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Exploded Views and Details

Oil Cooler Cover and Filter Housing

NOTE: Before removing oil cooler and filter housing, the following components must be removed first. See the appropriate sections for removal procedures:

- Fuel filter assembly and lines
- Dual turbocharger
- Oil filter base and housing
- The appropriate wiring harness connections

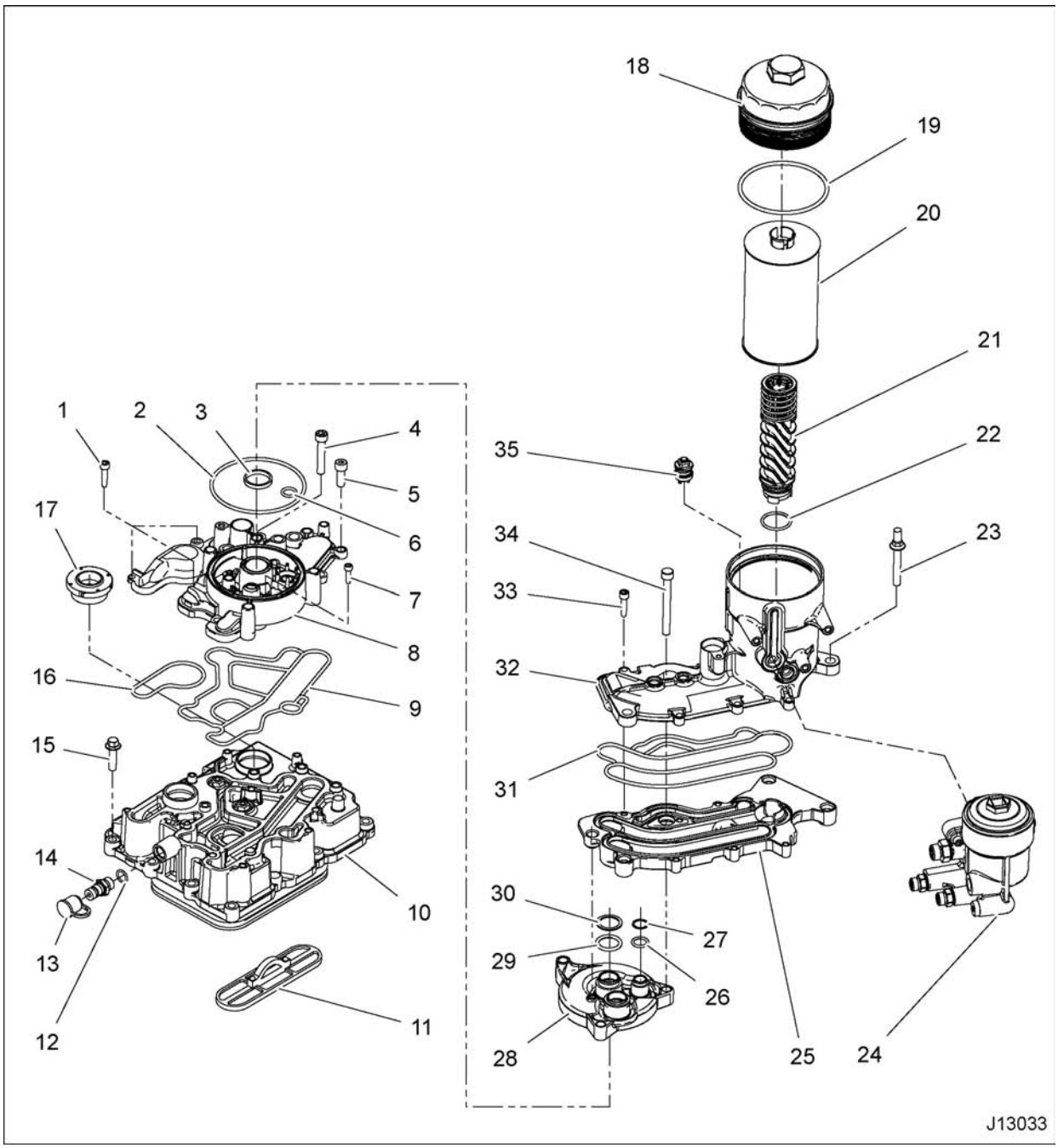

Figure 417 Oil cooler cover and filter housing assembly

1. Thread forming screw, M6 x 25 (3)
2. Viton O-ring, size #241
3. Return tube gasket
4. Bolt, M8 x 45 (Torx®)
5. Screw, M8 x 23 (6)
6. Viton O-ring, size #112
7. Screw, M5 x 18 (2)
8. Oil filter base assembly
9. Oil filter base gasket
10. Oil cooler cover assembly
11. High-pressure pump inlet strainer
12. O-ring, size #906
13. Dust cap
14. Diagnostic port
15. Bolt, M8 x 30 (10)
16. Coolant inlet gasket
17. Exhaust Gas Recirculation (EGR) coolant seal
18. Oil filter cap
19. Oil filter cap seal
20. Oil filter element
21. Latching return tube
22. Viton O-ring, size #122
23. Stud bolt, M8 x 50 x 16 (3)
24. Fuel filter housing (see Fuel System section)
25. Oil filter base
26. Viton O-ring, size #113
27. O-ring retaining washer
28. Oil filter adapter
29. Viton O-ring, size #212 (2)
30. O-ring retaining washer (2)
31. Oil filter assembly gasket
32. Oil filter housing
33. Screw, M6 x 25 (6)
34. Bolt, M8 x 75 (Torx®) (3)
35. Oil drain valve assembly

Oil Cooler Cover and Oil Filter Base Location Details

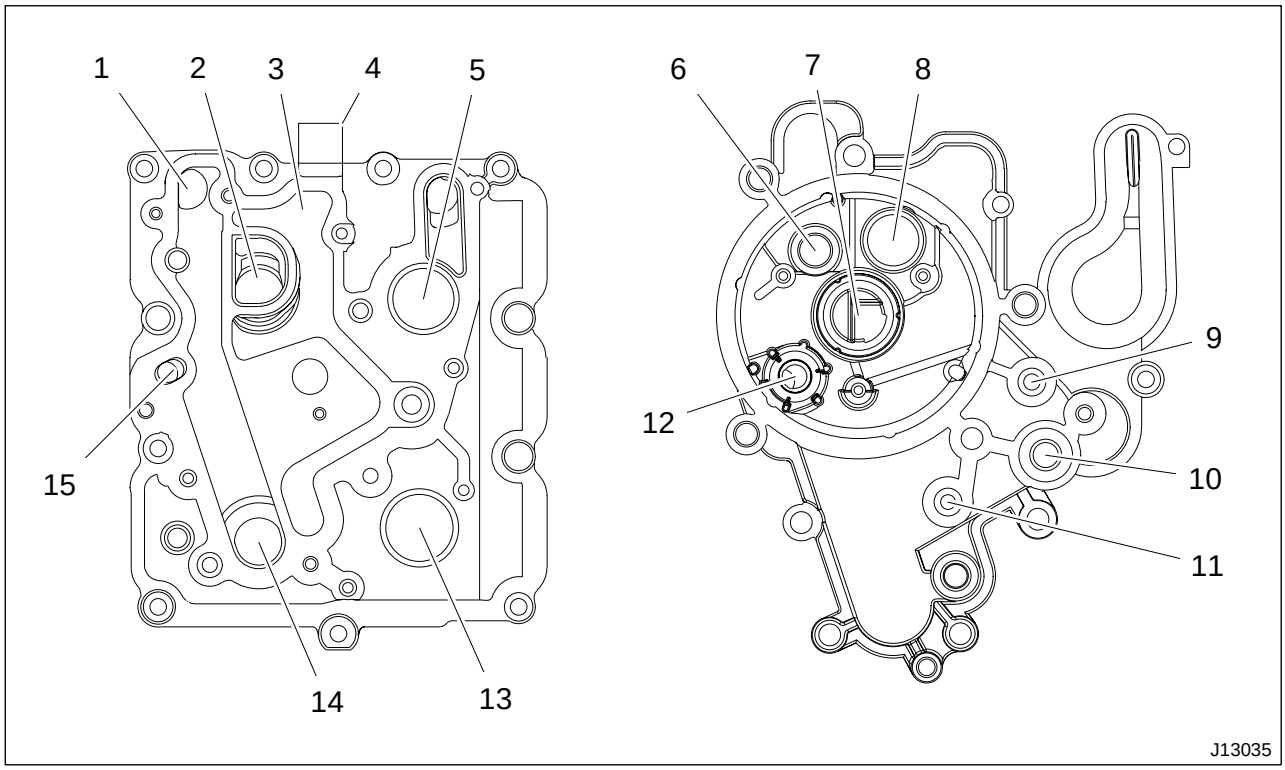

Figure 418 Oil cooler cover and oil filter base location details

1. Unfiltered oil flow from pump
2. Oil cooler outlet (oil)
3. Filtered oil to reservoir
4. Oil pressure test port fitting
5. Coolant inlet
6. Oil cooler bypass valve
7. Filtered oil to crankcase galleries and other components
8. Unfiltered oil inlet
9. Oil temperature sensor port
10. Dual turbocharger oil supply port
11. Oil pressure sensor port
12. Oil filter drain to sump
13. Coolant outlet
14. Oil cooler inlet (oil)
15. Oil drain to sump

Removal

Oil Filter Housing

WARNING: To avoid serious personal injury or possible death, make sure that the engine has cooled down sufficiently before attempting to remove any components. See "Safety Information (page 3)."

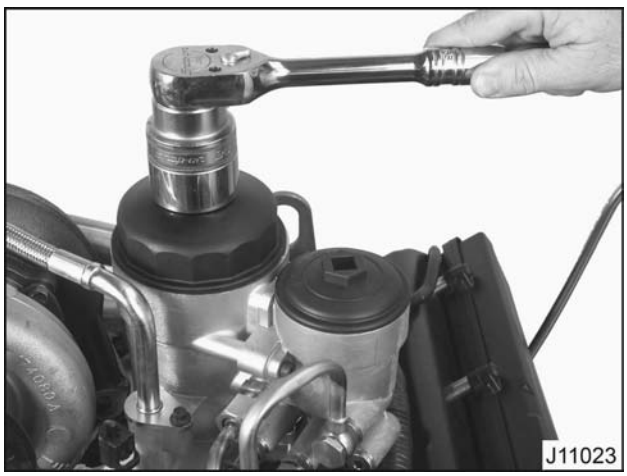

Figure 419 Removing the oil filter cap

1. Loosen oil filter cap and allow oil to drain through filter housing.

Figure 420 Removing the oil filter and cap assembly

2. Remove the oil filter and cap as a unit and discard O-ring gasket on cap.

CAUTION: To prevent engine damage, do not attempt to remove latching return tube unless oil filter housing and oil filter base have been separated.

3. Remove the one bolt (M8 x 50) securing the oil filter housing to the oil filter adapter.
4. Remove the two stud bolts (M8 x 50 x 16) securing the oil filter housing to the intake manifold.
5. Remove the six screws (M6 x 25) securing the oil filter housing to the oil filter base. Remove and discard oil filter assembly gasket.

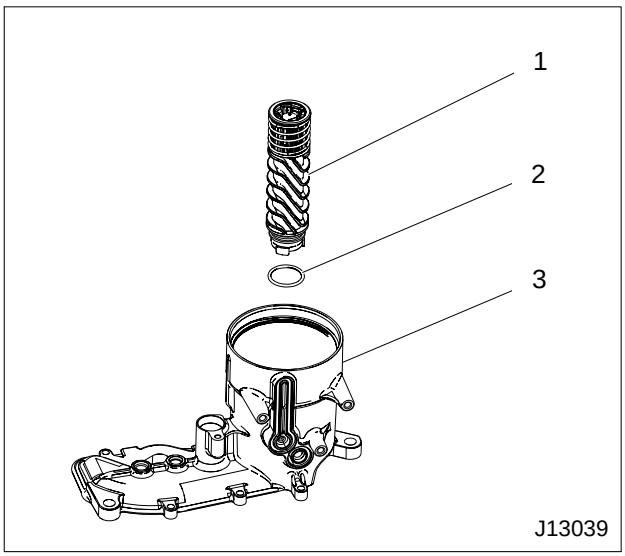

Figure 421 Latching return tube assembly

1. Latching return tube
2. Viton O-ring seal, size #122
3. Oil filter housing

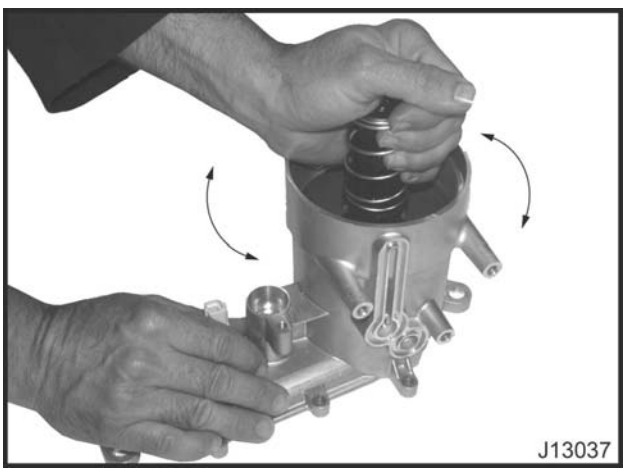

Figure 422 Removing the latching return tube assembly

6. Remove the oil filter latching return tube by pushing down and rotating tube counter-clockwise 120°, then lift tube straight up. Remove O-ring seal and discard.

Oil Cooler Cover

CAUTION: In the event of a catastrophic engine failure, always replace the oil cooler cover assembly. Debris cannot be removed from the oil cooler.

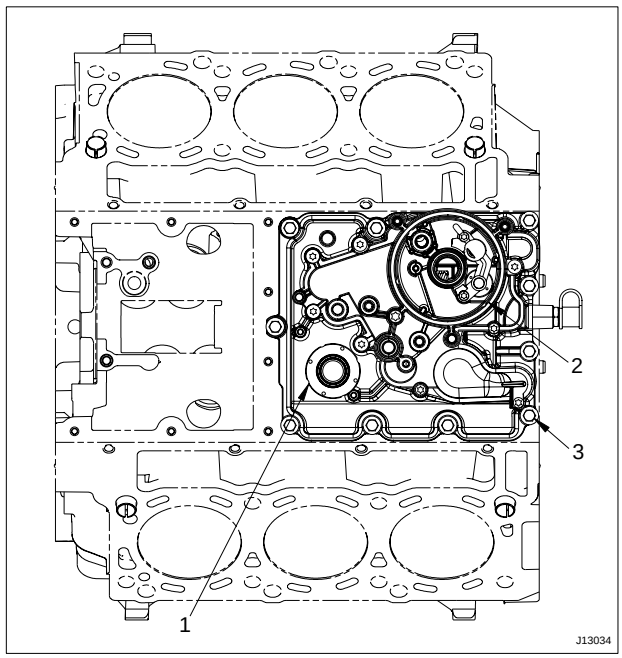

Figure 423 Oil cooler cover assembly mounting bolts

1. EGR coolant inlet seal
2. Oil cooler assembly with oil filter base
3. Bolt, M8 x 30 (10)

NOTE: Refer to the Manifolds and Exhaust Gas Recirculation section for intake manifold removal procedure before proceeding with the oil cooler removal.

1. Remove EGR coolant inlet seal and discard.
2. Remove ten oil cooler cover assembly mounting bolts (M8 x 30).

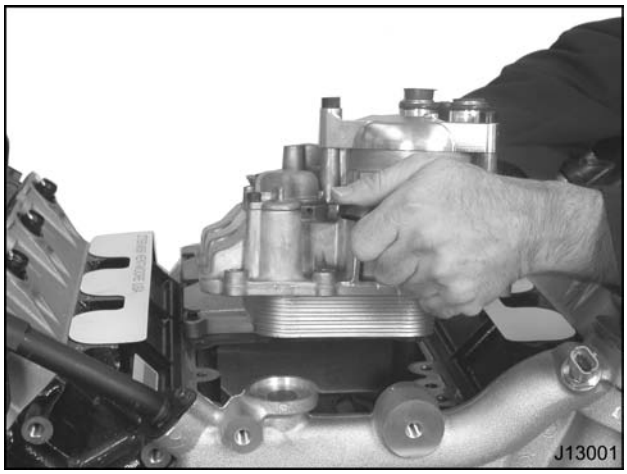

Figure 424 Remove oil cooler module assembly

3. Remove oil cooler cover module from crankcase.

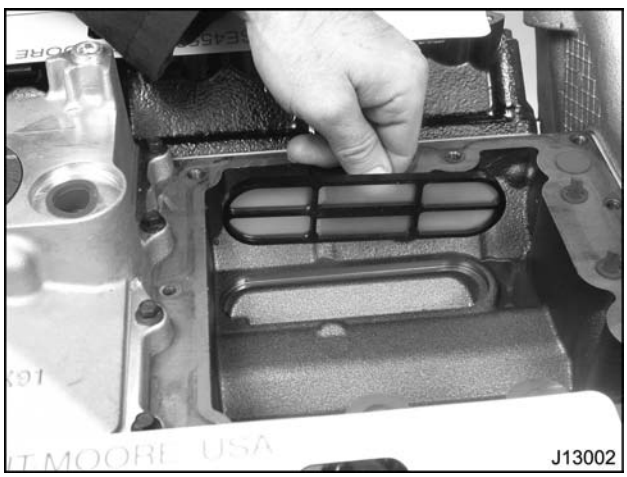

Figure 425 High-pressure oil pump inlet strainer

4. Remove pump inlet strainer from oil reservoir and discard.
5. Remove remaining oil from reservoir.

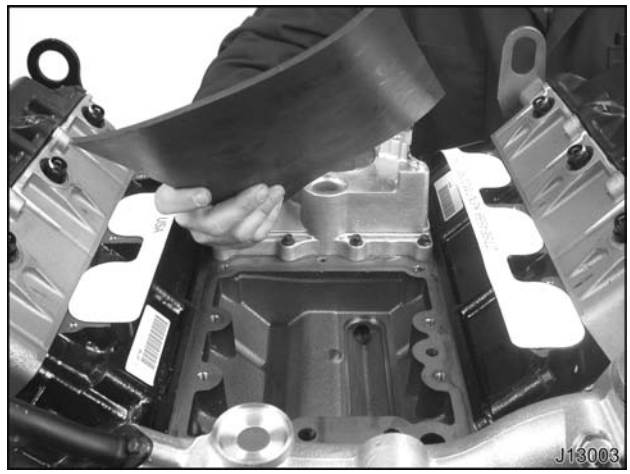

Figure 426 Installing the oil reservoir magnetic covers

6. Install the oil reservoir Magnetic Covers. See Special Service Tools (page 270).
7. Test oil cooler using the Oil Cooler Pressure Test Plate. See “Special Service Tools” (page 270). See Oil Cooler Leaks (Coolant Side) (page 262).

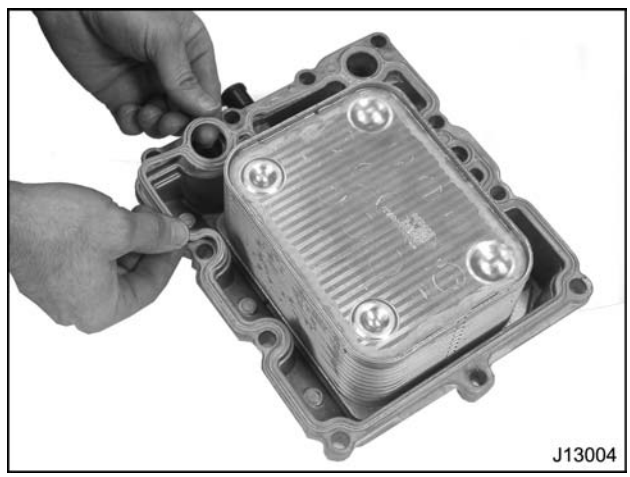

Figure 427 Removing the oil cooler cover gasket

8. Remove oil cooler cover gasket and discard.

Oil Filter Base Disassembly

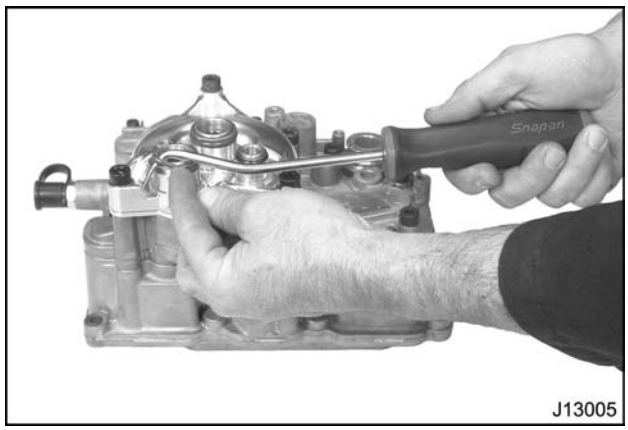

Figure 428 Removing the oil filter adapter O-rings

1. Remove and discard all three oil filter base assembly O-rings on top.
2. Remove the three Torx® bolts (M8 x 75) securing the oil filter adapter.

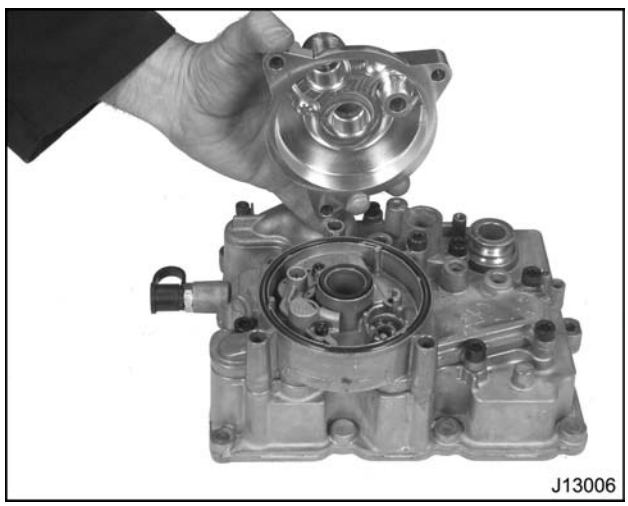

Figure 429 Removing the oil filter adapter

3. Remove the oil filter adapter and discard all three O-ring seals.

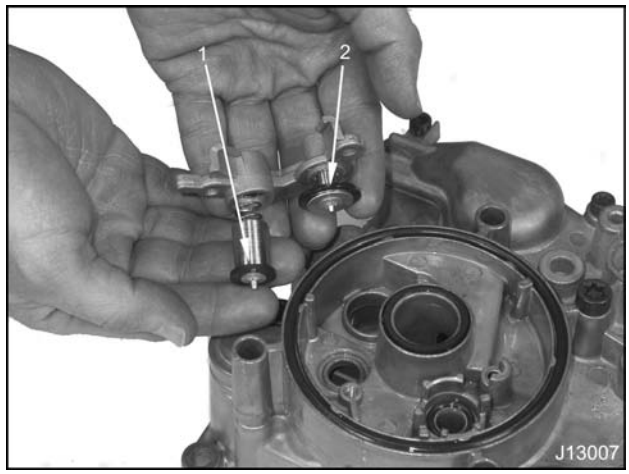

Figure 430 Oil bypass / filter inlet guide valve assembly

1. Oil cooler bypass valve washer seal
2. Oil filter inlet washer seal

NOTE: Remove oil bypass assembly only if you suspect any problems.

4. Remove two screws (M5 X 18), then the oil bypass / filter inlet guide valve.

NOTE: Do not remove the oil filter base until oil cooler pressure test has been performed.

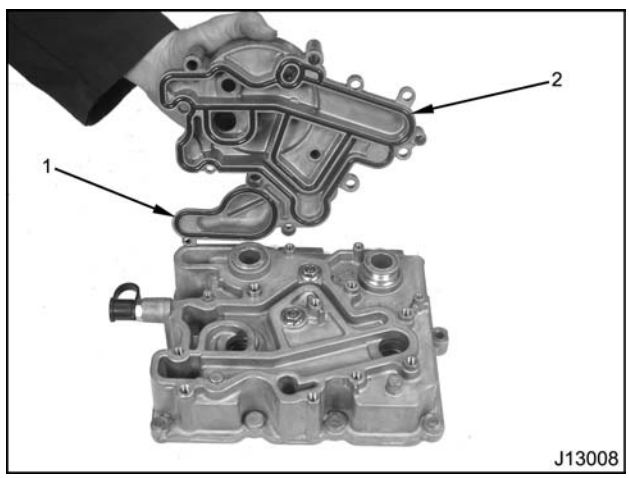

Figure 431 Removing the oil filter base

1. Coolant inlet gasket
2. Oil filter base gasket

NOTE: If diagnosing a problem do not remove filter base at this time.

5. Remove oil filter base assembly from oil cooler cover assembly. Remove and discard oil and coolant gaskets.

Cleaning, Inspection and Testing

Oil Cooler Cover and Oil Filter Base

1. Drain and flush oil cooler cover, oil filter base and housing to remove any internal residue.

WARNING: To avoid serious personal injury or possible death, wear safety glasses with side shields when using compressed air for cleaning to reduce the danger from flying debris. Limit the air pressure to 207 kPa (30 psi). See "Safety Information (page 3)."

2. Dry all components thoroughly with filtered compressed air.

Oil Cooler Leaks (Coolant Side)

NOTE: Perform the air pressure leakage test. If the oil cooler test indicates any signs of leaking, replace oil cooler cover assembly. There are no serviceable parts for this unit.

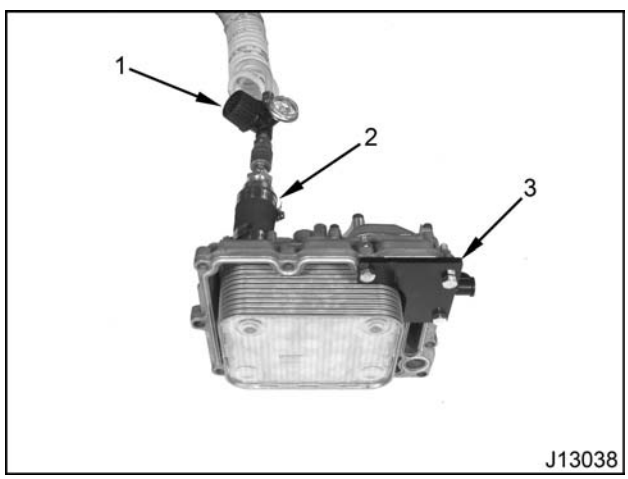

Figure 432 Air pressure leakage test

1. Air pressure regulator
2. Air adapter (make locally)
3. Test plate

NOTE: The oil filter base must be installed on the oil cooler cover assembly before a pressure test can be performed.

1. Fabricate an air adapter with the following items:
   - Rubber hose
   - Reducer bushing (hose to fitting)
   - Shop air fitting (male)
   - Two clamps
2. Fasten Oil Cooler Pressure Test Plate (page 270) to oil cooler assembly.
3. Install air pressure regulator to EGR cooler coolant outlet port (air adapter).
4. Apply 207 kPa (30 psi) of air pressure.
5. Spray a soapy water solution around oil cooler and oil filter base.

CAUTION: To prevent engine damage, do not submerge the oil cooler in water. Submerging could allow water to be introduced into oil passages, causing engine damage.

6. If leaking occurs, bubbles will be present between the oil cooler and cover. Replace oil cooler cover assembly as required.
7. Remove soapy water residue and blow off with filtered compressed air.

Installation

Oil Filter Base

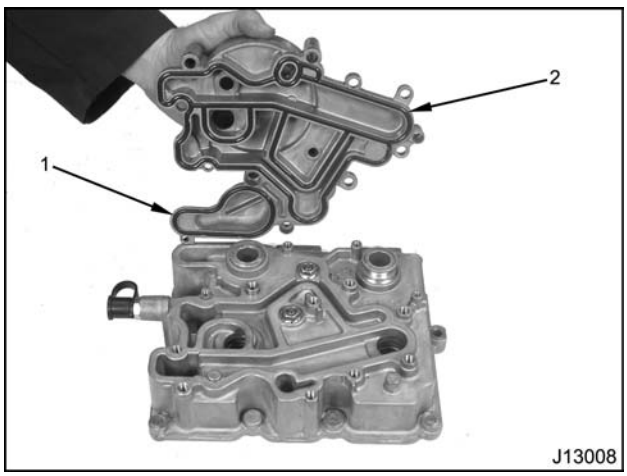

Figure 433 Oil filter base assembly gaskets

1. Coolant gasket
2. Oil gasket

1. Install new oil and coolant gaskets onto oil filter base assembly.
2. Install a new oil filter return tube gasket and filter housing to base seal.

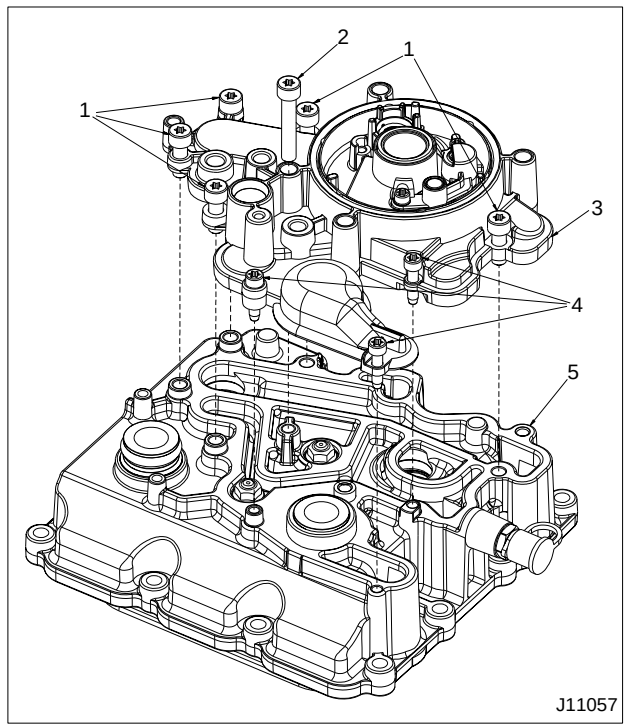

Figure 434 Oil filter base bolt arrangement

1. Screw, M8 X 23 (5)
2. Bolt, M8 X 45 (Torx®)
3. Oil filter base assembly
4. Screw, M6 X 25 (6)
5. Oil cooler cover assembly

3. Install oil filter base onto oil cooler cover assembly.

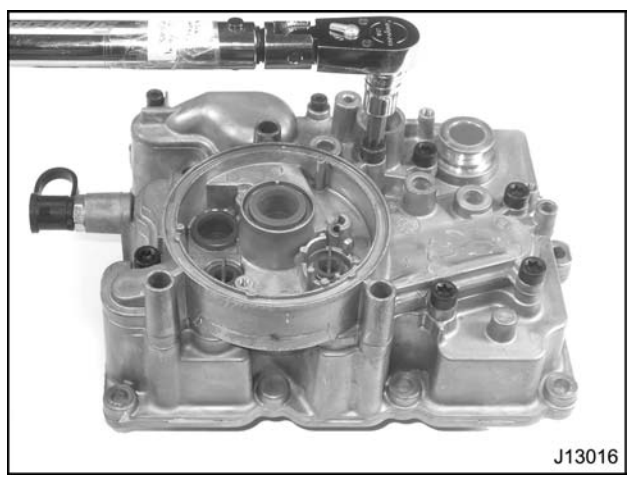

Figure 435 Torquing the oil filter base assembly bolts

4. Install all oil filter base assembly bolts and tighten to the Special Torque (page 270).

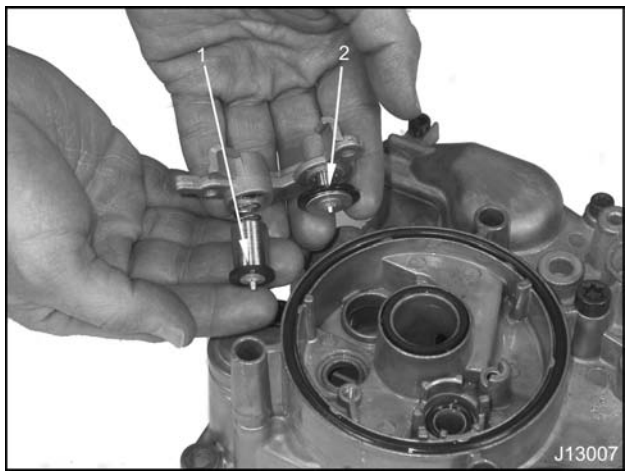

Figure 436 Oil bypass / filter inlet guide valve assembly

1. Oil cooler bypass valve washer seal
2. Oil filter inlet washer seal

5. If removed, install a new oil bypass / filter inlet guide valve and two screws.

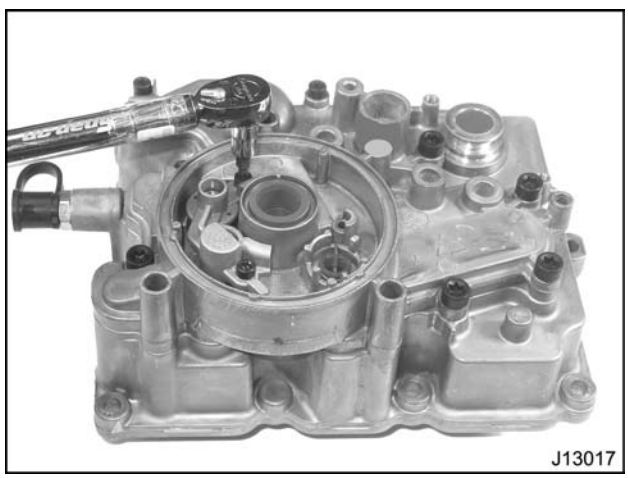

Figure 437 Torquing the oil bypass / filter inlet guide screws

6. Torque the oil bypass / filter inlet guide screws (M5 x 18) to the Special Torque (page 270).

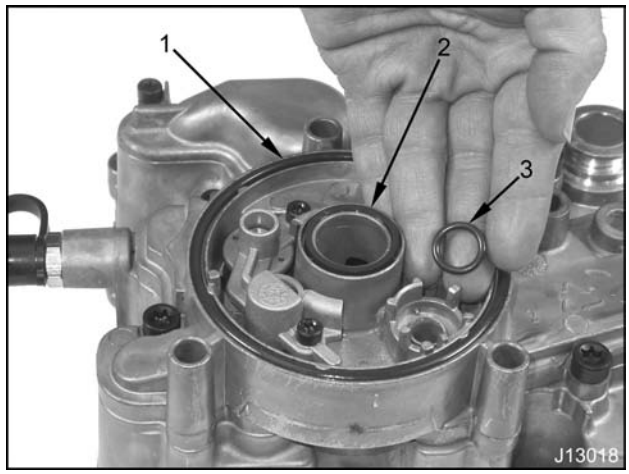

Figure 438 Installing the oil filter base O-rings

1. O-ring, size #241
2. Return tube gasket
3. O-ring, size #112

7. Install two oil adapter O-rings and one return tube gasket.

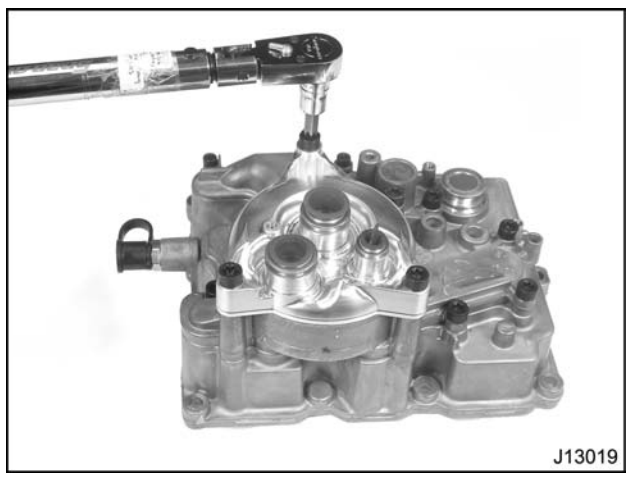

Figure 439 Torquing the oil adapter assembly bolts

8. Install oil adapter assembly onto oil filter base assembly. Tighten three Torx® socket screws (M8 x 75) to the Standard Torque (page 405).

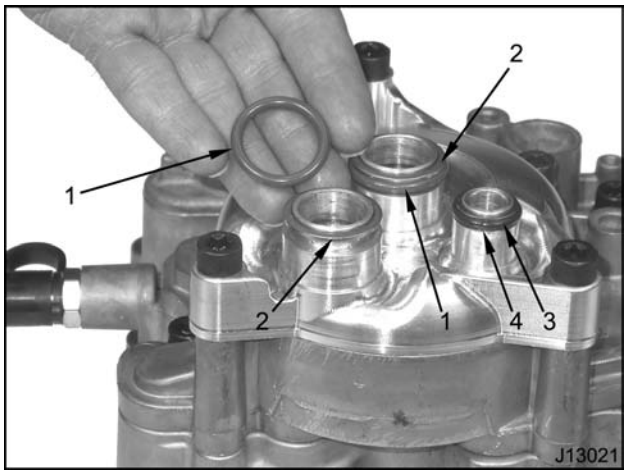

Figure 440 Installing the oil filter adapter O-rings

1. O-ring, size #212 (position below retainer washer)
2. O-ring retainer washer (position above O-ring)
3. O-ring retainer washer (position above O-ring)
4. O-ring, size #113 (position below retainer washer)

9. Install a new set of O-rings onto the oil filter adapter.

Oil Cooler Cover

Figure 441 Installing the pump inlet strainer (150 micron)

1. Install a clean pump inlet strainer in the oil reservoir.

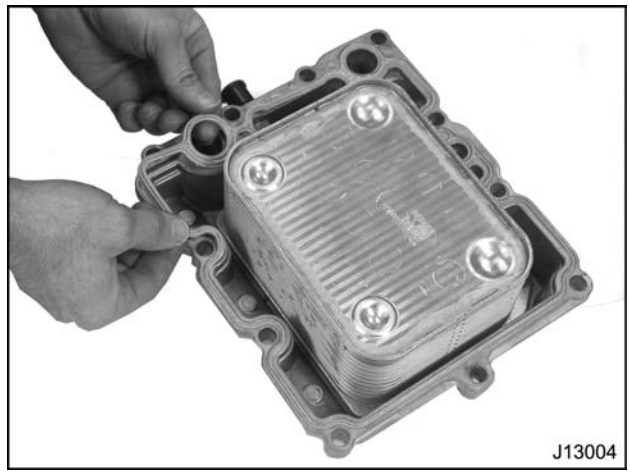

Figure 442 Installing the oil cooler cover gasket

2. Install a new reservoir cover gasket in the oil cooler cover assembly.

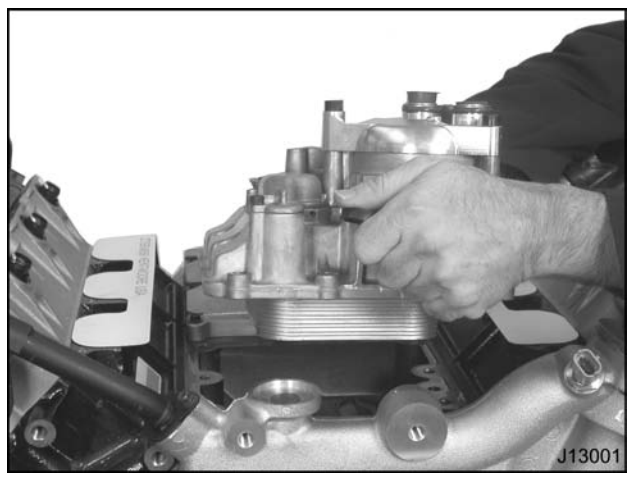

Figure 443 Installing the oil cooler cover assembly

3. Remove magnetic service cover and lower oil cooler cover assembly onto engine crankcase.

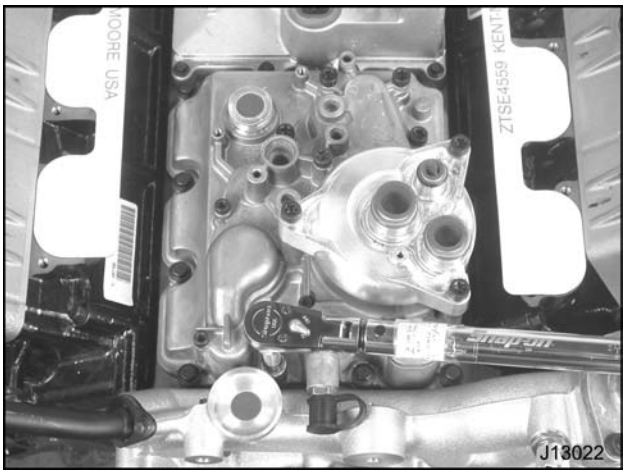

Figure 444 Torquing the oil cooler cover assembly bolts

4. Install ten oil cooler cover assembly mounting bolts (M8 x 30) and tighten to the Standard Torque (page 405).
5. Lubricate the three O-ring seals on top of the oil filter adapter with clean engine oil.

NOTE: At this time it will be necessary to install the intake manifold prior to building up the oil filter assembly. Refer to the Manifolds and Exhaust Gas Recirculation (EGR) section of this manual for intake manifold installation procedure.

Oil Filter Base and Housing

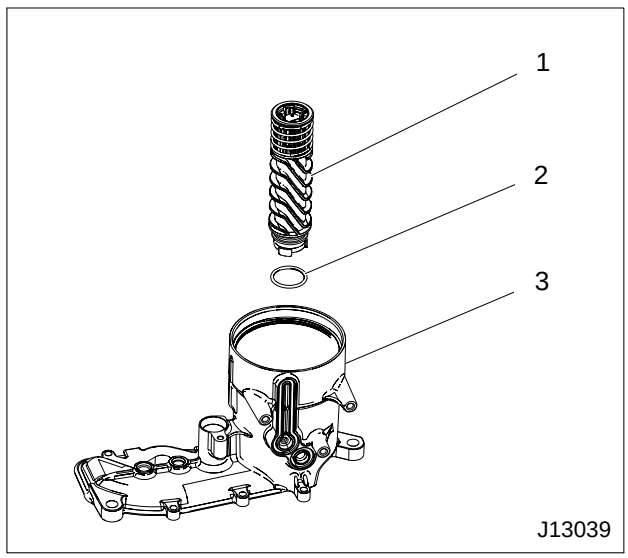

Figure 445 Latching return tube

1. Latching return tube
2. Latching return tube gasket
3. Oil filter housing

1. Lubricate a new latching return tube gasket with clean engine oil and install onto latching return tube.

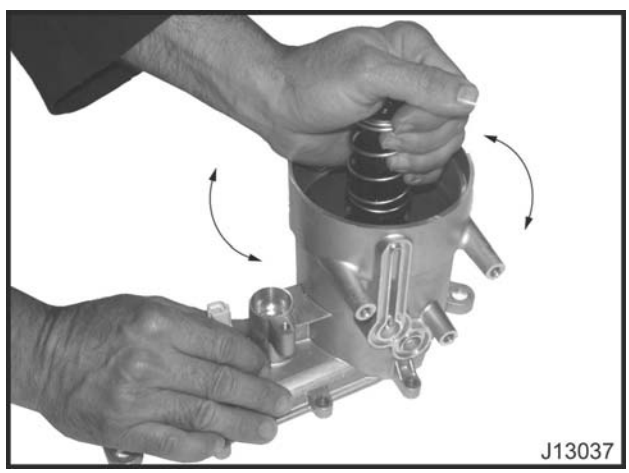

Figure 446 Installing the latching return tube

2. Install latching return tube by pushing down and twisting tube 120° clockwise until latched.

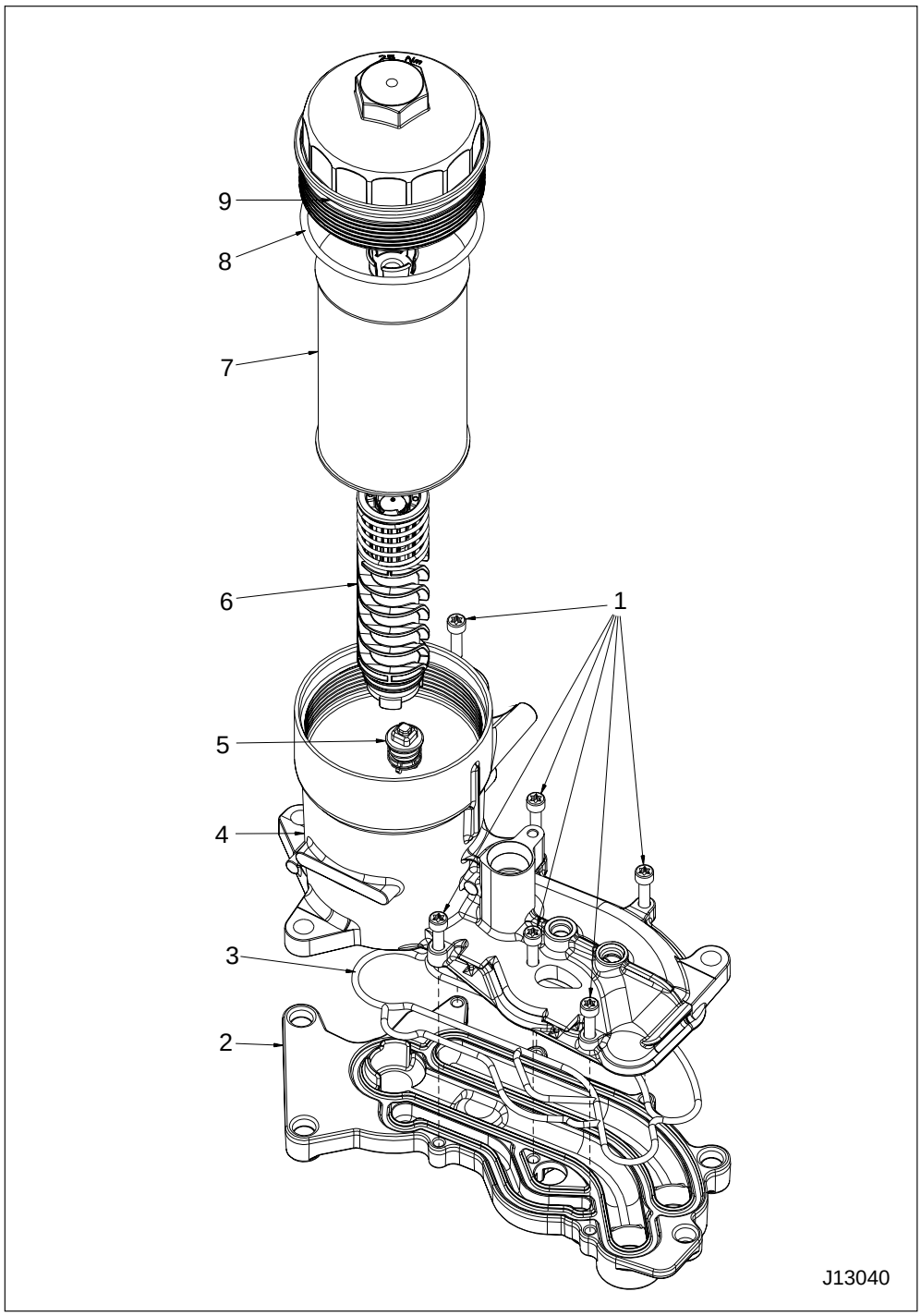

Figure 447 Oil filter base and housing details

1. Screw, (M6 x 25)
2. Oil filter base
3. Oil filter housing gasket
4. Oil filter housing
5. Oil drain valve assembly
6. Latching return tube assembly
7. Oil filter element
8. Oil filter cap seal
9. Oil filter cap

3. Position a new oil filter housing gasket between the housing and base.
4. Install six oil filter housing mounting bolts (M6 x 25). Tighten bolts to the Special Torque (page 270).

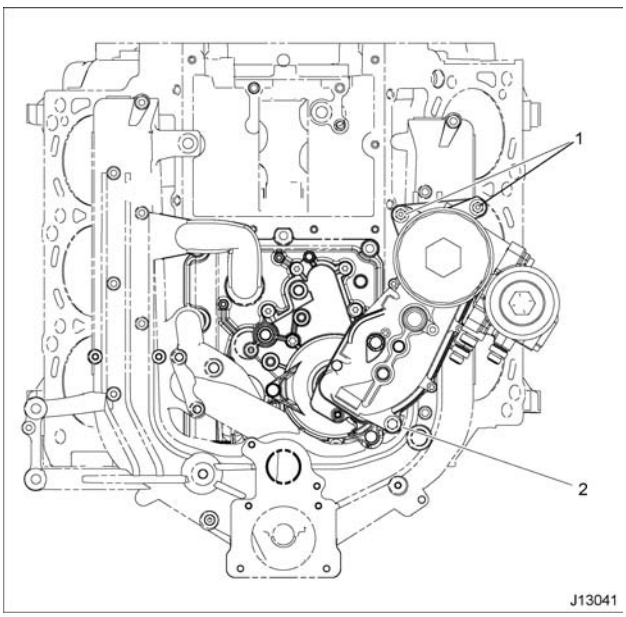

Figure 448 Oil filter housing assembly to engine

1. Stud bolt, M8 x 50 x 16 (2)
2. Bolt, M8 x 50

5. Position oil filter housing onto oil filter adapter and intake manifold. Tighten bolts to the Standard Torque (page 405).

Figure 449 Installing the oil filter and cap assembly

Figure 450 Installing the oil filter cap

6. Install oil filter and cap as a combined unit. Tighten cap to the Special Torque (page 270).

CAUTION: To prevent engine damage, add oil to the engine before starting. Also, see your Engine Operation and Maintenance Manual for engine oil and filter service interval. Proper maintenance of your engine will prolong service life.

CAUTION: The correct oil viscosity for diesel engines is important for satisfactory operation, especially in cold weather. Follow the chart in the Engine Operation and Maintenance Manual to determine which oil viscosity is best suited for the temperature range you expect to encounter.

7. Fill crankcase with oil. See the Operation and Maintenance Manual for correct refill capacity.

   NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in sewers, streams or bodies of water.

8. Start engine and check for leaks. Correct any leakage as necessary. Shut down engine and check engine oil level. Add oil or drain oil as needed to bring oil level to the FULL mark on oil level gauge. Do not overfill past the FULL mark.

Specifications

Oil Cooler and Oil Filter Assemblies	
Oil Cooler	
Type	Full-flow: 11 fins oil, 11 fins water
Heat transfer	1650 BTU / min / 60° ETD
Location	Engine valley (forward)
Oil Filter	
Type	Cartridge, full flow - disposable
Filtering efficiency	20 microns and larger
Location	Front, oil cooler mounted
Filter bypass location	Oil filter return tube assembly

Special Torque

Oil Cooler and Oil Filter Assemblies	
Oil filter base assembly (M6 x 25)	10 N·m (85 lbf·in)
Oil filter base assembly (M8 x 45)	11 N·m (97 lbf·in)
Oil filter base assembly (M8 x 23)	23 N·m (17 lbf·ft)
Oil bypass / filter inlet guide valve (M5 x 18)	7 N·m (62 lbf·in)
Oil cooler mounting bolts (M6 x 25)	15 N·m (132 lbf·in)
Diagnostic valve	16 N·m (144 lbf·in)
Oil filter cap	25 N·m (18 lbf·ft)

Special Service Tools

Oil Cooler Cover Assembly	
Description	**Tool Number**
Magnetic Covers	ZTSE4557
Oil Cooler Pressure Test Plate	ZTSE4525

Table of Contents

Location of Engine Sensors and Valves

Sensor and Valve Locations, Top View

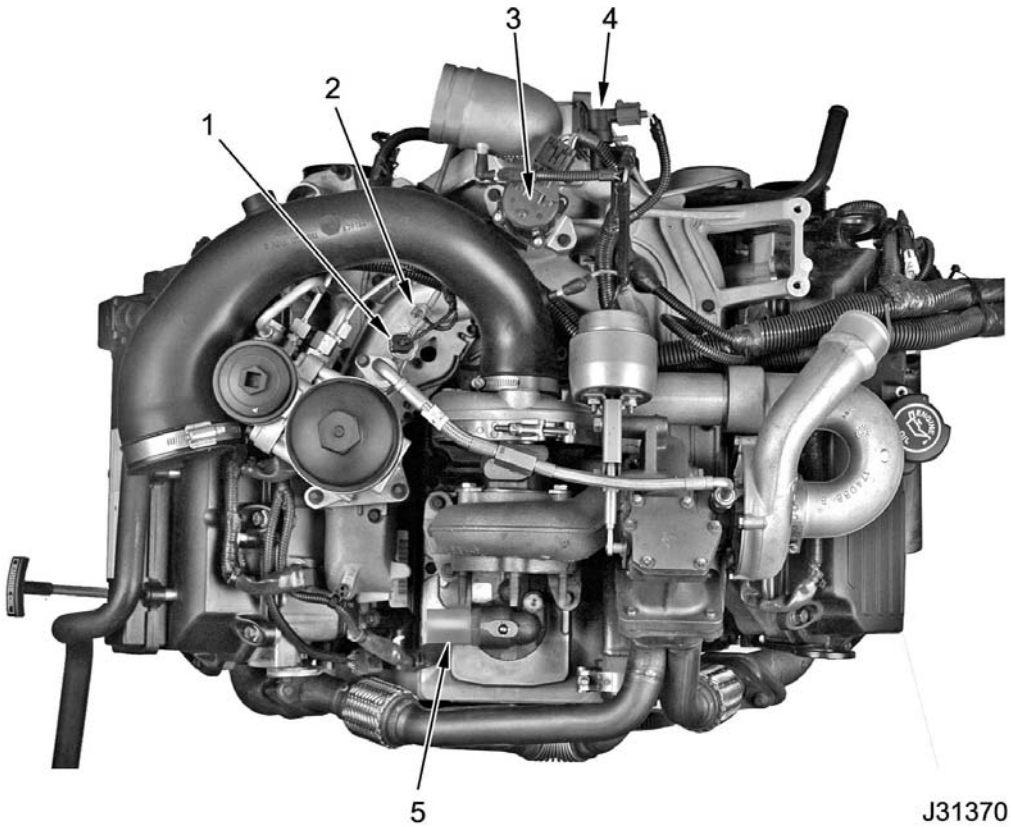

Figure 451 Sensor and switch locations, top view of engine (typical)

1. Engine Oil Temperature (EOT) sensor
2. Engine Oil Pressure (EOP) switch
3. Exhaust Gas Recirculation (EGR) valve
4. Boost Control Solenoid (BCS) assembly
5. Injection Pressure Regulator (IPR) valve

Sensor and Valve Locations, Right View of Engine

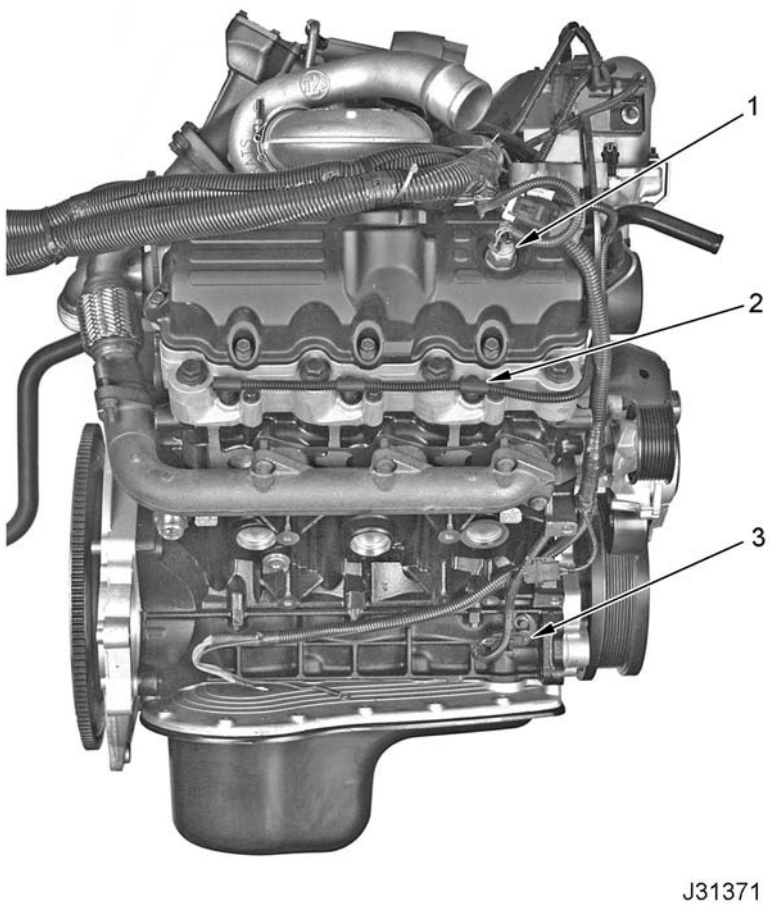

Figure 452 Sensor locations, right view of engine (typical)

1. Injection Control Pressure (ICP) sensor
2. Glow plug harness (right)
3. Crankshaft Position (CKP) sensor

Sensor and Valve Locations, Left View of Engine

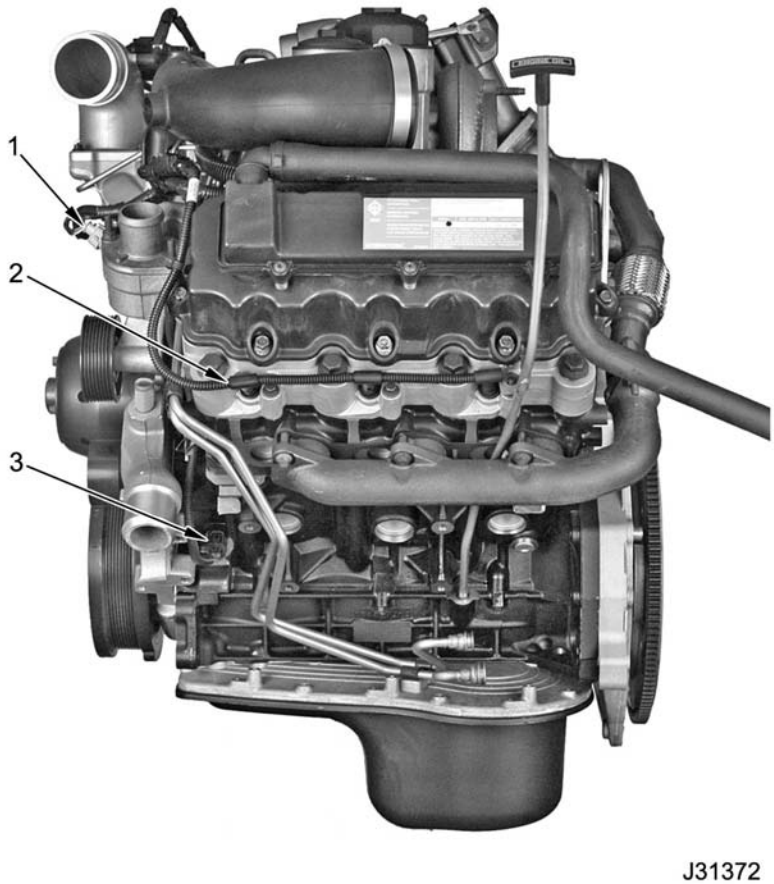

Figure 453 Sensor locations, left view of engine (typical)

1. Engine Coolant Temperature (ECT) sensor
2. Glow plug harness (left)
3. Camshaft Position (CMP) sensor

Sensor Locations, Front View of Engine

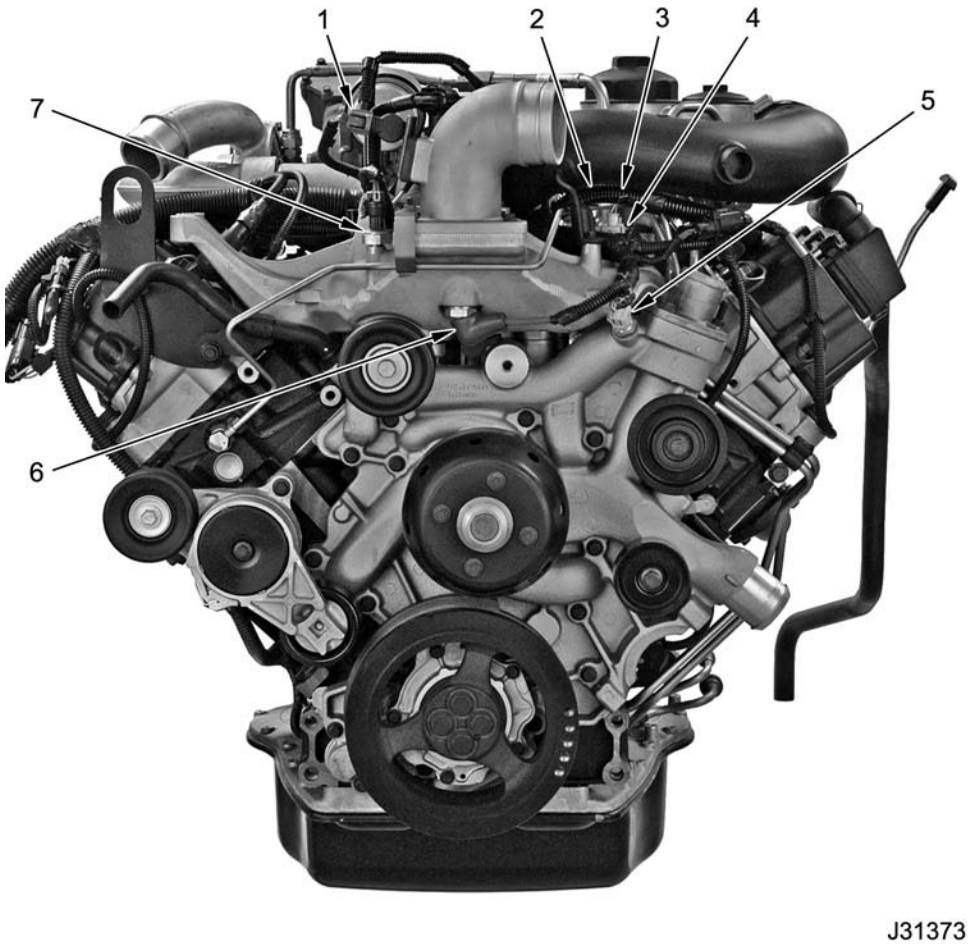

Figure 454 Sensor locations, front view of engine (typical)

1. Boost Control Solenoid (BCS) assembly
2. Engine Oil Temperature (EOT) sensor
3. Engine Oil Pressure (EOP) sensor
4. Manifold Air Temperature (MAT) sensor
5. Engine Coolant Temperature (ECT) sensor
6. Intake Air Heater (IAH)
7. Manifold Absolute Pressure (MAP) sensor

Description of Engine Electrical Components - Engine Mounted

BCS Assembly (Boost Control Solenoid)

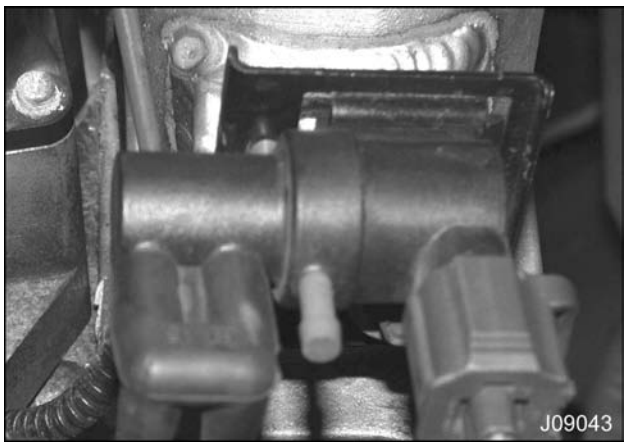

Figure 455 BCS solenoid

The BCS is mounted on the inlet elbow. The ECM sends a signal to the BCS assembly. The BCS controls the boost pressure to the turbocharger pneumatic actuator. The pneumatic actuator controls the turbocharger bypass valve.

CMP Sensor (Camshaft Position)

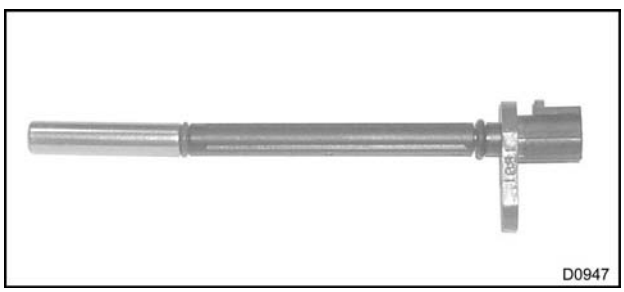

Figure 456 CMP sensor

A magnetic pickup that is mounted on the left side of the lower crankcase near the front cover of the engine. The CMP sensor provides the ECM with a signal that indicates camshaft position. As the cam rotates, the sensor identifies the position of the cam by locating a peg on the cam.

CKP Sensor (Crankshaft Position)

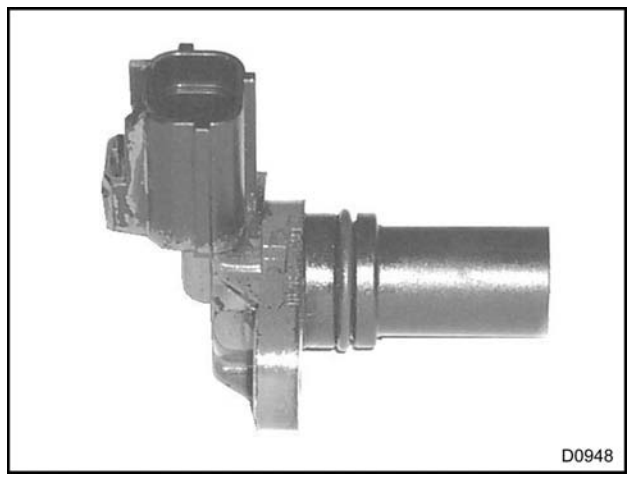

Figure 457 CKP sensor

A magnetic pickup that is mounted on the right side of the lower crankcase near the front cover of the engine. The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. As the crankshaft turns the CKP sensor detects a 60 tooth timing disk on the crankshaft. Teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements.

ECT Sensor (Engine Coolant Temperature)

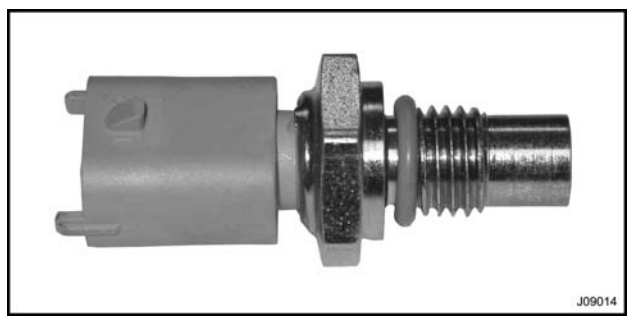

Figure 458 ECT sensor

A thermistor type sensor which is mounted on the left side of the engine's front cover, above the water pump. The ECM monitors the ECT signal and uses this information for the instrument panel temperature gauge, coolant compensation, Engine Warning

Protection system (EWPS), and glow plug operation. The ECT is a backup, if the EOT is out of range.

EOP Switch (Engine Oil Pressure)

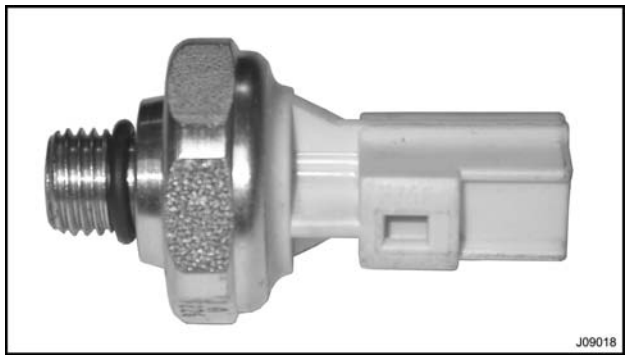

Figure 459 EOP switch

A ceramic diaphragm switch located in the oil filter base assembly. The ECM monitors the EOP signal for reference only. The ECM uses the EOP signal to control the instrument panel oil pressure gauge and for EWPS warning, lights the engine warning lamp for low oil pressure. The EOP switch closes a circuit to ground after the engine oil pressure reaches 34 kPa to 48 kPa (5 psi to 7 psi). When the pressure is above 48 kPa (7 psi) the gauge reads normal. If the oil pressure drops below 41 kPa (6 psi) the gauge reads 0 kPa (0 psi).

EOT Sensor (Engine Oil Temperature)

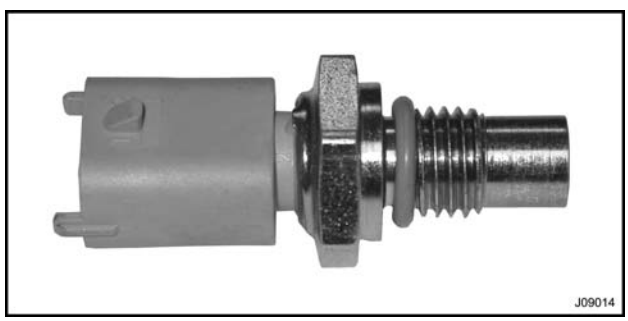

Figure 460 EOT sensor

The EOT sensor is a thermistor type sensor located in the oil filter base. The ECM monitors the EOT signal to control fuel quantity, inlet air heater operation, and timing during the operation of the engine. The EOT signal allows the ECM and IDM to compensate for differences in oil viscosity for temperature changes. This ensures that power and torque are available for all operating conditions.

EGR Valve Assembly (Exhaust Gas Recirculation)

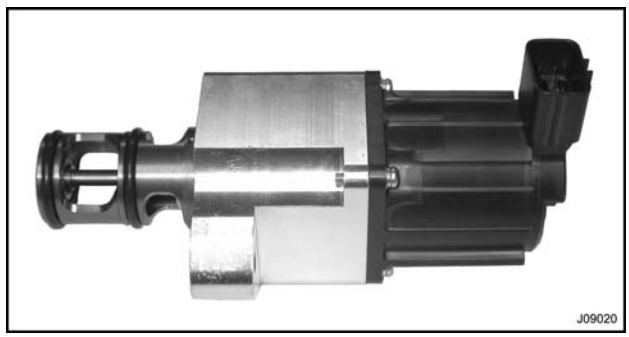

Figure 461 EGR valve assembly

The EGR valve assembly is located on the front of the intake manifold behind the air inlet. The ECM sends a desired position signal to the EGR drive module. The EGR drive module controls the EGR valve. The EGR drive module sends a position signal to the ECM for diagnostics.

Glow Plug

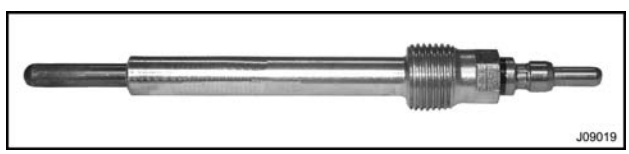

Figure 462 Glow plug

There are six glow plugs for the V6 engine, three on each side. The glow plug is a compact electric heating device located inside the combustion chamber. It preheats the air in the engine cylinders, which aids cold engine starting and reduces exhaust emissions during warm-up.

NOTE: For removal and installation, refer to the Cylinder Head section of the manual.

ICP Sensor (Injection Control Pressure)

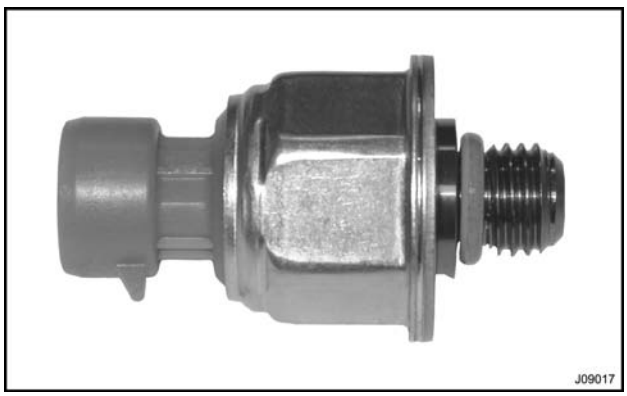

Figure 463 ICP sensor

A micro strain gauge sensor installed through the right side valve cover in the oil rail. The ECM monitors the ICP signal to determine the injection control pressure for engine operation. The ICP signal is used to control the IPR valve. The ICP sensor provides feedback to the ECM for Closed Loop ICP control.

IPR Valve (Injection Pressure Regulator)

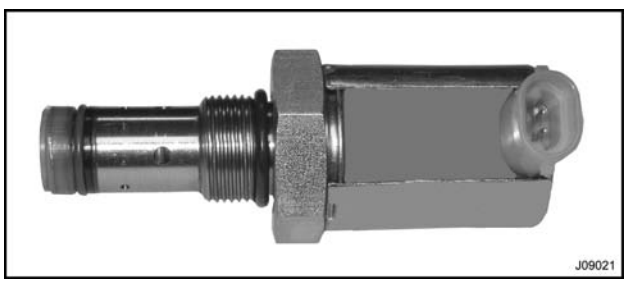

Figure 464 IPR valve

A Pulse Width Modulated (PWM) valve located in the left rear side of the high-pressure oil pump. The IPR valve controls pressure in the Injection Control Pressure (ICP) system to actuate the fuel injectors. The IPR valve is a variable position valve controlled by switching the ground circuit in the ECM.

IAH Element (Intake Air Heater)

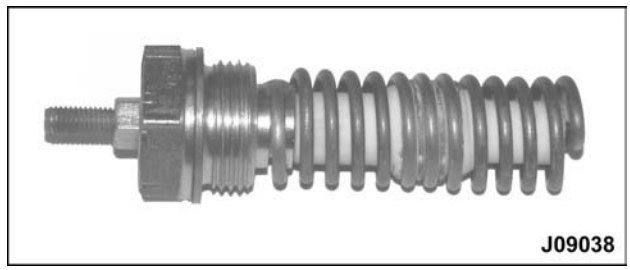

Figure 465 IAH element

A ceramic coiled element located at the front bottom center of the intake manifold. The ECM will command the IAH to be energized when ambient intake air temperature, manifold air temperature, and other functions provide the pre-determined feedback for cold start assistance. Glow plugs are on for a short time to initially start the engine, whereas the intake air heater will stay on much longer or until the Engine Coolant Temperature (ECT) sensor rises to a set value, thus sending a signal to the ECM to de-energize the heater.

IAH Relay (Intake Air Heater)

The intake air heater relay is the larger of the two relays. It is located under the dust cover, mounted to the ECM/IDM support bracket. The intake air heater relay controls the intake air heater which warms incoming air to aid cold engine starting and reduce exhaust emissions during warm-up.

MAP Sensor (Manifold Absolute Pressure)

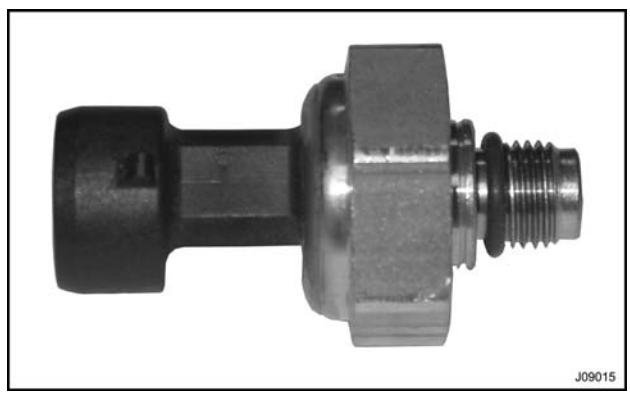

Figure 466 MAP sensor

A ceramic diaphragm sensor installed in the right front top of the intake manifold next to the inlet air elbow. The ECM monitors the MAP signal to determine intake manifold pressure (boost). This information is used to control the Boost Control Solenoid (BCS).

MAT Sensor (Manifold Air Temperature)

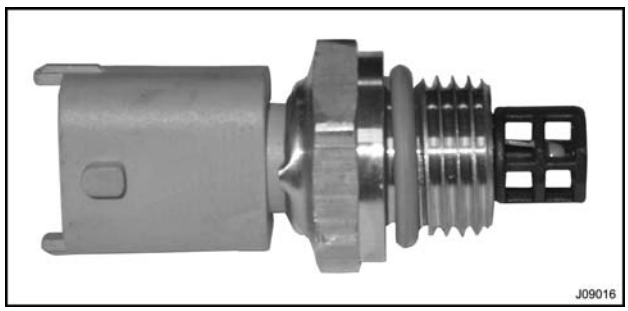

Figure 467 MAT sensor

A thermistor type sensor installed in the left side of the intake manifold toward the front of the engine. The ECM monitors the MAT signal for EGR operation.

MAF / IAT Sensor (Mass Airflow / Intake Air Temperature)

Figure 468 MAF/IAT sensor

The digital MAF/IAT sensor utilizes hot film anemometry to determine the amount of fresh air entering the engine. The MAF/IAT sensor is mounted in the air flow between the intake of the turbocharger and the air filter.

The ECM monitors the IAT signal to control timing and fuel rate during cold starts. The IAT sensor is mounted with the MAF/IAT sensor in the air flow between the intake of the turbocharger and the air filter.

NOTE: For information on diagnostics and troubleshooting, refer to the following publications:

- EGES-305-1, VT 275 *Diagnostic Manual*
- EGED-315-1, VT 275 Engine Performance Diagnostic Form
- EGED-310-1, VT 275 Electronic Control System Diagnostic Form

Description of Engine Electrical Components - Chassis Mounted

ECM (Electronic Control Module)

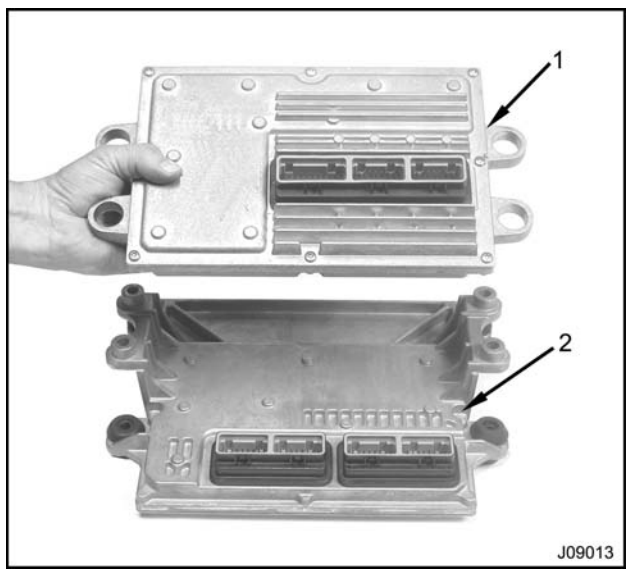

Figure 469 ECM and IDM Modules

1. IDM
2. ECM

The ECM monitors and controls engine performance to ensure maximum performance and adherence to

emissions standards. The ECM is mounted to the large support bracket located behind the cab. The dust cover must be removed to access the ECM.

IDM (Injection Drive Module)

The IDM distributes current to the injectors. The IDM controls fueling to the engine by sending high voltage pulses to the injector. The IDM uses information from the ECM to determine the timing and quantity of fuel for each injector.

The IDM creates a constant 48 volt (DC) supply to all injectors by making and breaking a 12 volt power source. The IDM controls when the injector is on and how long the injector is active.

EGR Drive Module (Exhaust Gas Recirculation)

Figure 470 EGR drive module

The EGR drive module controls the EGR actuator. The EGR drive module receives the desired EGR valve position from the ECM to activate the valve for exhaust gas recirculation. The EGR drive module provides feedback to the ECM on the valve position. The EGR drive module is typically located near the ECM / IDM assembly for CF and stripped chassis applications.

Glow Plug Relay

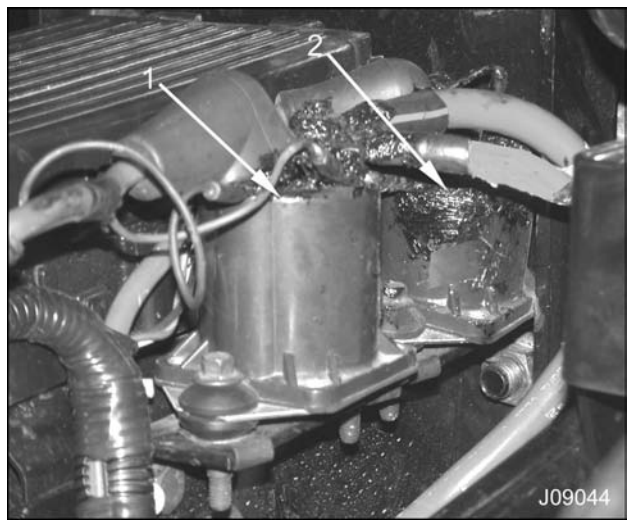

Figure 471 IAH and glow plug relays

1. IAH relay
2. Glow plug relay

It is mounted on the large support bracket behind the cab. The dust cover must be removed for access to the relay. The ECM controls the glow plug relay 2 (Figure 471) that controls the glow plugs to warm the engine cylinders to aid cold engine starting and reduce exhaust emissions during warm-up. The glow plug relay is the shorter of the two relays.

IAH Relay (Intake Air Heater)

It is mounted on the large support bracket behind the cab. The dust cover must be removed for access to the relay. The ECM controls the intake air heater relay 1 (Figure 471) that controls the intake air heater to warm the incoming air to aid cold engine starting and reduce exhaust emissions during warm-up. The intake air heater relay is the taller of the two relays.

NOTE: For information on diagnostics and troubleshooting, refer to the following publications:

- EGES-305-1, VT 275 *Diagnostic Manual*
- EGED-315-1, VT 275 Engine Performance Diagnostic Form
- EGED-310-1, VT 275 Electronic Control System Diagnostic Form

Removal

Electrical Components - Engine Mounted

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

Air Conditioner Clutch

Disconnect the air conditioner clutch electrical connector.

Alternator

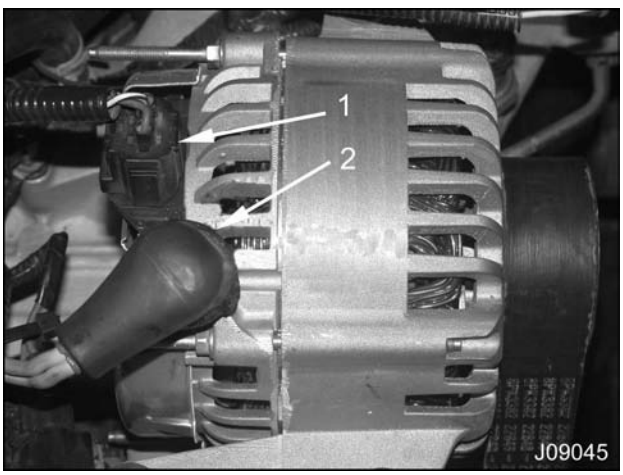

Figure 472 Alternator connections from sensor harness

1. Alternator control connector
2. Alternator power connector

1. Disconnect the alternator power electrical connector from the alternator.
2. Disconnect the alternator control electrical connection from the alternator.

Boost Control Solenoid (BCS)

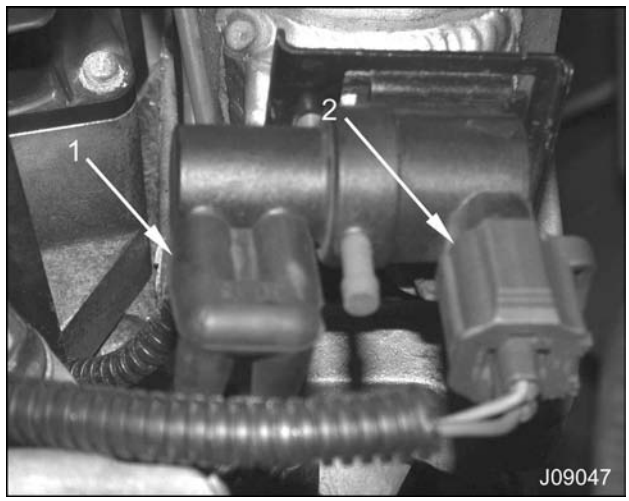

Figure 473 BCS from wiring harness

1. BCS tubing connector
2. BCS electrical connector

1. Disconnect the BCS electrical connector located on the inlet elbow.
2. Remove retaining bolt (M6 x 25) securing the BCS to the inlet elbow assembly.
3. Remove BCS from engine.

CMP Sensor (Camshaft Position)

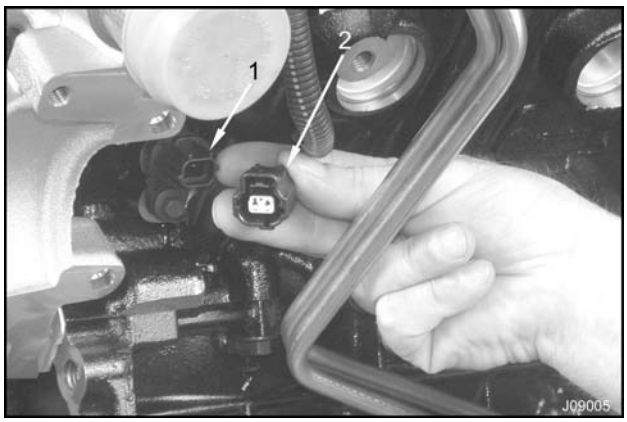

Figure 474 Disconnecting sensor harness from CMP sensor

1. CMP sensor
2. Sensor connector

1. Disconnect the CMP sensor electrical connector located on lower left side of the engine block near front cover.
2. Remove retaining bolt (M6 x 14) from the CMP sensor.
3. Remove CMP sensor.
4. Remove and discard the O-ring.

CKP Sensor (Crankshaft Position)

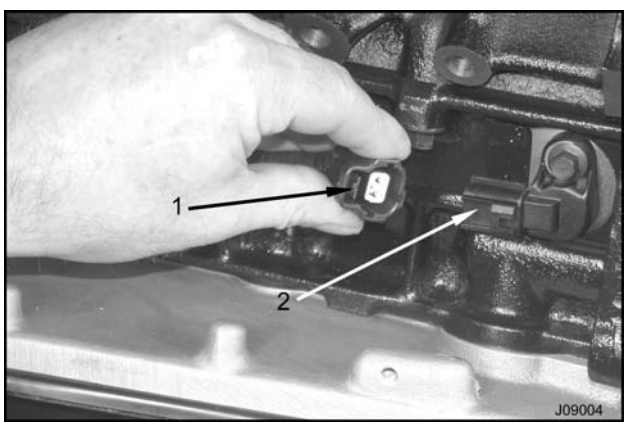

Figure 475 Disconnecting sensor harness from CKP sensor

1. Sensor connector
2. CKP sensor

1. Disconnect the CKP sensor electrical connector from the sensor harness.
2. Remove the retaining bolt (M6 x 14) from the CKP sensor, on the right side of the lower front of the engine.
3. Remove CKP sensor.
4. Remove and discard the O-ring.

8-Pin and 12-Pin Connectors

Pull the 8-pin and 12-pin connectors apart.

NOTE: Some stripped chassis applications may not require the 8-pin connector.

ECT Sensor (Engine Coolant Temperature)

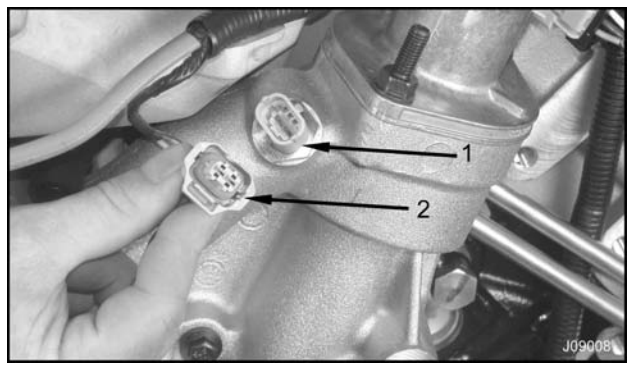

Figure 476 Disconnecting sensor harness from ECT sensor

1. ECT sensor
2. ECT sensor connector

1. Disconnect the ECT sensor electrical connector located above water pump on the left side of the engine front cover.
2. Remove the ECT sensor.
3. Remove and discard O-ring.

EOT Sensor (Engine Oil Temperature) and EOP Switch (Engine Oil Pressure)

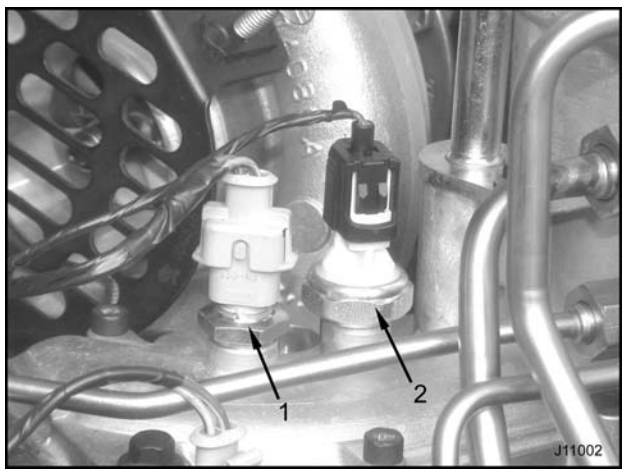

Figure 477 EOT sensor and EOP switch

1. EOT sensor
2. EOP switch

1. Disconnect EOT and EOP electrical connectors from their respective sensors located in the center of the oil filter base assembly.
2. Remove both the EOT sensor and EOP switch.
3. Remove and discard O-rings.

EGR Actuator (Exhaust Gas Recirculation)

Figure 478 Disconnecting sensor harness from EGR valve

1. Disconnect the EGR valve electrical connector from the EGR valve, located directly behind the intake manifold air inlet elbow.
2. Refer to “Manifolds and Exhaust Gas Recirculation (EGR)” for EGR valve removal procedure.

ICP Sensor (Injection Control Pressure)

Remove the ICP sensor as follows:

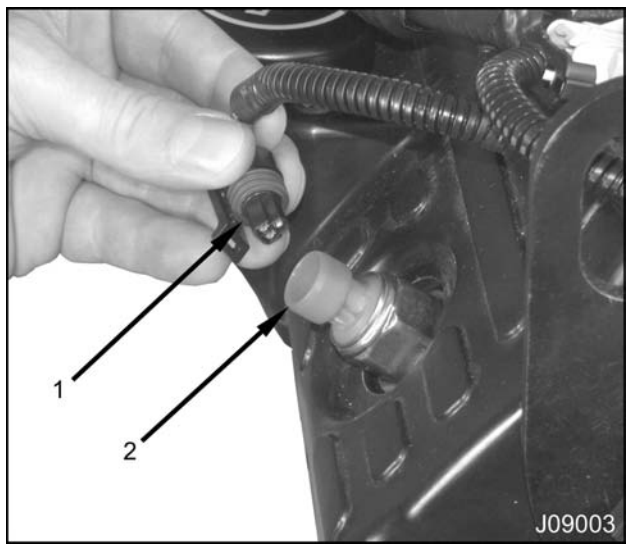

Figure 479 Disconnecting sensor harness from ICP sensor

1. ICP sensor connector
2. ICP sensor

1. Disconnect ICP sensor harness connector from the ICP sensor.
2. Loosen and remove the ICP sensor located in the right oil rail. Remove and discard the ICP sensor O-ring.
3. Remove valve cover, if necessary.

NOTE: The ICP sensor may be removed either before or after the valve cover is removed. The ICP sensor valve cover seal ring can only be removed after the valve cover is removed. If only the ICP sensor is removed, the valve cover seal ring under the valve cover does not need replacement.

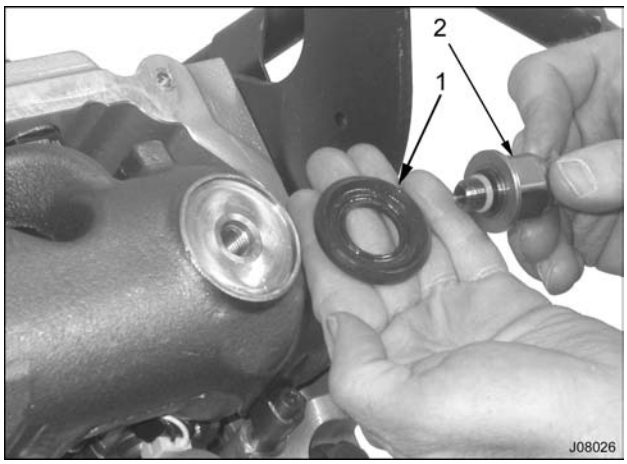

Figure 480 Removing the ICP sensor and seal ring with valve cover removed

1. ICP sensor seal ring
2. ICP sensor

4. Remove the ICP sensor and seal ring. The seal ring is reusable. Check for damage and replace if necessary.

IPR Valve (Injection Pressure Regulator)

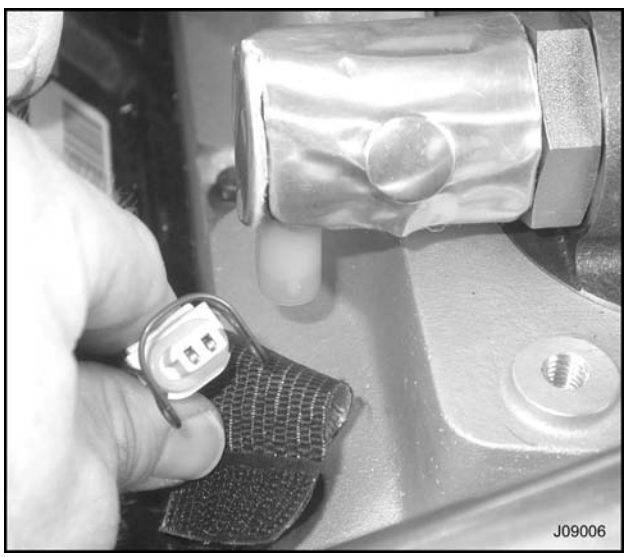

Figure 481 Disconnecting sensor harness from IPR valve

1. Disconnect the IPR valve electrical connector from the valve.

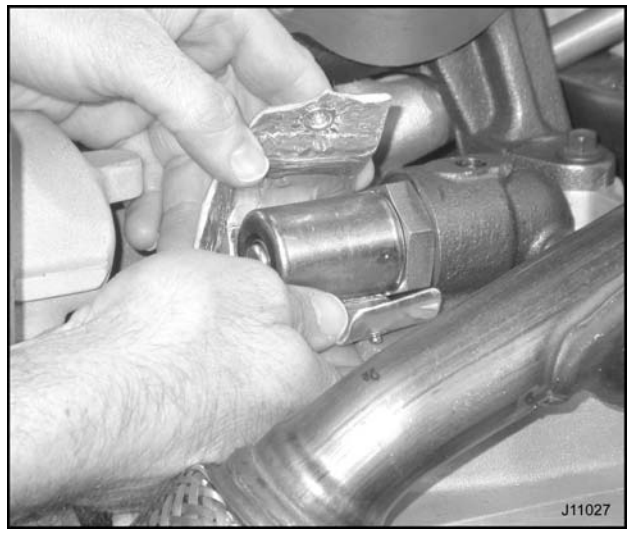

Figure 482 Removing IPR heat shield

2. If equipped, remove the IPR heat shield from the valve.

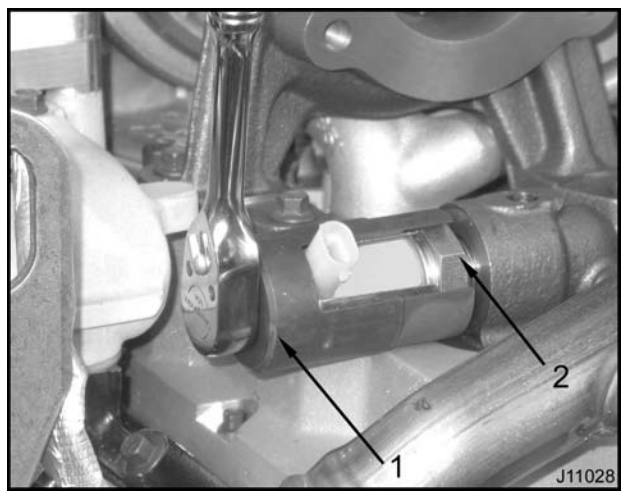

Figure 483 Removing IPR valve with socket

1. IPR valve socket
2. IPR valve

3. Loosen the IPR valve by using the IPR Valve Socket. See Special Service Tools (page 313).

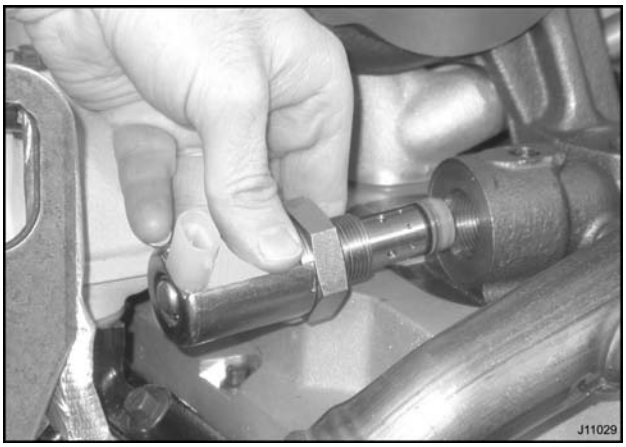

Figure 484 IPR valve removed

4. Remove IPR valve.
5. Remove and discard body O-ring, end O-ring, and backup ring.

IAH (Intake Air Heater)

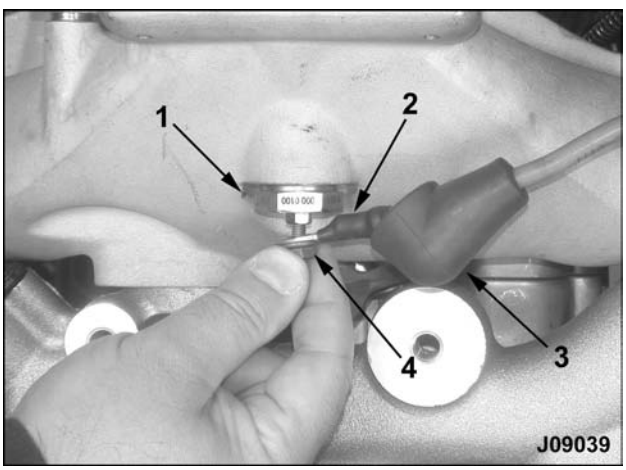

Figure 485 Disconnecting the intake air heater

1. Intake air heater and sealing ring
2. Heater cable
3. Rubber boot
4. Nut and washer, M5

1. Pull back rubber boot covering intake heater nut.
2. Loosen and remove intake heater nut and cable.

MAP Sensor (Manifold Absolute Pressure)

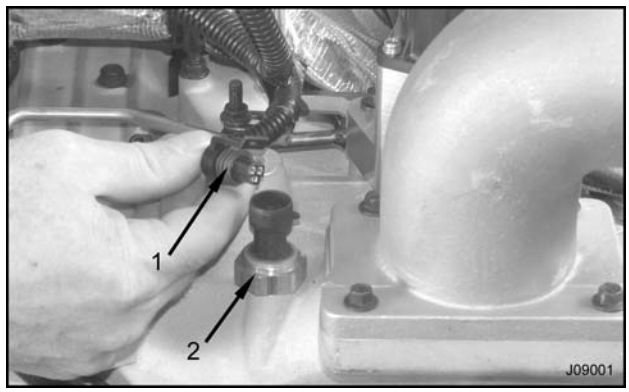

Figure 486 Disconnecting sensor harness from MAP sensor

1. MAP sensor connector
2. MAP sensor

1. Disconnect the MAP sensor electrical connector located next to air inlet on the front of intake manifold.
2. Remove MAP sensor.
3. Remove and discard O-ring.

MAT Sensor (Manifold Air Temperature)

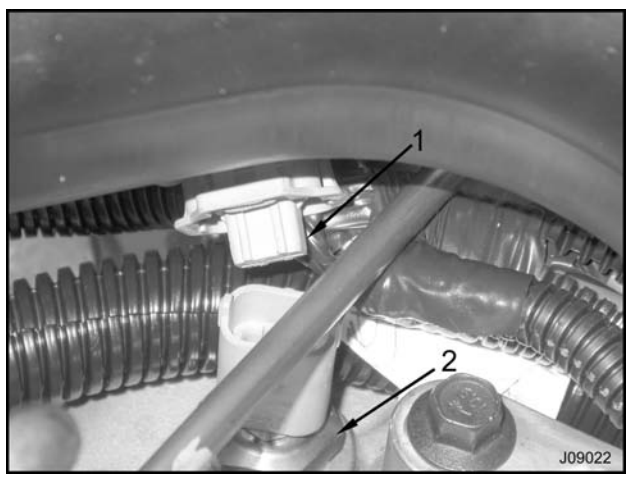

Figure 487 Disconnecting sensor harness from MAT sensor

1. MAT sensor connector
2. MAT sensor

1. Disconnect the MAT sensor electrical connector located in the left side of the intake manifold.
2. Remove MAT sensor.
3. Remove and discard O-ring.

MAF / IAT Sensor (Mass Airflow / Intake Air Temperature)

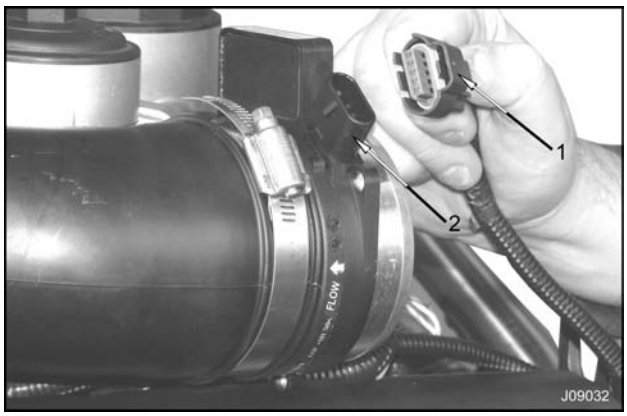

Figure 488 Disconnecting sensor harness from MAF/IAT connector

1. MAF/IAT sensor connector
2. MAF/IAT sensor

1. Disconnect MAF/IAT sensor electrical connector located in the air inlet duct assembly between the turbocharger and air cleaner.

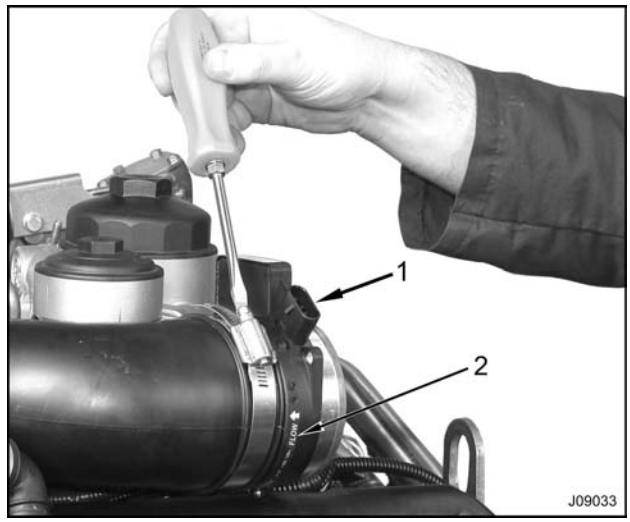

Figure 489 Loosening the tube clamp screw

1. MAF/IAT sensor
2. Air flow indicator mark

2. Loosen the tube clamp.

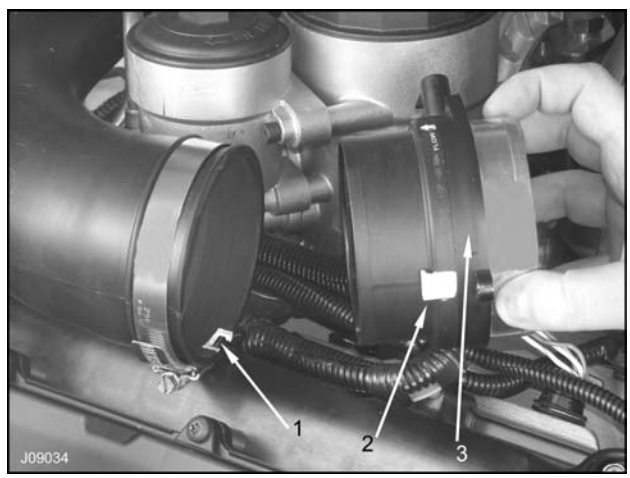

Figure 490 Removing the MAF/IAT sensor

1. Alignment notch
2. Alignment tab
3. MAF/IAT sensor

3. Remove the MAF/IAT sensor.

Electrical Components - Chassis Mounted

ECM and IDM

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on the engine sensor wiring harness while trying to remove it. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

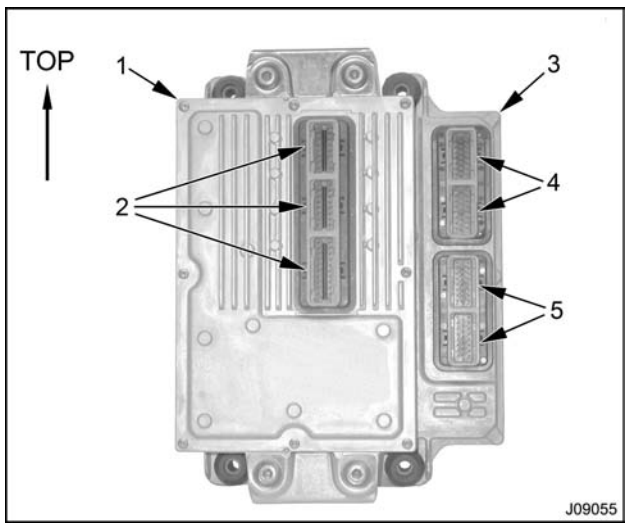

Figure 491 ECM and IDM harness recess connections

1. IDM
2. IDM harness recess
3. ECM
4. ECM harness recess (engine)
5. ECM harness recess (chassis)

1. Disconnect three IDM wiring harness connectors.
2. Disconnect four ECM wiring harness connectors (two for engine and two for chassis).

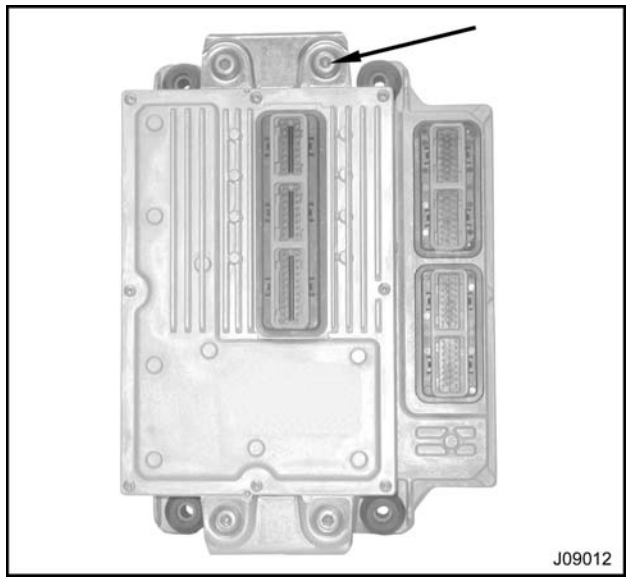

Figure 492 ECM and IDM assembly mounting bolts

3. Remove the IDM and ECM components by loosening and removing four nuts and washers from the mounting bolts.
4. Remove the ECM and IDM components from the engine.

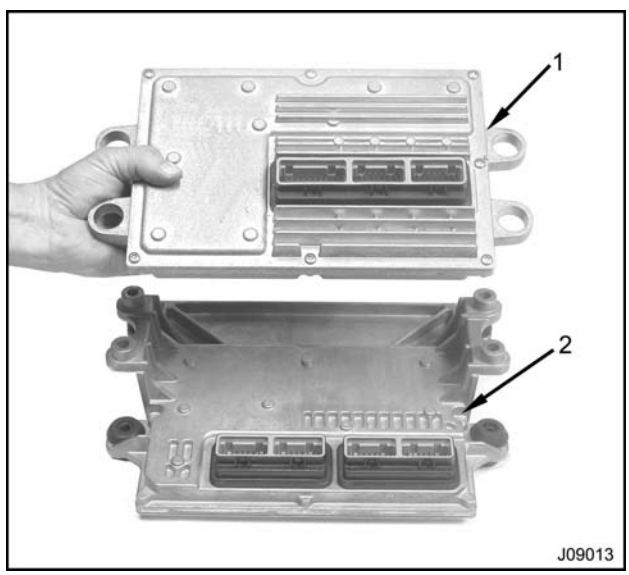

Figure 493 Removing the IDM from the ECM

1. IDM
2. ECM

5. Separate the ECM and IDM by loosening four (M8 x 70) bolts. Remove the bolts, nuts, and washers from the components and separate.

EGR Valve Drive Module

Figure 494 EGR valve drive module

1. Disconnect the electrical connector from the EGR valve drive module.
2. Remove the two mounting bolts securing the EGR drive module.
3. Remove the EGR drive module.

Glow Plug Relay

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

NOTE: There are two relays located next to the fuse box. The taller relay is the intake air heater relay. The shorter relay is the glow plug relay.

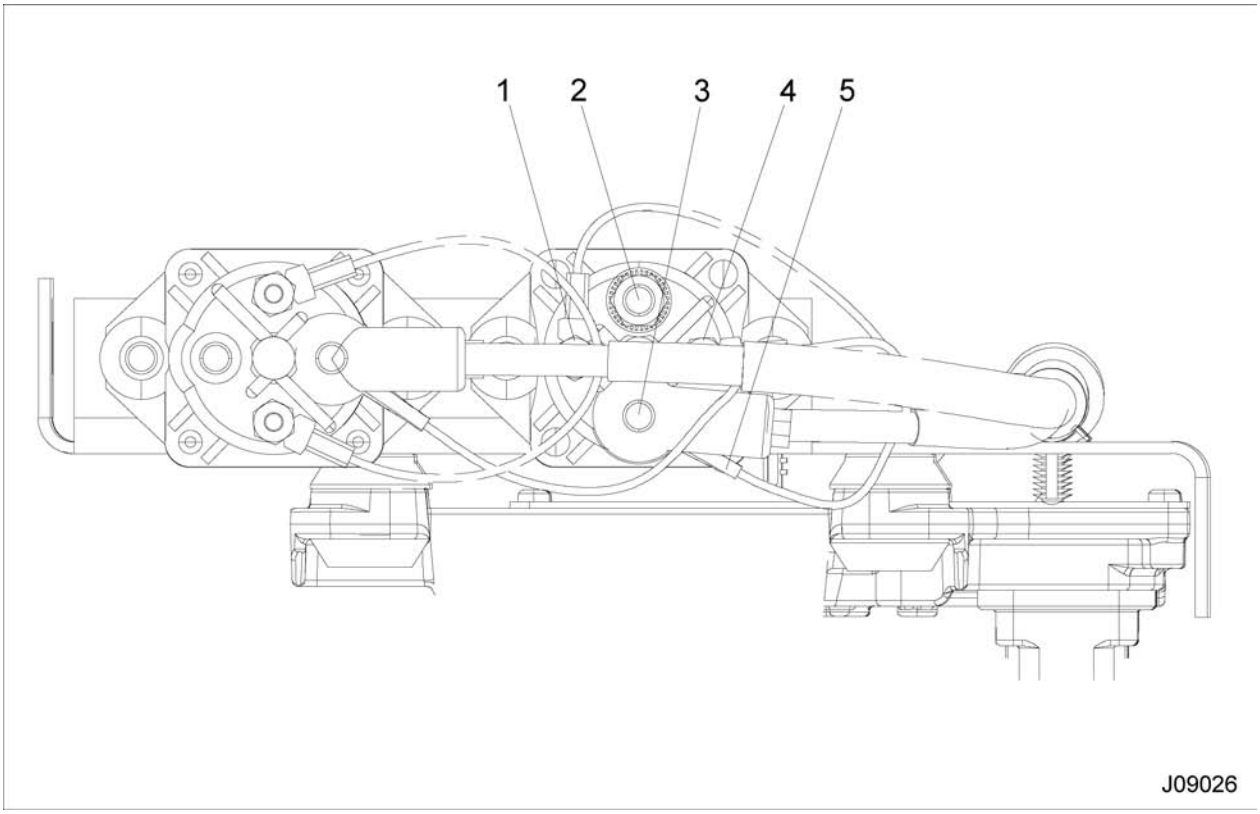

Figure 495 Glow plug relay wiring connections

1. Ground connection post
2. Battery connection post
3. Glow plug relay main connection post
4. Glow plug control post
5. Diagnostic lead

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

1. Verify the main battery negative terminal has been disconnected.
2. Remove ground lead from the ground connection post 1 (Figure 495).
3. Loosen nut and remove battery lead from battery connection post 2 (Figure 495).
4. Loosen nuts and remove both glow plug harness leads from glow plug relay main connection post 3 and glow plug control post 4 (Figure 495).
5. Loosen nut and remove diagnostic lead from diagnostic connection post 3 (Figure 495).

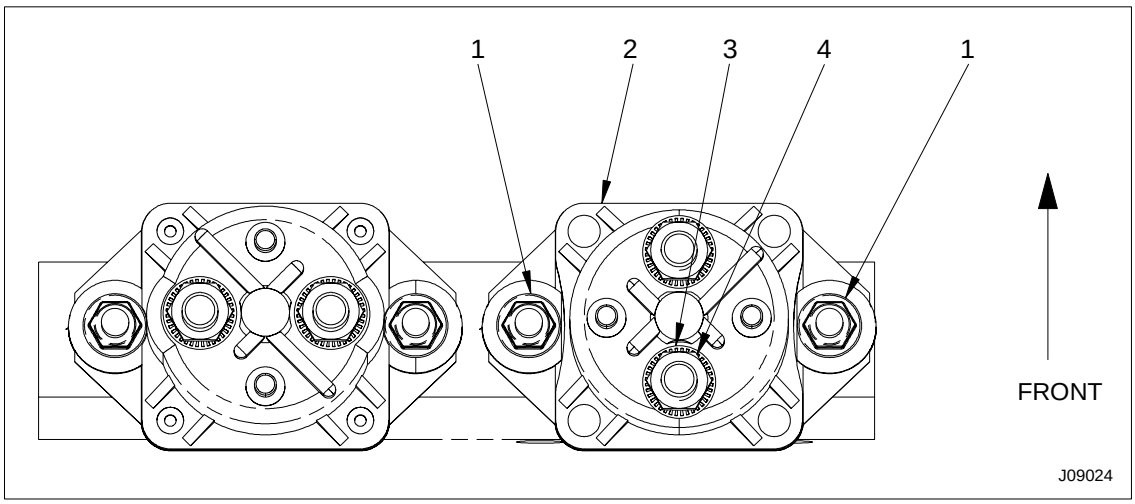

Figure 496 Glow plug relay mounting connections

1. Prevailing torque hex flange nuts M6 (2)
2. Glow plug relay
3. Belleville washer (2)
4. Hex nut (2)

6. Loosen and remove the two nuts 1 (Figure 496) securing the glow plug relay 2 (Figure 496) to the support bracket.
7. Remove glow plug relay 2 (Figure 496) from the support bracket.

IAH Relay (Intake Air Heater)

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

NOTE: There are two relays located next to the fuse box. The taller relay is the intake air heater relay. The shorter relay is the glow plug relay.

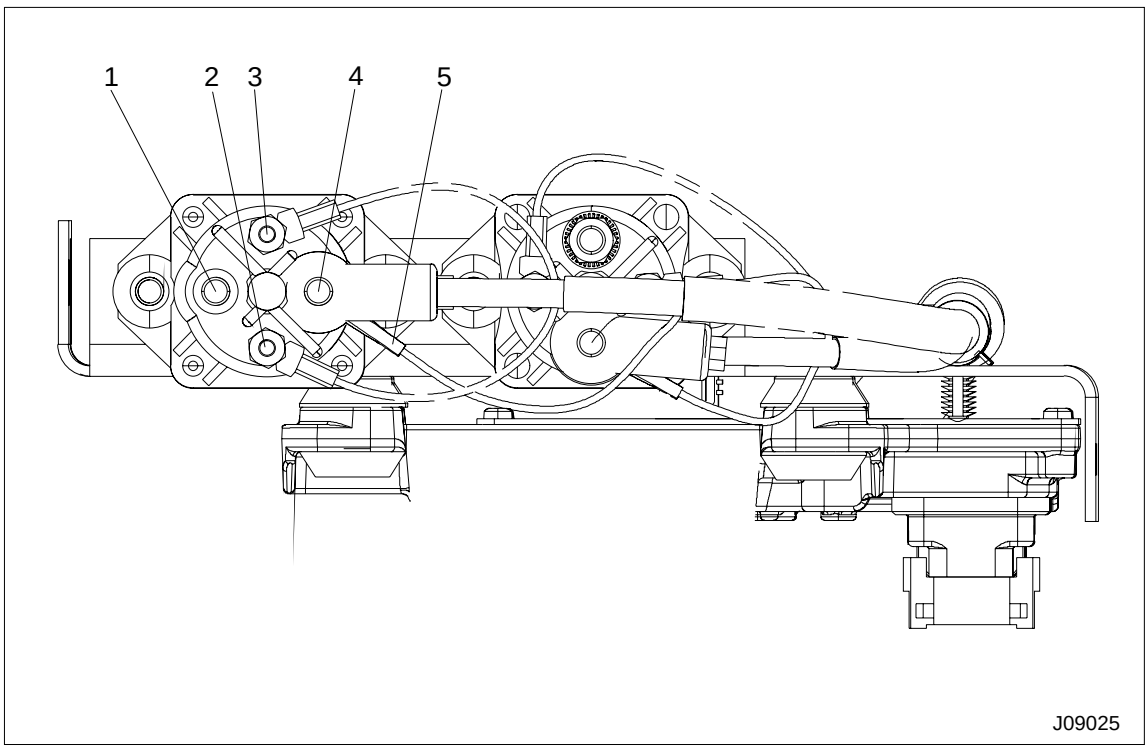

Figure 497 Intake air heater wiring connections

1. Battery connection post
2. Intake air heater control connection post
3. Ground connection post
4. Intake air heater relay main connection post
5. Diagnostic lead

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

1. Verify the main battery negative terminal has been disconnected.
2. Loosen and remove battery lead from battery connection post 1 (Figure 497).
3. Loosen and remove air intake lead from air intake control post 2 (Figure 497).
4. Loosen and remove ground lead from ground connection post 3 (Figure 497).
5. Loosen and remove intake air heater relay main lead from connection post 4 (Figure 497).
6. Loosen and remove diagnostic lead from post 4 (Figure 497).

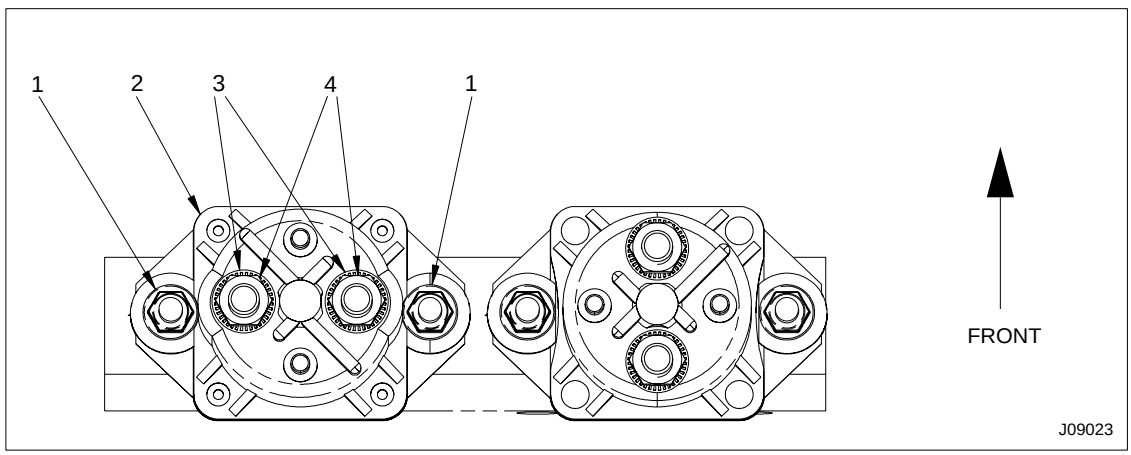

Figure 498 Intake air heater relay mounting connections

1. Prevailing torque hex flange nut M6, (2)
2. Intake air heater relay
3. Belleville washer (2)
4. Hex nut (2)

7. Loosen and remove the two nuts 1 (Figure 498) securing the intake air heater relay to the support bracket.
8. Remove intake air heater relay 2 (Figure 498) from the support bracket.

Removing Engine Wiring Harnesses

Engine Sensor Wiring Harness

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

NOTE: If removing the Glow Plug Harness only, refer to Removal - Glow Plug Harness in this section for further information.

NOTE: Refer to Removal for location photos of individual components.

1. Disconnect main negative (-) battery cable from battery.
2. Remove engine sensor wiring harness clamps and anchor points securing the wiring harness to the engine.
3. Disconnect the CMP sensor electrical connector, located on lower left side of the engine block near front cover.
4. Disconnect the MAF/IAT sensor electrical connector, located at the end of the air inlet duct assembly.

NOTE: If removing the complete wiring harness assembly (sensor and injector), disconnect the IDM ground stud and injectors 2, 4, and 6 at this time. Refer to Removing Injector Wiring Harness in this section for further information.

5. Disconnect the wiring harness from the IDM ground stud.
6. Disconnect EOT and EOP electrical connectors from their respective sensors located in the center of the oil filter base assembly.
7. Disconnect the MAT sensor electrical connector, located in the left side of the intake manifold.
8. Disconnect the ECT sensor electrical connector, located above water pump on the left side of the engine front cover.
9. Disconnect the left side glow plug harness from the sensor harness. Refer to Removal - Glow Plug Harness.
10. Disconnect the EGR valve electrical connector from the EGR valve, located directly behind the intake manifold air inlet elbow.
11. Disconnect the BCS electrical connector, located on the inlet elbow.
12. Disconnect the MAP sensor electrical connector, located next to air inlet on the front of intake manifold.
13. Pull back rubber boot covering intake heater nut. Loosen and remove intake heater nut and cable.
14. Disconnect the alternator power electrical connector and the alternator sensor electrical connection from the alternator.
15. Disconnect the right side glow plug harness from the sensor harness. Refer to Removal - Glow Plug Harness.

NOTE: If removing the complete wiring harness assembly (sensor and injector), disconnect injectors 1, 3, and 5 at this time. Refer to Removing - Injector Wiring Harness in this section for further information.

16. Disconnect the CKP sensor electrical connector located on the right side of the lower front of the engine.
17. Disconnect air conditioner clutch from the sensor harness.
18. Disconnect starter motor from the sensor harness.
19. Disconnect sensor harness connector from the ICP sensor located in the right oil rail.
20. Disconnect the intake air heater relay. Refer to Removal - Intake Air Heater Relay in this section, for disconnecting the wiring harness.

21. Disconnect the glow plug relay. Refer to Removal - Glow Plug Relay in this section, for disconnecting the wiring harness.
22. Disconnect the 8-pin and 12-pin wiring harness connectors.

    NOTE: Some stripped chassis applications may not require the 8-pin connector.
23. Disconnect three IDM wiring harness connectors and four ECM wiring harness connectors (two for engine and two for chassis) from the ECM/IDM modules.
24. Carefully lift main harness assembly away from engine.

Injector Wiring Harness

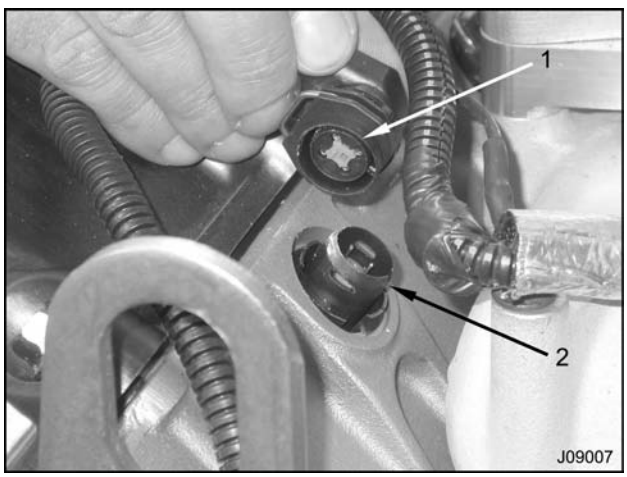

Figure 499 Disconnecting Injector Wiring Harness from connector

1. Injector wiring harness connector (6)
2. Injector connector

1. Depress snap ring into connector while lifting up to remove wiring harness connector.

NOTE: Do not pull snap ring out as it could easily fall into engine valley.

2. Disconnect two connectors from the IDM.
3. Remove and discard O-rings.

Glow Plug Wiring Harness

NOTE: Use this procedure if you are only removing the glow plug wiring harness. If the glow plug wiring harness is being removed with the engine sensor wiring harness refer to REMOVAL, Glow Plug Wiring Harness, Left and Right Hand Side.

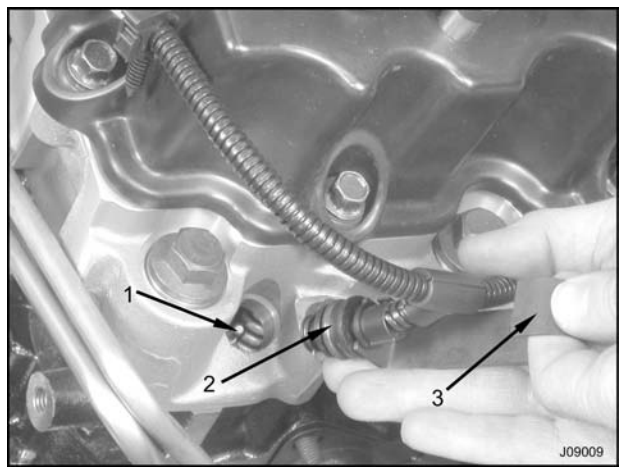

Figure 500 Using the Glow Plug Connector Remover / Installer tool

1. Glow plug
2. Glow plug harness connector
3. Glow Plug Connector Remover / Installer tool

1. Use the Glow Plug Connector Remover and Installer tool to remove each glow plug connector. See Special Service Tools (page 313).
2. Disconnect the glow plug wiring harness from the engine sensor wiring harness.
3. Remove and discard O-ring from glow plug connector.

Cleaning and Inspection

Engine Sensor Wiring Harness

1. Carefully inspect wiring harness for bent, missing or broken retaining clips, worn or cut conduit, frayed insulation, or heat damage to wires. Repair or replace as necessary.
2. Check engine wiring harness connectors, connector covers, seals, and cover shields for damage, cracks, cuts, or worn areas. Replace as required.
3. Inspect each sensor and actuator connector for the following conditions, replace as required:
   - Chaffing
   - Cracked connector body.
   - Bent, missing, or broken socket pins.
   - Corroded connectors (green or gray) and white deposits on metal terminals.
   - Terminals incorrectly latched in connector body or “pushed back” relative to other terminals in same connector.
   - Damaged or missing O-rings or seals.

   NOTE: Make sure that each connector has its ribbed seal in place. In some cases, upon disassembly, a ribbed seal may pull off of its connector and remain in the mating socket of a sensor or actuator. A connector that is assembled without the appropriate ribbed seal can become contaminated with moisture and corrode terminals, resulting in a poor electrical connection.

Sensors and Actuators

1. Check all connector pins on sensors and actuators. If any are bent or corroded, replace that sensor or actuator.
2. Remove any scale or carbon build up.
3. Check for sensor or actuator body cracks or other indication of leakage.
4. If any sensor orifices or actuators are plugged, replace sensor or actuator as necessary.

Glow Plug Harness

1. Inspect left and right glow plug wiring harness assemblies for defective or twisted O-rings and pin recesses that can be corroded.
2. Wipe down glow plug harness assemblies with a shop towel. Do not use solvents. Inspect the glow plug harness for missing or damaged O-rings, replace as necessary.

EGR Drive Module

Inspect the EGR drive module and replace if necessary. Check for the following:

- Bent connector pins.
- Corrosion to the pins or module.
- Heat damage to the module.

ECM and IDM Assembly

1. Inspect rubber seal on harness connector and in ECM and IDM assembly pin recesses.

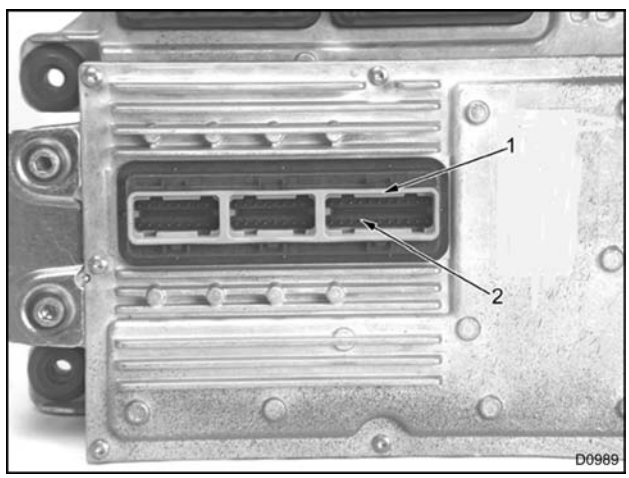

Figure 501 ECM and IDM assembly harness pin recesses (IDM shown)

1. Rubberized seal
2. Connector pins

2. Check for bent pins in ECM and IDM assembly connections.
3. Check for bent pins in the EGR drive module connection.

Installation

Installing Engine Wiring Harnesses

Glow Plug Harness

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

NOTE: Use this procedure only if you are installing the glow plug wiring harness with the engine sensor wiring harness.

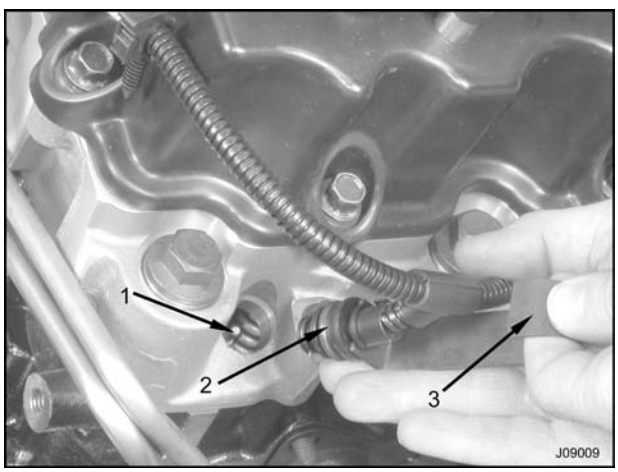

Figure 502 Using the Glow Plug Connector Removal and Installation tool

1. Glow plug
2. Glow plug harness connector
3. Glow Plug Connector Remover/Installer tool

1. Replace any cut, worn, or damaged O-rings.
2. Using the Glow Plug Connector Remover / Installer tool, install left and right side glow plug harnesses. See Special Service Tools (page 313).
3. Connect the glow plug wiring harness connector to the engine sensor wiring harness connector.

Injector Wiring Harness

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

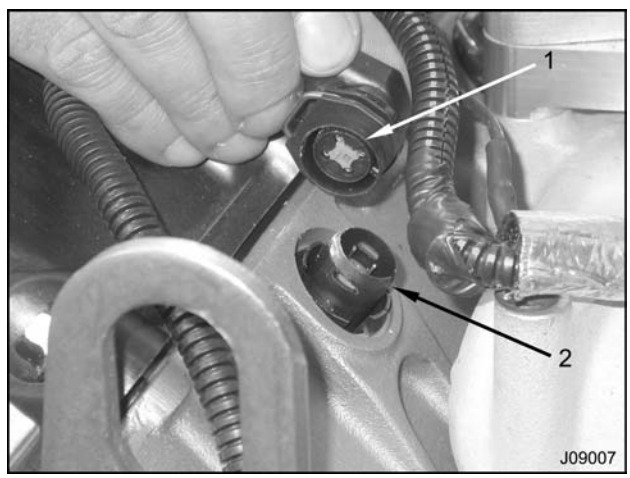

Figure 503 Connecting Injector Wiring Harness onto the connectors

1. Injector harness connector
2. Injector connector

1. Connect each injector wiring harness connector onto the injector connector.

Engine Sensor Wiring Harness

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting any electrical components.

CAUTION: To prevent engine damage, do not tug on any sensor wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free any connectors or clips that are caught before proceeding.

1. Carefully place the injector and engine sensor wiring harness (and glow plug harness, if attached) over the engine and support bracket located by the intake air and glow plug relays. Use the sensor and actuator location views at the front of this section to aid in the wiring harness routing.

NOTE: Begin connecting the injector and engine sensor wiring harness by placing the drain wire connection over the grounding terminal stud. Tighten nut to Standard Torque (page 405).

NOTE: If installing the Glow Plug Harness only, refer to Installation - Glow Plug Harness in this section for further information.

NOTE: Refer to Installation procedures for location photos of individual components.

2. Connect three IDM wiring harness connectors and four ECM wiring harness connectors (two for engine and two for chassis) to the ECM/IDM modules.
3. Connect the 8 and 12-pin wiring harness connectors.

   NOTE: Some stripped chassis applications may not require the 8-pin connector.
4. Connect the glow plug relay. Refer to Installation - Glow Plug Relay in this section, for connecting the wiring harness.
5. Connect the intake air heater relay. Refer to Installation - Intake Air Heater Relay in this section, for connecting the wiring harness.
6. Connect sensor harness connector to the ICP sensor, located in the right oil rail.
7. Connect starter motor to the sensor harness.
8. Connect air conditioner clutch to the sensor harness.
9. Connect the CKP sensor electrical connector located on the right side of the lower front of the engine.

NOTE: If installing the complete wiring harness assembly (sensor and injector), connect injectors 1, 3, and 5 at this time. Refer to Installing - Injector Wiring Harness in this section for further information.

10. Connect the right side glow plug harness to the sensor harness. Refer to Installation - Glow Plug Harness.
11. Connect the alternator power electrical connector and the alternator sensor electrical connection to the alternator.
12. Place electrical cable onto heater element and secure with a washer and nut (M5). Tighten nut to the Special Torque (page 312). Pull rubber boot over heater element threads and nut.
13. Connect the MAP sensor electrical connector located next to air inlet on the front of intake manifold.
14. Connect the BCS electrical connector located on the inlet elbow.
15. Connect the EGR valve electrical connector to the EGR valve, located directly behind the intake manifold air inlet elbow.
16. Connect the left side glow plug harness to the sensor harness. Refer to Installation - Glow Plug Harness.
17. Connect the ECT sensor electrical connector located above water pump on the left side of the engine front cover.

18. Connect the MAT sensor electrical connector located in the left side of the intake manifold.
19. Connect EOT and EOP electrical connectors to their respective sensors located in the center of the oil filter base assembly.

NOTE: If installing the complete wiring harness assembly (sensor and injector), connect the IDM ground stud and injectors 2, 4, and 6 at this time. Refer to Installation - Installing Injector Wiring Harness in this section for further information.

20. Connect the wiring harness to the IDM ground stud.
21. Connect MAF/IAT sensor electrical connector located at the end of the air inlet duct assembly.
22. With the IPR valve installed into the top of the high-pressure pump, rotate the IPR valve solenoid clockwise. Connect the IPR valve electrical connector to the valve.
23. Connect the CMP sensor electrical connector located on lower left side of the engine block near front cover.
24. Securing the wiring harness to the engine by connecting the harness to the engine clamps and anchor points
25. Connect main negative (-) battery cable to the battery.

Electrical Components - Chassis Mounted

ECM and IDM

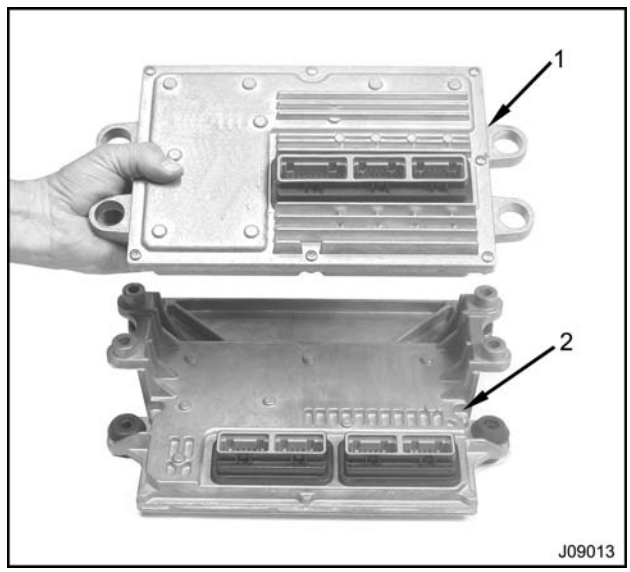

Figure 504 Installing the IDM onto the ECM

1. IDM
2. ECM

1. Place the IDM onto the ECM and insert four (M8 x 70) bolts through the two components.

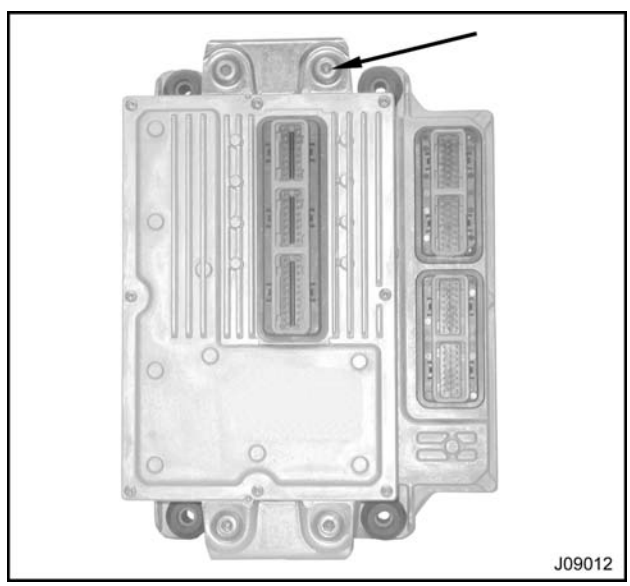

Figure 505 ECM and IDM assembly mounting bolts

2. Secure the two components together by placing washers and nuts onto the mounting bolts and tighten.

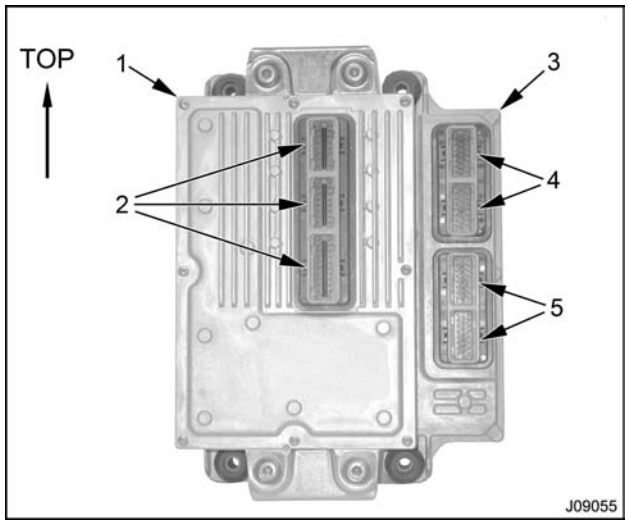

Figure 506 ECM and IDM harness connections

1. IDM
2. IDM harness pin connector
3. ECM
4. ECM harness pin connector (engine)
5. ECM harness pin connector (chassis)

3. Connect three IDM wiring harness connectors into the IDM.
4. Connect four ECM harness connectors (two for engine and two for chassis) into the ECM.

EGR Valve Drive Module

Figure 507 EGR valve drive module

1. If removed from the support bracket, install the EGR valve drive module and secure with two mounting bolts.
2. Connect the EGR connector to the EGR valve drive module.

IAH Relay (Intake Air Heater)

NOTE: There are two relays located next to the fuse box. The taller relay is the intake air heater relay. The shorter relay is the glow plug relay.

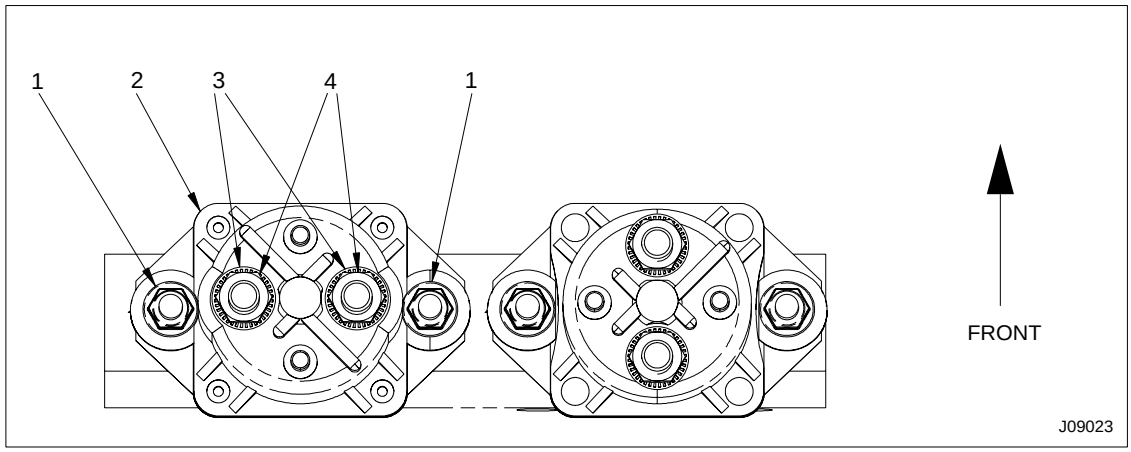

Figure 508 Intake air heater relay mounting connections

1. Prevailing torque hex flange nut M6, (2)
2. Intake air heater relay
3. Belleville washer (2)
4. Hex nut (2)

1. Install intake air heater relay 2 (Figure 508) onto studs of support bracket.
2. Tighten nuts 1 (Figure 508) to the Standard Torque (page 405).

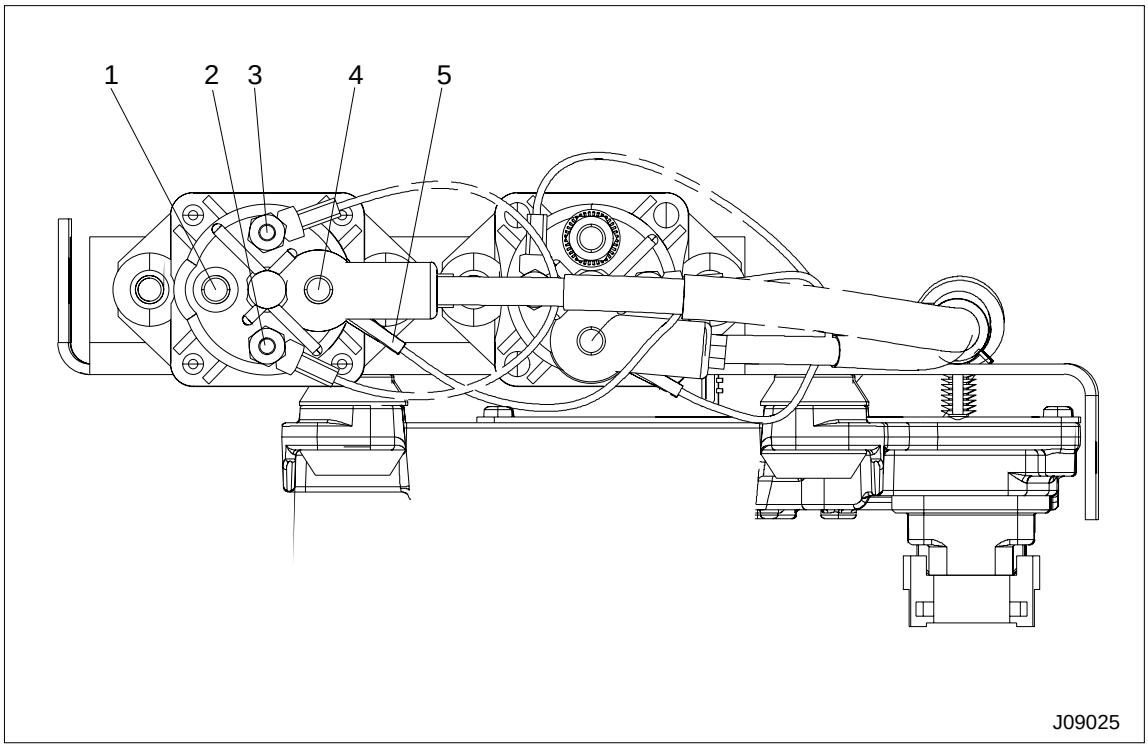

Figure 509 Intake air heater relay wiring connections

1. Battery connection post
2. Intake air heater control connection post
3. Ground connection post
4. Intake air heater relay main connection post
5. Diagnostic lead

3. Verify the main battery negative terminal has been disconnected before making any electrical connections to the intake air heater relay.
4. Connect battery connection to post 1 (Figure 509) and tighten nut.
5. Connect ground connection to post 2 (Figure 509) and tighten nut.
6. Secure the intake air heater relay main connection post 3 (Figure 509) and tighten nut.
7. Connect the intake air heater relay main power connection post 4 (Figure 509) and tighten nut.
8. Connect diagnostic lead to diagnostic connection post 4 (Figure 509) and tighten nut.

Glow Plug Relay

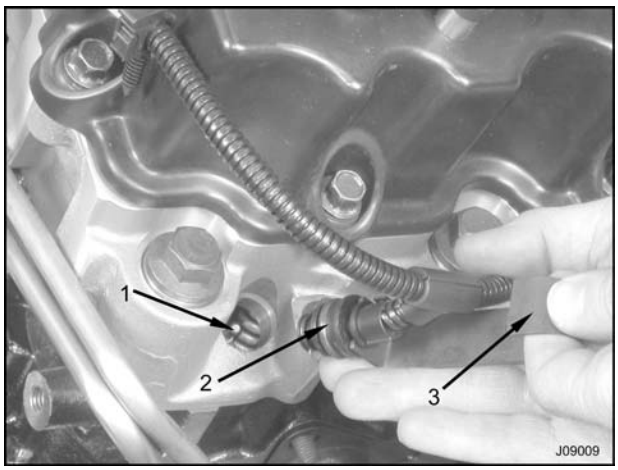

Figure 510 Using the Glow Plug Connector Removal and Installation tool

1. Glow plug
2. Glow plug harness connector
3. Glow Plug Connector Remover/Installer tool

1. Verify the main battery negative terminal has been disconnected before making any electrical connections to the glow plug relay.
2. Replace any cut, worn, or damaged O-rings.
3. Using the Glow Plug Connector Remover / Installer tool, install left and right side glow plug harnesses. See Special Service Tools (page 313).

NOTE: There are two relays located next to the fuse box. The taller relay is the intake air heater relay. The shorter relay is the glow plug relay.

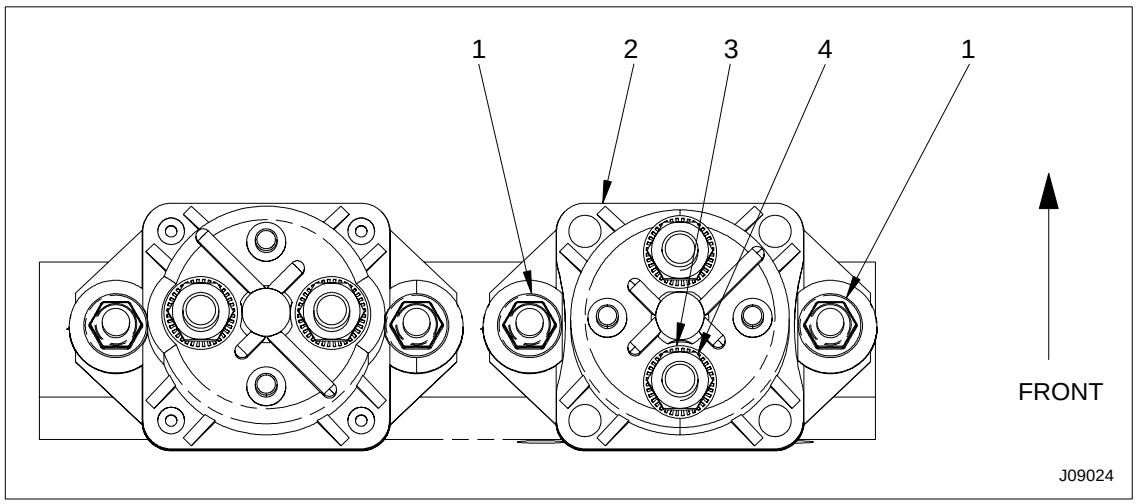

Figure 511 Glow plug relay mounting connections

1. Prevailing torque hex flange nuts M6 (2)
2. Glow plug relay
3. Belleville washer (2)
4. Hex nut (2)

4. Install the glow plug relay 2 (Figure 511) onto support bracket studs and tighten nuts.

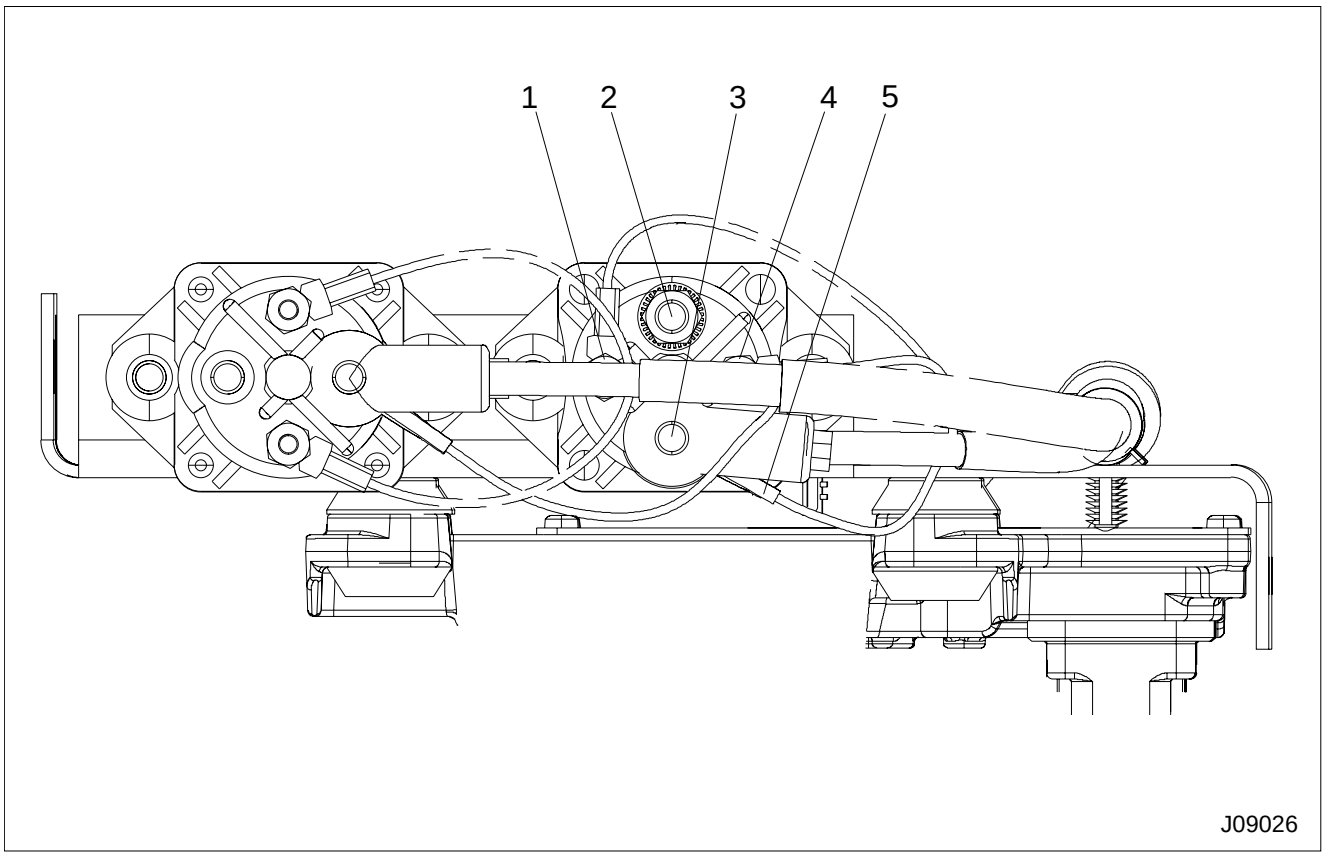

Figure 512 Glow plug relay wiring connections

1. Ground connection post
2. Battery connection post
3. Glow plug relay main connection post
4. Glow plug control post
5. Diagnostic lead

5. If not already done, connect the glow plug wiring harness connector to the engine sensor wiring harness connector.
6. Connect ground lead to post 1 (Figure 512) and tighten nut.
7. Connect battery lead to post 2 (Figure 512) and tighten nut.
8. Connect glow plug relay main connection to post 3 (Figure 512) and tighten nut.
9. Connect glow plug control to post 4 (Figure 512) and tighten nut.
10. Connect diagnostic lead to post 3 (Figure 512) and tighten nut.

Electrical Components - Engine Mounted

Air Conditioner Clutch

Connect the air conditioner clutch electrical connector.

Alternator

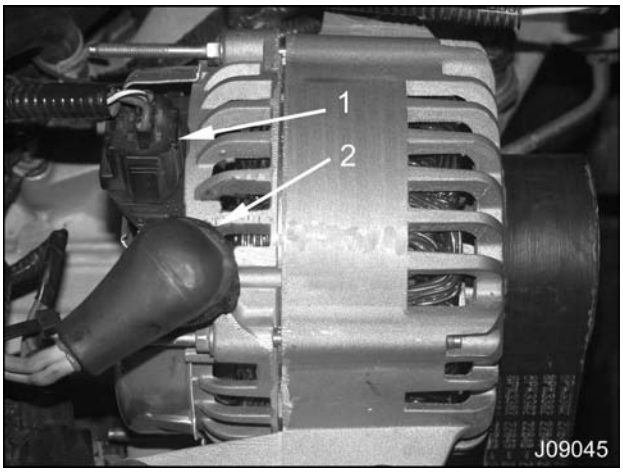

Figure 513 Connect sensor harness to Alternator

1. Alternator control connector
2. Alternator power connector

1. Connect the alternator power electrical connector to the alternator.
2. Connect the alternator control electrical connection to the alternator.

BCS (Boost Control Solenoid)

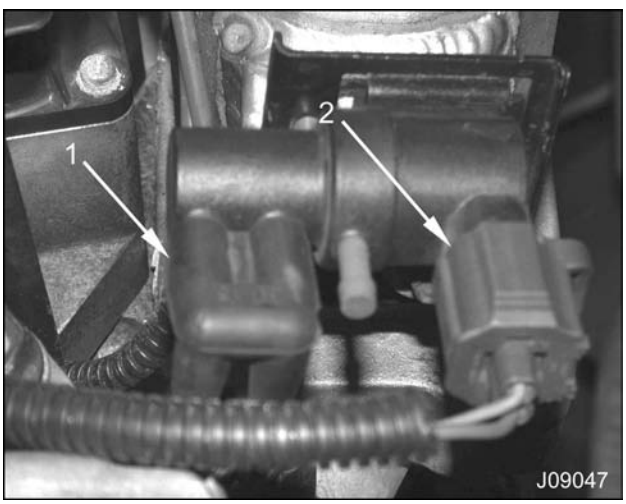

Figure 514 BCS to wiring harness

1. BCS tubing connector
2. BCS electrical connector

Install the BCS to the engine as follows:

1. Install the BCS onto the inlet elbow assembly and secure with a retaining bolt (M6 x 25) and tighten to the Standard Torque (page 405).
2. Connect the BCS electrical connector.

CMP Sensor (Camshaft Position)

1. Lubricate two new O-rings with clean engine oil and install onto CMP sensor.

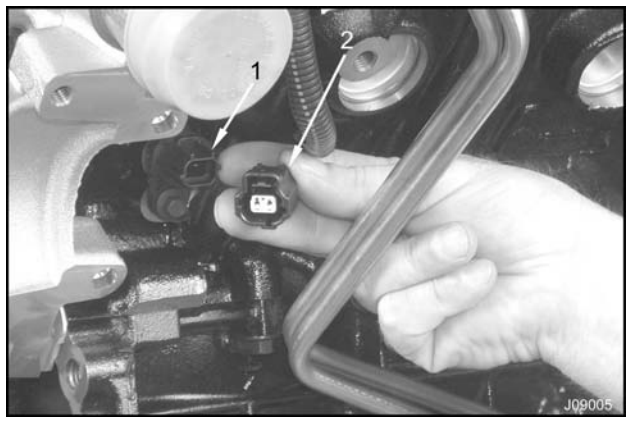

Figure 515 Connecting sensor harness to CMP sensor

1. CMP sensor
2. CMP sensor connector

2. Install CMP sensor into lower left side of crankcase near the front cover.
3. Secure CMP sensor with a bolt, M6 x 14 and tighten bolt to the Standard Torque (page 405).
4. Connect electrical connector to CMP sensor.

CKP Sensor (Crankshaft Position)

1. Lubricate O-ring with clean engine oil and install new O-ring on CKP sensor.

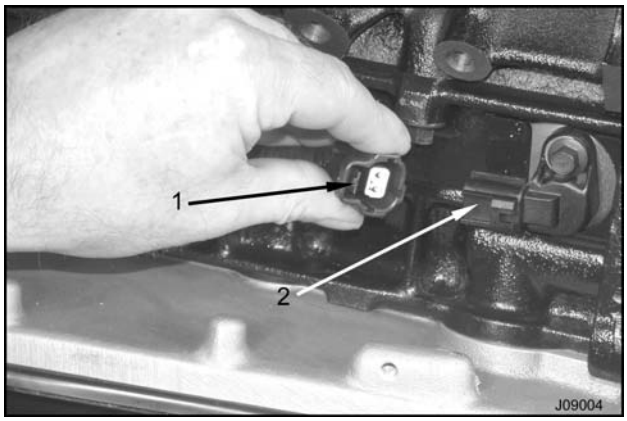

Figure 516 Connecting CKP sensor harness to sensor

1. CKP sensor connector
2. CKP sensor

2. Install CKP sensor on the lower right side of the crankcase near the front cover of the engine.
3. Secure CKP sensor with a bolt (M6 x 14) and tighten to the Standard Torque (page 405).
4. Connect electrical connector to CKP sensor.

8-Pin and 12-Pin Connectors

Push the 8-pin and 12-pin connectors together.

NOTE: Some stripped chassis applications may not require the 8-pin connector.

ECT Sensor (Engine Coolant Temperature)

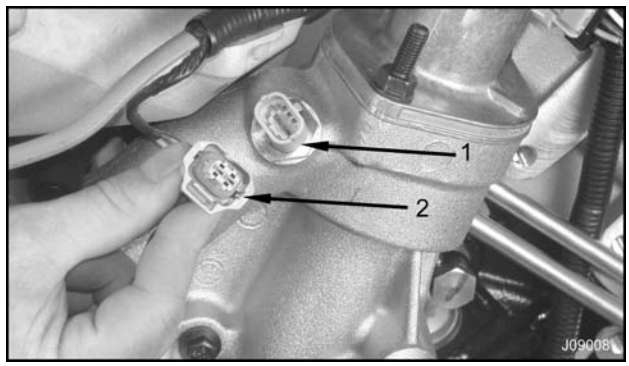

Figure 517 Connecting sensor harness to ECT sensor

1. ECT sensor
2. ECT sensor connector

1. Lubricate O-ring with clean engine oil.
2. Place new O-ring on ECT sensor.
3. Install ECT sensor into the front cover and tighten to the Special Torque (page 312).
4. Connect electrical connector to the ECT sensor.

EOT Sensor (Engine Oil Temperature) and EOP Switch (Engine Oil Pressure)

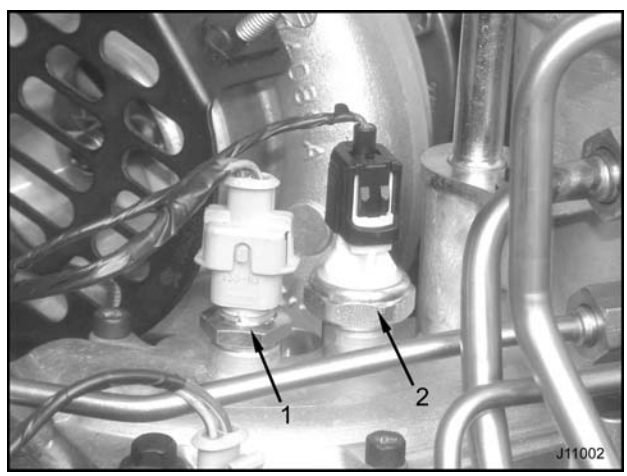

Figure 518 Connecting sensor harness to EOT sensor and EOP switch

1. EOT sensor
2. EOP switch

1. Lubricate new O-rings with clean engine oil and place O-rings onto EOT sensor and EOP switch.
2. Install and tighten the EOT sensor to the Special Torque (page 312).
3. Install and tighten EOP switch to the Special Torque (page 312).
4. Connect each electrical connector.

ICP Sensor (Injection Control Pressure)

NOTE: If the valve cover was removed, inspect the seal ring between the valve cover and the oil rail. If the valve cover was not removed, disregard steps 1 through 5.

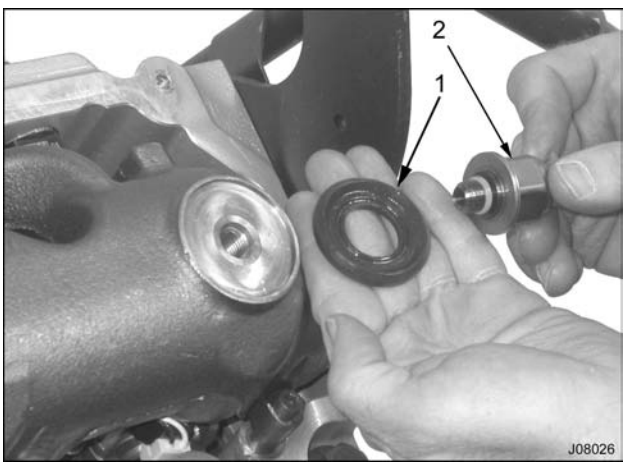

Figure 519 Installing ICP sensor and seal ring (if valve cover removed)

1. ICP seal ring
2. ICP sensor

1. Install seal ring between the right side valve cover and the oil rail. Cover seal lightly with clean engine oil.
2. Lubricate O-ring with clean engine oil.
3. Place O-ring on ICP sensor.
4. Install ICP sensor in the right oil rail.
5. Install valve cover and tighten bolts to the Standard Torque (page 405).
6. Tighten ICP sensor to the Special Torque (page 312).

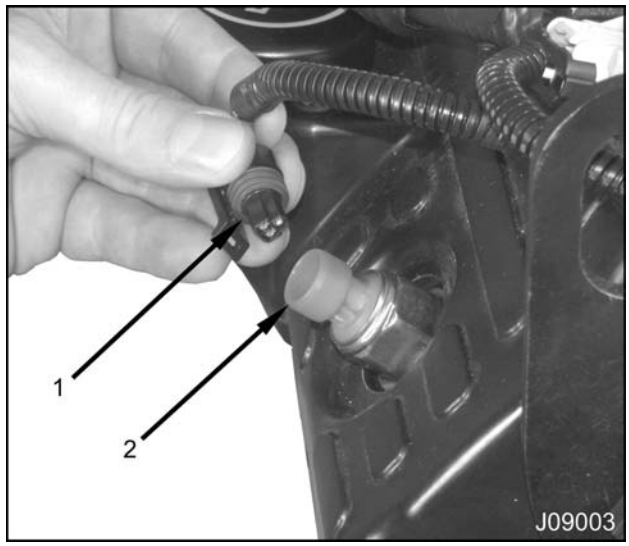

Figure 520 Connecting sensor harness to ICP sensor

1. ICP sensor connector
2. ICP sensor

7. Connect ICP electrical connector to the ICP sensor.

IPR Valve (Injection Pressure Regulator)

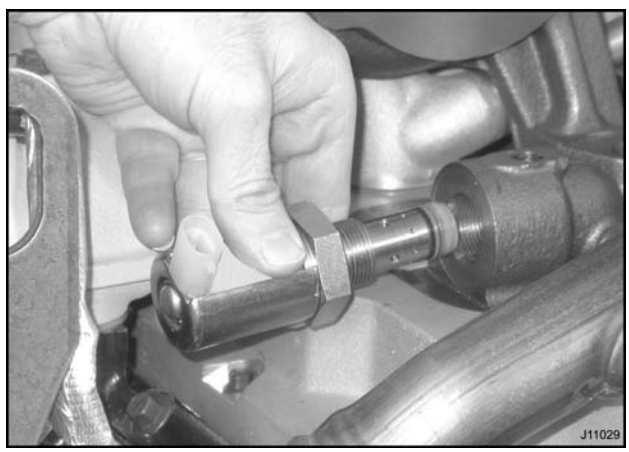

Figure 521 Installing the IPR valve

1. Using clean engine oil, lubricate new IPR valve body O-ring, end O-ring, and backup ring.
2. Install IPR valve in the top of the high-pressure pump.

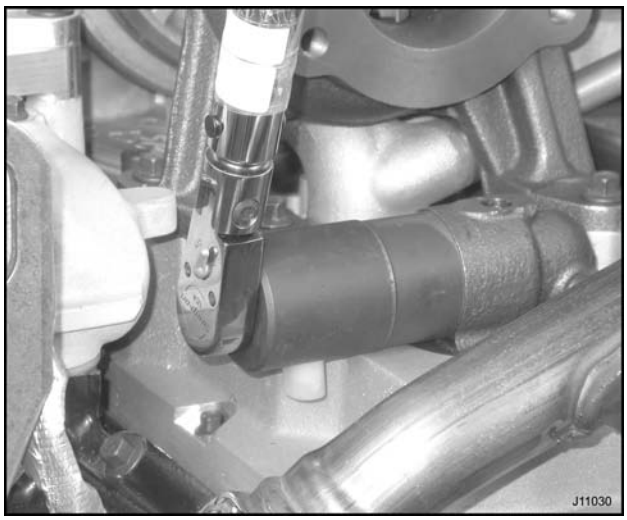

Figure 522 Torquing IPR Valve Socket

3. Using the IPR Valve Socket, tighten valve to the Special Torque (page 312). See Special Service Tools (page 313).

CAUTION: To prevent engine damage, ensure IPR heat shield (if equipped) is installed around the IPR valve.

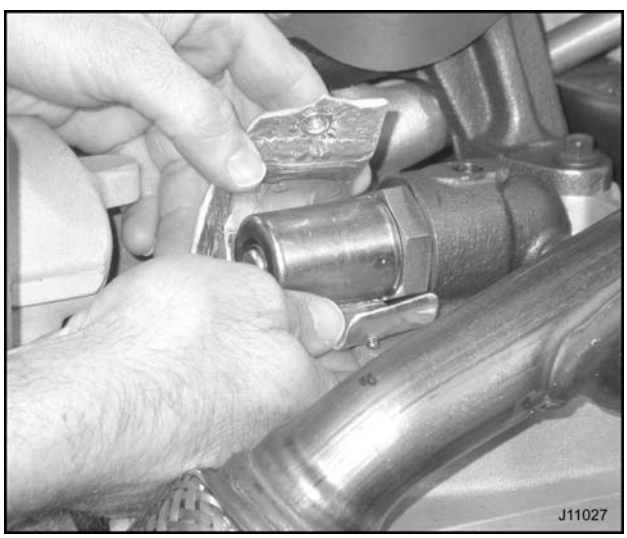

Figure 523 Installing IPR valve heat shield (if equipped)

4. If equipped, install the IPR heat shield around the valve and make sure the button is securely snapped.

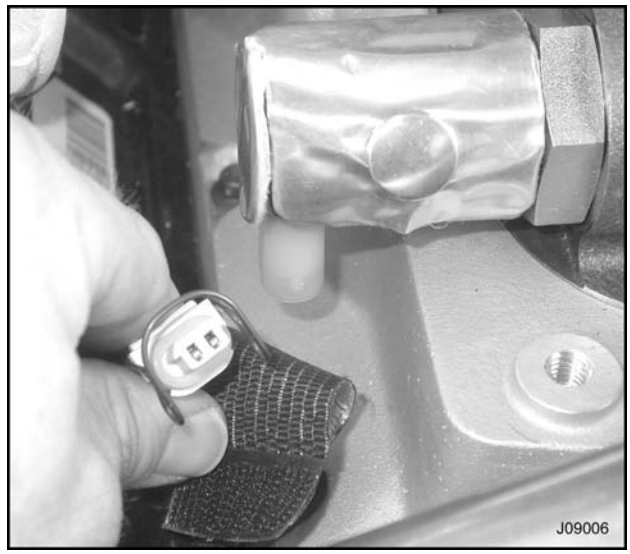

Figure 524 Connecting IPR valve harness to valve

5. Connect the IPR valve electrical connector to the IPR valve.

IAH (Intake Air Heater)

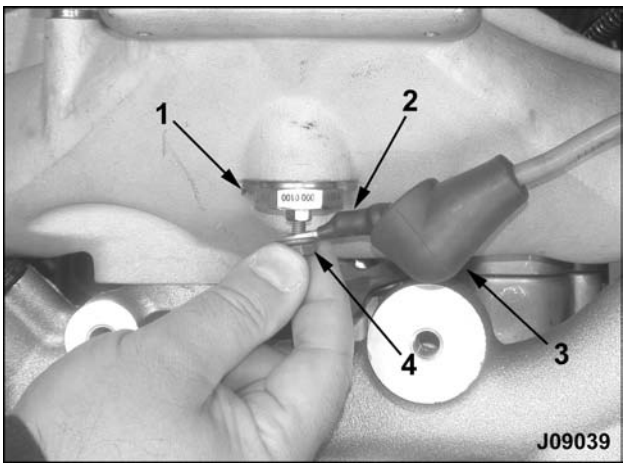

Figure 525 Connecting the cable to the intake air heater

1. Intake air heater and sealing ring
2. Heater cable
3. Rubber boot
4. Nut and washer, M5

1. Place electrical cable onto heater element and secure with a washer and nut (M5). Tighten nut to the Special Torque (page 312).
2. Pull rubber boot over heater element threads and nut.

MAP Sensor (Manifold Absolute Pressure)

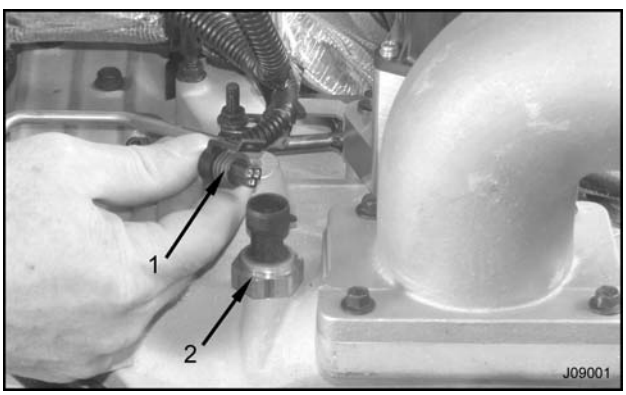

Figure 526 Connecting sensor harness to MAP sensor

1. MAP sensor connector
2. MAP sensor

1. Lubricate new O-ring with clean engine oil and install onto MAP sensor.
2. Install MAP sensor.
3. Tighten MAP sensor to the Special Torque (page 312).
4. Connect electrical connector to MAP sensor.

MAT Sensor (Manifold Air Temperature)

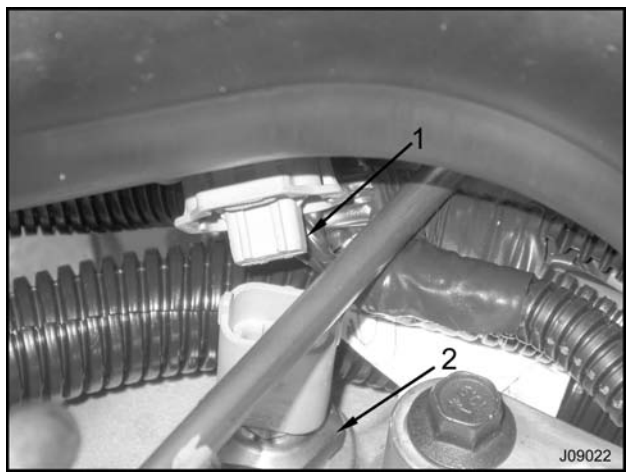

Figure 527 Connecting sensor harness to MAT sensor

1. MAT sensor connector
2. MAT sensor

1. Lubricate new O-ring with clean engine oil and install onto MAT sensor.
2. Install MAT sensor into the left side of the intake manifold and tighten to the Special Torque (page 312).
3. Connect electrical connector to the MAT sensor.

MAF / IAT Sensor (Mass Airflow / Intake Air Temperature)

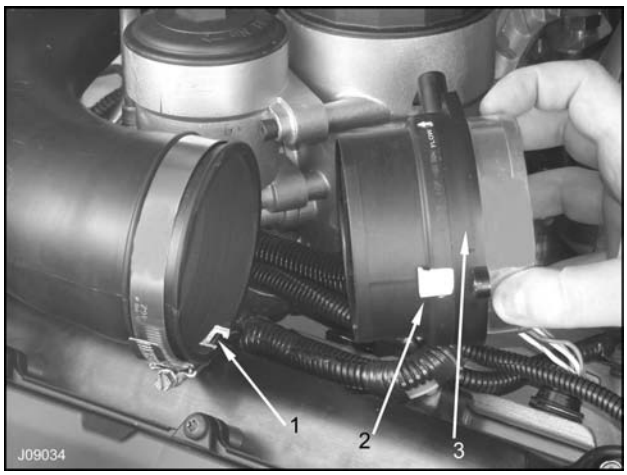

Figure 528 Installing the MAF sensor

1. Alignment notch
2. Alignment tab
3. MAF/IAT sensor

1. Align the alignment notch and tab, push the MAF/IAT sensor into the air inlet duct assembly.

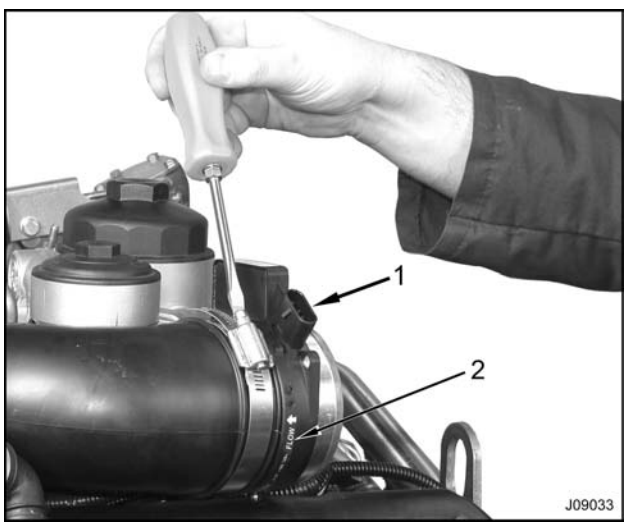

Figure 529 Tightening the hose clamp

1. MAF/IAT sensor
2. Airflow indicator

2. Tighten the hose clamp. The airflow indicating arrow will be about half way between the bottom of the air inlet duct and the top.

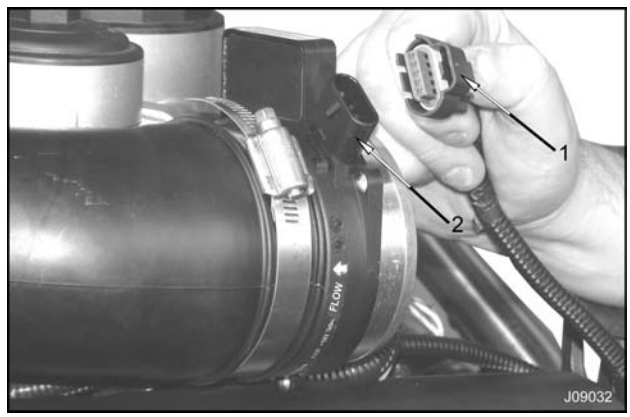

Figure 530 Connecting sensor harness to MAF/IAT sensor

1. MAF sensor harness connector
2. MAF/IAT sensor

3. Connect electrical connector to MAF/IAT sensor.

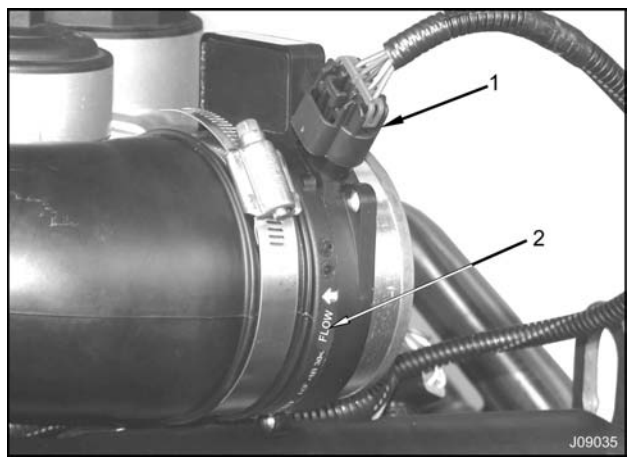

Figure 531 Orientation of the MAF/IAT sensor and airflow indicator

1. MAF sensor harness connector
2. Airflow indicator

4. Check the MAF/IAT sensor for correct orientation as shown in the figure above.

Specifications

Engine Electrical	
Glow Plugs	
Applied voltage	10.9 V to 11.1V
Intake Air Heater	
Amperage rating	60 Amps
CMP sensor (Camshaft Position)	
Operating speed	30 rpm to 3000 rpm
CKP sensor (Crankshaft Position)	
Operating actuator speed	15 rpm to 2000 rpm
Operating temperature	-40 °C to 130 °C (-40 °F to 266 °F)
IPR valve (Injection Pressure Regulator)	
Operating temperature range	-40 °C to 220 °C (-40 °F to 428 °F)
Maximum operating pressure	28 MPa (4,061 psi)

Special Torque

Engine Electrical	
IAH element (Intake Air Heater) (cable nut)	4 N·m (35 lbf·in)
ECT sensor (Engine Coolant Temperature)	18 N·m (158 lbf·in)
EOT sensor (Engine Oil Temperature)	19 N·m (168 lbf·in)
EOP sensor (Engine Oil Pressure)	14 N·m (123 lbf·in)
Glow plug	19 N·m (14 lbf·ft)
ICP sensor (Injection Control Pressure)	12 N·m (106 lbf·in)
IPR valve (Injection Pressure Regulator)	50 N·m (37 lbf·ft)
MAP sensor (Manifold Absolute Pressure)	12 N·m (108 lbf·in)
MAT sensor (Manifold Air Temperature)	18 N·m (156 lbf·in)

Special Service Tools

Engine Electrical	
Description	**Tool Number**
Glow Plug Connector Remover / Installer	ZTSE4670
IPR Valve Socket	ZTSE4666

Table of Contents

Exploded View and Flow Schematic

High-pressure Oil System

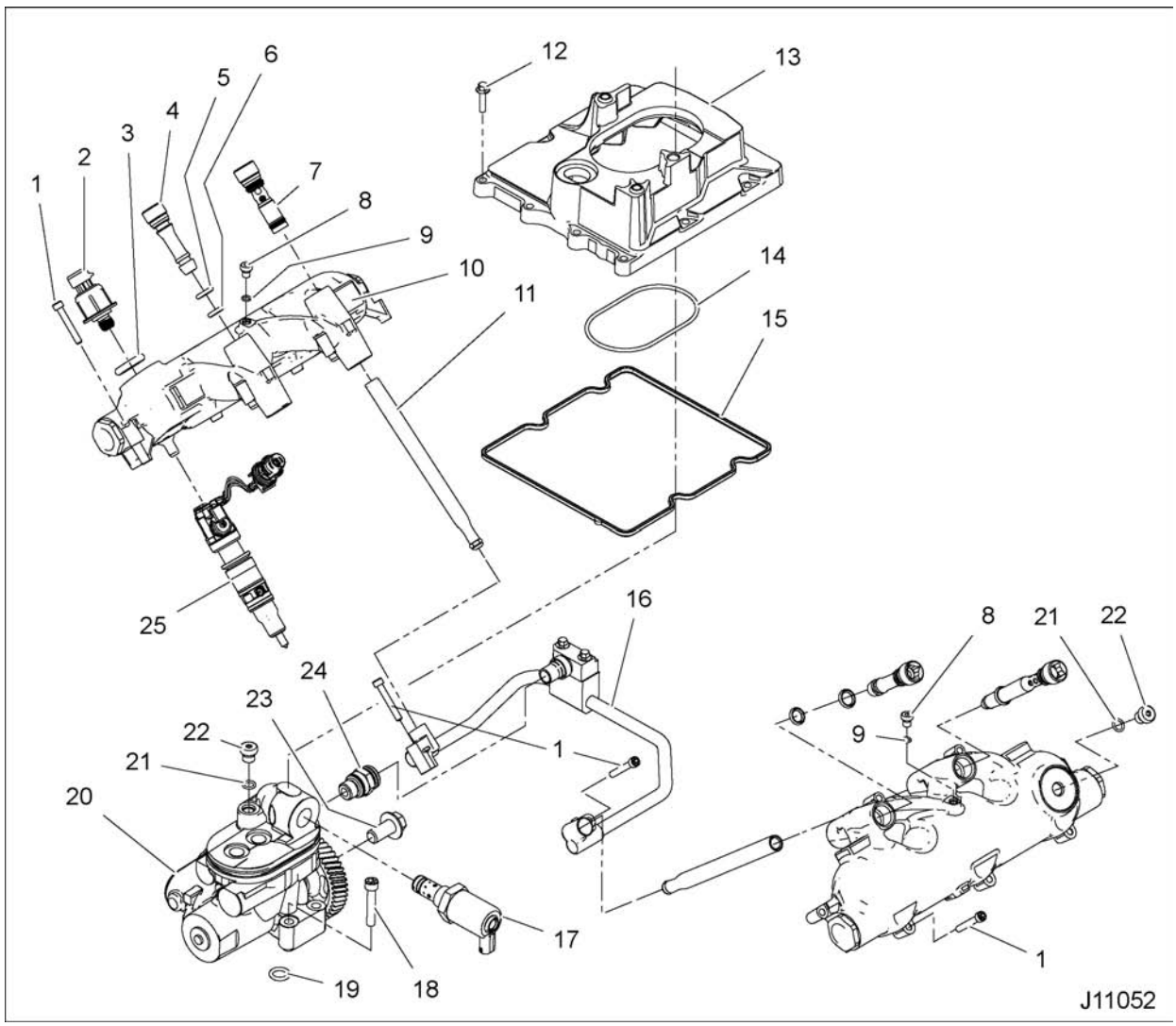

Figure 532 High-pressure oil system

1. Bolt, Torx® socket, M6 x 40 (16)
2. ICP sensor with O-ring
3. ICP seal ring
4. Rail port plug (2)
5. D-ring seal (2)
6. D-ring seal (2)
7. Case-to-head tube plug (2)
8. Prime port plug, M8 x 1 (2)
9. O-ring seal (2)
10. High-pressure oil rail (2)
11. Case-to-head tube (2)
12. Bolt, M6 x 25 (8)
13. High-pressure oil pump cover
14. Pump O-ring
15. Hydraulic pump cover gasket
16. Branch tube assembly
17. IPR valve
18. Bolt, Torx® socket, M8 x 45 (3)
19. O-ring seal, #207
20. High-pressure oil pump assembly
21. O-ring seal (2)
22. Plug, M12 (2)
23. Bolt, M14 x 1
24. Adapter, M18
25. Fuel injector assembly (6)

High-pressure Flow Schematic

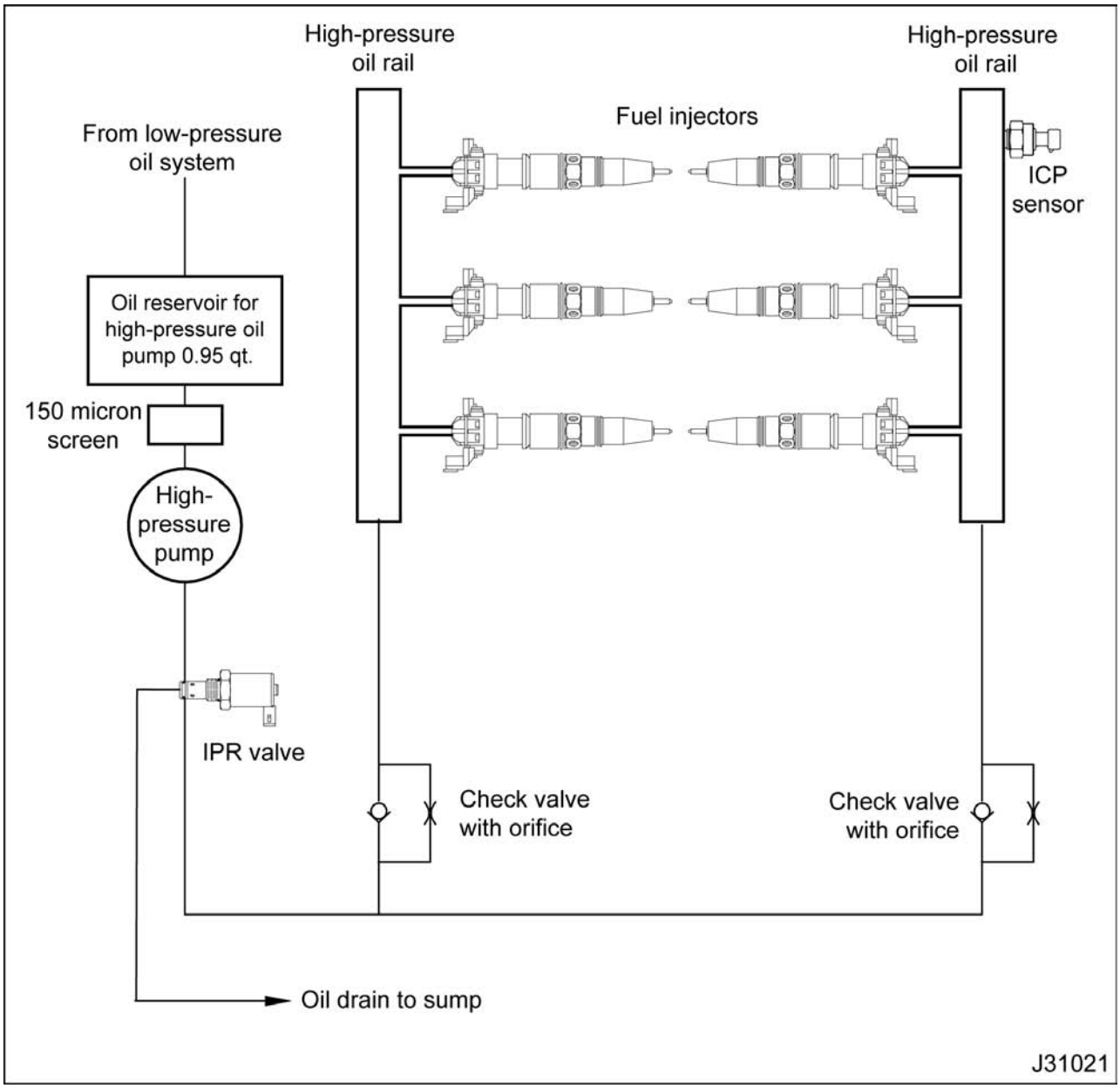

Figure 533 High-pressure Flow Schematic

Removal

Prerequisites

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle. See "Safety Information (page 3)."

NOTE: Before removing high-pressure oil system components, the following components must be removed or disconnected first. See the appropriate section for removal procedures:

- Turbocharger assembly
- Oil filter assembly
- Fuel system
- Intake manifold

NOTE: If removing only the high-pressure oil pump, it's not necessary to remove the branch tube assembly, rear cover or cylinder heads.

If you must remove the branch tube assembly, the rear cover and cylinder heads must also be removed. Refer to Rear Cover and Cylinder Head and Valve Train sections.

High-pressure Oil Pump Cover

WARNING: To avoid serious personal injury or possible death: Do not allow used engine fluids to stay on your skin. Clean your skin and nails with soap and water, or a good hand cleaner. Wash or properly throw away clothing or rags containing used engine fluids. Used engine fluids contain certain elements that may be unhealthy for skin and could even cause cancer. See "Safety Information (page 3)."

NOTE: Engine fluids, oil, fuel, and coolant, can be a threat to the environment. Never dispose of engine fluids by putting them in the trash, pouring them on the ground, in the sewers, in streams or bodies of water.

NOTE: The Injection Pressure Regulator (IPR) valve must be removed before removing the high-pressure oil pump cover. Refer to Engine Electrical Components for IPR valve removal procedure.

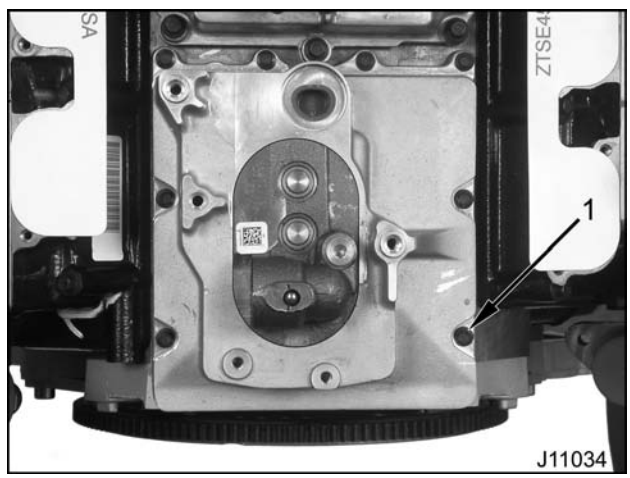

Figure 534 Remove the high-pressure oil pump cover bolts

1. High-pressure oil pump cover bolts (8)

1. Remove all eight bolts (M6 x 25) from the high-pressure oil pump cover.

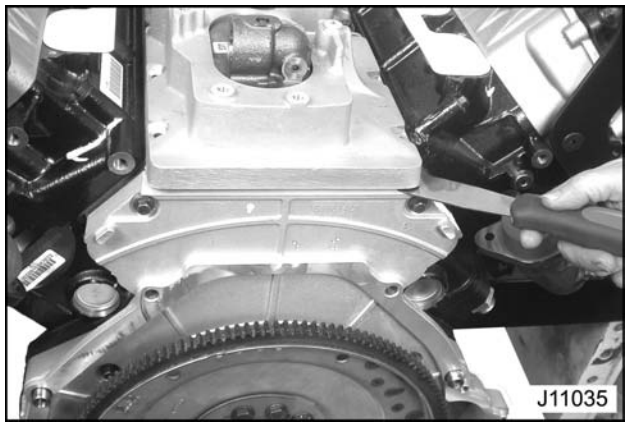

Figure 535 Breaking the sealant bond

2. Use a thin gasket scraper to separate the sealant bond between crankcase, rear cover, and high-pressure oil pump cover. Perform this procedure at both rear corners of the pump cover.

CAUTION: To prevent engine damage when removing the high pressure pump cover, make sure the Liquid Gasket (RTV) is cut prior to lifting up cover, otherwise the rear cover gasket could be pulled up and out resulting in removal of the rear cover to replace gasket.

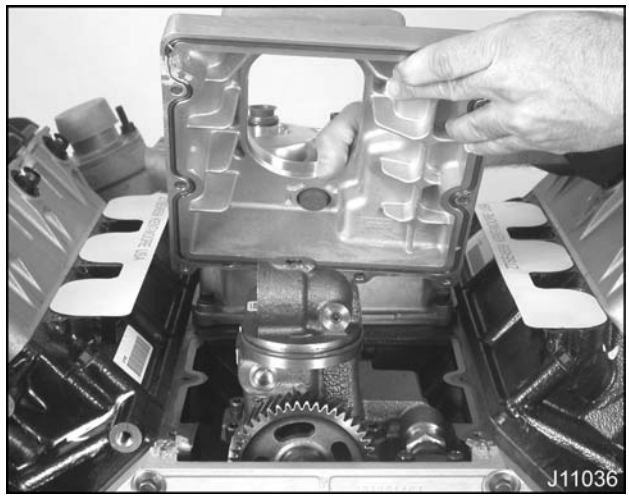

Figure 536 Removing the high-pressure oil pump cover

3. After cutting sealant, lift the high-pressure oil pump cover straight up to clear pump gear.

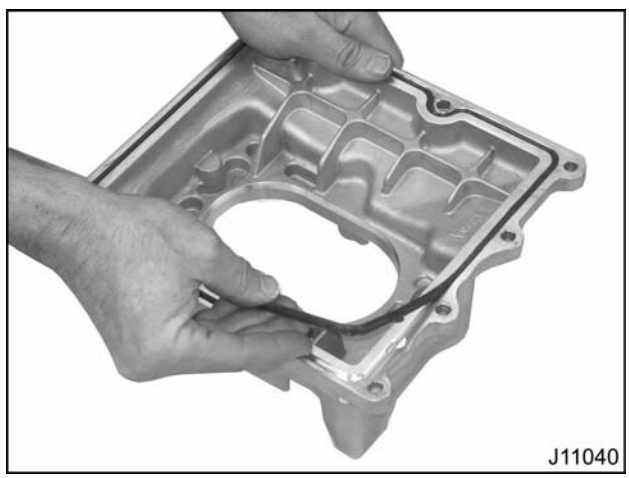

Figure 537 Removing the high-pressure pump cover gasket

4. Remove and discard the high-pressure pump cover gasket seal.

High-pressure Oil Pump

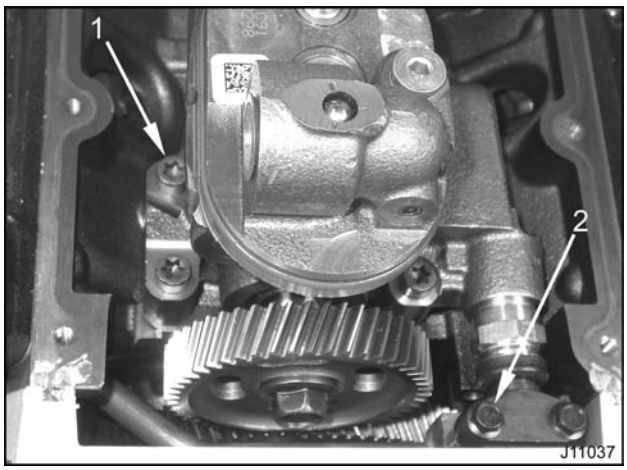

Figure 538 High-pressure oil pump related bolts

1. High-pressure oil pump bolts (3)
2. Branch tube adapter bolts (2)

1. Remove three Torx® socket bolts securing the high-pressure pump (M8 x 45) and loosen two bolts (M6 x 30) at the branch tube adapter assembly.

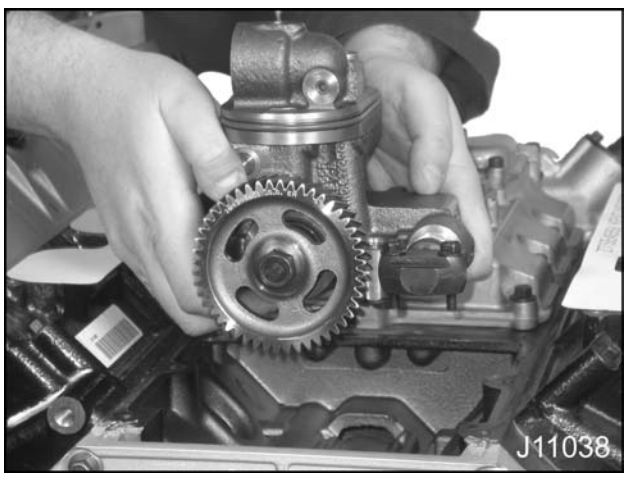

Figure 539 Removing the high-pressure oil pump assembly

2. Remove the high-pressure oil pump assembly and discard pump O-ring seal.

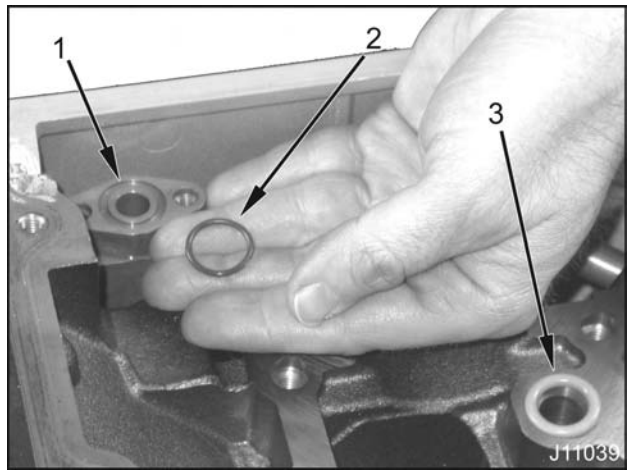

Figure 540 High-pressure oil pump assembly inlet and branch tube adapter O-rings

1. Branch tube adapter O-ring seal recess
2. Branch tube adapter O-ring seal
3. High-pressure pump inlet O-ring seal, #207

3. Remove and discard the high-pressure oil pump inlet and branch tube adapter O-rings. Cap off both oil holes.

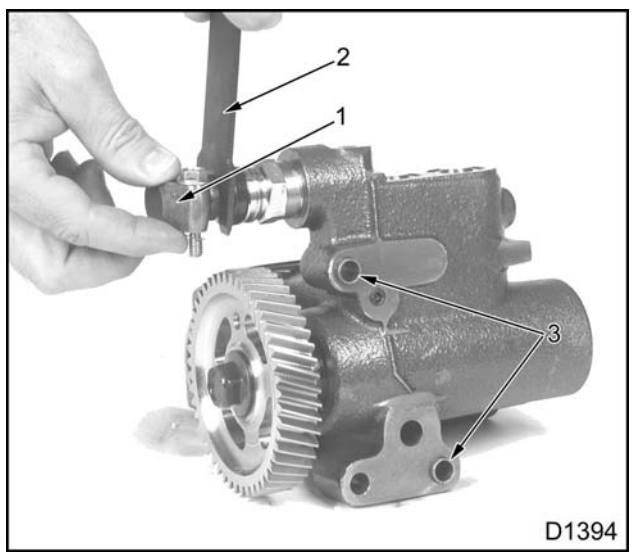

Figure 541 Removing the branch tube adapter

1. Branch tube adapter
2. Quick release tool #10
3. High-pressure oil pump alignment dowels

4. If replacement of the high-pressure oil pump assembly is required, disconnect branch tube

adapter from pump, using a #10 Quick Release Tool. See Special Service Tools (page 329).

Branch Tube

NOTE: To remove the branch tube assembly, the rear cover and cylinder heads must be removed. See the Rear Cover, and Cylinder Head and Valve Train sections.

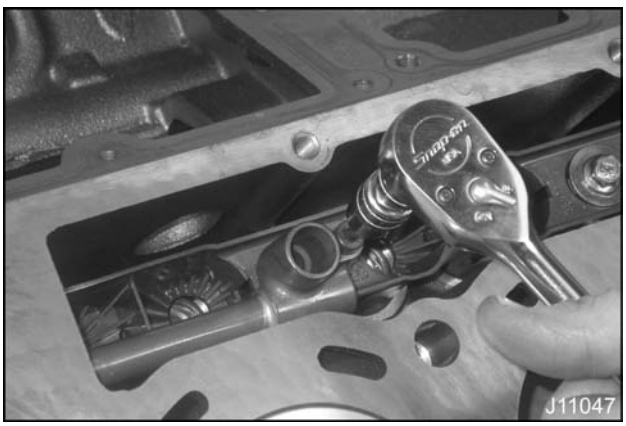

Figure 542 Removing the branch tube bolts

CAUTION: To prevent engine damage, take extra care to not drop these bolts. These bolts are not captured within the branch tube.

1. Remove a Torx® socket bolt (M6 x 40) from each side of branch tube assembly.

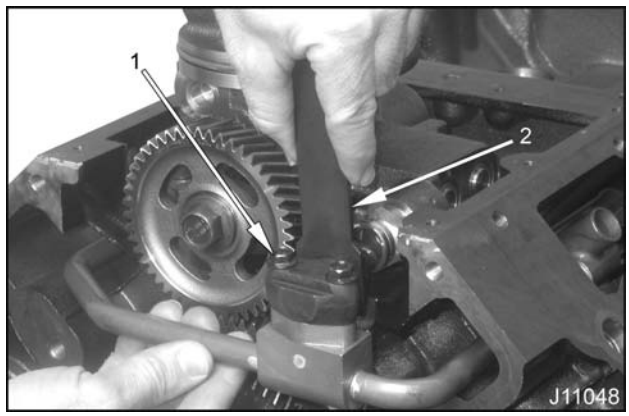

Figure 543 Removing the branch tube adapter

1. Branch tube adapter bolts (2)
2. #10 quick release tool

2. Disconnect the high-pressure oil pump from the branch tube adapter connection using a #10 Quick Release Tool. See Special Service Tools (page 329).

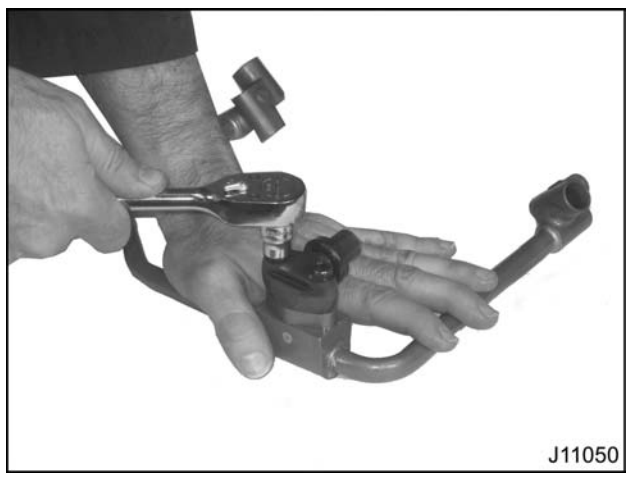

Figure 544 Removing the branch tube adapter from the branch tube assembly

CAUTION: To prevent engine damage, take extra care to not drop these bolts. These bolts are not captured within the branch tube adapter.

3. Loosen two bolts (M6 x 30) connecting the branch tube adapter to the branch tube assembly and discard O-ring, if not done so already.

Cleaning and Inspection

High-pressure Oil Pump Cover

1. Clean any old sealant residue from pump cover, crankcase and rear cover mating surfaces.
2. Inspect the high-pressure oil pump cover, crankcase and rear cover sealing surfaces for dirt, raised metal, cracking or other indications of seal failure. Correct as required.
3. Clean and inspect the IPR valve.
   a. Inspect the O-ring sealing surfaces for dirt, raised metal or other indications of seal failure. Correct as required.
   b. Inspect electrical connectors.
   c. Inspect valve openings for dirt or debris, investigate causes and correct as required.

High-pressure Oil Pump (Perform if Oil Pump was Removed)

NOTE: The high-pressure oil pump and gear are not serviceable independently. The pump and gear must be replaced as an assembly.

1. Clean and inspect the pump-to-cover O-ring sealing surface for dirt, raised metal or other indications of seal failure. Correct any defects as required.
2. Clean and inspect the branch tube adapter O-ring groove for dirt, raised metal or other indications of seal failure. Correct any defects as required.
3. Clean and inspect the branch tube adapter quick disconnect sealing surfaces for dirt, raised metal or other indications of seating seal failure. Correct any defects as required.
4. Clean and inspect the high-pressure oil pump inlet O-ring groove for dirt, raised metal or other indication of seal failure. Correct any defects as required.

Branch Tube

1. Clean and inspect the branch tube assembly end blocks for debris, galling or other damage indicating evidence of misalignment. Replace the branch tube assembly as required.
2. Inspect branch tube adapter bores, the outside of the adapter connection and the inside of the pump connection for debris, galling or other damage indicating misalignment or defects. Replace adapter as required.
3. Clean and inspect the brazed joints for cracks or other indications of joint failure. Replace branch tube assembly as required.
4. Clean and inspect the branch tube adapter (if high-pressure oil pump assembly was not removed) O-ring groove for dirt, raised metal or other indications of seal failure. Correct any defects as required.

Installation

NOTE: If only the high-pressure oil pump assembly was replaced, but not the branch tube assembly, skip the branch tube assembly procedure.

Branch Tube

1. Install the branch tube assembly.

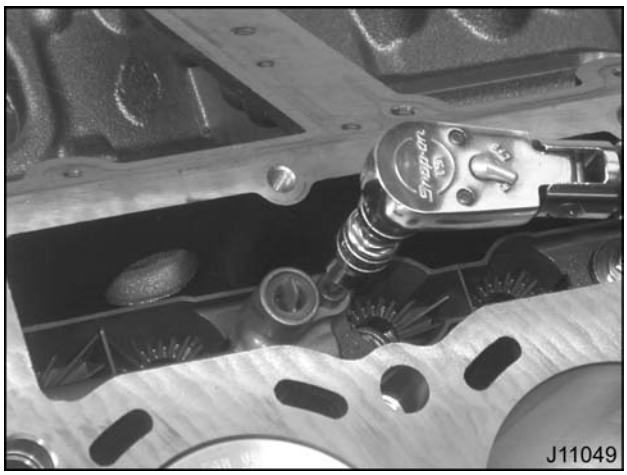

Figure 545 Installing the mounting bolt on branch tube assembly (right side shown)

CAUTION: To prevent engine damage, take extra care to not drop these bolts. These bolts are not captured within the branch tube.

2. Install a mounting bolt (M6 x 40) through the right side of the branch tube assembly, which mounts over the right rear roller follower guide.
3. Install a mounting bolt (M6 x 40) through the left side of the branch tube assembly, which mounts over the left rear roller follower guide (similar to the right side).
4. Tighten both branch tube assembly mounting bolts to the Standard Torque (page 405).
5. Install a new O-ring in the branch tube adapter recess.
6. Secure the branch tube adapter to the branch tube assembly using two bolts (M6 x 30). Tighten bolts to the Standard Torque (page 405).

CAUTION: To prevent engine damage, take extra care to not drop these bolts. These bolts are not captured within the branch tube adapter.

7. Refer to the appropriate section regarding installation of the rear cover, cylinder heads, intake manifold and turbocharger sections.

High-pressure Oil Pump

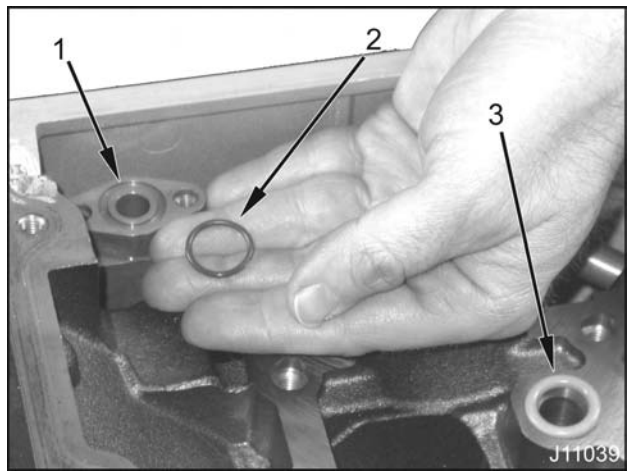

Figure 546 High-pressure oil pump assembly inlet and branch tube adapter O-rings

1. Branch tube adapter O-ring seal recess
2. Branch tube adapter O-ring seal
3. High-pressure pump inlet O-ring seal, #207

1. Lubricate and place a new O-ring onto the high-pressure oil pump inlet recess, and one onto the branch tube assembly (O-ring recess) for the branch tube adapter.

CAUTION: To prevent engine damage, use only approved pump to cover seal. Substitution could cause damage to the pump cover.

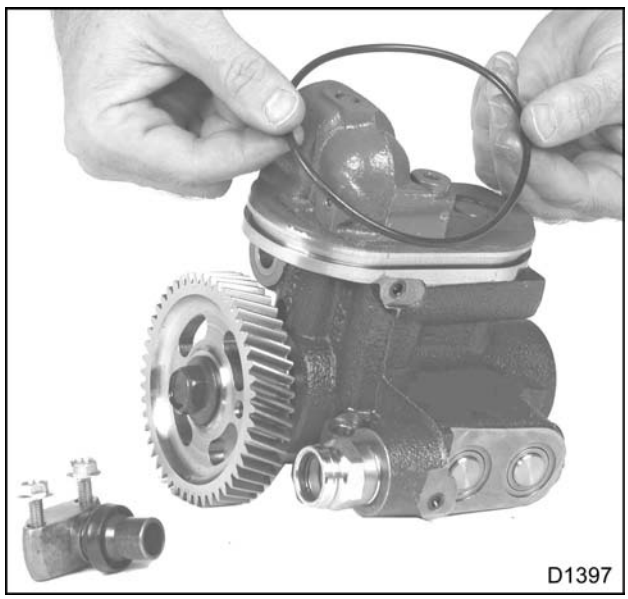

Figure 547 Installing the high-pressure oil pump cover O-ring (shown with the branch tube adapter removed)

2. Install a new O-ring onto the high-pressure oil pump to cover recess.
3. If removed, connect the branch tube adapter to the high-pressure oil pump.

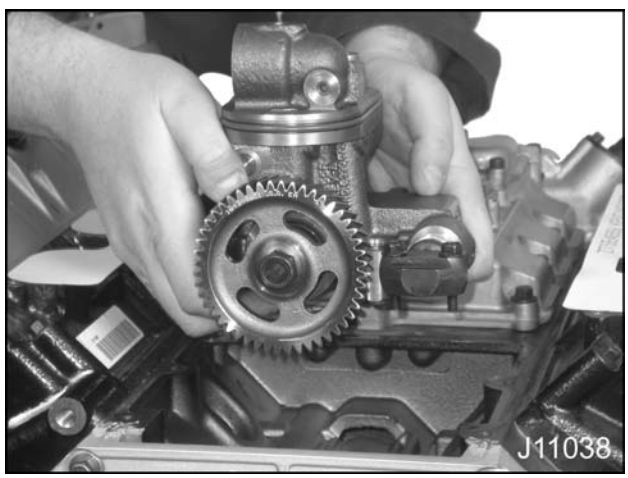

Figure 548 Installing the high-pressure oil pump

4. Install the high-pressure oil pump with attached branch tube adapter.

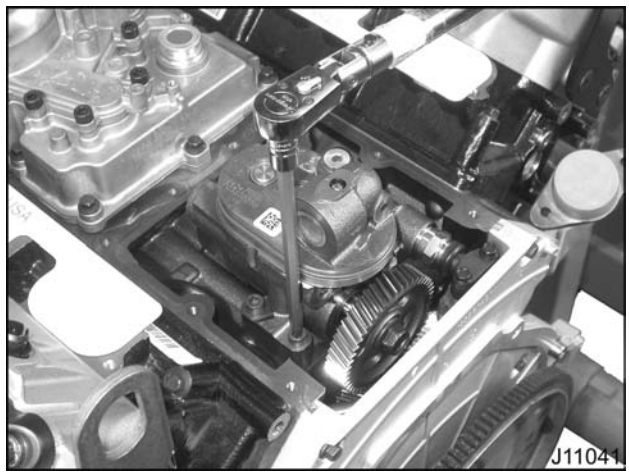

Figure 549 Torque the high-pressure oil pump bolts

CAUTION: To prevent engine damage, take extra care to not drop these bolts. These bolts are not captured within the high-pressure oil pump.

5. Install three Torx® socket bolts (M8 x 45) to secure the high-pressure pump to the crankcase. Tighten bolts to the Standard Torque (page 405).
6. Tighten two branch tube adapter bolts (M6 x 30) to the branch tube assembly to the Standard Torque (page 405).

High-pressure Oil Pump Cover

1. Place a new gasket in the recess in the high-pressure oil pump (if not already done).

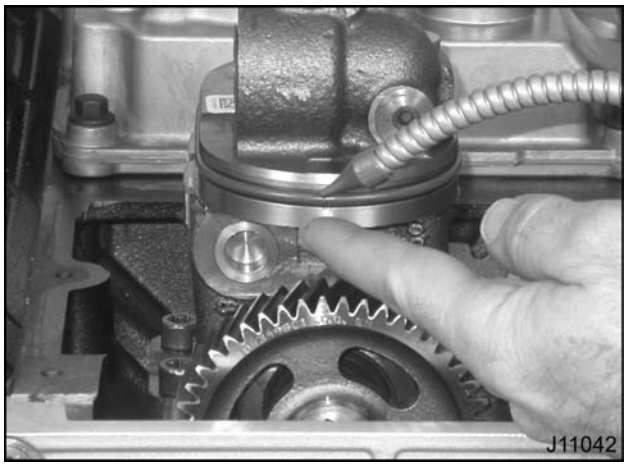

Figure 550 Lubricating the high-pressure oil pump O-ring

2. Lubricate high-pressure oil pump O-ring.

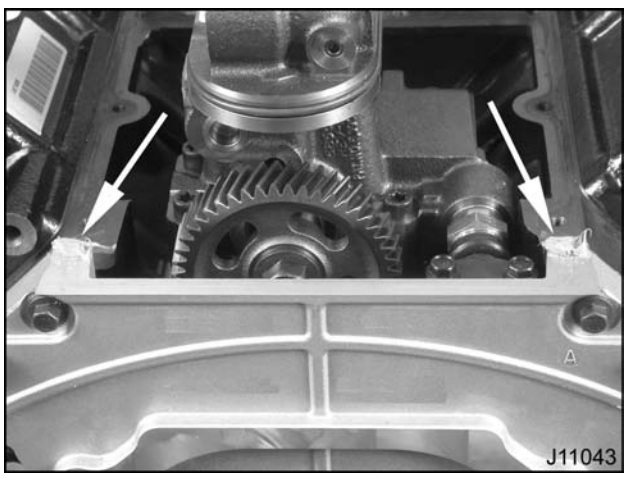

Figure 551 Apply Liquid Gasket (RTV) to crankcase and rear cover joining surfaces

3. Apply Liquid Gasket (RTV) to locations where rear cover, high-pressure pump cover and crankcase join. See Special Service Tools (page 329).

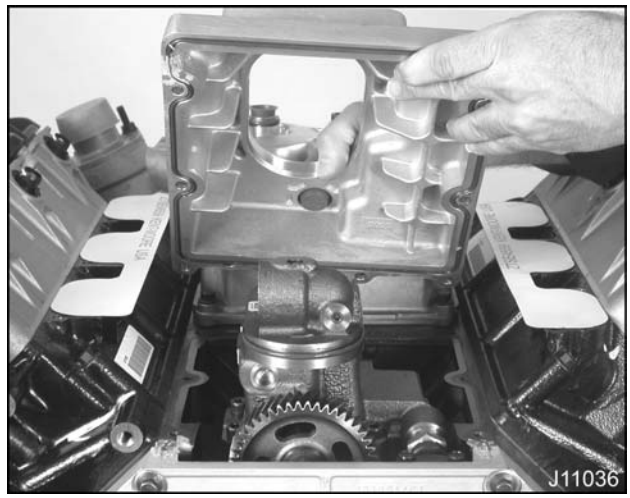

Figure 552 Installing the high-pressure oil pump cover

CAUTION: To prevent engine damage, the high-pressure oil pump cover must be firmly seated onto the high-pressure oil pump O-ring to prevent cracking the cover plate.

Figure 553 Seating the high-pressure oil pump cover

4. Apply firm even downward pressure to seat the high-pressure oil pump cover over the high-pressure pump O-ring.

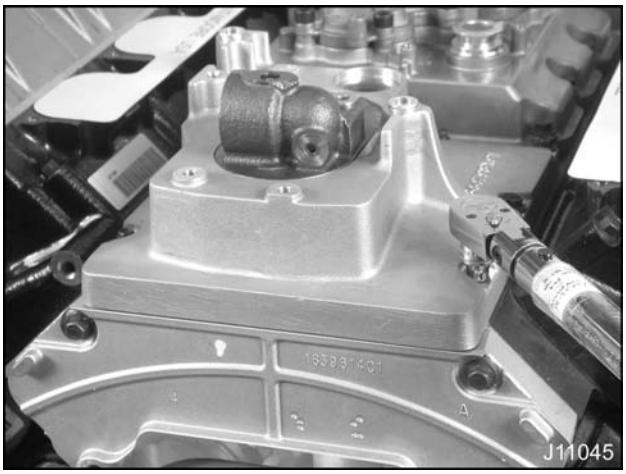

Figure 554 Torque the high-pressure oil pump cover

5. Install eight mounting bolts (M6 x 25) and tighten to the Special Torque (page 329).
6. Refer to Engine Electrical Components for IPR valve installation procedure.
7. Reinstall all safety guards, shields, and covers after servicing the engine. Make sure all tools, covers, loose parts and service equipment are removed from engine area after all work is done.

Specifications

IPR Valve and ICP Sensor	
Injection Control Pressure (ICP) Sensor	
Operating pressure range	0 to 30 MPa (0 to 4,350 psi)
Injection Pressure Regulator (IPR) Valve	
IPR valve relief pressure	31 MPa (4,500 psi)
IPR valve maximum pressure	38 MPa (5,500 psi)

Special Torque

High-pressure System Components	
Case-to-head tube	60 N·m (82 lbf·ft)
Injection Pressure Regulator (IPR)	50 N·m (37 lbf·ft)
Prime port plug	8 N·m (71 lbf·in)
High-pressure pump plug	35 N·m (26 lbf·ft)

Special Service Tools

High-pressure System	
Description	**Tool Number**
IPR Valve Socket	ZTSE4666
Liquid Gasket (RTV, 6 oz. tube)	1830858C1
#10 Quick Release Tool	ZTSE4581