(5) Remove rear crankshaft seal adapter(Refer to 9 - ENGINE/ENGINE BLOCK/CRANKSHAFT OIL SEAL - REAR - REMOVAL).

(6) Remove piston and connecting rod assemblies (Refer to 9 - ENGINE/ENGINE BLOCK/PISTON & CONNECTING ROD - REMOVAL).

**CAUTION: The crankshaft bearing caps are numbered consecutively, beginning with the first crankshaft bearing cap at the front of engine. Attention must be paid to the way crankshaft bearing caps fit.**

(7) Unbolt crankshaft bearing caps (Fig. 25).

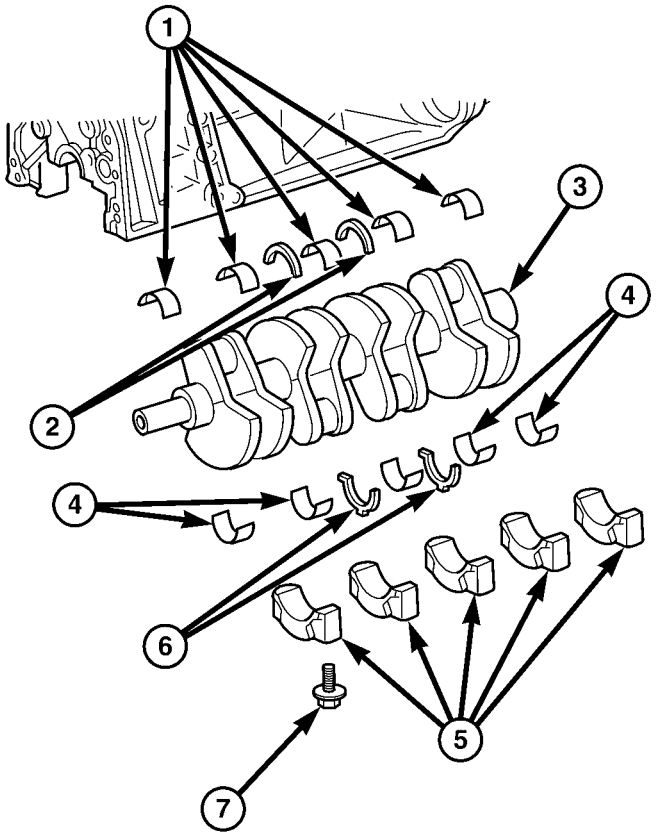



***Fig. 25 Crankshaft Assembly - Typical***

1 - BEARING HALVES IN ENGINE BLOCK
2 - THRUST WASHERS IN ENGINE BLOCK
3 - CRANKSHAFT
4 - BEARING HALVES IN MAIN BEARING CAPS
5 - MAIN BEARING CAPS
6 - THRUST WASHERS IN MAIN BEARING CAPS
7 - MAIN BEARING BOLTS

(8) Inspect crankshaft bearing caps and bolts for wear and stretching.

(9) Remove crankshaft from engine block.

## INSTALLATION

**CAUTION: Oil bearing shells before inserting crankshaft.**

**CAUTION: Oil grooves in thrust washers must point toward the thrust collars of the crankshaft.**

**CAUTION: Thrust washers in bearing cap each have two retaining lugs as a anti-twist lock.**

**CAUTION: Oil thread and head contact surfaces of bolts that retain crankshaft bearing caps; tighten bolts from inside to outside, beginning at fit bearing. Rotate crankshaft to check clearance.**

**CAUTION: The crankshaft bearing caps are numbered consecutively, beginning with the first crankshaft bearing cap at the front of engine. Attention must be paid to the way crankshaft bearing caps fit.**

(1) Install bearing halves into engine block.

(2) Install crankshaft into engine block..

(3) Install bearing halves into bearing caps.

(4) Install crankshaft bearing caps.Tighten bolts in two stages. 55N·m (40.5 lbs ft), then 90°.

(5) Install piston and connecting rod assemblies (Refer to 9 - ENGINE/ENGINE BLOCK/PISTON & CONNECTING ROD - INSTALLATION).

(6) Install rear crankshaft seal adapter (Refer to 9 - ENGINE/ENGINE BLOCK/CRANKSHAFT OIL SEAL - REAR - INSTALLATION).

(7) Install timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - INSTALLATION).

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

(9) Fill crankcase with the correct engine oil, to the proper level. Refer to the owners manual for specifications.

(10) Fill cooling system with the proper coolant, to the proper level (Refer to 7 - COOLING/ENGINE/ COOLANT - STANDARD PROCEDURE).

(11) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT STAND IN A DIRECT LINE WITH THE FAN. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS, OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(12) Start engine and inspect for leaks.

CRANKSHAFT (Continued)

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

# CRANKSHAFT OIL SEAL - REAR

## REMOVAL

This must be done with the transmission removed from the vehicle.

(1) Disconnect the negative battery cable.
(2) Raise and support the vehicle.
(3) Remove transmission assembly (Refer to 21 - TRANSMISSION/TRANSAXLE/MANUAL - REMOVAL).
(4) Drain the engine oil.

**NOTE: Loosen all of the oil pan bolts to assure that the oil pan gasket is not damaged when removing the rear main oil seal and adapter assembly.**

**NOTE: Inspect the oil pan gasket for damage. If the oil pan gasket is damaged, remove oil pan and replace oil pan gasket.**

(5) Loosen oil pan bolts.
(6) Remove flywheel.

**CAUTION: Care must be taken when removing the rear main seal and adaptor assembly. Failure to do so will result in damage to the oil pan gasket.**

(7) Remove the rear crankshaft seal adaptor retaining bolts and carefully pry adaptor from crankcase at adaptor shoulders (Fig. 26).

## INSTALLATION

**NOTE: Thoroughly clean all mating surfaces with the appropriate solvents to assure that no grease or oil is present during reassembly.**

**NOTE: Carefully position the rear main seal/adaptor evenly onto the assembly sleeve. The rear main oil seal lip MUST NOT roll over the edge of the tool.**

(1) Position the rear crankshaft oil seal adaptor with seal installer (special tool #8944) on crankshaft so that the dowel sleeves fit into guide holes (Fig. 26). Care must be taken so that oil pan gasket is not damaged.

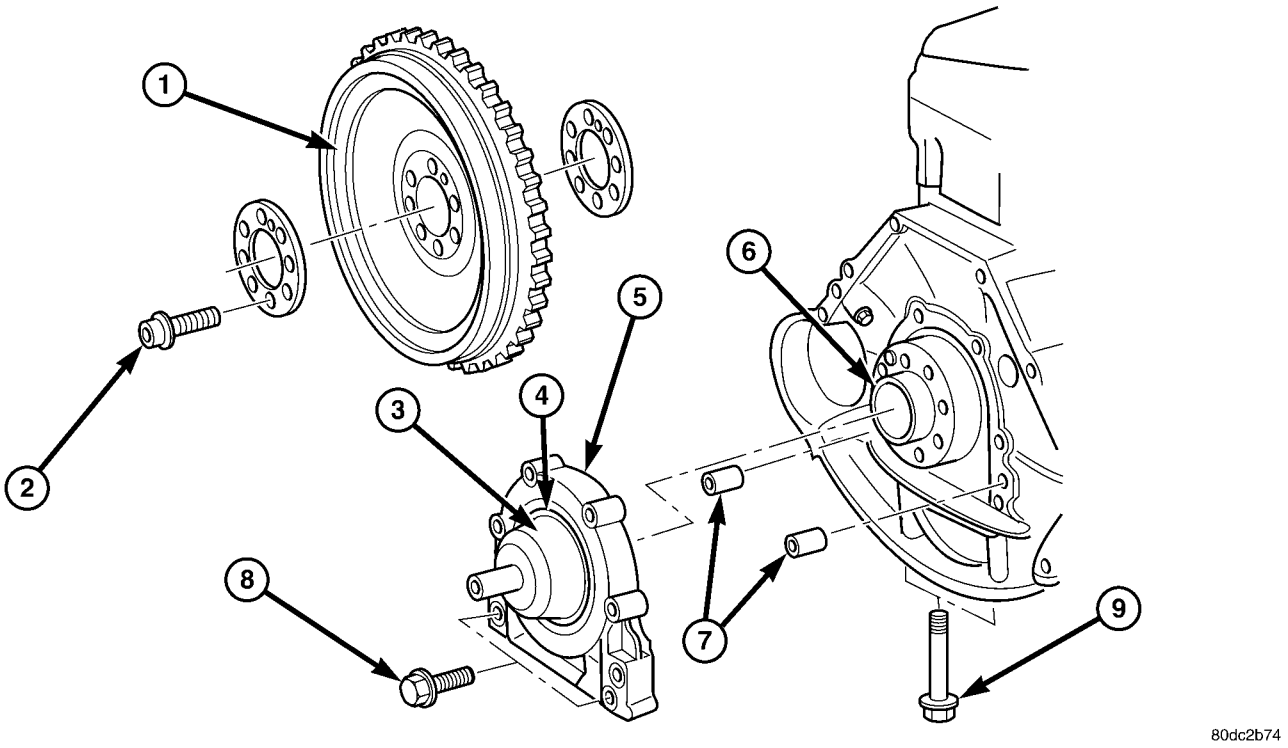



***Fig. 26 Rear Crankshaft Seal/Adapter***

1 - FLYWHEEL
2 - FLYWHEEL BOLTS
3 - SPECIAL TOOL #8944
4 - REAR CRANKSHAFT OIL SEAL
5 - REAR CRANKSHAFT SEAL ADAPTER
6 - CRANKSHAFT
7 - ALIGNMENT DOWELS
8 - REAR CRANKSHAFT SEAL ADAPTER RETAINING BOLT
9 - OIL PAN TO REAR CRANKSHAFT SEAL ADAPTER RETAINING BOLT

CRANKSHAFT OIL SEAL - REAR (Continued)

(2) Install the rear crankshaft seal/adaptor to crankcase bolts and tighten to 9·Nm (80 lbs.in) (Fig. 26).

(3) Tighten the M6 oil pan bolts to 9N·m (80 lbs in) and the M8 bolts to 20 N·m (15 lbs ft).

(4) Install fly wheel and tighten bolts in two stages (Fig. 26). 45N·m (33 lbs. ft.) then 90°.

(5) Install transmission assembly (Refer to 21 - TRANSMISSION/TRANSAXLE/MANUAL - INSTALLATION).

(6) Install the oil pan drain plug and tighten to 25N·m (18 lbs ft).

(7) Lower vehicle.

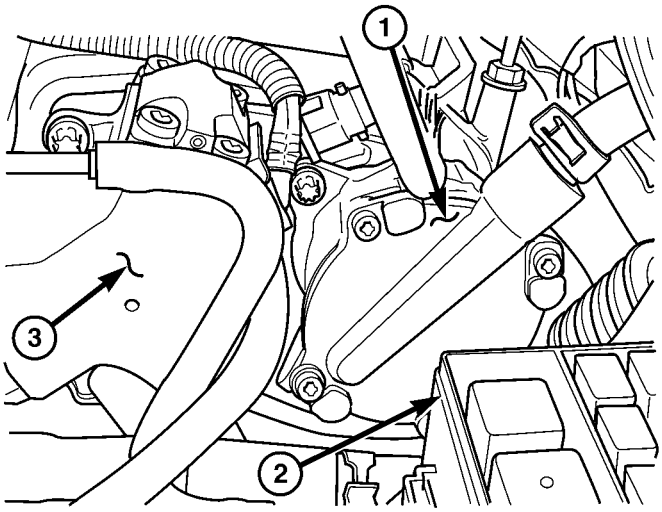
(8) Fill crankcase with the correct engine oil, to the proper level. Refer to owners manual for specifications.

(9) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(10) Start engine and inspect for leaks.

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




80ea16bc

***Fig. 27 Vacuum Pump Location***

1 - VACUUM PUMP
2 - PDC
3 - INJECTION PUMP

# VACUUM PUMP

## DESCRIPTION

The vacuum pump is mounted to the rear of the cylinder head next to the injection pump (Fig. 27). The vacuum pump is of the vane type. The pump supplies vacuum to the brake booster, EGR system, turbocharger wastegate solenoid, and the swirl valve actuator

## REMOVAL

(1) Disconnect negative battery cable.

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

(3) Remove air cleaner housing assembly (Refer to 9 - ENGINE/AIR INTAKE SYSTEM/AIR CLEANER HOUSING - REMOVAL).

(4) Disconnect vacuum hose from vacuum pump.

(5) Disconnect PDC from bracket and reposition out of way.

(6) Remove vacuum pump retaining bolts and remove pump from cylinder head.

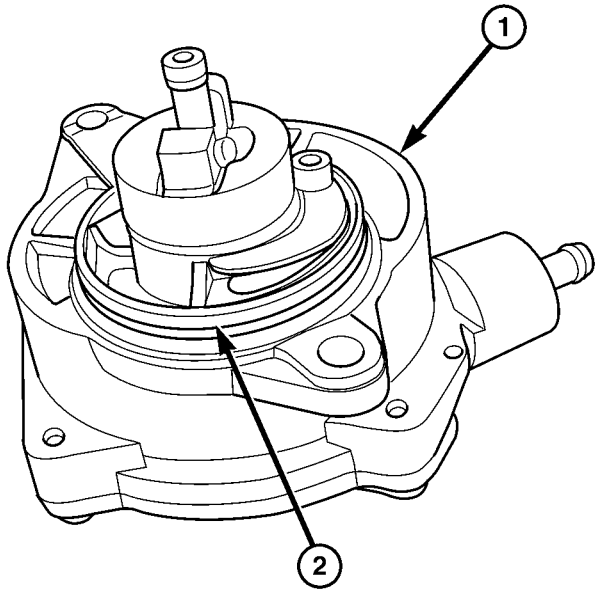
## INSTALLATION

(1) With o-ring installed on vacuum pump (Fig. 28), align pump with pump drive on camshaft.

(2) Slide vacuum pump into cylinder head and install retaining bolts. Torque bolts to 14N·m (124 lbs. in.).

(3) Reposition and connect PDC to mounting bracket.

(4) Connect vacuum hose to vacuum pump.




80ea123c

***Fig. 28 Vacuum Pump O-ring***

1 - VACUUM PUMP
2 - O-RING

(5) Install air cleaner housing assembly (Refer to 9 - ENGINE/AIR INTAKE SYSTEM/AIR CLEANER HOUSING - INSTALLATION).

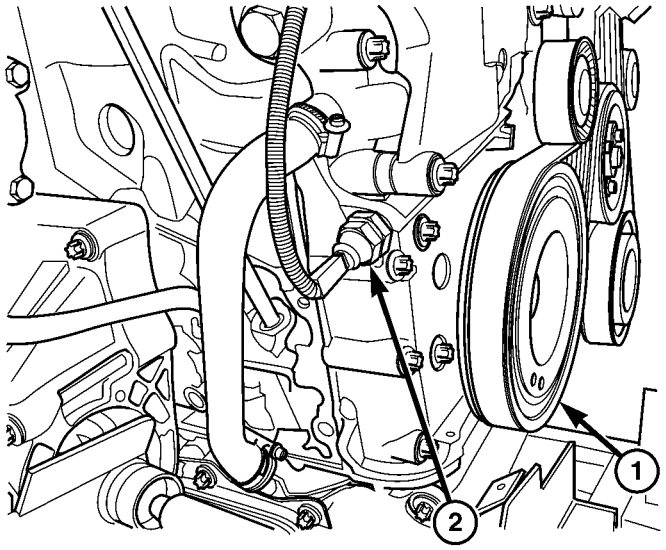
(6) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

(7) Connect negative battery cable.

# OIL PRESSURE SENSOR/ SWITCH

## DESCRIPTION

The oil pressure switch is located on the right front side of the engine block (Fig. 29). The oil pressure switch is a pressure sensitive switch that is activated by the engine's oil pressure (in the main oil gallery). The switch is a single terminal device.




80e7ded8

***Fig. 29 Oil Pressure Sensor Location***

1 - VIBRATION DAMPER/CRANKSHAFT PULLEY
2 - OIL PRESSURE SWITCH

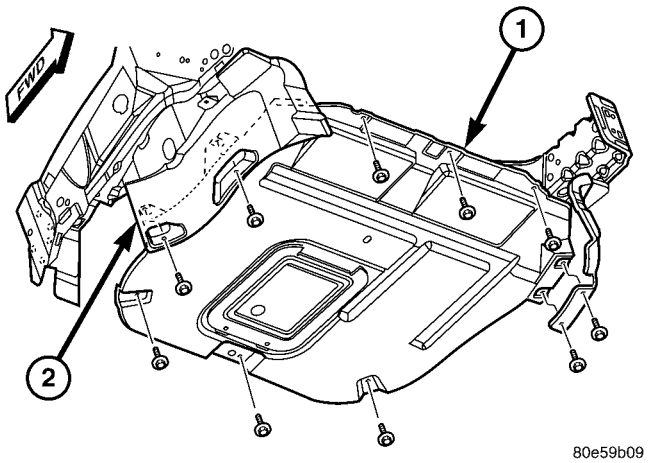
## OPERATION

The oil pressure switch is normally “Closed.” The switch changes from a ″Closed″ circuit to an ″Open″ circuit, on increasing pressure of 7 psig. The oil pressure switch changes from an ″Open″ circuit to a ″Closed″ circuit, on decreasing pressure, between 2 psig and 4 psig.

# OIL PAN

## REMOVAL

(1) Disconnect negative battery cable.
(2) Raise vehicle on hoist.
(3) Remove right front wheel.
(4) Remove engine compartment lower silencer and accessory drive belt splash shield (Fig. 30).

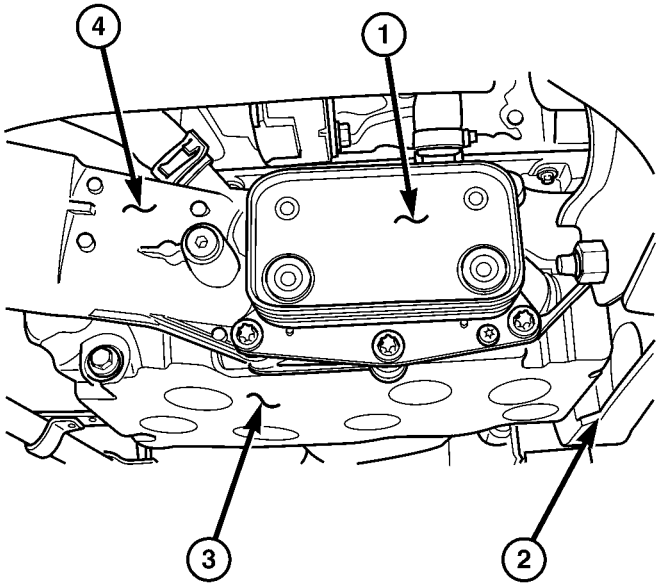



80e59b09

***Fig. 30 Engine Compartment Lower Silencer***

1 - ENGINE COMPARTMENT SILENCER
2 - ACCESSORY DRIVE BELT SPLASH SHIELD

(5) Drain engine oil.
(6) Remove power steering line to oil pan retaining bolts.
(7) Disconnect power steering line from steering gear and reposition out of way.
(8) Remove charge air cooler pipe to oil pan retaining bolts.
(9) Disconnect charge air cooler pipe from turbocharger and reposition out of way.
(10) Remove oil cooler/filter assembly retaining bolts and reposition assembly out of way (Fig. 31).




80ea83c5

***Fig. 31 Oil Cooler/FilterAssembly***

1 - OIL COOLER
2 - LOWER TORQUE STRUT
3 - OIL PAN
4 - OIL FILTER HOUSING

OIL PAN (Continued)

(11) Remove A/C compressor mount to oil pan brackets (Fig. 32).

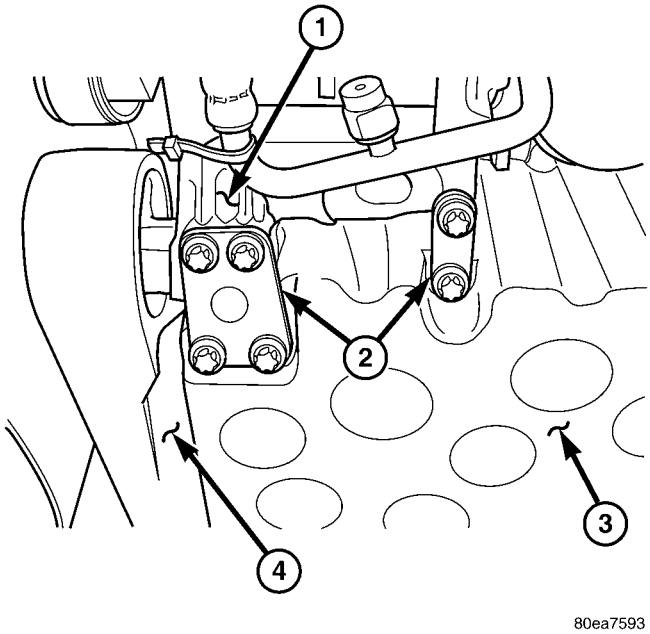



***Fig. 32 A/C Compressor Mount to Oil Pan Brackets***

1 - A/C COMPRESSOR MOUNT
2 - A/C COMPRESSOR BRACKET TO OIL PAN BRACKETS
3 - OIL PAN
4 - LOWER TORQUE STRUT

(12) Remove lower torque strut (Refer to 9 - ENGINE/ENGINE MOUNTING/TORQUE STRUT - REMOVAL).

(13) Remove oil pan fasteners and remove oil pan.

## INSTALLATION

(1) Clean oil pan and all sealing surfaces.

(2) Position new oil pan gasket onto pan.

(3) Install oil pan. Torque M6 bolts to 9N·m (80 lbs.in.). Torque M8 bolts to 20N·m (177 lbs.in.). Torque transmission to oil pan bolts to 40N·m (30lbs.ft.).

(4) Reposition oil cooler assembly and install retaining bolts (Fig. 31). Torque bolts to 20N·m(177 lbs.in.).

(5) Install lower torque strut (Refer to 9 - ENGINE/ENGINE MOUNTING/TORQUE STRUT - INSTALLATION).

(6) Install A/C compressor mount to oil pan brackets (Fig. 32). Torque bolts to 20N·m(177 lbs.in.).

(7) Connect charge air cooler pipe to turbocharger.

(8) Install charge air cooler pipe to oil pan retaining bolts.

(9) Connect power steering line to steering gear.

(10) Install power steering line to oil pan retaining bolts.

(11) Install accessory drive belt splash shield and engine compartment lower silencer (Fig. 30).

(12) Install right front wheel.

(13) Lower vehicle.

(14) Refill engine oil and power steering fluid to proper specifications.

(15) Connect negative battery cable.

# OIL PUMP

## REMOVAL

(1) Disconnect negative battery cable.

(2) Raise vehicle on hoist.

(3) Drain engine oil.

(4) Remove oil pan (Refer to 9 - ENGINE/LUBRICATION/OIL PAN - REMOVAL).

(5) Remove oil pump retaining bolts (Fig. 33).

(6) Push on oil pump chain tensioner to release tension on chain and remove oil pump chain from oil pump sprocket (Fig. 33).

(7) Remove oil pump.

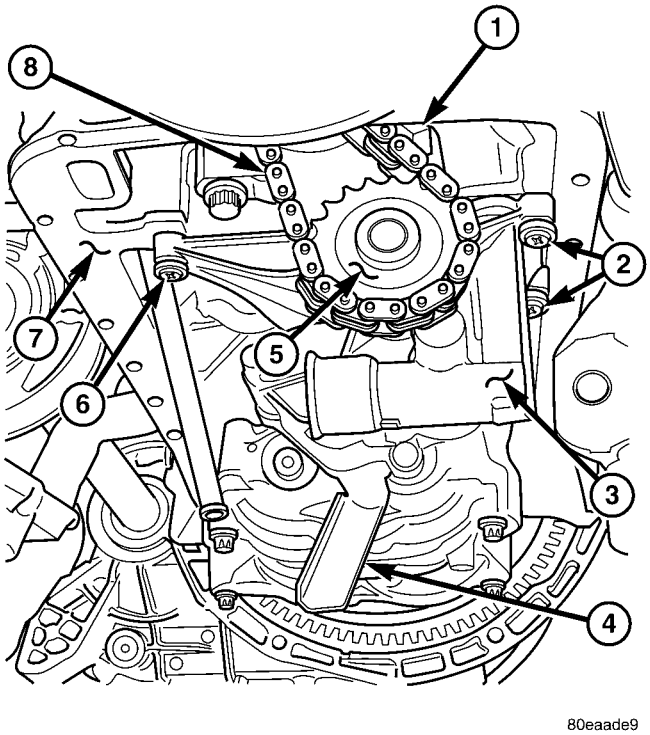



***Fig. 33 Oil Pump Assembly***

1 - OIL PUMP CHAIN TENSIONER
2 - OIL PUMP RETAINING BOLTS
3 - OIL PUMP
4 - OIL PUMP PICKUP
5 - OIL PUMP SPROCKET
6 - OIL PUMP RETAINING BOLT
7 - CYLINDER BLOCK
8 - OIL PUMP CHAIN

OIL PUMP (Continued)

### INSTALLATION

(1) Release tension from oil pump chain tensioner and install chain on oil pump sprocket (Fig. 33).

(2) Position oil pump on cylinder block and install retaining bolts (Fig. 33). Torque bolts to 18N·m(13 lbs.ft.).

(3) Install oil pan (Refer to 9 - ENGINE/LUBRICATION/OIL PAN - INSTALLATION).

(4) Lower vehicle from hoist.

(5) Refill engine oil to proper level.

(6) Connect negative battery cable.

## OIL JET

### DESCRIPTION

There are four oil jets installed in the engine block (Fig. 34). These oil jets are used to cool and lubricate the piston assemblies.

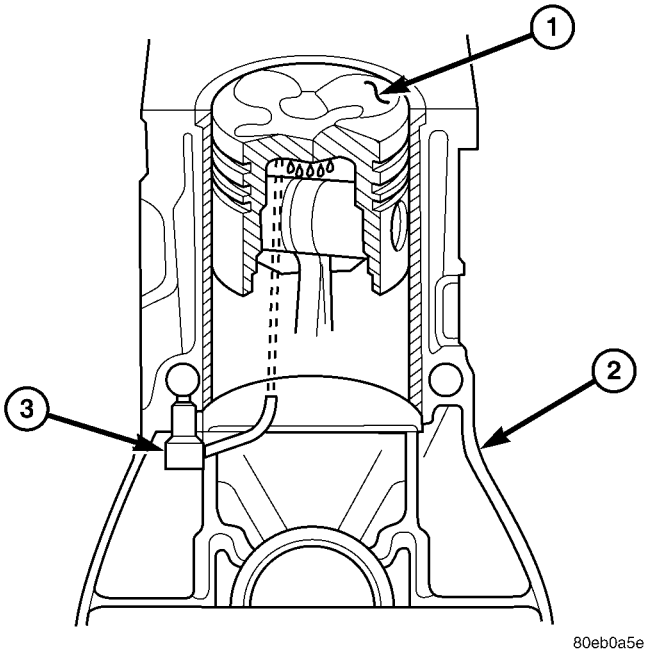



***Fig. 34 Oil Jet Location***

1 - PISTON ASSEMBLY
2 - ENGINE BLOCK
3 - OIL JET

### REMOVAL

The engine must be removed from the vehicle and completely dissassembled to replace the oil jets.

(1) Remove engine from vehicle.

(2) Completely dissassemble engine.

(3) Using an extraction claw and a slide hammer, remove the oil jets from engine block.

### INSTALLATION

(1) Install oil jet into special tool #8924.

(2) Align oil jet in location in engine block.

(3) Drive oil jets into block using special tool #8924 until oil jet is fully seated into engine block (Fig. 35).

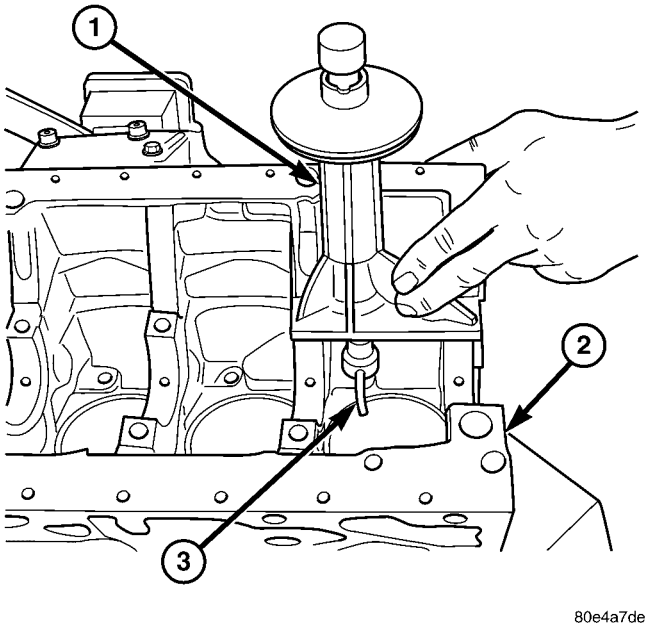



***Fig. 35 Oil Jet Installation***

1 - OIL JET INSTALLER #8942
2 - ENGINE BLOCK
3 - OIL JET

(4) Reassemble engine.

(5) Install engine into vehicle.

## BALANCE SHAFT

### DESCRIPTION

The 2.2L engine is equipped with two nodular cast iron balance shafts installed in a cast iron carrier attached to the lower cylinder block (Fig. 36).

### OPERATION

The balance shafts are driven by the crankshaft via a roller chain and sprockets. The balance shafts are connected by helical gears. The dual counter rotating shafts decrease second order vertical shaking forces caused by component movement.

BALANCE SHAFT (Continued)

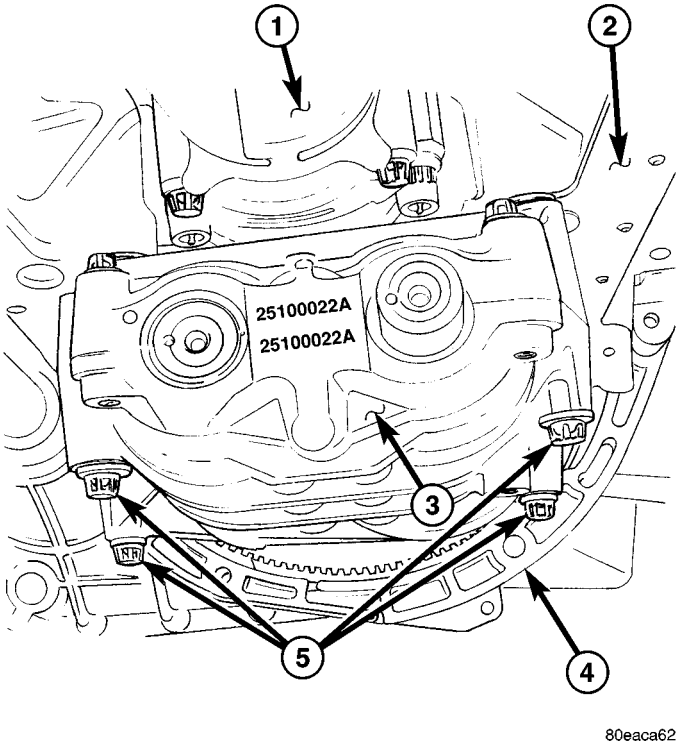



*Fig. 36 Balance Shaft Location*

1 - CRANKSHAFT
2 - CYLINDER BLOCK
3 - BALANCE SHAFT ASSEMBLY
4 - TRANSMISSION BELL HOUSING
5 - RETAINING BOLTS

## REMOVAL

(1) Disconnect negative battery cable.

(2) Raise vehicle on hoist.

(3) Remove engine compartment lower silencer and accessory drive belt splash shield (Fig. 37).

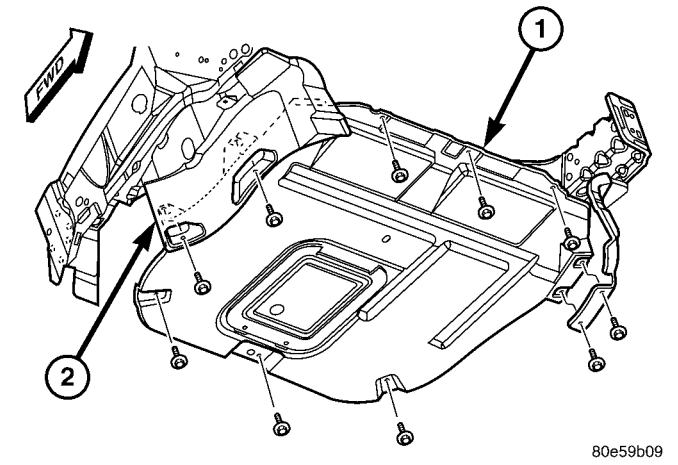



*Fig. 37 Engine Compartment Lower Silencer*

1 - ENGINE COMPARTMENT SILENCER
2 - ACCESSORY DRIVE BELT SPLASH SHIELD

(4) Drain engine oil.

(5) Remove oil pan (Refer to 9 - ENGINE/LUBRICATION/OIL PAN - REMOVAL).

(6) Remove balance shaft retaining bolts and remove assembly from engine block (Fig. 38).

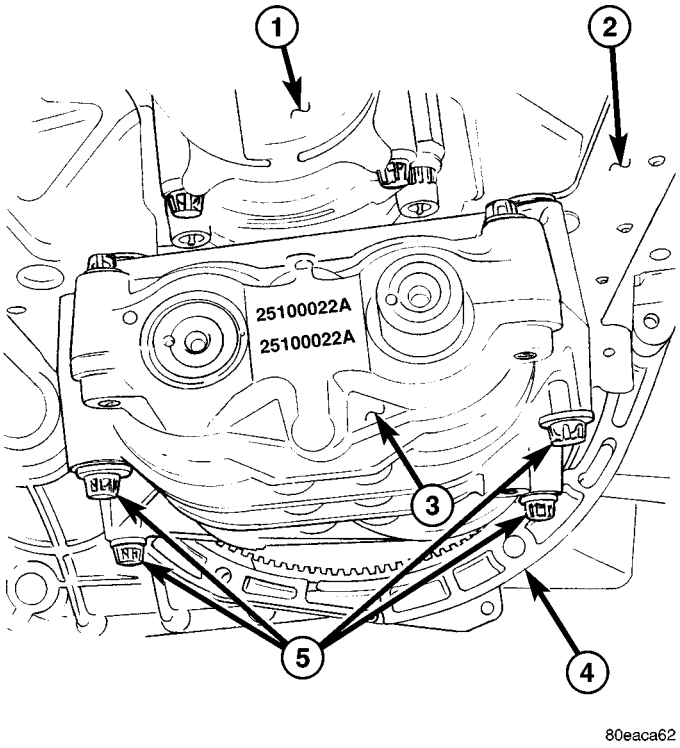



*Fig. 38 Balance Shaft Location*

1 - CRANKSHAFT
2 - CYLINDER BLOCK
3 - BALANCE SHAFT ASSEMBLY
4 - TRANSMISSION BELL HOUSING
5 - RETAINING BOLTS

## INSTALLATION

Before the balance shaft assembly can be installed, the balance shaft shim thickness must be determined. Follow steps below to determine shim thickness.

### DETERMINING BALANCE SHAFT SHIM THICKNESS

(1) Measure and determine dimensions A and B by measuring in the center of the gears. (Fig. 39). Measure 4 times approximately 90° apart. Determine mean of the 4 measurments

(2) After measuring dimension A and B, use chart below to determine shims needed for balance shaft assembly (Fig. 40).

BALANCE SHAFT (Continued)

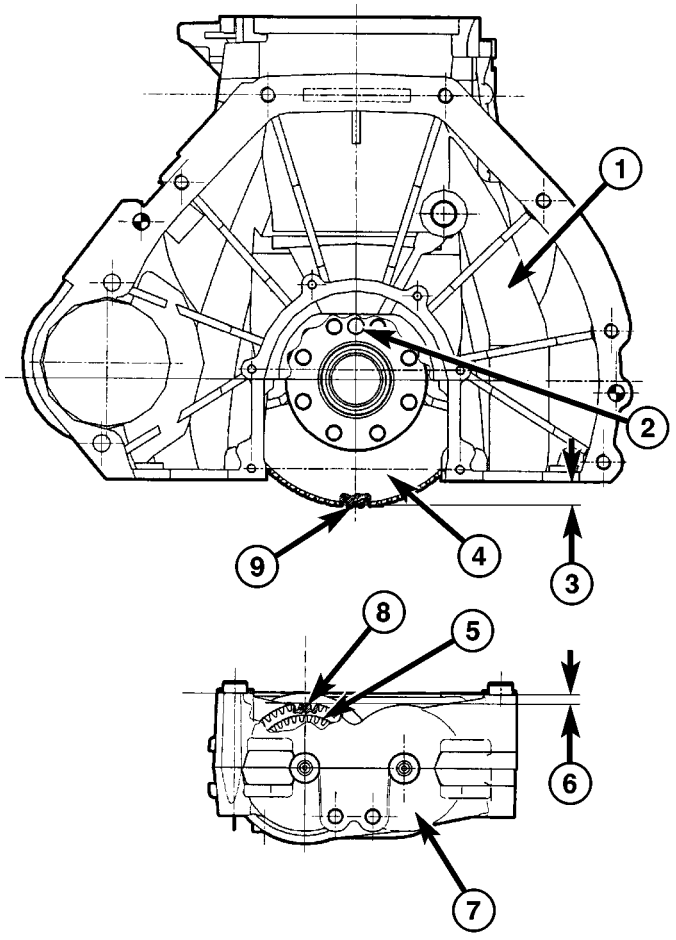



***Fig. 39 Measurements for Determining Shim Thickness***

1 - ENGINE BLOCK
2 - CRANKSHAFT POSITION DURING MEASURMENT
3 - DIMENSION B
4 - CRANKSHAFT
5 - BALANCE SHAFT SPROCKET
6 - DIMENSION A
7 - BALANCE SHAFT ASSEMBLY
8 - 2.5MM TEST BALL LOCATION
9 - 2.5MM TEST BALL LOCATION

After selecting proper balance shaft shims. Install shims on balance shaft assembly as shown (Fig. 41).

(1) Position #1 cylinder at Top Dead Center.

**BALANCE SHAFT SHIM THICKNESS CHART (SHOWN IN MM)**

| DIMENSION A (THICKNESS / CLEARANCE) | DIMENSION B 16.58 | 16.53 | 16.60 | 16.61 | 16.62 | 16.63 | 16.64 | 16.65 | 16.66 | 16.67 | 16.68 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6.24 | 2.00 / 88 | 2.00 / 84 | 2.00 / 81 | 2.00 / 77 | 2.00 / 73 | 2.00 / 69 | 2.00 / 66 | | | | |
| 6.19 | | 2.05 / 88 | 2.05 / 84 | 2.05 / 81 | 2.05 / 77 | 2.05 / 73 | 2.05 / 69 | 2.05 / 66 | | | |
| 6.14 | | | 2.10 / 88 | 2.10 / 84 | 2.10 / 81 | 2.10 / 77 | 2.10 / 73 | 2.10 / 69 | 2.10 / 66 | | |
| 6.09 | | | | 2.15 / 86 | 2.15 / 84 | 2.15 / 81 | 2.15 / 77 | 2.15 / 73 | 2.15 / 69 | 2.15 / 65 | |

80eacd7d

***Fig. 40 Balance Shaft Shim Thickness Chart***

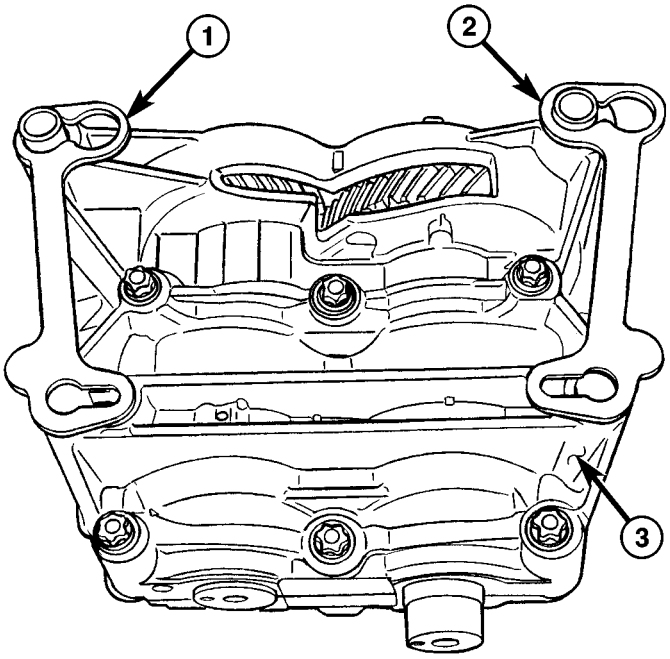



***Fig. 41 Balance Shaft Shim Position***

1 - BALANCE SHAFT SHIM
2 - BALANCE SHAFT SHIM
3 - BALANCE SHAFT ASSEMBLY

BALANCE SHAFT (Continued)

(2) Align drill holes at end of balance shafts with assembly point of carrier halves (Fig. 42).

(3) Position balance shaft assembly on engine block and install retaining bolts. Tighten bolts to 25N·m, then to 45N·m.

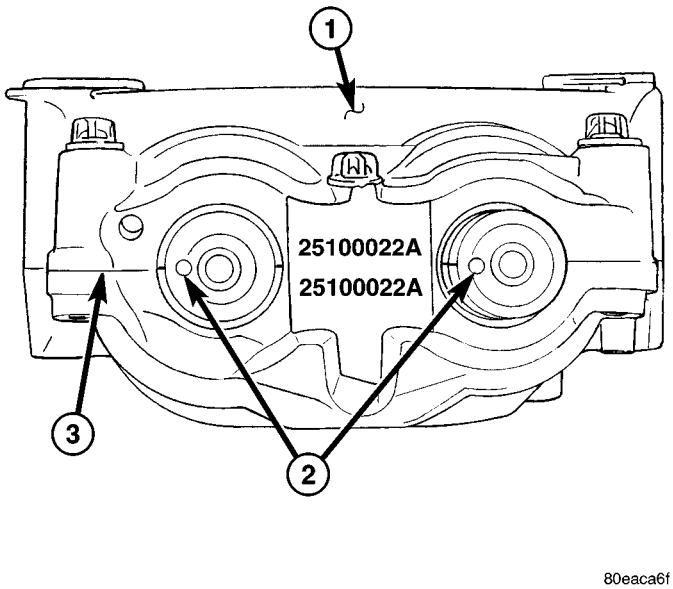



***Fig. 42 Balance Shaft Position Before Installation***

1 - BALANCE SHAFT ASSEMBLY
2 - DRILL HOLES IN END OF BALANCE SHAFTS
3 - ASSEMBLY POINT OF CARRIER HALVES

(4) Install oil pan (Refer to 9 - ENGINE/LUBRICATION/OIL PAN - INSTALLATION).

(5) Install engine compartment lower silencer and accessory drive belt splash shield (Fig. 37).

(6) Lower vehicle.

(7) Refill engine oil and power steering fluid to proper specifications.

(8) Connect negative battery cable.

# TIMING CHAIN COVER

## REMOVAL

The engine must be removed from the vehicle to remove the timing chain cover.

**WARNING: DO NOT OPEN COOLING SYSTEM UNLESS TEMPERATURE IS BELOW 90°C (194°F). OPEN CAP SLOWLY TO RELEASE PRESSURE. STORE COOLANT IN APPROVED CONTAINER ONLY. RISK OF INJURY TO SKIN AND EYES FROM SCALDING COOLANT. WEAR PROTECTIVE GLOVES, CLOTHING AND EYE WEAR.**

(1) Disconnect negative battery cable.

(2) Drain coolant (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).

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

(4) Remove engine (Refer to 9 - ENGINE - REMOVAL).

(5) Support engine on suitable engine stand.

(6) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

**NOTE: Rotate engine on crankshaft. DO NOT crank the engine at the bolt of the camshaft sprocket.**

**NOTE: DO NOT crank engine back.**

(7) Position piston of cylinder #1 to ignition TDC. **Markings on the camshaft bearing cap must be aligned.**

(8) Install retaining lock for crankshaft/starter ring gear.

(9) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL)

(10) Remove cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

(11) Remove vibration damper/crankshaft pulley (Refer to 9 - ENGINE/ENGINE BLOCK/VIBRATION DAMPER - REMOVAL)..

(12) Drain engine oil.

**NOTE: Remove the bolts in area of timing chain cover. Loosen all other oil pan bolts.**

(13) Remove oil pan bolts.

(14) Remove M8 bolts of cylinder head on timing chain cover.

(15) Remove timing case cover retaining bolts and remove cover from engine (Fig. 43).

(16) Remove remaining ancillary components attached to the timing chain cover.

## INSTALLATION

**NOTE: Thoroughly clean all mating surfaces with the appropriate solvents to assure that no grease or oil is present during assembly.**

(1) Inspect cylinder head gasket and oil pan gasket. If damaged, replace.

(2) Replace front crankshaft seal (Refer to 9 - ENGINE/ENGINE BLOCK/CRANKSHAFT OIL SEAL - FRONT - INSTALLATION).

(3) Install ancillary components to timing case cover.

(4) Apply sealant to the marked surfaces with a bead thickness of 1.5 ± 0.5 mm (Fig. 44).

TIMING CHAIN COVER (Continued)

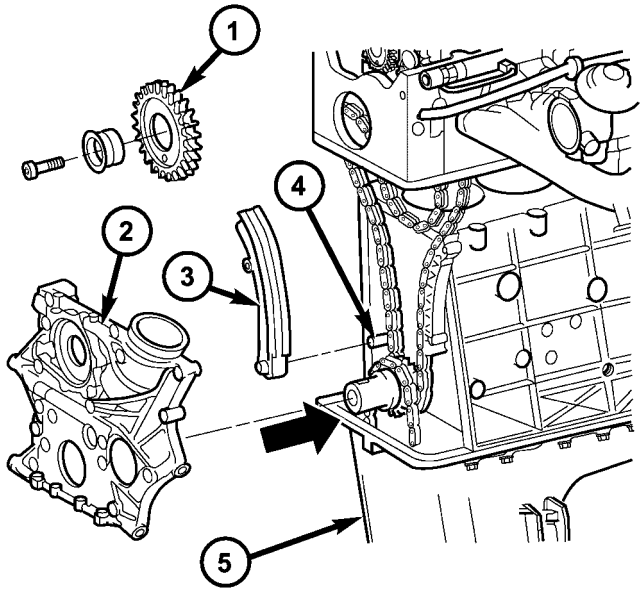



***Fig. 43 Timing Chain Cover***

1 - INTERMEDIATE GEAR
2 - TIMING CHAIN COVER
3 - TENSIONING RAIL
4 - BEARING PIN
5 - OIL PAN

**NOTE: Install timing cover within 10 minutes after applying sealant. Do not spread sealant bead.**

**NOTE: Do not seal pressurized oil galleries to the crankcase. Sealant applied at these points is entrained by the oil flow and blocks the oil supply passages.**

(5) Position and install timing case cover. Tighten bolts to 20 N·m (177 lbs in).

(6) Install M8 bolts of cylinder head on timing case cover. Tighten bolts to 20 N·m (177 lbs in).

(7) Position and install the oil pan. Tighten M6 bolts to 9 N·m (80 lbs in) and M8 bolts to 20 N·m (177 lbs in).

(8) Install vibration damper/crankshaft pulley. Tighten M8.8 bolt in two stages, 200N·m (147 lbs ft.) then 90°, M10.9 bolt 325N·m (240 lbs ft) then 90°.

(9) Install cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).

(10) Install timing chain tensioner with new seal (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).

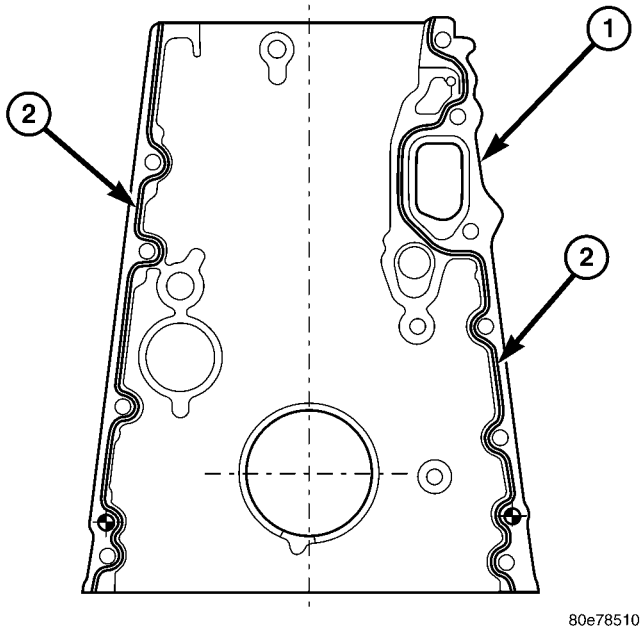



***Fig. 44 Timing Chain Cover Sealing Surface***

1 - TIMING CHAIN COVER
2 - SEALANT BEAD

(11) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).

(12) Remove retaining lock for crankshaft/starter ring gear.

(13) Install engine (Refer to 9 - ENGINE - INSTALLATION).

(14) Fill coolant to the proper level, with the proper coolant (Refer to 7 - COOLING/ENGINE/ COOLANT - STANDARD PROCEDURE).

(15) Tighten oil drain plug to 30N·m (265 lbs in).

(16) Fill crankcase with the correct oil, to the proper level. Refer to owners manual for specifications.

(17) Connect negative battery cable.

**WARNING: (Refer to 14 - FUEL SYSTEM/FUEL INJECTION - STANDARD PROCEDURE)**

(18) Start engine and inspect for leaks.

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

# TIMING CHAIN

## REMOVAL

### BOTTOM GUIDE RAIL

The engine must be removed to service the bottom guide rail.

(1) Disconnect negative battery cable.

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

(3) Drain coolant (Refer to 7 - COOLING/ENGINE/ COOLANT - STANDARD PROCEDURE).

(4) Remove engine (Refer to 9 - ENGINE - REMOVAL).

(5) Support engine on suitable engine stand.

(6) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL)

(7) Remove cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

**NOTE: Oil pan DOES NOT need to be removed. Remove bolts in the area of timing case cover then loosen the remaining bolts.**

**NOTE: Remove timing case cover carefully. Care must be taken not to damage oil pan gasket.**

(8) Remove timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - REMOVAL).

(9) Remove guide rail from bearing pin (Fig. 45).

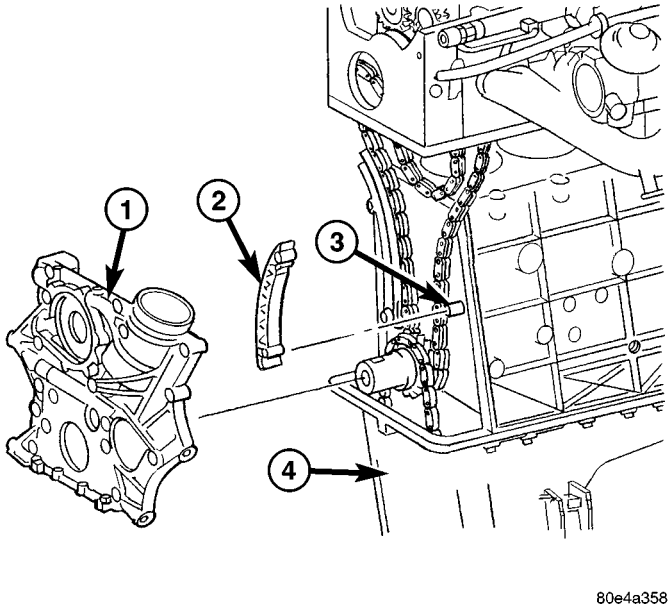



*Fig. 45 Bottom Guide Rail*

1 - TIMING CHAIN COVER
2 - BOTTOM SLIDE RAIL
3 - BEARING PIN
4 - OIL PAN

### INTERMEDIATE GEAR

(1) Disconnect negative battery cable located under the passenger seat.

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

(3) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

(4) Remove the intermediate gear cover (Fig. 47).

**NOTE: Rotate engine on crankshaft. DO NOT rotate the engine using the camshaft sprocket bolt.**

**NOTE: DO NOT rotate the engine backwards.**

(5) Position piston of cylinder #1 to ignition TDC. **Markings on the camshaft bearing cap must be aligned.**

(6) Install special tool #8933, crankshaft lock (Fig. 46).

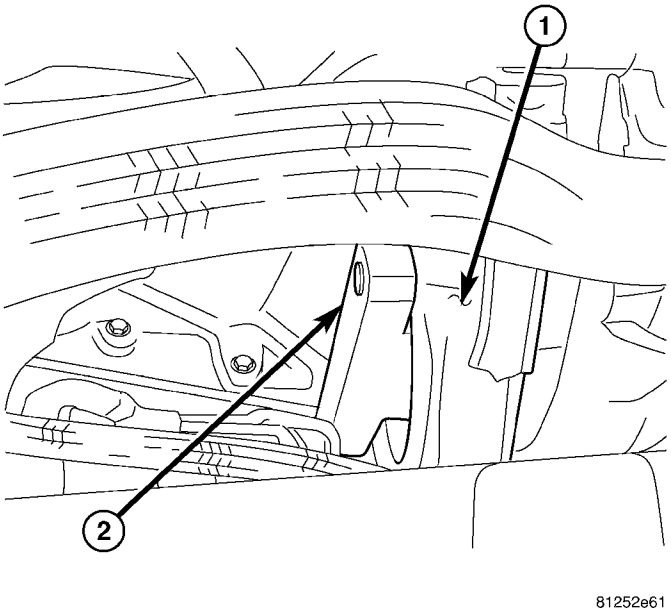



*Fig. 46 8933-Crankshaft Lock*

1 - ENGINE BLOCK
2 - SPECIAL TOOL #8933

TIMING CHAIN (Continued)

(7) Install special tool #8929, camshaft locking pin through first camshaft bearing cap into hole in the inlet camshaft sprocket to lock inlet camshaft (Fig. 47).

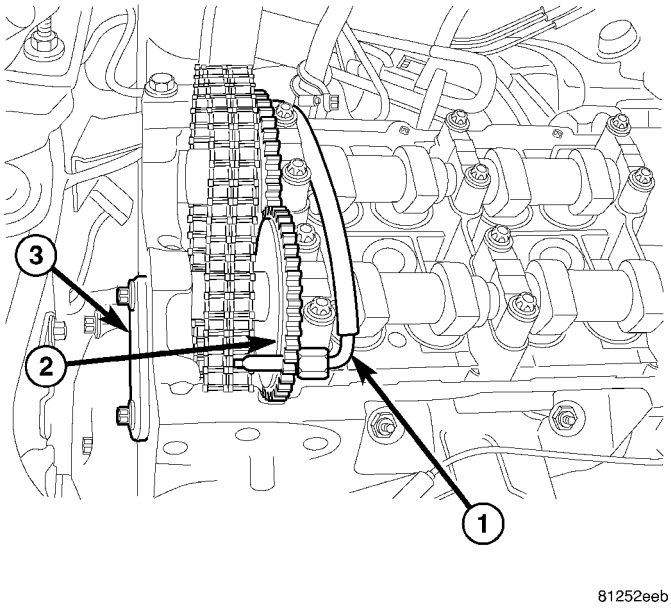



***Fig. 47 Special Tool 8929-Camshaft Locking Pin***

1 - SPECIAL TOOL #8929
2 - INTAKE CAM SPROCKET
3 - INTERMEDIATE GEAR COVER

(8) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).

(9) Remove cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - REMOVAL).

(10) Remove top slide rail (Refer to 9 - ENGINE/ CYLINDER HEAD - REMOVAL).

(11) Mark camshaft sprocket relative to timing chain.

(12) Unbolt camshaft sprocket from exhaust camshaft.

**NOTE: Note position of dowel pin for camshaft sprocket alignment during reassembly.**

(13) Secure camshaft sprocket to timing chain with tie strap.

(14) Remove camshaft sprocket.

(15) Remove intermediate gear and bushing (Fig. 48).

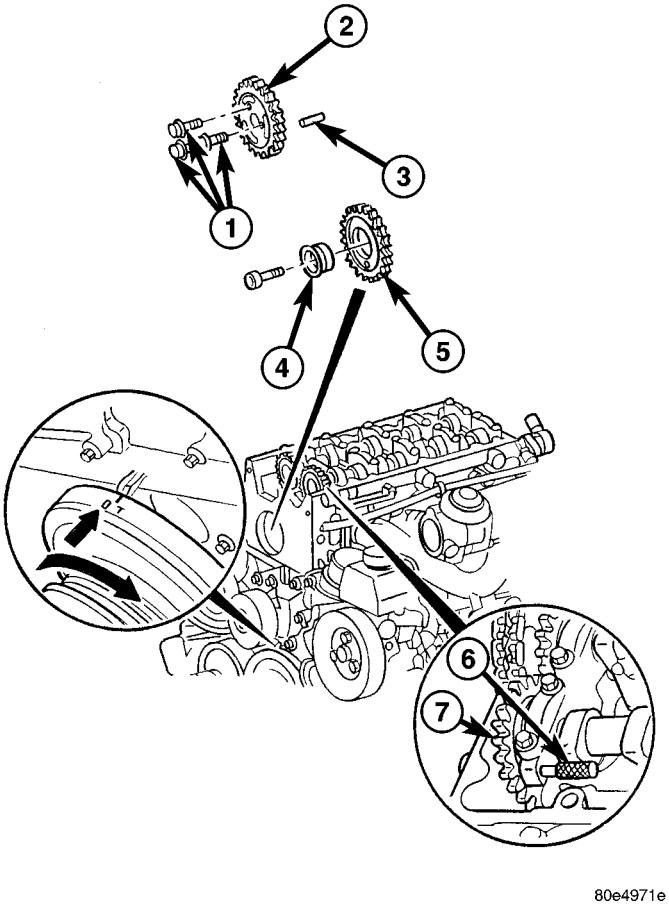



***Fig. 48 Intermediate Gear***

1 - CAMSHAFT SPROCKET BOLTS
2 - INTAKE CAMSHAFT
3 - DOWEL PIN
4 - INTERMEDIATE GEAR BUSHING
5 - INTERMEDIATE GEAR
6 - CAMSHAFT LOCKING PIN
7 - INTAKE CAMSHAFT SPROCKET

## TIMING CHAIN TENSIONING RAIL

(1) Disconnect negative battery cable.

(2) Remove cylinder head cover.

(3) Drain cooling system (Refer to 7 - COOLING/ ENGINE/COOLANT - STANDARD PROCEDURE).

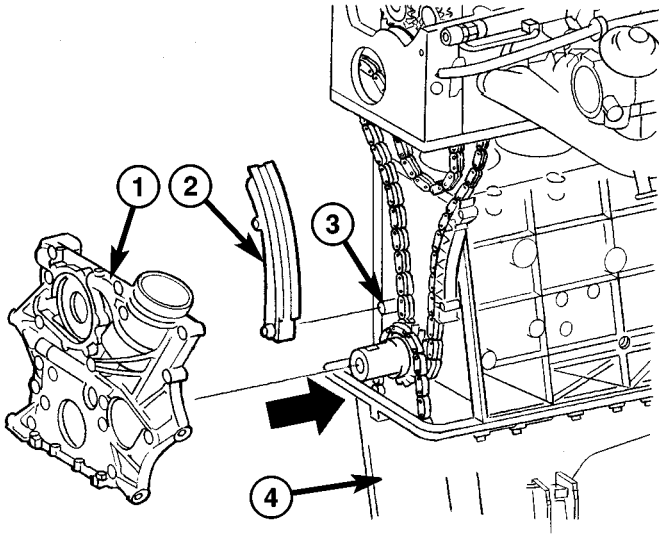
**NOTE: Oil pan DOES NOT need to be removed. Remove bolts in the area of timing case cover then loosen the remaining bolts.**

**NOTE: Remove timing case cover carefully. Care must be taken not to damage oil pan gasket.**

TIMING CHAIN (Continued)

(4) Remove timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - REMOVAL).

(5) Remove tensioning rail from bearing pin (Fig. 49).




80e49842

*Fig. 49 Timing Chain Tensioning Rail*

1 - TIMING CHAIN COVER
2 - TENSIONING RAIL
3 - BEARING PIN
4 - OIL PAN

## TIMING CHAIN

(1) Disconnect negative battery cable.

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

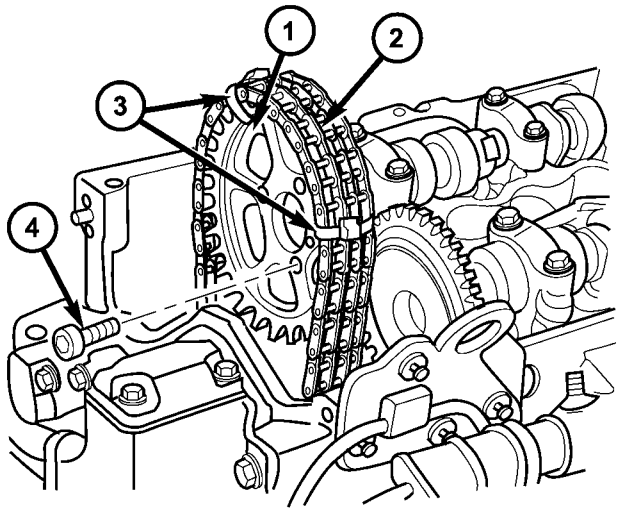
(3) Remove cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - REMOVAL).

(4) Remove cylinder head front cover and guide rail(Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).

(5) Remove timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - REMOVAL).

**CAUTION: Cover timing chain cover recess to prevent foreign material from entering engine.**

(6) Secure timing chain to camshaft sprocket with tie straps (Fig. 50).



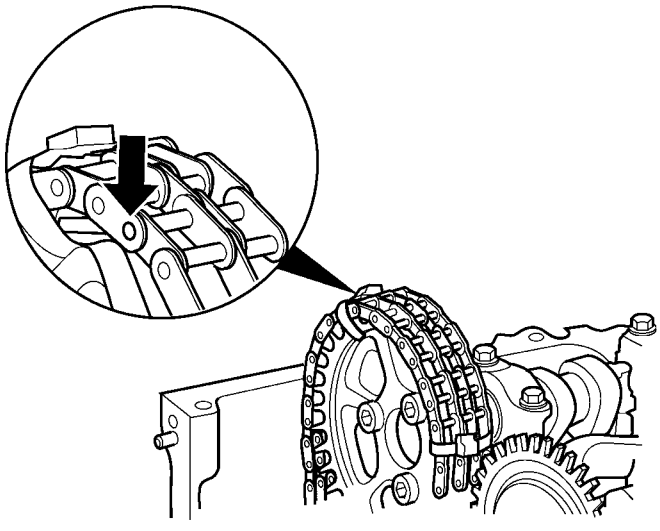

80e17fc0

*Fig. 50 Securing Timing Chain to Sprocket*

1 - CAMSHAFT SPROCKET
2 - TIMING CHAIN
3 - TIE STRAPS
4 - RETAINING BOLTS

(7) Remove camshaft sprocket with timing chain attached, from camshaft.

**NOTE: When fitting the thrust spindle, ensure that the thrust pin is positioned at the left timing chain pin of a chain link (Fig. 51).**



80e17f92

*Fig. 51 Thrust Pin Position*

(8) Using special tool #8948, position timing chain separating tool at the timing chain of the camshaft sprocket (Fig. 52).

TIMING CHAIN (Continued)

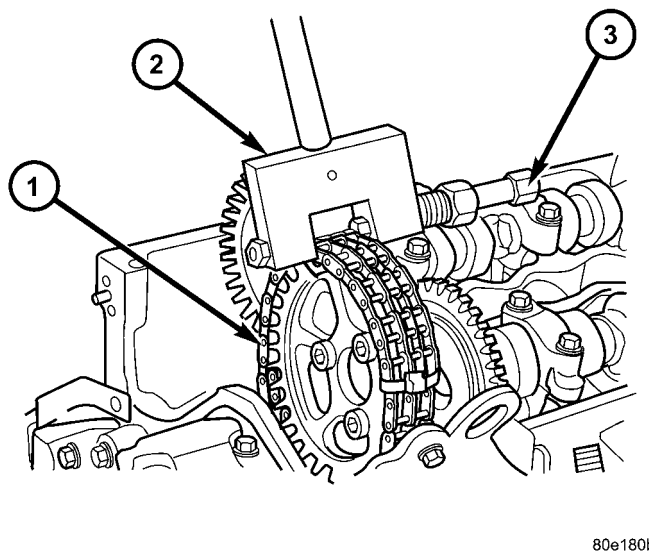



***Fig. 52 Seperating Timing Chain with Special Tool #8948***

1 - TIMING CHAIN
2 - SPECIAL TOOL #8948
3 - THRUST SPINDLE

(9) Screw the thrust pin in and separate the timing chain.

(10) Unscrew the thrust spindle and remove the tool.

**NOTE: DO NOT detach timing chain from camshaft sprocket.**

(11) Install camshaft sprocket with timing chain, to camshaft.

(12) Remove pressed - out timing chain pin from chain separation tool.

(13) Attach special tool 8931, timing chain retainer, to cylinder head with bolts supplied (Fig. 53).

(14) Remove timing chain to camshaft sprocket tie straps.

(15) Connect new timing chain and old timing chain with assembly link, assembly plate and locking element, and secure (Fig. 54) (Fig. 55).

**CAUTION: IT IS ESSENTIAL that the installation procedure for the timing chain is followed exactly. Failure to do so will result in severe engine damage.**

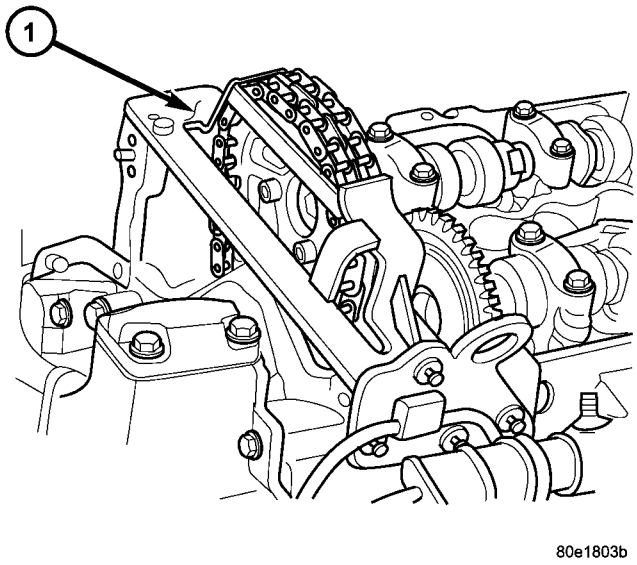



***Fig. 53 Special Tool # 8931***

1 - SPECIAL TOOL #8931

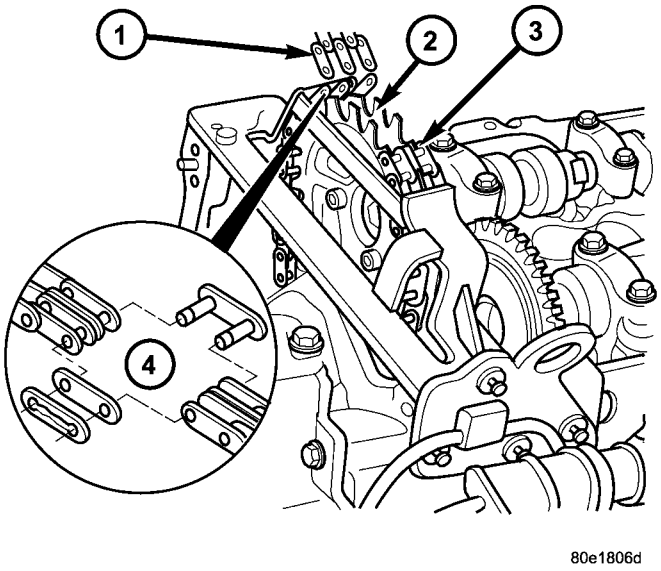



***Fig. 54 Installing Temporary Link***

1 - NEW TIMING CHAIN
2 - CAMSHAFT SPROCKET
3 - OLD TIMING CHAIN
4 - TEMPORARY LINK

TIMING CHAIN (Continued)

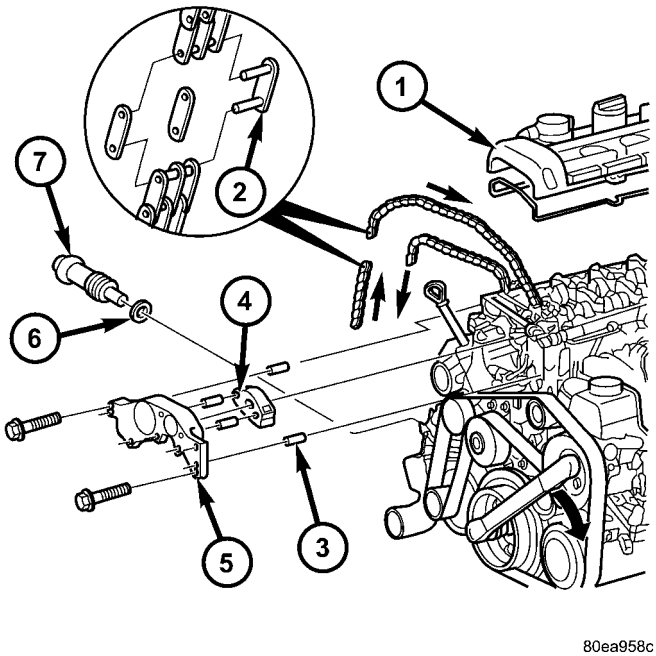



***Fig. 55 Timing Chain Temporary Link - Typical***

1 - CYLINDER HEAD COVER
2 - TIMING CHAIN TEMPORARY LINK
3 - ALIGNMENT PINS
4 - TOP GUIDE RAIL
5 - CYLINDER HEAD FRONT COVER
6 - TIMING CHAIN TENSIONER SEAL
7 - TIMING CHAIN TENSIONER

## INSTALLATION

### BOTTOM GUIDE RAIL

**NOTE: Carefully clean all mating surfaces with appropriate solvents to assure that no grease or oil is present during reassembly.**

(1) Install slide rail on bearing pin.
(2) Install timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - INSTALLATION).
(3) Install cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(4) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).
(5) Install engine (Refer to 9 - ENGINE - INSTALLATION).
(6) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(7) Start the engine and inspect for leaks.
(8) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).

### INTERMEDIATE GEAR

**NOTE: Refer to appropriate injector servicing procedures for cleaning of injectors and recesses.**

(1) Install intermediate gear and bushing. Tighten bolt to 40N·m (30 lbs.ft.)
(2) Install camshaft sprocket, noting dowel pin alignment. Tighten bolt to 18 N·m (159 lbs. in.).
(3) Remove tie strap retaining timing chain to sprocket.
(4) Install top slide rail (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).
(5) Install intermediate gear cover.
(6) Install cylinder head front cover (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(7) Install timing chain tensioner with new gasket (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).

**NOTE: Inspect basic position of camshaft and reset if necessary.**

(8) Remove crankshaft lock.
(9) Remove camshaft locking pin.
(10) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHING.**

(11) Start engine and inspect for leaks.
(12) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).
(13) Connect negative battery cable.

### TIMING CHAIN TENSIONING RAIL

**NOTE: Carefully clean all mating surfaces with appropriate solvents to assure that no grease or oil is present during reassembly.**

(1) Install tensioning rail on bearing pin
(2) Install timing chain cover (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT / CHAIN COVER(S) - INSTALLATION).
(3) Install cylinder head cover.
(4) Connect negative battery cable.

TIMING CHAIN (Continued)

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR THE PULLEYS, BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(5) Start the engine and inspect for leaks.
(6) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

## ADJUSTMENTS

### TIMING CHAIN

**CAUTION: IT IS ESSENTIAL that the installation procedure is followed exactly. Failure to do so will result in severe engine damage.**

**CAUTION: Cover timing case recesses to prevent foreign material from entering engine.**

(1) Connect new timing chain and old timing chain with the assembly link, the assembly plate and the assembly locking element, and secure (Fig. 56).

**NOTE: Always keep new timing chain meshed with camshaft sprocket.**

**NOTE: Rotate engine at crankshaft only. DO NOT crank engine and DO NOT rotate engine backward (Fig. 56).**

**NOTE: Draw out the end of old timing chain evenly as it becomes free, to the same extent that new timing chain is drawn in (Fig. 56).**

(2) Draw in new timing chain by rotating the crankshaft slowly in direction of rotation of engine until the ends of the new timing chain meet and can be connected (Fig. 56).

**NOTE: Assembly link is only an assembly aid and NOT designed for engine running.**

(3) Remove assembly locking element, assembly outer plate and assembly link (Fig. 57).
(4) Attach new timing chain to camshaft sprocket with tie straps..
(5) Insert new riveted link and new middle plate into ends of timing chain (Fig. 58).
(6) Take off retaining devise at cylinder head.
(7) Remove camshaft sprocket from camshaft with timing chain secured.

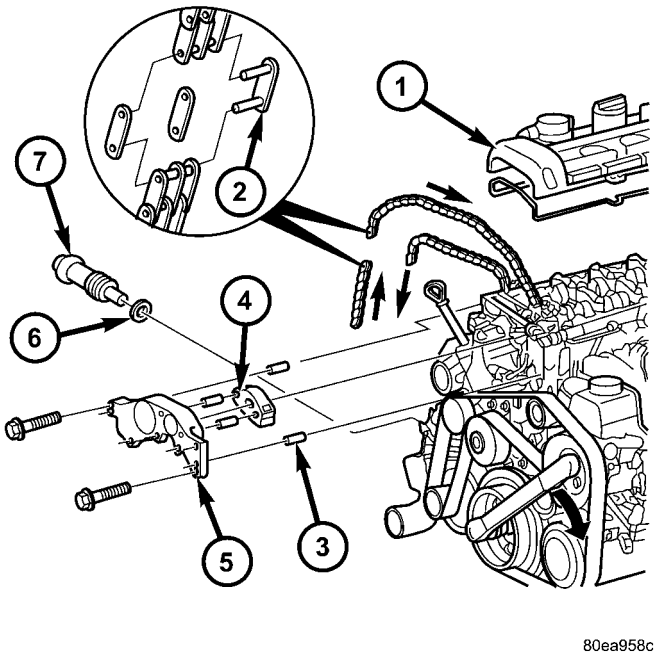



***Fig. 56 Timing Chain Temporary Chain Link - Typical***

1 - CYLINDER HEAD COVER
2 - TIMING CHAIN TEMPORARY LINK
3 - ALIGNMENT PINS
4 - TOP GUIDE RAIL
5 - CYLINDER HEAD FRONT COVER
6 - TIMING CHAIN TENSIONER SEAL
7 - TIMING CHAIN TENSIONER

TIMING CHAIN (Continued)

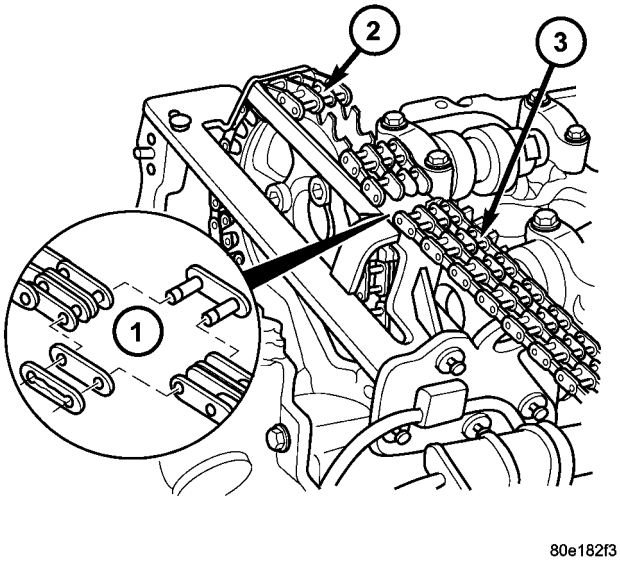



***Fig. 57 Removing Temporary Link***

1 - TEMPORARY LINK
2 - NEW TIMING CHAIN
3 - OLD TIMING CHAIN

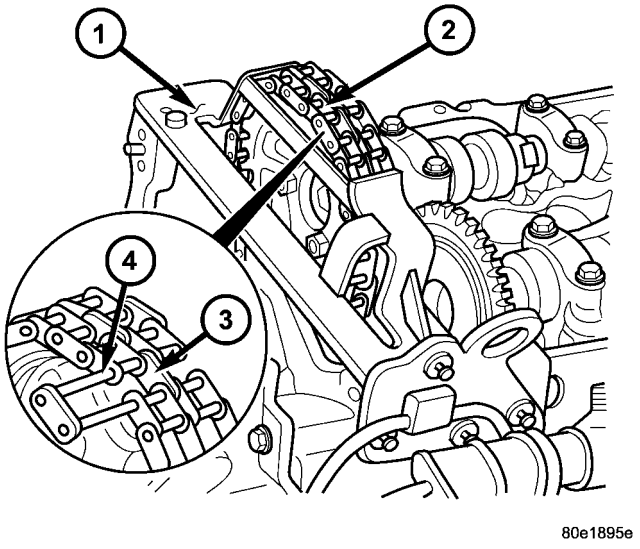



***Fig. 58 Insert New Riveted Link***

1 - SPECIAL TOOL #8931
2 - NEW TIMING CHAIN ENDS
3 - NEW MIDDLE PLATE
4 - NEW RIVETED LINK

**NOTE: When assembling riveting tool, piece F5 is secured by a screw and D9 can move loosely on thrust spindle**

(8) Assemble riveting tool by inserting pieces F5 and D9 (Fig. 59).

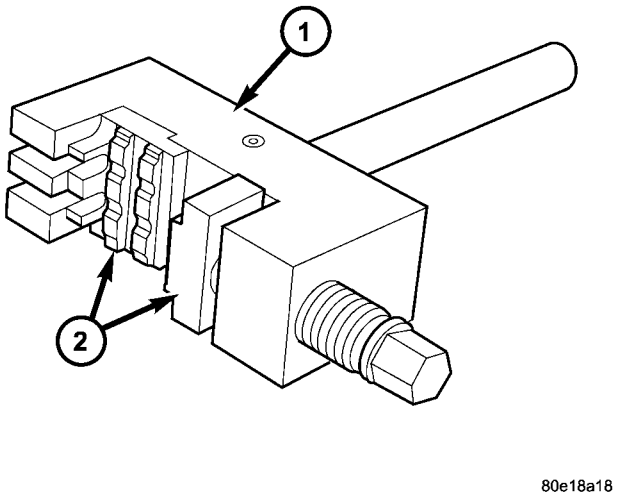



***Fig. 59 Installing Assembly Inserts into Riveting Tool***

1 - SPECIAL TOOL #8947
2 - SPECIAL TOOL #8952

**NOTE: Ensure that the riveted link and riveting tool are aligned.**

(9) Press in new riveted link as far as the stop (Fig. 60).

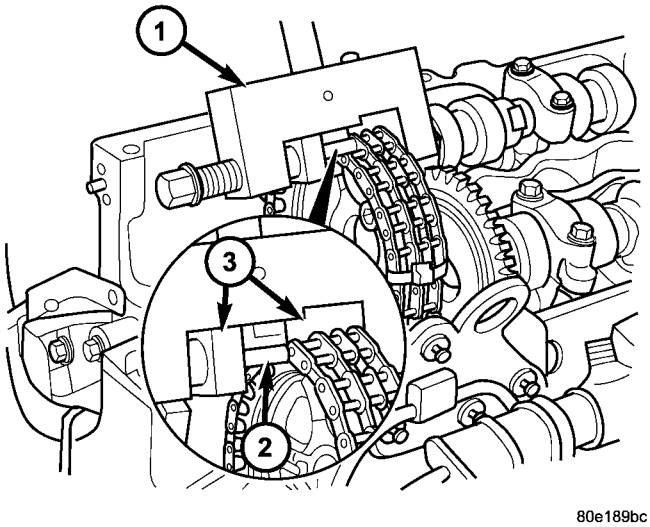



***Fig. 60 PRESSING IN NEW RIVETED LINK***

1 - SPECIAL TOOL #8947
2 - NEW RIVETED LINK
3 - SPECIAL TOOL #8952

TIMING CHAIN (Continued)

(10) Remove riveting tool to change inserts.
(11) Install insert F1 on riveting tool and secure with screw (Fig. 61).
(12) Install insert D8 on riveting tool (Fig. 61).

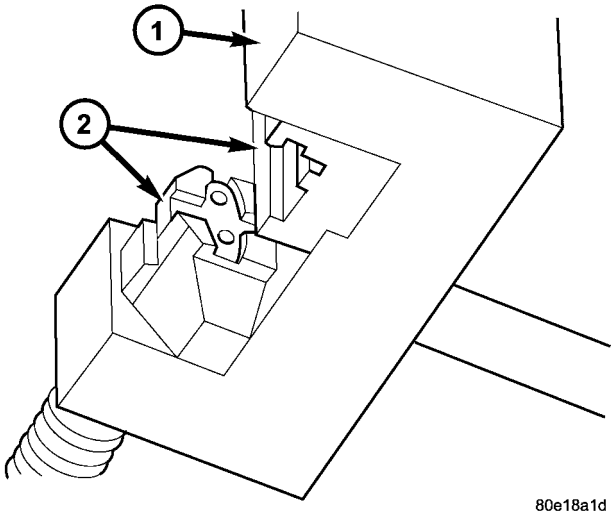



***Fig. 61 Installing Riveting Inserts Into Riveting Tool***

1 - SPECIAL TOOL #8947
2 - SPECIAL TOOL #8949

**NOTE: The outer plate is held magnetically by riveting tool.**

(13) Insert new outer plate into the moving assembly insert.
(14) Position riveting tool so that spacer webs of the guide are side by side.
(15) Ensure that riveted link and outer plate are aligned (Fig. 62).

**NOTE: When turning spindle of riveting tool, be sure that pins of riveted link are inserted into holes of outer plate (Fig. 62).**

(16) Screw in spindle of riveting tool until firm resistance is felt (Fig. 62).
(17) Remove riveting tool.
(18) Turn over moving assembly insert (D8) to the riveting profile.
(19) Position riveting tool exactly over middle of pin.
(20) Tighten riveting tool spindle to end of travel.
(21) Repeat procedure for both riveting pins (Fig. 63).
(22) Inspect riveting, rerivet if required (Fig. 64).
(23) Install camshaft sprocket with timing chain retained onto camshaft. Tighten camshaft bolts to 18N·m (159 lbs.in.).
(24) Remove camshaft sprocket to timing chain tie straps.

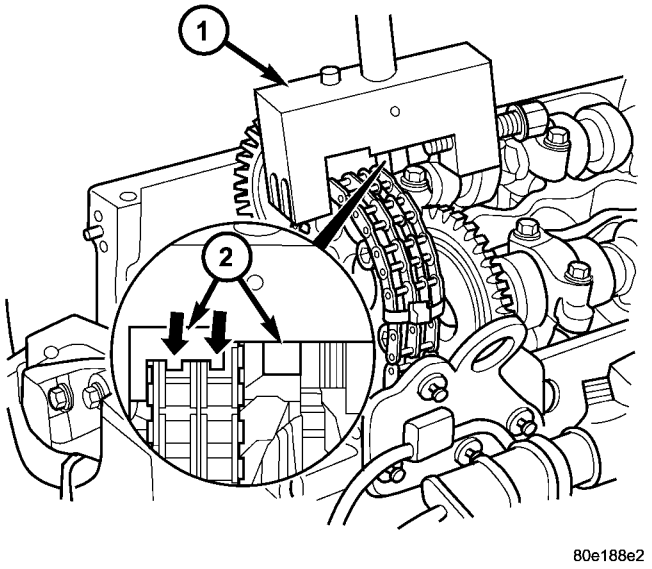



***Fig. 62 Installing Link Outer Plate***

1 - SPECIAL TOOL #8947
2 - SPECIAL TOOL #8949

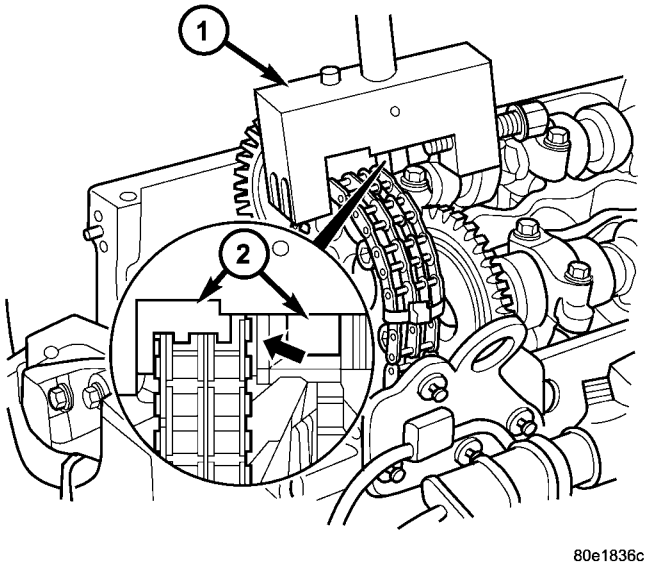
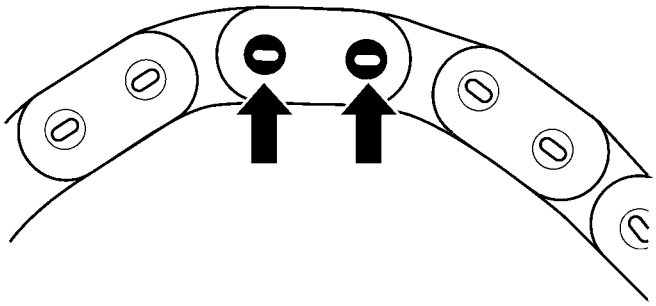



***Fig. 63 Riveting Links of the Riveted Link***

1 - SPECIAL TOOL #8947
2 - SPECIAL TOOL #8949

(25) Install cylinder head front cover and guide rail (Refer to 9 - ENGINE/CYLINDER HEAD - INSTALLATION).
(26) Install timing chain tensioner (Refer to 9 - ENGINE/VALVE TIMING/TIMING BELT/CHAIN AND SPROCKETS - INSTALLATION).
(27) Install cylinder head cover (Refer to 9 - ENGINE/CYLINDER HEAD/CYLINDER HEAD COVER(S) - INSTALLATION).
(28) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).

TIMING CHAIN (Continued)



80e1834d

*Fig. 64 Rivet Inspection*

(29) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN THE ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR THE PULLEYS BELTS OR FAN. DO NOT WEAR LOOSE CLOTHES.**

# TIMING CHAIN TENSIONER

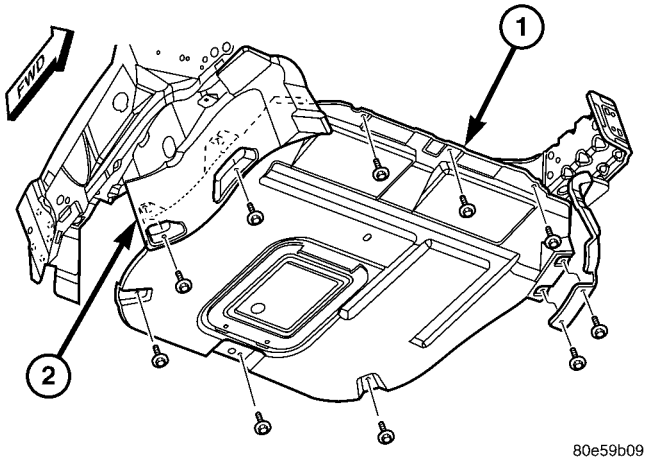
## REMOVAL

### TIMING CHAIN TENSIONER

(1) Disconnect negative battery cable.
(2) Raise vehicle on hoist.
(3) Remove engine compartment lower silencer and accessory drive belt splash shield (Fig. 65).

**CAUTION: Rotate engine at crankshaft only. DO NOT rotate the engine with the bolt of the camshaft sprocket. DO NOT rotate the engine counter clockwise.**

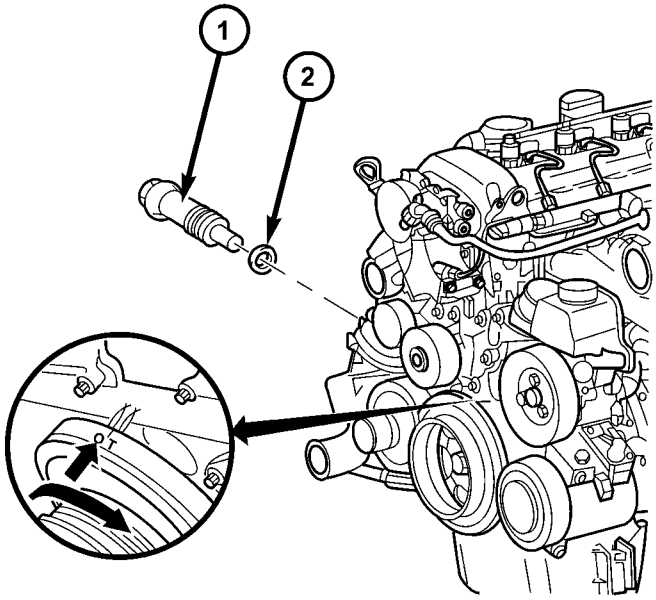
(4) Position piston of number #1 cylinder to ignition TDC.
(5) Remove timing chain tensioner (Fig. 66).




80e59b09

*Fig. 65 ENGINE COMPARTMENT LOWER SILENCER*

1 - ENGINE COMPARTMENT SILENCER
2 - ACCESSORY DRIVE BELT SPLASH SHIELD




80e1dc4f

*Fig. 66 TIMING CHAIN TENSIONER - TYPICAL*

1 - TIMING CHAIN TENSIONER
2 - TIMING CHAIN TENSIONER SEAL

TIMING CHAIN TENSIONER (Continued)

## INSTALLATION

### TIMING CHAIN TENSIONER

**NOTE: Carefully clean all mating surfaces with appropriate solvents to assure that no grease or oil is present during reassembly.**

(1) Install timing chain tensioner with new gasket. Tighten to 80N·m (59 lbs.ft.).
(2) Install engine compartment lower silencer and accessory drive belt splash shield.
(3) Lower vehicle.
(4) Connect negative battery cable.

# INTAKE MANIFOLD

### DESCRIPTION

The intake manifold is one-piece design and is made of a composite material (Fig. 67).

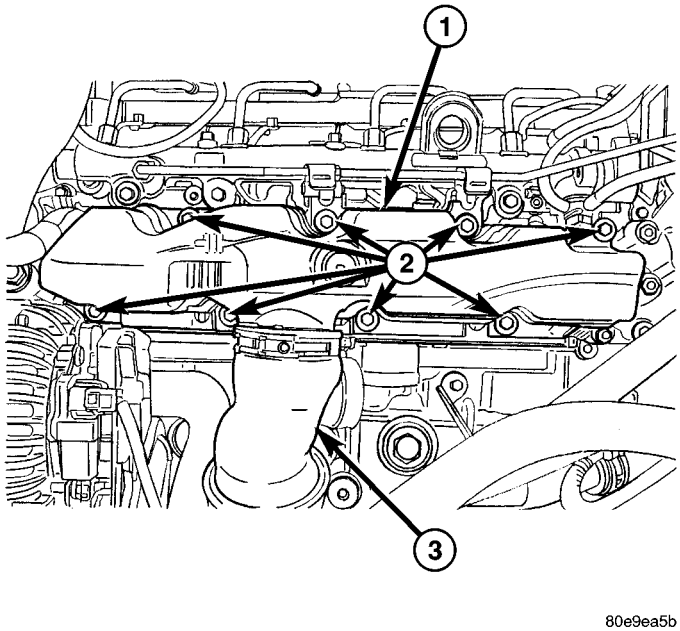



***Fig. 67 INTAKE MANIFOLD***

1 - INTAKE MANIFOLD
2 - INTAKE MANIFOLD RETAINING BOLTS
3 - INTAKE INLET HOSE

### REMOVAL

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Discharge air conditioning system (Refer to 24 - HEATING & AIR CONDITIONING - STANDARD PROCEDURE).
(4) Drain cooling system (Refer to 7 - COOLING/ ENGINE/COOLANT - STANDARD PROCEDURE).
(5) Remove front grille assembly (Refer to 23 - BODY/EXTERIOR/GRILLE - REMOVAL).
(6) Remove radiator closure panel (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - REMOVAL).
(7) Disconnect upper radiator hose from radiator.
(8) Raise vehicle on hoist.
(9) Disconnect lower radiator hose at radiator.
(10) Disconnect cooling fan electrical connector.
(11) Lower vehicle.
(12) Disconnect both A/C lines at condenser.
(13) Remove A/C condenser to radiator mounting screws and remove condenser.
(14) Unclip charge air cooler from radiator.
(15) Lift radiator and cooling fan assembly from vehicle.
(16) Disconnect swirl valve actuator hose at actuator (Fig. 68).
(17) Disconnect air inlet hose from intake manifold (Fig. 69).
(18) Remove high pressure fuel line to fuel rail retaining brackets (Fig. 68).

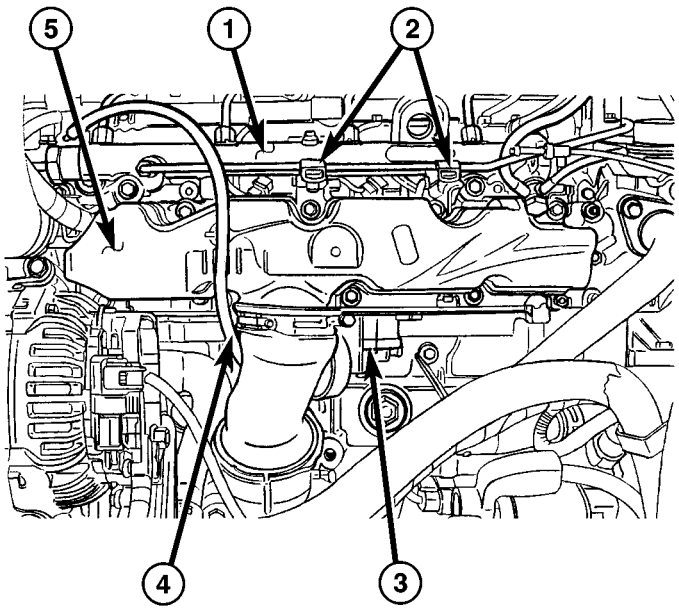
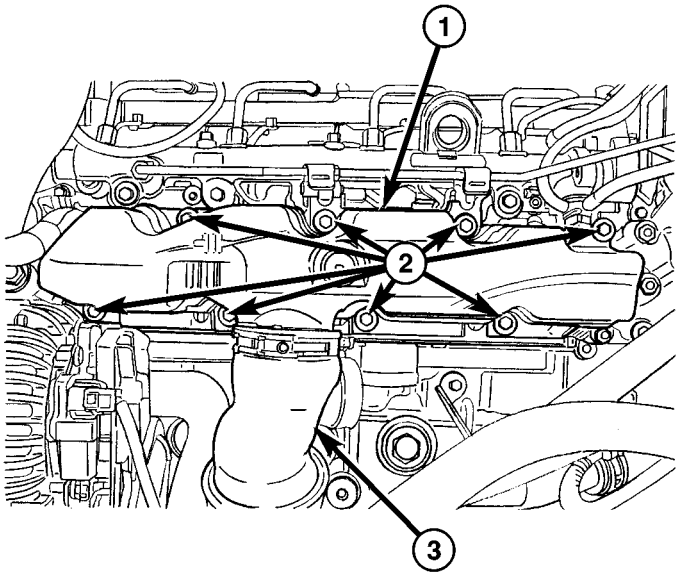



***Fig. 68 Intake Manifold Components***

1 - FUEL RAIL
2 - HIGH PRESSURE FUEL LINE BRACKETS
3 - SWIRL VALVE ACTUATOR
4 - SWIRL VALVE ACTUATOR VACUUM HOSE
5 - INTAKE MANIFOLD

INTAKE MANIFOLD (Continued)

(19) Remove remaining intake manifold retaining bolts and remove manifold from engine (Fig. 69).




80e9ea5b

***Fig. 69 Intake Manifold***

1 - INTAKE MANIFOLD
2 - INTAKE MANIFOLD RETAINING BOLTS
3 - INTAKE INLET HOSE

## CLEANING

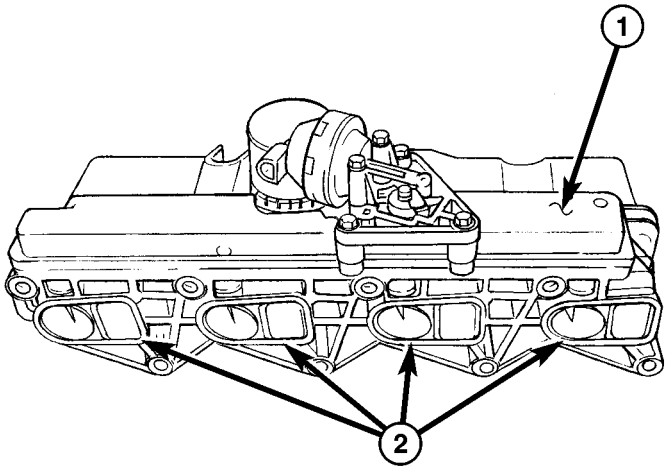
(1) Discard gasket(s).
(2) Clean all sealing surfaces.

## INSPECTION

(1) Inspect manifold for cracks or distortion. Replace manifold if necessary.
(2) Inspect manifold for gasket surface damage or warpage. Replace manifold if necessary.

## INSTALLATION

(1) Clean gaskets/seals mating surfaces.
(2) Install new intake manifold seals on intake manifold (Fig. 70).
(3) Place intake on cylinder head and install retaining bolts (Fig. 69). **Be sure to install high pressure fuel line brackets in proper position (Fig. 68).** Torque bolts to 20N·m (14.7 lbs.ft.).
(4) Connect air inlet hose at intake manifold (Fig. 69).
(5) Connect swirl valve actuator hose at actuator (Fig. 68).




80e9eab3

***Fig. 70 Intake Manifold Seals***

1 - INTAKE MANIFOLD
2 - INTAKE MANIFOLD SEALS

(6) Lower radiator and cooling fan assembly in vehicle. Attach charge air cooler to radiator.
(7) Attach A/C condenser to radiator with retaining screws.
(8) Connect both A/C lines at condenser.
(9) Raise vehicle on hoist.
(10) Connect cooling fan electrical connector.
(11) Connect lower radiator hose at radiator.
(12) Lower vehicle.
(13) Connect upper radiator hose at radiator.
(14) Install radiator closure panel (Refer to 23 - BODY/EXTERIOR/RADIATOR CROSSMEMBER - INSTALLATION).
(15) Install front grille assembly (Refer to 23 - BODY/EXTERIOR/GRILLE - INSTALLATION).
(16) Refill cooling system (Refer to 7 - COOLING/ ENGINE/COOLANT - STANDARD PROCEDURE).
(17) Evacuate and recharge air conditioning system (Refer to 24 - HEATING & AIR CONDITIONING - STANDARD PROCEDURE).
(18) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).
(19) Connect negative battery cable.

# AIR CLEANER ELEMENT

## REMOVAL

(1) Unfasten clasps on sides of air cleaner housing cover. Lift cover off air cleaner housing (Fig. 71).

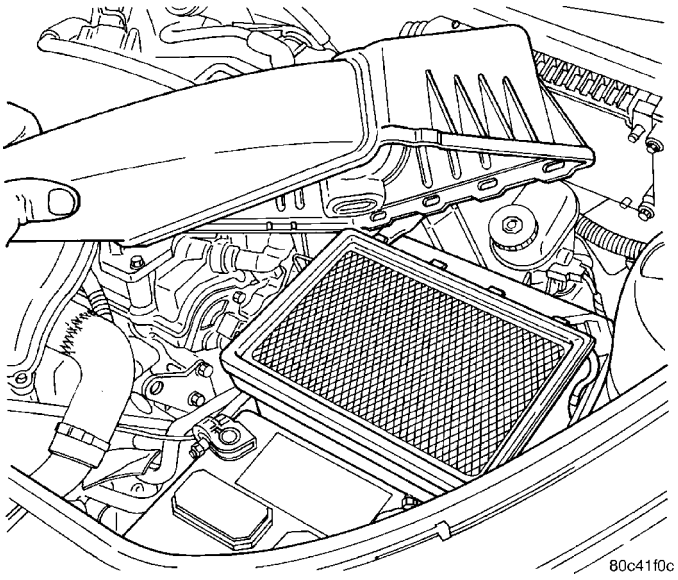



***Fig. 71 Air Cleaner Cover - Typical***

(2) Remove filter element.

(3) If necessary, clean the inside of the air cleaner housing.

## INSTALLATION

(1) Install new filter element.

(2) Place cover over air cleaner housing. Snap clasps in place.

# AIR CLEANER HOUSING

## DESCRIPTION

The air cleaner housing attaches to the inner fender in front of the left side strut tower (Fig. 72). An ambient air duct supplies underhood air for the engine. It attaches to the lower air cleaner box.

## REMOVAL

### AIR CLEANER HOUSING

(1) Disconnect turbocharger inlet hose at air cleaner (Fig. 72).

(2) Pull air cleaner housing straight up to remove (Fig. 72).

(3) Remove the inlet duct from the air cleaner housing (Fig. 72).

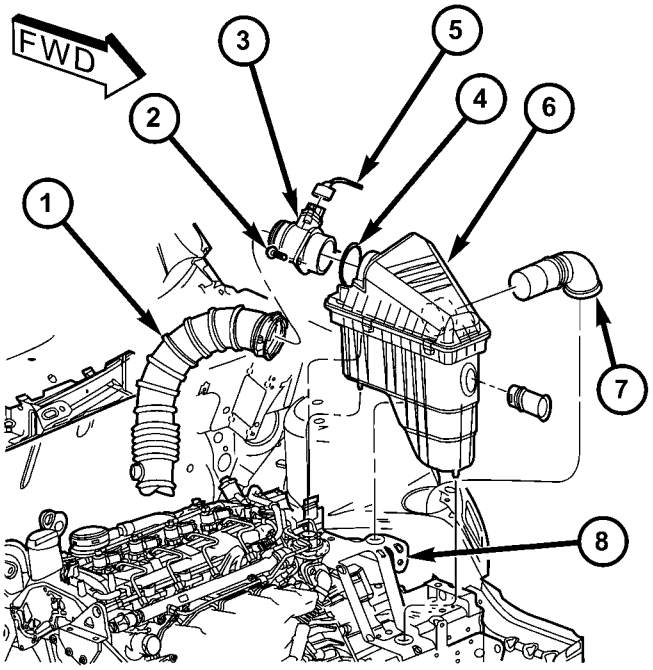



***Fig. 72 Air Cleaner Housing Assembly***

1 - TURBOCHARGER INLET HOSE
2 - MAF SENSOR RETAINING BOLT
3 - MAF SENSOR
4 - O-RING
5 - MAF SENSOR ELECTRICAL CONNECTOR
6 - AIR CLEANER ASSEMBLY
7 - INLET DUCT
8 - AIR CLEANER HOUSING ASSEMBLY BRACKET

AIR CLEANER HOUSING (Continued)

## REMOVAL

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

(2) Disconnect turbocharger inlet hose at MAF sensor (Fig. 73).

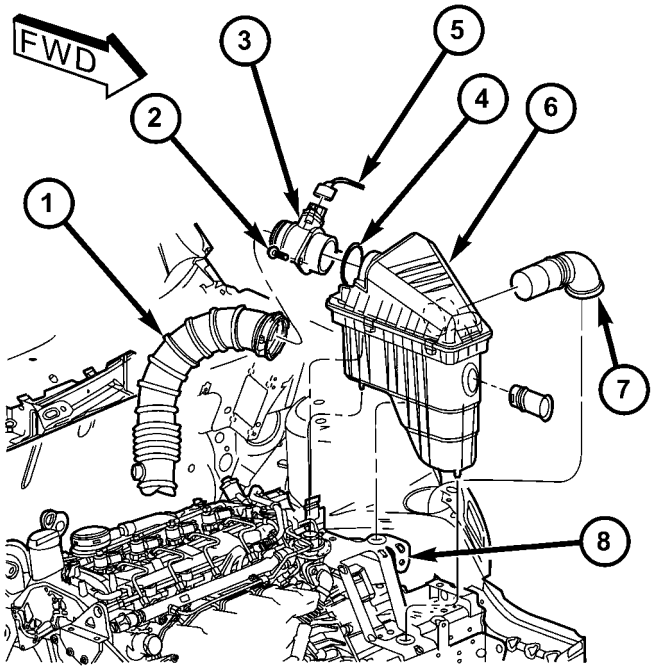



***Fig. 73 Air Cleaner Housing Assembly***

1 - TURBOCHARGER INLET HOSE
2 - MAF SENSOR RETAINING BOLT
3 - MAF SENSOR
4 - O-RING
5 - MAF SENSOR ELECTRICAL CONNECTOR
6 - AIR CLEANER ASSEMBLY
7 - INLET DUCT
8 - AIR CLEANER HOUSING ASSEMBLY BRACKET

(3) Disconnect turbocharger inlet hose at turbocharger and remove inlet tube (Fig. 74).

# INSTALLATION

## AIR CLEANER HOUSING

Make sure that the rubber grommets, for the lower pins, are in place when reinstalling the air cleaner housing (Fig. 72). The rubber grommet for the PDC bracket must be installed also.

(1) Install air inlet duct into air cleaner housing (Fig. 72).

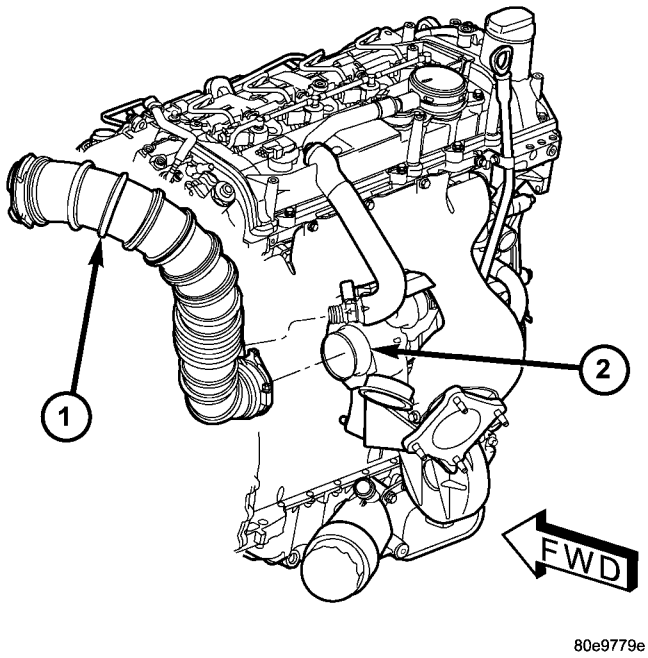



***Fig. 74 Turbocharger Inlet Hose***

1 - TURBOCHARGER INLET HOSE
2 - TURBOCHARGER

(2) Lower air cleaner housing assembly into engine compartment and align studs at bottom of housing with bracket. Push housing assembly down until fully seated in bracket (Fig. 72).

(3) Connect turbocharger inlet hose to air cleaner assembly (Fig. 72).

## INSTALLATION

(1) Connect turbocharger inlet hose at turbocharger (Fig. 74).

(2) Connect turbocharger inlet hose at MAF sensor (Fig. 73).

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

# ENGINE MOUNTING

## DESCRIPTION

The engine mounting system consists of a four-point system utilizing two load-carrying mounts and two torque struts. The load-carrying mounts are located on each frame rail. The right mount is a hydro-elastic mount and left mount is a conventional elastomeric isolator. The two torque controlling struts are attached at the front of the engine, straddling the right side load-carrying mount. The upper strut connects to the suspension strut tower and the lower to the suspension crossmember.

ENGINE MOUNTING (Continued)

### OPERATION

The four-point engine mounting system minimizes the transmission of structure-borne engine noise to the passenger compartment. The load-carrying right and left mounts dampen and isolate vertical motion and vibration. The two struts absorbs torque reaction forces and torsional vibrations.

## TORQUE STRUT

## REMOVAL

### REMOVAL - UPPER

(1) Remove bolts attaching upper torque strut to shock tower bracket and engine mount bracket (Fig. 75).

(2) Remove the upper torque strut.

### REMOVAL - LOWER

(1) Raise vehicle on hoist.

(2) Remove accessory drive belt splash shield (Fig. 76).

(3) Remove pencil strut (Fig. 77).

(4) Remove bolts attaching lower torque strut to crossmember and strut bracket (Fig. 77).

(5) Remove lower torque strut.

## INSTALLATION

### UPPER

(1) Position the upper torque strut into mounting location (Fig. 75).

(2) Install the torque strut mounting bolts and perform the torque strut adjustment procedure (Refer to 9 - ENGINE/ENGINE MOUNTING/TORQUE STRUT - ADJUSTMENTS).

### LOWER

(1) Position lower torque strut into mounting locations.

(2) Install mounting bolts and perform torque strut adjustment procedure (Refer to 9 - ENGINE/ ENGINE MOUNTING/TORQUE STRUT - ADJUSTMENTS).

(3) Install pencil strut and tighten nuts to 58 N·m (43 ft. lbs.) (Fig. 77).

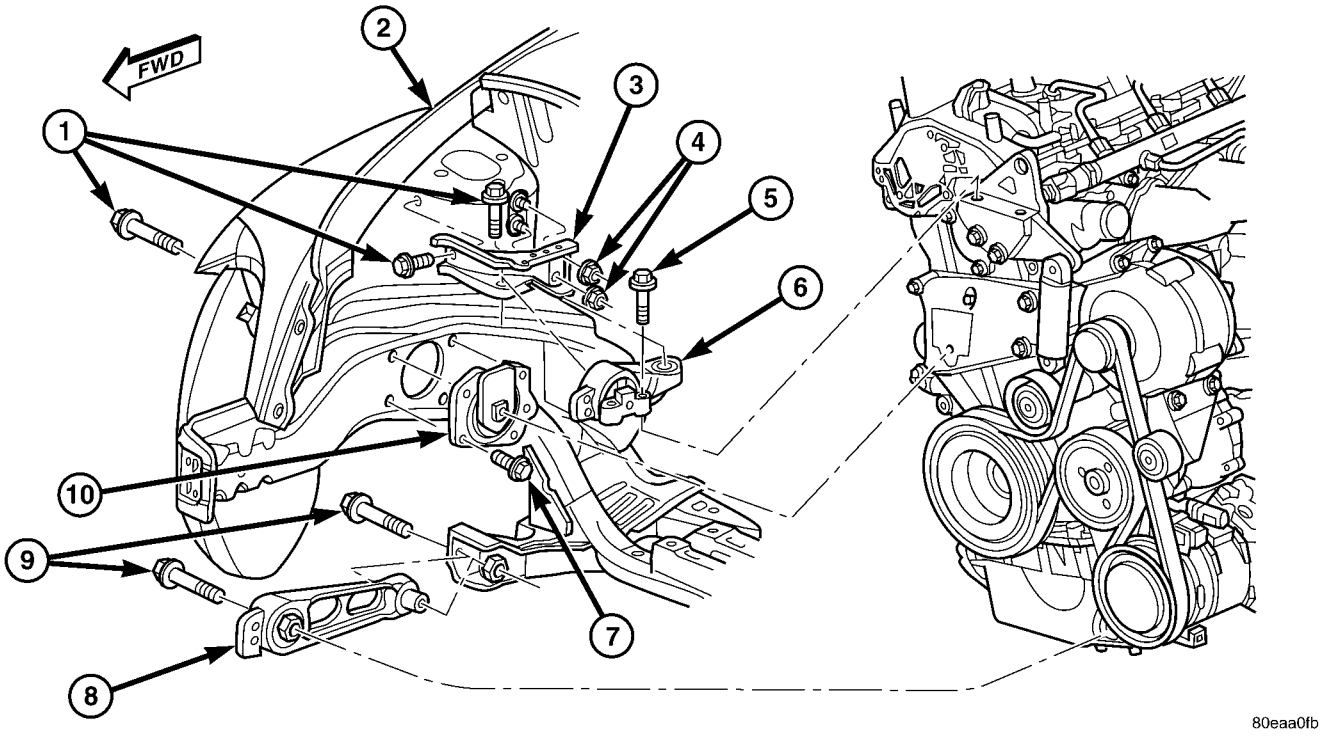



***Fig. 75 Engine Mounting - Right Side***

1 - BOLT
2 - RIGHT FENDER
3 - UPPER TORQUE STRUT BRACKET
4 - NUTS
5 - BOLT
6 - UPPER TORQUE STRUT
7 - BOLT
8 - LOWER TORQUE STRUT
9 - BOLT
10 - RIGHT ENGINE MOUNT

TORQUE STRUT (Continued)

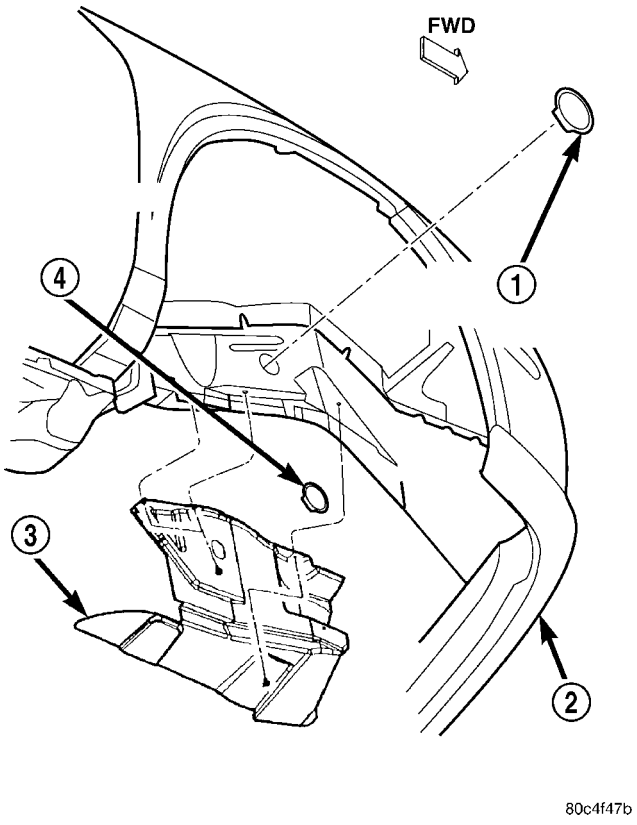



***Fig. 76 Splash Shield***

1 - RIGHT MOUNT BOLT ACCESS PLUG
2 - FASCIA
3 - SPLASH SHIELD
4 - CRANKSHAFT BOLT ACCESS PLUG

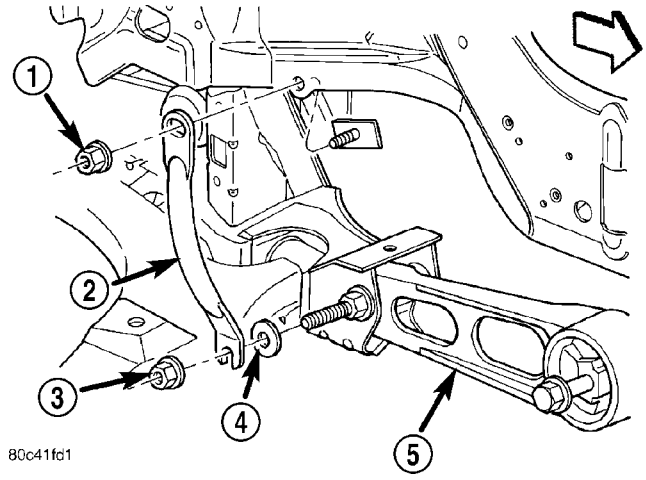



***Fig. 77 Pencil Strut***

1 - NUT
2 - PENCIL STRUT
3 - NUT
4 - FLAT WASHER
5 - LOWER TORQUE STRUT

(4) Install accessory belt splash shield (Fig. 76) and lower vehicle.

## ADJUSTMENTS

### ENGINE TORQUE STRUT ADJUSTMENT

The upper and lower torque struts need to be adjusted together to assure proper engine positioning and engine mount loading. Whenever a torque strut bolt(s) is loosened, this procedure must be performed.

(1) Remove accessory drive belt splash shield (Fig. 76).

(2) Remove pencil strut (Fig. 77).

(3) Loosen the upper and lower torque strut attaching bolt at the suspension crossmember and shock tower bracket (Fig. 75).

(4) The engine position may now be adjusted by positioning a suitable floor jack on the forward edge of the transmission bell housing (Fig. 78).

**NOTE: The floor jack must be positioned as shown in (Fig. 78) to prevent minimal upward lifting of the engine.**

(5) With the engine supported, remove the upper and lower torque strut attachment bolt(s) at shock tower bracket and suspension crossmember (Fig. 78). Verify that the torque struts are free to move within the shock tower bracket and crossmember. Reinstall the torque strut bolt(s), but do not tighten.

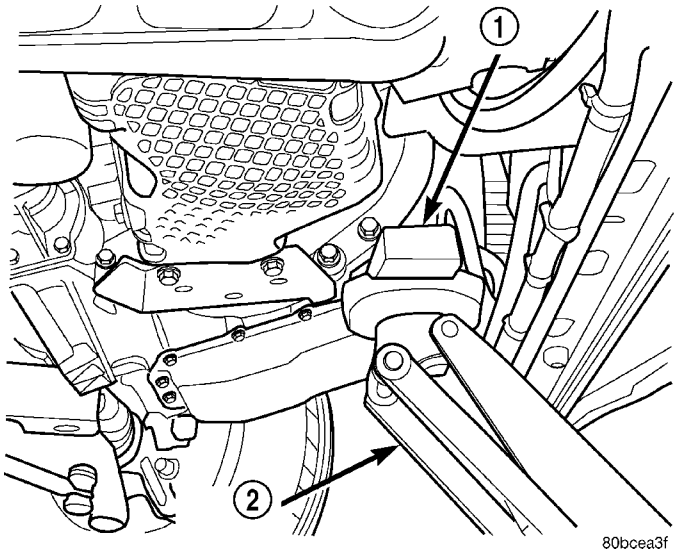



***Fig. 78 Floor Jack Positioning***

1 - WOOD BLOCK
2 - FLOOR JACK

TORQUE STRUT (Continued)

(6) Carefully apply upward force, allowing the upper engine to rotate rearward until the distance between the center of the rearmost attaching bolt on the engine mount bracket (point “A”) and the center of the hole on the shock tower bracket (point “B”) is 119 mm (4.70 in.) (Fig. 79).

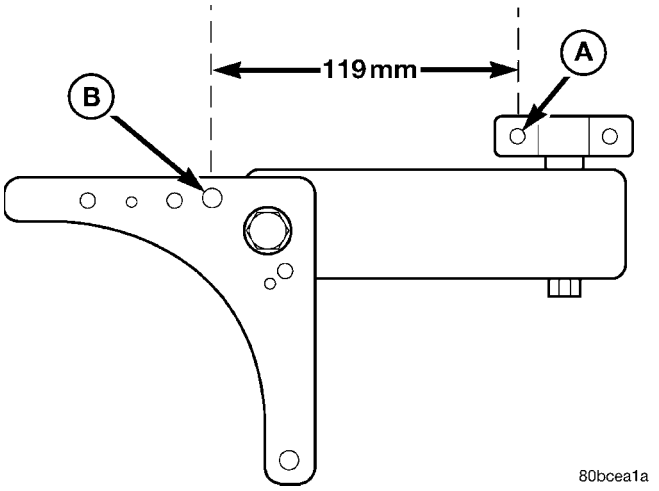



*Fig. 79 Engine Position Measurement*

**CAUTION: The engine must be held in position with jack until both the upper and lower torque strut bolts are tightened.**

(7) With the engine held at the proper position, tighten both the upper and lower torque strut bolts to 115 N·m (85 ft. lbs.) (Fig. 75).

(8) Remove the floor jack.

(9) Install pencil strut and tighten nuts to 58 N·m (43 ft. lbs.) (Fig. 77).

(10) Install accessory drive belt splash shield (Fig. 76).

# RIGHT MOUNT

## REMOVAL

(1) Remove the engine assembly for the required clearance to access the engine mount (Refer to 9 - ENGINE - REMOVAL).

**NOTE: The right engine mount attaching holes are slightly oversize to compensate for manufacturing tolerances. The mount has been set at the manufacturing plant for proper powertrain alignment. Therefore, it is necessary to mark the position of the mount before the attaching bolts are loosened.**

(2) Using a permanent ink marker or equivalent, mark the position of engine mount to the body frame rail.

(3) Remove bolts attaching mount to body (Fig. 80).

(4) Remove mount.

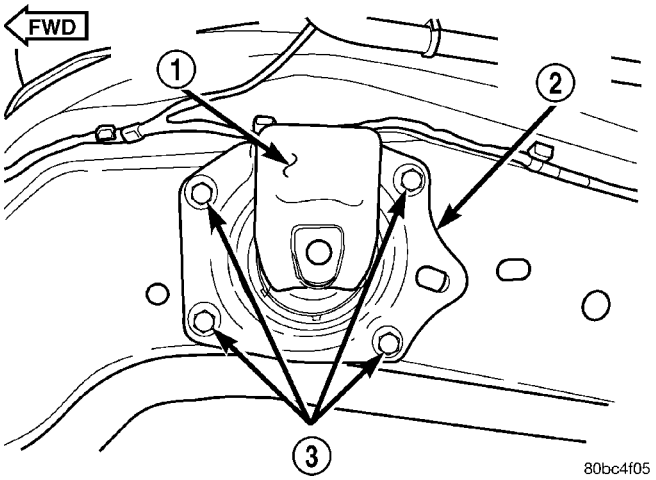



*Fig. 80 Engine Mount—Right*

1 - SNUBBER PAD
2 - RIGHT ENGINE MOUNT
3 - BOLTS

## INSTALLATION

(1) Position mount into the original position on body frame rail (Fig. 80).

**NOTE: Engine mount must be installed in the original position on body frame rail. If mount was not marked or frame rail was replaced, perform the following procedure.**

(2) Perform the following procedure if the mount position was not previously marked, or the frame rail was replaced:

(a) Insert new mount loosely in frame rail.

(b) Align the four holes in the mount with the mating holes in the rail such that the holes are concentric (frame rail holes centered in the mount holes).

(c) Using a permanent ink marker or equivalent, mark the position of engine mount to the body frame rail while maintaining mounting hole concentricity.

(3) Ensure the mount maintains originally marked position and install mount bolts. Tighten bolts to 28 N·m (250 in. lbs.) (Fig. 80).

(4) Install the engine assembly (Refer to 9 - ENGINE - INSTALLATION).

# LEFT MOUNT

## REMOVAL

(1) Disconnect negative battery cable.
(2) Remove air cleaner assembly.
(3) Remove bolts attaching the power distribution center (PDC) bracket to left mount and battery tray (Fig. 81).
(4) Support transaxle with a suitable jack.
(5) Remove mount to transaxle bolts (Fig. 82).
(6) Remove left mount bracket to body frame rail fasteners (Fig. 82).
(7) Remove mount.

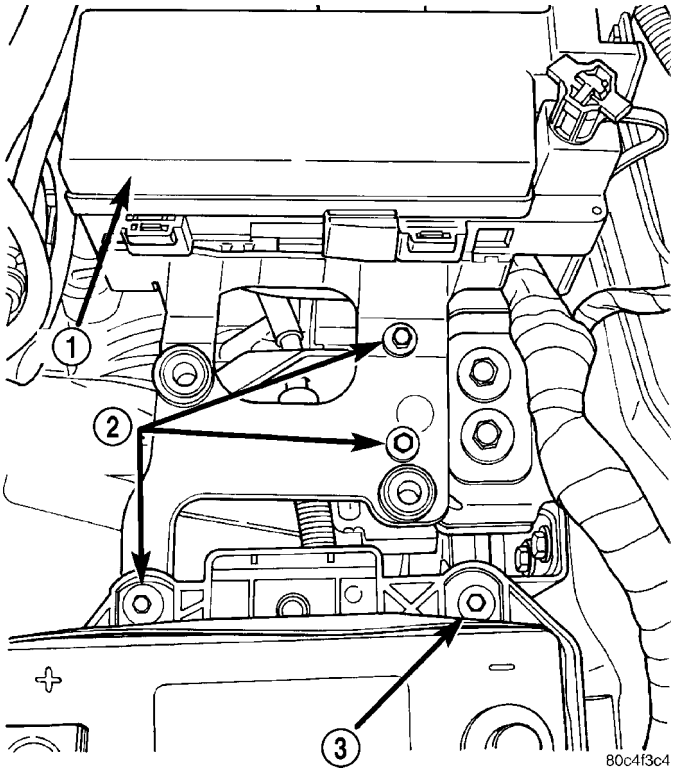



***Fig. 81 PDC Brackett Attaching Bolts - Typical***

1 - PDC
2 - PDC BRACKET BOLTS
3 - BATTERY TRAY BOLT

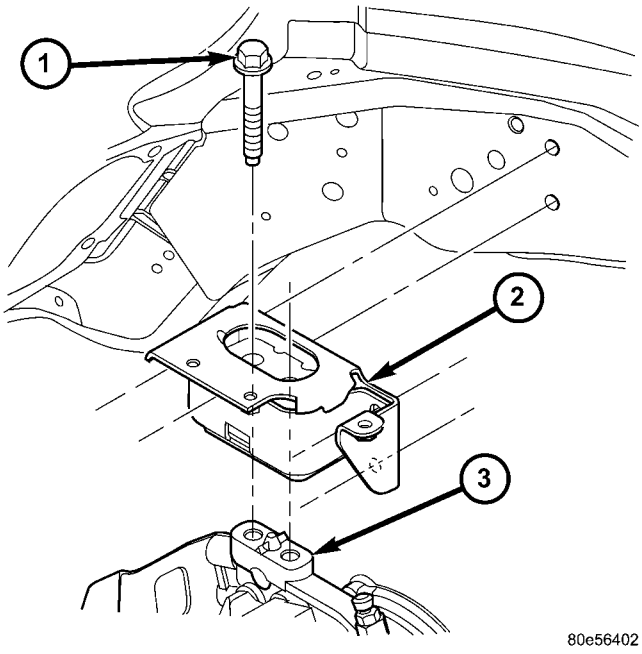



***Fig. 82 LEFT MOUNT - TYPICAL***

1 - BOLT (2)
2 - MOUNT
3 - BRACKET

## INSTALLATION

(1) Install engine mount bracket to body frame rail and tighten fasteners to 28 N·m (250 in. lbs.) (Fig. 82).
(2) Position engine/transaxle for installation of mount to transaxle bolts. Install and tighten bolts to 68 N·m (50 ft. lbs.) (Fig. 82).
(3) Remove jack from under transaxle.
(4) Install bolts attaching the power distribution center (PDC) bracket to left mount and battery tray (Fig. 81).
(5) Install air cleaner assembly.
(6) Connect negative battery cable.

# FUEL SYSTEM

TABLE OF CONTENTS


page

**FUEL SYSTEM - 2.2L DIESEL**
WARNING
WARNING - HIGH FUEL SYSTEM PRESSURE . . . . . 1
WARNING . . . . . 1
DIAGNOSIS AND TESTING
DIAGNOSIS AND TESTING - HIGH PRESSURE FUEL LINES . . . . . 1
DIAGNOSIS AND TESTING - AIR IN FUEL SYSTEM . . . . . 2
DIAGNOSIS AND TESTING - INJECTOR LEAK QUANTITY . . . . . 2

page

STANDARD PROCEDURE
STANDARD PROCEDURES - CLEANING FUEL SYSTEM COMPONENTS . . . . . 3
STANDARD PROCEDURES - DRAINING WATER FROM FUEL FILTER . . . . . 3
STANDARD PROCEDURE - LOW PRESSURE FUEL PUMP TEST . . . . . 3
SPECIAL TOOLS . . . . . 5
**FUEL DELIVERY** . . . . . 6
**FUEL INJECTION** . . . . . 17


## FUEL SYSTEM - 2.2L DIESEL

### WARNING

#### 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.**

#### WARNING

**WARNING: UNDER NO CIRCUMSTANCES SHOULD GASOLINE BE MIXED WITH DIESEL FUEL (NOT EVEN DURING WINTER). THE HIGH PRESSURE PUMP IS LUBRICATED BY DIESEL FUEL. IMMEDIATE FUEL SYSTEM DAMAGE MAY OCCUR CAUSING REPLACEMENT AND FLUSHING OF THE COMPLETE DIESEL FUEL SYSTEM. HIGH PRESSURE PUMP SEIZURE WILL CAUSE METAL PARTICLES TO SPREAD THROUGH OUT THE FUEL CIRCUIT. ALL CDI FUEL SYSTEM COMPONENTS CONNECTED TO THE FUEL CIRCUIT WILL HAVE TO BE EXCHANGED AND THE LINES FLUSHED.**

### DIAGNOSIS AND TESTING

#### DIAGNOSIS AND TESTING - HIGH PRESSURE FUEL LINES

**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 FOR HIGH-PRESSURE FUEL LEAKS WITH A SHEET OF CARDBOARD PLACED IN THE SUSPECTED AREA WHILE THE ENGINE IS NOT RUNNING. START THE VEHICLE AND ALLOW THE ENGINE TO RUN FOR A SHORT PERIOD. TURN THE ENGINE OFF AND INSPECT THE PIECE OF CARDBOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

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

- Turn the engine off.
- Place a piece for cardboard in the suspected area (Fig. 1).
- Start the engine and allow to run for a short period.
- Turn the engine off.
- Inspect the cardboard.

If a high-pressure line connection is leaking, counterhold and tighten the connection to specification then perform this procedure again (Refer to 14 -

FUEL SYSTEM - STANDARD PROCEDURE). Replace any damaged, restricted or leaking high-pressure fuel lines with the correct replacement line.

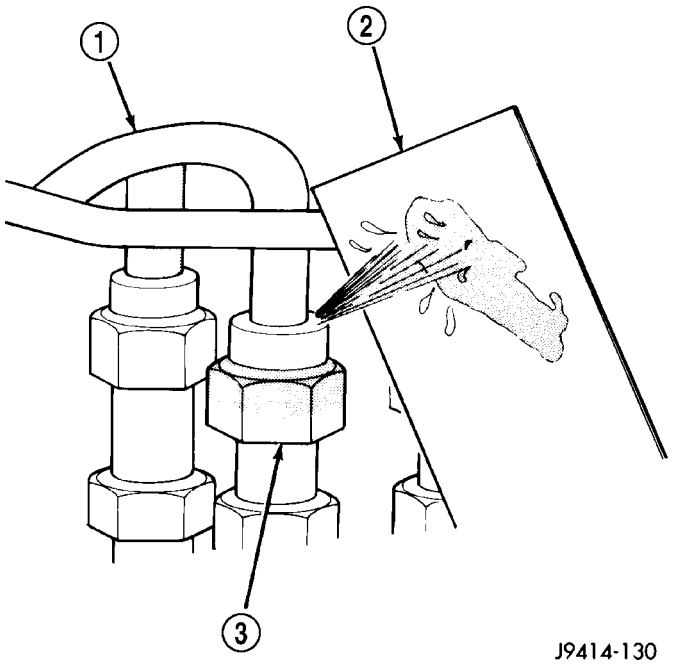



*Fig. 1 Typical Test for Leaks with Cardboard*

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 replacement of high-pressure fuel line is necessary.**

## 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 fuel pump. Inspect the fuel tank module and fuel lines for damage 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, inspect the fuel system for air intrusion.

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 control valve (Refer to 14 - FUEL SYSTEM/ FUEL INJECTION/FUEL PRESSURE SOLENOID - REMOVAL), and recheck.

## DIAGNOSIS AND TESTING - INJECTOR LEAK QUANTITY

**WARNING: REVIEW THE HIGH PRESSURE FUEL SYSTEM WARNING BEFORE BEGINNING SERVICE (Refer to 14 - FUEL SYSTEM - WARNING).**

**NOTE: If an injector is found to be out of specification, repeat this test procedure after the injector replacement. Hydraulic flow will take the path of least resistance and multiple failures may be identified.**

Perform this test with the engine at operating temperature. This test will assist in determining a defective or internally leaking injector(s) is present by measuring the amount of fuel return.

(1) Turn the ignition off.

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

(3) Disconnect the fuel return hoses at the top of the injectors.

(4) Disconnect and block off the oil return line at the banjo bolt fitting of the fuel rail.

(5) Disconnect the fuel rail solenoid.

(6) Install the test vials onto the injectors and secure with the return hose clips (Fig. 2).

(7) Crank the engine for ten seconds while monitoring each inner test vial.

After ten seconds, a maximum of two graduation lines may be reached. If the level has exceeded the two graduation line, replace that effected cylinder's injector, clear the memory using the scan tool, empty the test vials, and retest. If the level did not pass the two graduation line limit, continue to the next step.

(8) Turn the ignition off. Leave the emptied test vials in place. Reconnect the fuel pressure solenoid. Disconnect the cam position sensor, crank the engine for ten seconds.

After ten seconds, a maximum of four graduation lines of the inner test vial may be reached. If the level has exceeded the four graduation line, replace that effected cylinder's injector, clear the memory using the scan tool, empty the test vials, and retest.

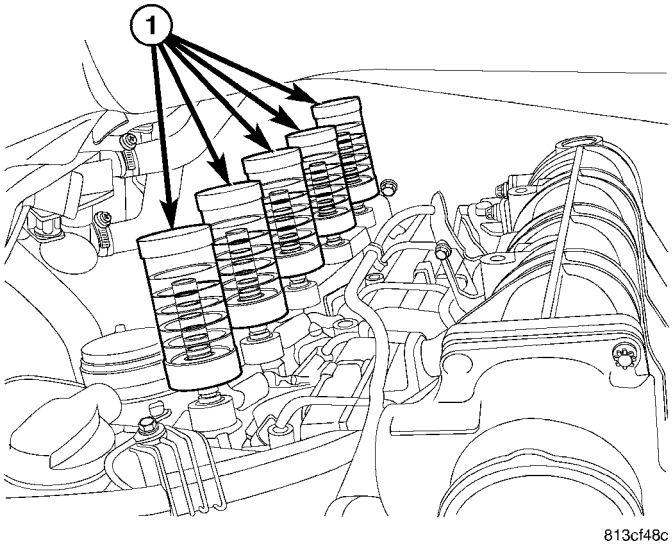



***Fig. 2 Special Tool # 9545***

1 - SPECIAL TOOL #9545

If the level did not pass the four graduation line limit, continue with the diagnostic manual.

## STANDARD PROCEDURE

### 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.**

### STANDARD PROCEDURES - DRAINING WATER FROM FUEL FILTER

Connect a hose to the Water in Fuel (WIF) drain and place it in a clearly marked and suitable container. Open the WIF drain by turning counterclockwise (Fig. 3). Turn the ignition key on for 20 seconds (Refer to low pressure fuel pump operation). Repeat the procedure until all water is removed, close the drain and remove the hose.

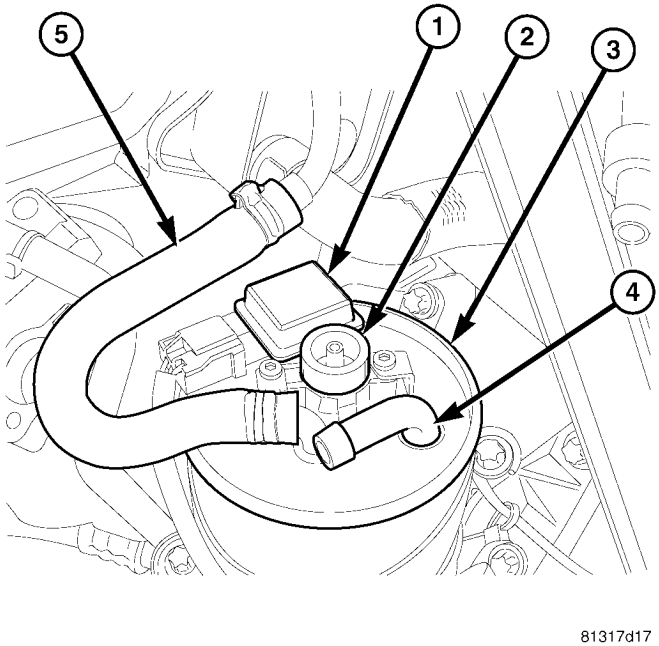



***Fig. 3 WATER IN FUEL SENSOR***

1 - WIF SENSOR
2 - WIF DRAIN
3 - FUEL FILTER
4 - FUEL SUPPLY FROM TANK
5 - FUEL SUPPLY TO HIGH PRESSURE PUMP

### STANDARD PROCEDURE - LOW PRESSURE FUEL PUMP TEST

**NOTE: Assure fuel tank quantity and proper fuel gauge operation. Assure that the fuel pump fuse or relay is not open. Capture any fuel spillage and store in appropriately marked containers.**

**NOTE: When the ignition switch is turned to the On position the fuel pump will begin to run for 20–30 seconds and then it stops.**

The low pressure pump draws fuel out of the fuel tank module mixing bowl and pushes the fuel towards the fuel filter. If the pressure reading is below specification, look for damaged or leaking fuel lines or a restricted fuel filter. If no problem is found with the fuel system replace the low pressure fuel pump.

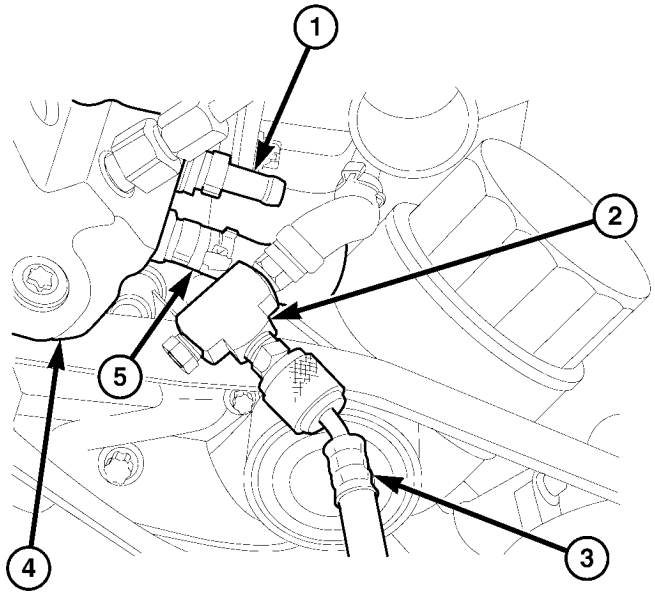
(1) Disconnect the negative battery cable.

(2) Connect a fuel gauge to the low pressure fuel supply to the high pressure pump (Fig. 4).

(3) Connect negative battery cable.

(4) Turn the ignition to the On position and observe the fuel gauge reading (Fig. 5).

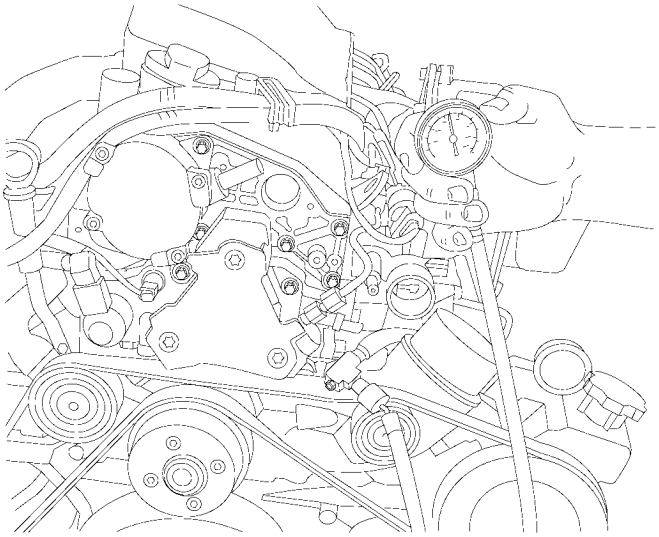
FUEL SYSTEM - 2.2L DIESEL (Continued)




81335dde

***Fig. 4 FUEL GAUGE CONNECT AT HIGH PRESSURE PUMP***

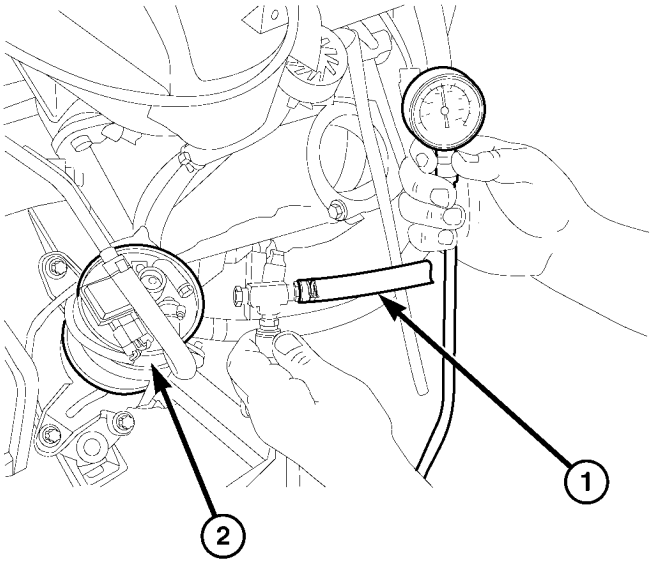
1 - FUEL SUPPLY FITTING
2 - ADAPTOR
3 - FUEL GAUGE HOSE
4 - HIGH PRESSURE PUMP
5 - FUEL RETURN FITTING



81335ddd

***Fig. 5 FUEL PRESSURE TEST AT HIGH PRESSURE PUMP***

If the fuel pressure is within specification, reconnect the fuel line to the high pressure pump and continue with the diagnostics. If the fuel pressure is below specification, disconnect the low pressure fuel pump input line to the fuel filter and re-test following the steps above (Fig. 6).




81335ddb

***Fig. 6 FUEL PRESSURE TEST AT FILTER***

1 - FUEL SUPPLY FROM FUEL TANK
2 - FUEL FILTER ASSEMBLY

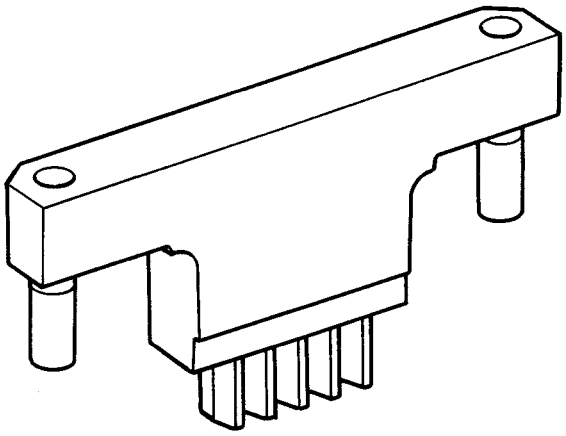
If the fuel pressure is below specification, replace the fuel pump. If the fuel pressure is equal to the specification, replace the fuel filter.

*FUEL PRESSURE SPECIFICATIONS*

| | |
|---|---|
| SUCTION PRESSURE | 7.25 PSI (0.5 bar) |
| DELIVERY PRESSURE | 65 PSI (4.5 bar) |
| MAXIMUM FUEL DELIVERY | 53 gallons/hour(200 liters/hour) |

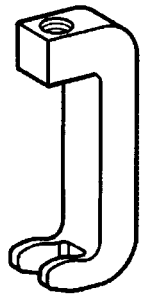
FUEL SYSTEM - 2.2L DIESEL (Continued)

## SPECIAL TOOLS



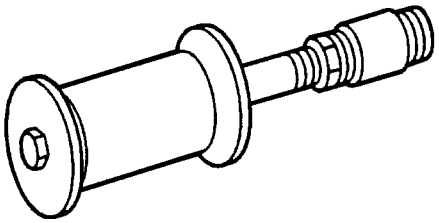
80ea91fc

***#8933 CRANKSHAFT LOCK***



80e492ee

***#8938 EXTRACTION CLAW***



80e492f2

***#8937 SLIDE HAMMER***

# FUEL DELIVERY

## TABLE OF CONTENTS


page

**FUEL DELIVERY**
DIAGNOSIS AND TESTING - FUEL DELIVERY SYSTEM . . . . . 6
**FUEL DRAIN TUBES**
DESCRIPTION . . . . . 7
**FUEL INJECTION PUMP**
DESCRIPTION . . . . . 7
OPERATION . . . . . 7
REMOVAL . . . . . 8
INSTALLATION . . . . . 9
**FUEL RAIL**
DESCRIPTION . . . . . 9
OPERATION . . . . . 9
REMOVAL . . . . . 10
INSTALLATION . . . . . 10
**FUEL LINES**
REMOVAL - HIGH PRESSURE LINES . . . . . 11
INSTALLATION - HIGH PRESSURE LINES . . . . 11

page

**FUEL TANK**
DESCRIPTION . . . . . 12
OPERATION . . . . . 12
**FUEL PUMP MODULE**
DESCRIPTION - FUEL PUMP MODULE . . . . . 13
OPERATION . . . . . 13
**FUEL FILTER/FUEL HEATER**
DESCRIPTION . . . . . 13
DIAGNOSIS AND TESTING
DIAGNOSIS AND TESTING - FUEL FILTER . . 14
DIAGNOSIS AND TESTING - FUEL HEATER . 15
REMOVAL
REMOVAL . . . . . 15
REMOVAL - FUEL FILTER . . . . . 15
INSTALLATION
INSTALLATION . . . . . 16
INSTALLATION - FUEL FILTER . . . . . 16


# FUEL DELIVERY

## DIAGNOSIS AND TESTING - FUEL DELIVERY SYSTEM

**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.**

| CONDITION | POSSIBLE CAUSES | CORRECTION |
|---|---|---|
| No Start/Hard Start/Start and Stall | Contaminated Fuel | Drain, Flush and Refill Fuel System |
| | Low Fuel Pressure to Fuel Filter | Test Fuel Pump Pressure |
| | Restricted Fuel Filter | Replace Fuel Filter |
| | Fuel Heater Inoperative | Test Fuel Heater and circuitry |
| | Restricted or Leaking Fuel Lines | Inspect/ Replace necessary fuel line(s) |
| | Stored Diagnostic Trouble Codes | Refer to the appropriate Diagnostic Service Manual |
| Stalls Under Aggressive Maneuvers/Loss Of Fuel Pressure | Restricted or Damaged Fuel Pump Lower Filter | Test Fuel Pump Pressure |
| | Contaminated Fuel | Drain, Flush and Refill Fuel System |
| | Damaged Fuel Tank | Replace Fuel Tank |

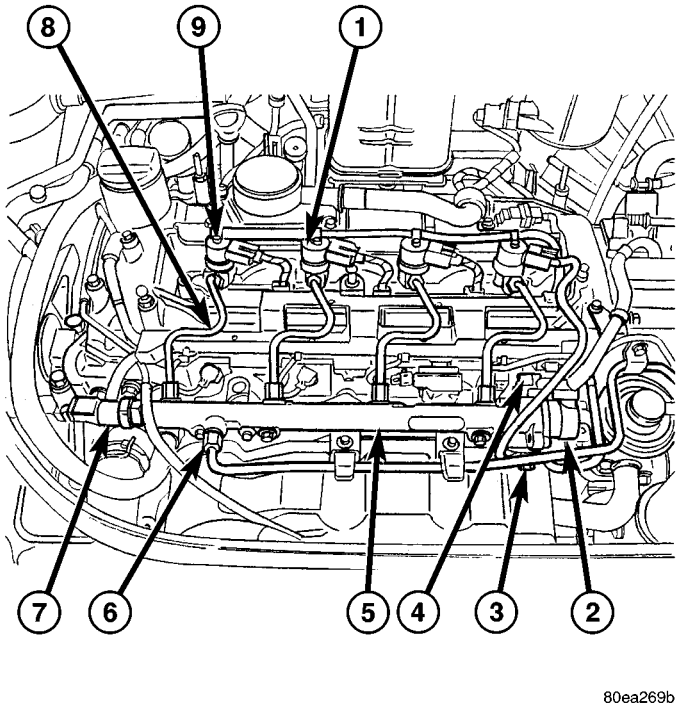
FUEL DELIVERY (Continued)

| CONDITION | POSSIBLE CAUSES | CORRECTION |
|---|---|---|
| | Restricted Fuel Filter | Replace Fuel Filter |
| Cannot Refill Fuel Tank/Excessive Pressure in Fuel Tank When Cap Is Removed | Sticking or Damaged Fuel Tank Fill/Vent Valve | Replace Fuel Tank |
| | Restricted or Damaged Fuel Tank Fill/Vent Valve Filter or Hose | Replace Fuel Tank Vent Filter |

# FUEL DRAIN TUBES

## DESCRIPTION

The fuel drain tubes connect to the top of all four injectors (Fig. 1). These tubes are used to return unused fuel from the fuel injectors to the fuel filter.




80ea269b

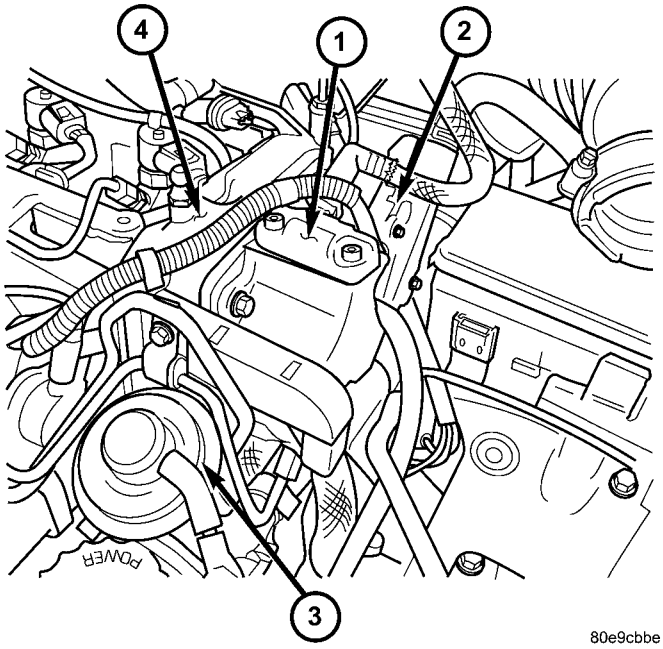
***Fig. 1 FUEL SYSTEM COMPONENTS***

1 - FUEL INJECTOR
2 - FUEL PRESSURE SOLENOID
3 - FUEL RETURN TO FILTER
4 - FUEL RETURN TO INJECTION PUMP
5 - FUEL RAIL
6 - HIGH PRESSURE FUEL LINE FROM PUMP TO RAIL
7 - FUEL PRESSURE SENSOR
8 - HIGH PRESSURE LINE FROM RAIL TO INJECTOR
9 - FUEL DRAIN TUBES

# FUEL INJECTION PUMP

## DESCRIPTION

The fuel injection pump is a radial piston pump with three pistons arranged at an angle of 120°. The injection pump is driven by the intake camshaft. The pump is mounted to the rear of the cylinder head (Fig. 2).




80e9cbbe

***Fig. 2 INJECTION PUMP LOCATION***

1 - INJECTION PUMP
2 - VACUUM PUMP
3 - EGR VALVE
4 - CYLINDER HEAD COVER

## OPERATION

### LOW PRESSURE SIDE

The fuel supplied by the fuel delivery pump flows through the fuel feed to the throttle valve. Any air entrained by the fuel is directed through the restrictor to the return flow. The throttle valve opens against the force of the spring at a pressure of

FUEL INJECTION PUMP (Continued)

approx. 0.4 bar and the fuel is able to flow along a ring line to the individual pistons. The eccentric shaft with its eccentric plate moves the pistons up and down against the piston spring of the three pump elements. The leak fuel from the pistons flows along the return flow to the fuel tank. The fuel flowing out of the throttle valve, also flows off along the return flow.

## HIGH PRESSURE SIDE

**A. Filling the piston:** The piston is moved down as a result of the piston spring. The fuel supplied by the fuel delivery pump flows along the ring passage, the valve disk and the valve spring into the cylinder. The ball valve prevents the fuel from being able to flow back from the high pressure passage.

**B. Producing high pressure:**The piston is moved up by the rising eccentric shaft and the fuel is thus compressed. The valve disk shuts off the delivery volume to the fuel feed. Once the fuel pressure in the cylinder rises beyond the pressure which exists in the high pressure circuit, the ball valve opens and the fuel is pumped into the high pressure circuit.

## REMOVAL

**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.**

(1) Disconnect negative battery cable.

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

(3) Disconnect MAF sensor electrical connector.

(4) Disconnect air inlet hose from air cleaner housing.

(5) Remove air cleaner housing assembly by pulling straight up out of mounts (Refer to 9 - ENGINE/ AIR INTAKE SYSTEM/AIR CLEANER HOUSING - REMOVAL).

(6) Remove fuel line retainer and retaining bolt from pump. Disconnect fuel supply and return lines at pump (Fig. 3).

(7) Disconnect high pressure fuel line from pump to rail at injection pump (Fig. 3).

(8) Remove injection pump retaining bolts and remove pump from cylinder head (Fig. 4).

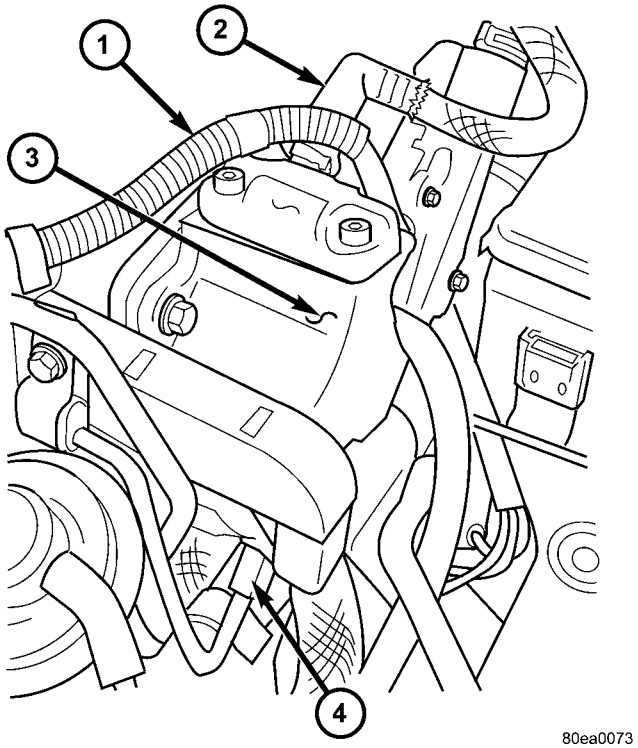



*Fig. 3 INJECTION PUMP FUEL LINES*

1 - RETURN LINE FROM FUEL RAIL
2 - INJECTION PUMP FEED LINE
3 - INJECTION PUMP
4 - HIGH PRESSURE LINE TO FUEL RAIL

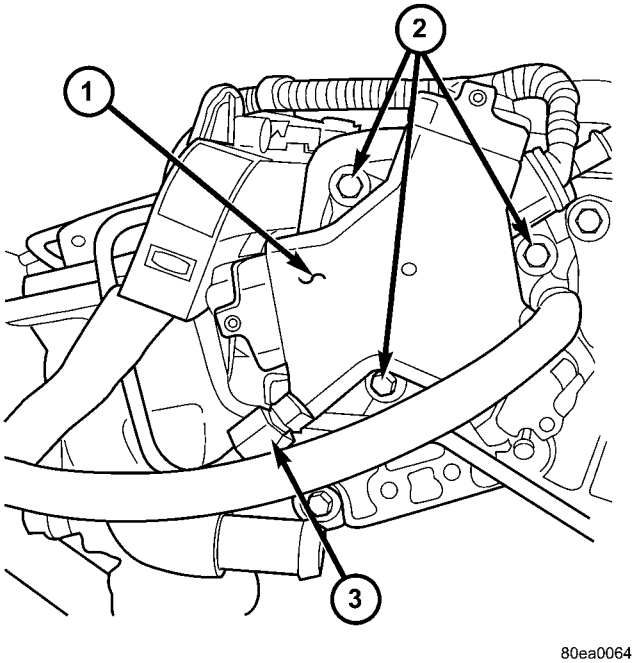



*Fig. 4 INJECTION PUMP RETAINING BOLTS*

1 - INJECTION PUMP
2 - INJECTION PUMP RETAINING BOLTS
3 - HIGH PRESSURE LINE TO FUEL RAIL

FUEL INJECTION PUMP (Continued)

## INSTALLATION

**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.**

(1) Align injection pump with pump drive and slide into cylinder head.
(2) Install retaining bolts (Fig. 4). Torque to 14N·m (124 lbs. in.).
(3) Install fuel supply and return lines to injection pump (Fig. 3). Install bracket and retaining bolt. Torque bolt to 9N·m (80 lbs. in.).
(4) Connect high pressure fuel line to fuel rail at injection pump. Torque line to 22N·m (16 lbs.ft.).
(5) Install air cleaner housing assembly (Refer to 9 - ENGINE/AIR INTAKE SYSTEM/AIR CLEANER HOUSING - INSTALLATION).
(6) Connect air cleaner inlet hose.
(7) Connect MAF sensor electrical connector.
(8) Connect negative battery cable.

**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.**

(9) Start engine and check for leaks.
(10) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).

# FUEL RAIL

## DESCRIPTION

The fuel rail acts like a high pressure store. It is available to all injectors for drawing fuel which has been compressed by the injection pump. The rail pressure sensor, rail pressure solenoid, high pressure line, and the return flow line are attached to the fuel rail (Fig. 5).

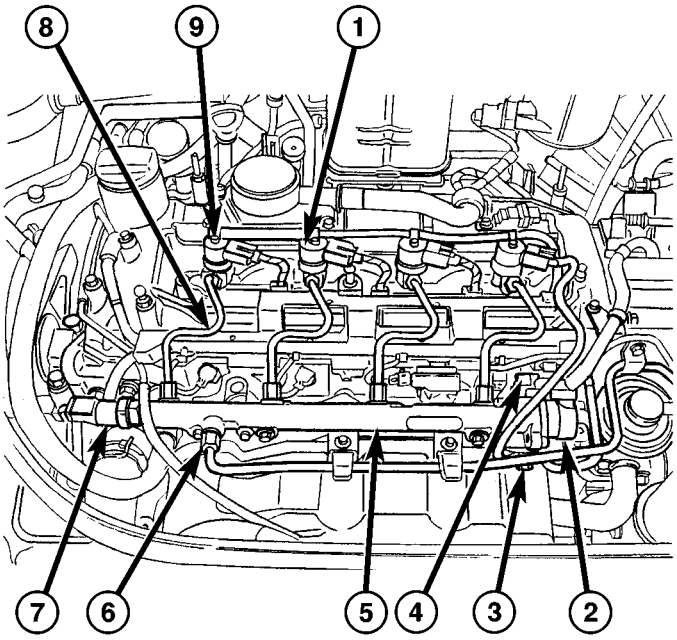



***Fig. 5 FUEL SYSTEM COMPONENTS***

1 - FUEL INJECTOR
2 - FUEL PRESSURE SOLENOID
3 - FUEL RETURN TO FILTER
4 - FUEL RETURN TO INJECTION PUMP
5 - FUEL RAIL
6 - HIGH PRESSURE FUEL LINE FROM PUMP TO RAIL
7 - FUEL PRESSURE SENSOR
8 - HIGH PRESSURE LINE FROM RAIL TO INJECTOR
9 - FUEL DRAIN TUBES

## OPERATION

The stored fuel volume inside the rail acts as a damper for pressure fluctuations which result because of pulsating supply and brief large extractions of fuel during injector firing. The rail primarily influences the atomization of fuel at the injector nozzle, and the accuracy of injected quantity during injection.

FUEL RAIL (Continued)

## REMOVAL

**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.**

**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) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Disconnect fuel rail pressure sensor and fuel pressure solenoid electrical connectors (Fig. 5).

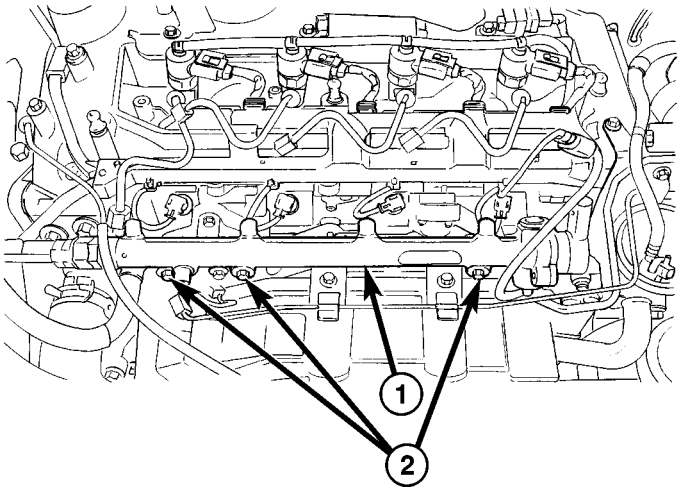
**CAUTION: When slackening and tightening fuel injection line union nuts, counter hold with wrench at threaded connection. ON NO ACCOUNT exceed the tightening torque at any time. Do NOT crimp or bend lines.**

**NOTE: After removing lines, seal connections and ensure cleanliness.**

(4) Remove injector high pressure lines (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL LINES - REMOVAL) (Fig. 5).
(5) Remove pressure line of high pressure pump from rail (Fig. 5).
(6) Detach fuel return flow line to high pressure pump at rail (Fig. 5).
(7) Detach fuel return flow line to fuel filter at fuel rail (Fig. 5).
(8) Remove fuel rail mounting bolts and remove fuel rail from cylinder head (Fig. 6).

## INSTALLATION

**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.**




80ea26bc

***Fig. 6 FUEL RAIL MOUNTING BOLTS***

1 - FUEL RAIL
2 - FUEL RAIL MOUNTING BOLTS

**WARNING: NO FIRE, FLAMES OR SMOKING. RISK OF POISONING FROM INHALING OR 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) Position fuel rail to cylinder head. **Tighten bolts finger tight only** (Fig. 6).
(2) Position and loosely install fuel return line from fuel filter, with new seals to rail (Fig. 6).
(3) Connect high pressure line from pump to rail at rail (Fig. 5). **Tighten line finger tight only.**
(4) Torque fuel rail bolts to 14 N·m (124 lbs.in.) (Fig. 6).
(5) Tighten nut of high pressure line at fuel rail to 22N·m (194 lbs.in.).
(6) Tighten banjo bolt of fuel return line to fuel rail to 20N·m (177 lbs.in.).

FUEL RAIL (Continued)

**CAUTION: Inspect sealing cones at the lines. Replace as necessary. Ensure that all fuel pressure lines are exactly located in original position.**

(7) Install injector lines high pressure lines (Fig. 5). Tighten nut of pressure line to rail/injector to 22N·m (194 lbs.in.).

(8) Reconnect fuel rail pressure sensor and fuel pressure solenoid electrical connectors (Fig. 5).

(9) Connect negative battery cable.

**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.**

(10) Start engine and inspect for leaks.

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

# FUEL LINES

## REMOVAL - HIGH PRESSURE LINES

**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.**

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

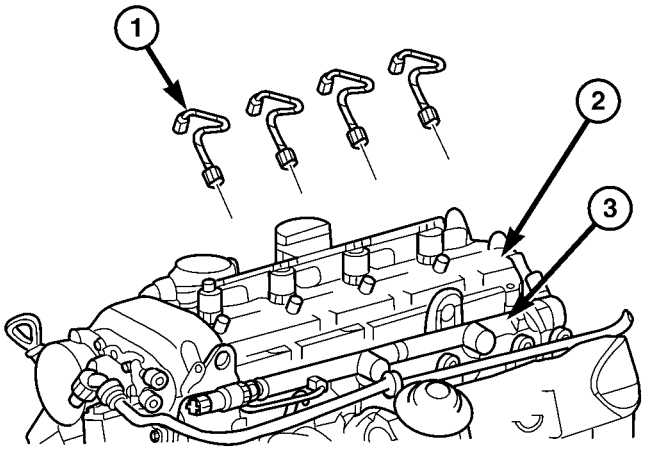
**CAUTION: Counterhold with wrench at threaded connections of injectors. DO NOT EXCEED the tightening torque in order to avoid also loosening the threaded connection.**

**CAUTION: DO NOT crimp or bend lines.**

**NOTE: After removing injection lines, seal connections and ensure cleanliness.**

(3) Unscrew union nuts of injection lines.

(4) Remove injection lines (Fig. 7).




80e1c168

***Fig. 7 HIGH PRESSURE LINES AT INJECTORS - TYPICAL***

1 - HIGH PRESSURE LINE
2 - CYLINDER HEAD COVER
3 - FUEL RAIL

## INSTALLATION - HIGH PRESSURE LINES

**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 LINES (Continued)

**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) Loosen the fuel rail mounting bolts to install lines free of stress.

**CAUTION: Inspect sealing cone at lines. Replace if compression points exist. Ensure lines are exactly located.**

(2) Position and install fuel lines (Fig. 7). Tighten to 22N·m (195 lbs. in.) using a wrench to counterhold at threaded connection.
(3) Tighten fuel rail to 14N·m (124 lbs. in.).
(4) Connect negative battery cable.

**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.**

(5) Start engine and inspect for leaks.
(6) Install engine cover (Refer to 9 - ENGINE - INSTALLATION).

# FUEL TANK

## DESCRIPTION

The fuel tank is made from High Density Polyethylene (HDPE) material with 2 permanently mounted vent valves and a replaceable fuel tank vent filter. Its main functions are for fuel storage and placement of the fuel pump module (Fig. 8).

## OPERATION

Fuel tanks pass a full 360 degree roll over test without fuel leakage. To accomplish this, fuel and vapor flow controls are required for all fuel tank connections.

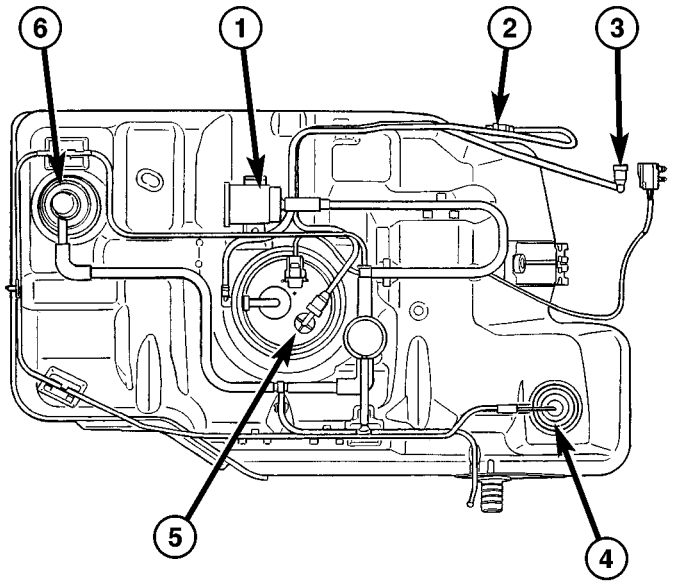



*Fig. 8 FUEL TANK*

1 - FUEL TANK VENT FILTER
2 - FUEL SUPPLY LINE
3 - FUEL RETURN LINE
4 - FUEL TANK VENT VALVE
5 - FUEL PUMP MODULE
6 - FUEL TANK FILL VENT VALVE

The fuel tank is equipped with two permanent vent valves, mounted diagonally to the top of the fuel tank. This allows the fuel tank to vent properly regardless of driving angle, or when refueling.

A fuel tank vent filter is connected inline to the fuel fill valve, and vapor valve, to reduce emissions of fuel vapors into the atmosphere, when the tank is being filled or venting due to thermal expansion. This filter also prevents contaminants from entering the fuel system through the vapor valves.

### INLET CHECK VALVE

All vehicles have an inlet check valve on the inside of the fuel tank at the filler inlet

The valve prevents fuel from splashing back on customer during vehicle refueling. The valve is a non-serviceable item.

# FUEL PUMP MODULE

## DESCRIPTION - FUEL PUMP MODULE

The fuel pump module is located in the fuel tank and consists of a fuel pump, fuel contaminant filtering screen, fuel reservoir and fuel tank level monitoring devise. The fuel pump is a high pressure, high flow pump regulated to 2.5 bar (36psi), in order to maintain an adequate supply of fuel to the high pressure injection pump (Fig. 9).

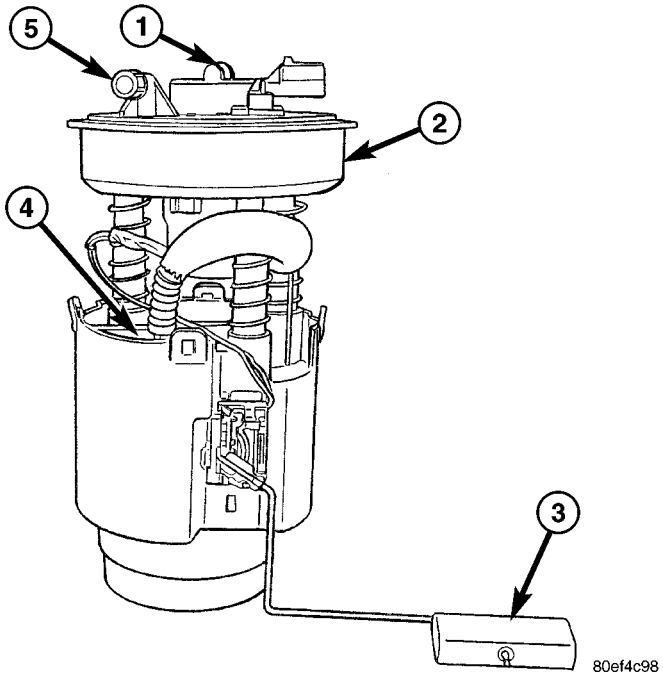



***Fig. 9 FUEL PUMP MODULE***

1 - FUEL SUPPLY
2 - FUEL PUMP MODULE
3 - FUEL GAGE SENDING UNIT FLOAT
4 - FUEL PUMP
5 - FUEL RETURN

## OPERATION

When the ECM senses the ignition switch in the On, Crank or Run mode, battery positive voltage is supplied from the ASD relay and the PDC to the fuel pump relay. The ECM will also ground the fuel pump relay driver at this time, closing the fuel pump relay contacts, completing the fuel pump circuit to chassis ground. If the ECM senses the ignition in the ON position, without a engine crank signal for more than 30 seconds, it will open the fuel pump driver circuit, turning off the fuel pump.

The regulated fuel pump, in On and Crank mode will produce 0.4 to 1.5 bar (6 psi. to 22 psi.). In Run mode the fuel pump will produce at least 2.5 bar (36 psi.) not to exceed 2.9 bar (42 psi.) to maintain constant fuel pressure to the injection pump.

# FUEL FILTER/FUEL HEATER

## DESCRIPTION

The fuel filter assembly is mounted underhood to the engine controller bracket on the dash panel and incorporates a fuel heater element. The paper element of the fuel filter protects the fuel injection pump by removing contaminates from the fuel. The fuel heater keeps the fuel at a suitable temperature range to improve cold starting, cold engine drivability and cold exhaust emissions. Integral to the fuel filter assembly is a single spring diaphram fuel pressure regulator used to maintain the fuel pressure at a constant value under all driving conditions. The fuel heater and fuel regulator are serviced along with the housing as an assembly, where as the fuel filter should be replaced every 20,000 km.

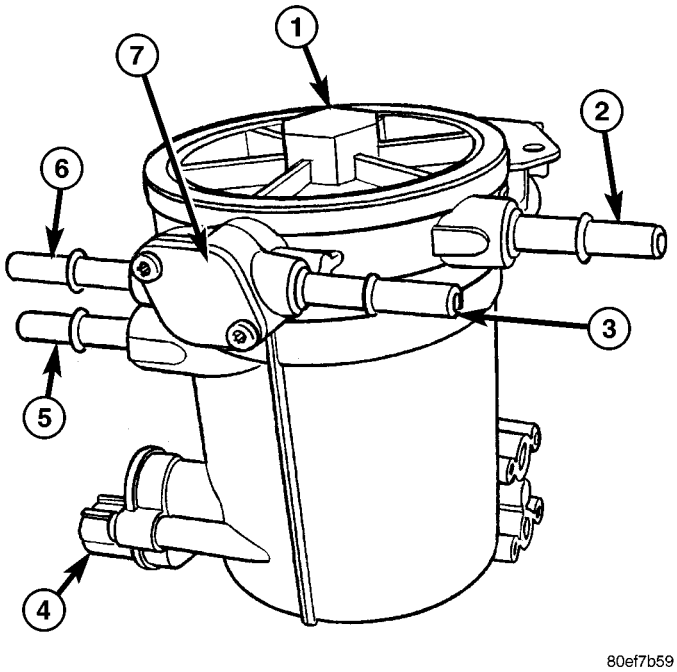



***Fig. 10 FUEL FILTER/FUEL HEATER***

1 - FUEL FILTER
2 - FUEL SUPPLY TO INJECTION PUMP
3 - FUEL RETURN FROM INJECTION PUMP
4 - FUEL HEATER
5 - FUEL SUPPLY FROM FUEL TANK
6 - FUEL RETURN TO FUEL TANK
7 - FUEL PRESSURE REGULATOR

FUEL FILTER/FUEL HEATER (Continued)

## DIAGNOSIS AND TESTING

### DIAGNOSIS AND TESTING - 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.**

This diagnostic will test for a failing fuel pump or restricted fuel filter.

(1) Disconnect the negative battery cable.

(2) Disconnect the fuel supply line to the fuel filter/fuel heater assembly, at the filter assembly.

**NOTE: Obtain the correct Fuel Line Pressure Test Adapter Tool Hose. Tool number 6539 is used for 5/16" fuel lines and tool number 6631 is used for 3/8"lines.**

(3) Connect correct Fuel Line Pressure Test Adaptor Tool Hose between the disconnected fuel line and filter/heater assembly (Fig. 11).

(4) Connect the 0-4.1bar (0-60 psi.) fuel pressure gauge (from Gauge Set 5069) to the test port on the appropriate Adaptor Tool.

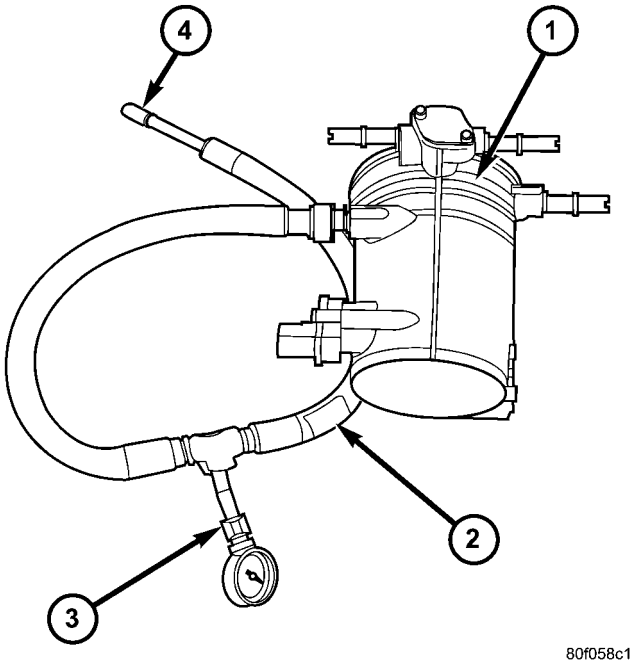



*Fig. 11 FUEL PRESSURE GAUGE*

1 - FUEL FILTER/FUEL HEATER
2 - FUEL PRESSURE TEST HOSE
3 - FUEL PRESSURE GAUGE
4 - CONNECT TO FUEL TANK SUPPLY LINE

(5) Connect negative battery cable.

(6) Crank or run engine and record the fuel pressure reading.

(7) Turn off the ignition (fuel pressure should begin to bleed down immediately).

(8) Disconnect negative battery cable.

**WARNING: THERE MAY BE FUEL IN THE PRESSURE TEST ADAPTOR TOOL HOSE, WRAP SHOP TOWELS AROUND HOSES TO CAPTURE ANY FUEL SPILLAGE.**

(9) Disconnect Fuel Line Pressure Adaptor Tool Hose.

(10) Reconnect fuel tank supply line to fuel filter/fuel heater assembly.

(11) Disconnect fuel supply line to injector pump, at the fuel filter/fuel heater assembly (Fig. 12).

(12) Connect Fuel Line Pressure Test Adaptor Tool Hose between the disconnected fuel line and filter/heater assembly.

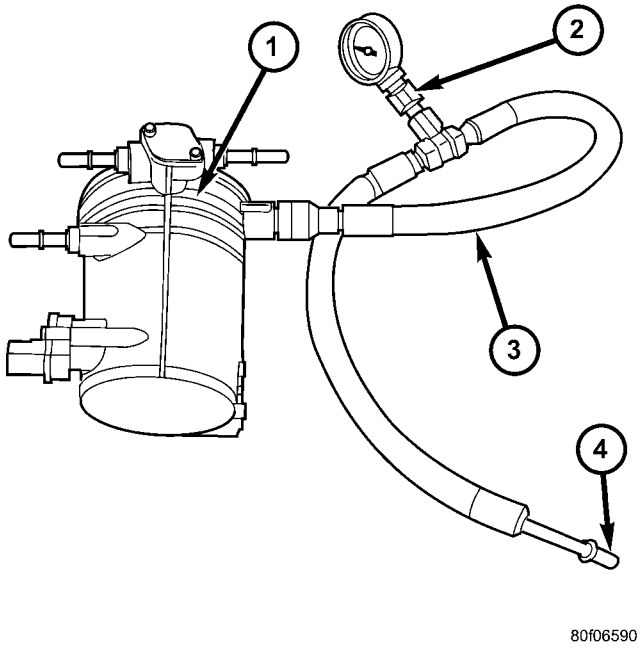



*Fig. 12 FUEL PRESSURE GAUGE*

1 - FUEL FILTER/FUEL HEATER
2 - FUEL PRESSURE GAUGE
3 - FUEL LINE PRESSURE TEST ADAPTOR HOSE
4 - CONNECT TO INJECTOR PUMP FUEL SUPPLY LINE

(13) Connect negative battery cable.

(14) Crank or run engine and record the fuel pressure reading.

(15) Turn off the ignition.

(16) Disconnect negative battery cable.

(17) Reconnect the fuel supply line to the fuel filter/fuel heater.

FUEL FILTER/FUEL HEATER (Continued)

Inspect fuel lines and fuel tank for leaks and damage, replace the fuel pump module if the first pressure reading test did not obtain 1.5bar (22 psi.). Retest system after repair.

Replace the fuel filter if the pressure difference between test one and test two is more than 0.5bar (8 psi.).

## DIAGNOSIS AND TESTING - FUEL HEATER

| CONDITION | POSSIBLE CAUSES | CORRECTION |
|---|---|---|
| Fuel Heater Inoperative | No ignition positive voltage to heater. | Open or Shorted ignition positive voltage circuit. |
| | | Poor connector terminal end connection. |
| | No fuel heater ground. | Open or Shorted ground circuit. |
| | | Poor connector terminal end connection. |
| | Open fuel heater element. | Replace fuel filter/fuel heater assembly. |

## REMOVAL

### REMOVAL

**WARNING: THERE IS FUEL PRESENT IN THE FILTER HOUSING. REMOVE HOSES, AND HANDLE THE FILTER HOUSING CAREFULLY TO REDUCE SPLASH.**

**NOTE: Use a shop towel to capture any residual fuel spillage during this procedure.**

(1) Disconnect negative battery cable.
(2) Disconnect fuel supply line form fuel tank.
(3) Disconnect fuel supply line to injection pump.
(4) Disconnect both fuel return lines from pressure regulator.
(5) Disconnect fuel heater electrical connector.
(6) Remove the right ECM mounting bracket to dash panel screws.
(7) Carefully pull back on the ECM mounting bracket and remove fuel filter housing retaining screws and filter housing from vehicle.

### 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.

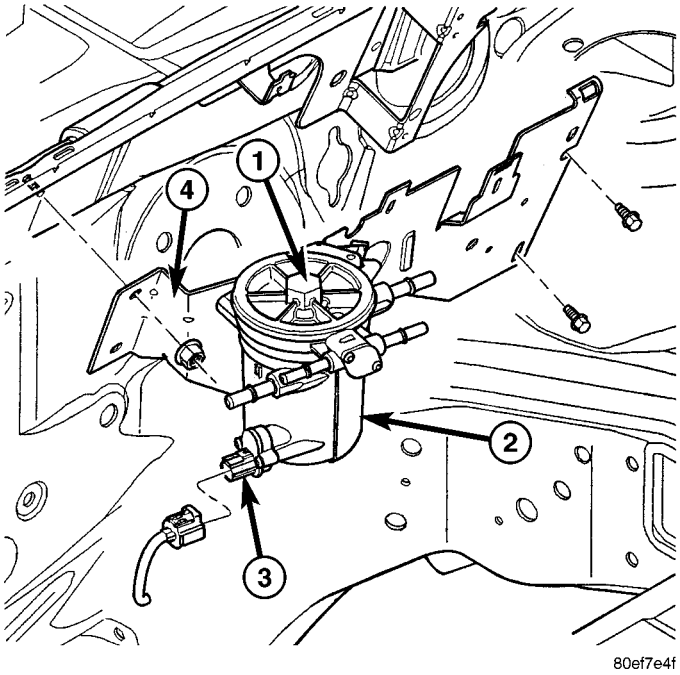



***Fig. 13 FUEL FILTER HOUSING ASSEMBLY***

1 - FUEL FILTER
2 - FUEL FILTER HOUSING
3 - FUEL HEATER
4 - ECM BRACKET

**NOTE: Use a shop towel to capture any residual fuel spillage during this procedure.**

(2) Unscrew the fuel filter element from the top of the housing and discard (Fig. 10).

FUEL FILTER/FUEL HEATER (Continued)

INSTALLATION

## INSTALLATION

**NOTE: Use shop towels to capture any residual fuel spillage during this procedure.**

(1) Position the fuel filter housing against ECM mounting bracket and install screws. Tighten screws to 28N·m (250 lbs.in.). (Fig. 13).

(2) Position and install the ECM bracket. Tighten ECM mounting bracket retaining screws to 12 N·m. (115 lbs.in.).

(3) Connect fuel heater electrical connector.

(4) Connect both fuel return lines to pressure regulator.

(5) Connect fuel supply line to injector pump.

(6) Connect fuel supply line to fuel tank.

(7) Connect negative battery cable.

(8) Start engine and inspect for leaks.

## 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) Lubricate new fuel filter element seal with clean diesel fuel and screw into housing.

(2) Torque fuel filter element to 35N·m (310 lbs. in.).

(3) Connect negative battery cable.

(4) Start engine and inspect for leaks.

# FUEL INJECTION

## TABLE OF CONTENTS


page

**FUEL INJECTION**
STANDARD PROCEDURE - TESTING FUEL INJECTORS . . . 17
**ACCELERATOR PEDAL POSITION SENSOR**
DESCRIPTION . . . 18
**BOOST PRESSURE SENSOR**
DESCRIPTION . . . 19
OPERATION . . . 19
DIAGNOSIS AND TESTING - BOOST PRESSURE SENSOR . . . 19
**CRANKSHAFT POSITION SENSOR**
DESCRIPTION . . . 19
OPERATION . . . 19
**FUEL INJECTOR**
DESCRIPTION . . . 20
OPERATION . . . 20
STANDARD PROCEDURE
STANDARD PROCEDURE - CLEANING FUEL INJECTORS . . . 21
STANDARD PROCEDURE - INJECTOR CLASSIFICATION . . . 21
REMOVAL . . . 22
INSTALLATION . . . 23
**FUEL PRESSURE SENSOR**
DESCRIPTION . . . 24
OPERATION . . . 24
REMOVAL . . . 25
INSTALLATION . . . 25
**INTAKE AIR TEMPERATURE SENSOR**
DESCRIPTION . . . 25

page

OPERATION . . . 25
**CAMSHAFT POSITION SENSOR**
DESCRIPTION . . . 26
OPERATION . . . 26
REMOVAL . . . 26
INSTALLATION . . . 26
**MANIFOLD AIR FLOW (MAF) SENSOR**
DESCRIPTION . . . 26
OPERATION . . . 26
REMOVAL . . . 27
INSTALLATION . . . 27
**FUEL PRESSURE SOLENOID**
DESCRIPTION . . . 27
OPERATION . . . 27
REMOVAL . . . 28
INSTALLATION . . . 29
**SWIRL ACTUATOR**
DESCRIPTION
DESCRIPTION - INTAKE MANIFOLD SWIRL VALVE . . . 29
DESCRIPTION - SWIRL VALVE ACTUATOR SOLENOID . . . 30
OPERATION
OPERATION - INTAKE MANIFOLD SWIRL VALVE . . . 30
OPERATION - SWIRL ACTUATOR SOLENOID . . . 30


# FUEL INJECTION

## STANDARD PROCEDURE - TESTING FUEL INJECTORS

**WARNING: AVOID ALL CONTACT WITH FUEL SPRAY. THE HIGH PRESSURE PUMP SUPPLIES HIGH-PRESSURE FUEL TO EACH INDIVIDUAL INJECTOR THROUGH HIGH-PRESSURE LINES. FUEL UNDER THIS AMOUNT OF PRESSURE CAN PENETRATE SKIN AND CAUSE PERSONAL INJURY. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

**NOTE: The fuel pump pressure must be 1.5 bar (22 psi.), and the engine must be at operating temperature 80°C (176°F).**

(1) Run the engine until operating temperature is obtained.
(2) Turn OFF the ignition.
(3) Disconnect the fuel injector return hose at the return hose fitting directly below the fuel pressure solenoid (Fig. 1).
(4) Block off fuel return fitting at the fuel rail.
(5) Place the fuel return hose into a suitable container.
(6) Start the engine and measure the amount of return fuel into the container for one minute at idle.

FUEL INJECTION (Continued)

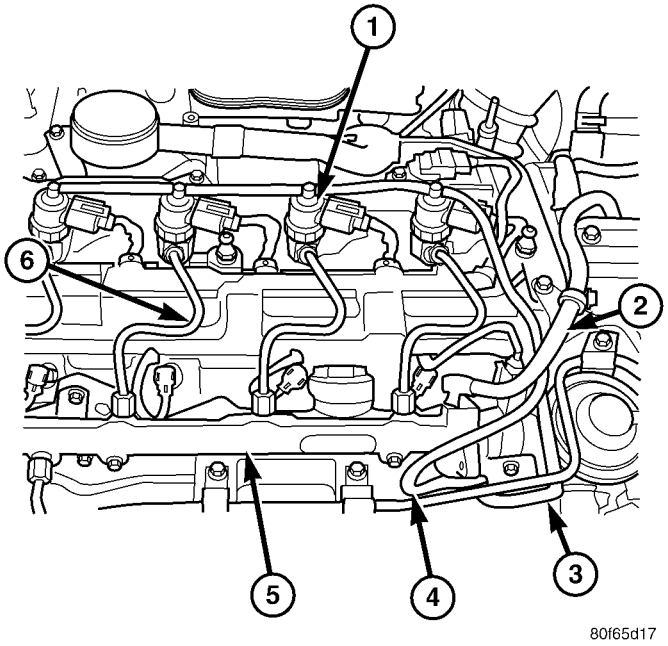



***Fig. 1 FUEL SYSTEM COMPONENTS***

1 - FUEL INJECTOR
2 - FUEL RAIL SUPPLY
3 - FUEL RETURN LINE TO FUEL FILTER/FUEL HEATER
4 - FUEL INJECTOR RETURN HOSE
5 - FUEL RAIL
6 - HIGH PRESSURE FUEL INJECTOR LINE

**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, reconnect the return hose at the fitting, disconnect each injector return hose singularly, at the injector and measure the amount of return fuel into the container.

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

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

# ACCELERATOR PEDAL POSITION SENSOR

## DESCRIPTION

The Accelerator Pedal Position Sensor (APPS) is a variable resistor that provides the PCM with an input signal (voltage) (Fig. 2). The signal represents throttle blade position. As the position of the accelerator pedal changes, the resistance of the APPS changes (Fig. 3).

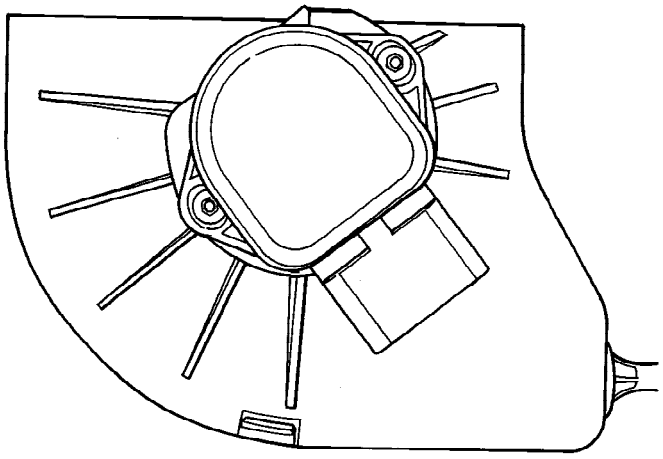



***Fig. 2 APPS MODULE***

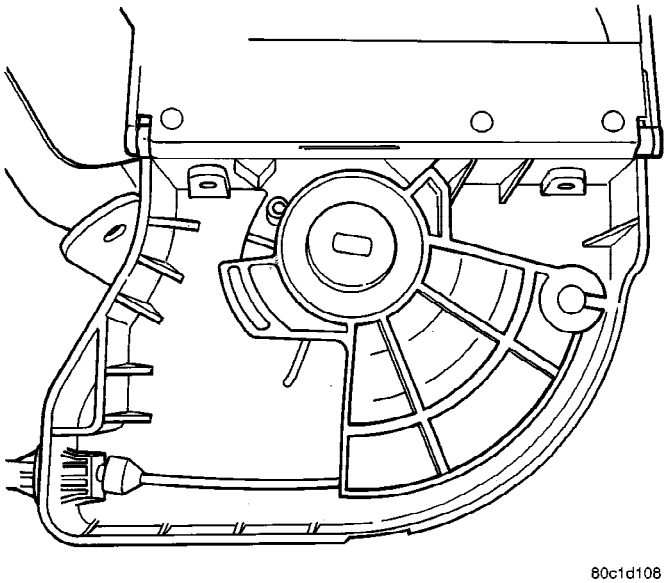



***Fig. 3 APPS MODULE OPEN***

# BOOST PRESSURE SENSOR

## DESCRIPTION

The boost pressure sensor is mounted in the mixing chamber below the intake manifold (Fig. 4). The sensor allows the ECM to monitor air pressure within the intake manifold.

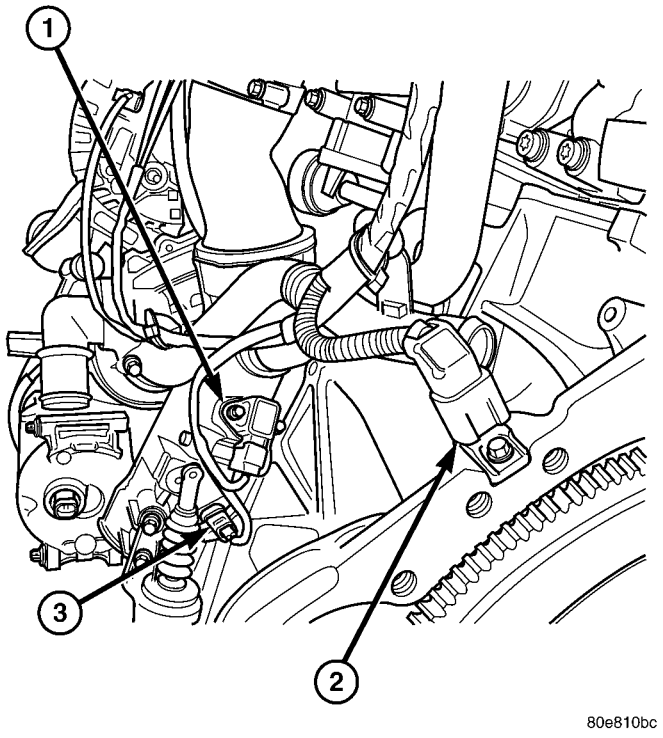



***Fig. 4 SENSOR LOCATIONS***

1 - BOOST PRESSURE SENSOR
2 - CRANKSHAFT POSITION (CKP) SENSOR
3 - INTAKE AIR TEMPERATURE SENSOR

## OPERATION

When the intake manifold pressure is low (high vacuum) 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 provides 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 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.

# CRANKSHAFT POSITION SENSOR

## DESCRIPTION

The crankshaft position sensor is located at the left rear of the engine just above the starter motor (Fig. 5). This sensor is used to detect engine speed.

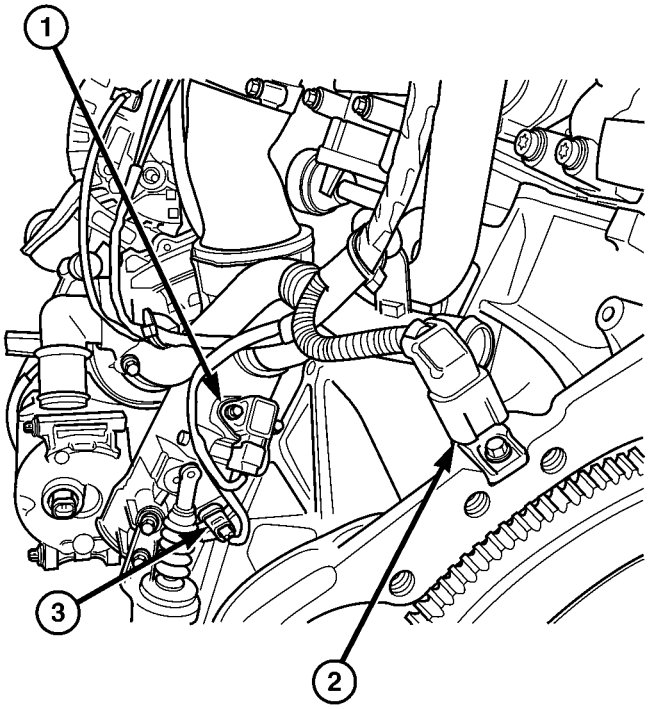



***Fig. 5 SENSOR LOCATIONS***

1 - BOOST PRESSURE SENSOR
2 - CRANKSHAFT POSITION (CKP) SENSOR
3 - INTAKE AIR TEMPERATURE SENSOR

## OPERATION

The crankshaft position and engine speed are detected contactless signal (hall effect). The distance between the crankshaft position sensor and the teeth of the driven plate is fixed by the installation position.

When the crankshaft rotates, an alternating voltage is generated in the crankshaft position sensor by the teeth of the driven plate.

CRANKSHAFT POSITION SENSOR (Continued)

In this case, the front edge of a tooth generates a positive voltage pulse and the rear edge a negative voltage pulse. The distance from the positive to the negative voltage peak equals the length of a tooth.

The gap created by 2 missing teeth (arrow) has the effect that no voltage is generated in the crankshaft position sensor. This is analyzed in order to detect the TDC position of cylinder 1

# FUEL INJECTOR

## DESCRIPTION

There are individual fuel injectors for all four cylinders. These fuel injectors are used to spray fuel into the combustion chamber (Fig. 6).

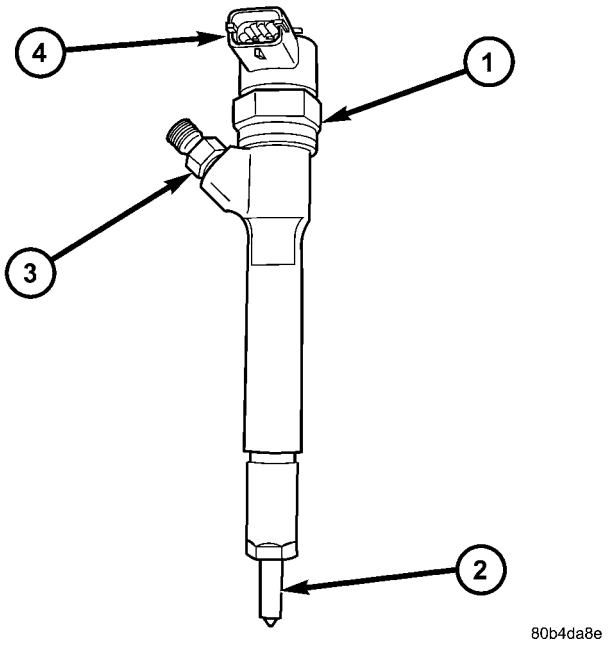



***Fig. 6 FUEL INJECTOR***

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

## OPERATION

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. 7).

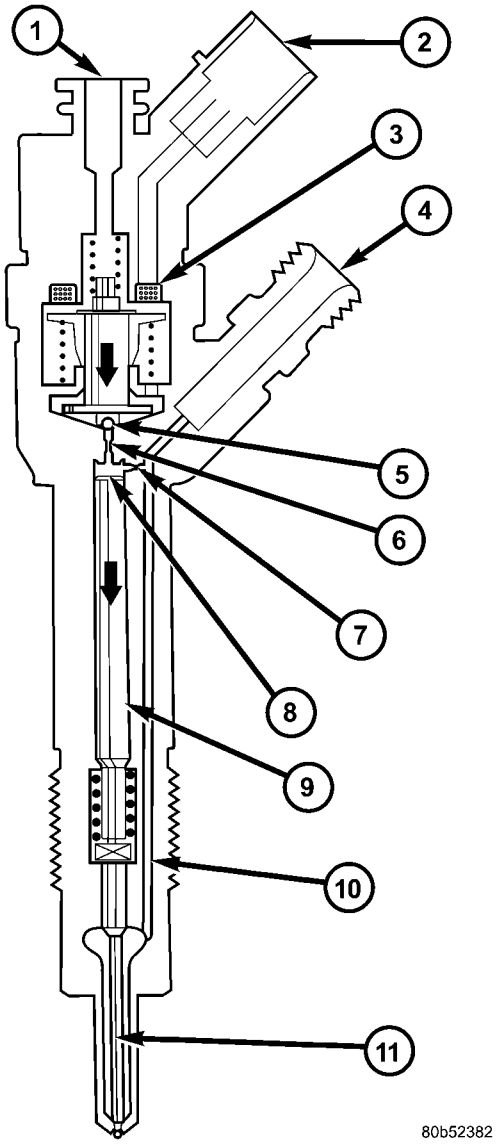



***Fig. 7 INJECTOR COMPONENTS***

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

FUEL INJECTOR (Continued)

### Injector opens (start of injection)

The solenoid valve is energized with the pickup current which serves to ensure that it open 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 open as a result, and injection starts (Fig. 7).

### 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. 7).

### 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. 7).

## STANDARD PROCEDURE

## STANDARD PROCEDURE - CLEANING FUEL INJECTORS

**NOTE: Before cleaning the injector recesses, seal the injector holes in the injector recesses with the appropriate pin to prevent debris from falling into the recesses and entering the motor.**

(1) Seal the injector holes inside the cylinder head recesses.
(2) Wipe out injector recesses with a non-woven cloth, then clean with a cylinder brush.
(3) Clean the bottom of the cylinder recess with a round brush.
(4) Blow out the recess and clean again with a non-woven cloth and cover over.
(5) Perform these steps for each injector recess.

**NOTE: DO NOT clean the tip of the injector with a wire brush. Use a non - woven cloth.**

(6) Clean injector body with a wire brush.
(7) Clean injector tips with a non-woven cloth.

**NOTE: Do Not apply antiseize lubricant to the injector nozzle area.**

(8) Grease injector body with anti seize lubricant.

**NOTE: Always replace the seals that seal off the injectors at the cylinder head to the combustion chamber and replace the retaining screws.**

## STANDARD PROCEDURE - INJECTOR CLASSIFICATION

The classification of injectors into 3 classes describes the quantity characteristic of the injector. This will make it possible in the future to match the engine software to the tolerances of the injector within a more narrowly graduated range. Classification can be clearly recognized, and assigned only by means of a DRBIII®.

Classified injectors can be recognized by the part number and identification on the magnetic head (circle with a number between 1 and 3 inside) (Fig. 8). The number corresponds to the classification stage.

These general conditions equally apply if, as a result of replacing an engine, carrying out repairs to the cylinder head etc., the cylinder selective assignment of the injectors or the engine control module assignment may have changed. If proper attention is not paid to the classification on these vehicles driveability and smoking concerns could result.

FUEL INJECTOR (Continued)

If an injector is replaced, it is then necessary to assign the classification number to the corresponding cylinder with the **DRBIII®** in the control module.

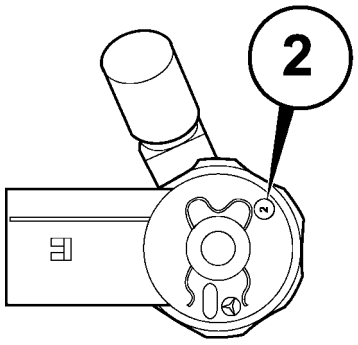



*Fig. 8 INJECTOR CLASSIFICATION MARKINGS*

## INJECTOR CLASSIFICATION PROCEDURE

(1) Turn ignition switch "ON".
(2) Using a DRB III® and select ENGINE then MISCELLANEOUS.
(3) Select LEARN INJECTORS.
(4) Using the up and down arrows, scroll to the appropriate injector.
(5) Using the right and left arrows, set injector to proper classification.
(6) Once injectors are classified, cycle ignition to complete.

## REMOVAL

**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.**

**CAUTION: PAY CLOSE ATTENTION TO THE FOLLOWING POINTS WHEN REMOVING FUEL INJECTORS:**

- **Injectors MUST be removed only using the special tools provided for this purpose.**
- **Injectors MUST NOT be disassembled.**
- **Before cleaning injector recesses, seal all injector holes in the injector recesses with a pin.**
- **Clean all injector recesses in the cylinder head with a non-woven cloth and then a cylinder brush.**
- **Carefully clean sealing surfaces of injector recesses with the round brush. DO NOT us a power brush.**

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Disconnect fuel injector supply line from injector and fuel rail and remove from engine (Fig. 9) (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/ FUEL LINES - REMOVAL).

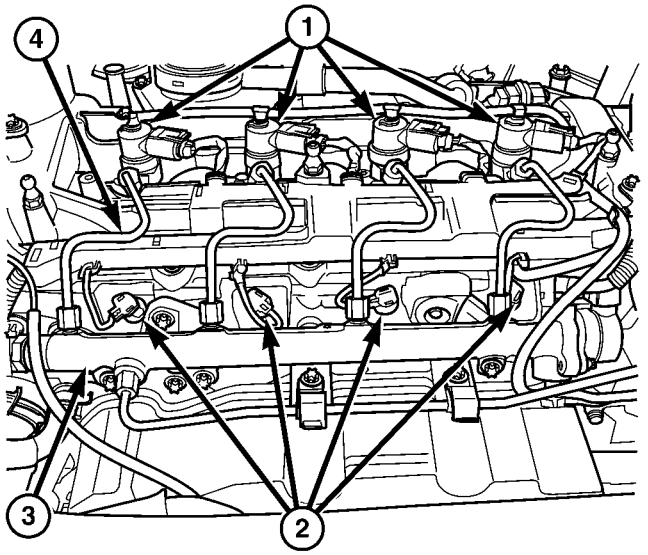



*Fig. 9 FUEL INJECTOR AND GLOW PLUG LOCATIONS*

1 - FUEL INJECTORS
2 - GLOW PLUGS
3 - FUEL RAIL
4 - HIGH PRESSURE FUEL LINE

**NOTE: If injectors are tight and cannot be removed by hand, remove with special tools #8937 slide hammer and #8938 extraction claw (Fig. 10).**

(4) Remove fuel injector retaining bolt and tensioning claw (Fig. 10).
(5) Remove fuel injector from cylinder head (Fig. 10).

FUEL INJECTOR (Continued)

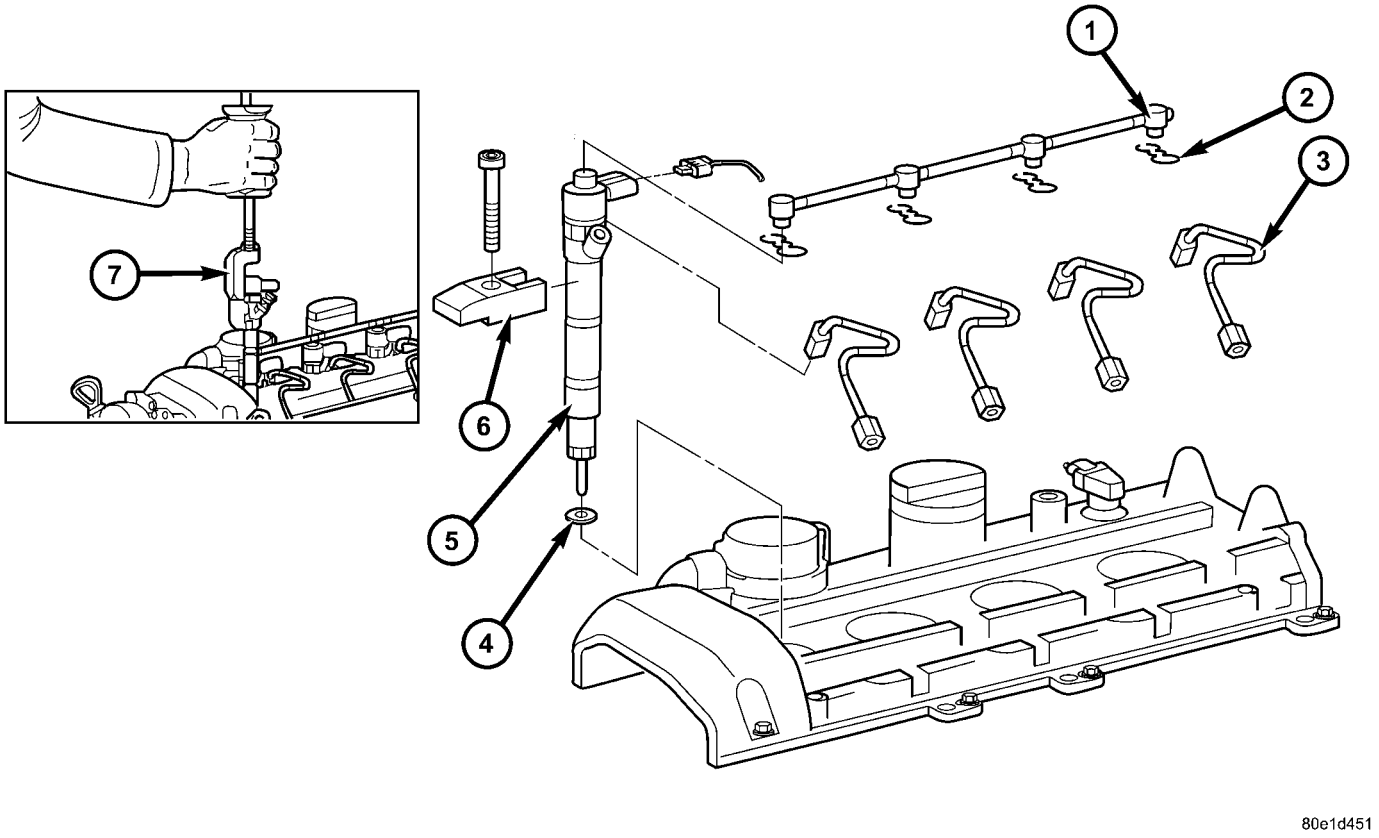



***Fig. 10 FUEL INJECTOR REMOVAL/INSTALLATION - TYPICAL***

1 - INJECTOR DRAIN TUBES
2 - RETAINING CLIP
3 - INJECTOR HIGH PRESSURE LINE
4 - INJECTOR SEAL
5 - FUEL INJECTOR
6 - TENSIONING CLAW
7 - SPECIAL TOOLS #8938 AND #8937

## INSTALLATION

**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 INJECTOR (Continued)

**CAUTION: PAY CLOSE ATTENTION TO THE FOLLOWING POINTS WHEN INSTALLING FUEL INJECTORS.**

- **Blow out injector recesses, clean again with non-woven cloth and then cover over. Fiber residues from non-woven cloth ARE NOT permissible.**
- **Carefully carry out a visual inspection of the sealing surfaces of the injector recesses.**
- **The length of the round brush can be adjusted and should be approximately 3mm for cleaning the seal seat. Optimal cleaning is achieved only if a brush with a flat surface is used. If necessary the surface of the brush can be ground flat on a grinding stone.**
- **ALWAYS replace the seals which seal off the injectors at the cylinder head to the combustion chamber. It is important that no grease gets onto the seal. Any impurities on the seal, on the sealing surfaces at the injector and cylinder head as a result of combustion residue or similar are absolutely impermissible.**
- **The screws attaching the injectors must always be replaced. The screws must screw in easily, if not, clean the threaded whole with an appropriate thread tap.**
- **The tip of the injector nozzle MUST NOT be cleaned with a wire brush. Use a non-woven cloth.**
- **Clean entire injector with a non-woven cloth.**
- **Fiber residues from a non-woven cloth are not permissible.**
- **Apply a thin film of special grease to the injector stems.**
- **Remove the pin in the nozzle holes with the extension.**

(1) Clean injectors and recesses (Refer to 14 - FUEL SYSTEM/FUEL INJECTION/FUEL INJECTOR - STANDARD PROCEDURE).

(2) Coat injector body with anti seize lubricant and install injectors with new seals (Fig. 10).

(3) Install tensioning claw with new fastener (Fig. 10). Torque in two stages, 7N·m (62 lbs.in.) then 90°.

**NOTE: If drain tube locking clips have been removed from injectors, the clips must be replaced.**

(4) Connect fuel drain tubes at injectors (Fig. 10).

(5) Install high pressure fuel lines from rail to injectors (Fig. 10) (Refer to 14 - FUEL SYSTEM/FUEL DELIVERY/FUEL LINES - INSTALLATION).

(6) Connect injector electrical connectors.

(7) Connect negative battery cable.

**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.**

(8) Start engine and check for leaks.

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

# FUEL PRESSURE SENSOR

## DESCRIPTION

The fuel pressure sensor monitors and passes on the current rail pressure to the control module (Fig. 11). The non-constant system pressure influences the position of the sensor diaphragm which alters the sensors electrical resistance.

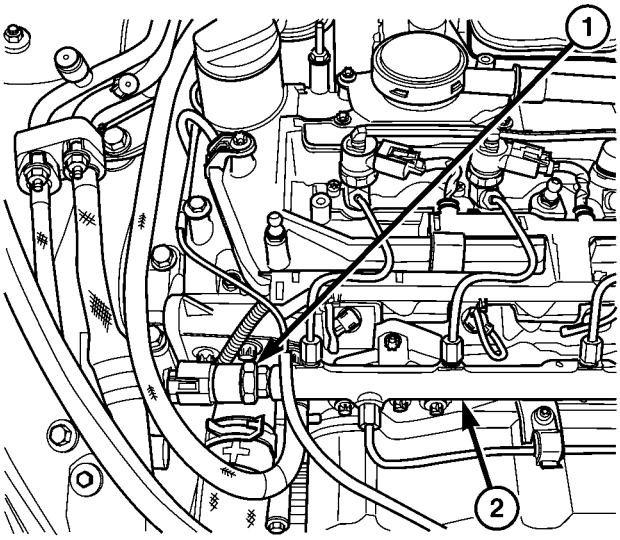



***Fig. 11 FUEL RAIL AND FUEL PRESSURE SENSOR LOCATIONS***

1 - FUEL PRESSURE SENSOR
2 - FUEL RAIL

## OPERATION

The rail pressure sensor measures the current rail pressure and supplies an appropriate voltage signal to the Engine Control Module (ECM). The pressure control valve is then actuated by the ECM through a control loop until the desired rail pressure is reached.

FUEL PRESSURE SENSOR (Continued)

## REMOVAL

**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.**

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Disconnect fuel pressure sensor electrical connector (Fig. 11).
(4) Remove fuel pressure sensor from fuel rail (Fig. 11).

## INSTALLATION

**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.**

(1) Install fuel pressure sensor into fuel rail (Fig. 11).
(2) Connect fuel pressure sensor electrical connector (Fig. 11).
(3) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).
(4) Connect negative battery cable.

# INTAKE AIR TEMPERATURE SENSOR

## DESCRIPTION

This sensor is used to monitor the intake air temperature (Fig. 12).

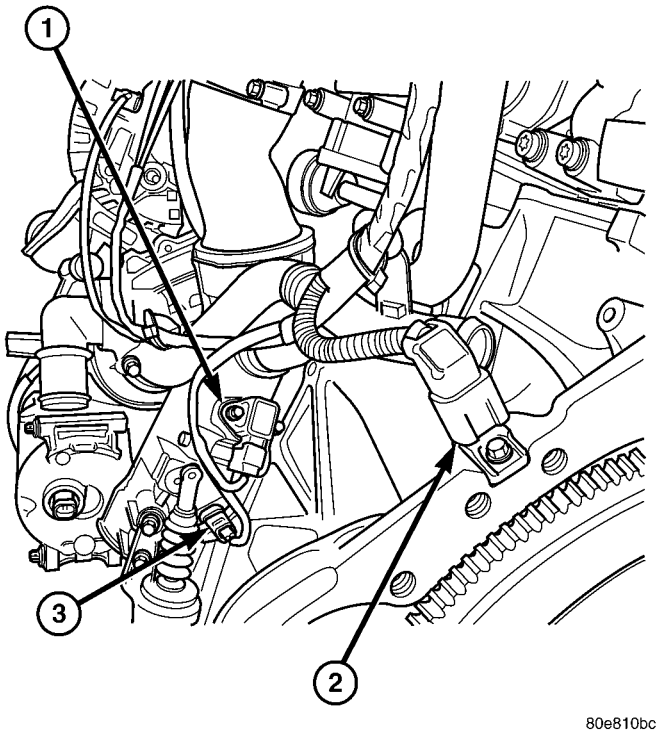



***Fig. 12 SENSOR LOCATIONS***

1 - BOOST PRESSURE SENSOR
2 - CRANKSHAFT POSITION (CKP) SENSOR
3 - INTAKE AIR TEMPERATURE SENSOR

## OPERATION

The intake air temperature sensor is a negative temperature coefficient (NTC) thermistor (resistance varies 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.

# CAMSHAFT POSITION SENSOR

## DESCRIPTION

The camshaft position sensor is mounted on the cylinder head cover (Fig. 13). The sensor detects the camshaft position by a contactless signal (hall effect). The electronic control module (ECM) detects TDC position of cylinder 1 by means of the signal supplied by the camshaft sensor. Injection timing is synchronized by means of the camshaft signal and the crankshaft signal.

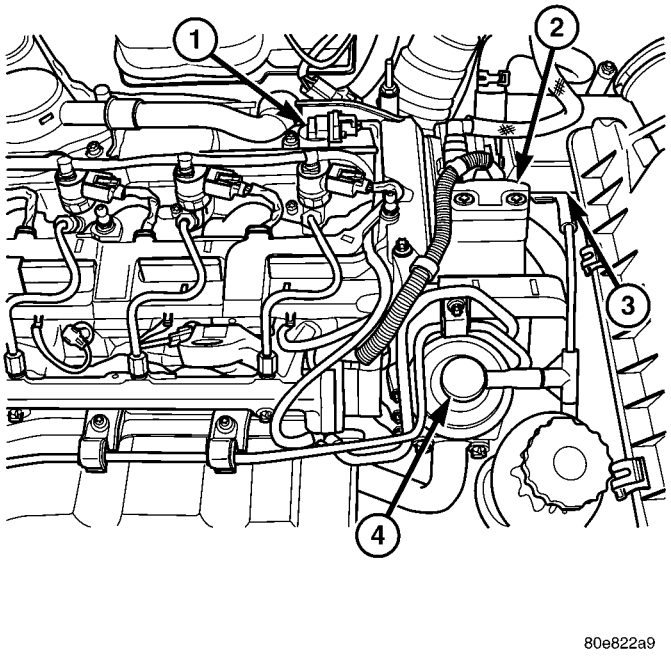



***Fig. 13 ENGINE COMPONENT LOCATIONS***

1 - CAMSHAFT POSITION SENSOR
2 - INJECTION PUMP
3 - POWER DISTRIBUTION CENTER (PDC)
4 - EGR VALVE

## OPERATION

The signal circuit of the camshaft sensor has a voltage of approximately 5V. If the segment machined into the exhaust camshaft sprocket is positioned opposite the camshaft sensor, the camshaft signal is approximately 0V. This 0V to 5V signal is used by the engine control module (ECM) for detecting ignition TDC of cylinder 1 as the engine rotates. If no signal is supplied by the camshaft position sensor, the vehicle will not start.

## REMOVAL

(1) Disconnect negative battery cable.
(2) Remove engine cover (Refer to 9 - ENGINE COVER - REMOVAL).
(3) Disconnect camshaft position sensor electrical connector.
(4) Remove retaining bolt and remove sensor from cylinder head cover.

## INSTALLATION

(1) Install camshaft position sensor into cylinder head cover.
(2) Connect electrical connector.
(3) Install engine cover (Refer to 9 - ENGINE COVER - INSTALLATION).
(4) Connect negative battery cable.

# MANIFOLD AIR FLOW (MAF) SENSOR

## DESCRIPTION

The miromechanical Mass Air Flow (MAF) sensor is a hot film thermal flowmeter with an integrated temperature sensor which detects the intake air temperature. The sensor is designed for recording load on combustion engines with diesel fuel injection and has a cylinder size in accordance with the required air flow rate. The MAF Sensor is mounted inline in the air intake between the air filter and the turbocharger (Fig. 14).

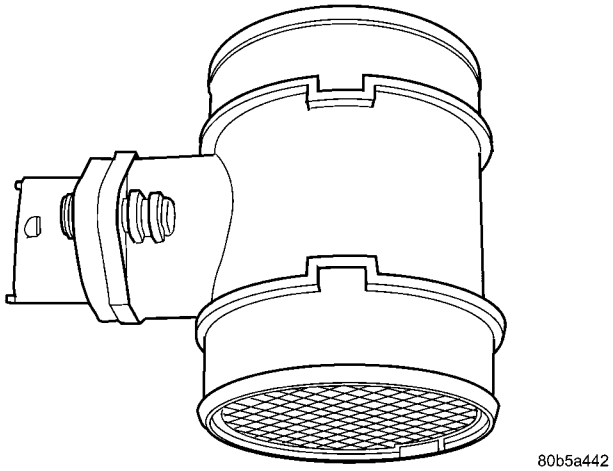



***Fig. 14 MASS AIR FLOW (MAF) SENSOR***

## OPERATION

The MAF sensing element consists or two temperature sensors symmetrical to a heating area sitting on a thin membrane. Up and down stream sensors see the same temperature when there is no air flowing through the sensor. With incoming flow, the upstream heating area is cooled down due to heat transfer, while the downstream area retains it's temperature because the air has been heated up after it

MANIFOLD AIR FLOW (MAF) SENSOR (Continued)

flows through the heating area. The characteristic of temperature change in relation to airflow at the upstream area is utilized to determine the mass airflow passing through the sensor. This signal voltage variation is used by the ECM along with internal calibrations to coordinate the total mass air flow.

To reduce contamination during sensing, a partial air flow is directed at an angle with respect to the main flow in the measuring channel for the fact that moisture and other particles tend not to react in the same manner that air does after they hit the channel wall. The Diesel Power Relay supplies battery power the to MAF sensor, ground is provided by the ECM. The MAF sensor signal is provided by the ECM.

## REMOVAL

(1) Disconnect negative battery cable.

(2) Disconnect mass air flow (MAF) sensor electrical connector (Fig. 15).

(3) Disconnect air cleaner to turbocharger hose (Fig. 15).

(4) Remove MAF to air cleaner housing retaining bolts and remove sensor (Fig. 15).

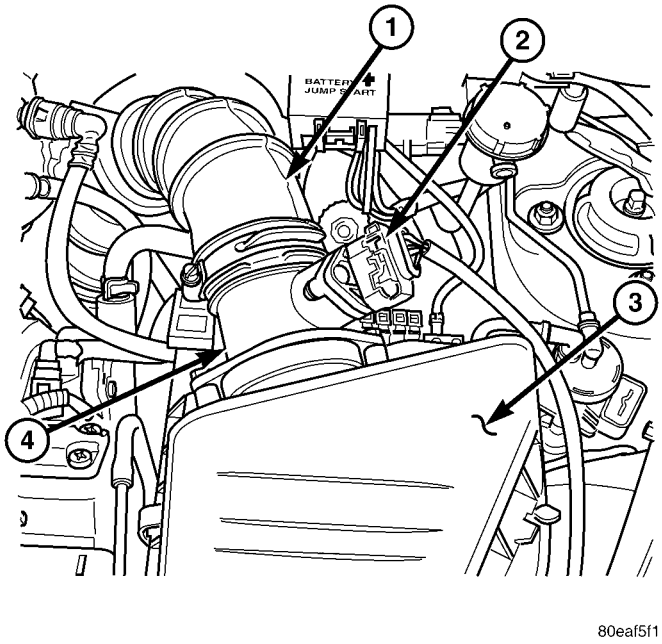



***Fig. 15 MAF SENSOR LOCATION***

1 - AIR CLEANER TO TURBOCHARGER HOSE
2 - MAF SENSOR ELECTRICAL CONNECTOR
3 - AIR CLEANER HOUSING
4 - MAF SENSOR

## INSTALLATION

(1) Position mass air flow (MAF) sensor to air cleaner housing and tighten bolts (Fig. 15).

(2) Connect air cleaner to turbocharger hose at MAF sensor (Fig. 15).

(3) Connect MAF sensor electrical connector (Fig. 15).

(4) Connect negative battery cable.

# FUEL PRESSURE SOLENOID

## DESCRIPTION

The fuel pressure solenoid is attached to the rear of the fuel rail. The solenoid controls and maintains the rail pressure constant along with a control current transmitted by the engine control module (ECM) (Fig. 16).

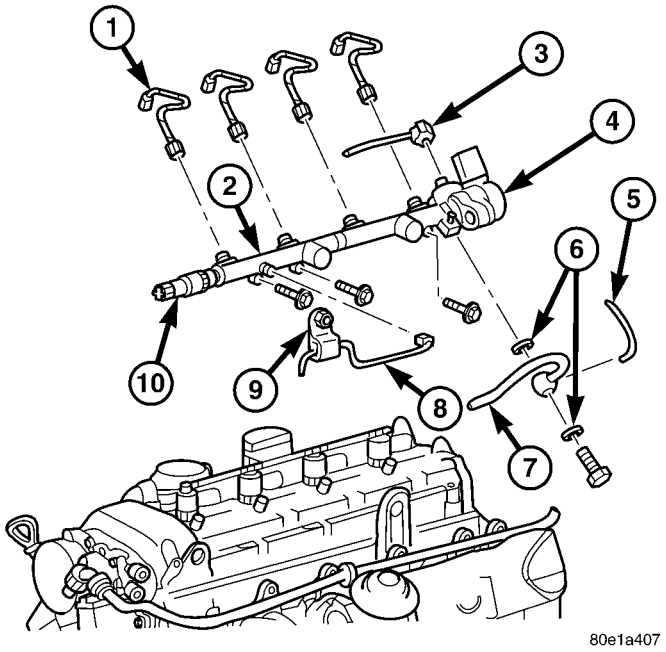



***Fig. 16 FUEL PRESSURE SOLENOID - TYPICAL***

1 - INJECTION LINES
2 - FUEL RAIL
3 - FUEL RETURN LINE
4 - FUEL PRESSURE SOLENOID
5 - OIL LINE
6 - SEALS
7 - FUEL RETURN LINE AT COOLER
8 - HIGH PRESSURE FUEL LINE TO FUEL RAIL
9 - FUEL LINE BRACKET
10 - FUEL PRESSURE SENSOR

## OPERATION

High pressure which is present in the fuel rail flows to the ball seat of the solenoid (Fig. 17). The specified pressure required by the system is built up in the rail by the fuel pressure solenoid building up a magnetic force which corresponds to this specific pressure by means of a control current from the electronic control module (ECM) (Fig. 17). This magnetic force equals a certain outlet cross section at the ball seat of the solenoid. The rail pressure is altered as a result of the quantity of fuel which flows off (Fig. 17).

FUEL PRESSURE SOLENOID (Continued)

The current fuel pressure is signaled by the fuel pressure sensor to the engine control module (ECM). The controlled fuel flows back along the return fuel line, into the tank.

In a de-energized state, the fuel pressure solenoid is closed as the spring force presses the ball into the ball seat (Fig. 17). When driving, the fuel pressure solenoid is constantly open (Fig. 17). When engine is started, the fuel pressure solenoid is held closed by magnetic force (Fig. 17). When driving, the pressure of the fluid counteracts the magnetic force of the coil and the slight spring force (Fig. 17).

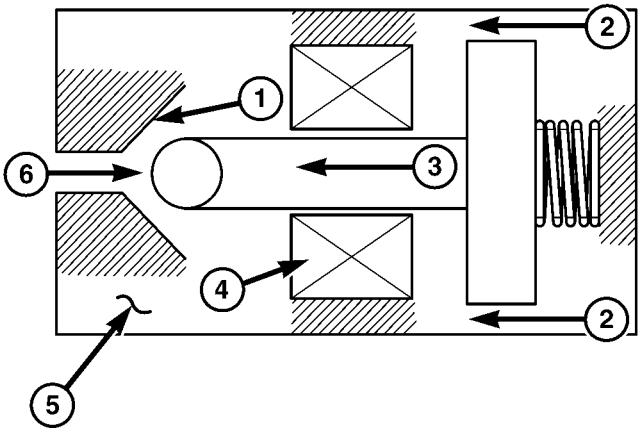



*Fig. 17 FUEL PRESSURE SOLENOID OPERATION*

1 - BALL SEAT
2 - SPRING FORCE
3 - MAGNETIC FORCE
4 - COIL
5 - FUEL PRESSURE SOLENOID
6 - HIGH PRESSURE FEED

## REMOVAL

**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 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 LEAKS WITH A SHEET OF CARD BOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

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

(3) Remove fuel rail (Refer to 14 - FUEL SYSTEM/ FUEL INJECTION/FUEL INJECTOR - REMOVAL).

(4) Clamp fuel rail securely in vise with protective jaws.

**NOTE: Once removed, the pressure solenoid must always be replaced.**

(5) Remove fuel pressure solenoid retaining screws and remove solenoid (Fig. 18).

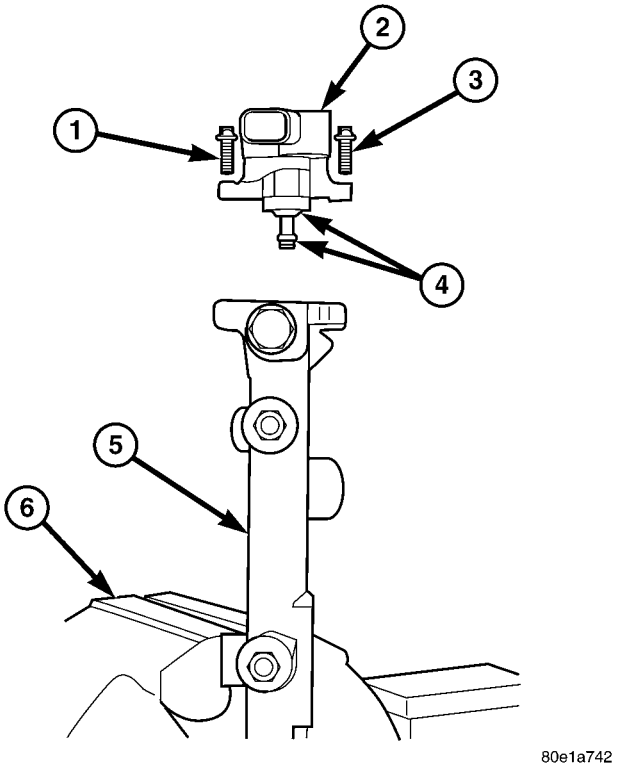



*Fig. 18 FUEL PRESSURE SOLENOID ASSEMBLY*

1 - RETAINING BOLT
2 - FUEL PRESSURE SOLENOID
3 - RETAINING BOLT
4 - O-RING LOCATION
5 - FUEL RAIL
6 - VISE

FUEL PRESSURE SOLENOID (Continued)

## INSTALLATION

**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 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 LEAKS WITH A SHEET OF CARD BOARD. WEAR SAFETY GOGGLES AND ADEQUATE PROTECTIVE CLOTHING WHEN SERVICING FUEL SYSTEM.**

**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: Apply a thin film of special grease to the seals before installing. If the seals are damaged when being installed, an internal leak may occur which can not be recognized externally.**

(1) Position fuel pressure solenoid to fuel rail and retain with screws (Fig. 18). Tighten in two stages, 3N·m (26 lbs. in.) then 5N·m (44 lbs. ft.).

(2) Install fuel rail (Refer to 14 - FUEL SYSTEM/ FUEL INJECTION/FUEL INJECTOR - INSTALLATION).

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

(4) Connect negative battery cable.

**WARNING: USE EXTREME CAUTION WHEN ENGINE IS OPERATING. DO NOT PUT YOUR HANDS NEAR PULLEYS, BELTS, OR FAN. DO NOT WEAR LOOSE CLOTHES.**

(5) Start engine and inspect for leaks.

# SWIRL ACTUATOR

## DESCRIPTION

### DESCRIPTION - INTAKE MANIFOLD SWIRL VALVE

The intake manifold swirl valve is located in the bottom of the intake manifold (Fig. 19).

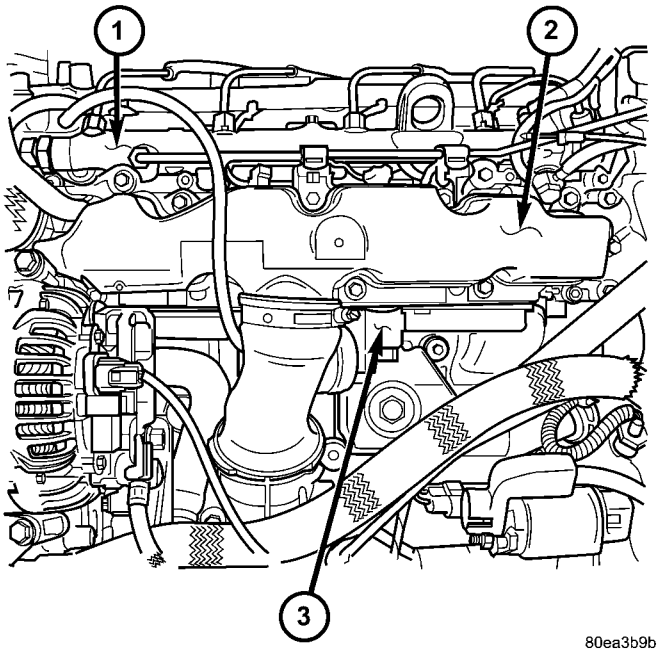



***Fig. 19 INTAKE MANIFOLD SWIRL VALVE LOCATION***

1 - FUEL RAIL
2 - INTAKE MANIFOLD
3 - INTAKE MANIFOLD SWIRL VALVE

SWIRL ACTUATOR (Continued)

## DESCRIPTION - SWIRL VALVE ACTUATOR SOLENOID

The swirl actuator solenoid is mounted next to the coolant recovery pressure container behind the wastegate solenoid (Fig. 20).

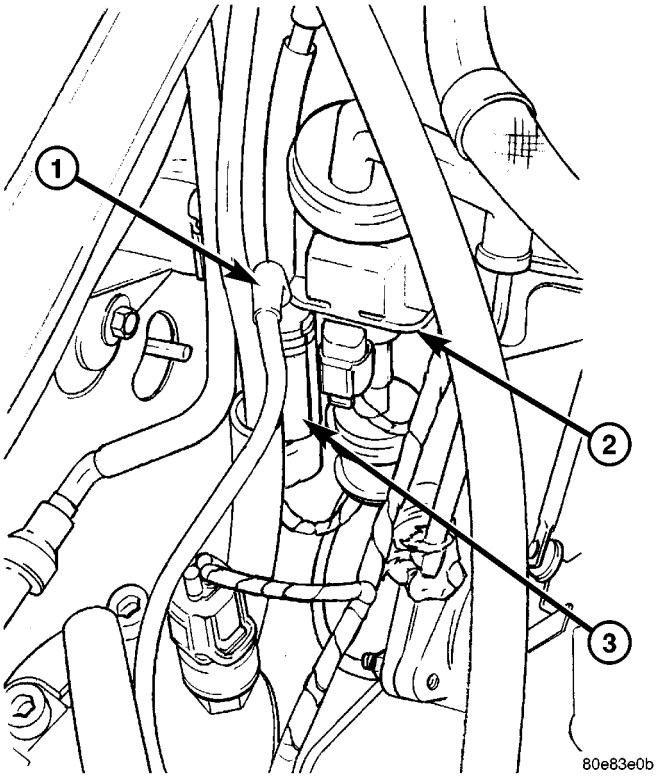



*Fig. 20 SWIRL ACTUATOR SOLENOID*

1 - SWIRL ACTUATOR OUTPUT HOSE
2 - WASTEGATE SOLENOID
3 - SWIRL ACTUATOR SOLENOID

# OPERATION

## OPERATION - INTAKE MANIFOLD SWIRL VALVE

A swirl and a charge inlet port are provided in the intake manifold for each cylinder (Fig. 21). The charge inlet port can be closed by means of flaps. The flaps are connected to each other by means of a linkage, which is operated by the swirl valve actuator (Fig. 21). They are held in the open position by means of spring force.

In the lower engine speed and load range all the charge inlet ports are sealed off by the flaps. The entire air flows through the swirl inlet ports only. This results in high air swirling which in turn produces more effective mixing of the fuel with the air, which improves combustion and reduces the amount of soot particulants in the exhaust.

As engine speed and loads rise, the charge inlet ports are continuously opened to obtain the best possible ratio between air swirling and air mass for each engine operating point, which will optimize exhaust characteristics and engine power output.

The position of the flaps in the charge inlet ports is determined by the map stored in the Engine Control Module (ECM). The swirl valve actuator is actuated by the swirl valve actuator solenoid. This is a PWM solenoid.

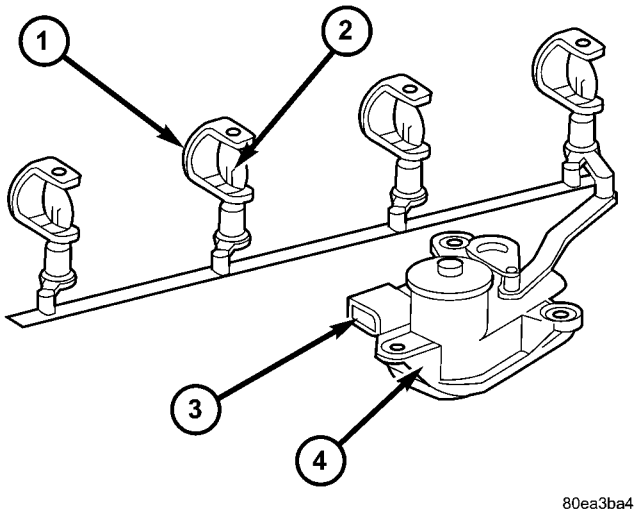



*Fig. 21 INTAKE MANIFOLD SWIRL VALVE COMPONENTS*

1 - CHARGE INLET PORT
2 - FLAP
3 - VACUUM PORT FROM SOLENOID
4 - SWIRL VALVE ACTUATOR

## OPERATION - SWIRL ACTUATOR SOLENOID

The swirl actuator solenoid is used to control the amount of vacuum supplied to the swirl valve actuator.

# EMISSIONS CONTROL

TABLE OF CONTENTS

page

EMISSIONS CONTROL - 2.2L DIESEL
DESCRIPTION . . . . . 1

page

EXHAUST GAS RECIRCULATION . . . . . 2
ON-BOARD DIAGNOSTICS . . . . . 5

## EMISSIONS CONTROL - 2.2L DIESEL

### DESCRIPTION

The 2.2L diesel Engine Control Module (ECM) controls many different circuits in the fuel injection and engine systems. If the ECM senses a problem with a monitored circuit that indicates an actual problem, a Diagnostic Trouble Code (DTC) will be stored in the ECM's memory, and eventually may illuminate the MIL (Malfunction Indicator Lamp) constantly while the key is on. If the problem is repaired, or is intermittent, the ECM will erase the DTC after 40 warm-up cycles without the fault detected. A warm-up cycle consists of starting the vehicle when the engine is cold, then the engine is warmed up to a certain temperature, and finally, the engine temperature falls to a normal operating temperature, then the key is turned off.

Certain criteria must be met for a DTC to be entered into ECM memory. The criteria may be a specific range of engine rpm, engine or fuel temperature and/or input voltage to the ECM. A DTC indicates that the ECM has identified an abnormal signal in a circuit or the system.

There are several operating conditions that the ECM does not monitor and set a DTC for. Refer to the following Monitored Circuits and Non–Monitored Circuits in this section.

### ECM MONITORED SYSTEMS

The ECM can detect certain problems in the electrical system.

**Open or Shorted Circuit** – The ECM will not distinguish between an open or a short to ground, however the ECM can determine if there is excessive current on a circuit, such as a short to voltage or a decrease in component resistance.

**Output Device Current Flow** – The ECM senses whether the output devices are electrically connected.

If there is a problem with the circuit, the ECM senses whether the circuit is open, shorted to ground (–), or shorted to (+) voltage.

**Fuel Pressure:** Fuel pressure is controlled by the fuel injection pump and fuel pressure solenoid. The ECM uses a fuel pressure sensor to determine if a fuel pressure problem exists.

**Fuel Injector Malfunctions:** The ECM can determine if a fuel injector has an electrical problem. The fuel injectors on the diesel engine are **controlled** by the ECM.

### ECM NON–MONITORED SYSTEMS

The ECM does not monitor the following circuits, systems or conditions that could have malfunctions that result in driveability problems. A DTC will not be displayed for these conditions.

**Cylinder Compression:** The ECM cannot detect uneven, low, or high engine cylinder compression.

**Exhaust System:** The ECM cannot detect a plugged, restricted or leaking exhaust system.

**Vacuum Assist:** Leaks or restrictions in the vacuum circuits of the Exhaust Gas Recirculation System (EGR) are not monitored by the ECM.

**ECM System Ground:** The ECM cannot determine a poor system ground. However, a DTC may be generated as a result of this condition.

**ECM/PCM Connector Engagement:** The ECM cannot determine spread or damaged connector pins. However, a DTC may be generated as a result of this condition.

### HIGH AND LOW LIMITS

The ECM compares input signals from each input device. It has high and low limits that are programmed into it for that device. If the inputs are not within specifications and other DTC criteria are met, a DTC will be stored in memory. Other DTC criteria might include engine rpm limits or input voltages from other sensors or switches. The other inputs might have to be sensed by the ECM when it senses a high or low input voltage from the control system device in question.

# EXHAUST GAS RECIRCULATION

**TABLE OF CONTENTS**


page

**EXHAUST GAS RECIRCULATION**
DESCRIPTION . . . . . 2
OPERATION . . . . . 2
**VALVE**
DESCRIPTION . . . . . 2
OPERATION . . . . . 2
REMOVAL . . . . . 3
INSTALLATION . . . . . 3
**SOLENOID**
DESCRIPTION . . . . . 4
REMOVAL . . . . . 4
INSTALLATION . . . . . 4


## EXHAUST GAS RECIRCULATION

### DESCRIPTION

The EGR system reduces oxides of nitrogen (NOx) in the engine exhaust. This is accomplished by allowing a predetermined amount of hot exhaust gas to recirculate and dilute the incoming fuel/air mixture.

A malfunctioning EGR system can cause engine stumble, sags, or hesitation, rough idle, engine stalling and poor driveability.

### OPERATION

The system consists of:

- An EGR valve assembly, located toward the rear of the engine on the intake manifold.
- An EGR solenoid, located in the left rear of engine compartment near EGR valve. The EGR solenoid controls the “on time” of the EGR valve.
- The ECM operates the EGR solenoid. The ECM is located inside the vehicle under the instrument panel.
- The vacuum pump supplies vacuum for the EGR solenoid and the EGR valve. This pump also supplies vacuum for operation of the power brake booster and the heating and air conditioning system. The pump is located in the rear of the cylinder head and is driven by the exhaust camshaft.
- Vacuum lines and hoses connect the various components.

When the ECM supplies a variable ground signal to the EGR solenoid, EGR system operation begins. The ECM will monitor and determine when to supply and remove this variable ground signal. This will depend on inputs from the engine coolant temperature, throttle position and engine speed sensors.

When the variable ground signal is supplied to the EGR solenoid, vacuum from the vacuum pump will be allowed to pass through the EGR solenoid and on to the EGR valve with a connecting hose.

Exhaust gas recirculation will begin in this order when:

- The ECM determines that EGR system operation is necessary.
- The engine is running to operate the vacuum pump.
- A variable ground signal is supplied to the EGR solenoid.
- Variable vacuum passes through the EGR solenoid to the EGR valve.
- The inlet seat (poppet valve) at the bottom of the EGR valve opens to dilute and recirculate exhaust gas back into the mixing chamber.

The EGR system will be shut down by the ECM after 60 seconds of continuous engine idling to improve idle quality.

## VALVE

### DESCRIPTION

The EGR valve is mounted to the cylinder head at the left front corner of the engine (Fig. 1).

### OPERATION

The engines use Exhaust Gas Recirculation (EGR) systems. The EGR system reduces oxides of nitrogen (NOx) in engine exhaust and helps prevent detonation (engine knock). Under normal operating conditions, engine cylinder temperature can reach more than 1649°C (3000°F). Formation of NOx increases proportionally with combustion temperature. To reduce the emission of these oxides, the cylinder temperature must be lowered. The system allows a predetermined amount of hot exhaust gas to recirculate and dilute the incoming air/fuel mixture. The diluted air/fuel mixture reduces peak flame temperature during combustion.

VALVE (Continued)

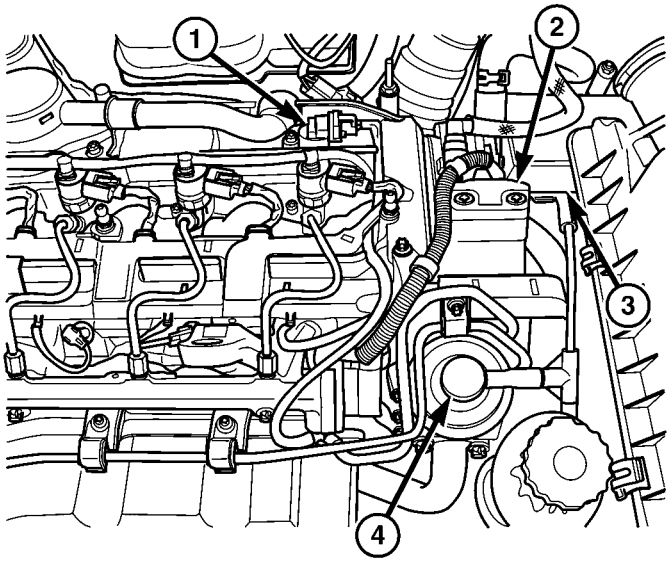



***Fig. 1 EGR VALVE LOCATION***

1 - CAMSHAFT POSITION SENSOR
2 - INJECTION PUMP
3 - POWER DISTRIBUTION CENTER (PDC)
4 - EGR VALVE

## REMOVAL

(1) Disconnect negative battery cable.

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

(3) Partially drain cooling system (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).

(4) Disconnect EGR valve vacuum line.

(5) Disconnect coolant hose at EGR valve.

(6) Disconnect EGR valve to mixing chamber pipe at valve (Fig. 2).

(7) Remove EGR valve retaining bolts and remove EGR valve (Fig. 3).

## INSTALLATION

(1) Clean EGR valve sealing surfaces.

(2) Install EGR valve to cylinder head (Fig. 3). Torque retaining bolts to 20N·m (15 lbs.ft.).

(3) Connect EGR valve to mixing chamber pipe at valve (Fig. 2). Torque retaining bolts to 20N·m (15 lbs.ft.).

(4) Connect coolant hose at EGR valve.

(5) Connect EGR valve vacuum line.

(6) Refill cooling system (Refer to 7 - COOLING/ENGINE/COOLANT - STANDARD PROCEDURE).

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

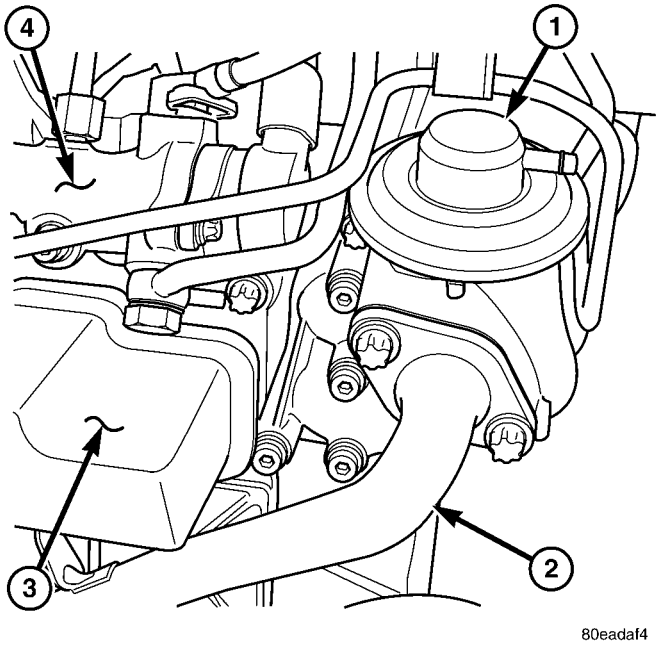



***Fig. 2 EGR VALVE TO MIXING CHAMBER PIPE***

1 - EGR VALVE
2 - EGR VALVE TO MIXING CHAMBER PIPE
3 - INTAKE MANIFOLD
4 - FUEL RAIL

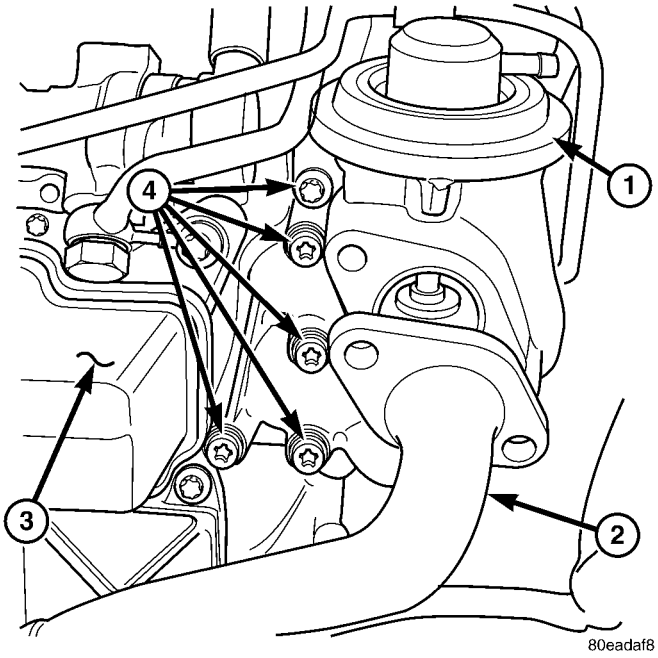



***Fig. 3 EGR VALVE RETAINING BOLTS***

1 - EGR VALVE
2 - EGR VALVE TO MIXING CHAMBER PIPE
3 - INTAKE MANIFOLD
4 - EGR VALVE RETAINING BOLTS

(8) Connect negative battery cable.

# SOLENOID

## DESCRIPTION

The EGR solenoid is mounted in the left-rear of the engine compartment (Fig. 4). The EGR solenoid serves two different functions. One is to control vacuum bleed-off of the EGR valve. The other is to control the “on time” of the EGR valve.

## REMOVAL

(1) Disconnect negative battery cable.
(2) Disconnect EGR solenoid electrical connector (Fig. 4).
(3) Disconnect vacuum harness from EGR solenoid (Fig. 4).
(4) Remove EGR solenoid from bracket (Fig. 4).

## INSTALLATION

(1) Position and install EGR solenoid onto bracket (Fig. 4).
(2) Connect engine vacuum harness to EGR solenoid (Fig. 4).
(3) Connect EGR solenoid electrical connector (Fig. 4).
(4) Connect negative battery cable.

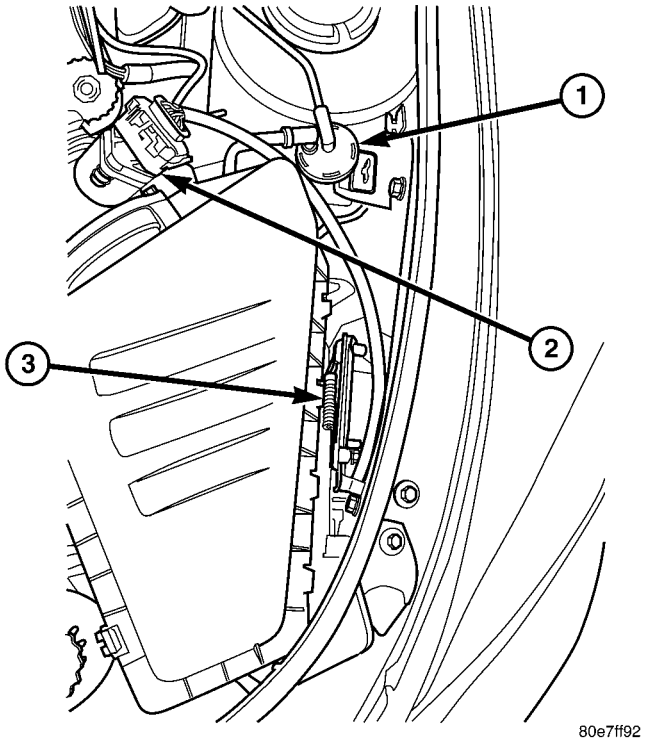



***Fig. 4 EGR SOLENOID LOCATION***

1 - EGR SOLENOID
2 - MAF SENSOR
3 - ENGINE CONTROL MODULE (ECM)

# ON-BOARD DIAGNOSTICS

**TABLE OF CONTENTS**

page

**ON-BOARD DIAGNOSTICS**
DESCRIPTION - DIAGNOSTIC TROUBLE CODES . . . . . 5

# ON-BOARD DIAGNOSTICS

## DESCRIPTION - DIAGNOSTIC TROUBLE CODES

On the following pages, a list of DTC's is provided for the 2.2L diesel engine. A DTC indicates that the ECM has recognized an abnormal signal in a circuit or the system. A DTC may indicate the result of a failure, but most likely will not identify the failed component directly. Refer to the appropriate diagnostic manual for more information on diagnosis of trouble codes.

### ACCESSING DIAGNOSTIC TROUBLE CODES

A stored DTC can be displayed through the use of the DRBIII® scan tool. The DRBIII® connects to the data link connector. The data link connector is located under the instrument panel near bottom of the steering column (Fig. 1).

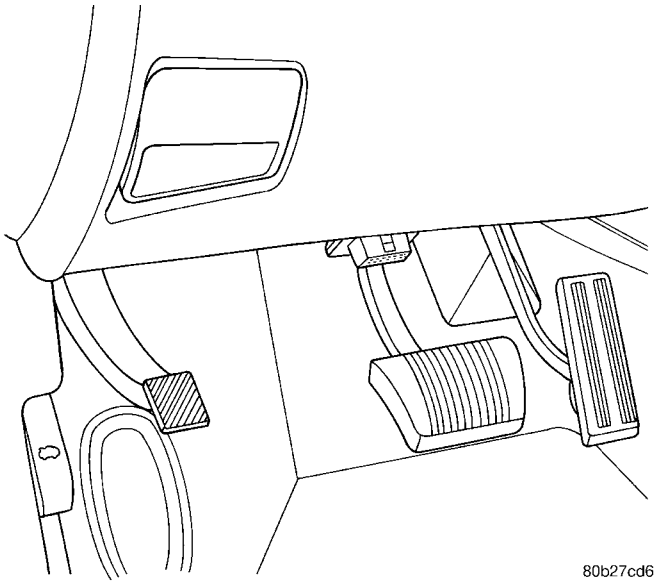



*Fig. 1 DATA LINK CONNECTOR - TYPICAL*

### ERASING TROUBLE CODES

After the problem has been repaired, use the DRBIII® scan tool to erase a DTC.

### ENGINE CONTROL MODULE (ECM) - DRBIII® CODES

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P0070 | Ambient Air Temperature Circuit Signal Voltage Too High<br>Ambient Air Temperature Circuit Signal Voltage Too Low |
| P0100 | Mass Air Flow Sensor Signal Voltage Too High<br>Mass Air Flow Sensor Signal Voltage Too Low<br>Mass Air Flow Sensor Supply Voltage Out of Range |
| P0105 | Barometric Pressure Circuit Signal Voltage To High<br>Barometric Pressure Circuit Signal Voltage To Low |
| P0110 | Charge Air Temperature Sensor Circuit Signal Too High<br>Charge Air Temperature Sensor Circuit Signal Too Low |
| P0115 | Engine Coolant Temperature Sensor Circuit Voltage To Low<br>Engine Coolant Temperature Sensor Circuit Voltage To High |

ON-BOARD DIAGNOSTICS (Continued)

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P0190 | Fuel Pressure Sensor Signal Voltage Too High<br>Fuel Pressure Sensor Signal Voltage Too Low<br>Fuel Pressure Sensor Signal Voltage Out of Range |
| P0201 | Injector 1 Over Current Low Side<br>Injector 1 Over Current High Side<br>Injector 1 Load Drop<br>Injector 1 SL Error |
| P0202 | Injector 2 Over Current Low Side<br>Injector 2 Over Current High Side<br>Injector 2 Load Drop<br>Injector 2 SL Error |
| P0203 | Injector 3 Over Current Low Side<br>Injector 3 Over Current High Side<br>Injector 3 Load Drop<br>Injector 3 SL Error |
| P0204 | Injector 4 Over Current Low Side<br>Injector 4 Over Current High Side<br>Injector 4 Load Drop<br>Injector 4 SL Error |
| P0205 | Injector 5 Over Current Low Side<br>Injector 5 Over Current High Side<br>Injector 5 Load Drop<br>Injector 5 SL Error |
| P0235 | Boost Pressure Sensor Plausibility<br>Boost Pressure Sensor Signal Voltage Too Low<br>Boost Pressure Sensor Signal Voltage Too High<br>Boost Pressure Sensor Signal Voltage Too High Or Low |
| P0243 | Boost Pressure EVM Short Circuit<br>Boost Pressure EVM Open Circuit<br>Boost Pressure EVM Positive Governor Deviation<br>Boost Pressure EVM Negative Governor Deviation |
| P0335 | Engine Speed Sensor |
| P0340 | CMP Signal Frequency Too High<br>IAT Failure<br>IAT Dynamically Implausible<br>CMP Signal Static Defect |
| P0380 | Glow Plug Relay 1 Open Circuit<br>Glow Plug Relay 1 Short Circuit |

ON-BOARD DIAGNOSTICS (Continued)

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P0382 | Glow Plug Relay 2 Open Circuit<br>Glow Plug Relay 2 Short Circuit |
| P0403 | EGR EVM Open Load<br>EGR EVM Short Circuit<br>EGR EVM Negative Governor Deviation |
| P0460 | Fuel Level Sensor Signal Too Low<br>Fuel Level Sensor Signal Too High |
| P0500<br>test | Vehicle Speed Sensor Frequency Too High<br>Vehicle Speed Sensor Plausibility<br>Vehicle Speed Sensor Signal Voltage Too High |
| P0514 | Battery Temperature Sensor Signal Too High<br>Battery Temperature Sensor Signal Too Low |
| P0520 | Oil Pressure Sensor Signal Too High<br>Oil Pressure Sensor Signal Too Low<br>Oil Pressure Sensor Supply Out of Range |
| P0530 | A/C Pressure Transducer Out of Range<br>A/C Pressure Transducer Signal Voltage Too High<br>A/C Pressure Transducer Signal Voltage Too Low |
| P0560 | Battery Voltage Signal Too High<br>Battery Voltage Signal Too Low |
| P0579 | Speed Control Switch Signal Too High<br>Speed Control Switch Signal Too Low<br>Speed Control Switch Plausibility Error |
| P0606 | ECM Recovery Flag<br>ECM Redundant Monitoring<br>ECM Gate Array Monitoring |
| P0615 | Starter Relay Circuit Short Circuit |
| P0620 | Generator Battery Voltage Too Low<br>Generator Battery Voltage Too High<br>Generator Short Circuit<br>Generator Open Load<br>Generator High Current<br>Generator High Battery Voltage Difference<br>Generator Low Battery Voltage Difference |
| P0641 | ECM Sensor Supply Too High<br>ECM Sensor Supply Too Low |

ON-BOARD DIAGNOSTICS (Continued)

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P0645 | A/C Compressor Relay Control Open Load<br>A/C Compressor Relay Control Short Circuit |
| P0651 | ECM Sensor Supply Too Low<br>ECM Sensor Supply Too High |
| P0685 | ECM (ASD) Relay Control Circuit Shuts Off Too Early<br>ECM (ASD) Relay Control Circuit Shuts Off Too Late |
| P700 | EGS Transmission Faults<br>Shift Solenoid A Electrical<br>Shift Solenoid B Electrical<br>Shift Solenoid C Electrical<br>Torque Converter Clutch Electrical<br>Pressure Control Solenoid Electrical<br>Pressure Control Solenoid B Electrical<br>Transmission Control System Electrical |
| P702 | Input Turbine Speed Circuit Malfunction<br>Selector Lever: Code Invalid or CAN Message Distorted or Position Implausible<br>CAN: Right and Left Rear Wheel Speed Implausible or Inconsistent ABS - Node or ABS Information Distorted<br>Transmission Fault<br>CAN: T - Case Information Implausible or Information Distorted<br>Torque Converter Lock - Up - Clutch<br>Gear Recognition Negative |
| P0703 | Brake Switch Signal Plausibility<br>Brake Switch Signal Plausibility After Initialization |
| P0836 | 4 Wheel Drive Switch Signal Too Low<br>4 Wheel Drive Switch Signal Too High<br>4 Wheel Drive Switch Plausibility Error 2<br>4 Wheel Drive Switch Plausibility Error 1 |
| P0850 | Park/Neutral Switch Signal Plausibility |
| P1130 | Fuel Pressure Plausibility, Minimum Pressure at Eng Speed Too Low<br>Fuel Pressure Plausibility, Maximum Exceeded<br>Fuel Pressure Plausibility, Regulator Sticks<br>Fuel Pressure Plausibility, Leakage |
| P1131 | Fuel Pressure Actuator Open Load<br>Fuel Pressure Actuator Short Circuit<br>Fuel Pressure Actuator Power Stage Error |
| P1205 | Injector Classification Checksum Error<br>Injector Classification Invalid Injector Class |

ON-BOARD DIAGNOSTICS (Continued)

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P1235 | EGS Fuel Quantity Demand, Parity Error<br>EGS Fuel Quantity Demand, Toggle Bit<br>EGS Fuel Quantity Demand, Demand Not Plausible |
| P1242 | CAN BUS Message Missing From EGS<br>CAN BUS Mute<br>CAB BUS |
| P1270 | Swirl Actuator Short Circuit<br>Swirl Actuator Open Load<br>Swirl Actuator Diagnosis Ground Switching |
| P1499 | Hydraulic Fan Solenoid Short Circuit<br>Hydraulic Fan Solenoid Open Load |
| P1511 | Battery Sense 1 Too High<br>Battery Sense 1 Too Low |
| P1512 | Battery Sense 2 Too High<br>Battery Sense 2 Too Low |
| P1536 | Generator Excitation Current Too High |
| P1601 | Injector Boost Capacitor Voltage 1 Too High<br>Injector Boost Capacitor Voltage 1 Too Low |
| P1605 | Ignition Signal Plausibility After Initalization |
| P1606 | After Run Test Failure, Zero Fuel Quantity<br>After Run Test Failure, Injector Power Stage |
| P1608 | A to D Monitoring, RAM Test Failure<br>A to D Monitoring, Ground Connection to PPS Failure<br>A to D Monitoring, Test Voltage Failure |
| P1610 | 5 Voltage Supply Too High<br>5 Voltage Supply Too Low |
| P1643 | Cabin Heater Relay Short Circuit<br>Cabin Heater Relay Load Open |
| P1651 | J1850: IFR Error<br>J1850: Status Error |
| P1652 | J1850 BUS Short to Plus<br>J1850 BUS Short to Ground<br>J1850 BUS Transmit Buffer Full<br>J1850 BUS Arbitration Error<br>J1850 BUS Internal SPI Transmission Error<br>J1850 BUS Receive Dead/PV Test<br>J1850 BUS Not Permitted Reset |

ON-BOARD DIAGNOSTICS (Continued)

| Generic Scan Tool Code | DRB III® Scan Tool Display |
|---|---|
| P1680 | EEPROM Fault Checksum<br>EEPROM Fault Checksum Error<br>EEPROM Fault Communication Error<br>EEPROM Fault Different Variation Number<br>EEPROM Fault Code Work Incorrect or Missing<br>EEPROM Fault VIN Write Error |
| P1685 | SKIM Write Access to Secret Key in EEPROM Bad<br>SKIM Read Access to Secret Key in EEPROM RAM Mirror Bad<br>SKIM Timed Out During Communication<br>SKIM Received Invalid Key Code |
| P2120 | Acc. Pedal Position Sensor Supply Out of Range<br>Acc. Pedal Position Sensor Plausibility With Brake Switch<br>Acc. Pedal Position Sensor Signal Too High |
| P2125 | Accel Pedal Sensor Signal to High<br>Accel Pedal Sensor Supply Out of Range<br>Accel Pedal Sensor (PGS) Plausibility w/ PWG |

(Continued)

REMOVAL
ENGINE - 4.0L DIESEL
DISASSEMBLY
STANDARD PROCEDURE
CYLINDER LINER - REMOVE/INSTALL
CYLINDER LINER - REMOVE TIGHT
INSPECTION
CYLINDER LINER - PREMEASURE LINER
CRANKSHAFT OIL PREMEASURE
REMOVAL
ENGINE COVER
ENGINE
REMOVAL
ENGINE COVER
ENGINE COVER
ENGINE
INSTALLATION
CYLINDER
GENERAL TORQUE
CYLINDER LINER
STANDARD PROCEDURE
CYLINDER LINER - REMOVE/INSTALL
MEASURE CYLINDER LINER PROTRUSION
REMOVAL
CYLINDER HEAD
CYLINDER HEAD CHOKE TUBING
CYLINDER HEAD - REMOVE TIGHT
INSTALLATION
CYLINDER HEAD
CYLINDER HEAD - CLEAN THREAD RECESSES
CYLINDER HEAD CHOKE TUBING
CYLINDER HEAD GLOW PLUG
CYLINDER HEAD COVER
REMOVAL
VALVE SPRING
VALVE SPRING
REMOVAL
VALVE SPRING
VALVE SPRING
INSTALLATION
VALVE SPRING
VALVES
DISASSEMBLY
STANDARD PROCEDURE
CRANKING COMPRESSION CHECKING
REMOVAL
INSTALLATION
STANDARD PROCEDURE
REPLACING ENGINE COOL AND OIL VALUABLY FOUND
CRANKSHAFT - CLEAN AND INSPECT BEARING
CRANKSHAFT
STANDARD PROCEDURE
MEASURE CRANKSHAFT AND BLOCK ATLANTA-S
CHECK CRANKSHAFT BEARING CLEAN-S
REMOVAL
INSTALLATION
CRANKSHAFT OIL SEAL - REAR
REMOVAL
INSTALLATION
VACUUM PUMP
DISASSEMBLY
REMOVAL
DISASSEMBLY
OIL PRESSURE MANOMETRATIO
DISASSEMBLY
OIL PUMP
REMOVAL
INSTALLATION
OIL PUMP
REMOVAL
INSTALLATION
OIL JET
DISASSEMBLY
REMOVAL
INSTALLATION
BALANCER SHAFT
DISASSEMBLY
REMOVAL
INSTALLATION
DISTRIBUTION BALANCER SHAFT GEAR TIMEMARK
TIMING CHAIN COVER
REMOVAL
INSTALLATION
TIMING CHAIN
REMOVAL
INSTALLATION
INTERMEDIATE GEAR
TIMING CHAIN TENSIONING DEV
TIMING CHAIN
REMOVAL
INSTALLATION
INTERMEDIATE GEAR
TIMING CHAIN TENSIONING DEV
DISASSEMBLY
REMOVAL
TIMING CHAIN TENSIONER
REMOVAL
TIMING CHAIN TENSIONER
INSTALLATION
TIMING CHAIN TENSIONER
INSTALLATION
CAMSHAFT
DISASSEMBLY
INSTALLATION
CAMSHAFT BEARING
REMOVAL
CAM FOLLOWER ARM/SHAFT
REMOVAL
INSTALLATION
CAM FOLLOWER ARM/SHAFT
REMOVAL
CAM FOLLOWER ARM/SHAFT
INSTALLATION
CAM FOLLOWER ARM/SHAFT
REMOVAL
CAM FOLLOWER ARM/SHAFT
INSTALLATION
LIFTER
REMOVAL
DISASSEMBLY
ENGINE TORQUE STRAT ARRANGEMENT
START AHEAD
REMOVAL
INSTALLATION
UNIT WEIGHT
REMOVAL
INSTALLATION
FUEL SYSTEM
FUEL SYSTEM - 4.0L DIESEL
REMOVAL
DISASSEMBLY - ENGINE FUEL SYSTEMS OVERHEADS
REMOVAL
DISASSEMBLY
DISASSEMBLY AND TESTING
DISASSEMBLY AND TESTING - SMALL FUEL SYSTEMS
DISASSEMBLY AND TESTING - AIR IN FUEL SYSTEM
DISASSEMBLY AND TESTING - FUEL INJECTOR TIMING
STANDARD PROCEDURE
STANDARD PROCEDURE - CHANGING FUEL SYSTEM CONTAMINANTS
STANDARD PROCEDURE - DRAINING WATER FROM FUEL FILTER
STANDARD PROCEDURE - FUEL PRESSURE RELEASE
GENERAL TOOLS
FUEL GAUGE
FUEL PRESSURE
DISASSEMBLY AND TESTING - FUEL PRESSURE SYSTEM
FUEL RAIL TUBES
DISASSEMBLY
INSTALLATION
FUEL PUMP
DISASSEMBLY
INSTALLATION
FUEL RAIL
DISASSEMBLY
INSTALLATION
FUEL LINES
REMOVAL - FUEL PRESSURE LINES
INSTALLATION - FUEL PRESSURE LINES
FUEL TUBE
DISASSEMBLY
INSTALLATION
FUEL FILTER - DIESEL
REMOVAL - FUEL PUMP
DISASSEMBLY AND TESTING - FUEL PUMP
DISASSEMBLY AND TESTING - FUEL RETURN
DISASSEMBLY AND TESTING - FUEL RELIEF
REMOVAL
REMOVAL - FUEL SYSTEM
INSTALLATION
INSTALLATION - FUEL SYSTEM
FUEL INJECTOR
FUEL INJECTOR
DISASSEMBLY AND TESTING - TESTING FUEL INJECTORS
STANDARD PROCEDURE - PRIMING SYSTEM
DISASSEMBLY
BOOST PRESSURE SENSOR
DISASSEMBLY
INSTALLATION
DISASSEMBLY AND TESTING - BOOST PRESSURE SENSOR
DISASSEMBLY AND TESTING SENSOR
REMOVAL
INSTALLATION
FUEL INJECTOR
DISASSEMBLY
INSTALLATION
REMOVAL - FUEL INJECTOR TIP NOZZLE(S) AGREE
ENGINE - MAIN, AND AT ENGINE
ENGINE MAIN OIL
ENGINE - MAIN, AND AT ENGINE
STANDARD PROCEDURE
STANDARD PROCEDURE - ADJUSTING FUEL INJECTORS
STANDARD PROCEDURE - INJECTOR CLASSIFICATION
INJECTOR CLASSIFICATION PROGRAMS
REMOVAL
INSTALLATION
FUEL PRESSURE SENSOR
DISASSEMBLY
INSTALLATION
REMOVAL AND TRANSMISSIONS SENSOR
DISASSEMBLY
INSTALLATION
CAMSHAFT POSITION SENSOR
DISASSEMBLY
INSTALLATION
FUEL INJECTOR
DISASSEMBLY
INSTALLATION
REMOVAL - FUEL INJECTOR TIP NOZZLE(S) AGREE
ENGINE - MAIN, AND AT ENGINE
ENGINE MAIN OIL
ENGINE - MAIN, AND AT ENGINE
STANDARD PROCEDURE
STANDARD PROCEDURE - ADJUSTING FUEL INJECTORS
STANDARD PROCEDURE - INJECTOR CLASSIFICATION
INJECTOR CLASSIFICATION PROGRAMS
REMOVAL
INSTALLATION
FUEL PRESSURE SENSOR
DISASSEMBLY
INSTALLATION
REMOVAL AND TRANSMISSIONS SENSOR
DISASSEMBLY
INSTALLATION
CAMSHAFT POSITION SENSOR
DISASSEMBLY
INSTALLATION
BACKBONE AIR FLOW (MAF) SENSOR
DISASSEMBLY
DISASSEMBLY
INSTALLATION
INSTALLATION
FUEL PRESSURE SENSOR
DISASSEMBLY
DISASSEMBLY
REMOVAL
INSTALLATION
SENSE SETTLERS
DISASSEMBLY
DISASSEMBLY - SPRING MANIFOLD TEMPS VALVE
DISASSEMBLY - SMALL ACTUATOR MANAGER
DISASSEMBLY
DISASSEMBLY - SPRING MANIFOLD TEMPS VALVE
DISASSEMBLY - SMALL ACTUATOR MANAGER
REMOVAL
FUEL/AIR/WATER CONTROL
EMISSIONS SYSTEMS - 4.0L DIESEL
REMOVAL
EGR SYSTEMS
EGR SYSTEMS
EGR SOLENOID
DISASSEMBLY
DISASSEMBLY
REMOVAL
INSTALLATION
EGR VALVE
DISASSEMBLY
REMOVAL
INSTALLATION
EGR COOLER CHARACTERS
ON-BOARD DIAGNOSTICS
DISASSEMBLY - DIAGNOSTIC TROUBLE CODES

(Continued)

# SERVICE MANUAL COMMENTS

**What errors(s) have you found?**

_____

_____

_____

_____

**In order for us to assist you, please include as much details as possible when reporting an error**

**Comments / Suggestions**

_____

_____

_____

_____

☐ **Dealership Technician**
**Dealer Code:** _____

**Retail Customer** ☐

**Manual Title, Year, Number and Page:** _____

_____

**Your Name:** _____

**Address:** _____

_____

_____

**All comments become property of DaimlerChrysler Corporation and may be used without compensation.**

Fold Here

Place
Stamp
Here

DaimlerChrysler Corporation
Attn. Publications Dept.
CIMS 486-02-70
800 Chrysler Drive
Auburn Hills, MI 48326-2757

Fold Here