# Table of Contents

**Component Exploded View....281**

**Removal....283**
- **Oil System Module....283**
- **Secondary Filtration Assembly....286**
- **Disassembling the Oil System Module....287**
- **Disassembling the Secondary Filtration Filter....289**

**Cleaning and Inspection....290**
- **Cleaning the Oil System Module....290**
- **Checking the Cooler Heat Exchanger for Leakage....290**
  - **External....290**
  - **Internal....292**

**Installation....293**
- **Assembling the Oil System Module....293**
- **Assembling the Secondary Filtration Filter....295**
- **Secondary Filtration Assembly....296**
- **Oil System Module....296**
- **Priming the Lubrication System....298**
- **Alternate Method....298**

**Specifications....299**

**Special Torque....299**

**Special Service Tools....299**


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## Component Exploded View

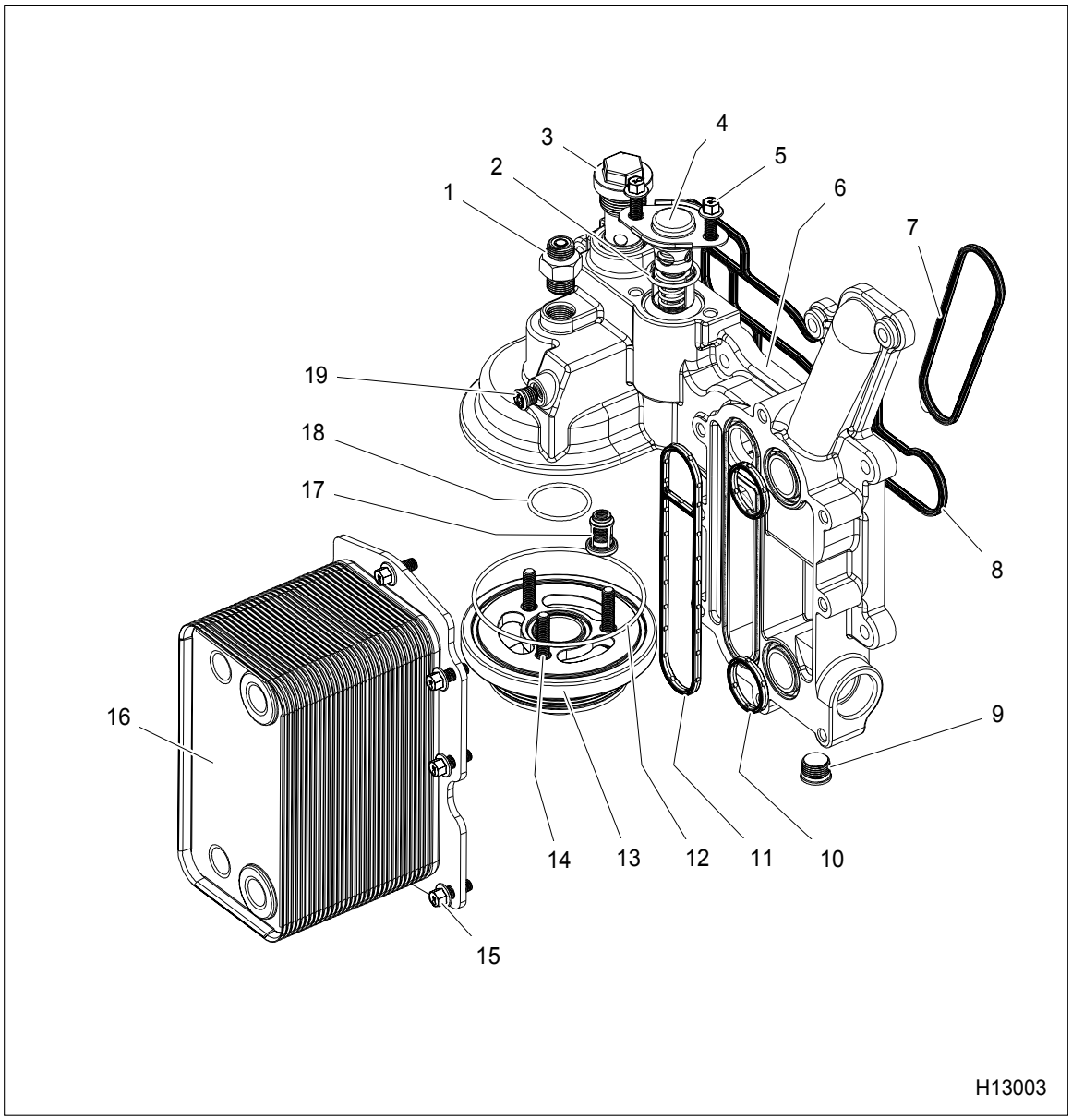


**Figure 404 Oil system module assembly**

1. Oil supply tube fitting and O-ring
2. O-ring gasket
3. Regulator valve assembly
4. Hex flange screw, M8 x 20 (2)
5. Oil thermal valve assembly
6. Oil cooler housing
7. Coolant seal
8. Oil seal
9. Plug assembly, M18 (coolant)
10. Coolant seal (2)
11. Oil seal
12. O-ring gasket
13. Lube adapter (not serviceable)
14. Bolt, M8 x 25 (3)
15. Bolt, M8 x 20 (8)
16. Cooler heat exchanger (23 or 33 plates)
17. Bypass valve
18. O-ring gasket
19. Plug assembly, M12


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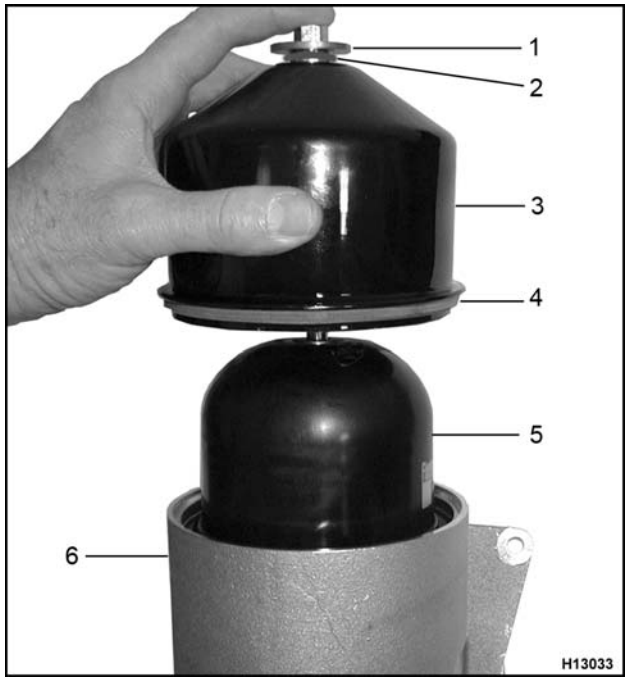


**Figure 405 Secondary filter components**

1. Stud assembly
2. O-ring
3. Cover
4. O-ring gasket
5. Filter element
6. Filter header


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## Removal

**Oil System Module**

**GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.**

**WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.**

**WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.**

**WARNING: To prevent personal injury or death, allow engine to cool before removing components.**

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

**WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.**

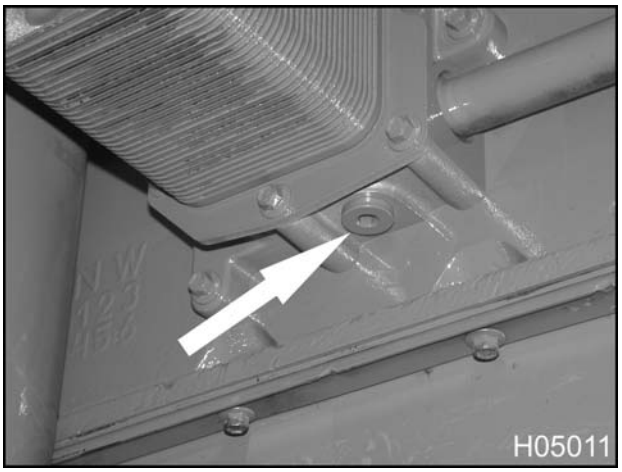


**Figure 406 Coolant drain plug**

1. Place a coolant drain pan under the oil system module.
2. Remove the coolant drain plug (M18) at the bottom of the oil system module. Open radiator cap to allow system to drain faster.
3. Remove and discard coolant drain plug O-ring .
4. Install a new O-ring on the coolant drain plug.
5. After coolant has drained, install coolant drain plug in the oil system module.
6. Tighten coolant drain plug to special torque (Table 42).
7. Recycle or dispose of coolant according to applicable regulations.


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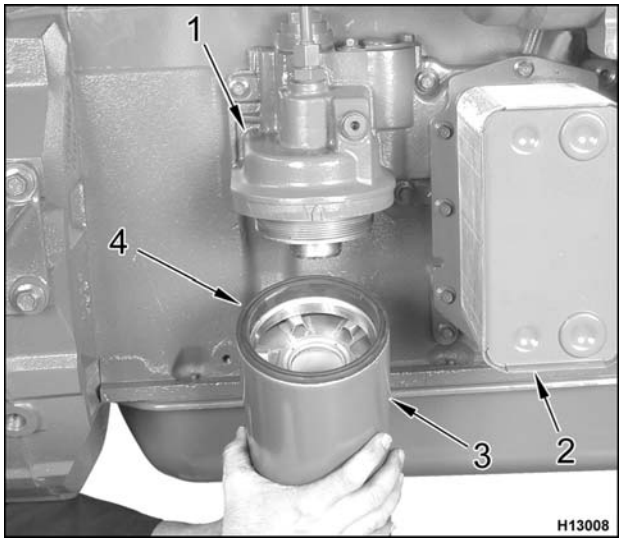


**Figure 407 Removing the oil filter**

1. Oil system module assembly
2. Oil cooler
3. Oil filter
4. Gasket

8. Place an oil drain pan under oil filter. After waiting for oil to cool down, remove, drain, and discard oil filter. Dispose or recycle oil and filter in accordance with local regulations.

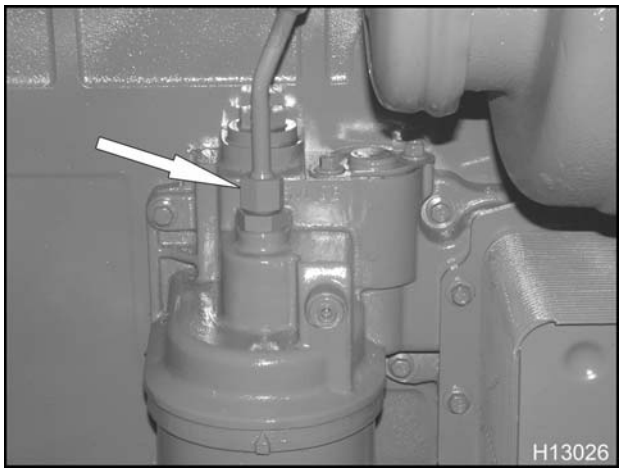


**Figure 408 VGT oil supply tubing**

9. Remove the VGT oil supply tube fitting from the oil system module assembly.

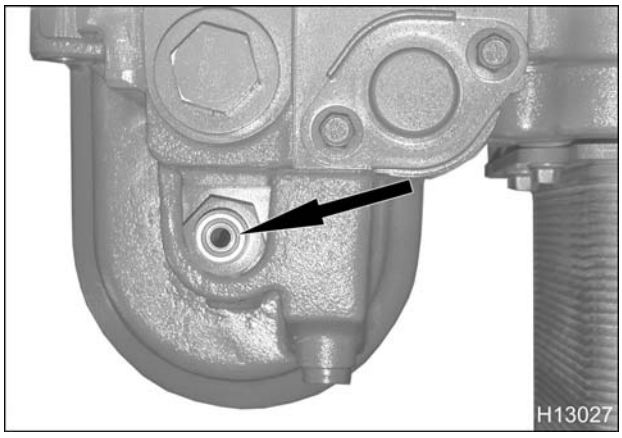


**Figure 409 VGT oil supply tubing O-ring**

10. Remove the VGT oil supply tube O-ring and discard.


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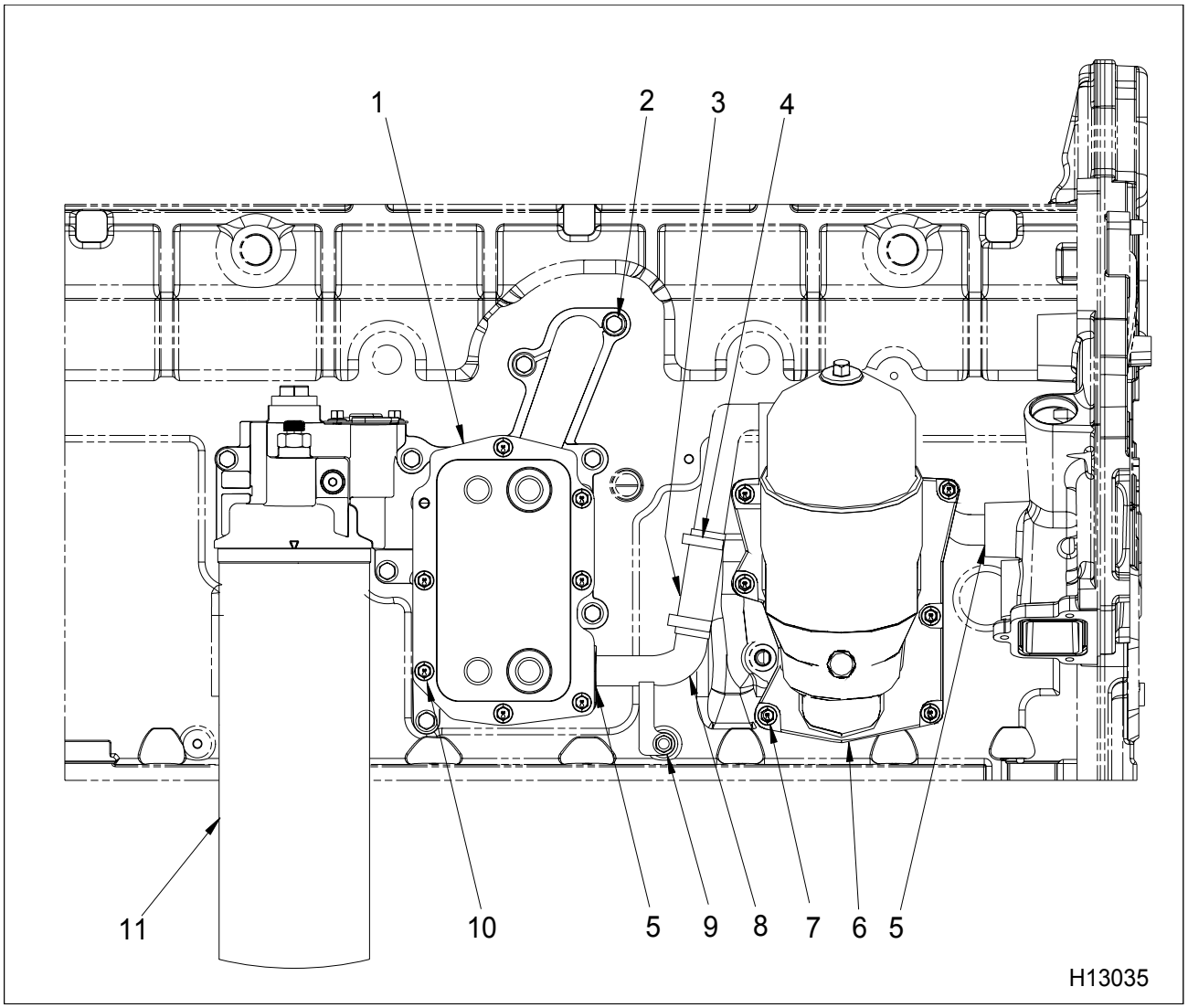


**Figure 410 Oil system module and secondary filter assembly**

1. Oil system module assembly
2. Bolt, M8 x 30 (8)
3. Hose, 1 in O.D.
4. Hose clamp (2)
5. O-ring (2)
6. Secondary filtration filter assembly
7. Bolt, M8 x 25 (6)
8. Oil cooler drain tube
9. Support bracket bolt, M8 x 16
10. Bolt, M8 x 20 (8)
11. Oil filter (spin-on)

11. Remove oil cooler drain tube support bracket bolt (M8 x 16) at lower end.
12. Pull oil cooler drain tube (lower end) out of oil cooler module and discard O-ring.
13. Remove eight oil system module assembly bolts (M8 x 30).
14. Remove the complete oil system module including the oil cooler and filter header as a unit (less oil filter) and place onto a clean workbench.


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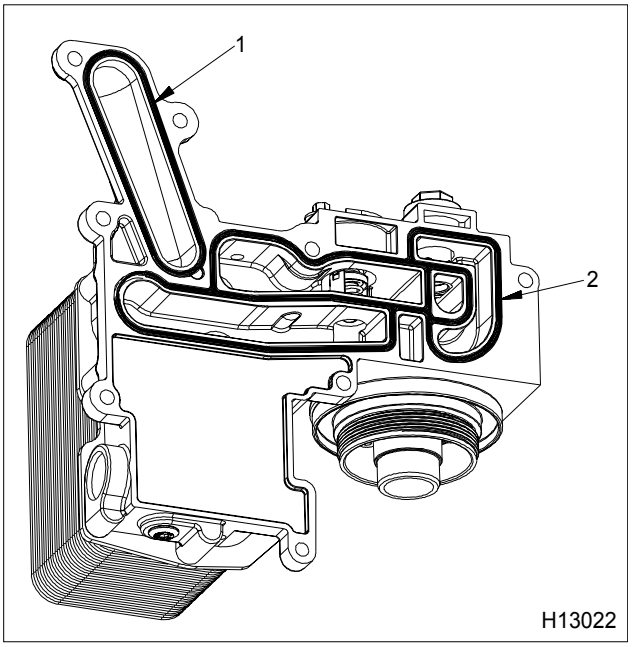


**Figure 411 Oil and coolant seal locations**

1. Coolant seal
2. Oil seal

15. Remove and discard the oil and coolant seals.
16. Cap the open end of the VGT oil supply tube and fitting.

### Secondary Filtration Assembly

**NOTE:** Remove only if evidence of external leakage has occurred or oil cooler drain tube requires servicing.

Oil in secondary filter drains back into crankcase, therefore no additional draining procedures are required.

1. Remove six bolts (M8 x 25) securing secondary filter assembly to crankcase.

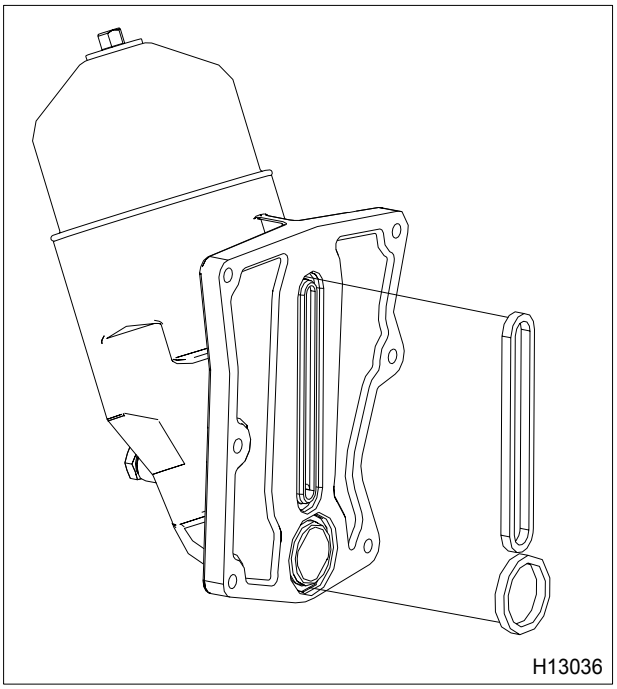


**Figure 412 Secondary filtration gasket seals**

2. Remove assembly and discard secondary filtration gasket seals.
3. Pull oil cooler drain tube (upper end) out of front cover assembly. Remove O-ring from tube and discard.


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### Disassembling the Oil System Module

**NOTE:** Perform the following disassembly procedures as required for your particular repair situation. Do not disassemble any components unless component failure or leakage has been detected.


**Figure 413 Removing the regulating valve**

1. Using a 24 mm or 15/16 in wrench, remove the regulating valve from the oil system module. Remove and discard both O-ring seals.
2. Remove two bolts (M8 x 20) retaining the oil thermal valve assembly.

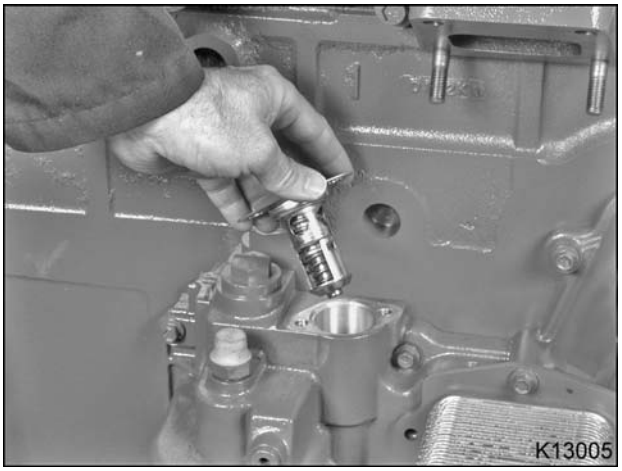


**Figure 414 Removing the oil thermal valve**

3. Remove the oil thermal valve from the oil system module. Remove O-ring and discard.

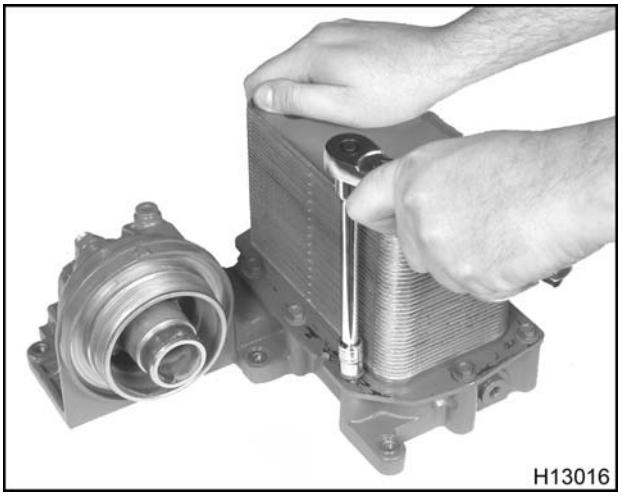


**Figure 415 Separating cooler heat exchanger from oil cooler housing**

**CAUTION:** To prevent oil cooler heat exchanger damage, do not use power tools to remove or install bolts. Bolts will be damaged if removed to quickly.

4. Remove eight bolts (M8 x 20) and separate cooler heat exchanger from the oil cooler housing.

   **NOTE:** Bolts are thread-forming fasteners. These bolts may be removed and reinstalled or replaced with standard machined bolts.

**CAUTION:** To prevent engine damage, when removing the cooler heat exchanger from its base housing, do not use excessive force against the aluminum cooler plate to separate from base. Do not apply any force to the fins of the cooler heat exchanger.

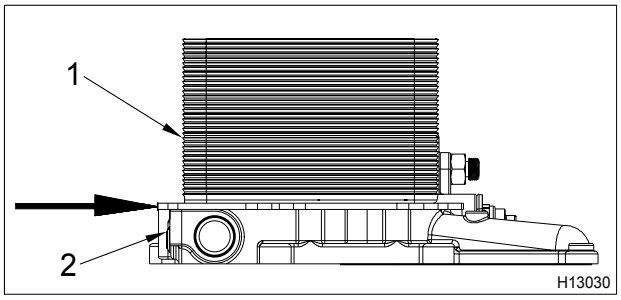


**Figure 416 Separation of cooler heat exchanger from oil cooler housing base**

1. Cooler heat exchanger
2. Oil cooler housing base


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5. Using a small hammer and a piece of wood, apply just enough force (at large arrow) to break the coolant and oil gasket bonds.

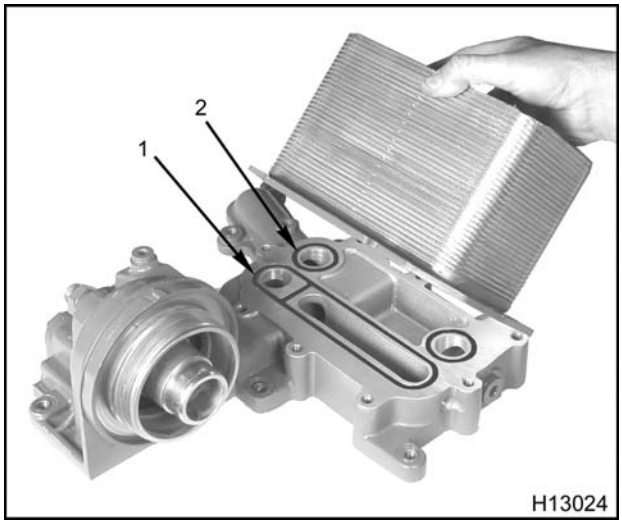


**Figure 417 Oil and coolant seals**

1. Oil seal
2. Coolant seal (2)

6. Discard one oil seal two coolant seals.
7. Remove the three bolts (M8 x 25) retaining the lube adapter to the oil cooler housing.

   **NOTE:** Bolts are thread-forming fasteners. These bolts may be removed and reinstalled, or may be replaced with standard machined bolts.

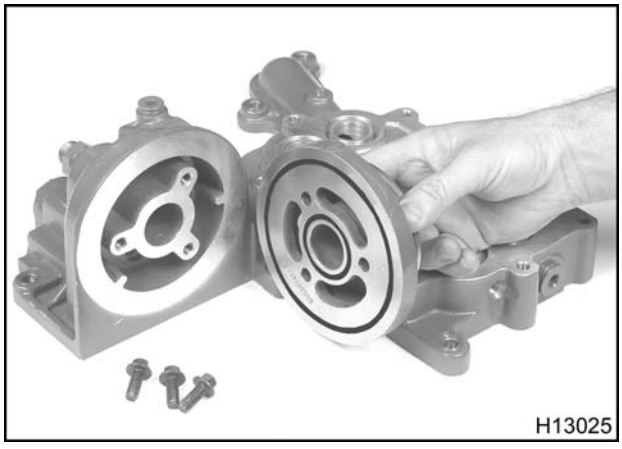


**Figure 418 Lube adapter assembly and gaskets**

8. Remove the lube adapter to provide access to the oil bypass valve, which is pressed into the housing. Discard the two O-ring gaskets.

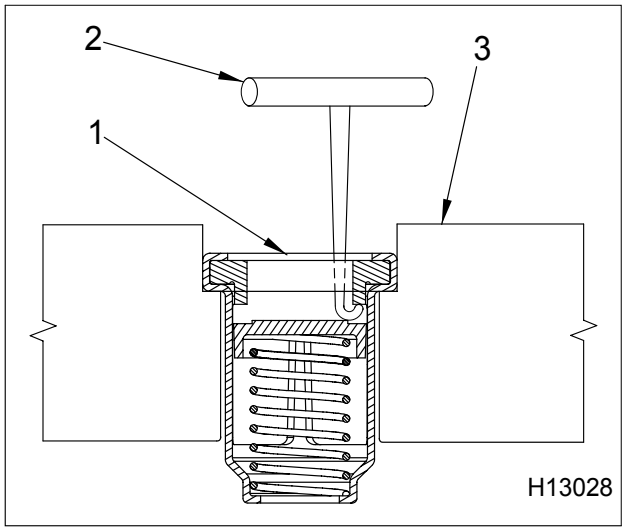


**Figure 419 Removing the oil bypass valve**

1. Oil bypass valve
2. Hooked shaped tool (tool size shown not to scale)
3. Oil system module casting

9. Remove the oil bypass valve (only if determined to be defective) by inserting a hook shaped tool (make locally) and depressing the check valve, while catching the valve seat. The use of a Slide Hammer (Table 43) threaded completely through valve is an alternative method.


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### Disassembling the Secondary Filtration Filter

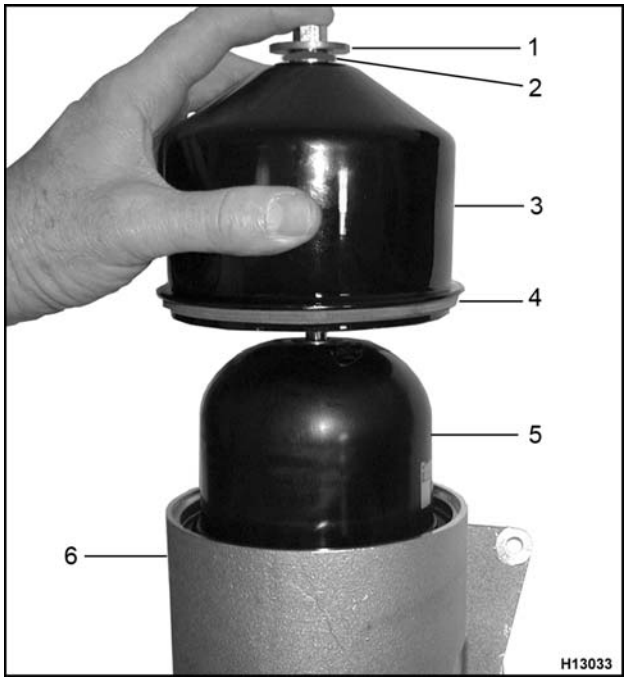


**Figure 420 Secondary filter components**

1. Stud assembly
2. O-ring
3. Cover
4. O-ring gasket
5. Filter element
6. Filter header

1. Remove stud assembly from the top of the secondary filtration filter and O-ring.
2. Lift cover off of filter header and discard O-ring gasket.


**Figure 421 Secondary filter removed**

1. Filter removed
2. Filter header

3. Lift out filter and dispose of properly.


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## Cleaning and Inspection

### Cleaning the Oil System Module

**CAUTION:** To prevent engine damage, the oil cooler must be replaced if there was a bearing failure. Debris from a bearing failure cannot be removed from the oil cooler.

**CAUTION:** To prevent engine damage, do not attempt to clean the assembled oil system module in solvent. Solvent will be trapped in the oil cooler, regulator valve assembly, and oil thermal valve assembly. Failure to follow this caution could result in engine damage.

The following items should be removed:

- **Oil cooler**
- **Regulator valve assembly**
- **Oil thermal valve assembly**

The oil system module housing and lube adapter can be cleaned in solvent and blown dry with clean filtered compressed air.

1. Immerse the disassembled oil cooler housing and lube adapter into a suitable solvent.

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

2. Flush and drain the oil cooler housing and lube adapter to remove any residue. Dry all components with filtered compressed air.
3. Check the oil cooler housing for blocked orifices and damaged threads. Replace oil cooler housing if required.
4. Remove any debris that may be blocking the filter bypass valve.
5. Remove turbocharger oil supply fitting (M18) on top of oil filter header and discard O-ring seal.

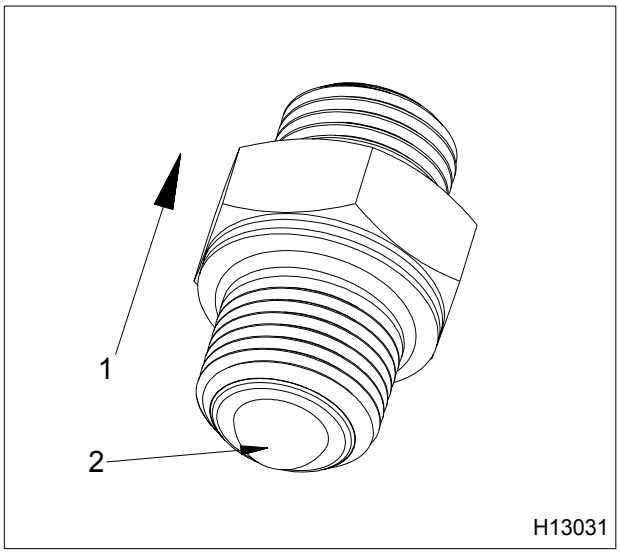


**Figure 422 Oil supply tube fitting**

1. Direction of oil flow
2. Oil supply wire mesh screen

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

6. Inspect screen for damage or particle obstruction. Clean or replace oil supply tube fitting screen as necessary.
7. Install a new O-ring onto fitting and thread into oil filter header. Tighten to the special torque value (Table 42).

### Checking the Cooler Heat Exchanger for Leakage

#### External

**CAUTION:** To prevent engine damage, do not allow water to enter oil side of cooler heat exchanger assembly.

1. Remove the eight bolts (M8 x 20) securing cooler heat exchanger to the oil system module, if not done so already.
2. Fasten Oil Cooler Test Plate (Table 43) to cooler heat exchanger.
3. Make sure oil port valve is closed.


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4. Immerse cooler heat exchanger and test plate combination into a suitably sized container of **clean** tap water (large shop sink).
5. Open coolant valve and allow water to fill **coolant side** of the cooler heat exchanger.

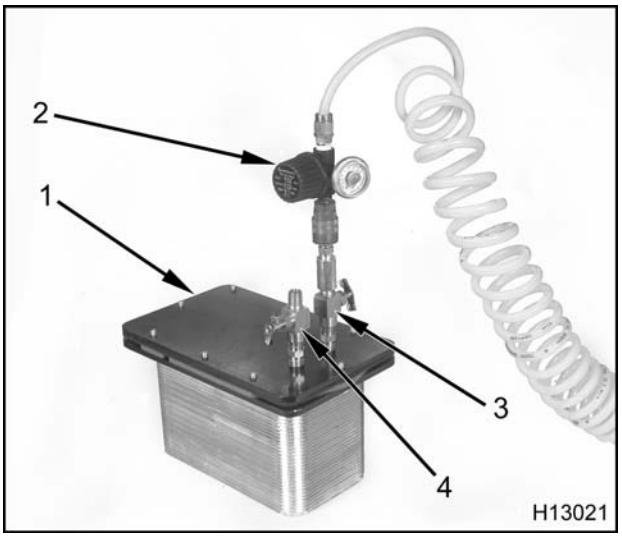


**Figure 423 Checking cooler heat exchanger for external leakage**

1. Test plate set
2. Air pressure regulator
3. Coolant port
4. Oil port (closed)

6. Connect an air pressure regulator between the test plate coolant port and the shop air supply.
7. Apply approximately 172-276 kPa (25-40 psi) of air pressure to the test plate while the assembly is immersed in water.
8. Observe exterior of cooler heat exchanger and test plate surfaces for signs of leakage. If test plate fittings leak, lift out of water, tighten fittings then continue to look for leaks at cooler heat exchanger. Air bubbles evident at any external location indicate a leak from the coolant passage. Replace the cooler heat exchanger.

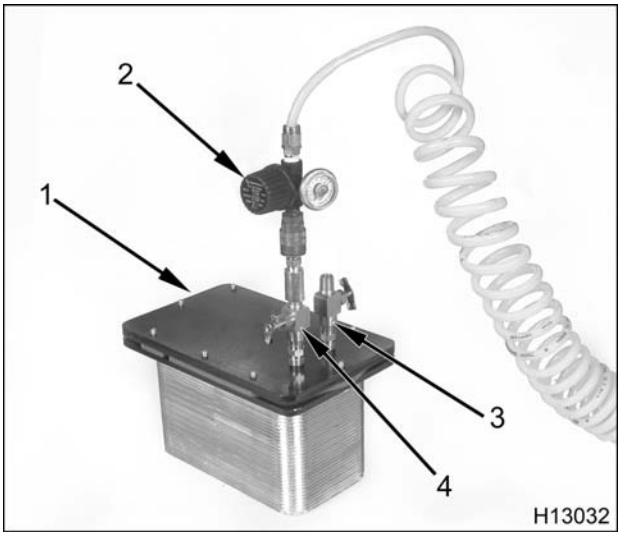


**Figure 424 Checking cooler heat exchanger for external leakage**

1. Test plate set
2. Air pressure regulator
3. Coolant port (closed)
4. Oil port

**CAUTION:** To prevent engine damage, do not allow water to enter oil side of cooler heat exchanger assembly.

9. Connect an air pressure regulator between the test plate oil port and the shop air supply.
10. Immerse cooler heat exchanger and test plate combination into a suitably sized container of **clean** tap water (large shop sink).
11. Apply approximately 172-276 kPa (25-40 psi) of air pressure to the test plate while the assembly is immersed in water.
12. Observe exterior of cooler heat exchanger and test plate surfaces for signs of leakage. If test plate fittings leak, lift out of water, tighten fittings, then continue to look for leaks at cooler heat exchanger. Air bubbles evident at any external location indicate a leak from the oil passage. Replace the cooler heat exchanger.


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**Internal**

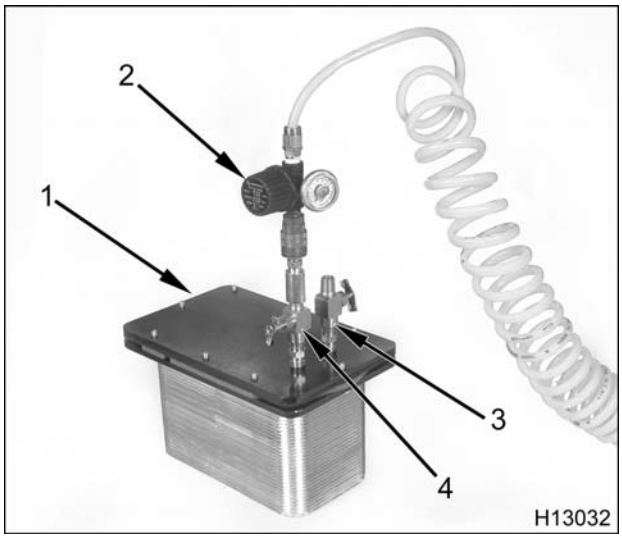


**Figure 425 Checking cooler heat exchanger for internal leakage**

1. Test plate set
2. Air pressure regulator
3. Coolant port (open)
4. Oil port

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

1. Connect an air pressure regulator between the test plate oil port and the shop air supply.
2. Open coolant valve and allow water to fill **coolant side** of cooler heat exchanger.
3. Immerse cooler heat exchanger and test plate combination into a suitably sized container of **clean** tap water (large shop sink).
4. Apply approximately 172-276 kPa (25-40 psi) of air pressure to the test plate while the assembly is immersed in water.
5. Observe coolant port valve for air bubbles. Bubbles at this point indicate a leak path between the oil and coolant fluid passages. Replace the cooler heat exchanger.


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## Installation

### Assembling the Oil System Module

**NOTE:** Do the following assembly procedures as required for your particular situation. Not all of these components may have been removed.

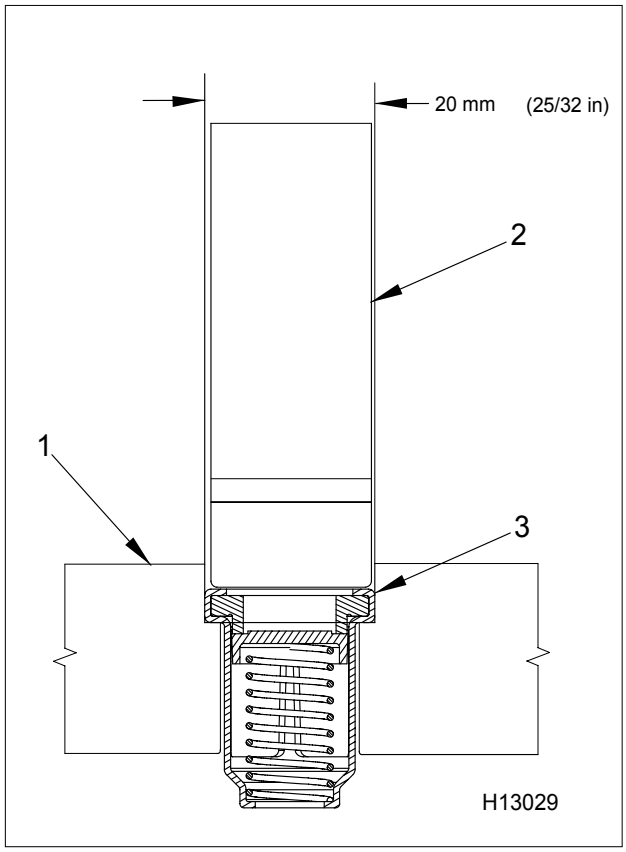


**Figure 426 Installing the oil bypass valve**

1. Oil system module casting
2. Deep socket
3. Oil bypass valve

**NOTE:** Measure socket outside diameter. Do not go by the socket bolt size stamped on the socket.

1. Install oil filter bypass valve (only if removed) by placing a deep socket with a **physical outside diameter** of < 20 mm (25/32 in) but > 16 mm (5/8 in). Tap socket and bypass valve into oil system module casting, until oil bypass valve has been thoroughly seated.

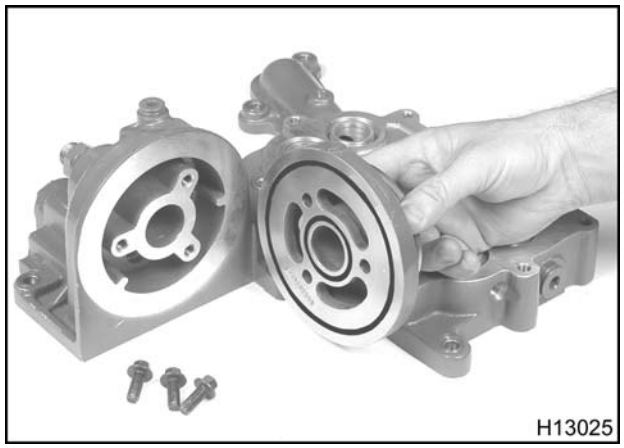


**Figure 427 Lube adapter assembly and gaskets**

2. Install small and large diameter O-rings into the grooves of the oil lube adapter. Fasten the oil lube adapter to the oil cooler header using three bolts (M8 x 25). Tighten bolts to the special torque value (Table 42).

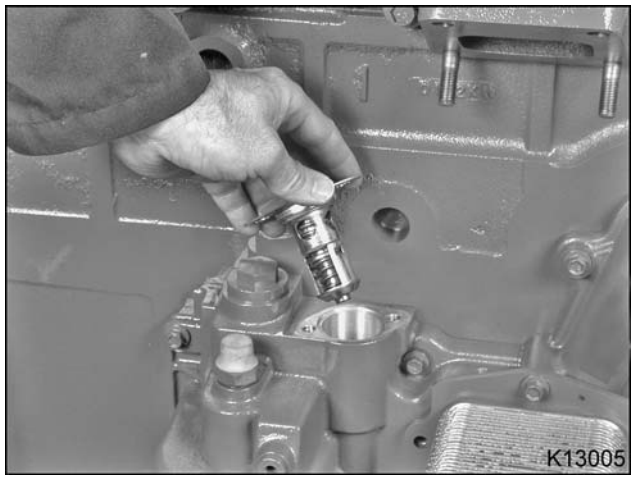


**Figure 428 Installing the oil thermal valve**

3. Install the oil thermal valve assembly into the oil system module with a new O-ring. Tighten two bolts (M8 x 20) to the special torque value (Table 42).
4. Install two new O-rings onto the oil pressure regulator valve. Only lubricate the bottom O-ring with clean engine oil.


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**Figure 429 Installing the oil pressure regulating valve**

5. Install the oil pressure regulator valve into the oil system module and tighten to the special torque value (Table 42).

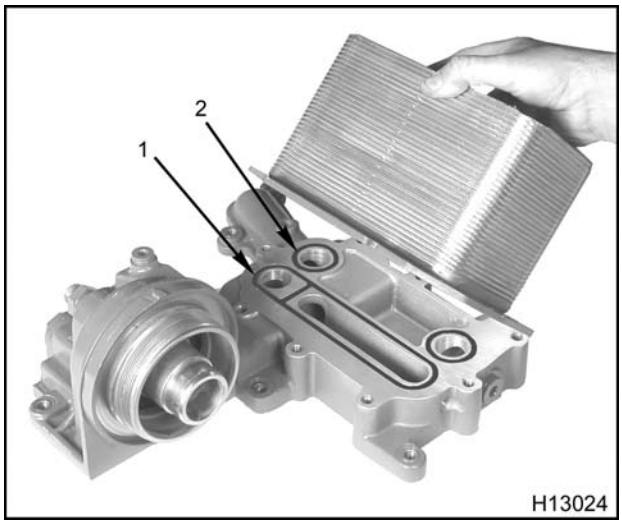


**Figure 430 Oil and coolant seals**

1. Oil seal
2. Coolant seal (2)

6. Install one new oil seal and two new coolant seals to the oil cooler housing seal grooves.

**CAUTION:** To prevent oil cooler heat exchanger damage, do not use power tools to remove or install bolts. Bolts will be damaged if removed to quickly.

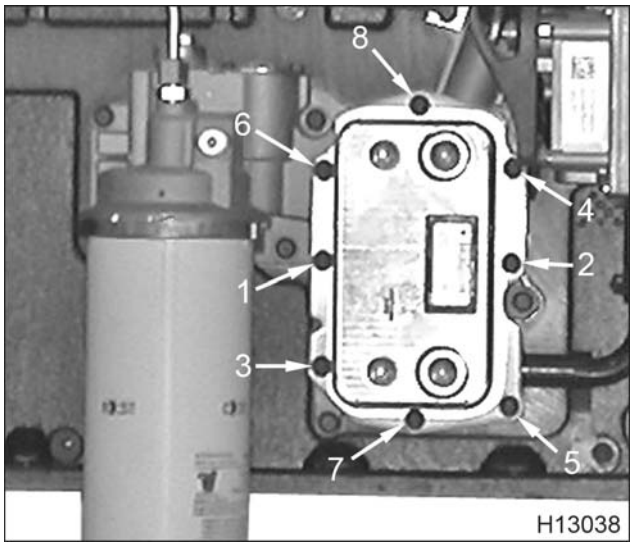


**Figure 431 Bolt torque sequence for cooler heat exchanger**

7. Position the new cooler heat exchanger on the oil cooler housing and finger tighten eight new M8 x 20 bolts.
8. Tighten M8 x 20 bolts (1 and 2) to 20 N·m (15 lbf·ft).
9. Tighten all eight M8 x 20 bolts to special torque value (Table 42) in the following sequence: 3, 4, 5, 6, 7, 8, 1, 2.


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### Assembling the Secondary Filtration Filter


**Figure 432 Secondary filter installation**

1. Filter element
2. Filter header

1. Install a new secondary oil filter.

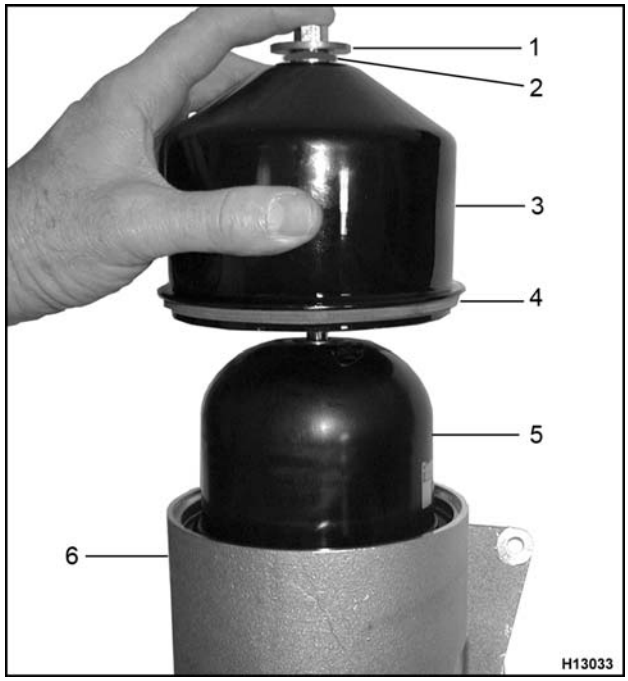


**Figure 433 Secondary filter components**

1. Stud assembly
2. O-ring
3. Cover
4. O-ring Gasket
5. Filter element
6. Filter header

2. Place a new O-ring gasket onto filter cover.
3. Position cover onto filter header.
4. Place a new O-ring onto stud assembly and thread into top of secondary filter cover and tighten to the special torque value (Table 42).


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**Secondary Filtration Assembly**

1. If oil cooler drain tube was removed for any reason, install new O-rings onto each end of the tube assembly.
2. Install oil cooler drain tube into front cover assembly.

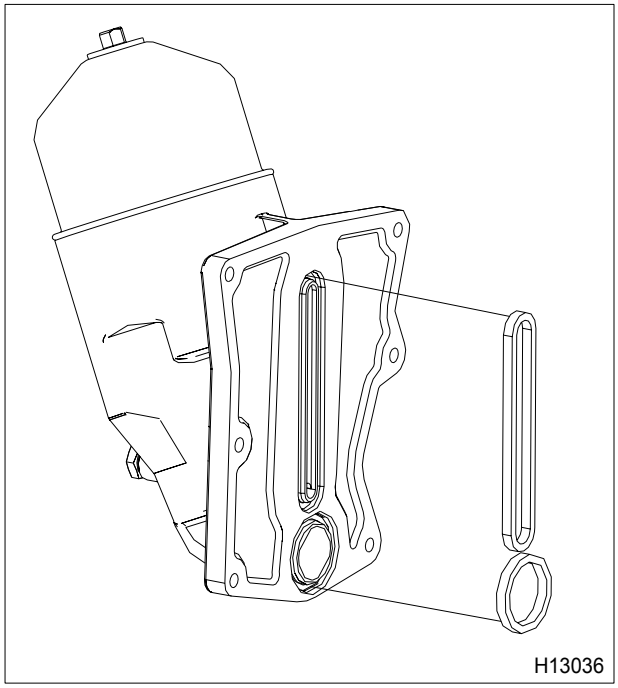


**Figure 434 Secondary filtration gasket seals**

3. If secondary filtration filter assembly was removed, install new oil gasket seals to assembly.
4. Secure secondary filter assembly to crankcase with six bolts (M8 x 25). Make sure oil cooler drain tube bracket is secured by upper left side bolt. Do not torque upper left mounting bolt until oil system module and oil cooler drain tube have been installed. Tighten bolts to the special torque value (Table 42).

**Oil System Module**

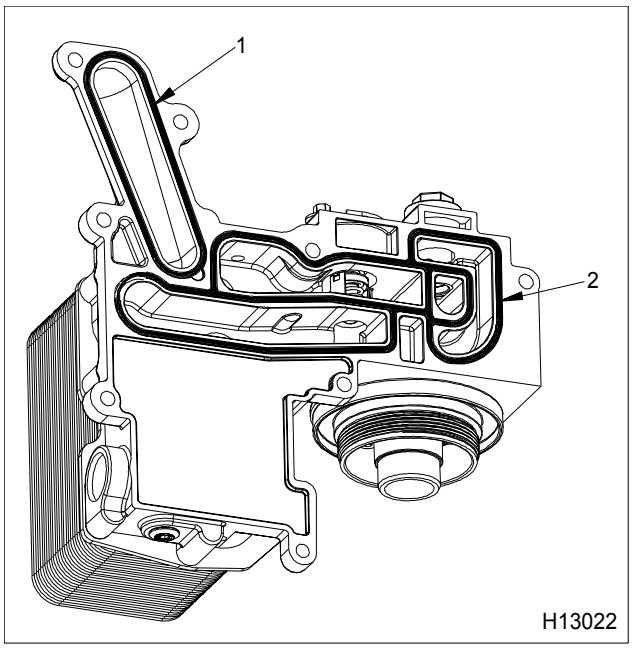


**Figure 435 Oil and coolant seal locations**

1. Coolant seal
2. Oil seal

1. Position oil and coolant gasket seals onto the oil cooler housing and begin working the seals into the seal recesses at intersections and mid-points. Do not work the seal from one end to the other, or seal may stretch resulting in difficult installation.
2. Ensure that the machined surface of the crankcase is clean and free of debris, old seals or damage that could affect the new seals of the oil system module.
3. Position oil system module onto the crankcase mounting surface and install eight mounting bolts (M8 x 20). Tighten these bolts to the special torque value (Table 42).


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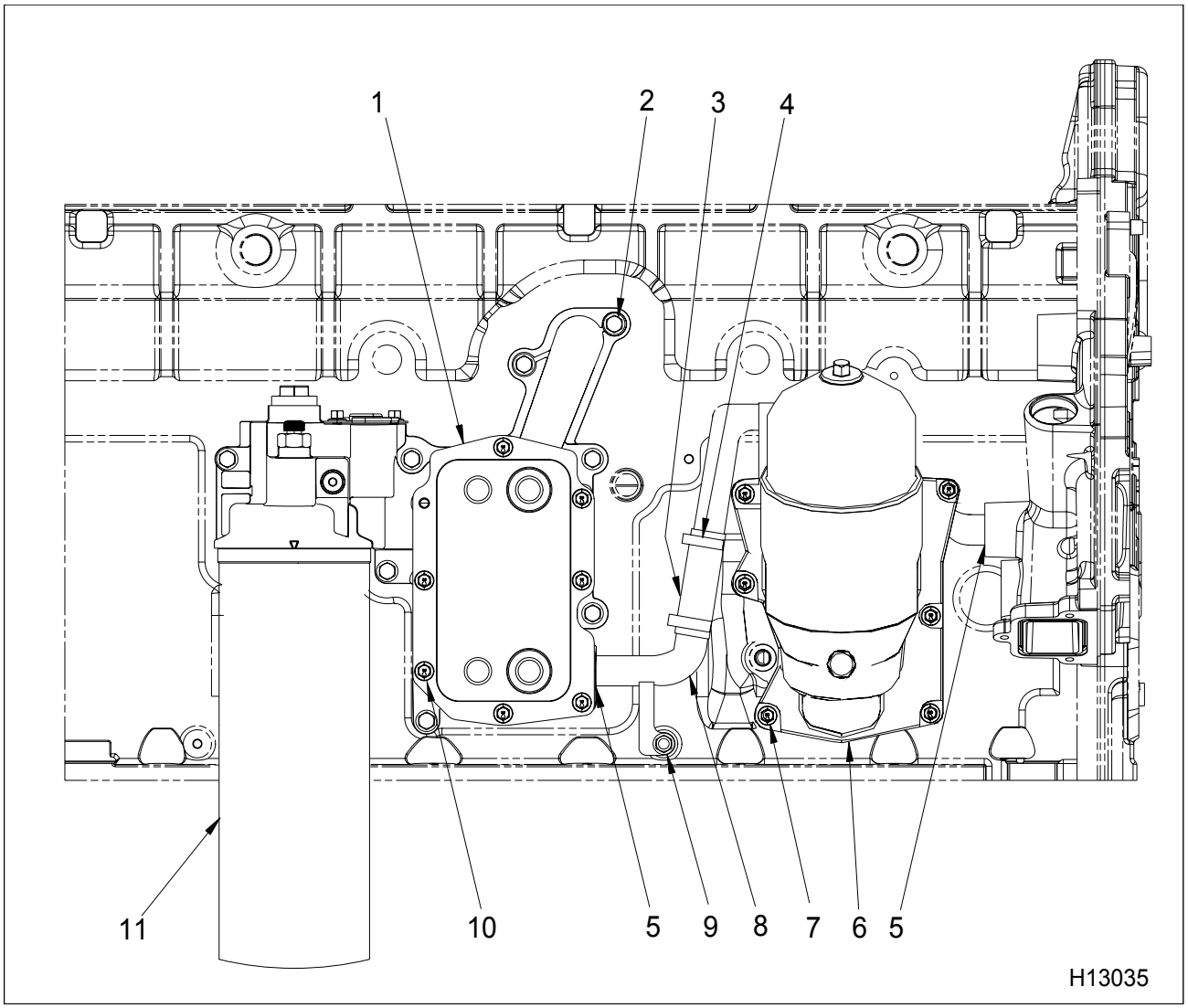


**Figure 436 Oil system module and secondary filter assembly**

1. Oil system module assembly
2. Bolt, M8 x 30 (8)
3. Hose, 1 in O.D.
4. Hose clamp (2)
5. O-ring (2)
6. Secondary filtration filter assembly
7. Bolt, M8 x 25 (6)
8. Oil cooler drain tube assembly
9. Support bracket bolt, M8 x 16
10. Bolt, M8 x 20 (8)
11. Oil filter (spin-on)

4. Make sure a new O-ring has been installed onto the oil cooler drain tube. Slide tube into front side of oil cooler and position a support bracket bolt (M8 x 16) through bracket and into crankcase. Torque both oil cooler drain tube bracket bolts to the special torque value (Table 42).


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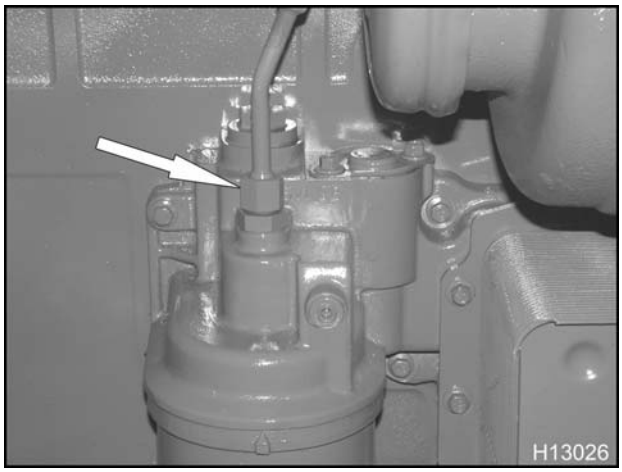


**Figure 437 Installing oil supply tube**

5. Connect the oil supply tube fitting to the filter header. Tighten nut on the tube to the special torque value (Table 42).
6. Fill oil filter with the proper grade and viscosity of engine oil. See the *DT 466, DT 570 and HT 570 Engine Operation and Maintenance Manual*.
7. Lubricate new oil filter gasket with clean engine oil.
8. Fasten Spin oil filter onto header until the gasket initially makes contact. Using an Oil Filter Wrench with a band width of 38 mm (1.5 in) or greater, (Table 43) tighten filter an additional one full turn.

**NOTE:** Do not overtighten filter. A damaged filter may fracture or leak.

9. If not already installed, install coolant drain plug (M18) and tighten to the special torque (Table 42).
10. Refill cooling system.

### Priming the Lubrication System

#### Preferred Method

When the engine has been assembled, lubricate the engine with oil before starting. This will aid internal components with the proper lubrication requirements during the critical initial startup phase. The following procedure is the preferred method to use when priming the lubrication system.

1. If engine was completely disassembled and rebuilt, remove the plug assembly (M12) (Figure 404) and pressurize the lubrication system with sufficient oil to fill the oil filter and charge the entire lubrication system.
2. Install plug assembly (M12 and tighten to the special torque (Table 42).
3. Check the oil level before starting engine.

#### Alternate Method

**CAUTION:** To prevent engine damage, make sure that all moving internal components of the engine have been well oiled during assembly, if using this procedure.

1. Crank the engine – but do not start the engine (ensure CMP sensor is disconnected) – until the oil pressure gauge indicates sufficient oil pressure.
2. After oil pressure is evident in the lubrication system, reconnect CMP sensor connector and start engine.


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## Specifications

**Table 41 Oil System Module and Secondary Filter Specifications**

| | |
|---|---|
| Cooler heat exchanger, DT 466 | 23 plates |
| Cooler heat exchanger, HT 570 | 33 plates |
| Cooler heat exchanger, all engines with front drive axle | 33 plates |
| Oil pressure regulating valve, opening pressure | 380 kPa (55 psi) @ 38° C (100° F) |
| Oil filter bypass valve, opening pressure | 345 kPa (50 psi) |
| Oil thermal valve, opening temperature | 111° C (232° F) |

## Special Torque

**Table 42 Oil System Module and Secondary Filter Special Torques**

| | |
|---|---|
| Coolant drain plug, M18 | 24 N·m (18 lbf·ft) |
| Lube adapter bolts | 29 N·m (21 lbf·ft) |
| Oil system module mounting bolts | 26 N·m (19 lbf·ft) |
| Oil pressure regulator valve | 68 N·m (50 lbf·ft) |
| Oil thermal valve assembly | 29 N·m (21 lbf·ft) |
| Cooler heat exchanger mounting bolts, M8 | 29 N·m (21 lbf·ft) |
| Oil cooler drain tube bracket bolt | 26 N·m (19 lbf·ft) |
| Oil supply tube fitting (turbocharger) | 24 - 26 N·m (17 - 19 lbf·ft) |
| Plug assembly, M12 | 5 N·m (46 lbf·in) |
| Secondary filter mounting bolts | 26 N·m (19 lbf·ft) |
| Secondary filter stud assembly | 20 N·m (15 lbf·ft) |

## Special Service Tools

**Table 43 Oil System Module and Secondary Filter Special Tools**

| | |
|---|---|
| Air Pressure Regulator | Obtain locally |
| Oil Cooler Test Plate | ZTSE4654 |
| Oil Filter Wrench | ZTSE1879 |
| Slide Hammer Puller Set | Obtain locally |


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# Table of Contents

**Sensor Identification....303**

**Removal....306**
- **Sensor Wiring Harness....306**
- **Injector Wiring Harness....312**
- **ECM, IDM, EGR Drive Module, and Intake Air Heater....313**
- **Valve Cover Gasket with Pass-Through Connectors....317**

**Cleaning and Inspection....319**
- **Checking Wiring Harness and Electrical Connectors....319**

**Installation....320**
- **Valve Cover Gasket with Pass-Through Connectors....320**
- **ECM, IDM, EGR Drive Module, and Intake Air Heater....321**
- **Injector Wiring Harness....327**
- **Sensor Wiring Harness....328**

**Special Torque....334**


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## Sensor Identification

For a more detailed description of the electrical sensors, see (Engine and Vehicle Sensors, page 47) in the “Engine Systems” section in this manual.

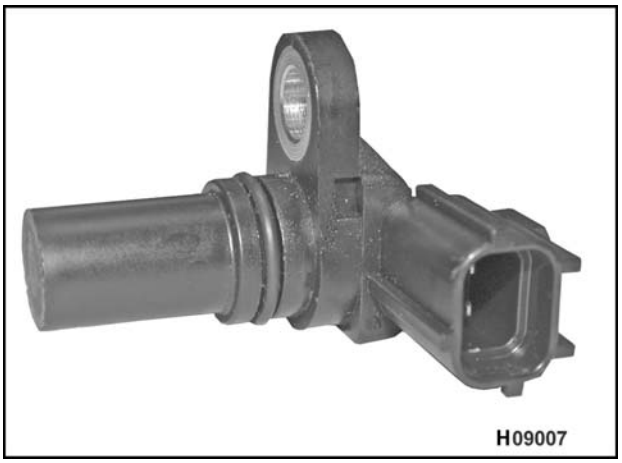


**Figure 438 Camshaft Position (CMP) sensor**

The CMP sensor is a magnetic type sensor. It responds to a rotating actuator positioned on the camshaft gear. The CMP sensor is installed in the front cover, above and to the right of the water pump pulley.

**NOTE:** This short CMP sensor, used with International® DT 466, DT 570, and HT 570 diesel engines, is the Crankshaft Position (CKP) sensor used with other International® diesel engines.


**Figure 439 Crankshaft Position (CKP) sensor**

The CKP sensor is a magnetic pickup sensor. The CKP sensor is installed on the top left of the flywheel housing.

**NOTE:** This long CKP sensor, used with International® DT 466, DT 570, and HT 570 diesel engines, is the Camshaft Position (CMP) sensor used with other International® diesel engines.

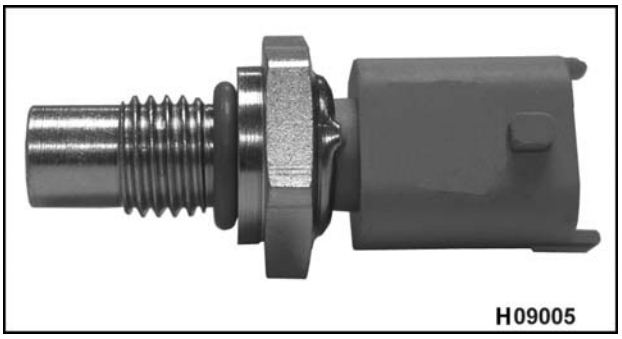


**Figure 440 Engine Oil Temperature (EOT) sensor and Engine Coolant Temperature (ECT) sensor**

The EOT sensor is a thermistor type sensor. The EOT sensor is installed in the rear of the front cover, left of the high-pressure oil pump assembly.

The ECT sensor is a thermistor type sensor. The ECT sensor is installed in the water supply housing (Freon® compressor bracket), left of the flat idler pulley assembly, as viewed from the front of the engine.

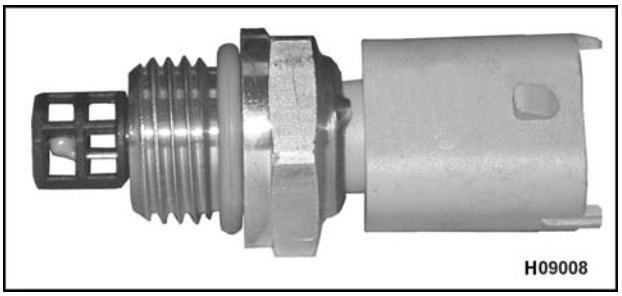


**Figure 441 Manifold Absolute Temperature (MAT) sensor**

The MAT sensor is a thermistor type sensor. The MAT sensor is installed to the right of the MAP sensor in the intake manifold.


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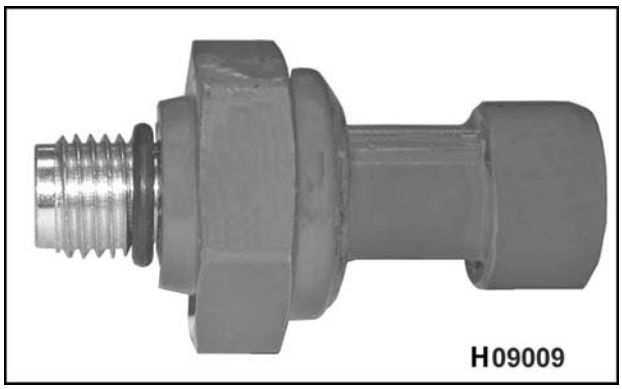


**Figure 442 Engine Oil Pressure (EOP) sensor**

The EOP sensor is a variable capacitance sensor. The EOP sensor is installed on the left of the crankcase below and left of the fuel filter housing.

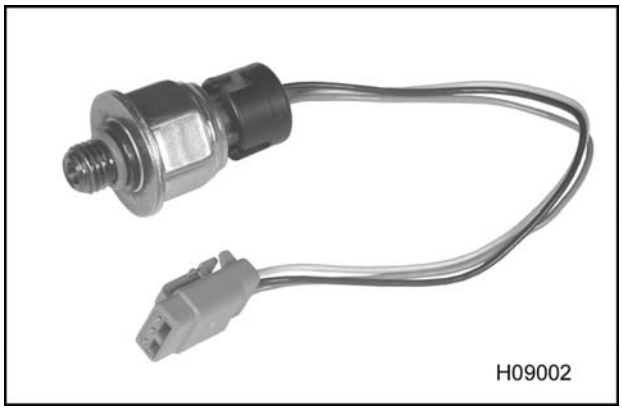


**Figure 443 Injection Control Pressure (ICP) sensor**

The ICP sensor is a variable capacitance sensor. The ICP sensor is installed left of the engine Brake shutoff valve in the high-pressure rail.

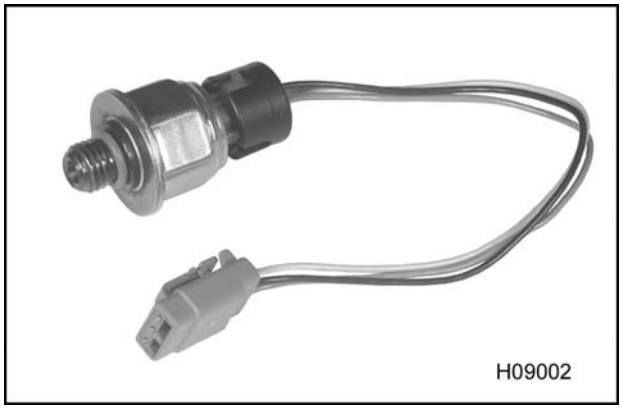


**Figure 444 Brake Control Pressure (BCP) sensor**

The BCP sensor is a variable capacitance sensor. The BCP sensor is installed forward of the engine Brake shutoff valve in the high-pressure rail.

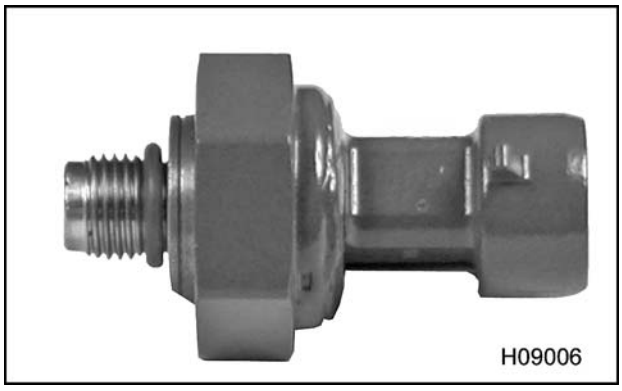


**Figure 445 Engine Fuel Pressure (EFP) sensor**

The EFP sensor is a variable capacitance sensor. The EFP sensor is installed in the rear of the fuel filter assembly (crankcase side).


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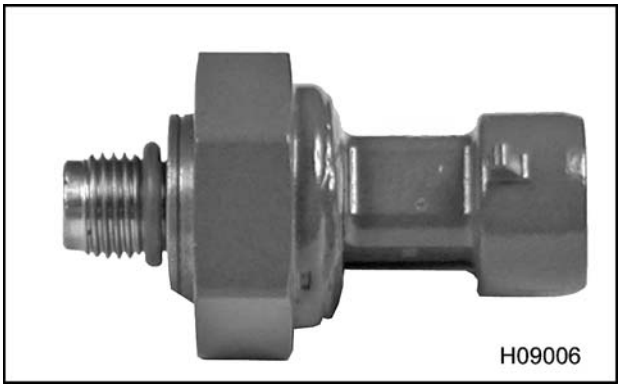


**Figure 446 Manifold Absolute Pressure (MAP) sensor**

The MAP sensor is a variable capacitance sensor. The MAP sensor is installed left of the MAT sensor in the intake manifold.

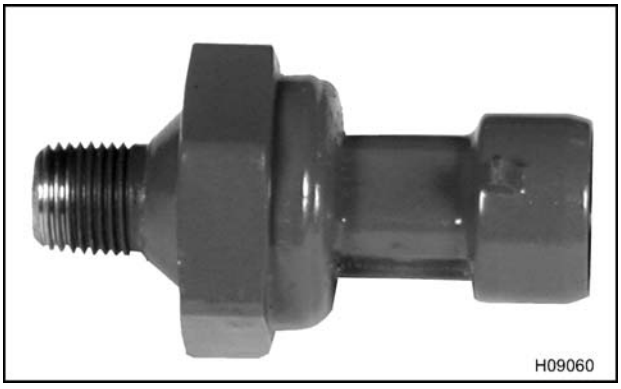


**Figure 447 Exhaust Back Pressure (EBP) sensor**

The EBP sensor is a variable capacitance sensor. The EBP sensor is installed in a bracket mounted on the water supply housing (Freon® compressor bracket).

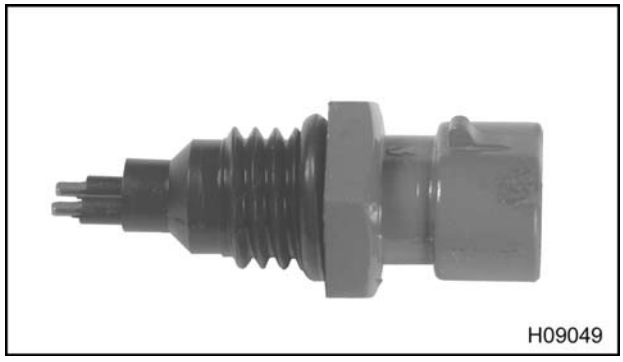


**Figure 448 Water In Fuel (WIF) sensor**

The Water In Fuel sensor detects water in the fuel. The WIF sensor is installed at the base of the fuel filter housing.

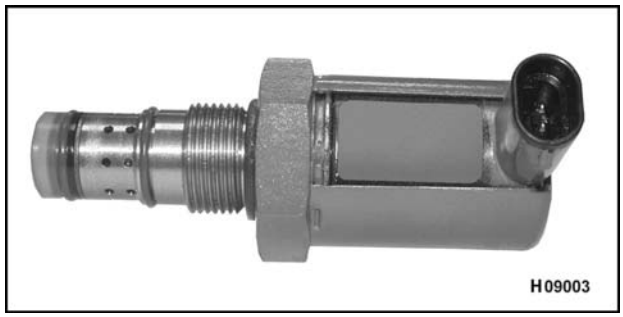


**Figure 449 Injection Pressure Regulator (IPR) valve**

The IPR valve is a pulse width modulated valve that regulates the injection control pressure. The valve is located on the rear of the high-pressure oil pump.


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## Removal

**GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.**

**WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.**

**WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.**

**WARNING: To prevent personal injury or death, disconnect the main battery negative terminal before disconnecting or connecting electrical components.**

**WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

**CAUTION:** To prevent engine damage, do not tug on wiring harnesses; if resistance is felt, find the problem and free connectors or clips.

**Sensor Wiring Harness**

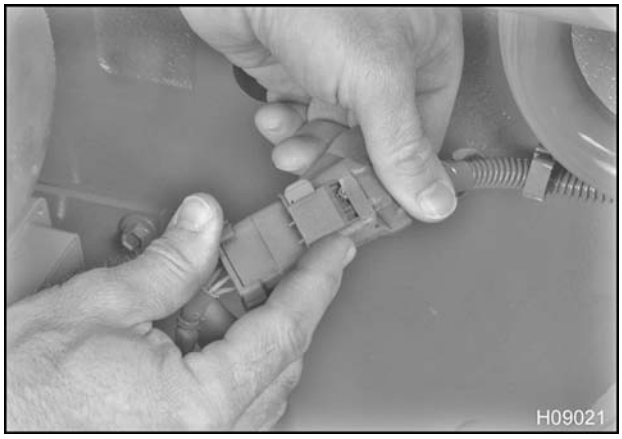


**Figure 450 Disconnecting the VGT connector**

1. Disconnect the wiring harness connector from the VGT actuator.

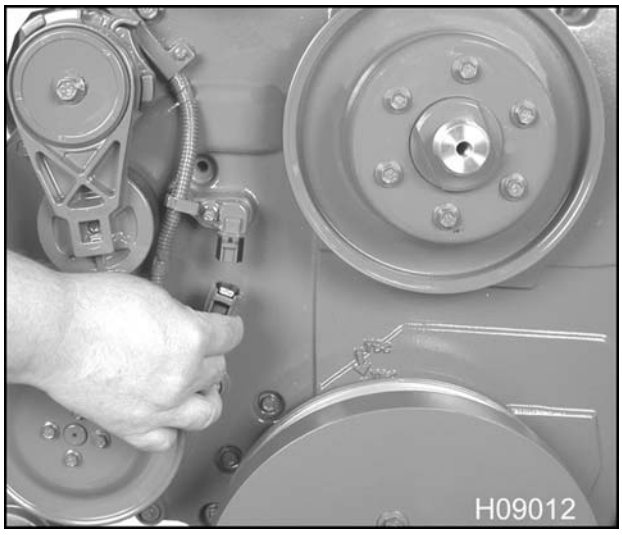


**Figure 451 Disconnecting the CMP sensor**

2. Disconnect the wiring harness connector from the CMP sensor.


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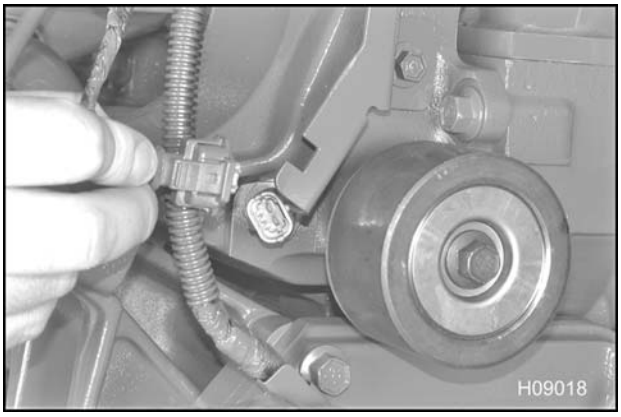


**Figure 452 Disconnecting the ECT sensor**

3. Disconnect the wiring harness connector from the ECT sensor.

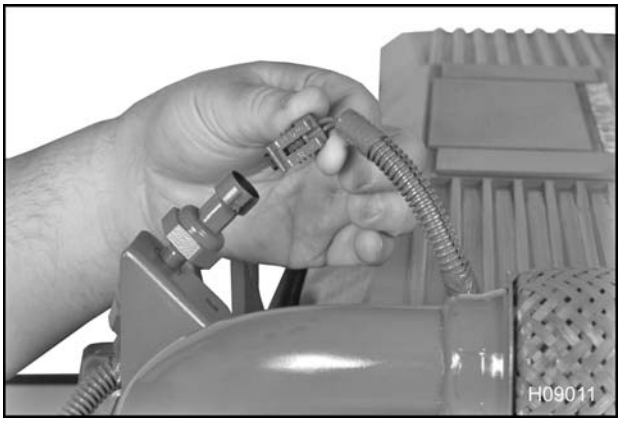


**Figure 453 Disconnecting the EBP sensor**

4. Disconnect the wiring harness connector from the EBP sensor.

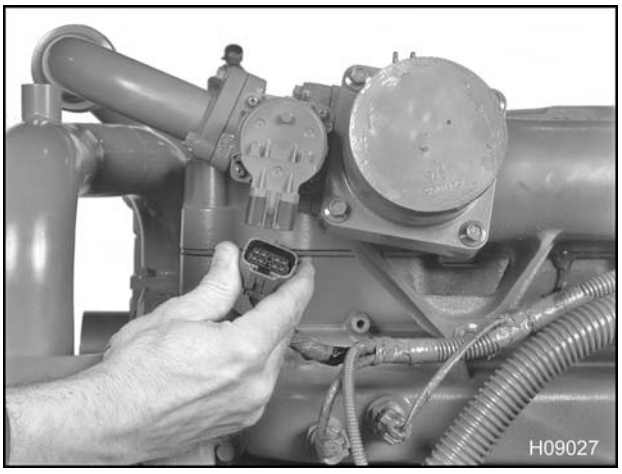


**Figure 454 Disconnecting the EGR control valve connector**

5. Disconnect the wiring harness connector from the EGR control valve.

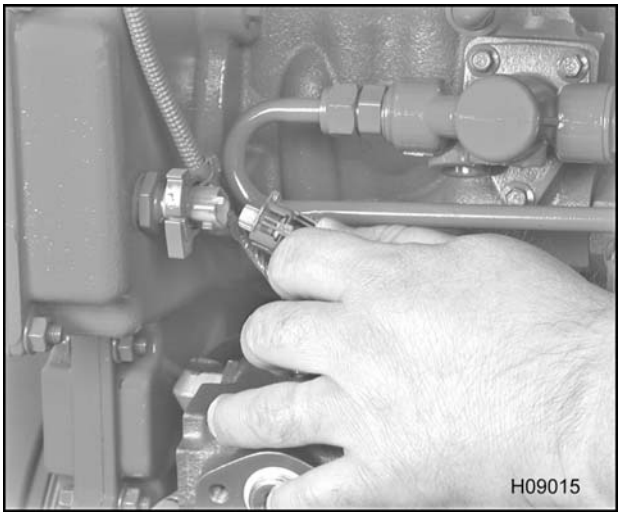


**Figure 455 Disconnecting the EOT sensor**

6. Disconnect the wiring harness connector from the EOT sensor.


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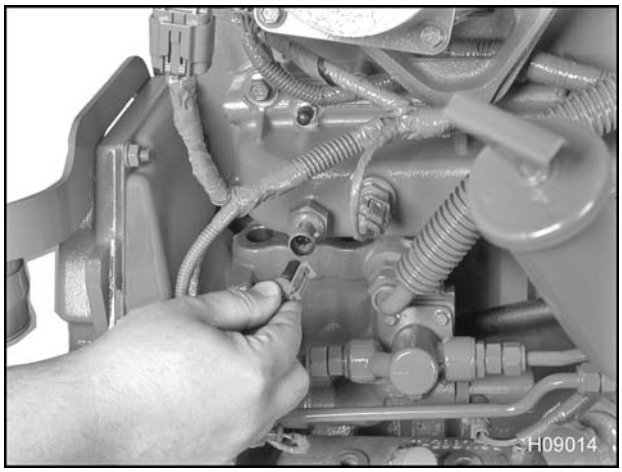


**Figure 456 Disconnecting the MAP sensor**

7. Disconnect the wiring harness connector from the MAP sensor.

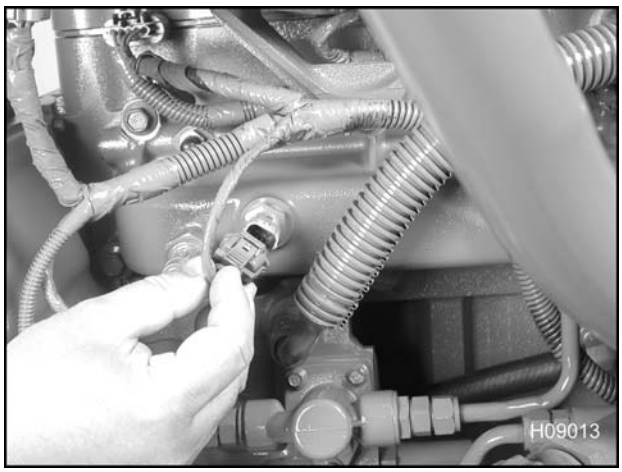


**Figure 457 Disconnecting the MAT sensor**

8. Disconnect the wiring harness connector from the MAT sensor.

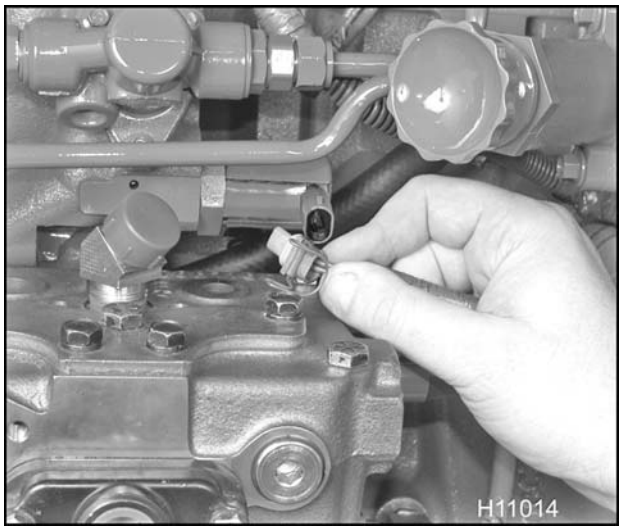


**Figure 458 Disconnecting the IPR valve connector**

9. Disconnect wiring harness connector from the IPR valve.

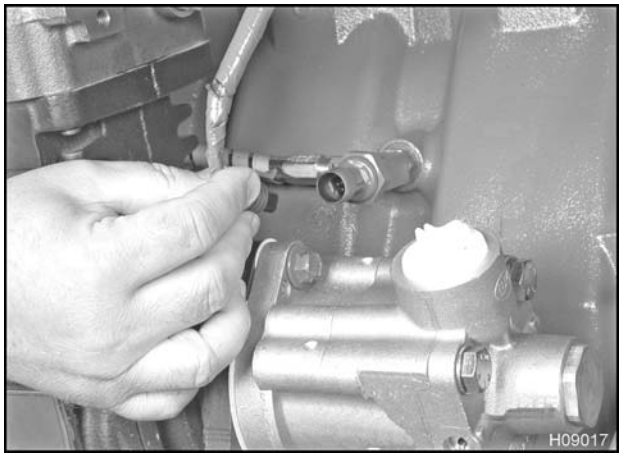


**Figure 459 Disconnecting the EOP sensor**

10. Disconnect the wiring harness connector from the EOP sensor.


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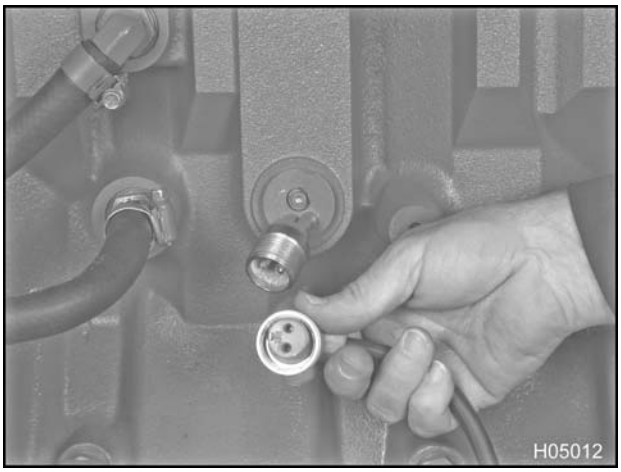


**Figure 460 Disconnecting the block heater**

11. Disconnect the block heater cable (optional).

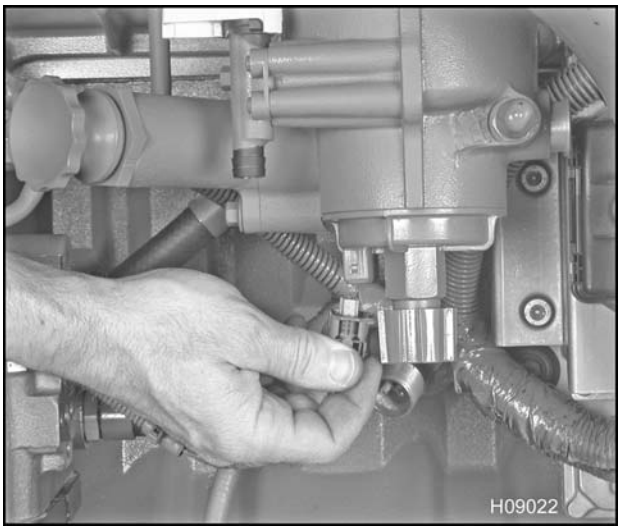


**Figure 461 Disconnecting the fuel heater connector**

12. Disconnect the wiring harness connector from the fuel heater (optional).

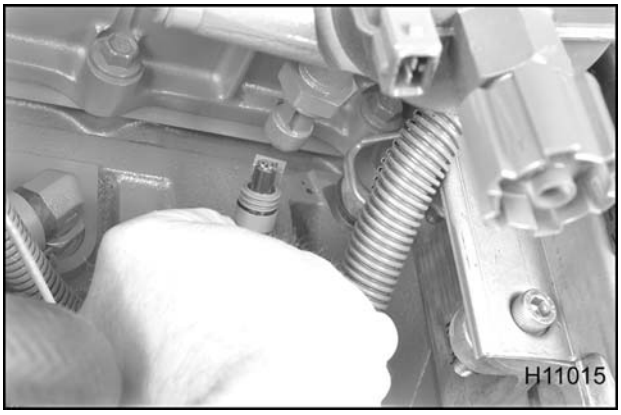


**Figure 462 Disconnecting the fuel pressure sensor**

13. Disconnect the wiring harness connector from the fuel pressure sensor (optional).


**Figure 463 Disconnecting the WIF sensor**

14. Disconnect the wiring harness connector from the WIF sensor.


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**Figure 464 Disconnecting the CKP sensor**

15. Disconnect the wiring harness connector from the CKP sensor.
16. Disconnect two additional, three wire connectors for the BCP sensor connector and brake shutoff valve connector to the valve cover gasket (optional).

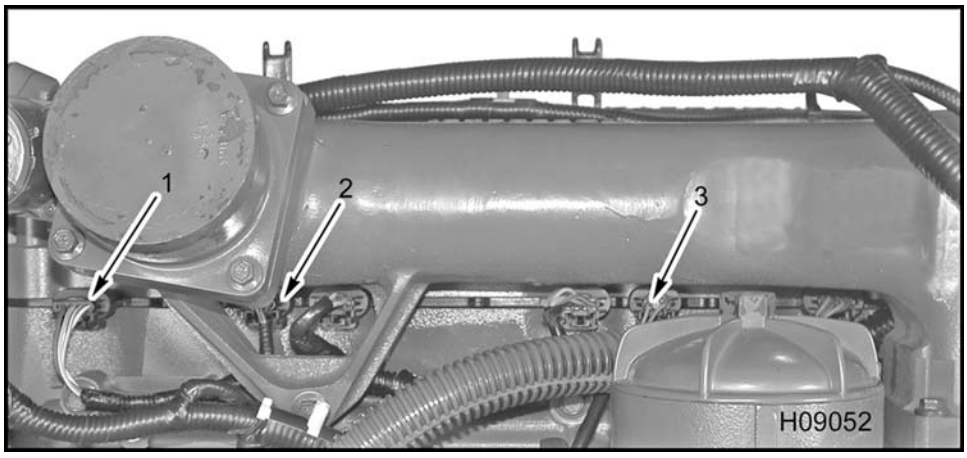


**Figure 465 BCP, Brake shutoff valve, and injector locations**

1. Injector connector (6)
2. BCP sensor connector (optional)
3. Brake shutoff connector (optional)

17. Disconnect one, three wire ICP connector from valve cover gasket.
18. Disconnect wiring harness at EGR drive module.
19. Disconnect one IDM connector. This is the one of three IDM connectors in the most forward position on the IDM.
20. Disconnect two ECM engine connectors. These are the two connectors towards the rear of the ECM.


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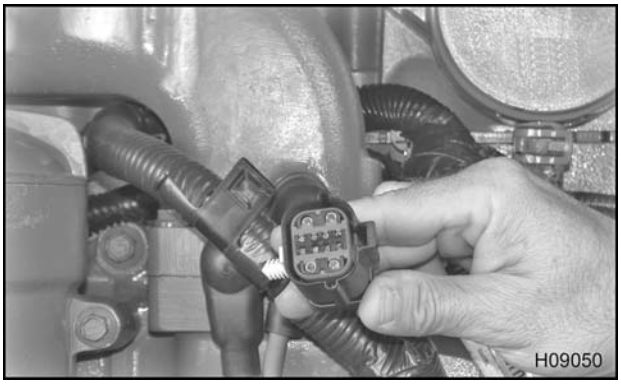


**Figure 466 12 wire engine connector**

21. Disconnect one, 12 wire engine connector.

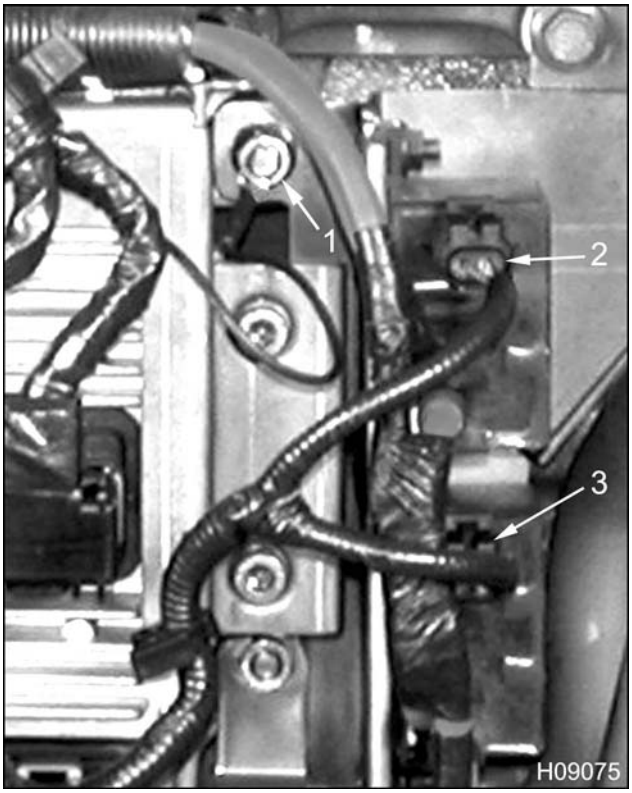


**Figure 467 Intake air heater relay connectors (2)**

1. Injector shield ground nut
2. Top relay connector
3. Bottom relay connector

22. Disconnect two intake air heater relay connectors.
23. Remove injector shield ground nut.
24. Remove the sensor harness by disconnecting harness at the various tie down locations.
    - If removing complete harness; sensor and injector harnesses, continue with injector harness removal before attempting to remove the sensor harness.


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**Injector Wiring Harness**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

**CAUTION:** To prevent engine damage, do not tug on any wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free up any connectors or clips that are caught before proceeding. If necessary, remove the valve cover to gain clearance for injector harness.

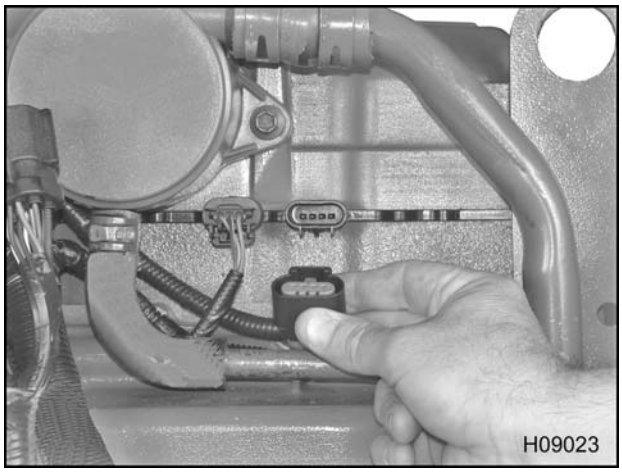


**Figure 468 Disconnecting the No. 6 fuel injector connector**

1. Disconnect six, four wire injector connectors from valve cover gasket.

- If only removing the injector harness, separate it from the sensor harness and remove from various tie down locations.
- If removing both the sensor and injector harnesses together, it is assumed the sensor harness removal procedure was followed by removing both harnesses at the various tie down locations.


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**ECM, IDM, EGR Drive Module, and Intake Air Heater**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

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

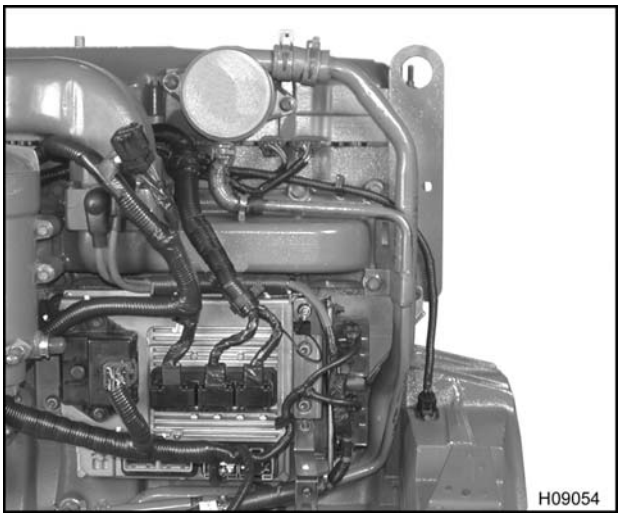


**Figure 469 ECM, IDM, EGR drive module, and tube assembly overview**

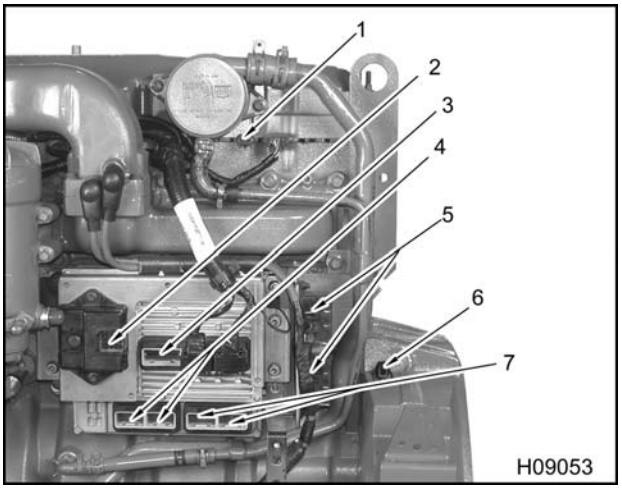


**Figure 470 ECM and sensor harness locations**

1. ICP sensor connector
2. EGR drive module
3. IDM connector
4. ECM chassis connectors (2)
5. Intake air heater relay connections (2)
6. CKP sensor
7. ECM engine connectors (2)

**Disconnecting the sensor wiring harness at the drive modules.**

1. Disconnect the ICP connector from the valve cover connection.
2. Disconnect the EGR drive module.
3. Disconnect the IDM connector.
4. Disconnect two ECM chassis connectors.
5. Disconnect two intake air heater relay connectors.
6. Disconnect the CKP sensor.
7. Disconnect two ECM engine connectors.


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**Injector wiring harness at ECM and IDM drive modules**

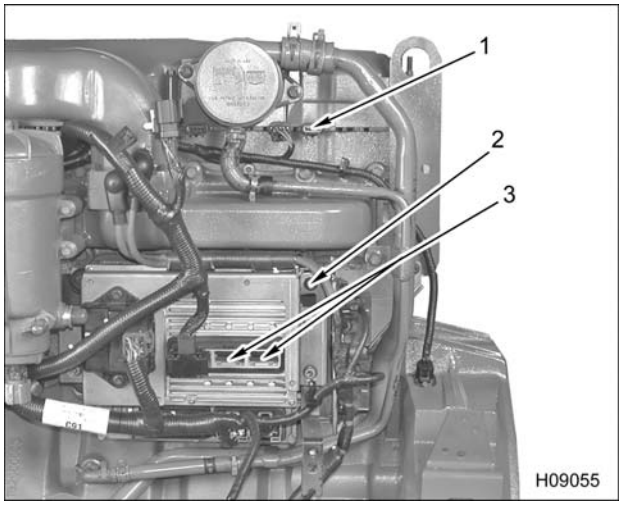


**Figure 471 Injector harness locations**

1. Injector connectors (6)
2. Injector shield ground stud connection
3. IDM connectors (2)

8. Disconnect six injector connectors from the valve cover gasket.
9. Disconnect the injector shield ground stud connection.
10. Disconnect two IDM connectors.
11. Disconnect two ECM engine connectors.
12. Disconnect two ECM chassis connectors.

**Intake Air Heater Wiring Harness Assembly**

13. Disconnect intake air heater cable at starter solenoid.

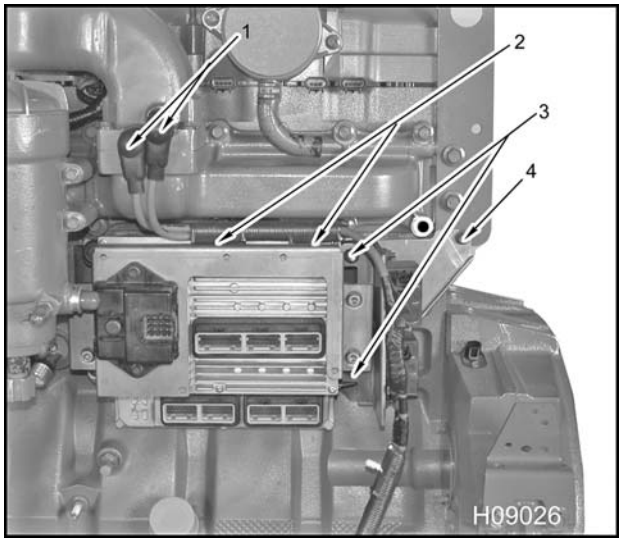


**Figure 472 Intake air heater and relay wiring harness**

1. Intake air heater mounting nuts (2)
2. Intake air heater wiring harness tie downs
3. Intake air heater mounting nut stud bolts (2)
4. Intake air heater and relay bracket mounting bolt

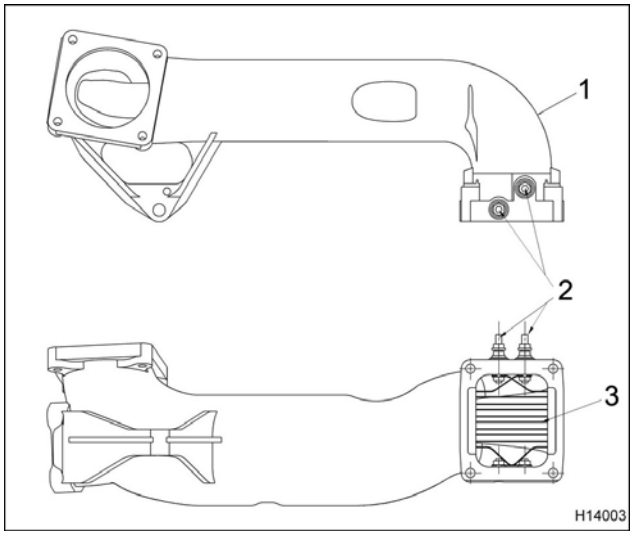


**Figure 473 Intake air heater – dual element**

1. Inlet and EGR mixer
2. Intake air heater cable locations
3. Intake air heater element

See (TSI-05-12-35 New 1500 Watt Single Grid Intake Air Heater Production Option, page460).


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14. Disconnect Inlet Air Heater (IAH) cable(s).
15. Pull up on intake air heater wiring harness to disengage two tie down locations from ECM / IDM bracket.

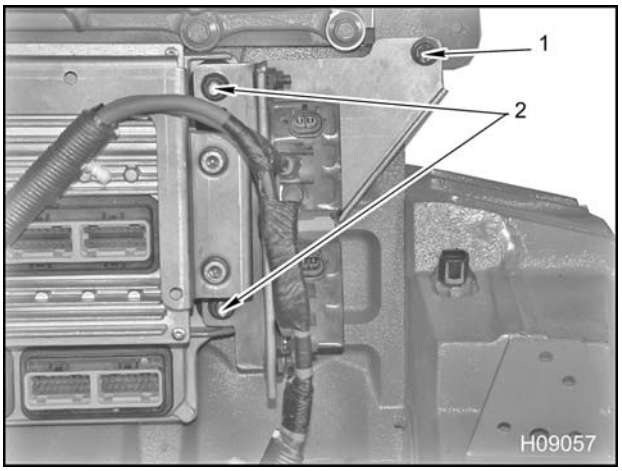


**Figure 474 Intake air heater relay bracket**

1. Heater relay bracket bolt, M6 x 20 and nut, M6
2. Heater relay bracket nuts, M8 (2)

16. Remove two intake air heater mounting nuts (M8) and heater relay bracket bolt (M6 x 20) and nut (M6).
17. Remove intake air heater bracket with harness assembly.

**NOTE:** Heater relay bracket and heater wiring harness are removed as an assembly. There is no need to disconnect the air heater wiring harness connectors from the air heater relays.

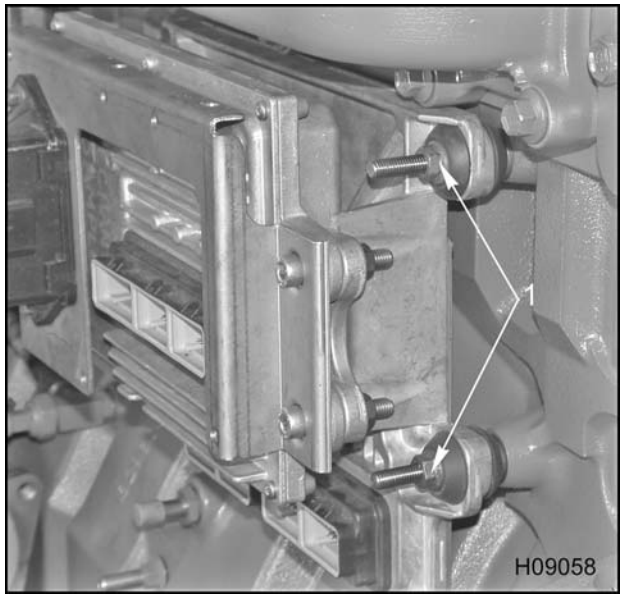


**Figure 475 ECM, IDM, and EGR drive module assembly (side view)**

1. Module assembly mounting stud bolts (2)

18. Remove two module assembly to engine mounting stud bolts on right side (M8 x 45/19).
19. Remove two module assembly mounting bolts on left side (M8 x 45).

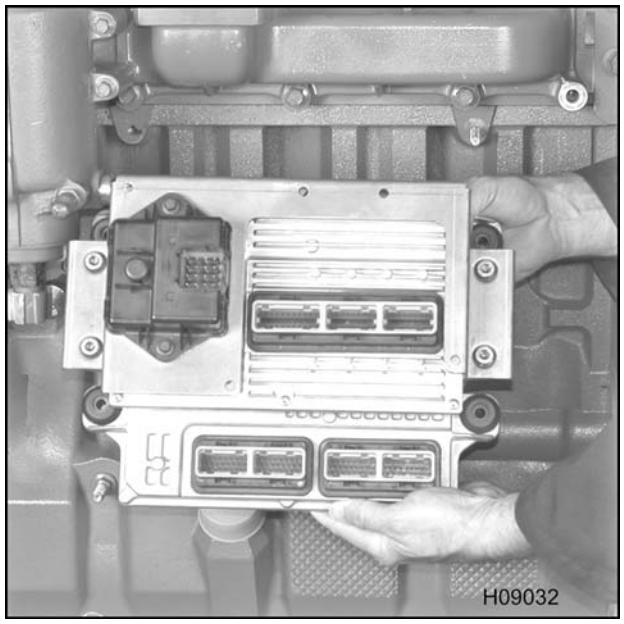


**Figure 476 ECM, IDM, and EGR drive module assembly**


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20. Remove module assembly.

**NOTE:** The ECM, IDM, and EGR drive module can be removed as a single unit and disassembled on a workbench, or they can be replaced individually on the engine. It will be disassembled on a workbench for illustrative purposes.


**Figure 477 EGR drive module, IDM, and ECM assembly**

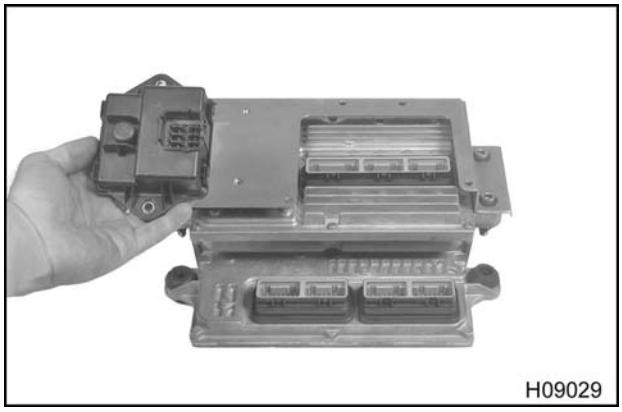


**Figure 478 EGR drive module**

21. Remove two bolts (M6 x 16) securing EGR drive module to the ECM / IDM bracket and lift off.

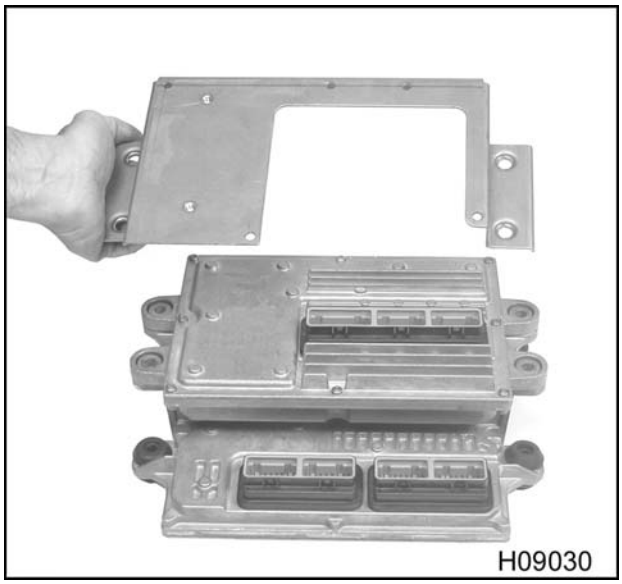


**Figure 479 ECM / IDM bracket**

22. Remove four bolts (M8 x 40) and four M8 nuts and special lockwashers securing the ECM / IDM bracket to both modules then remove bracket.

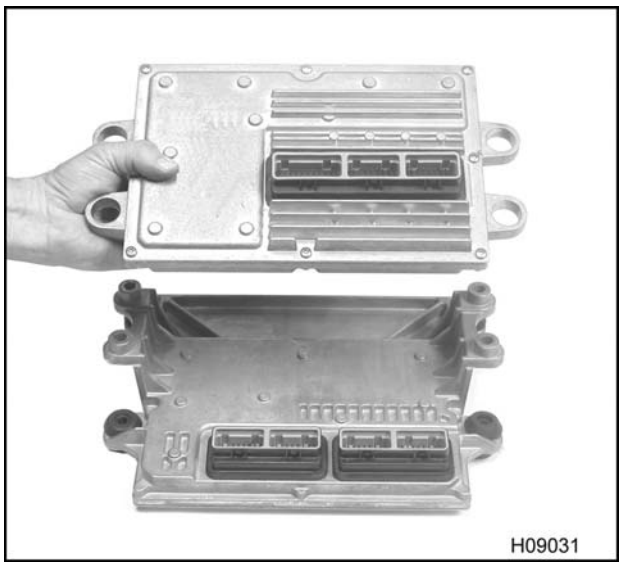


**Figure 480 Removing IDM from ECM**

23. Both IDM and ECM modules can now be separated.


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**Valve Cover Gasket with Pass-Through Connectors**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

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

**NOTE:** When removing, disconnecting, or installing the brake shutoff valve, ICP and BCP sensors, the valve cover must be removed.

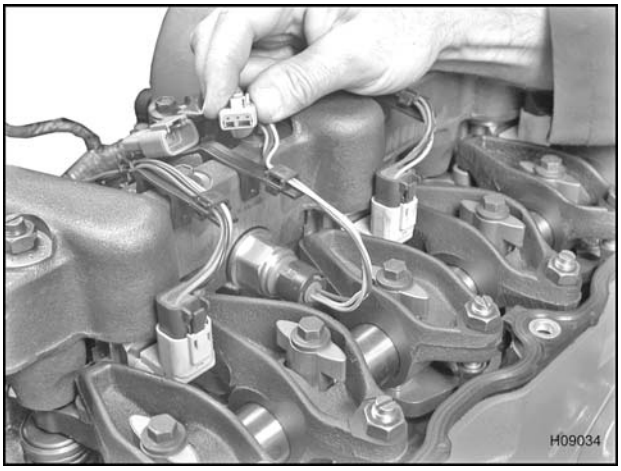


**Figure 481 Disconnecting the ICP sensor**

1. Disconnect the wiring harness connector from the ICP sensor.

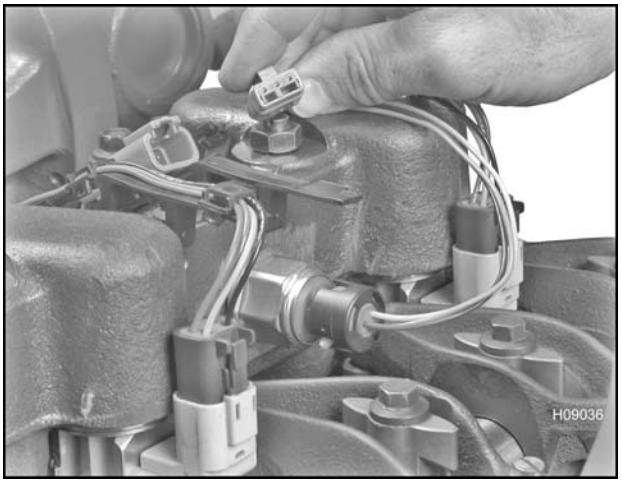


**Figure 482 Disconnecting the BCP sensor**

2. Disconnect the wiring harness connector from the BCP sensor (optional).

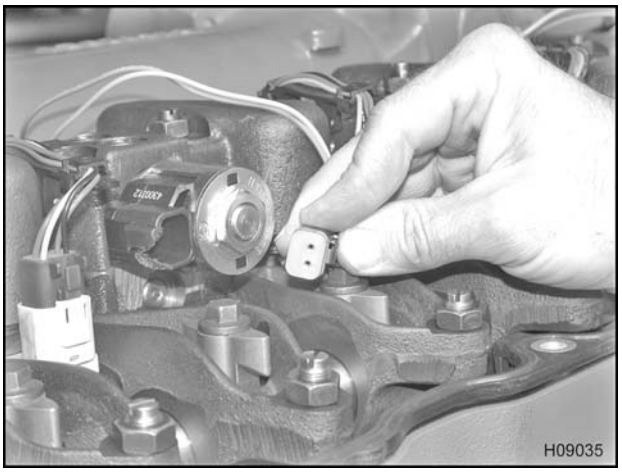


**Figure 483 Brake shutoff valve connector**

3. Disconnect the wiring harness connector from the Brake shutoff valve (optional).


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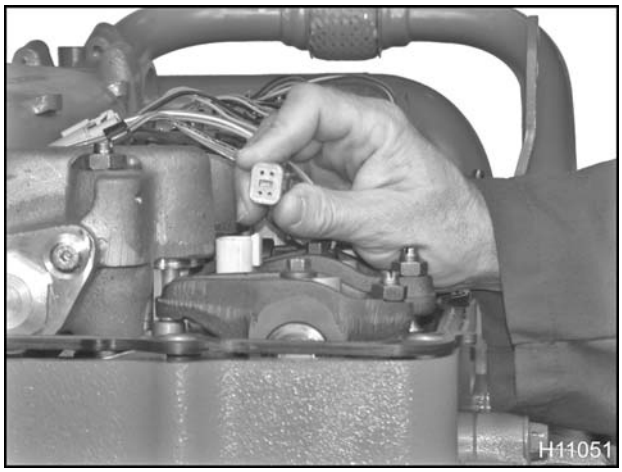


**Figure 484 Injector connector**

4. Disconnect the wiring harness connector from each of the six injectors.
5. Disconnect from the valve cover gasket.
6. Release valve cover harness by unclipping from the high-pressure oil manifold.


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## Cleaning and Inspection

### Checking Wiring Harness and Electrical Connectors

1. Check the connector pins on all electrical components. If any pins are bent, replace component.
2. Check each wiring harness for worn flexible conduit, and heat damage to wiring. Repair or replace each wiring harness as necessary.
3. Check each wiring harness connector for corrosion (green or gray and white deposits on the terminals), female connector sleeves that are spread open, and terminals that are pushed back relative to the other terminals in the same connector. Replace damaged connectors and terminals as necessary.
4. Inspect vibration isolator grommets for wear. If worn, install new grommets.


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## Installation

**Valve Cover Gasket with Pass-Through Connectors**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

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

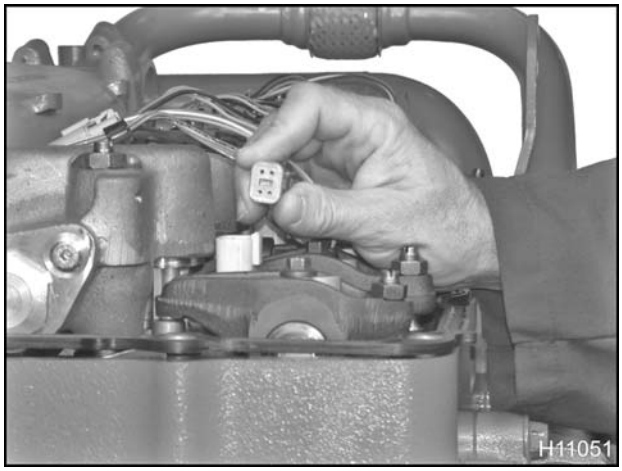


**Figure 485 Injector connector**

1. Install the valve cover harness by connecting harness to the high-pressure oil manifold.
2. Install valve cover gasket.
3. Connect (6) injectors connectors.

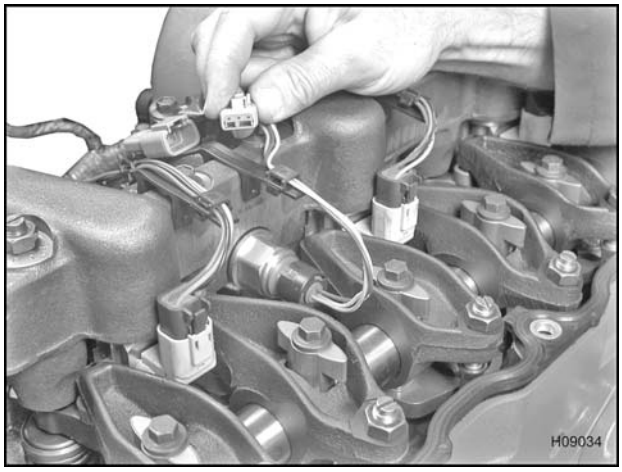


**Figure 486 Connecting the ICP sensor**

4. Connect the ICP sensor connector to the valve cover gasket connection.

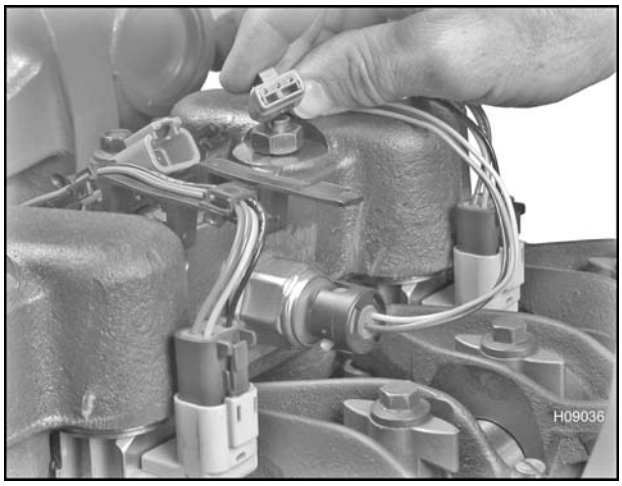


**Figure 487 Connecting the BCP sensor**

5. Connect the BCP sensor connector to the valve cover gasket connection.


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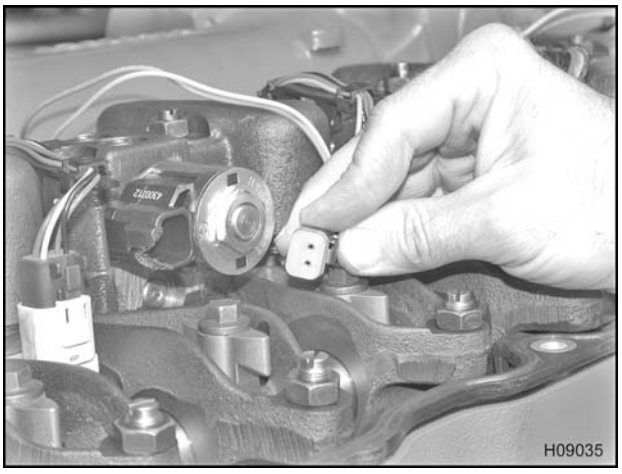


**Figure 488 Connecting brake shutoff valve**

6. Connect the brake shutoff valve connector to the valve cover gasket connection.

**NOTE:** When removing, disconnecting, or installing the brake shutoff valve, ICP and BCP sensors, the valve cover must be removed.

**ECM, IDM, EGR Drive Module, and Intake Air Heater**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

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

**NOTE:** The ECM, IDM, and EGR drive modules can be assembled as a single unit on a workbench or they can be installed individually on the crankcase. It will be assembled here on a workbench for illustrative purposes.


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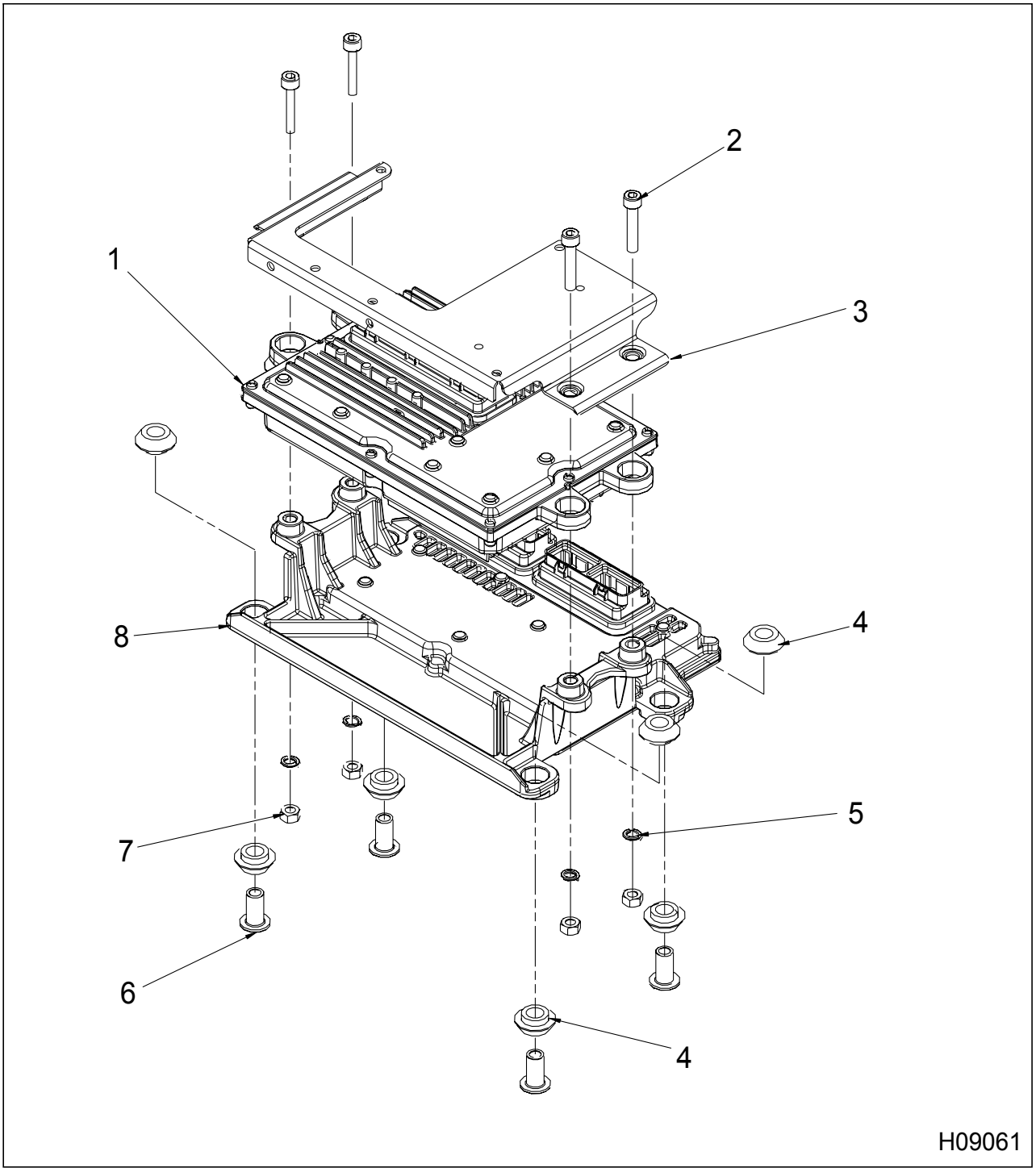


**Figure 489 ECM / IDM module assembly**

1. Injector Drive Module (IDM)
2. Hex socket head screws, M8 x 40 (4)
3. ECM / IDM bracket
4. Vibration isolation grommet (8)
5. Spiral lockwasher (4)
6. Vibration isolation bushing (4)
7. Nut, M8 (4)
8. Electronic Control Module (ECM)


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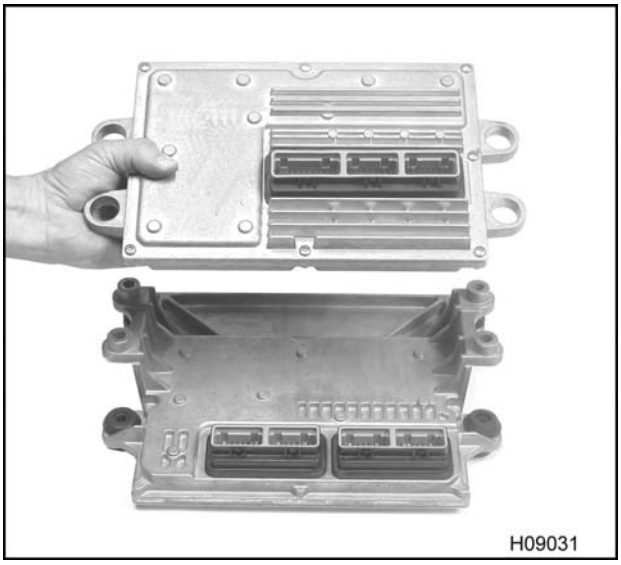


**Figure 490 Installing the IDM onto the ECM**

1. Lay the IDM over the ECM as shown.

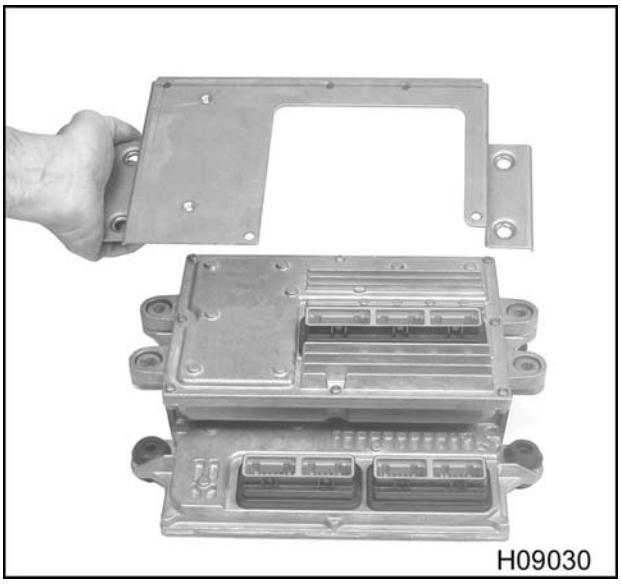


**Figure 491 IDM / ECM bracket assembly**

2. Lay the IDM / ECM bracket assembly over the IDM.
3. Install four hex socket head screws (M8 x 40), lockwashers and nuts (M8) to secure the IDM / ECM bracket assembly to the IDM and hand tighten. These screws will be torqued later when mounting assembly onto crankcase.

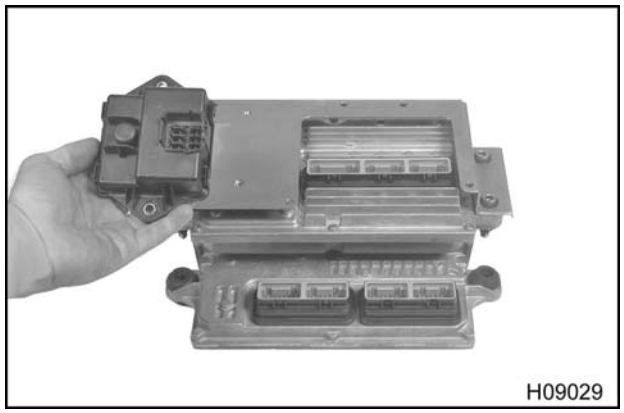


**Figure 492 EGR drive module**

4. Install the EGR drive module with two bolts (M6 x 16) and hand tighten. Bolts will be torqued later when mounting to crankcase.


**Figure 493 ECM, IDM and EGR drive modules assembled**


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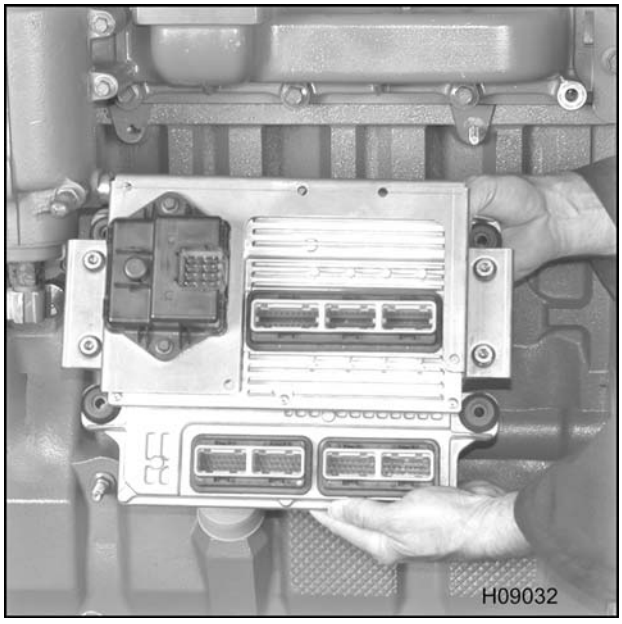


**Figure 494 Installing the ECM, IDM, and EGR drive module assembly to crankcase**

5. Install ECM, IDM, and EGR drive module assembly to the crankcase with two mounting stud bolts (M8 x 45/19) on right side.

   Install two bolts (M8 x 45) on left side to secure ECM, IDM, and EGR drive module assembly to crankcase.

6. Torque module assembly mounting bolts (M8 x 45) and stud bolts (M8 x 45/19) to the special torque value (Table 44).

7. Torque both EGR drive module bolts (M6 x 16) to the standard torque value (General Torque Guidelines, page445).

**NOTE:** If your engine has the intake air heater feature, then continue with the following steps.

**Intake Air Heater Wiring Harness Assembly**

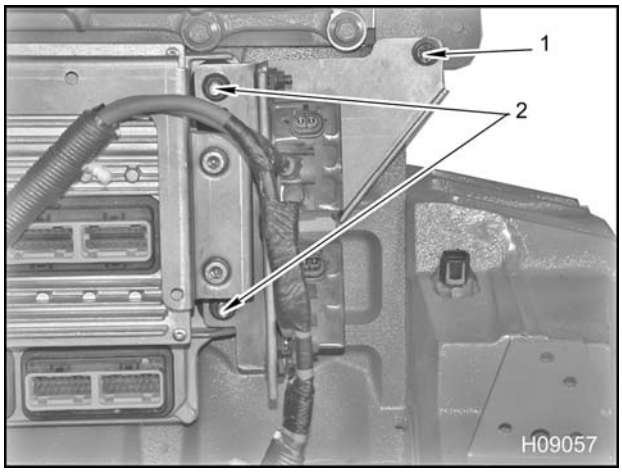


**Figure 495 Intake air heater relay bracket**

1. Heater relay bracket bolt, M6 x 20 and nut, M6
2. Heater relay bracket nuts, M8 (2)

8. If applicable, install the intake air heater and bracket assembly over the two ECM / IDM assembly mounting stud bolts (M8 x 45/19).

9. Place injector shield ground wire onto top stud. Install a nut (M8) onto each stud and torque to the standard torque value (General Torque Guidelines, page445).

10. Secure bracket to crankcase with an M6 x 20 bolt and M6 nut. Tighten to the standard torque value (General Torque Guidelines, page445).


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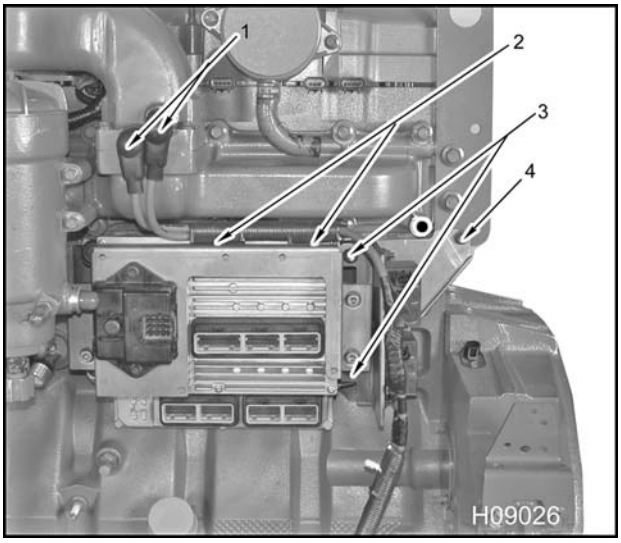


**Figure 496 Intake air heater and relay wiring harness**

1. Intake air heater mounting nuts, M6 (2)
2. Harness routing anchor points (2)
3. Heater relay bracket nuts, M8 (2)
4. Heater relay bracket bolt, M6 x 20 and nut, M6

11. Position intake heater harness assembly into place.

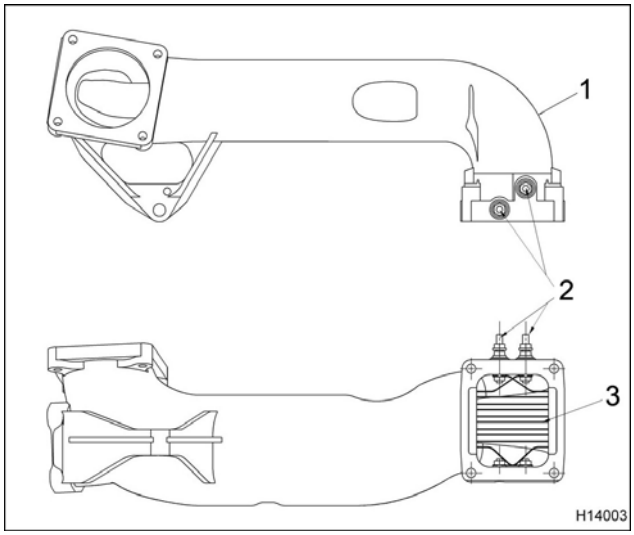


**Figure 497 Intake air heater – dual element**

1. Inlet and EGR mixer
2. Intake air heater cable locations
3. Intake air heater element

12. Install intake air heater cable at starter solenoid.

See (TSI-05-12-35 New 1500 Watt Single Grid Intake Air Heater Production Option, page460).

13. Connect Inlet Air Heater (IAH) cable(s). Slide boots over the connections.

**Injector harness at ECM, IDM, and EGR drive module**

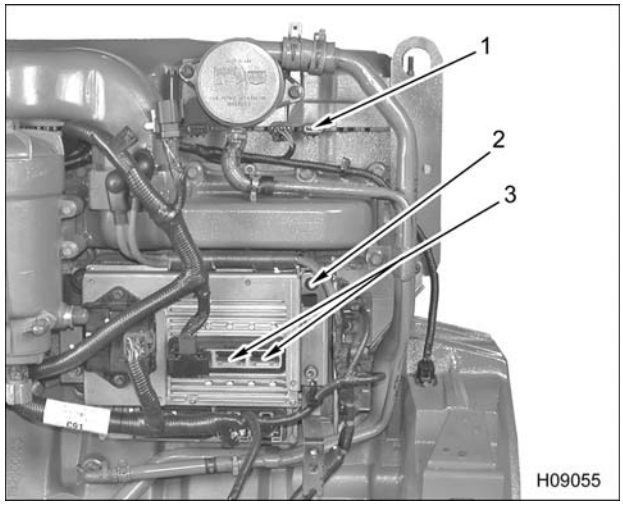


**Figure 498 Injector harness locations**

1. Injector connectors (6)
2. Injector shield ground connection
3. IDM connectors (2)

14. Connect two ECM engine connectors.
15. Connect two IDM connectors.
16. Connect the injector shield ground connection.
17. Connect six injector connectors to the valve cover gasket.


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**Sensor harness at ECM, IDM, and EGR drive module**

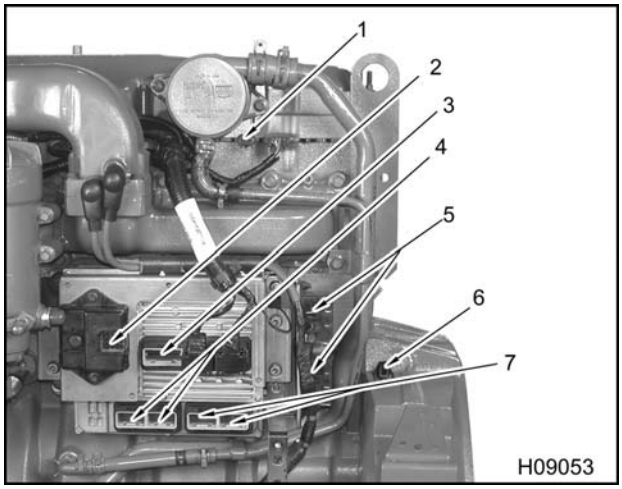


**Figure 499 Sensor harness locations**

1. ICP sensor connector
2. EGR drive module
3. IDM connector
4. ECM chassis connectors (2)
5. Intake air heater relay connections
6. CKP sensor
7. ECM engine connectors (2)

18. Connect two ECM engine connectors.
19. Connect the CKP sensor.
20. Connect two intake air heater relay connectors.
21. Connect two ECM chassis connectors.
22. Connect the IDM connector.
23. Connect the EGR drive module.
24. Connect the ICP connector to the valve cover gasket.

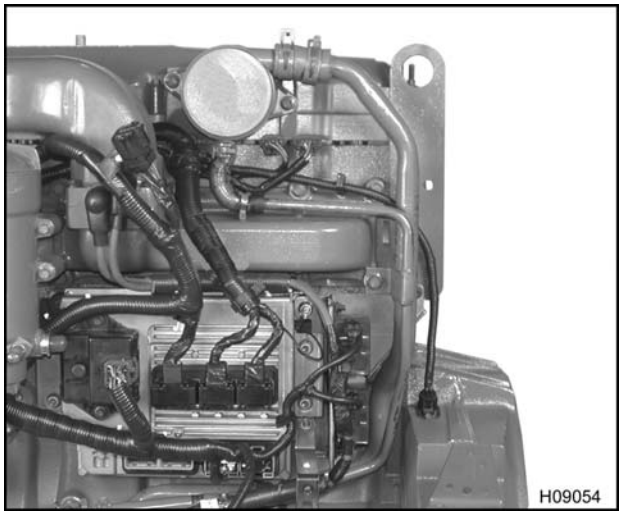


**Figure 500 ECM, IDM, EGR drive module, and tube assembly overview**

25. Install injector wiring harness underneath the EGR mixer duct and place harness snaps into anchor locations along the top side of the intake manifold.
26. Install all wiring harness snaps securing the sensor and injector wiring harnesses to the engine.


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**Injector Wiring Harness**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

**CAUTION:** To prevent engine damage, do not tug on any wiring harnesses while trying to remove them. If resistance is felt, find the source of resistance and free up any connectors or clips that are caught before proceeding. If necessary, remove the valve cover to gain clearance for the installation of the injector harness.

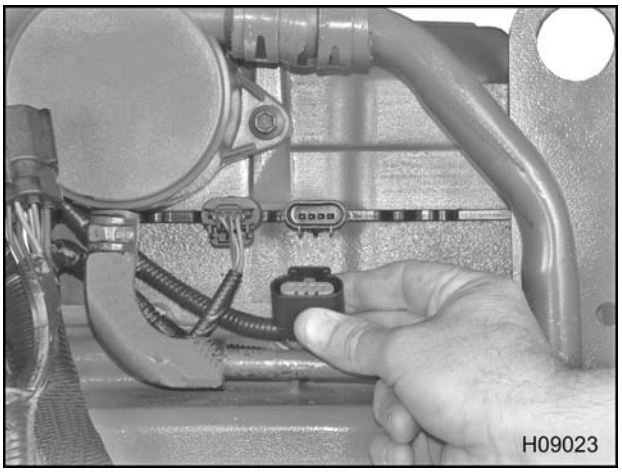


**Figure 501 Connecting the No. 6 fuel injector connector**

1. Connect six, four wire injector drive connectors to the valve cover gasket.
2. Slide ground eyelet over injector shielded ground stud (Figure 471). Install nut and tighten.


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**Sensor Wiring Harness**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, disconnect the main negative battery terminal before removing or installing any electrical components.**

**CAUTION:** To prevent engine damage, make sure the key is in the OFF position before unplugging the connector or relay for the ECM, IDM, and EGR drive module. Failure to turn the key to the OFF position will cause a voltage spike and damage the electrical components.

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

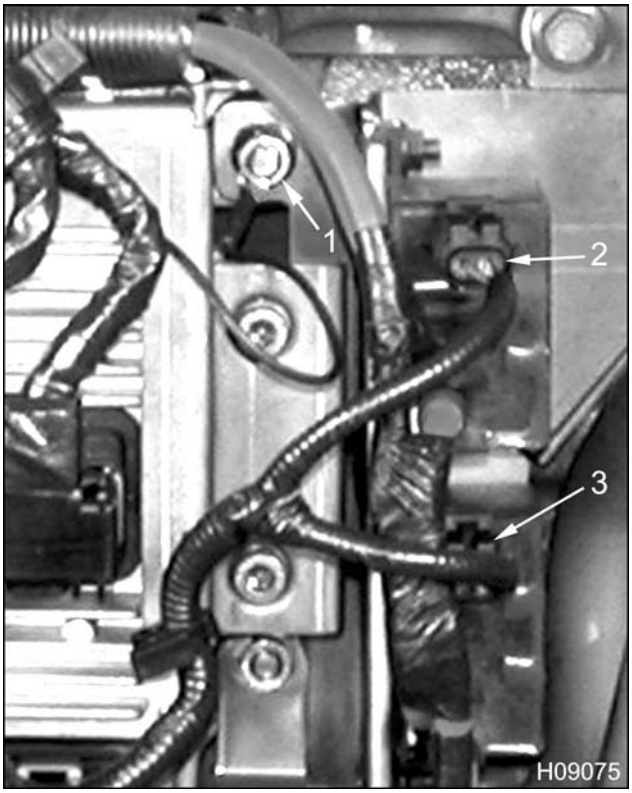


**Figure 502 Intake air heater relay connectors (2)**

1. Injector ground stud
2. Top relay connector
3. Bottom relay connector

1. Position the sensor harness by connecting the harness at various tie down locations.
2. Connect two intake air heater relay connectors at the intake air heater relays.

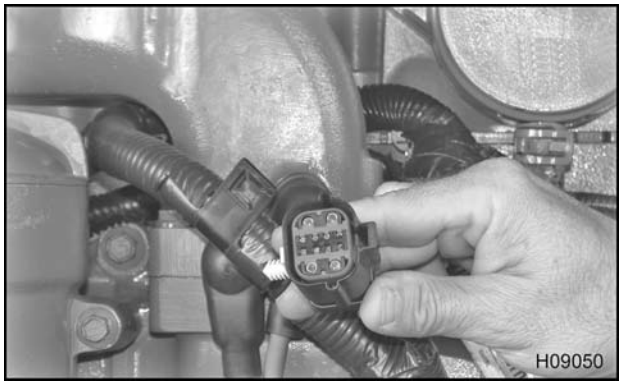


**Figure 503 12 wire engine connector**

3. Connect one, 12 wire connector engine to the chassis connection point.


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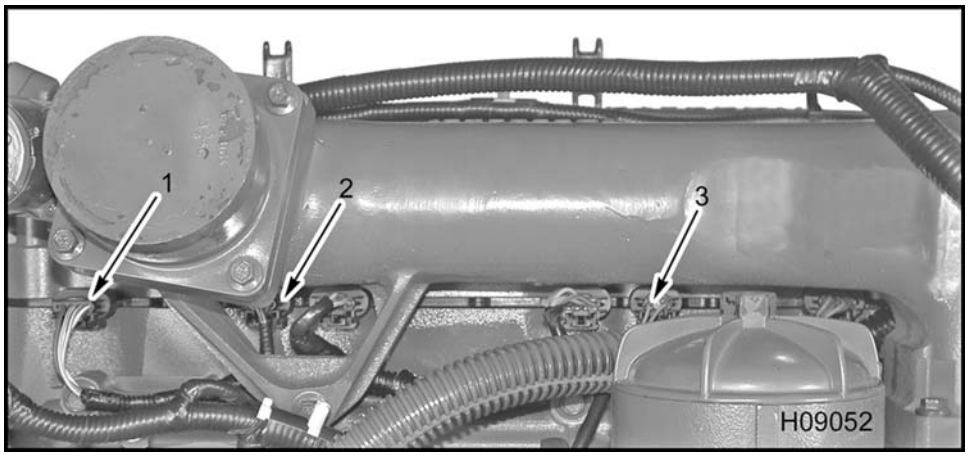


**Figure 504 BCP, brake shutoff valve, and injector locations**

1. Injector connector (6)
2. BCP sensor connector (optional)
3. Brake shutoff valve connector (optional)

4. Connect two ECM engine connectors.
5. Connect one IDM connector.
6. Connect one connector at EGR drive module.
7. Connect one, three wire ICP connector to the valve cover gasket.
8. Connect two additional, three wire connectors for the BCP sensor connector and brake shutoff valve connector to the valve cover gasket (optional).
9. Connect wiring harness at EGR drive module.
10. Connect the ECM, IDM, and EGR drive module assembly ground.
11. Connect two ECM engine module connectors.
12. Connect three IDM Module connectors.
13. Connect the engine harness by connecting the harness at the various tie down locations.


**Figure 505 Connecting to the CKP sensor**

14. Connect the wiring harness to the CKP sensor.


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**Figure 506 Connecting to the WIF sensor**

15. Connect the wiring harness at the WIF sensor.

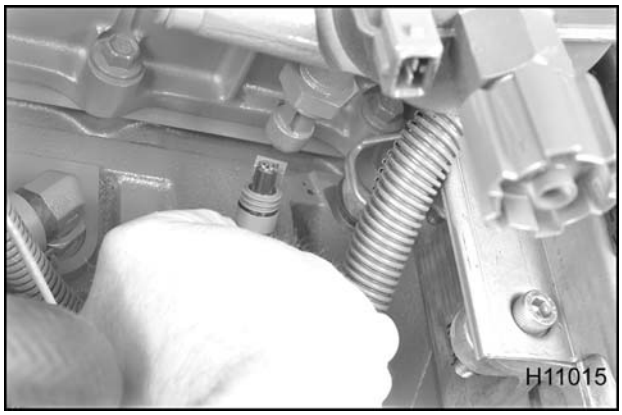


**Figure 507 Connecting to the fuel pressure sensor**

16. Connect the wiring harness to the fuel pressure sensor (optional).

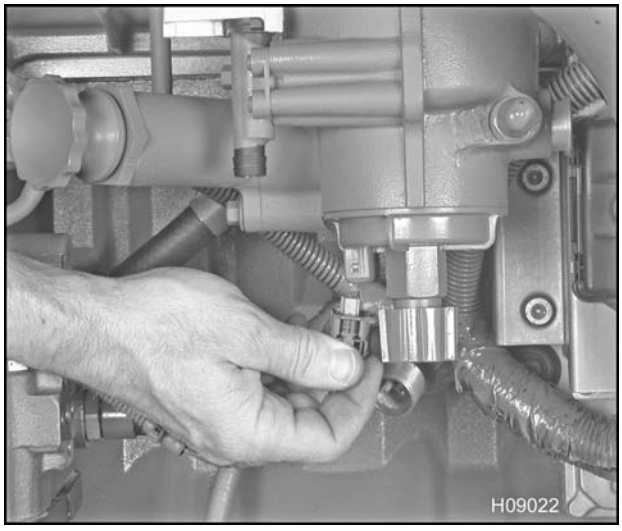


**Figure 508 Connecting to the fuel heater**

17. Connect the wiring harness at the fuel heater (optional).

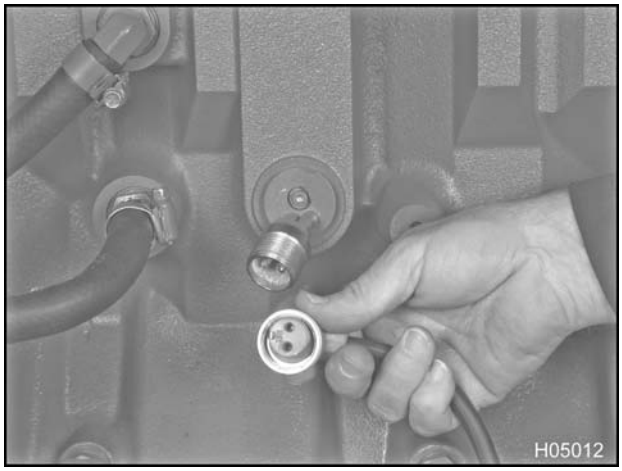


**Figure 509 Connecting to the block heater**

18. Install the block heater cable connections (optional).


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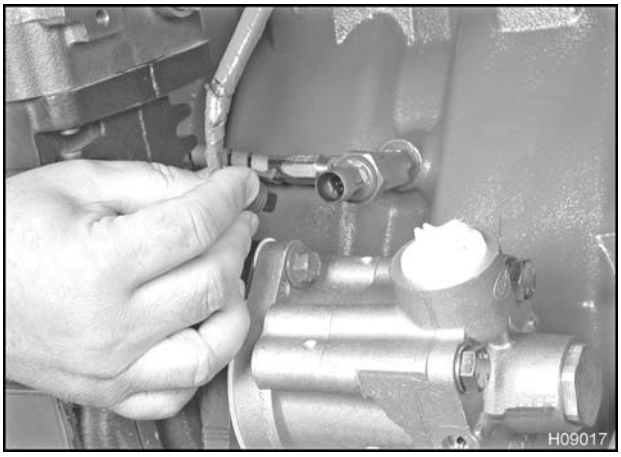


**Figure 510 Connecting to the EOP sensor**

19. Connect the wiring harness connector to the EOP sensor.

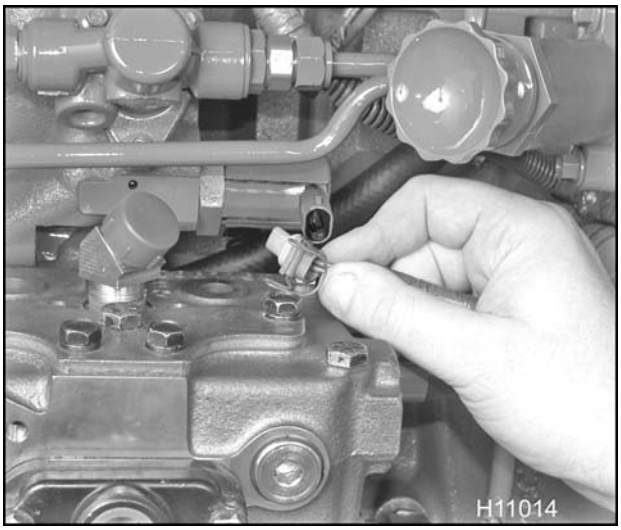


**Figure 511 Connecting to the IPR valve**

20. Connect wiring harness connector to the IPR valve solenoid.


**Figure 512 Connecting to the MAT sensor**

21. Connect the wiring harness connector to the MAT sensor.

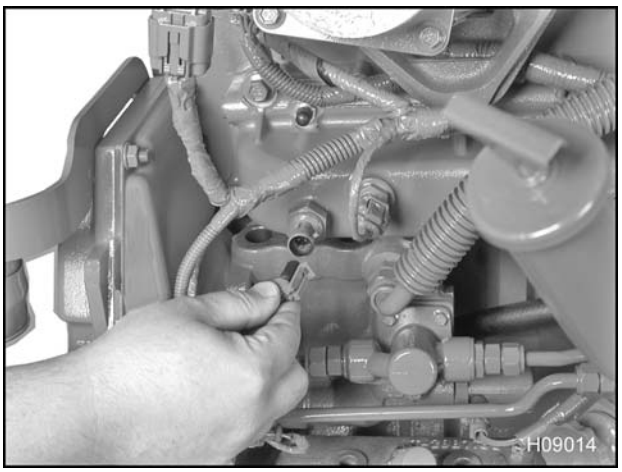


**Figure 513 Connecting the MAP sensor**

22. Connect the wiring harness connector to the MAP sensor.


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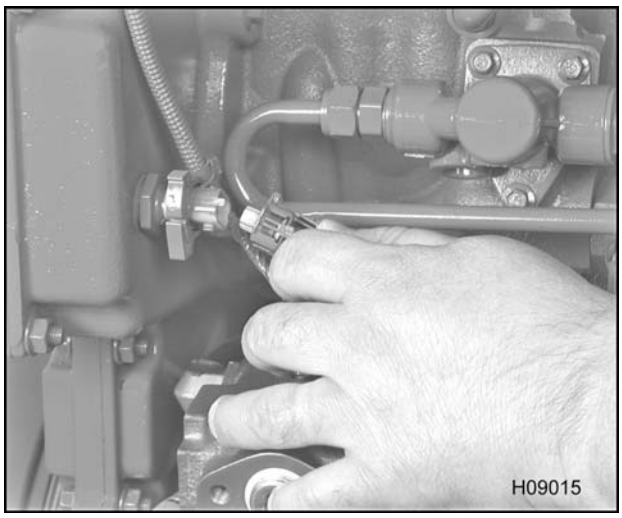


**Figure 514 Connecting to the EOT sensor**

23. Connect the wiring harness connector to the EOT sensor.

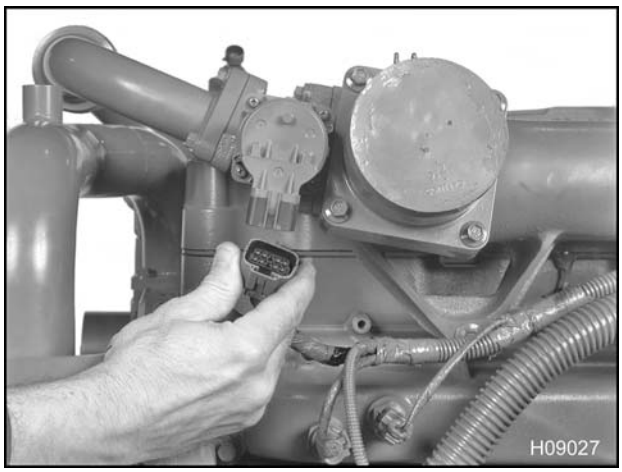


**Figure 515 Connecting to the EGR control valve**

24. Connect the wiring harness connector at the EGR control valve.

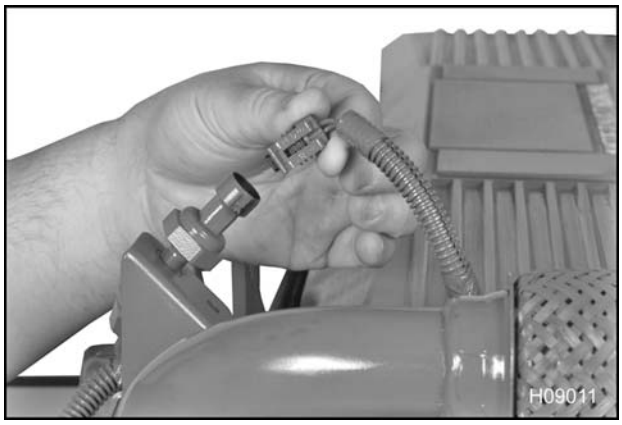


**Figure 516 Connecting to the EBP sensor**

25. Connect the wiring harness connector to the EBP sensor.

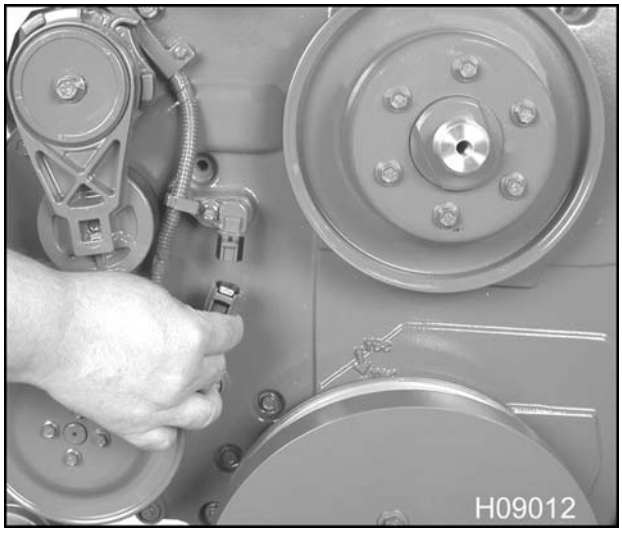


**Figure 517 Connecting to the CMP sensor**

26. Connect the wiring harness connector to the CMP sensor.


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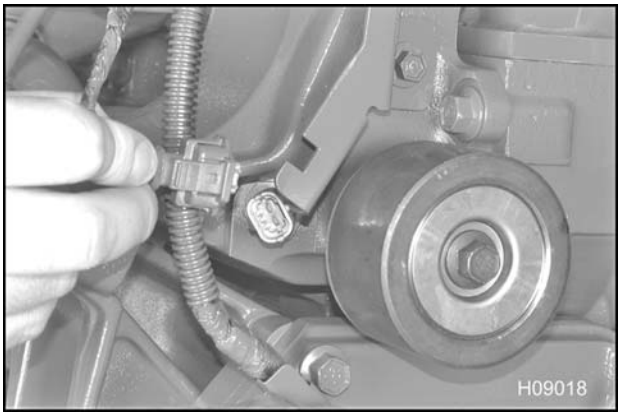


**Figure 518 Connecting to the ECT sensor**

27. Connect the wiring harness connector to the ECT sensor.

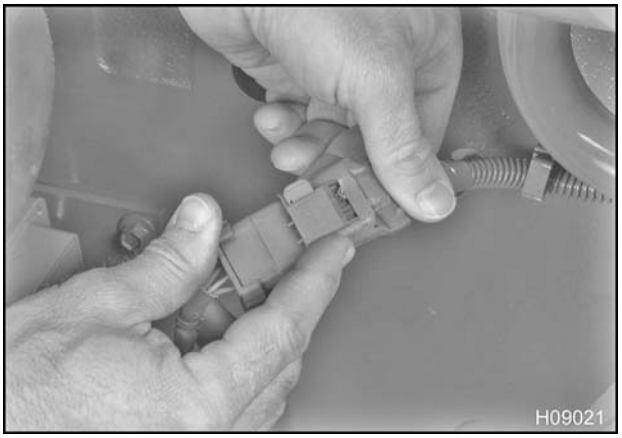


**Figure 519 Connecting to the VGT harness**

28. Connect the VGT harness at the VGT.


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## Special Torque

**Table 44 Engine Electrical Special Torques**

| | |
|---|---|
| ECM / IDM mounting bolts (2), M8 x 45 | 20 N·m (15 lbf·ft) |
| ECM / IDM mounting stud bolts (2), M8 x 45/19 | 20 N·m (15 lbf·ft) |
| Engine coolant temperature (ECT) sensor | 15-20 N·m (11-15 lbf·ft) |
| Engine oil pressure (EOP) sensor | 9-14 N·m (79-124 lbf·in) |
| Engine oil temperature (EOT) sensor | 15-20 N·m (11-15 lbf·ft) |
| Injection control pressure (ICP) sensor and Brake Control (BCP) sensor | 20-30 N·m (15-22 lbf·ft) |
| Intake Manifold Air Pressure (MAP) sensor | 10-20 N·m (88-176 lbf·in) |
| Intake Manifold Air Temperature (MAT) sensor | 10-20 N·m (88-176 lbf·in) |


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# Table of Contents

**Description**.....337

**Low-pressure Fuel System**.....337

**High-pressure Oil System**.....338

**Periodic Service**.....340
- **Fuel Strainer**.....340
- **Fuel Filter**.....341

**Removal**.....342
- **Low-pressure Fuel Supply Pump and Tubing**.....342
- **Fuel Filter Header Assembly and Intake Manifold**.....343
- **High-pressure Hose Assembly – Generation 1**.....345
- **High-pressure Hose Assembly with 70 and 90 Degree Elbows – Generation 2**.....345
- **High-pressure Pump and IPR Valve**.....346
- **High-pressure Oil Rail Assembly**.....346
- **Fuel Injector Assemblies**.....348

**Disassembly**.....350
- **Fuel Filter Header Assembly**.....350

**Installation**.....352
- **Fuel Injectors**.....352
- **High-pressure Oil Rail Assembly**.....353
- **High-pressure Oil Pump and IPR Valve Assembly**.....356
  - **IPR Valve Assembly**.....356
  - **High-pressure Oil Pump**.....356
- **High-pressure Hose Assembly – Generation 1**.....357
- **High-pressure Hose Assembly with 70 and 90 Degree Elbows – Generation 2**.....357
- **Fuel Filter Header Assembly and Intake Manifold**.....359
- **Low-pressure Fuel Supply Pump and Tubing**.....360
- **Priming Fuel System after Out of Fuel**.....362

**Specifications**.....363

**Special Torque**.....363

**Special Service Tools**.....364


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## Description

## Low-pressure Fuel System

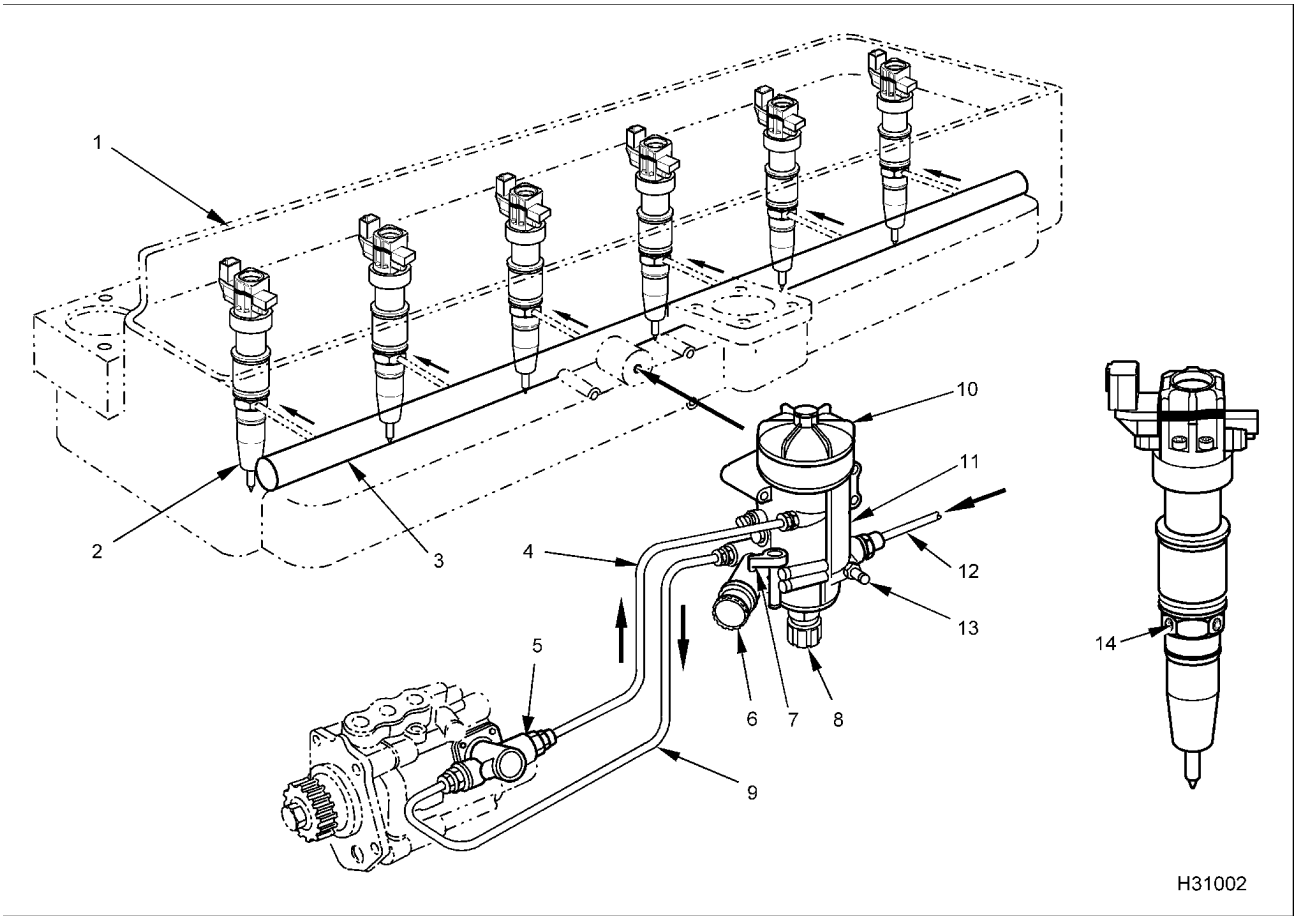


**Figure 520 Low-pressure fuel system**

1. Cylinder head
2. Fuel injector assembly (6)
3. Low-pressure fuel rail (cast in intake manifold)
4. Transfer pump outlet tube assembly
5. Low-pressure fuel supply pump
6. Primer pump assembly
7. Water drain valve
8. Drain valve (strainer)
9. Transfer pump inlet tube assembly
10. Fuel filter cover
11. Fuel filter assembly
12. Fuel piping from tank(s)
13. Fitting (service port)
14. Fuel inlet ports (4)

The low-pressure fuel system draws fuel from the fuel tank with a low-pressure fuel pump. Fuel first enters the fuel filter header, is heated by the optional fuel heater (if necessary) and passes through the fuel strainer. Fuel then passes through the low-pressure fuel pump, tubing, and through the fuel filter. Fuel finally passes through the intake manifold and cylinder head and is delivered to each fuel injector.


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### High-pressure Hose Assembly

The high-pressure hose assembly was modified as a production running change from (high-pressure hose – generation 1 to high-pressure Hose with 70 and 90 Degree Elbows – generation 2).

See removal and installation procedures for (High-pressure Hose – Generation 1 and High-pressure Hose with 70 and 90 Degree Elbows – Generation 2), listed in the Table of Contents in this section.

## High-pressure Oil System

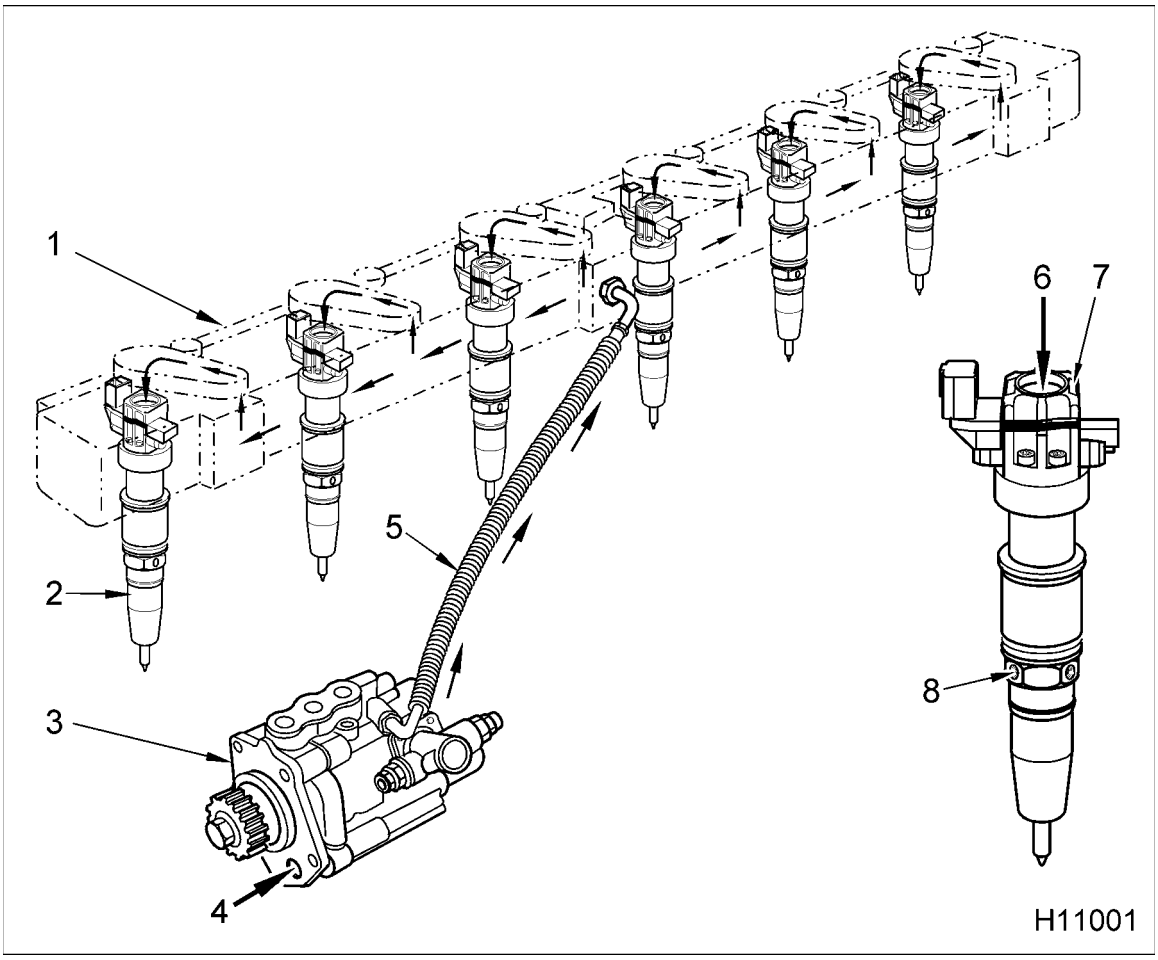


**Figure 521 High-pressure oil system**

1. High-pressure oil manifold
2. Fuel injector assembly (6)
3. High-pressure pump assembly
4. Oil inlet from front cover reservoir
5. High-pressure hose
6. Oil inlet from high-pressure oil manifold
7. Oil outlet (2)
8. Fuel inlet port (4)


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The high-pressure oil system draws oil from the front cover reservoir into the high-pressure oil pump. The high-pressure oil pump pressurizes this oil which is forced through the high-pressure hose, high-pressure oil manifold, and sent to the oil inlet on top of each fuel injector. High-pressure oil increases fuel pressure inside the injectors, which deliver high-pressure fuel to each cylinder.


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## Periodic Service

**GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.**

**WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.**

**WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.**

**WARNING: To prevent personal injury or death, disconnect the main battery negative terminal before disconnecting or connecting electrical components.**

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

**WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.**

**WARNING: To prevent personal injury or death, do not smoke and keep fuel away from flames and sparks.**

**Fuel Strainer**

1. Loosen drain valve below strainer and drain fuel into a suitable container. Dispose of properly.

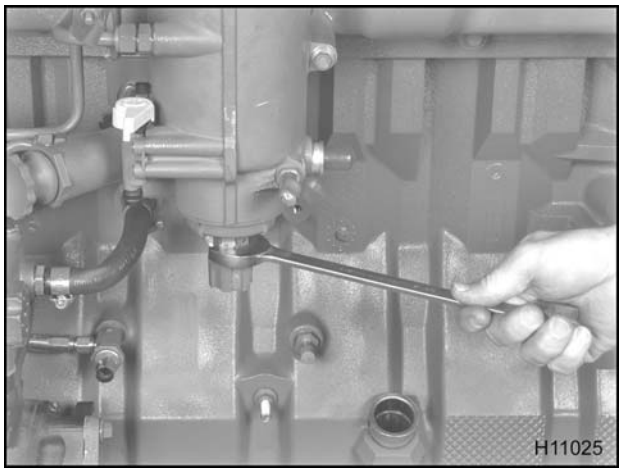


**Figure 522 Removing the fuel strainer**

2. Use a 24 mm or 15/16 inch open end wrench to remove the fuel strainer from fuel filter assembly.

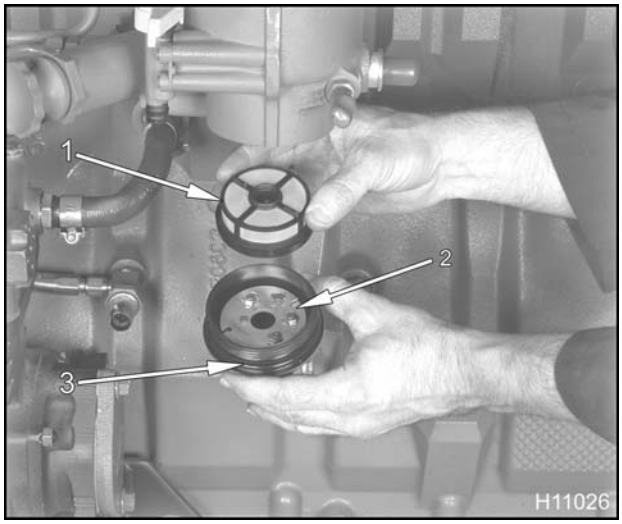


**Figure 523 Strainer and heater assembly**

1. Fuel strainer
2. Heater assembly (optional)
3. Fuel bowl O-ring

3. Remove strainer for cleaning or replacement and discard fuel bowl O-ring.
4. Clean all debris from fuel bowl or heater bowl.
5. Place new or cleaned strainer into fuel bowl.
6. Coat fuel bowl threads and a new O-ring with clean fuel. Thread fuel bowl into fuel filter header


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assembly and torque to the special torque value (Table 47).

**Fuel Filter**

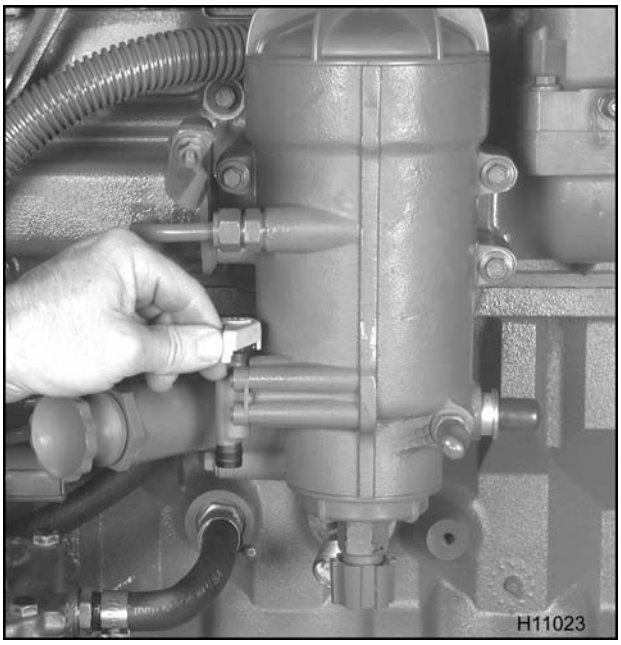


**Figure 524 Water drain valve**

1. Open water drain valve and drain fuel into a suitable container.

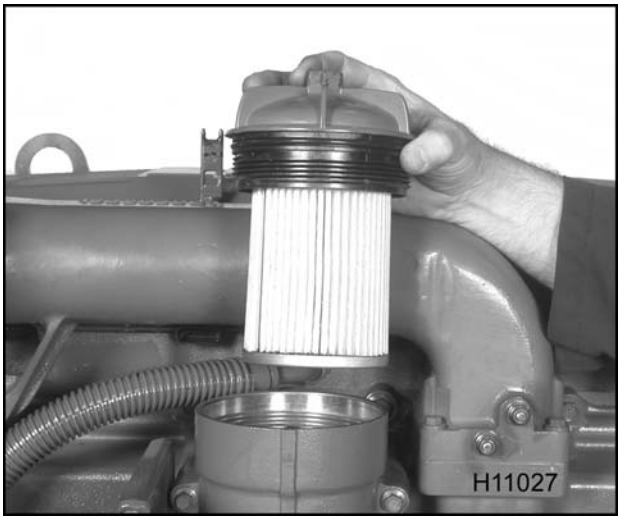


**Figure 525 Fuel filter element**

2. Unthread housing cover and fuel filter as an assembly.
3. Pull fuel filter from housing cover and discard O-ring gasket.
4. Place a new O-ring gasket onto housing cover.
5. Install a new fuel filter onto housing cover.
6. Lubricate housing cover threads and O-ring gasket with diesel fuel.
7. Thread fuel filter and housing cover in as an assembly. Torque to the special value (Table 47).


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## Removal

### Low-pressure Fuel Supply Pump and Tubing

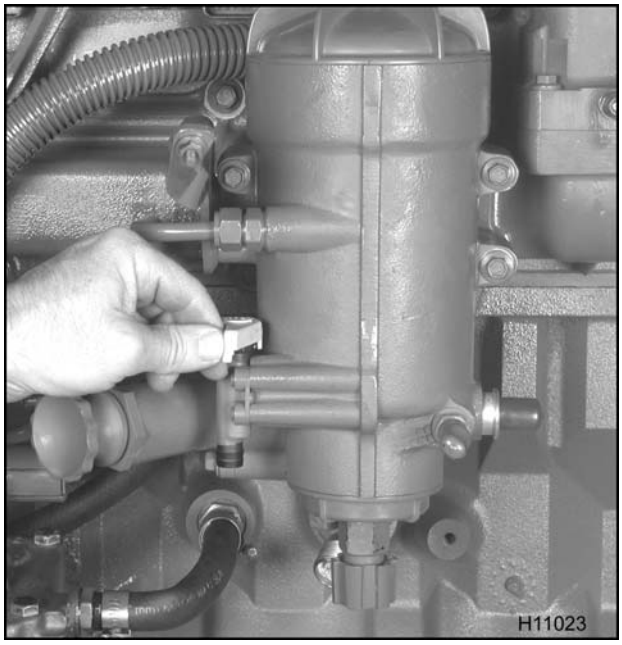


**Figure 526 Water drain valve**

1. Open water drain valve and drain fuel into a suitable container.

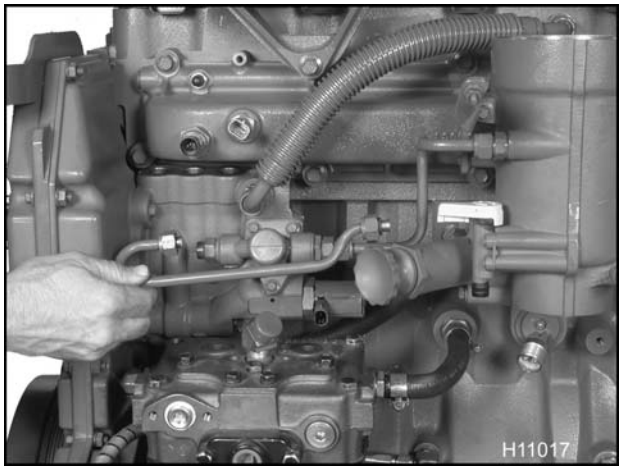


**Figure 527 Removing the transfer pump inlet tube assembly**

2. Remove the transfer pump inlet tube assembly.

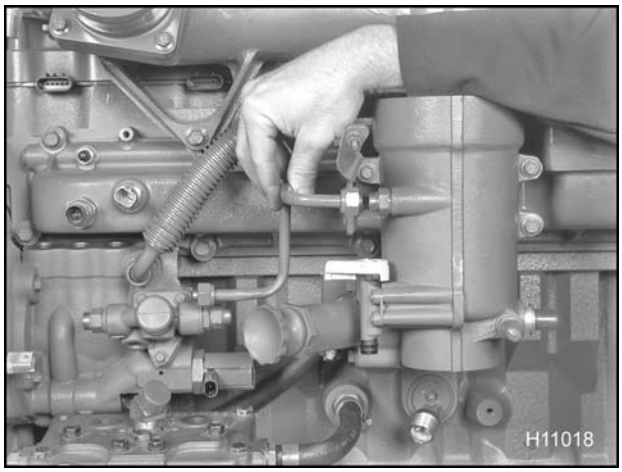


**Figure 528 Removing the transfer pump outlet tube assembly**

3. Remove the transfer pump outlet tube assembly. Cap all pump openings to the fuel filter and low-pressure fuel supply pump.

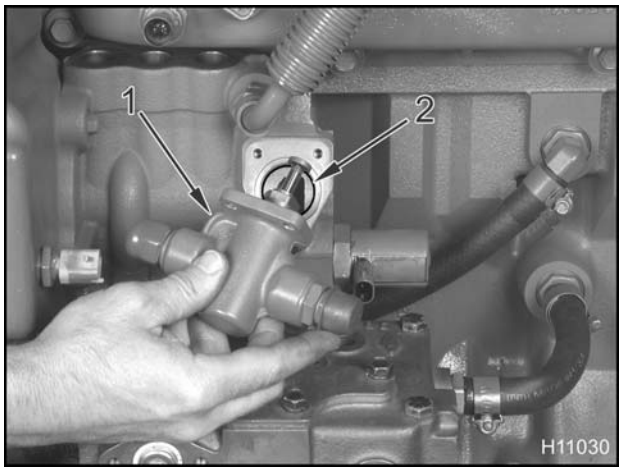


**Figure 529 Removing the low-pressure fuel pump**

1. Low-pressure fuel supply pump
2. Seal

4. Remove three mounting bolts (M6 x 16) and the low-pressure fuel supply pump from high-pressure oil pump. Discard seal.
5. Check the low-pressure fuel supply pump tappet for cracks, burrs and straightness. Replace low-pressure fuel supply pump if necessary.


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6. Check all fuel lines for kinks, obstructions, or other damage. Replace individual fuel lines as necessary.

**Fuel Filter Header Assembly and Intake Manifold**

1. Drain fuel filter assembly (Figure 526), if not done so already.
2. Drain fuel bowl by performing the following steps:
   a. Have a suitable container handy to catch draining fuel. Open drain valve completely. In most cases, the portion of fuel **below** the fuel strainer will pour out.
   b. Turn primer pump assembly knob counterclockwise to unlock. Pump primer knob approximately 3-4 times to force fuel through strainer.
   c. Turn primer pump assembly knob clockwise to lock.

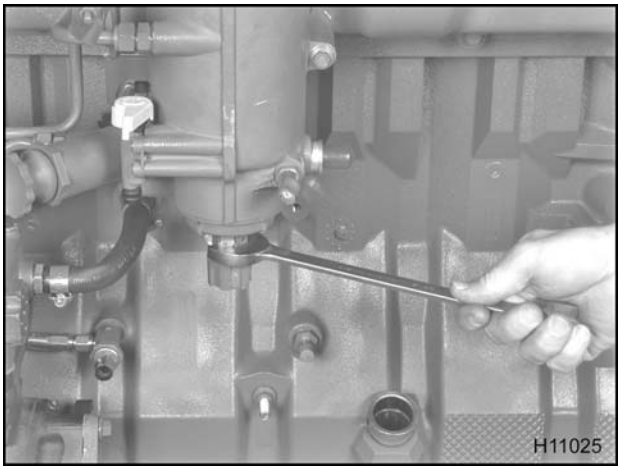


**Figure 530 Removing fuel bowl and strainer**

   d. Use a 24 mm or 15/16 inch open end wrench to remove the fuel strainer from fuel filter assembly.

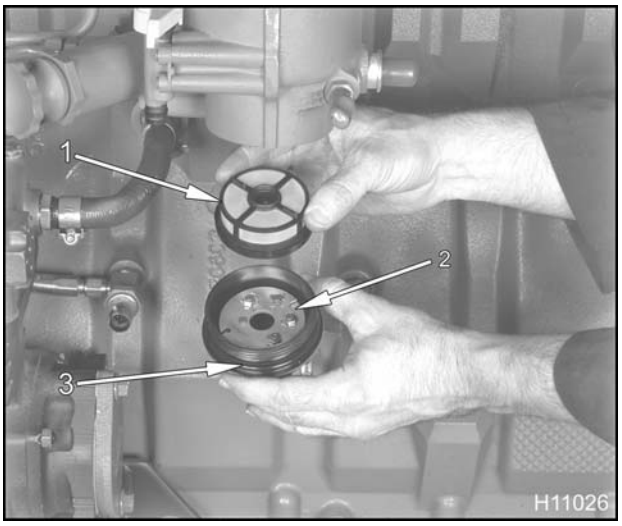


**Figure 531 Strainer and heater assembly**

1. Fuel strainer
2. Heater assembly (optional equipment)
3. Fuel bowl O-ring

3. Remove strainer for cleaning or replacement and discard fuel bowl O-ring.

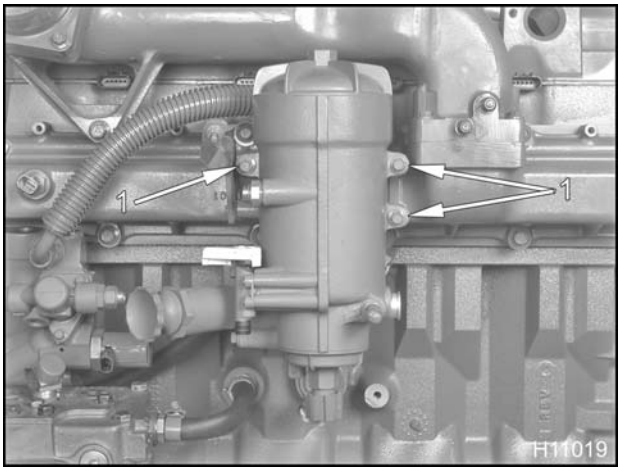


**Figure 532 Fuel filter assembly mounting bolts**

1. Bolts, M8 x 100

4. Remove three mounting bolts (M8 x 100) and fuel filter assembly from intake manifold.


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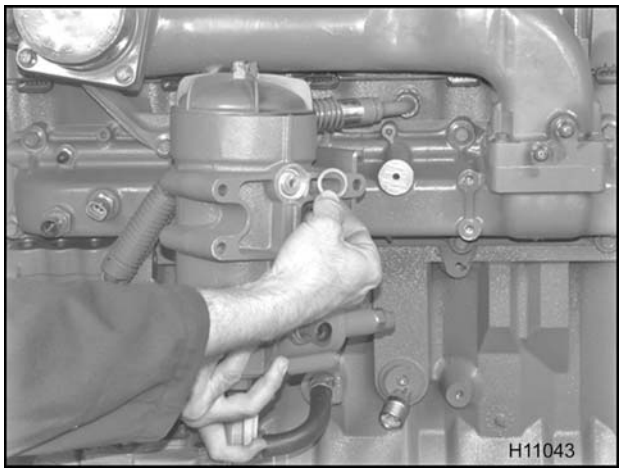


**Figure 533 Removing the fuel filter outlet gasket**

5. Discard the fuel filter outlet gasket between fuel filter assembly and intake manifold.

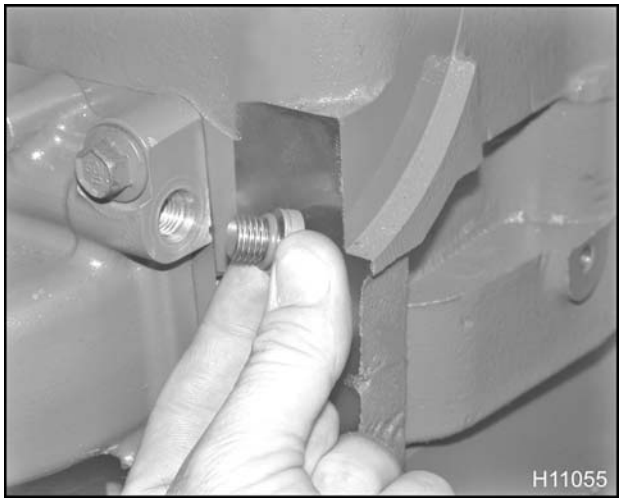


**Figure 534 Removing the fuel rail plug assembly (2)**

6. Remove the plug assembly (M12) from each end of the intake manifold and discard O-ring seal. You may also need to remove the rear engine lifting eye to gain access to remove the rear plug.

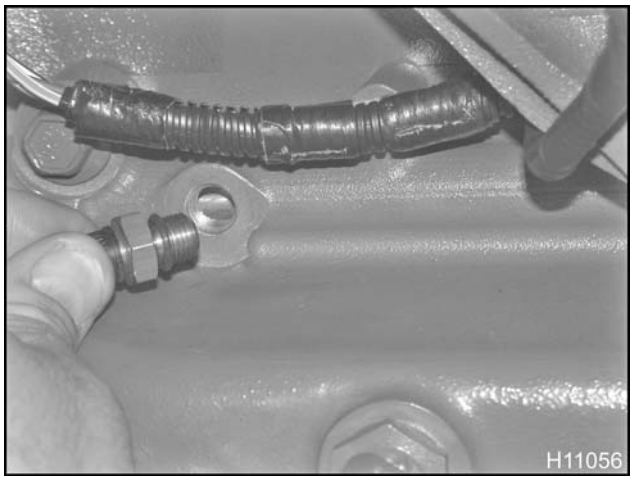


**Figure 535 Removing the fuel valve assembly (air bleed and pressure test port)**

7. Remove the fuel valve assembly (air bleed and pressure test port), located at the front end of the intake manifold. Discard O-ring seal.


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### High-pressure Hose Assembly – Generation 1

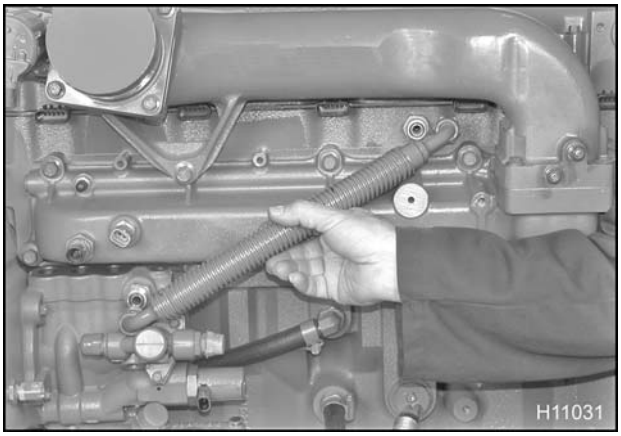


**Figure 536 Removal of high-pressure oil hose assembly**

1. Remove the high-pressure oil hose assembly between the high-pressure pump assembly and cylinder head.
2. Remove and discard O-ring at each fitting.
3. If necessary, remove high-pressure hose fitting located at cylinder head.

### High-pressure Hose Assembly with 70 and 90 Degree Elbows – Generation 2

1. Remove the conduit cover from the high-pressure hose assembly.

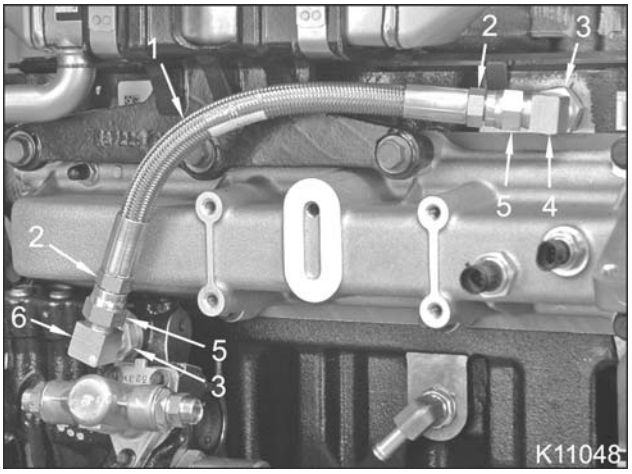


**Figure 537 High-pressure hose assembly connections (typical)**

1. High-pressure oil hose
2. High-pressure oil hose nut (2)
3. Elbow jam nut (2)
4. 70 degree elbow
5. Swivel nut (2)
6. 90 degree elbow

2. Remove high-pressure oil hose swivel nuts from 70 and 90 degree elbows. Use one wrench to hold the high-pressure oil hose nut in place while loosening its corresponding swivel nut using another wrench. Remove the high-pressure hose.

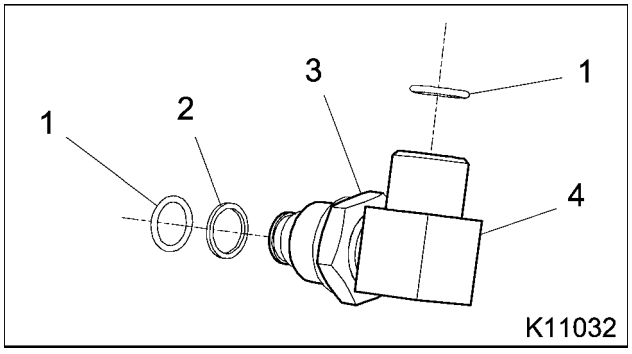


**Figure 538 High-pressure oil elbow (typical)**

1. O-ring seal (#14) (2)
2. Back-up ring
3. Elbow jam nut
4. Elbow


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3. Loosen jam nuts on each elbow.
4. Remove 70 and 90 degree elbows.
5. Remove and discard each elbow back-up ring and O-rings.

**High-pressure Pump and IPR Valve**

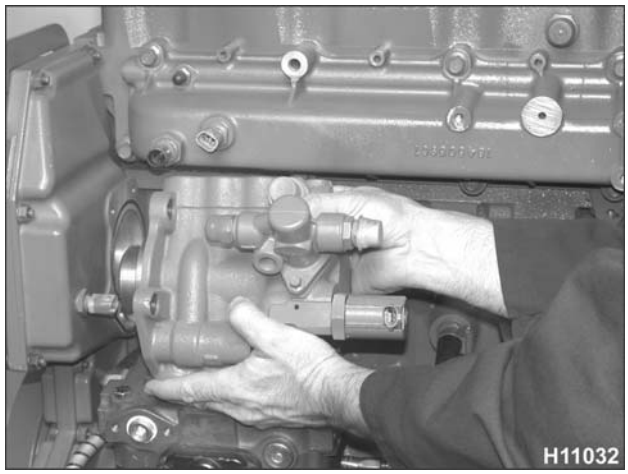


**Figure 539 Removing the high-pressure pump assembly**

1. Remove two bolts (M8 x 100) behind pump and two (M8 x 30) bolts securing the high-pressure pump to the front cover. Remove pump assembly and discard seal.

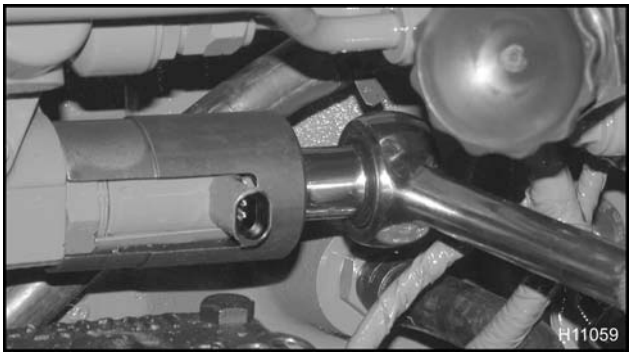


**Figure 540 Removing the IPR valve**

2. Use an IPR removal / installation tool (Table 48) to remove the IPR valve. Check inlet screen for restrictions. Remove O-rings and discard.

**High-pressure Oil Rail Assembly**

1. Remove valve cover. See (Valve Cover, page120) in the “Cylinder Head and Valve Train” section of this manual.

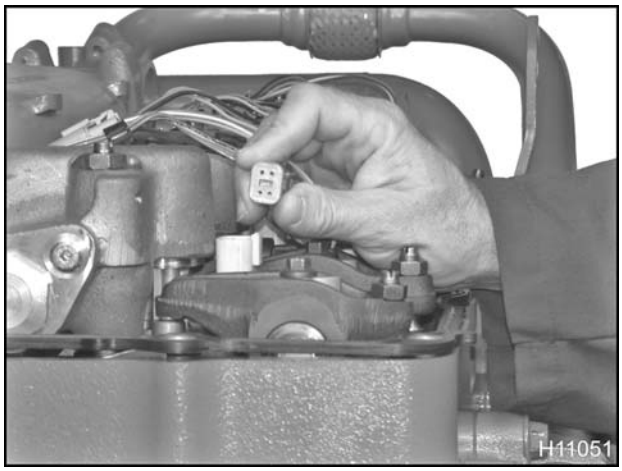


**Figure 541 Removing the injector harness connector**

2. Disconnect the injector harness connector at the top of each injector.

**WARNING: To prevent personal injury or death, get assistance to remove and install the high-pressure oil rail assembly.**

3. Remove 12 bolts (M8 x 90) securing high-pressure oil rail to cylinder head.

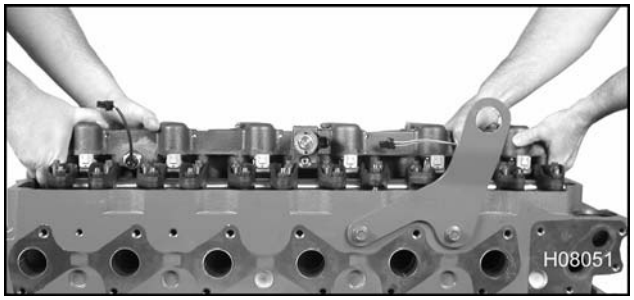


**Figure 542 Removing the high-pressure oil rail**

4. Remove all bolts and lift high-pressure oil rail up just enough to drain as much oil out of high-pressure oil rail before lifting it away from cylinder head.


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5. Clean outside of high-pressure oil rail using appropriate solvent.

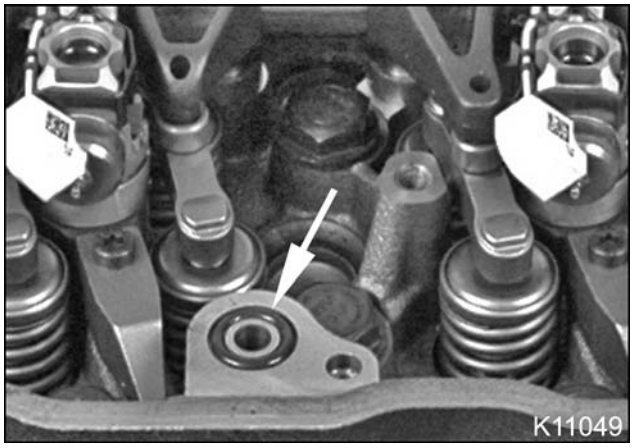


**Figure 543 High-pressure oil rail**

6. Remove oil inlet O-ring from recess in cylinder head and discard O-ring.

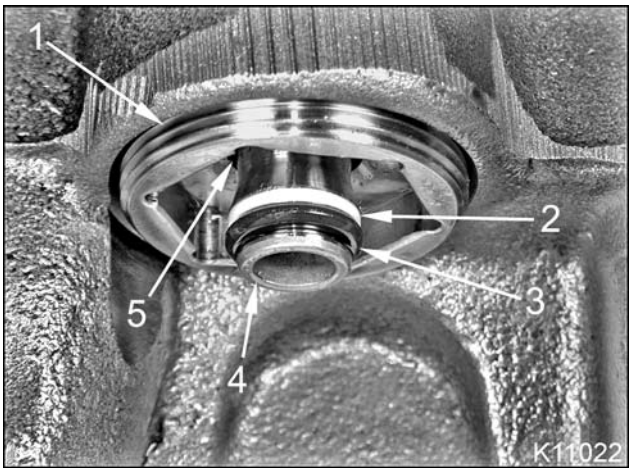


**Figure 544 Injector oil inlet adapter installed in high-pressure oil rail**

1. Injector oil inlet adaptor
2. Backup ring
3. Injector oil inlet seal
4. Oil inlet tube
5. Internal O-ring (not serviceable)

**NOTE:** It is not necessary to remove an injector oil inlet adaptor to install a new backup ring and injector inlet seal.

7. Remove and discard backup ring and injector inlet seal from injector oil inlet adapters in the high-pressure oil rail.


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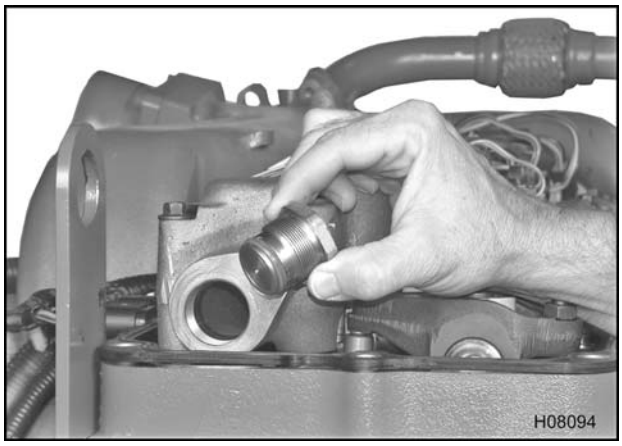


**Figure 545 Rail end plug assembly**

8. If necessary, remove rail end plug or attenuator. See (TSI-05-12-28 New High-pressure Oil Rails, page465).


**Figure 546 ICP sensor assembly**

9. Remove ICP sensor assembly and discard O-ring.

**Fuel Injector Assemblies**

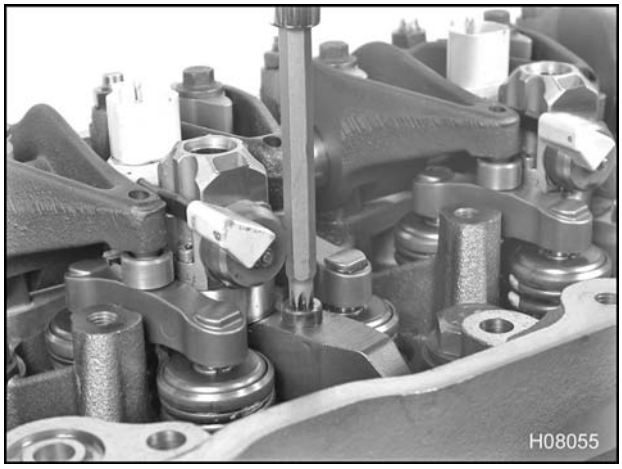


**Figure 547 Removing the injector clamp and injector**

1. Use the fuel injector remover tool (#40 Torx®) (Table 48) to extract the injector clamp and injector.

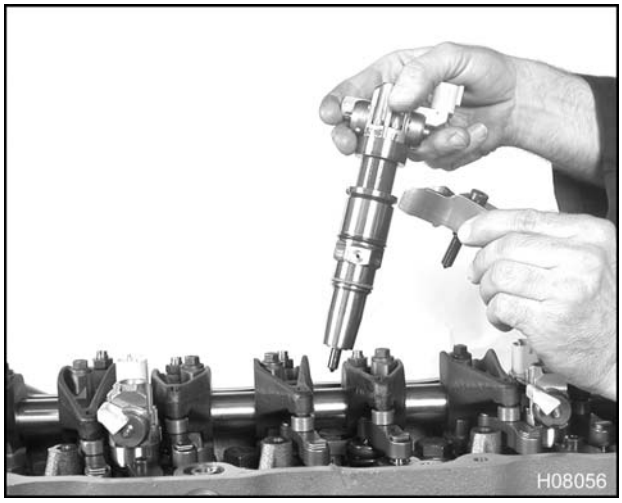


**Figure 548 Removing the fuel injector assembly**

**CAUTION:** To prevent engine damage, do not clean fuel injectors with parts solvents or chemicals.

**CAUTION:** To prevent engine damage, put hydraulically actuated fuel injectors in an oil filled closeable plastic container; this prevents contamination or oxidation damage.


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2. Carefully remove each fuel injector assembly. Remove and discard two external O-rings and the nozzle gasket from each injector; put each injector into an oil filled plastic container and close container.

**NOTE:** If any nozzle gaskets were missing on any of the removed injectors, check the bottom of the injector sleeves. Remove gaskets and discard.


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## Disassembly

### Fuel Filter Header Assembly

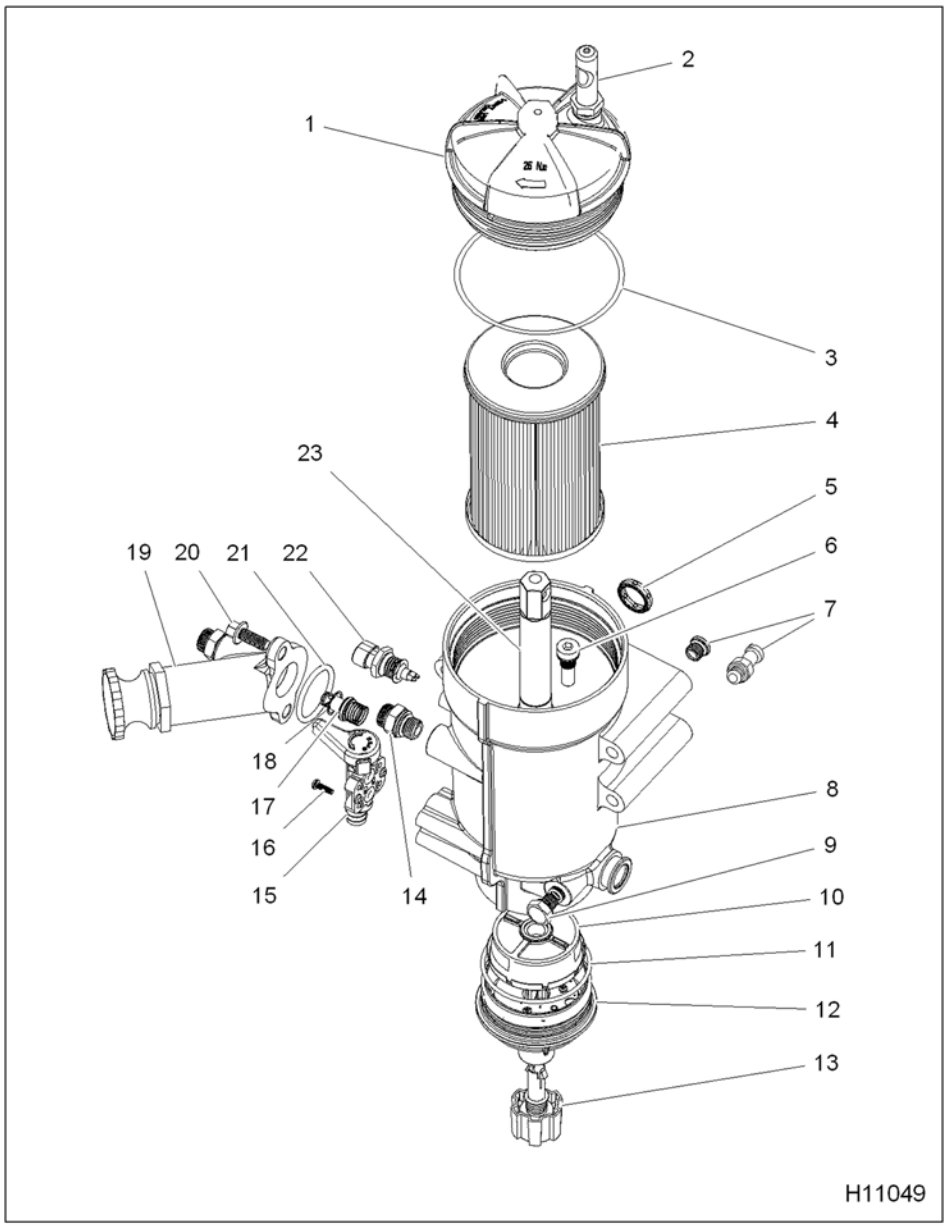


**Figure 549 Fuel filter header assembly**

1. Housing cover assembly
2. M12 port fitting (factory fill)
3. O-ring seal
4. Fuel filter element
5. O-ring seal
6. Fuel pressure regulator assembly
7. Plug or EFP sensor (optional)
8. Fuel filter housing
9. M10 Plug assembly
10. Fuel strainer
11. Bowl O-ring seal
12. Fuel bowl (with heater option)
13. Drain valve
14. Fitting assembly, 3/8 tube
15. Water drain valve assembly
16. Self tapping screw (4)
17. Cartridge check valve
18. Retainer ring
19. Primer pump assembly
20. Bolt, M8 x 20 (2)
21. Primer pump seal
22. Water In Fuel (WIF) sensor
23. Stand pipe


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**NOTE:** Early fuel filter assemblies may have an M12 port fitting (item 2) in the location of M10 plug assembly (item 9). Item 2 is used by the assembly plants as a fuel fill.

- If item 2 is installed on housing cover assembly, it can be used to measure unfiltered fuel pressure.
- If item 2 is installed in item 9 location, it can be used to measure fuel inlet restriction.

It is not recommended to disassemble the fuel filter beyond circumstances involving periodic servicing that include the following:

- Fuel filter element replacement
- Fuel strainer
- Sensor replacements (if determined by a DTC)

The fuel filter assembly can and should be disassembled if any of the following issues have been observed:

- Contaminated fuel has been introduced to the engine, resulting in poor performance.
- Fuel or air leaks involving the priming pump assembly.

**NOTE:** If the fuel filter header assembly is disassembled, use clean diesel fuel to lubricate the following parts and during reassembly.

- Threads of fuel bowl.
- O-ring gasket.
- Threads and O-ring on Water In Fuel (WIF) sensor.
- Threads and O-ring on drain valve.

Tighten items to the special torque (Table 47).


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## Installation

### Fuel Injectors

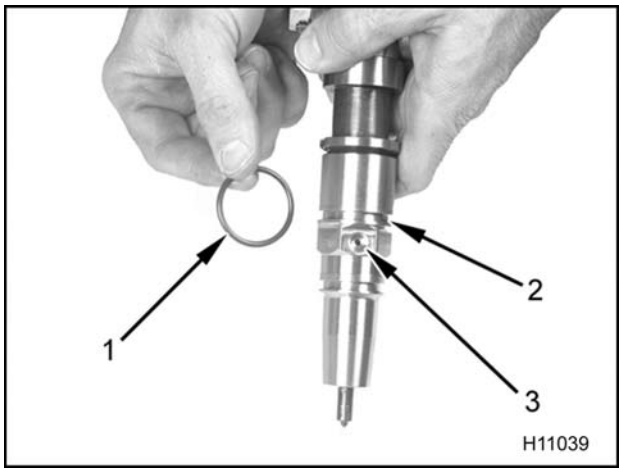


**Figure 550 Injector upper O-ring**

1. Upper O-ring (black)
2. O-ring recess
3. Fuel inlet port

1. Lubricate a new upper O-ring with clean engine oil and slide it into the recess just above the four fuel inlet ports.

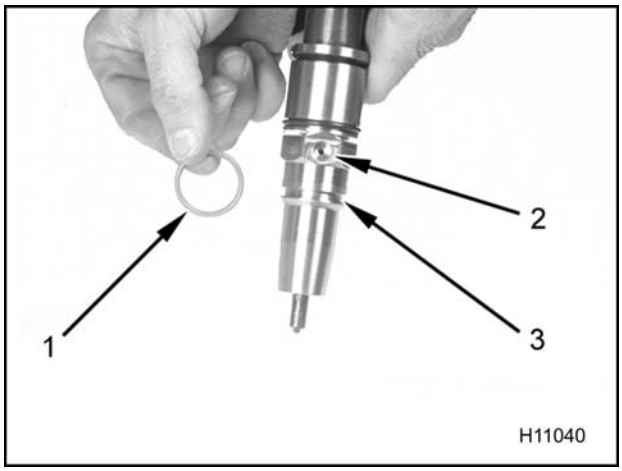


**Figure 551 Injector lower O-ring**

1. Lower O-ring (yellow)
2. Fuel inlet port
3. O-ring recess

2. Lubricate a new lower O-ring with clean engine oil and slide it into the recess just below the four fuel inlet ports.

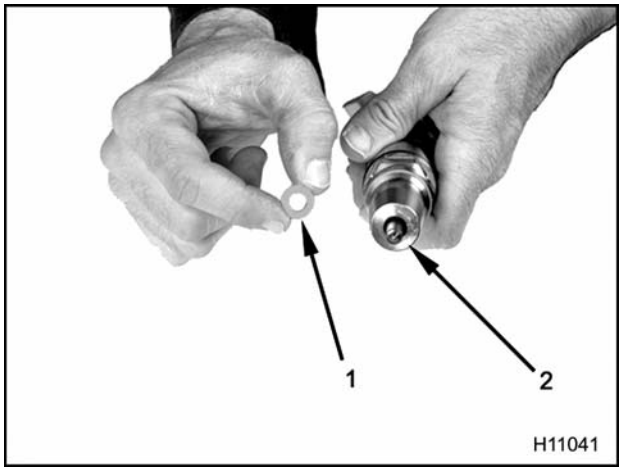


**Figure 552 Installing injector nozzle gasket**

1. Injector nozzle gasket
2. Gasket location

**CAUTION:** To prevent engine damage, do not nick, scratch or mar nozzle gasket in any way.

3. Install new injector nozzle gasket onto end of nozzle. It can go on either way.

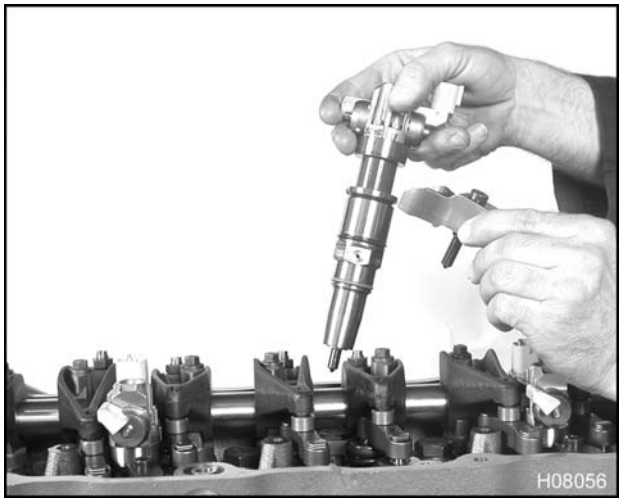


**Figure 553 Install injector assembly**

4. Align injector assembly slot with hold down clamp assembly.


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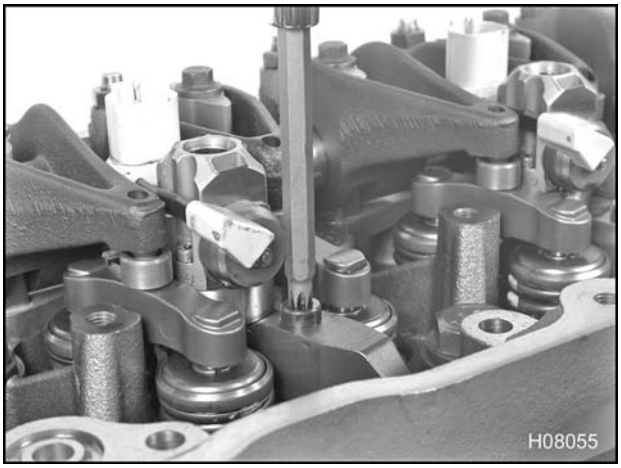


**Figure 554 Installing the injector clamp**

5. Using the fuel injector remover tool (Table 48), install injector hold down clamp assembly. Injector will be placed at the correct height. Tighten bolt to the special torque value (Table 47).

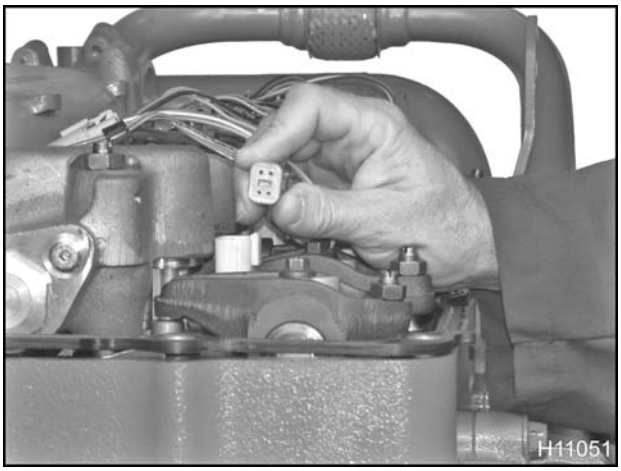


**Figure 555 Injector connector**

6. Connect each injector harness connector to each injector.

**High-pressure Oil Rail Assembly**

**CAUTION:** To prevent engine damage, a new backup ring and injector inlet seal must be installed on all six injector oil inlet tubes.

**CAUTION:** To prevent engine damage, when installing new backup rings, a new backup ring must match the backup ring removed from the injector oil inlet tubes.

**NOTE:** To determine the correct width of the new backup ring, see Groove Measurement (M) in Oil Inlet Tube and Required Backup Ring (Table 45).

1. Inspect injector oil inlet adaptors for internal O-ring extrusion and high-pressure oil leak paths. Verify that each oil inlet tube is moveable. Replace any adaptor having an extruded internal O-ring, high-pressure oil leak path or seized oil inlet tube.

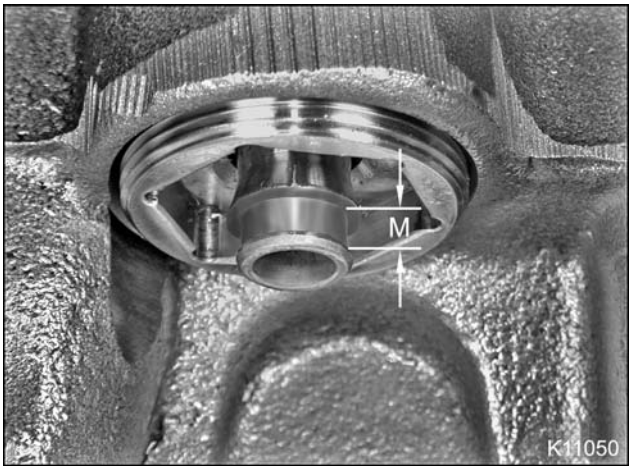


**Figure 556 Groove Measurement (M) in injector oil inlet tube**

2. Measure groove in the injector oil inlet tube.


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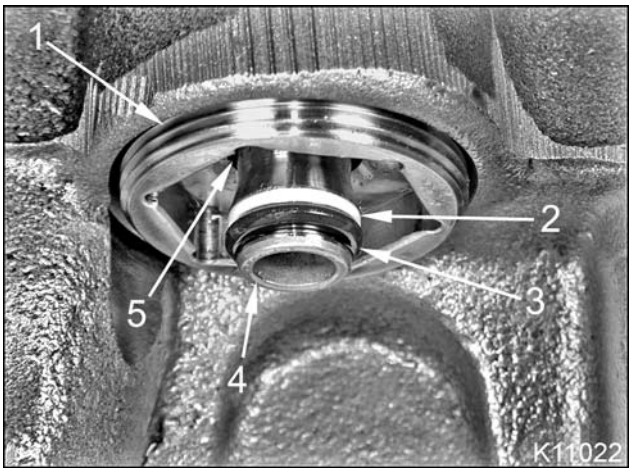


**Figure 557 Injector oil inlet adapter installed in high-pressure oil rail**

1. Injector oil inlet adaptor
2. Backup ring
3. Injector oil inlet seal
4. Oil inlet tube
5. Internal O-ring (not serviceable)

**Table 45 Groove Measurement (M) in Oil Inlet Tube and Required Backup Ring**

| Groove (M) in Oil Inlet Tube | Backup Ring |
|---|---|
| 5.080 mm (0.200 in) | Backup ring 1.8 mm (0.07 in) |
| 4.877 mm (0.192 in) | Backup ring 1.6 mm (0.06 in) |
| 4.420 mm (0.174 in) | Backup ring 1.1 mm (0.04 in) |

3. Install a new backup ring onto injector oil inlet tubes, according to the groove measurements listed in the table.
4. Install new injector inlet seal onto injector oil inlet tubes.
5. Coat backup rings and injector oil inlet seals with clean engine oil.

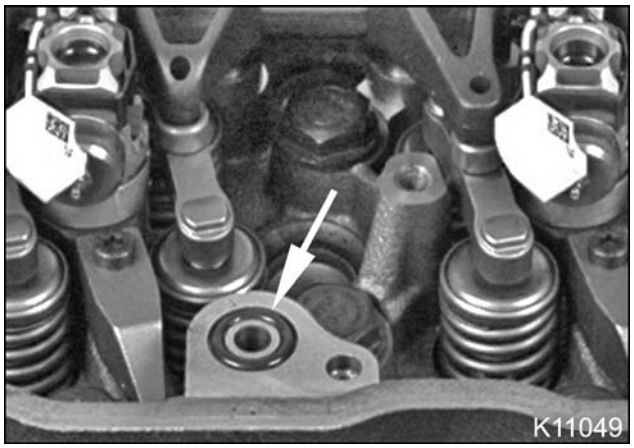


**Figure 558 Oil inlet O-ring**

6. Coat new oil inlet O-ring with clean engine oil and install O-ring in recess in cylinder head.

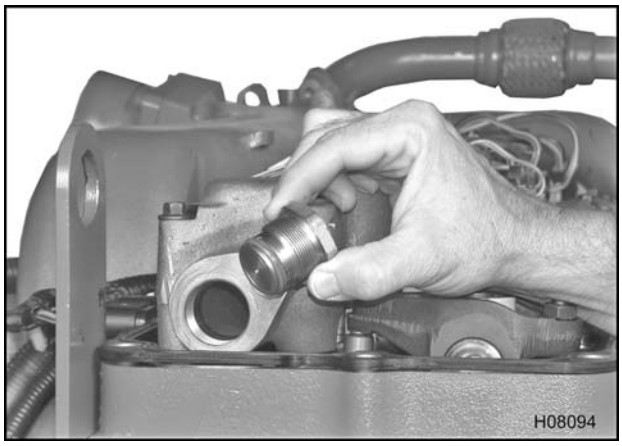


**Figure 559 Rail end plug assembly**

7. See (TSI-05-12-28 New High-pressure Oil Rails, page 465). If rail end plugs or attenuators were removed, install new plugs or attenuators and tighten to the special torque (Table 47).

**WARNING: To prevent personal injury or death, get assistance to remove and install the high-pressure oil rail assembly.**


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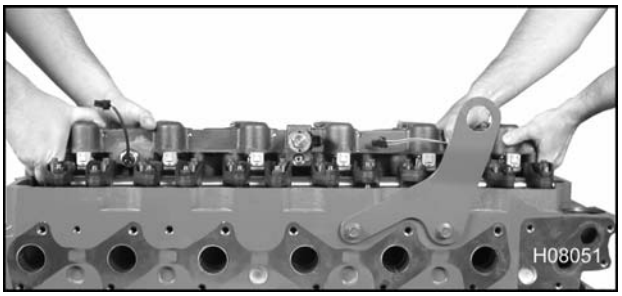


**Figure 560 Installing the high-pressure oil rail assembly**

8. Lift high-pressure oil rail assembly up and place onto engine. Align injector oil supply nozzles with oil inlet adapters.

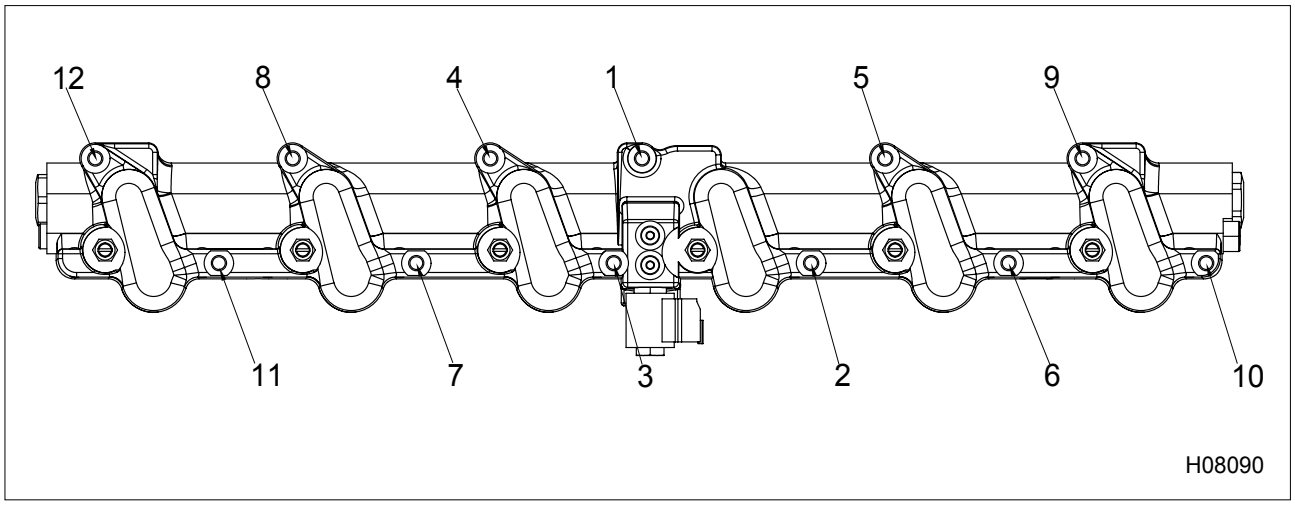


**Figure 561 High-pressure oil rail bolt torque sequence (typical)**

9. Install and hand tighten 12 bolts (M8 x 90) to secure the high-pressure oil rail to the cylinder head. Tighten bolts to the special torque value (Table 47) and in the circular pattern, beginning from the center.


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### High-pressure Oil Pump and IPR Valve Assembly

### IPR Valve Assembly

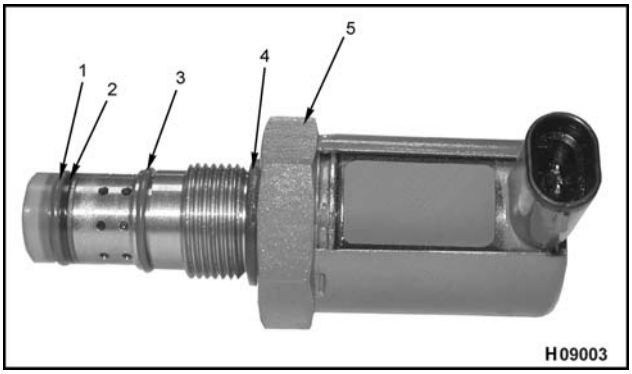


**Figure 562 IPR valve assembly**

1. O-ring seal #015 (green)
2. Back-up ring seal
3. O-ring seal #016 (green)
4. O-ring
5. IPR valve assembly

1. Install new O-rings onto IPR valve assembly.

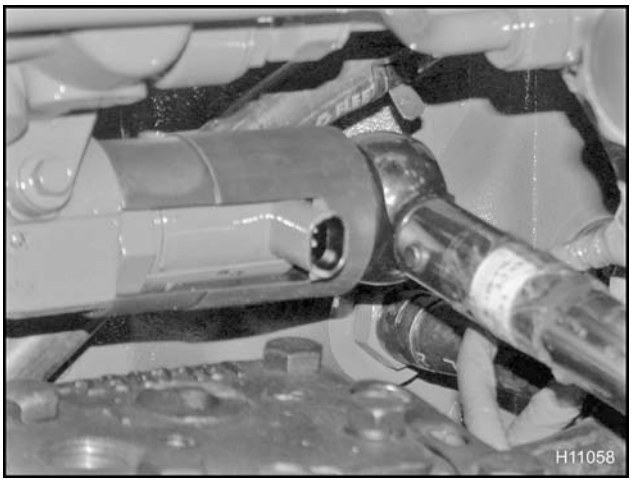


**Figure 563 Installing the IPR valve**

2. Install the IPR valve into the high-pressure pump assembly finger tight. Use the IPR removal / installation tool (Table 48) and a torque wrench to tighten IPR valve to the special torque value (Table 47).

### High-pressure Oil Pump

**NOTE:** A high-pressure pump inlet filter service kit is available. See (TSI-09-12-02 High-pressure Pump Assembly Inlet Filter Service Kit, page483).

1. Use petroleum jelly to hold a new O-ring gasket into the recessed groove, located on the backside of the front cover.
2. Position high-pressure oil pump making sure gear meshes with upper idler gear.

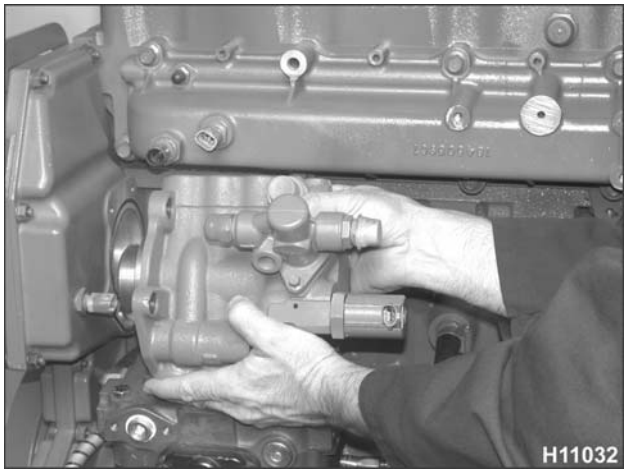


**Figure 564 Installing the high-pressure pump assembly**


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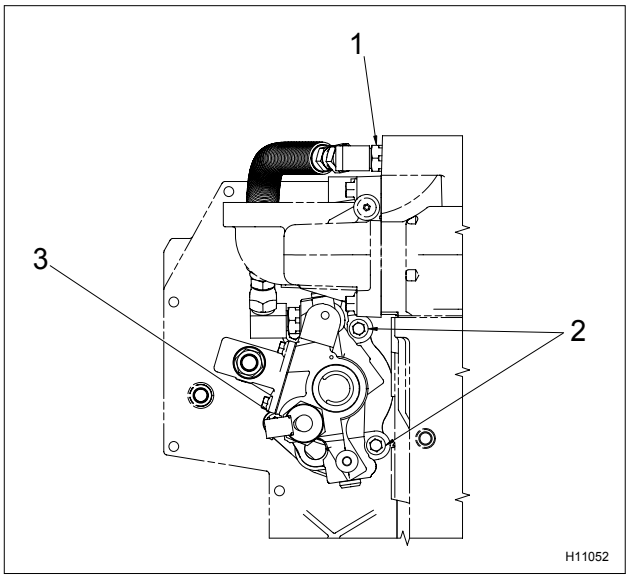


**Figure 565 IPR orientation**

1. Fitting assembly, M18
2. Bolt, M8 x 100 (2)
3. Bolt, M8 x 30 (2)

3. Install two bolts (M8 x 100) behind pump and two bolts (M8 x 30) outside, securing the high-pressure pump to the front cover. Tighten bolts to the special torque value (Table 47).

**High-pressure Hose Assembly – Generation 1**

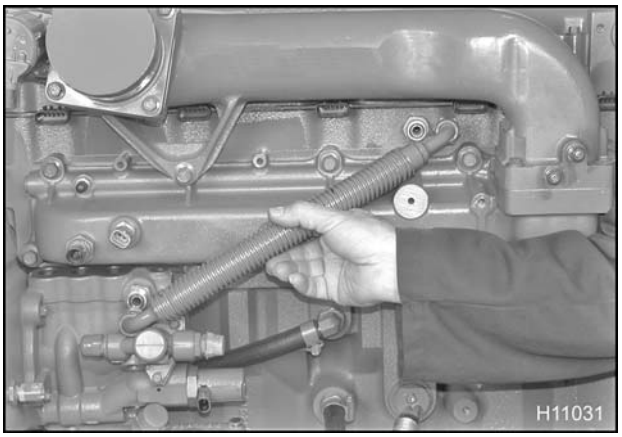


**Figure 566 Installation of high-pressure hose assembly**

1. Install a new O-ring seal onto the high-pressure pump assembly before installing the high-pressure hose assembly. Tighten swivel nut by hand.
2. Install a new O-ring seal onto the high-pressure fitting (M18) at the cylinder head before installing the high-pressure hose assembly.
3. Orient hose fitting assembly at the cylinder head at 0°± 7° relative to horizontal. Tighten swivel nut by hand.
4. Using a crowfoot, tighten both swivel nuts to the special torque value (Table 47) making sure hose is not under any excess tension.

**High-pressure Hose Assembly with 70 and 90 Degree Elbows – Generation 2**

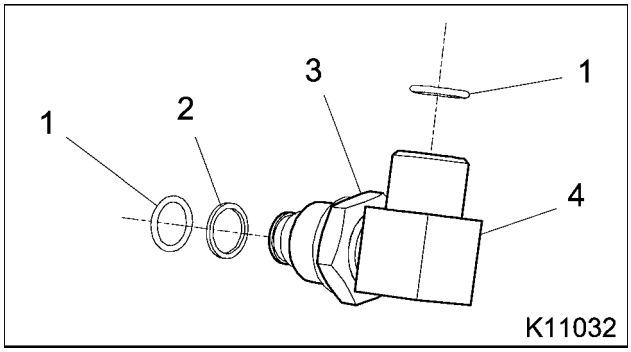


**Figure 567 High-pressure oil elbow (typical)**

1. O-ring seal (#14) (2)
2. Back-up ring
3. Elbow jam nut
4. Elbow

1. Rotate both elbow jam nuts all the way to the base of the elbows.
2. Install new O-rings and back-up ring on the 70 and 90 degree elbows.
3. Lubricate new O-rings with clean engine oil.

**CAUTION:** To prevent engine damage, make all adjustments to the high-pressure oil elbows within 15 minutes of applying Loctite®.

4. Apply two beads of Loctite® 246 Threadlocker (Table 48) to the threads of both high-pressure oil elbows.


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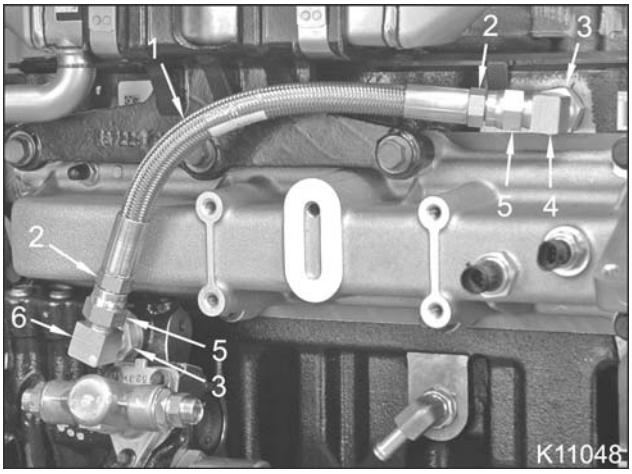


**Figure 568 Good position and alignment of new high-pressure oil hose (typical)**

1. High-pressure oil hose
2. High-pressure oil hose nut (2)
3. Elbow jam nut
4. 70 degree elbow
5. Swivel nut (2)
6. 90 degree elbow

5. Install 70 degree elbow into high-pressure oil port on intake side of the cylinder head. Run fitting all the way in finger tight and then back fitting off (less than one full turn) to orient fitting toward the front of the engine.
6. Install 90 degree elbow into high-pressure oil pump. Run fitting all the way in finger tight and then back fitting off (less than one full turn) to orient fitting.
7. Connect the high-pressure oil hose to the 70 and 90 degree elbows and finger tighten swivel nuts.

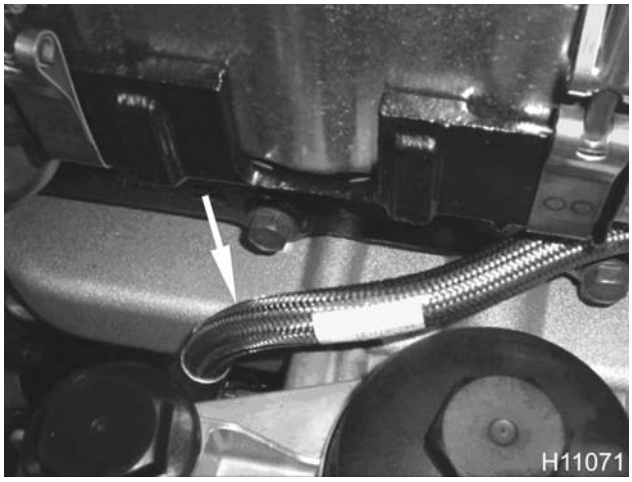


**Figure 569 Bad alignment of high-pressure oil hose (hose twisted)**


**Figure 570 Good alignment of high-pressure oil hose (hose not twisted)**

**CAUTION:** To prevent engine damage, the high-pressure oil hose must be positioned and aligned in a smooth arc, not twisted, under excess tension or touching engine components.

8. Position and align the high-pressure oil hose, so the hose is not under excess tension or twisted. Tighten each swivel nut on the high-pressure hose, using one wrench to hold the hose nut, while using another wrench to tighten the swivel nut to special torque value (Table 47).
9. Position and align the high-pressure oil hose, so the hose is not under excess tension and the hose bends in a smooth arc. Use one wrench to hold


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each elbow, while using another wrench to tighten the elbow jam nut to special torque value (Table 47).

10. Install the conduit cover onto the high-pressure hose.

**Fuel Filter Header Assembly and Intake Manifold**

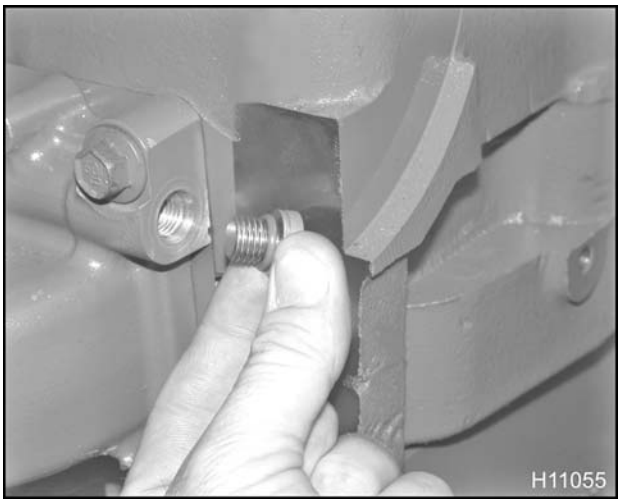


**Figure 571 Installing the fuel rail plug assembly (2)**

1. Install a new O-ring seal onto the plug assembly (M12) and install into each end of intake manifold. Tighten plug to the special torque value (Table 47).

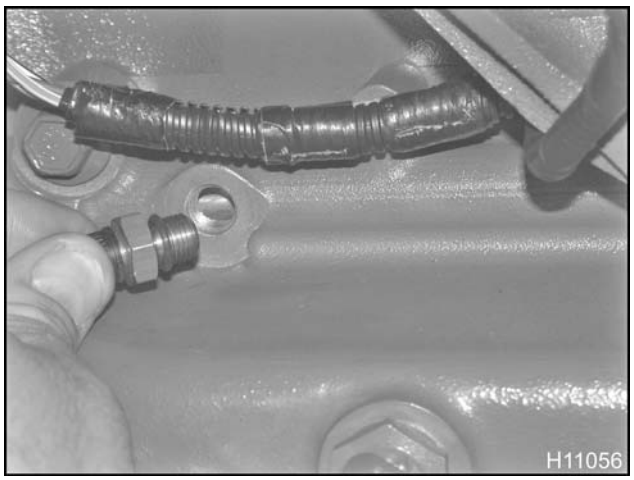


**Figure 572 Installing the fuel valve assembly (air bleed and pressure test port)**

2. Install a new O-ring seal onto the fuel valve assembly (air bleed and pressure test port) and install into port located towards the front of the intake manifold. Tighten to the special torque value (Table 47).

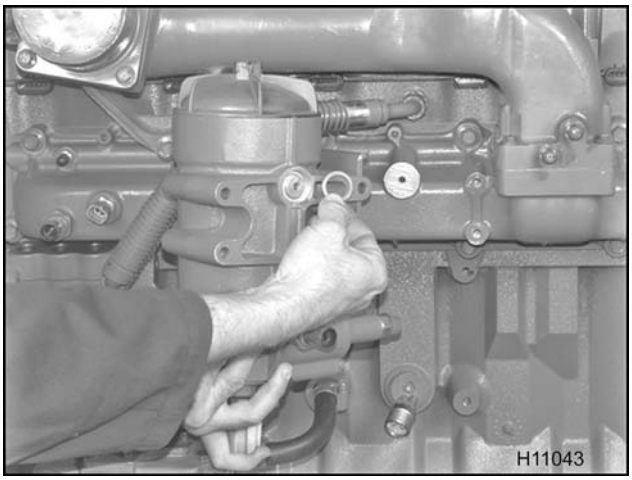


**Figure 573 Installing the fuel filter outlet gasket**

3. Coat the fuel filter outlet gasket with petroleum jelly and set into recess located on backside of fuel filter header. The petroleum jelly will help it stay in position while the filter header is being oriented into position.

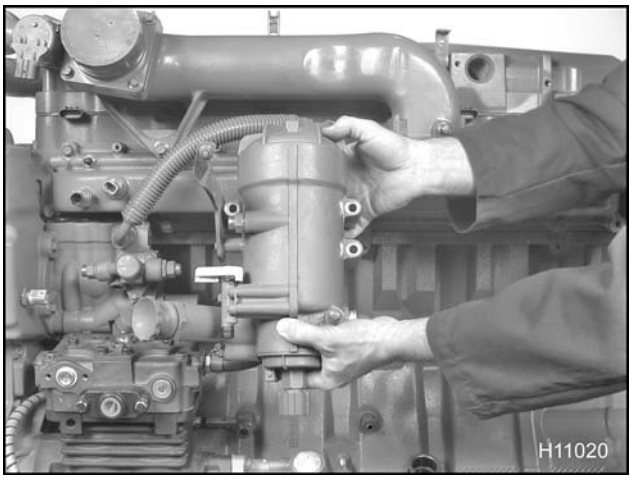


**Figure 574 Installing fuel filter header**

4. Install the fuel filter header and three mounting bolts (M8 x 100) to the intake manifold.


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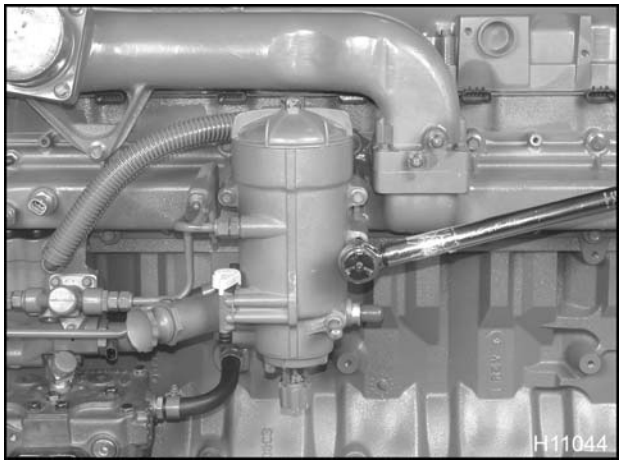


**Figure 575 Fuel filter mounting bolts**

5. Tighten mounting bolts to the special torque value (Table 47).

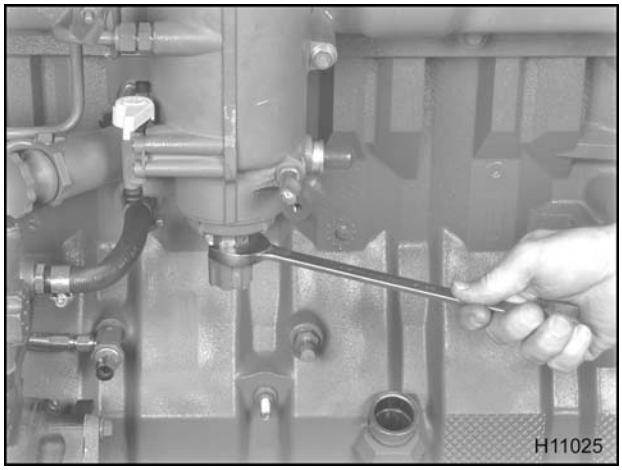


**Figure 576 Installing the fuel strainer**

6. If removed, install the fuel strainer into the filter header with the open end of strainer facing the bowl.
7. Coat fuel bowl threads and a new O-ring with clean fuel. Thread fuel bowl into fuel filter header assembly and torque to the special torque value (Table 47).

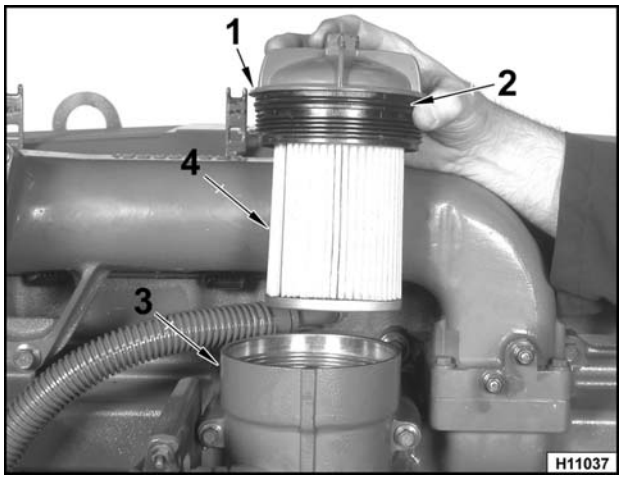


**Figure 577 Installing the fuel filter**

1. Housing cover
2. O-ring
3. Fuel filter housing
4. Fuel filter element

8. Install a new fuel filter element into the fuel filter housing.
9. Place a new O-ring gasket onto housing cover.
10. Install a new fuel filter onto housing cover.
11. Lubricate housing cover threads and O-ring gasket with diesel fuel.
12. Thread fuel filter and housing cover in as an assembly. Torque to the special value (Table 47).

**Low-pressure Fuel Supply Pump and Tubing**

1. Apply clean engine oil to a new seal and place into low-pressure fuel pump recess.


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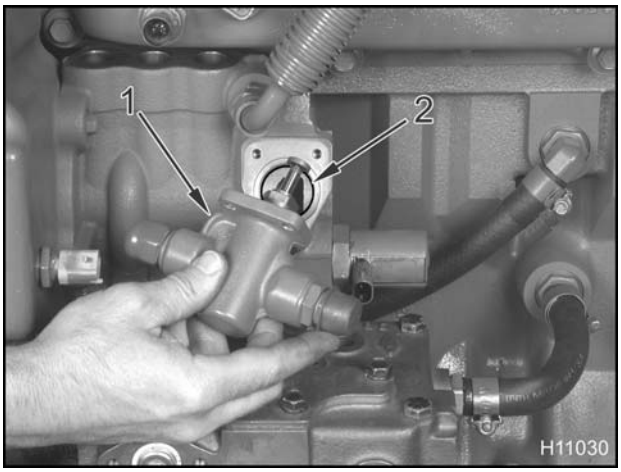


**Figure 578 Installing the low-pressure fuel supply pump**

1. Low-pressure fuel supply pump
2. Seal

2. Install the low-pressure fuel supply pump and three mounting bolts onto the high-pressure oil pump. Tighten mounting bolts to the special torque value (Table 47).

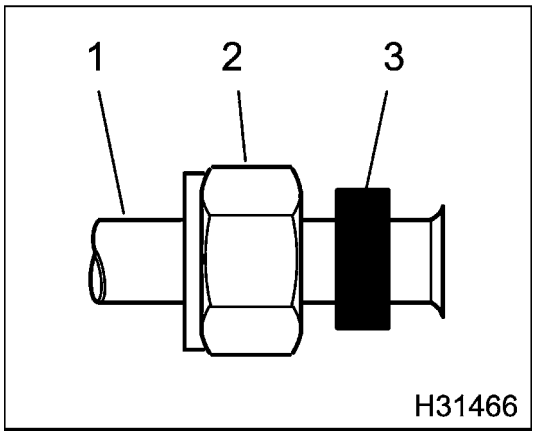


**Figure 579 Position of tube sleeve on fuel line ends**

1. Fuel line
2. Coupling nut
3. Tube sleeve 3/8

**NOTE:** Tube sleeves on fuel lines of engines that used Low Sulfur Diesel (LSD) fuel could leak after changing to Ultra Low Sulfur Diesel (ULSD) fuel.

**CAUTION:** To prevent engine damage, new 3/8 tube sleeves should be installed to prevent leakage.

3. Install a new 3/8 tube sleeve on each end of both transfer tubes (inlet and outlet).

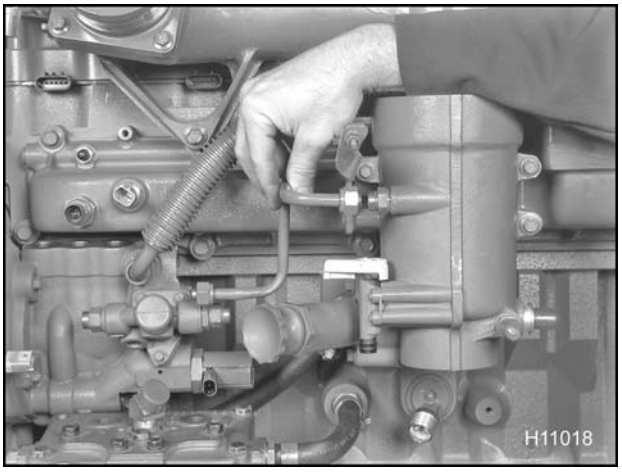


**Figure 580 Connecting the transfer pump outlet tube assembly**

4. Connect transfer pump outlet tube assembly and tighten all fittings.

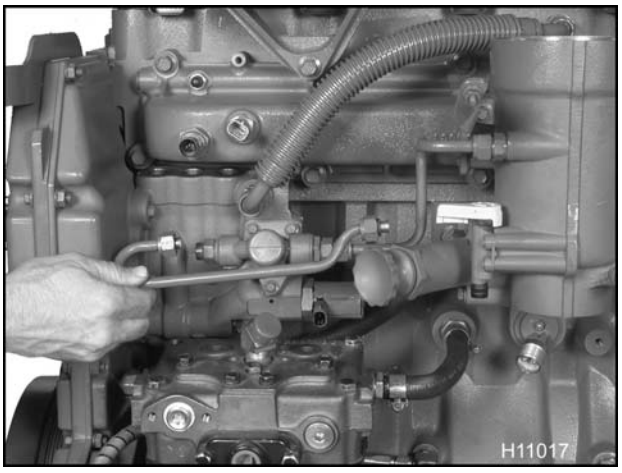


**Figure 581 Connecting fuel lines**

5. Connect transfer pump inlet tube assembly and tighten all fittings to the special torque (Table 47).


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**Priming Fuel System after Out of Fuel**

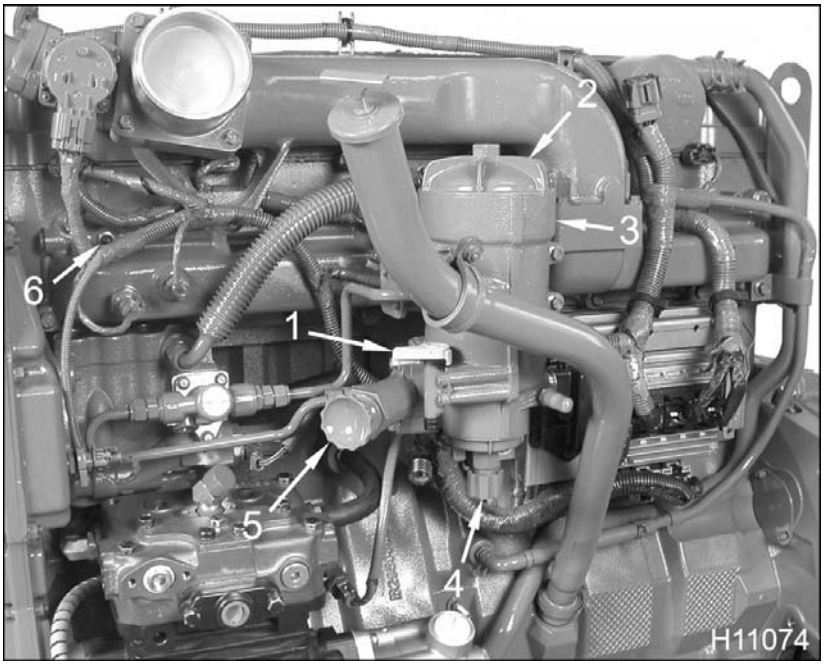


**Figure 582 Fuel filter components and fuel valve assembly**

1. Water drain valve
2. Fuel filter cover
3. Fuel filter header
4. Drain valve (fuel)
5. Fuel primer pump assembly
6. Fuel valve assembly (air bleed and pressure test port)

**WARNING: To prevent 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.**

**CAUTION:** Do not add fuel to the fuel filter header; this can add contaminates to the fuel.

If the engine runs out of fuel, do the following:

1. Set parking brake and place transmission control lever to NEUTRAL or PARK.
2. Unlock the fuel primer pump assembly by turning the knob counterclockwise.
3. Fill the fuel filter header with fuel by pumping the fuel primer pump.

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

4. To aid in filling the fuel filter header and bleed the fuel rail, do the following:

- Bleed the fuel rail by pressing down on the center stem of the fuel valve assembly and pump the fuel primer pump until fuel starts coming out of the fuel valve assembly.
- Once the air has bled out of the fuel rail, release the center stem of the fuel valve assembly and push the fuel primer pump a couple of more times.
- Push the fuel primer pump in one more time and turn the knob clockwise to lock in place.

5. See specific starting procedures in the DT 466, DT 570, and HT 570 *Engine Operation and Maintenance Manual*.


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## Specifications

**Table 46 Fuel System Specifications**

| | |
|---|---|
| Fuel heater switching points | **On**: 2 °C (36 °F) |
| | **Off**: 24 °C (75 °F) |
| Fuel pressure regulator assembly opening pressure | 448 - 517 kPa (65-75 psi) |
| Fuel strainer | 150 micron |
| High-pressure oil manifold, range | 5 - 28 MPa (725 - 4,075 psi) |

## Special Torque

**Table 47 Fuel System Special Torques**

| | |
|---|---|
| Bolt, M8 x 20 | 29 N·m (21 lbf·ft) |
| Drain valve | 0.5 -1 N·m (5 -10 lbf·in) |
| Elbow jam nut | 88 N·m (65 lbf·in) |
| End plug assembly (AWA) or attenuator | 204 N·m (150 lbf·ft) |
| Fitting assembly, 3/8 tube | 27 N·m (20 lbf·ft) |
| Fuel bowl | 39 N·m (29 lbf·ft) |
| Fuel drain plug | 24 N·m (18 lbf·ft) |
| Fuel fitting | 27 N·m (20 lbf·ft) |
| Fuel filter header mounting bolts, M8 x 100 | 27 N·m (20 lbf·ft) |
| Fuel filter housing cover | 25 N·m (18 lbf·ft) |
| Fuel pressure regulator | 1 - 1.7 N·m (10 -15 lbf·in) |
| Fuel valve assembly (air bleed and pressure test port) | 15 N·m (132 lbf·in) |
| High-pressure oil hose fitting, M18 (at head) | 54 N·m (40 lbf·ft) |
| High-pressure oil hose (swivel nuts) | 46 N·m (34 lbf·ft) |
| High-pressure oil manifold bolts, M8 x 90 | 27 N·m (20 lbf·ft) |
| High-pressure oil pump assembly bolts | 30 N·m (22 lbf·ft) |
| High-pressure oil pump assembly (gear) | 231-279 N·m (170 - 205 lbf·ft) |
| Injector hold down clamp assembly | 41 N·m (30 lbf·ft) |
| IPR valve assembly | 50 N·m (37 lbf·ft) |
| Low-pressure fuel pump bolts, M6 x 16 | 15 - 18 N·m (132 - 160 lbf·in) |
| Low-pressure fuel pump tube coupling nuts | 18 N·m (155 lbf·in) |
| Plug assembly, M12 (intake manifold fuel rail) | 24 N·m (18 lbf·ft) |
| Post | 8 N·m (72 lbf·in) |
| Self tapping screw | 5 N·m (41 lbf·in) |
| Water In Fuel (WIF) sensor | 1.7 N·m (15 lbf·in) |


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## Special Service Tools

**Table 48 Fuel System Special Service Tools**

| | |
|---|---|
| Cap kit, injectors | ZTSE4660 |
| Fuel injector remover tool (#40 Torx®) | ZTSE4524 |
| IPR removal / installation tool | ZTSE4666 |
| Loctite® 246 Threadlocker | Obtain locally |


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# Table of Contents

**Description** ..... 367

**Flywheel and Flexplate Applications** ..... 369
- **Manual Transmissions** ..... 369
- **Automatic Transmissions** ..... 372

**Removal** ..... 375
- **Flywheel Assembly** ..... 375
- **Flexplate (Automatic Transmissions)** ..... 376
  - **Allison 2000 Series Transmissions** ..... 376
  - **MD-3000 and HD-4000 Series Transmissions** ..... 376
- **Crankshaft Timing Disk and Rear Oil Seal** ..... 376

**Inspection** ..... 378
- **Flywheel Housing Face Runout** ..... 378
- **Flywheel Housing Bore Concentricity** ..... 378
- **Crankshaft Pilot Concentricity** ..... 378
- **Removing Flywheel Housing** ..... 379

**Flywheel Reconditioning** ..... 379
- **Cleaning** ..... 379
- **Inspection** ..... 379
- **Flywheel Resurfacing** ..... 379
- **Ring Gear Replacement** ..... 380

**Installation** ..... 380
- **Flywheel Housing** ..... 380
- **Rear Oil Seal** ..... 381
- **Crankshaft Timing Disk** ..... 382
- **Flywheel Assembly** ..... 383
- **Checking Flywheel Surface Runout** ..... 384
- **Flexplate (Automatic Transmissions)** ..... 384
  - **Allison 2000 Series Transmissions** ..... 384
  - **MD-3000 and HD-4000 Series World Transmissions** ..... 385

**Specifications** ..... 386

**Special Torque** ..... 387

**Special Service Tools** ..... 387


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## Description

The flywheel housing assembly is bolted to the crankcase and supports the starter motor, rear engine support brackets, and crankshaft position sensor. All transmission applications are designed to be mated to one of four flywheel housing assemblies. Although all are similar in design there are some subtle changes to accommodate a variety of transmission applications. The following lists breaks down the various configurations:

- Flywheel housing SAE #1 houses a flywheel or flexplate with a 138 tooth ring gear.

  Starter location will work only with a 138 tooth ring gear.

  Standard SAE #2 side mount locations.

- Flywheel housing SAE #1A houses a flywheel or flexplate with a 148 tooth ring gear.

  Starter location will work only with a 148 tooth ring gear.

  Standard SAE #2 side mount locations.

- Flywheel housing SAE #2 houses a flywheel or flexplate with a 138 tooth ring gear.

  Starter location will work only with a 138 tooth ring gear.

  Standard SAE #2 side mount locations.

- Flywheel housing (Bus) SAE #2 houses a flywheel or flexplate with a 138 tooth ring gear.

  Starter location will work only with a 138 tooth ring gear.

  High side mounts for bus.

The following illustrations will expand upon the various flywheel and flexplate applications used with the DT466 and 570 engines.


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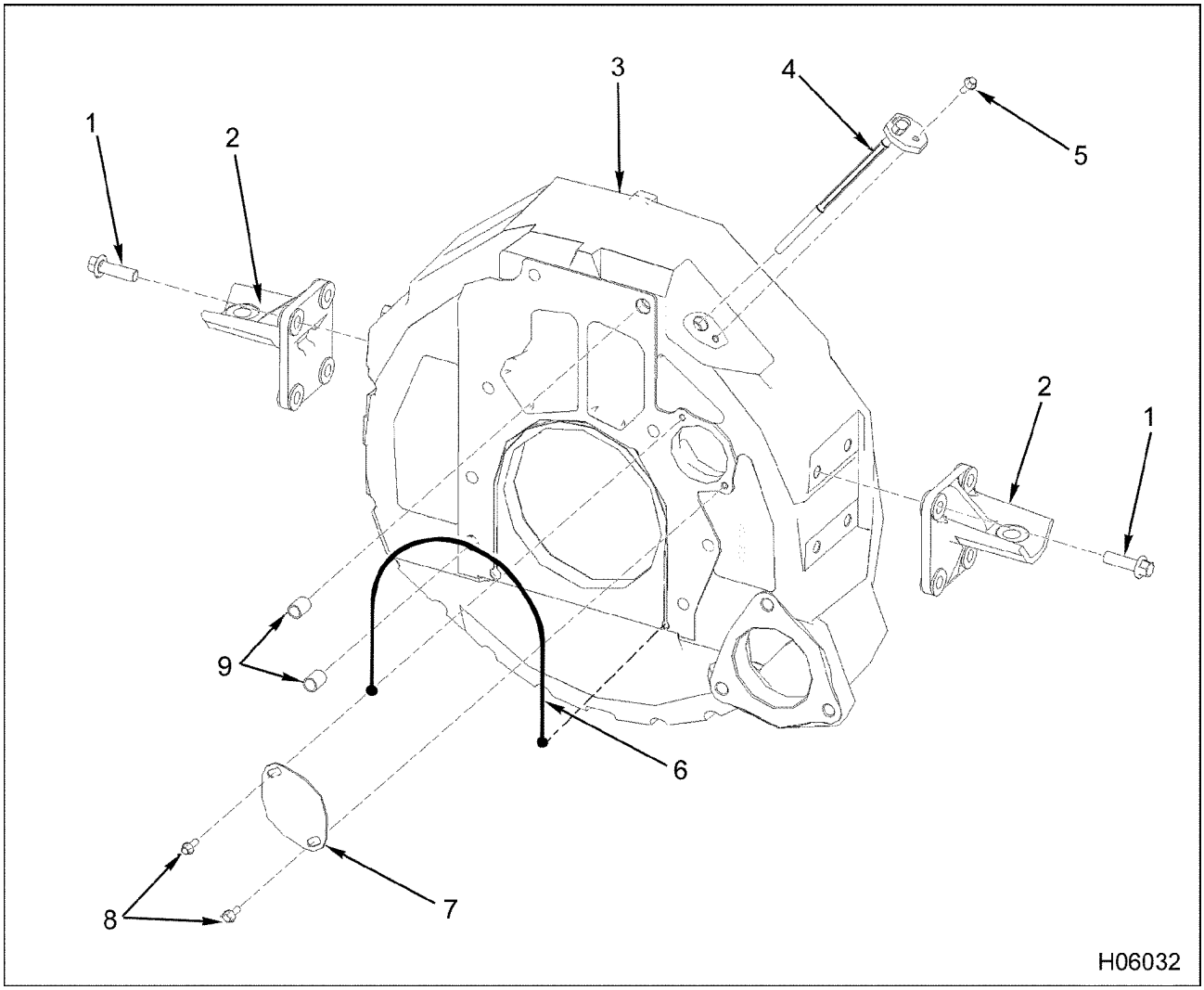


**Figure 583 Flywheel housing and related parts**

1. Bolt, M12 x 40 (8)
2. Rear engine mounting bracket (2)
3. Flywheel housing
4. Crankshaft Position sensor (CKP)
5. Bolt, M6 x 16
6. Flywheel housing seal
7. Cover plate
8. Bolt, M6 x 16 (2)
9. Hollow dowel (2)


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# Flywheel and Flexplate Applications

### Manual Transmissions

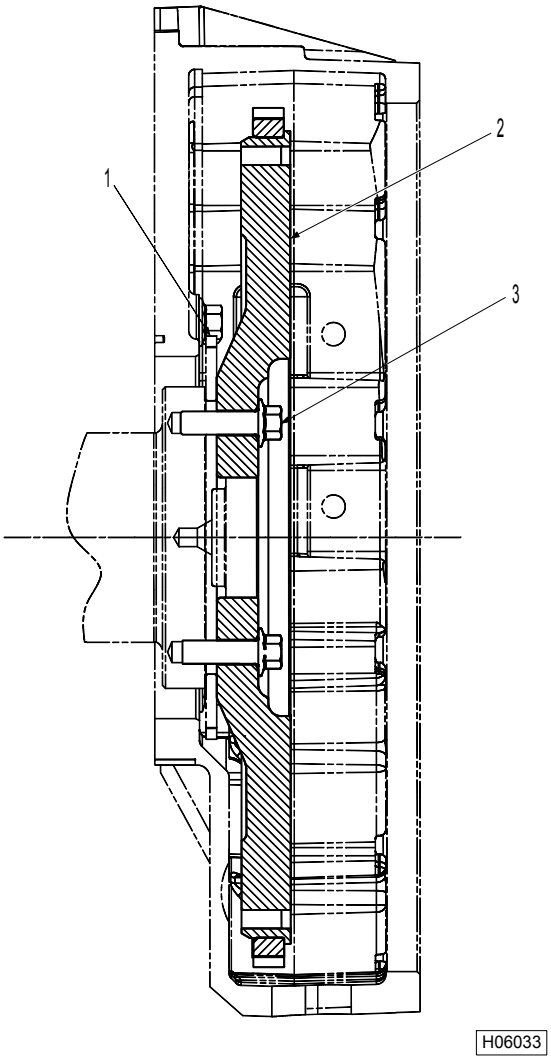


**Figure 584 14 inch flywheel - for multiple plate clutch applications, 800 lbf·ft and below**

1. Crankshaft timing disk
2. Flywheel assembly
3. Bolt, M12 x 40 (12)


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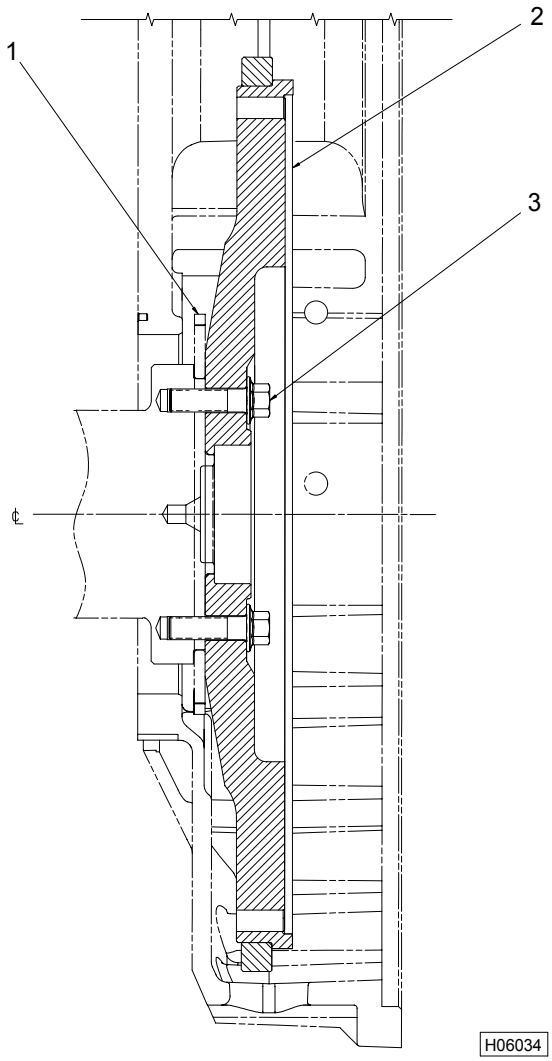


**Figure 585 15.5 inch flywheel - for multiple plate clutch applications, 800 lbf·ft and above**

1. Crankshaft timing disk
2. Flywheel assembly
3. Bolt, M12 x 40 (12)


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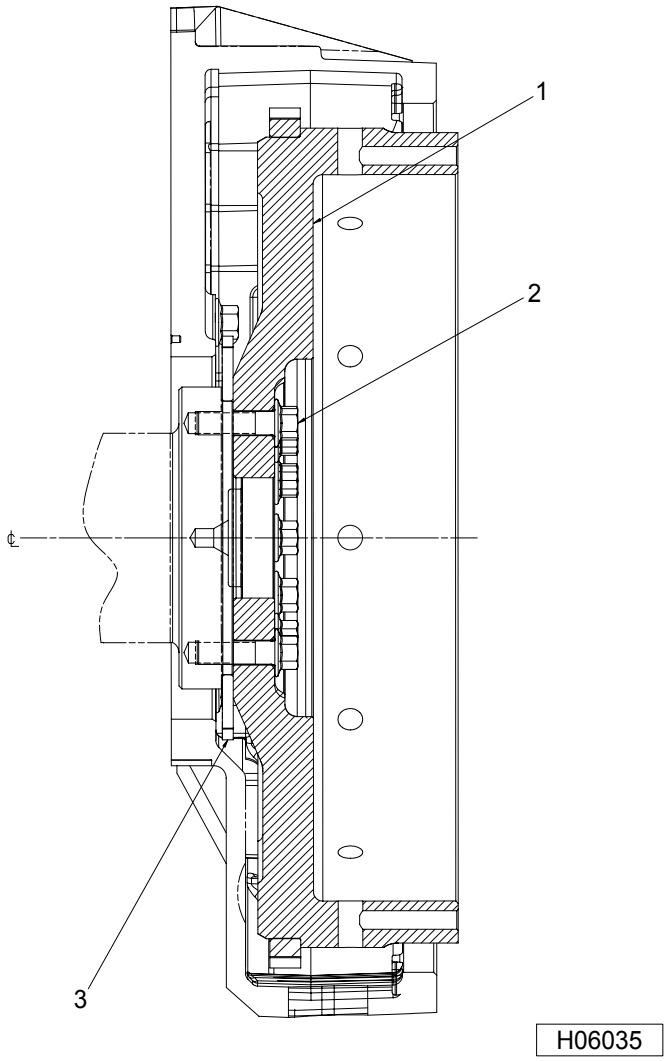


**Figure 586 Pot type flywheel – for multiple plate clutch applications, 800 lbf·ft and above**

1. Flywheel assembly
2. Bolt, M12 x 40 (12)
3. Crankshaft timing disk


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**Automatic Transmissions**

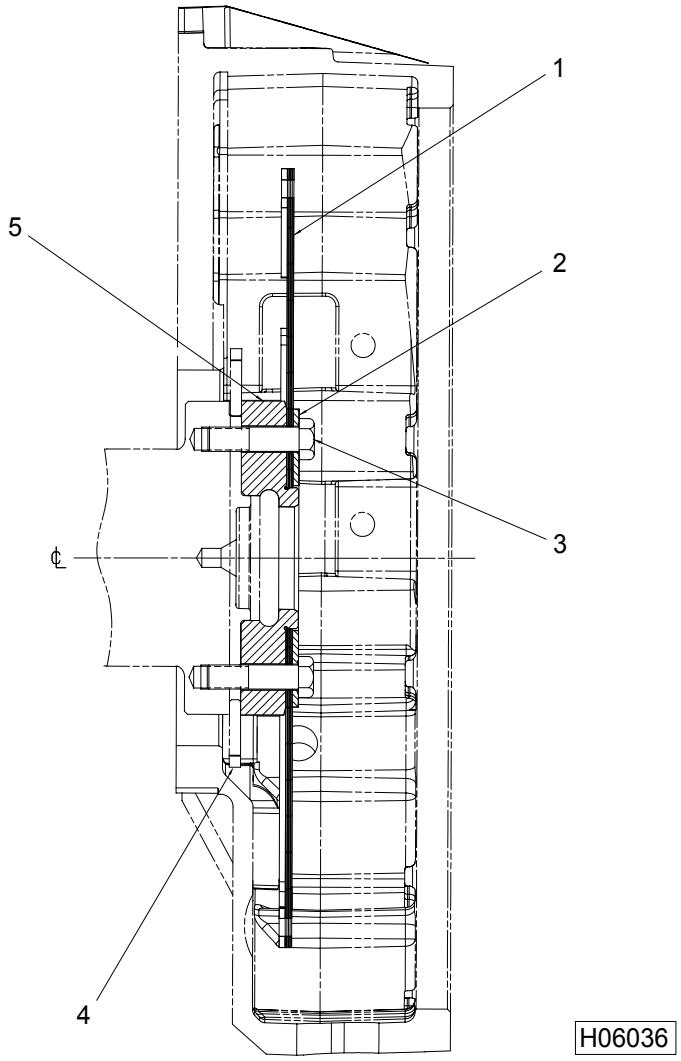


**Figure 587 Application for Allison World Transmissions - MD-3060, MD-3560**

1. Flexplate assembly
2. Reinforcement ring (Allison transmissions only)
3. Bolt, M12 x 45 (12)
4. Crankshaft timing disk
5. Flexplate adapter


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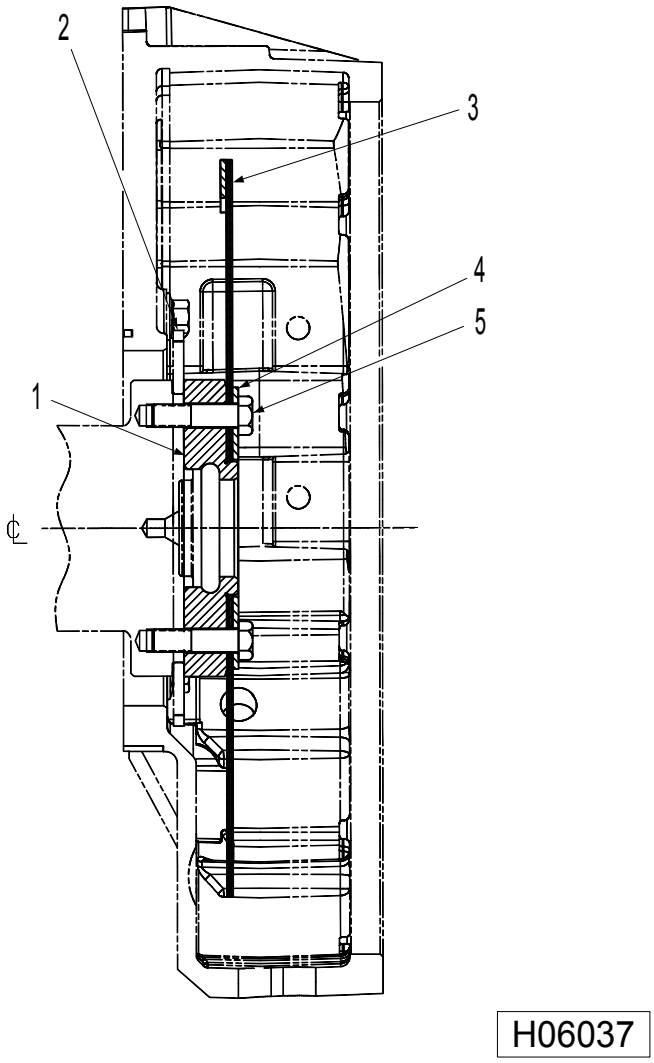


**Figure 588 Application for Allison World Transmission - HD-4000**

1. Flexplate adapter
2. Crankshaft timing disk
3. Flexplate assembly
4. Reinforcement ring
5. Bolt, M12 x 45 (12)


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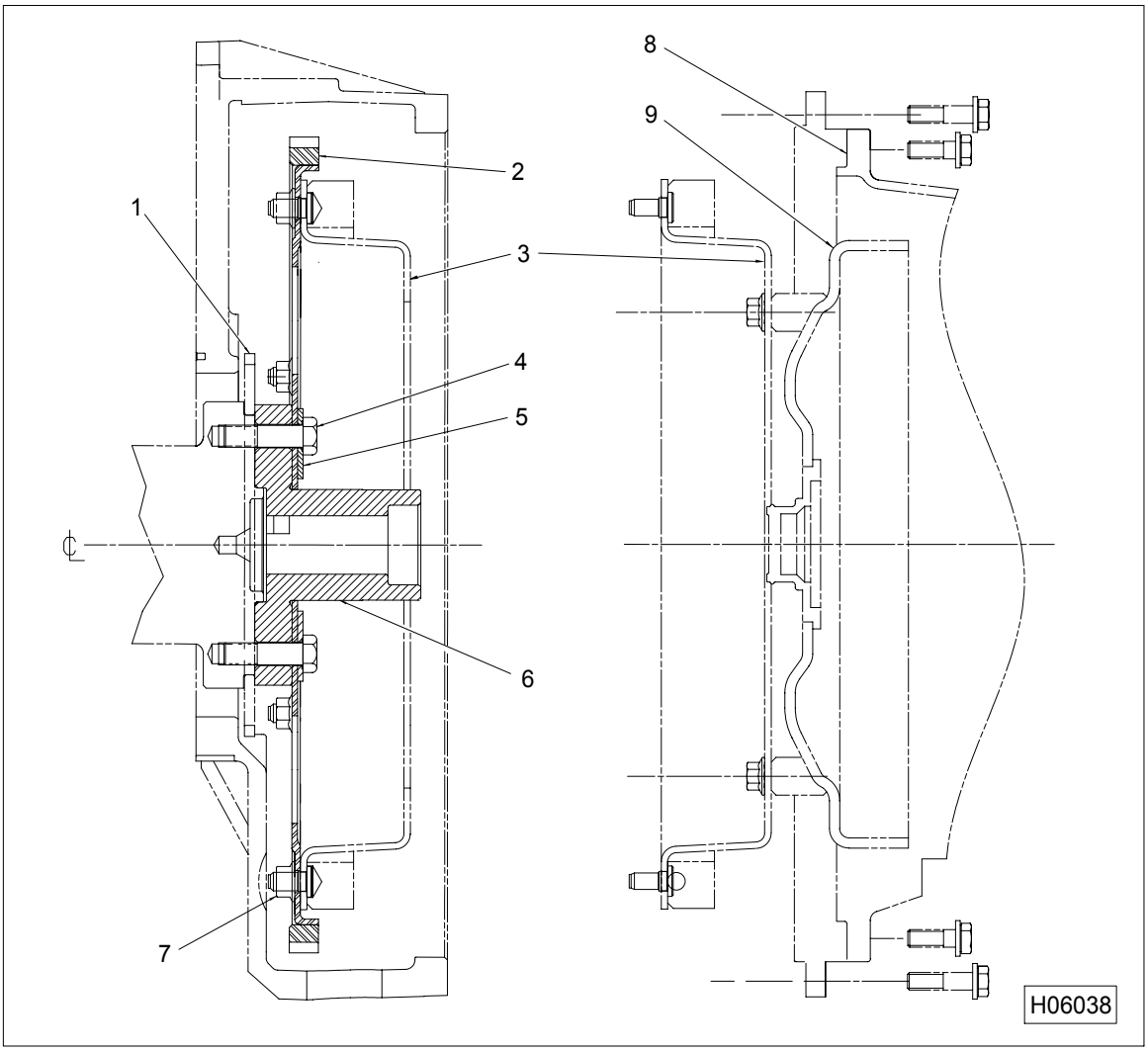


**Figure 589 Application for Allison transmissions - 2000 through 2400 Series**

1. Crankshaft timing disk
2. Flexplate assembly
3. Plate assembly, Allison AT transmissions
4. Bolt, M12 x 43 (12)
5. Reinforcement ring
6. Adapter hub, AT
7. Hex flange nut, M10 x 1.5
8. Transmission case
9. Torque converter assembly


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## Removal

**Flywheel Assembly**

**GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.**

**WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.**

**WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.**

**WARNING: To prevent personal injury or death, disconnect ground (-) cable from battery before doing service or diagnostic procedures.**

**WARNING: To prevent personal injury or death, use a suitable lifting device to support the transmission assembly during removal and installation.**

**WARNING: To prevent personal injury or death, support engine (if in chassis) before removing any engine mounting bracket or flywheel housing bolts.**

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

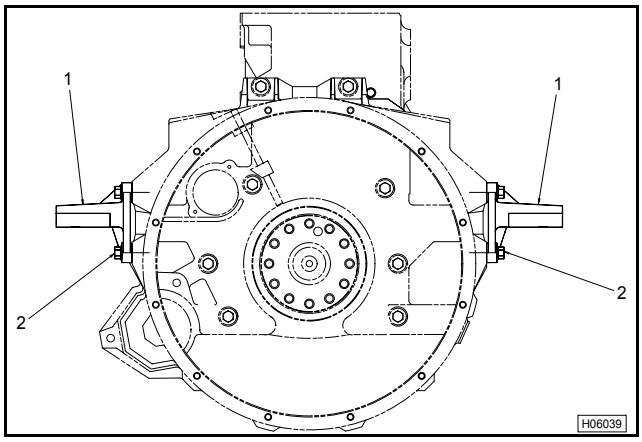


**Figure 590 Loosening engine mounting bolts (148–tooth ring gear only)**

1. Rear engine mounting brackets (2)
2. Mounting bolts, M12 x 40 (8)

1. There are two types of flywheels for manual transmissions: 138–tooth ring gear and 148–tooth ring gear. For flywheels with 148–tooth ring gears, first loosen the two lowest, rear most mounting bolts for the engine mounts on each side of the flywheel housing (SAE #1A). This will provide enough clearance for removal of the ring gear.

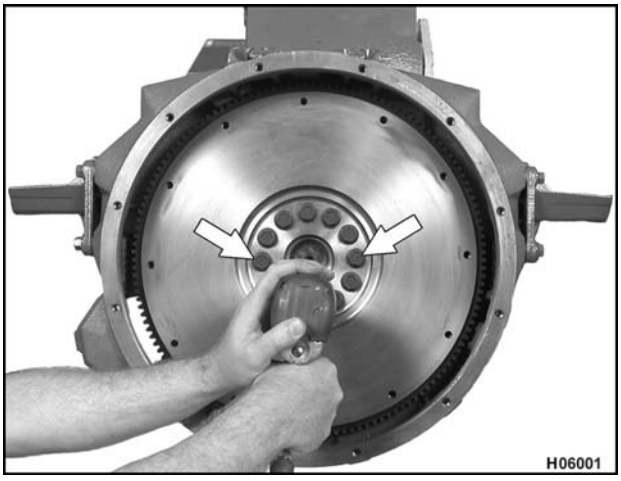


**Figure 591 Removing flywheel mounting bolts**

2. Remove the two flywheel mounting bolts at the 3 o'clock and 9 o'clock positions.
3. Install two guide pins (made locally) in place of the two flywheel mounting bolts.


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4. Remove the remaining ten flywheel mounting bolts.
5. Slide the flywheel out of the flywheel housing and off the guide pins.
6. Remove guide pins.

### Flexplate (Automatic Transmissions)

**NOTE:** The flexplate assembly is available as a service part. Typically, there will be no need to disassemble the flexplate assembly.

#### Allison 2000 Series Transmissions

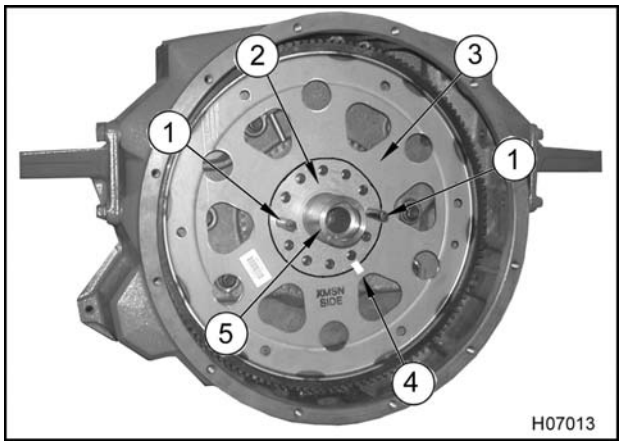


**Figure 592 Removing flexplate (Allison 2000 Series Transmission)**

1. Guide pins
2. Reinforcement ring
3. Flexplate assembly
4. Paint marking index
5. Adapter hub

1. Paint mark the exposed face of the reinforcement ring and flexplate for installation later on.
2. Remove the two flexplate mounting bolts at the 3 and 9 o'clock positions.
3. Install two guide pins (made locally) in place of the two flexplate mounting bolts.
4. Remove the remaining ten flexplate mounting bolts.
5. Slide the reinforcement ring, flexplate and adapter hub off guide pins.
6. Remove guide pins.

#### MD-3000 and HD-4000 Series Transmissions

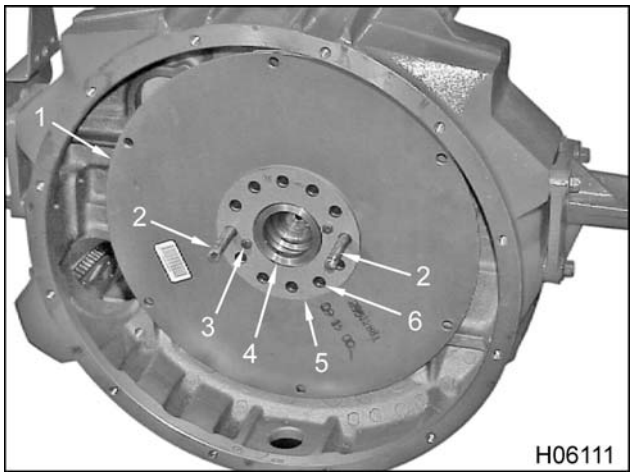


**Figure 593 Removing flexplate (MD-3000 and HD-4000 Series Transmissions)**

1. Flexplate assembly
2. Guide pins
3. Flexplate assembly bolts (2)
4. Adapter hub
5. Reinforcement ring
6. Mounting bolt holes

**NOTE:** Do not remove the two small flexplate assembly bolts.

1. Remove the two flexplate mounting bolts at the 3 o'clock and 9 o'clock positions.
2. Install two guide pins (made locally) in place of the two flexplate mounting bolts.
3. Remove the remaining ten flexplate mounting bolts.
4. Slide the flexplate assembly off the guide pins.
5. Remove the guide pins.

### Crankshaft Timing Disk and Rear Oil Seal

**CAUTION:** To prevent engine damage, if only replacing the timing disk, do not use bolts to remove timing disk from crankshaft. Damage to the rear oil seal could occur resulting in a leak.


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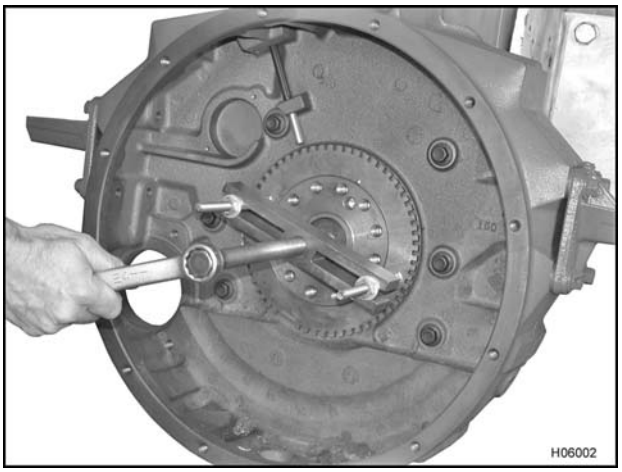


**Figure 594 Removing the crankshaft timing disk**

1. Use an H-bar puller to remove the crankshaft timing disk from the end of the crankshaft (Table 52).

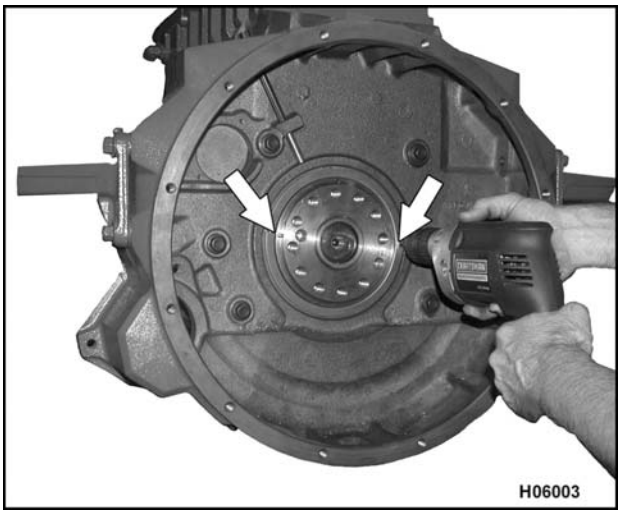


**Figure 595 Drilling holes in the rear oil seal**

**NOTE:** Use appropriate size drill bit for pulling screw.

2. Drill two holes of appropriate diameter for slide hammer use into the rear oil seal at approximately the 3 and 9 o'clock positions.

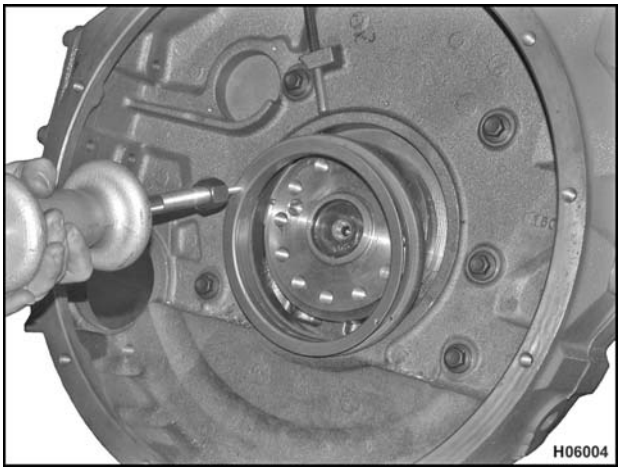


**Figure 596 Removing the rear oil seal**

3. Use a slide hammer (Table 52) to alternately pull on each side of the rear oil seal using the two previously drilled holes. Discard oil seal assembly.


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## Inspection

### Flywheel Housing Face Runout

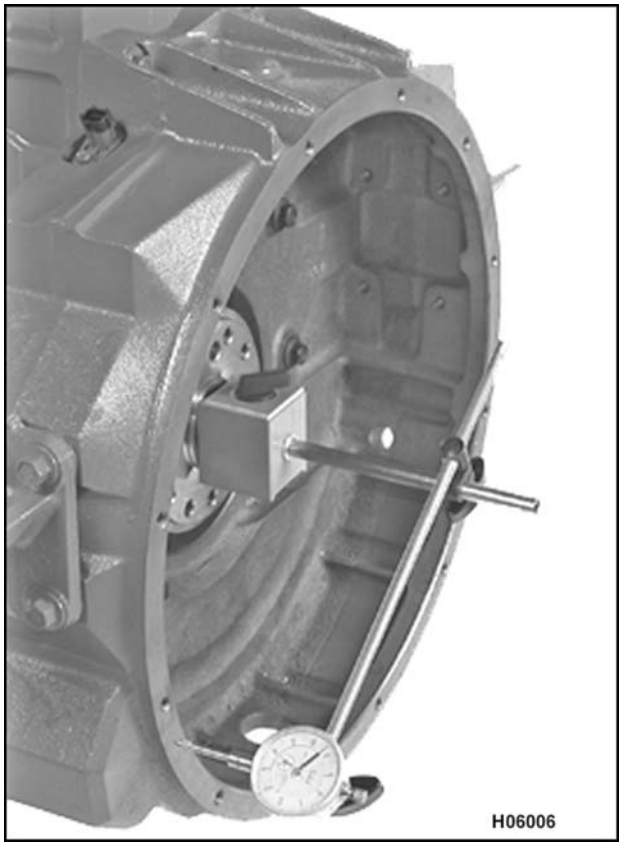


**Figure 597 Flywheel housing face runout**

1. Attach a dial indicator to the crankshaft. Place the tip of the dial indicator against the face of the flywheel housing.
2. Zero the dial indicator.
3. Measure the runout at each 90 degree interval (four locations) around the face of the flywheel housing.
4. Record the total variation of the four measurements and compare the result to the flywheel housing face runout specification.

### Flywheel Housing Bore Concentricity

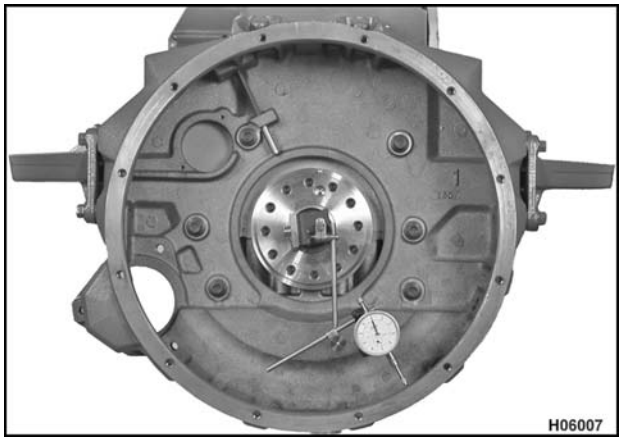


**Figure 598 Flywheel housing bore concentricity**

1. Attach a dial indicator to the crankshaft. Place the tip of the dial indicator against the flywheel housing bore.
2. Zero the dial indicator.
3. Slowly rotate the crankshaft. Record the total indicator variation and compare the result to the flywheel housing bore concentricity specification.

### Crankshaft Pilot Concentricity

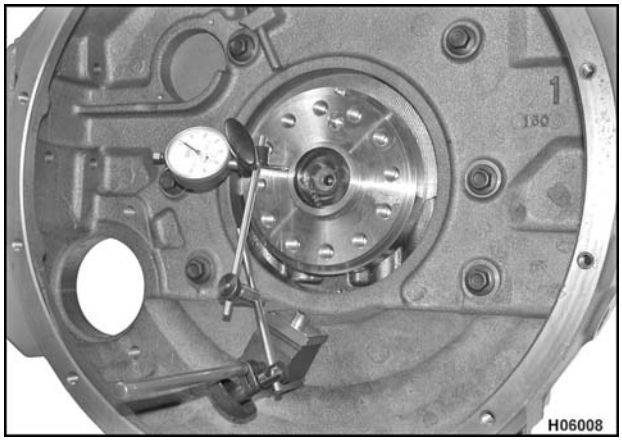


**Figure 599 Crankshaft pilot concentricity**

1. Attach a dial indicator to the flywheel housing. Place the tip of the dial indicator against the crankshaft pilot.
2. Zero the dial indicator.


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3. Slowly rotate the crankshaft. Record the total indicator variation and compare the result to the crankshaft pilot concentricity specification.

### Removing Flywheel Housing

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, do not remove any engine mounting hardware until the engine is properly supported.**

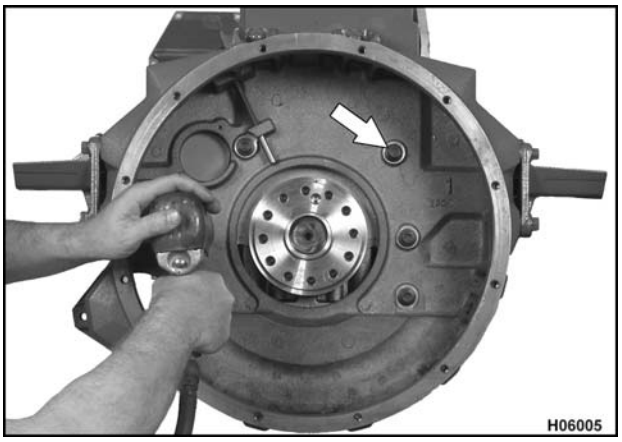


**Figure 600 Removing flywheel housing mounting bolts**

1. Remove the eight mounting bolts that secure the flywheel housing to the crankcase.
2. Use an assistant to help remove the flywheel housing from the engine.
3. Inspect for cracks.

## Flywheel Reconditioning

### Cleaning

Clean the flywheel with a non-caustic solvent and dry with filtered compressed air.

### Inspection

1. Inspect the flywheel for cracks, heat checks, and extensive scoring which would make it unfit for further service. Replace or resurface as required.
2. Inspect ring gear for worn, chipped, or cracked teeth. If teeth are damaged, replace ring gear.

### Flywheel Resurfacing

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, carefully examine the flywheel after resurfacing for any cracks or heat checks. Flywheel resurfacing information is provided for guidance only. Navistar, Inc. assumes no responsibility either for the results of any work performed in accordance with this information or for the ability of service personnel to detect heat cracks. Any cracks or heat checks in the flywheel could cause it to separate, creating the possibility of injury to the operator or bystanders. If there are any questions, do not use the flywheel.**

**CAUTION:** Flexplates used with automatic transmissions cannot be resurfaced. If damaged, replace flexplate.

Flywheels used with manual transmissions may be resurfaced to correct minor wear and scoring.

When resurfacing the flywheel, see dimension “A” on figure below, to determine if the flywheel was previously refaced or if it has adequate stock for refacing.


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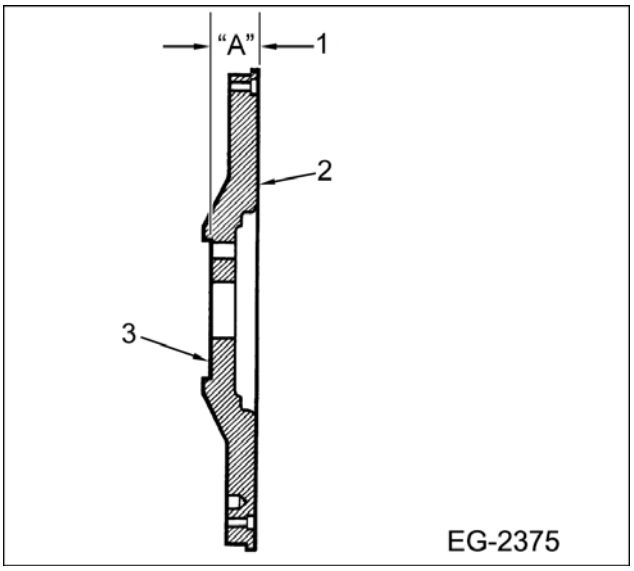


**Figure 601 Flywheel reconditioning**

1. Dimension "A": New flywheel: 38 + 0.025 mm (1.500 in + 0.010 in). Minimum permissible after resurfacing: 36 mm (1.430 in).
2. Clutch disc mounting face
3. Crankshaft flange mounting face

**NOTE:** If the dimensions depicted in the figure above cannot be maintained, the flywheel must be replaced.

### Ring Gear Replacement

1. Remove any damaged ring gear from the flywheel as follows:
   A. Heat ring gear with a torch to expand gear.
   B. Once heated, knock the ring gear off flywheel. Do not hit the flywheel when removing gear.

**WARNING: To prevent serious personal injury or possible death, wear heat resistant gloves when handling heated components.**

2. Install a new ring gear as follows:
   A. Heat the new ring gear evenly until the gear expands enough to slip onto the flywheel.
   B. Make sure the ring gear is seated properly against the flywheel shoulder.

**NOTE:** Do not heat ring gear to a temperature higher than 278 °C (500 °F). Heating beyond this temperature will adversely affect the ring gear hardness.

## Installation

### Flywheel Housing

**NOTE:** Make sure the camshaft seal (page 266) is installed in the crankcase.

**NOTE:** Verify that the two hollow dowels and the flywheel housing seal are in place before installing the flywheel housing (Figure 583).

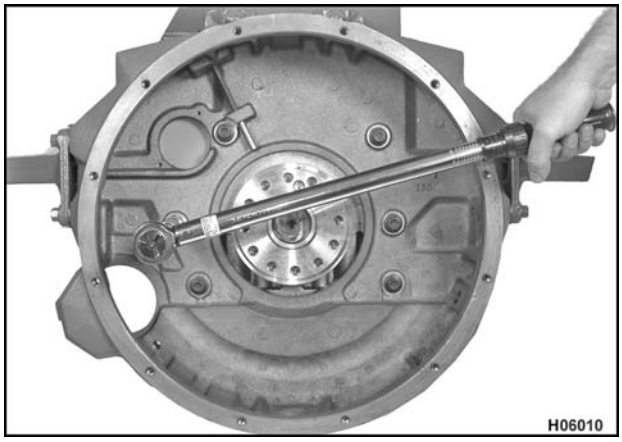


**Figure 602 Torquing flywheel housing mounting bolts**

1. Use an assistant to help lift the flywheel housing into position.
2. Install all eight flywheel housing mounting bolts (M12 x 50) finger tight. Then tighten the bolts to the special torque value (Table 51).
3. Install rear engine mounting brackets and bolts (M12 x 40). Tighten bracket bolts to the special torque value (Table 51).

**NOTE:** On engines with a 148–tooth ring gear, leave the lowest, rear most mounting bracket bolt loose (2 or 3 threads) on each side of the flywheel housing (SAE #1A). This will provide enough clearance for installation of the flywheel and ring gear assembly.


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**Rear Oil Seal**

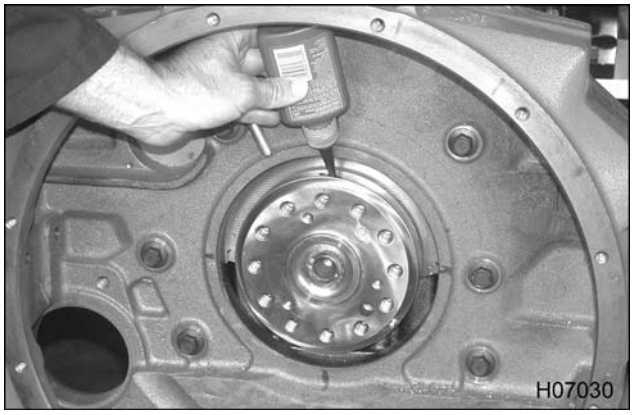


**Figure 603 Applying sealant to the crankshaft and seal assembly**

1. Apply a 360° bead of Loctite® hydraulic sealant to the crankshaft where the rear oil seal assembly will be positioned.

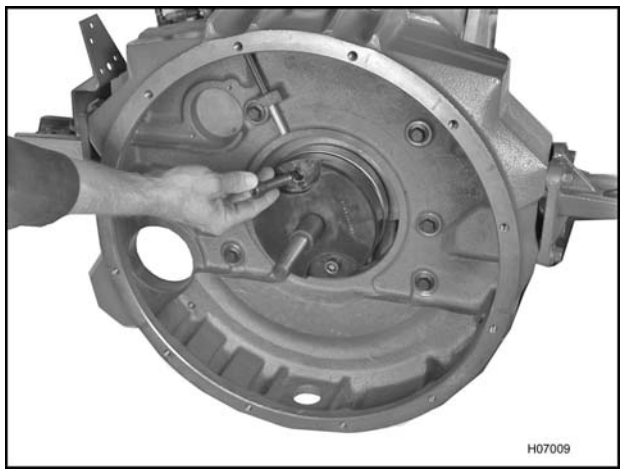


**Figure 604 Installing the rear oil seal installer base**

2. Install base component of oil seal installer onto crankshaft and tighten bolts (2).

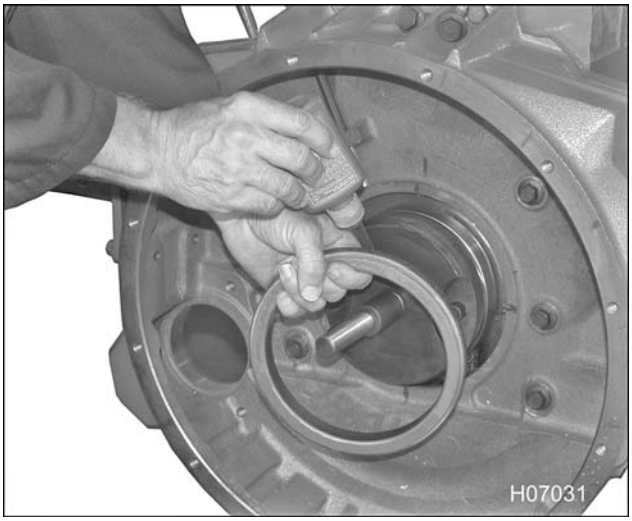


**Figure 605 Applying sealant to the seal assembly**

3. Apply a 360° bead of Loctite® hydraulic sealant to the outside diameter of the rear oil seal assembly.

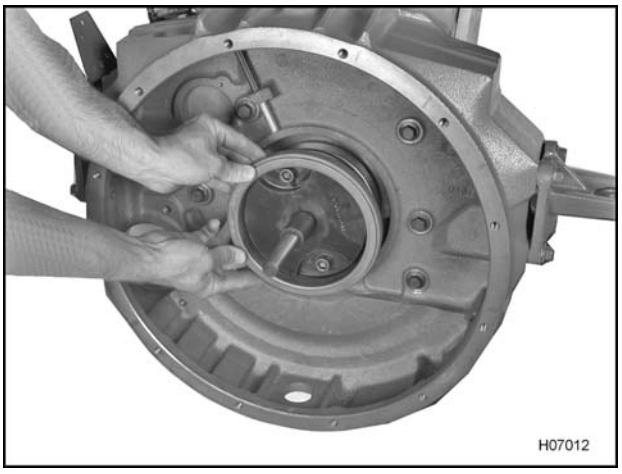


**Figure 606 Placing oil seal onto rear oil seal installer base**

4. Orient steel face of oil seal outward (towards transmission) and start seal onto oil seal installer base.


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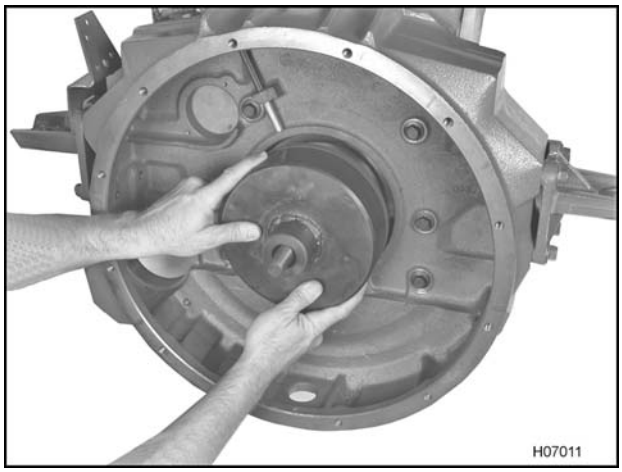


**Figure 607 Installing rear oil seal installer onto base**

5. Place oil seal installer up to steel face of seal and gently push by hand into flywheel housing as far as possible.

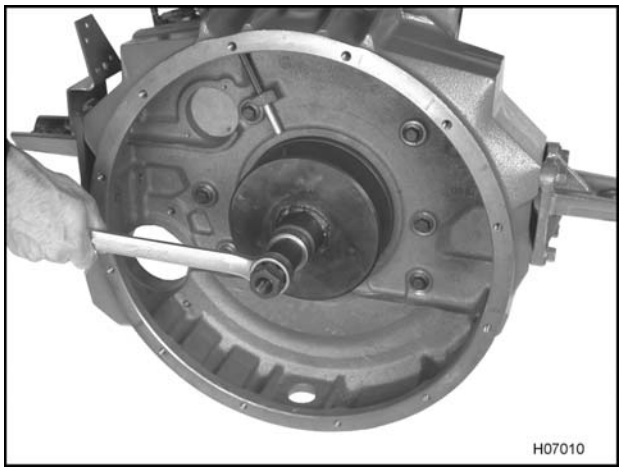


**Figure 608 Installing the rear oil seal**

6. Put washer and forcing nut onto shaft and tighten until rear oil seal bottoms out in flywheel housing. The seal will be placed at the correct location (depth).

### Crankshaft Timing Disk

**NOTE:** Alignment dowel pin convex end must protrude out of crankshaft (Figure 583).

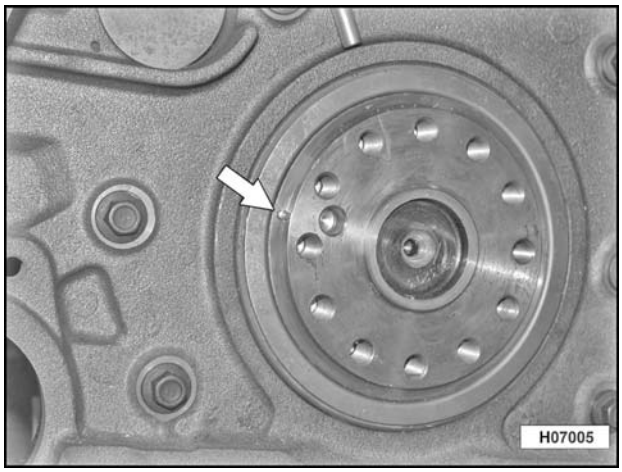


**Figure 609 Crankshaft timing disk alignment dowel**

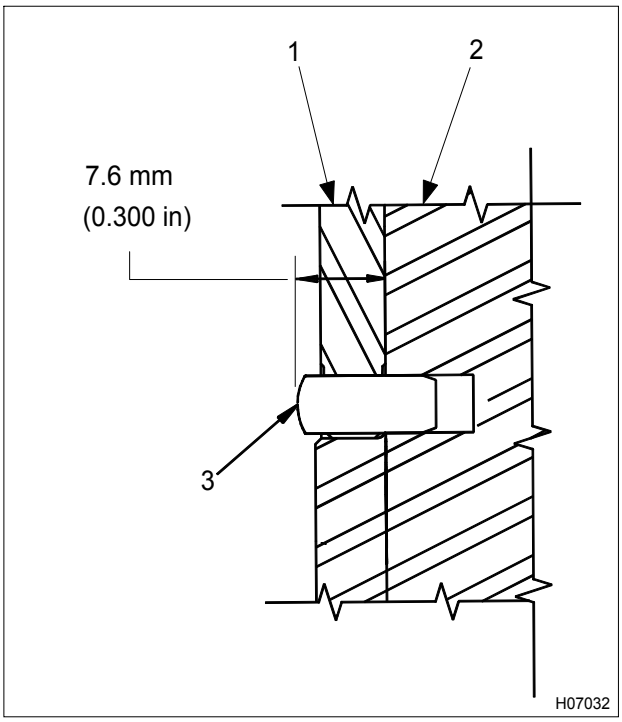


**Figure 610 Crankshaft timing disk alignment dowel details**

1. Crankshaft timing disk
2. Crankshaft
3. Alignment dowel (convex end)


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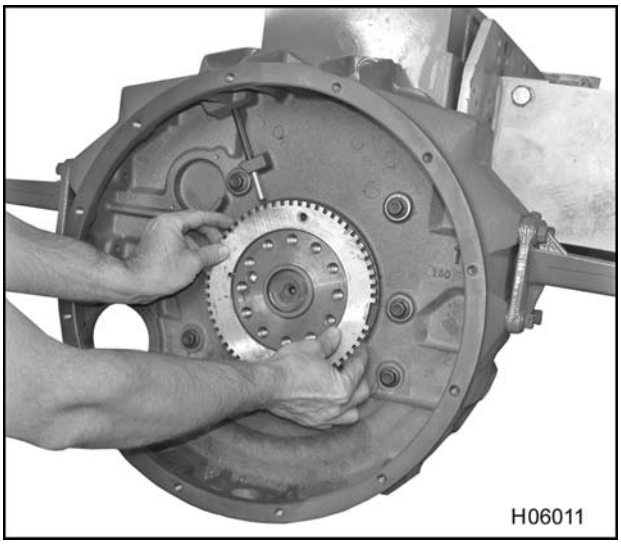


**Figure 611 Installing the crankshaft timing disk**

**NOTE:** Crankshaft timing disk can be installed with either side out.

1. Align index notch of the crankshaft timing disk with alignment dowel. Use a rubber mallet to tap the crankshaft timing disk onto the crankshaft. Tap evenly around the crankshaft timing disk to ensure a flush fit against the end of the crankshaft.

### Flywheel Assembly

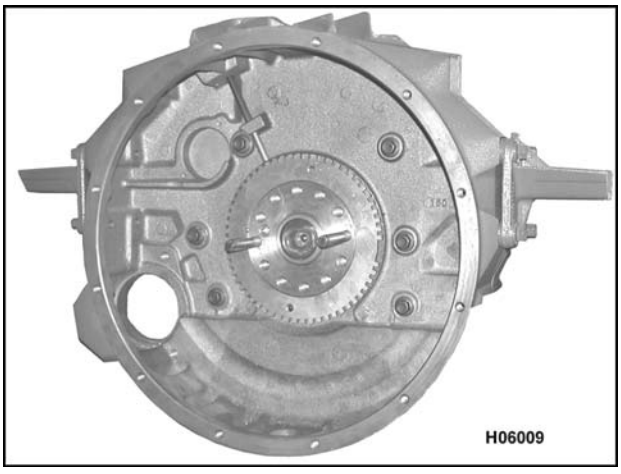


**Figure 612 Installing guide pins**

1. Install two guide pins in the flywheel mounting bolt holes at the 3 o'clock and 9 o'clock positions.
2. Install the flywheel onto the guide pins.
3. Install ten flywheel mounting bolts finger tight.
4. Remove the guide pins and install the remaining two flywheel mounting bolts finger tight.

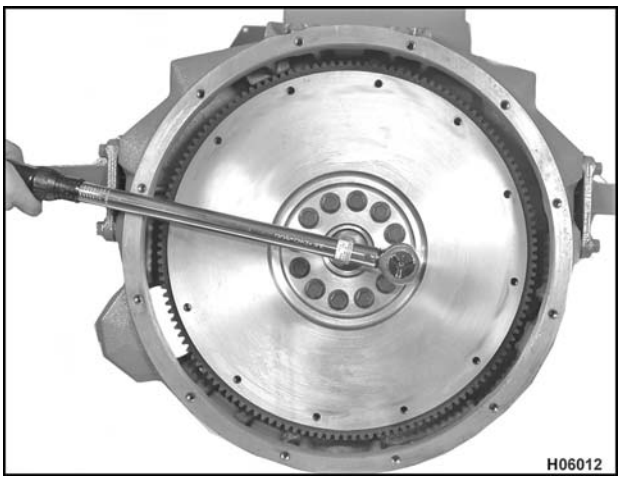


**Figure 613 Torquing the flywheel mounting bolts**

5. Tighten the flywheel mounting bolts to the special torque value (Table 51).
6. Tighten two remaining rear engine mounting bracket bolts on manual transmission applications with 148 tooth ring gears to the special torque value (Table 51).


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### Checking Flywheel Surface Runout


**Figure 614 Checking flywheel surface runout**

1. Attach a dial indicator to the face of the flywheel housing. Place the tip of the dial indicator against the face of the flywheel.
2. Zero the dial indicator.
3. Slowly rotate the flywheel. Record the total indicator variation and compare the result to the flywheel surface runout specification.

### Flexplate (Automatic Transmissions)

### Allison 2000 Series Transmissions

**CAUTION:** To prevent engine damage, if the vehicle is being reconfigured with an Allison 2000 Series transmission, make sure that the correct flywheel housing is installed on the engine. Otherwise, there will be interference between the flexplate studs and the flywheel housing that will only be evident after the transmission has been installed.

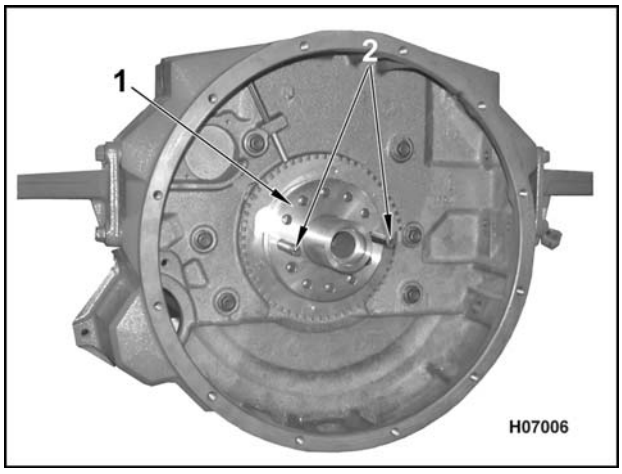


**Figure 615 Installing guide pins and adapter hub**

1. Adapter hub
2. Guide pins

1. Install two guide pins in the flexplate mounting bolt holes at the 3 o'clock and 9 o'clock positions.
2. Install the adapter hub on the guide pins.

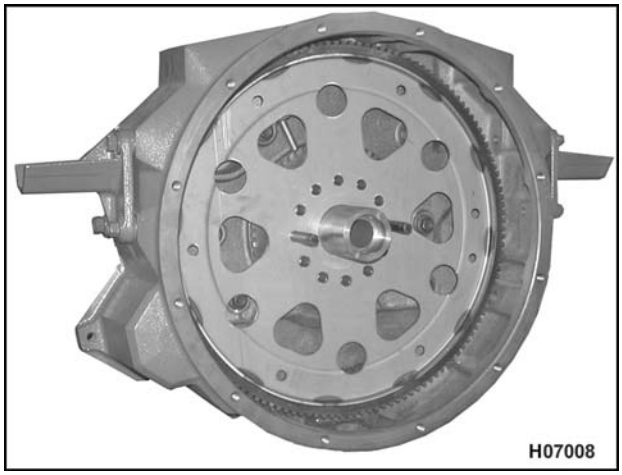


**Figure 616 Installing the flexplate**

1. Flexplate assembly

**NOTE:** When installed correctly, the ring gear on the flexplate is offset (not centered) toward the transmission.

3. Install the flexplate assembly on the guide pins.


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**CAUTION:** To prevent engine damage, make sure the reinforcement ring is installed with the paint mark or XMSN SIDE facing outward (towards the transmission), otherwise, premature flexplate failure may occur.

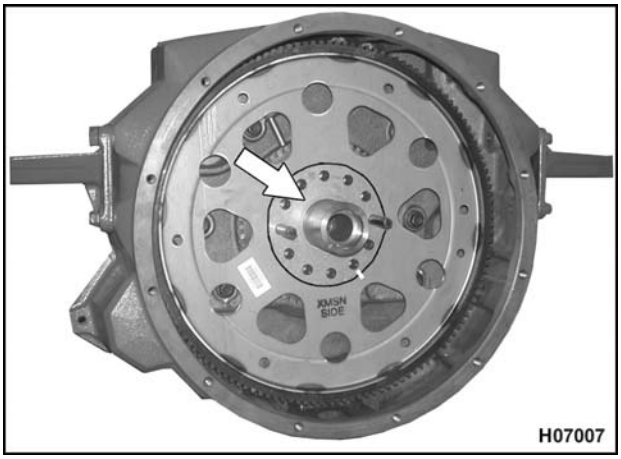


**Figure 617 Installing reinforcement ring with paint mark**

4. Install the reinforcement ring on the guide pins (made locally) with paint mark facing outward.
5. Install ten flexplate mounting bolts finger tight.
6. Remove the guide pins and install the remaining two flexplate mounting bolts finger tight.
7. Tighten the flexplate mounting bolts to the special torque value (Table 51).

**MD-3000 and HD-4000 Series World Transmissions**

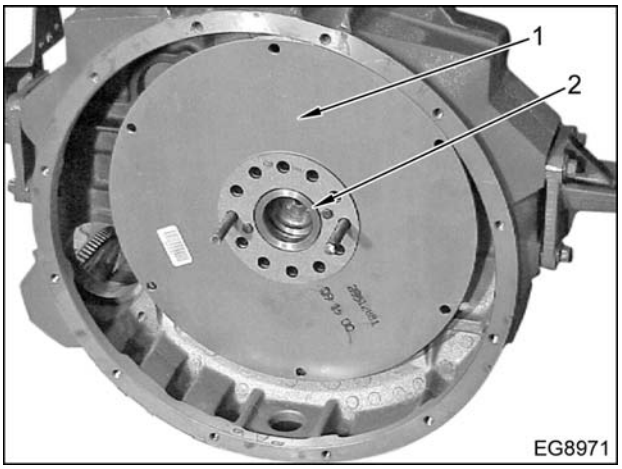


**Figure 618 Installing the flexplate assembly**

1. Flexplate assembly
2. End of crankshaft

1. Install two guide pins in the flexplate mounting bolt holes at the 3 o'clock and 9 o'clock positions.

**NOTE:** The flexplate assembly is available as a completely assembled service part.

2. Install the flexplate assembly on the guide pins.

**NOTE:** This following step applies to MD transmissions only.

3. Install reinforcement ring with part number or logo facing outward (towards the transmission).
4. Install ten flexplate mounting bolts finger tight.
5. Remove the guide pins and install the remaining two flexplate mounting bolts finger tight.
6. Tighten the flexplate mounting bolts to the special torque value (Table 51).

**NOTE:** Flywheel and ring gear are part of the torque converter assembly.

**NOTE:** Make sure that the paint mark, part number or XMSN SIDE on the flexplate is facing outward (towards the transmission).


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## Specifications

**Table 49 Flywheel and Flywheel Housing Specifications**

| | |
|---|---|
| **Flywheel housing:** | |
| Flywheel housing bore concentricity | SAE # 1 = 0.30 mm (0.012 in)<br>SAE # 2 = 0.28 mm (0.011 in) |
| Flywheel housing face runout | SAE # 1 = 0.30 mm (0.012 in)<br>SAE # 2 = 0.28 mm (0.011 in) |
| **Crankshaft pilot:** | |
| Crankshaft pilot concentricity | 0.13 mm (0.005 in) |
| **Flywheel:** | |
| Flat flywheel surface runout at clutch mounting holes. | 0.20 mm (0.008 in) |
| Pot flywheel surface runout | 0.20 mm (0.008 in) |
| Pot flywheel clutch mounting surface runout | 0.30 mm (0.012 in) |

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, do not machine beyond minimum dimensions specified for flywheel resurfacing.**

**WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, carefully examine the flywheel after resurfacing for any cracks or heat checks. Flywheel resurfacing information is provided for guidance only. Navistar, Inc. assumes no responsibility either for the results of any work performed in accordance with this information or for the ability of service personnel to detect heat cracks. Any cracks or heat checks in the flywheel could cause it to separate, creating the possibility of injury to the operator or bystanders. If there are any questions, do not use the flywheel.**

**Table 50 Flywheel Resurfacing Specifications**

| | |
|---|---|
| Flat flywheel minimum thickness after resurfacing | 36.32 mm (1.430 in) |
| Pot flywheel minimum thickness after resurfacing | 39.37 mm (1.550 in) |
| Requires measurement from crankshaft mounting surface of flywheel to clutch surface of flywheel. | |


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## Special Torque

**Table 51 Flywheel and Flywheel Housing Special Torques**

| | |
|---|---|
| Engine mounting bracket bolts | 108 N·m (80 lbf·ft) |
| Flexplate mounting bolts | 136 N·m (100 lbf·ft) |
| Flywheel housing mounting bolts | 108 N·m (80 lbf·ft) |
| Flywheel mounting bolts | 136 N·m (100 lbf·ft) |
| Rear engine mounting bracket bolts | 108 N·m (80 lbf·ft) |

## Special Service Tools

**Table 52 Flywheel and Flywheel Housing Special Service Tools**

| | |
|---|---|
| Crankshaft timing disk puller (H-bar) | Obtain locally |
| Dial indicator with magnetic base | Obtain locally |
| Guide pins | Obtain locally |
| Rear seal installer | ZTSE4637 |
| Slide hammer puller set | ZTSE1879 |


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# Table of Contents

**Brake Specific High-pressure Oil Rail Assembly....391**

**Periodic Service....392**
**Engine Brake Actuator Lash....392**
**Brake Lash Adjustment....392**

**Reconditioning....394**
**Diagnostic Tests Procedures and Service Parts....394**
**Reconditioning Procedures....394**
**Brake Shutoff Valve....395**
**BCP Sensor....396**
**ICP Sensor....396**
**M12 Plug assembly....397**
**Rail End Plug Assembly....397**
**Oil Pressure Relief Valve....397**
**Brake Actuator Piston Assembly....397**

**Removal....399**
**Valve Cover....399**
**Electrical Connectors....399**
**High-pressure Oil Rail....400**

**Installation....401**
**High-pressure Oil Rail....401**
**Electrical Connections....403**

**Specifications....405**

**Special Torque....405**

**Special Tools....405**


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## Brake Specific High-pressure Oil Rail Assembly

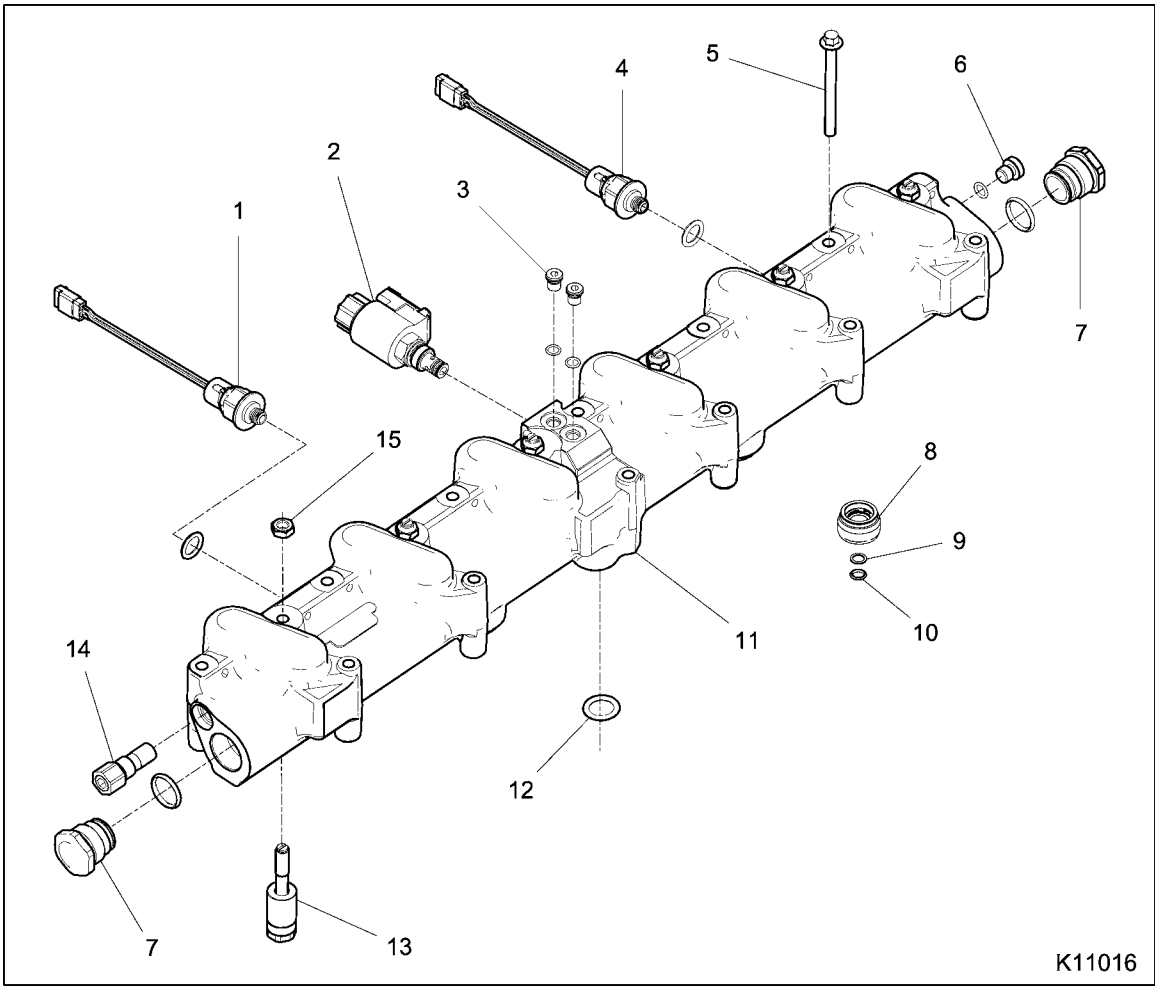


**Figure 619 Brake specific high-pressure oil rail assembly**

1. Brake Control Pressure (BCP) sensor
2. Brake Shut-off Valve (BSV) assembly
3. M10 plug (2)
4. Injection Control Pressure (ICP) sensor
5. M8 x 90 bolt (12)
6. M12 plug
7. Rail end plug assembly or attenuator (2)
8. Injector oil inlet adaptor assembly (6)
9. Back-up ring (6)
10. Injector oil inlet seal (6)
11. High-pressure oil rail (brake)
12. Oil inlet O-ring
13. Brake actuator piston (6)
14. Oil pressure relief valve
15. Brake actuator piston locknut (6)


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## Periodic Service

**GOVERNMENT REGULATION: Engine fluids (oil, fuel, and coolant) may be a hazard to human health and the environment. Handle all fluids and other contaminated materials (e.g. filters, rags) in accordance with applicable regulations. Recycle or dispose of engine fluids, filters, and other contaminated materials according to applicable regulations.**

**WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of this manual.**

**WARNING: To prevent personal injury or death, shift transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.**

**WARNING: To prevent personal injury or death, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).**

**WARNING: To prevent personal injury or death, disconnect the main battery negative terminal before disconnecting or connecting electrical components.**

**WARNING: To prevent personal injury or death, do not let engine fluids stay on your skin. Clean skin and nails using hand cleaner and wash with soap and water. Wash or discard clothing and rags contaminated with engine fluids.**

**NOTE:** If the valve cover is removed for any reason, check six brake piston locknuts. If loose, reset during brake lash adjustment.

**Engine Brake Actuator Lash**

During the procedure to adjust brake lash, the crankshaft is rotated two times:

- Three actuators are adjusted when piston 1 is at Top Dead Center (TDC) compression.
- Three actuators are adjusted when piston 6 is at Top Dead Center (TDC) compression.

Corresponding intake and exhaust valve lash can be adjusted before and after rotating the crankshaft. See (Adjusting Valve Lash, page150) in the “Cylinder Head and Valve Train” section of this manual.

**Brake Lash Adjustment**

1. Remove valve cover. See (Valve Cover, page120) in the “Cylinder Head and Valve Train” section of this manual.
2. Turn the crankshaft in the direction of engine rotation to remove gear lash. Position piston 1 at TDC compression by observing cylinder 6 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover. Cylinder 6 exhaust valve will be closing (coming up) and the intake valve will be starting to open (going down).
3. If piston 1 is at TDC compression, see Chart 3 (page392) and do steps 4 and 5 for cylinders 1, 3, and 5.


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**Chart 3**

| Brake and valve lash adjustments (inches) with piston 1 at TDC compression (Chart 3) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cylinder 1 | | Cylinder 2 | | Cylinder 3 | | Cylinder 4 | | Cylinder 5 | | Cylinder 6 | |
| intake 1 | exhaust 2 | intake 3 | exhaust 4 | intake 5 | exhaust 6 | intake 7 | exhaust 8 | intake 9 | exhaust 10 | intake 11 | exhaust 12 |
| 0.019 | 0.019 | 0.019 | | | 0.019 | 0.019 | | | 0.019 | | |
| Brake 0.019 | | | | Brake 0.019 | | | | Brake 0.019 | | | |

**Brake and valve lash adjustments with piston 1 at TDC compression**

**Chart 4**

| Brake and valve lash adjustments (inches) with piston 6 at TDC compression (Chart 4) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Cylinder 1 | | Cylinder 2 | | Cylinder 3 | | Cylinder 4 | | Cylinder 5 | | Cylinder 6 | |
| intake 1 | exhaust 2 | intake 3 | exhaust 4 | intake 5 | exhaust 6 | intake 7 | exhaust 8 | intake 9 | exhaust 10 | intake 11 | exhaust 12 |
| | | | 0.019 | 0.019 | | | 0.019 | 0.019 | | 0.019 | 0.019 |
| | | Brake 0.019 | | | | Brake 0.019 | | | | Brake 0.019 | |

**Brake and valve lash adjustments with piston 6 at TDC compression**

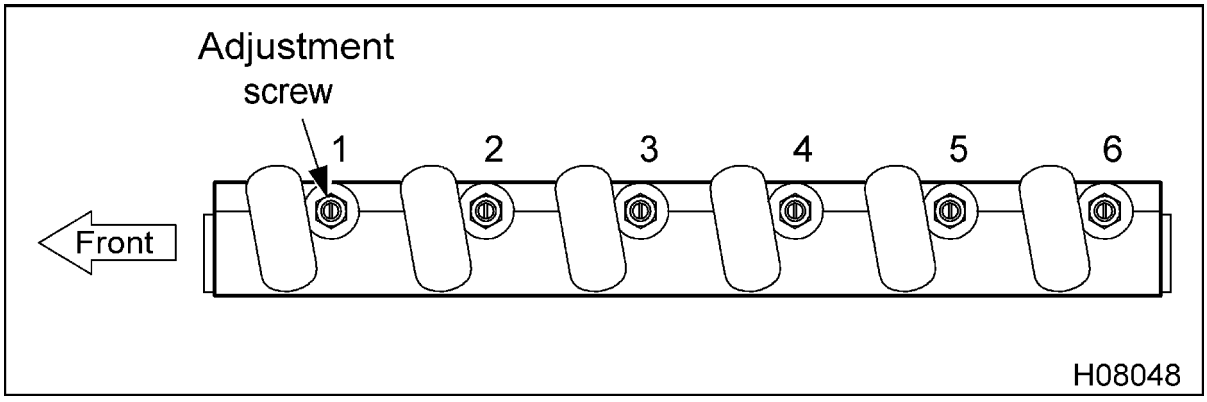


**Figure 620 Brake lash adjustment**


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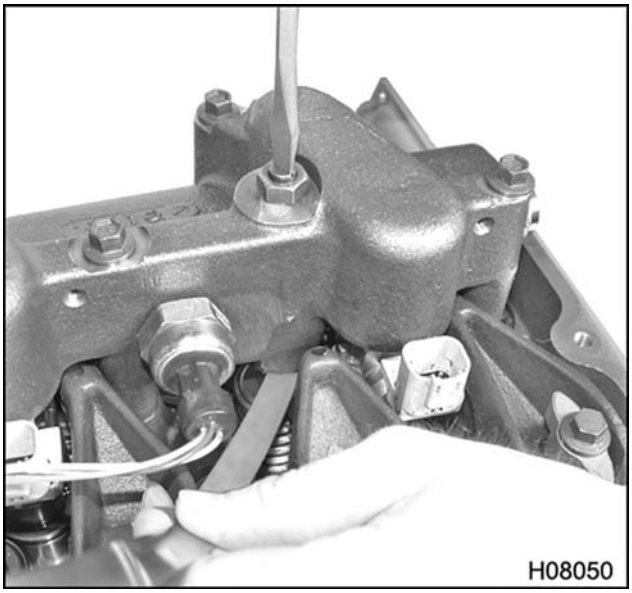


**Figure 621 Measure between valve bridge and brake actuator**

4. Measure brake lash when engine is cold. Put 0.048 mm (0.019 in) feeler gauge (long) (Table 56) between the pivot foot and valve bridge, a light drag on the feeler gauge should be felt. If adjustment is required, loosen locknut and turn actuator adjustment screw.
5. Once brake lash is set, tighten the locknut to Special Torque (Table 55) and remove the feeler gauge. Recheck for light drag on feeler gauge. If drag is too tight or loose, repeat steps 4 and 5.

   Corresponding valve lash can be adjusted before rotating crankshaft.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash from gear train and realign the timing mark on the damper pulley with the TDC mark on the front cover.
7. If piston 6 is at TDC compression, see Chart 2 (page393) and do steps 4 and 5 for cylinders 2, 4, and 6.

# Reconditioning

### Diagnostic Tests Procedures and Service Parts

See *Engine Diagnostic Manual* for diagnostic test procedures. The following service parts are available, if required after diagnostic testing.

- BCP sensor
- Brake actuator piston assembly
- Brake shutoff valve assembly
- High-pressure oil rail bolt, M8 x 90 (12)
- ICP sensor
- Oil inlet O-ring
- Oil pressure relief valve
- Plug assembly, M12
- Rail end plug assembly (2)

The following reconditioning procedures are provided to replace specific components determined faulty during diagnostic tests. A new Brake Shutoff Valve, BCP sensor, or ICP Sensor can be installed without removing the high-pressure oil rail, The High-pressure oil rail must be removed to install new brake actuator pistons.

### Reconditioning Procedures

**NOTE:** Remove valve cover. See (Valve Cover, page 120) in the “Cylinder Head and Valve Train” section of this manual.

**NOTE:** If the valve cover is removed for any reason, check six brake piston locknuts. If loose, reset during brake lash adjustment.


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**Brake Shutoff Valve**

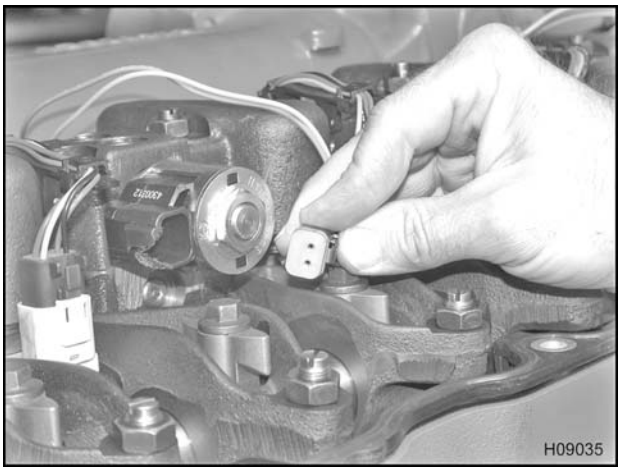


**Figure 622 Disconnecting brake shutoff valve**

1. Unclip and disconnect brake shutoff valve electrical connector from the high-pressure oil rail and valve cover gasket.

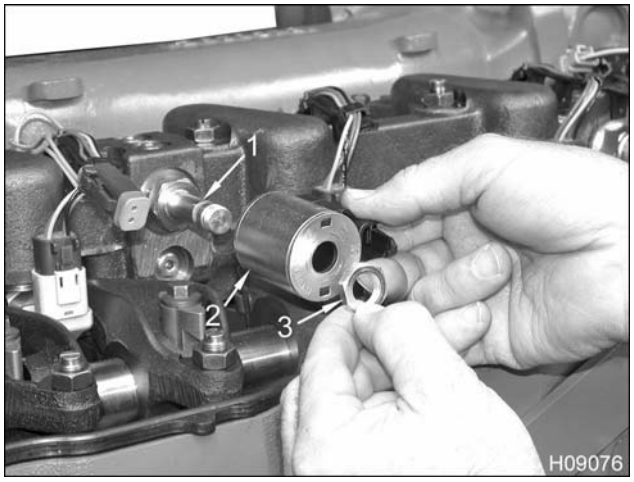


**Figure 623 Brake shutoff valve assembly**

1. Brake shutoff valve
2. Solenoid
3. Tinnerman nut

2. Remove Tinnerman nut and solenoid.

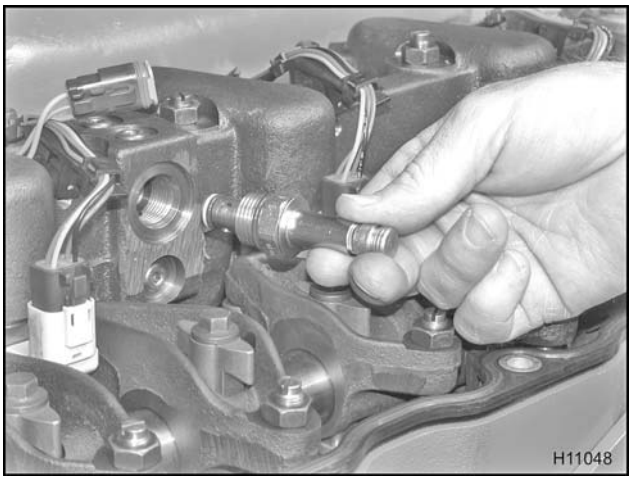


**Figure 624 Brake shutoff valve**

3. Remove shutoff valve.
4. Install new O-ring on new brake shutoff valve, and lubricate O-ring with clean engine oil.
5. Install new brake shutoff valve.
6. Move valve in and out against spring tension to check for any binding.
7. Place solenoid over the brake shutoff valve.
8. Install Tinnerman nut and tighten to Special Torque (Table 55).

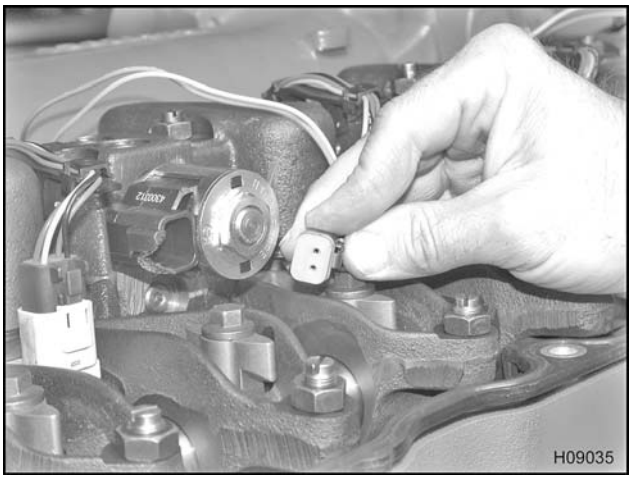


**Figure 625 Connect brake shutoff valve**

9. Connect brake shutoff valve electrical connector to valve cover gasket pass-through connector and clip harness to high-pressure oil rail.


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**BCP Sensor**

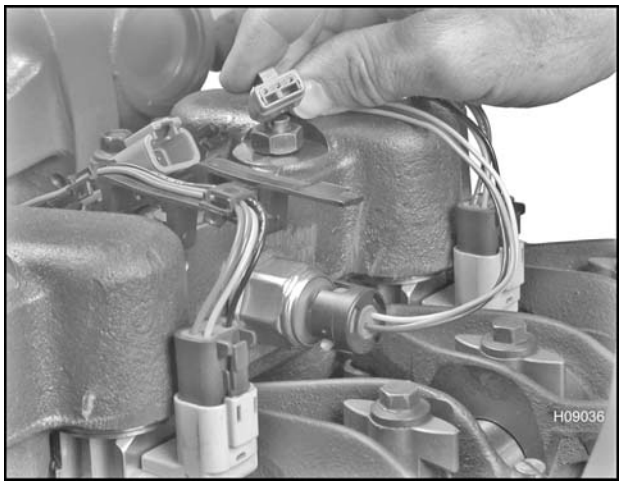


**Figure 626 Disconnecting BCP sensor**

1. Unclip and disconnect Brake Control Pressure (BCP) sensor electrical connector from the high-pressure oil rail and valve cover gasket (front).

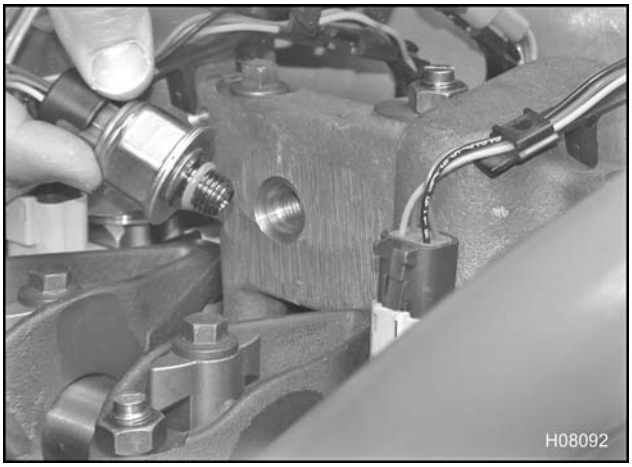


**Figure 627 BCP sensor**

2. Remove BCP sensor.
3. Install new O-ring on new BCP sensor, and lubricate O-ring with clean engine oil.
4. Install new BCP sensor and tighten to the Special Torque (Table 55).
5. Connect the BCP sensor electrical connector to the valve cover gasket pass-through connector (front) and clip harness to high-pressure oil rail.

**ICP Sensor**

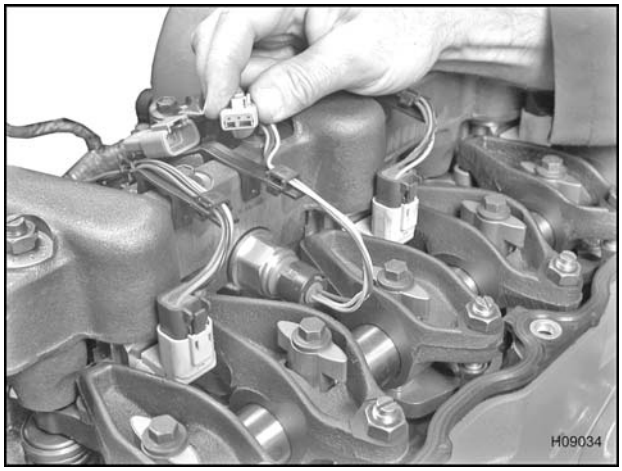


**Figure 628 Disconnecting ICP sensor**

1. Unclip and disconnect the Injection Control Pressure (ICP) sensor electrical connector from the high-pressure oil rail and valve cover gasket (rear).


**Figure 629 ICP sensor**

2. Remove ICP sensor.
3. Install new O-ring on new ICP sensor, and lubricate O-ring with clean engine oil.


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4. Install new ICP sensor and tighten to the Special Torque (Table 55).
5. Connect ICP sensor electrical connector to valve cover gasket pass-through connector (rear) and clip harness to high-pressure oil rail.

**M12 Plug assembly**

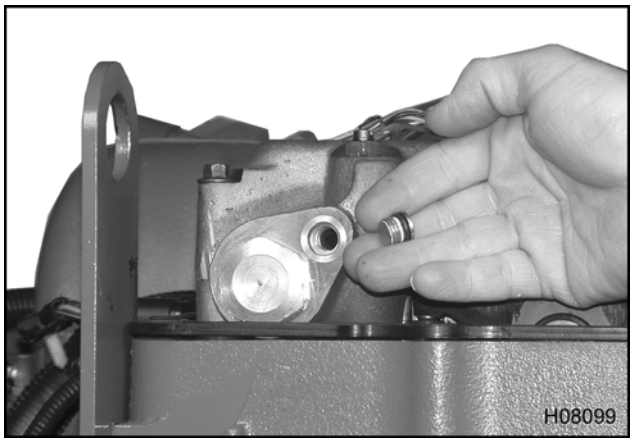


**Figure 630 M12 Plug assembly,**

1. Remove M12 plug assembly,
2. Install new O-ring on new M12 plug, and lubricate O-ring with clean engine oil.
3. Install new M12 plug and tighten to the Special Torque (Table 55).

**Rail End Plug Assembly**

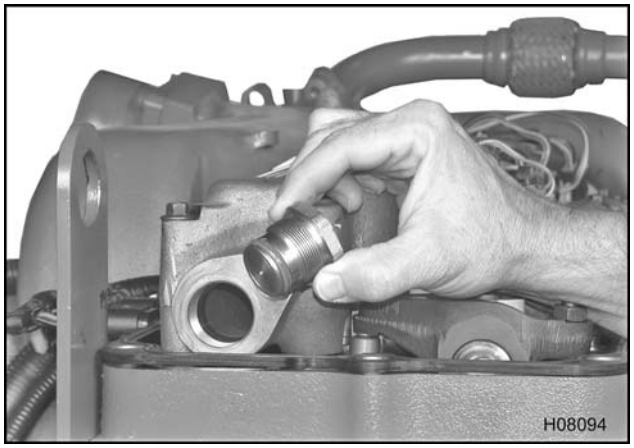


**Figure 631 Rail end plug assembly**

1. If necessary, remove rail end plug or attenuator. See (TSI-05-12-28 New High-pressure Oil Rails, page465).
2. Install new O-ring on new rail end plug or attenuator, and lubricate O-ring with clean engine oil.
3. Install new rail end plug or attenuator and tighten to the special torque (Table 55).

**Oil Pressure Relief Valve**

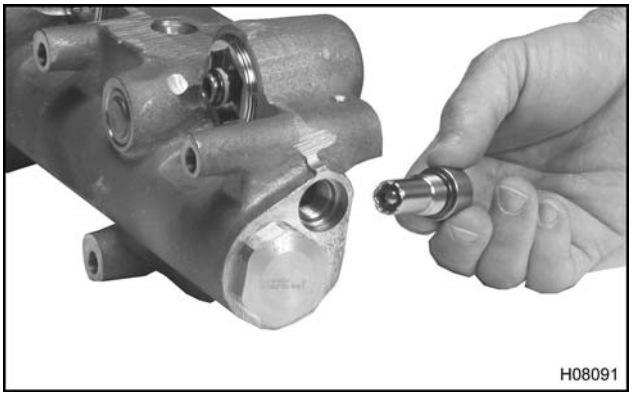


**Figure 632 Oil pressure relief valve**

1. Remove oil pressure relief valve.
2. Install new O-ring on new oil pressure relief valve, and lubricate O-ring with clean engine oil.
3. Install new oil pressure relief valve and tighten to the Special Torque (Table 55).

**Brake Actuator Piston Assembly**

1. Inspect all brake actuator pistons and valve bridge contact surfaces. Look for pitting and material transfer deformation. Replace pitted or deformed parts if necessary. Polished surfaces are acceptable.


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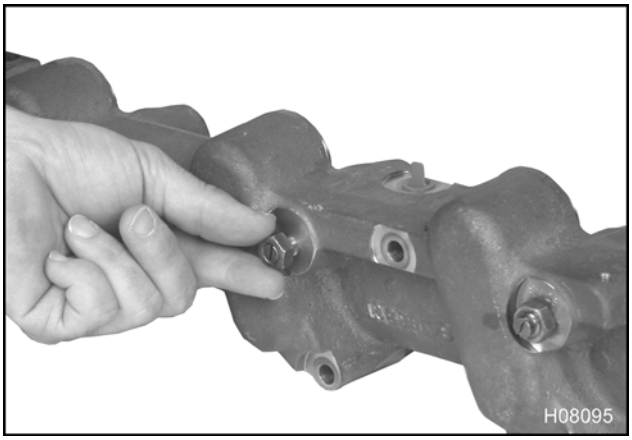


**Figure 633 Brake actuator lash locknut**

2. Remove brake actuator lash locknut.

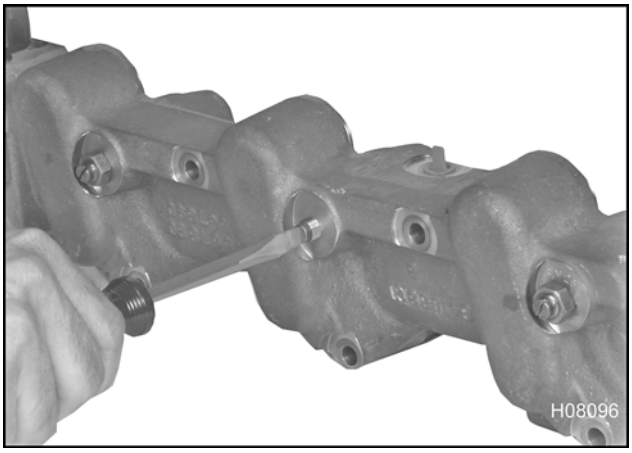


**Figure 634 Removing brake actuator piston**

3. Use screwdriver to remove brake actuator piston assembly from the high-pressure oil rail.

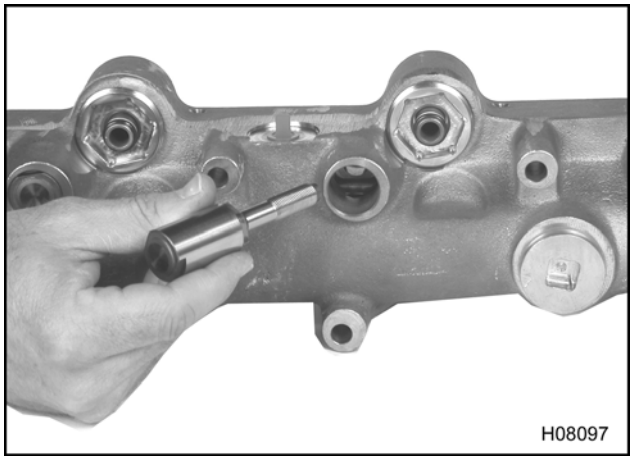


**Figure 635 Brake actuator piston assembly**

4. Install new brake actuator piston assembly.
5. Final lash adjustments will be made after the high-pressure oil rail is installed on cylinder head.

**NOTE:** Install valve cover after completing final brake lash adjustments. See Valve Cover (Valve Cover, page 152) in the “Cylinder Head and Valve Train” section of this manual.


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## Removal

### Valve Cover

1. Remove valve cover. See (Valve Cover, page120) in the “Cylinder Head and Valve Train” section of this manual.

### Electrical Connectors

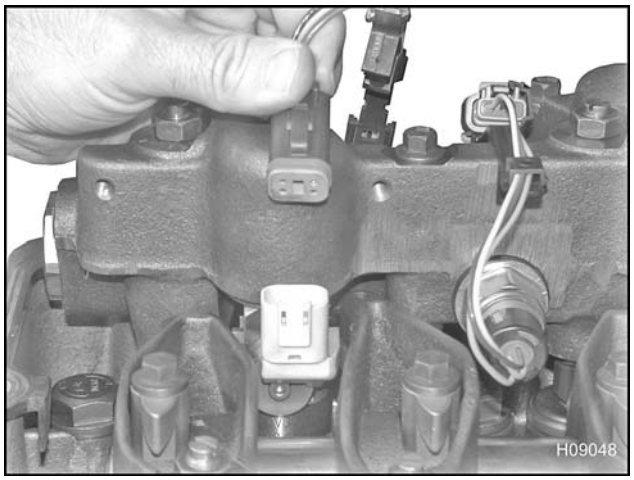


**Figure 636 Injector electrical connector**

1. Unclip and disconnect each injector electrical connector from the high-pressure oil rail and valve cover gasket and place aside.

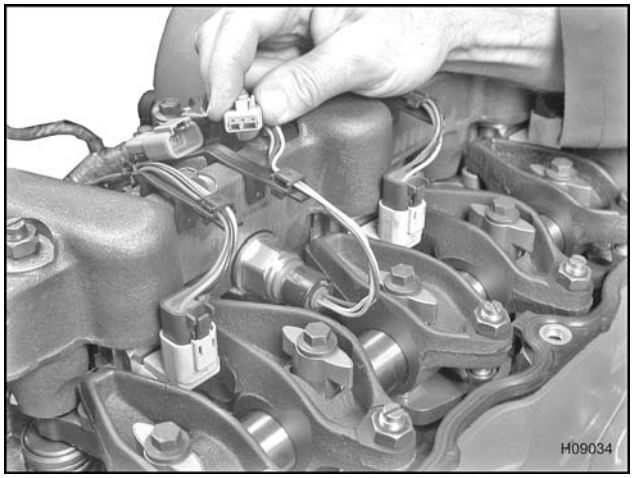


**Figure 637 ICP sensor electrical connector**

2. Unclip and disconnect the Injection Control Pressure (ICP) sensor electrical connector from the high-pressure oil rail and valve cover gasket (rear).

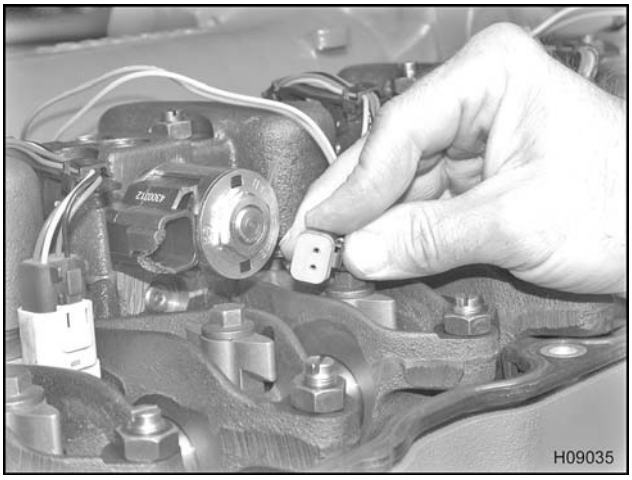


**Figure 638 Brake shutoff valve assembly electrical connector**

3. Unclip and disconnect Brake Shutoff Valve (BSV) electrical connector from the high-pressure oil rail and valve cover gasket.

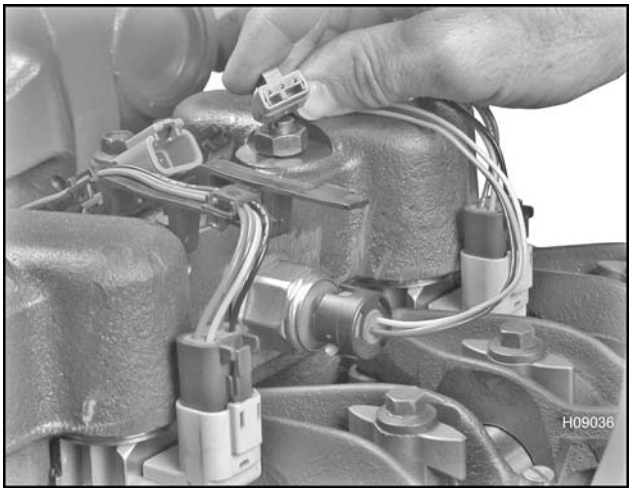


**Figure 639 BCP sensor electrical connector**

4. Unclip and disconnect Brake Control Pressure (BCP) sensor electrical connector from the high-pressure oil rail and valve cover gasket (front).

**NOTE:** The ICP and BCP sensors are identical and share the same part number.


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5. Loosen all high-pressure oil rail bolts (M8 x 90) in a circular pattern beginning from either end.

**High-pressure Oil Rail**

**⚠ WARNING: To prevent personal injury or possible death, get assistance to remove or install the high-pressure oil rail.**

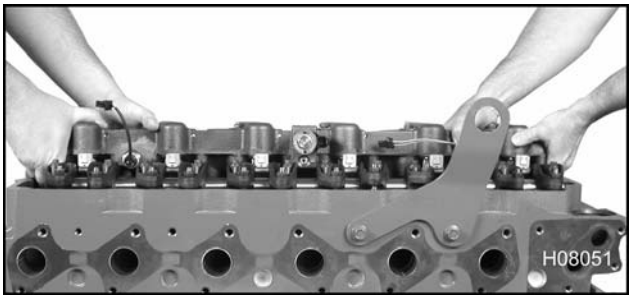


**Figure 640 Removing the high-pressure oil rail**

1. Remove all bolts and lift high-pressure oil rail up just enough to drain as much oil out of high-pressure oil rail before lifting it away from cylinder head.
2. Clean outside of high-pressure oil rail using appropriate solvent.

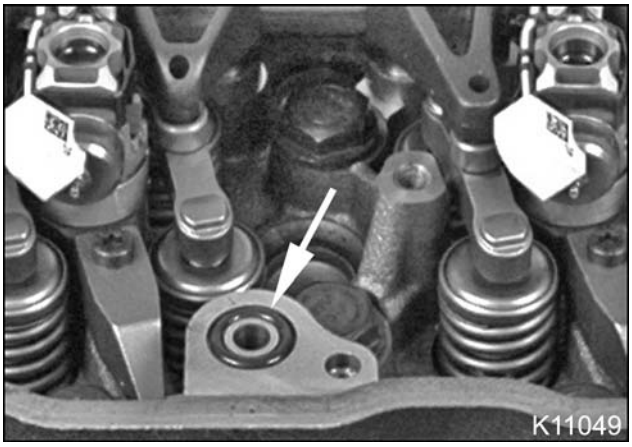


**Figure 641 Oil inlet O-ring**

3. Remove oil inlet O-ring from recess in cylinder head and discard O-ring.

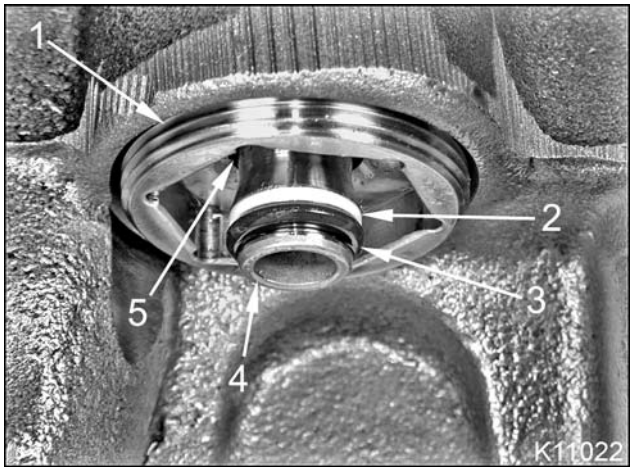


**Figure 642 Injector oil inlet adapter installed in high-pressure oil rail**

1. Injector oil inlet adaptor
2. Backup ring
3. Injector oil inlet seal
4. Oil inlet tube
5. Internal O-ring (not serviceable)

**NOTE:** It is not necessary to remove an injector oil inlet adaptor to install a new backup ring and injector inlet seal.

4. Remove and discard backup ring and injector inlet seal from injector oil inlet adapters in the high-pressure oil rail.


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## Installation

### High-pressure Oil Rail

1. Back off all valve lash adjustments. This must be done to eliminate the possibility of additional forces on the high-pressure oil rail when mounting bolts are torqued.

**CAUTION:** To prevent engine damage, a new backup ring and injector inlet seal must be installed on all six injector oil inlet tubes.

**CAUTION:** To prevent engine damage, when installing new backup rings, a new backup ring must match the backup ring removed from the injector oil inlet tubes.

2. Inspect injector oil inlet adaptors for internal O-ring extrusion and high-pressure oil leak paths. Verify that each oil inlet tube is moveable. Replace any adaptor having an extruded internal O-ring, high-pressure oil leak path or seized oil inlet tube.

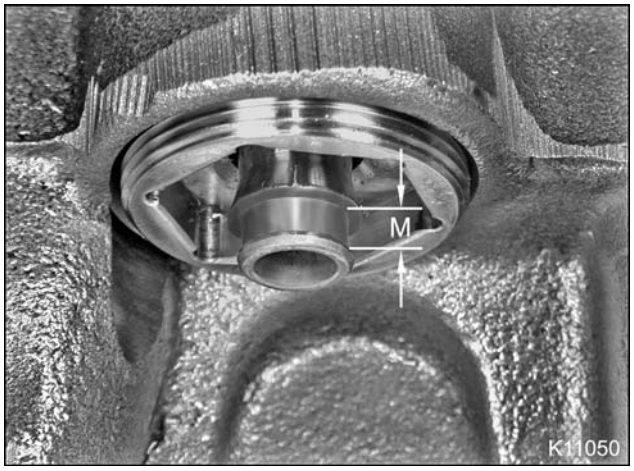


**Figure 643 Groove Measurement (M) in injector oil inlet tube**

3. Measure groove in the injector oil inlet tube.

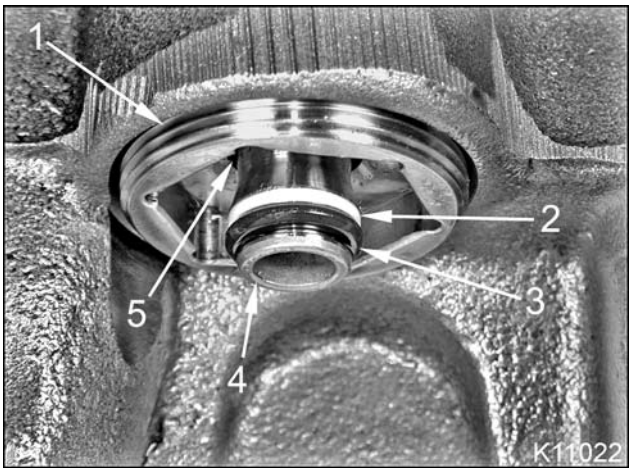


**Figure 644 Injector oil inlet adapter installed in high-pressure oil rail**

1. Injector oil inlet adaptor
2. Backup ring
3. Injector oil inlet seal
4. Oil inlet tube
5. Internal O-ring (not serviceable)

**Table 53 Groove Measurement (M) in Oil Inlet Tube and Required Backup Ring**

| Groove (M) in Oil Inlet Tube | Backup Ring |
|---|---|
| 5.080 mm (0.200 in) | Backup ring 1.8 mm (0.07 in) |
| 4.877 mm (0.192 in) | Backup ring 1.6 mm (0.06 in) |
| 4.420 mm (0.174 in) | Backup ring 1.1 mm (0.04 in) |

4. Install a new backup ring onto injector oil inlet tubes, according to the groove measurements listed in the table.
5. Install new injector inlet seal onto injector oil inlet tubes.
6. Coat backup rings and injector oil inlet seals with clean engine oil.


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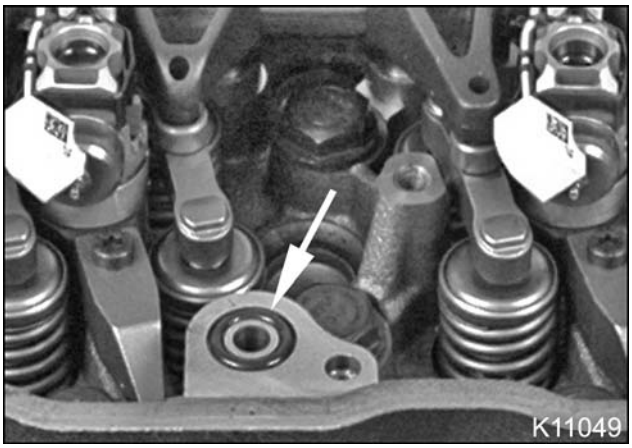


**Figure 645 Oil inlet O-ring**

7. Coat new oil inlet O-ring with clean engine oil and install O-ring in recess in cylinder head.

**WARNING: To prevent personal injury or possible death, have an assistant help remove or install the high-pressure oil rail when working within the chassis.**

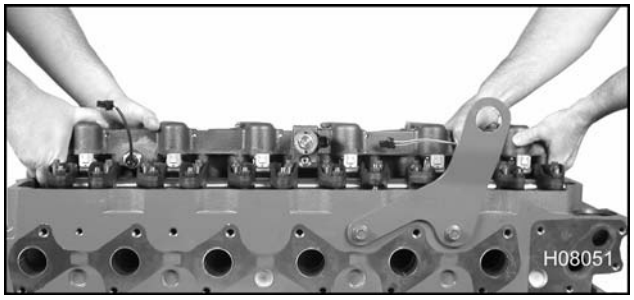


**Figure 646 High-pressure oil rail**

1. Lift high-pressure oil rail up and place on engine. Align injector oil inlet adaptors with injector inlets.


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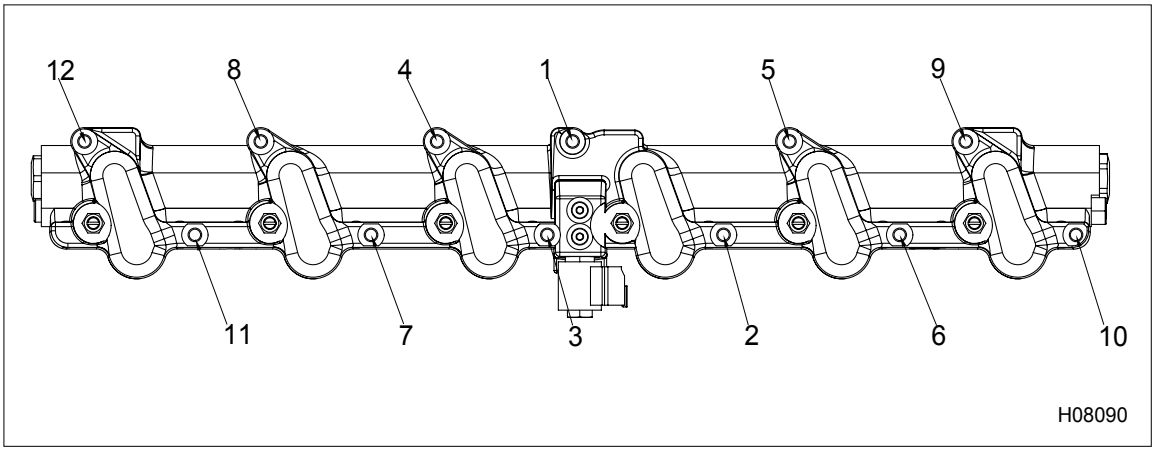


**Figure 647 Torque sequence for high-pressure oil rail bolts**

2. Install and hand tighten all high-pressure oil rail bolts (M8 x 90). Torque bolts to the special torque value (Table 55) in a circular pattern, beginning from the center.

**NOTE:** Air trapped in the engine brake rail will be purged automatically during the cranking and start up phase.

**Electrical Connections**

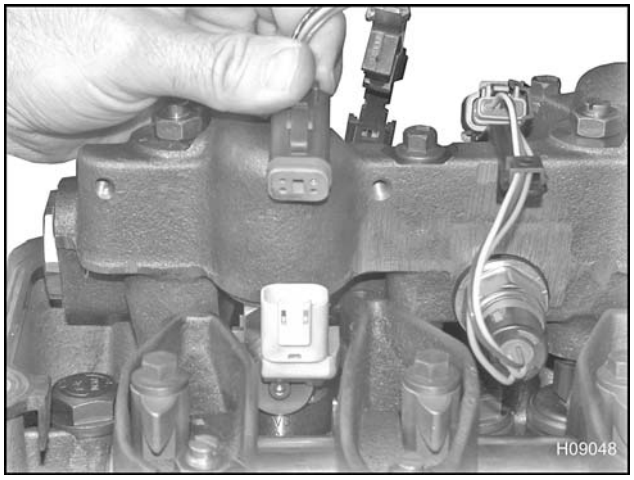


**Figure 648 Injector electrical connector**

1. Connect each valve cover gasket pass-through connector to its respective injector and clip harness on the high-pressure oil rail.

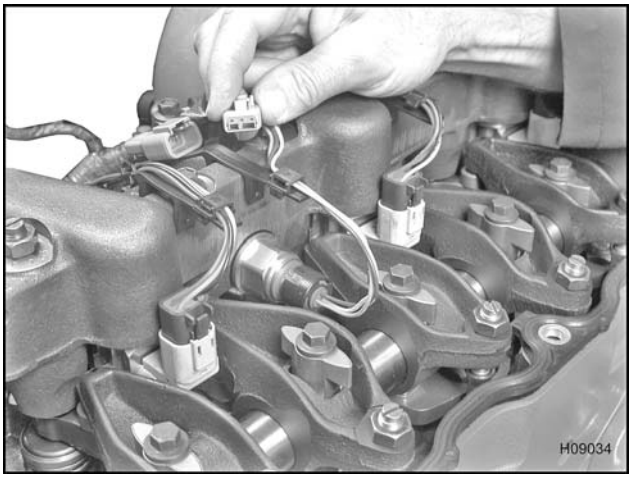


**Figure 649 ICP sensor electrical connector**

2. Connect ICP sensor electrical connector to valve cover gasket pass-through connector (rear) and clip harness to high-pressure oil rail.


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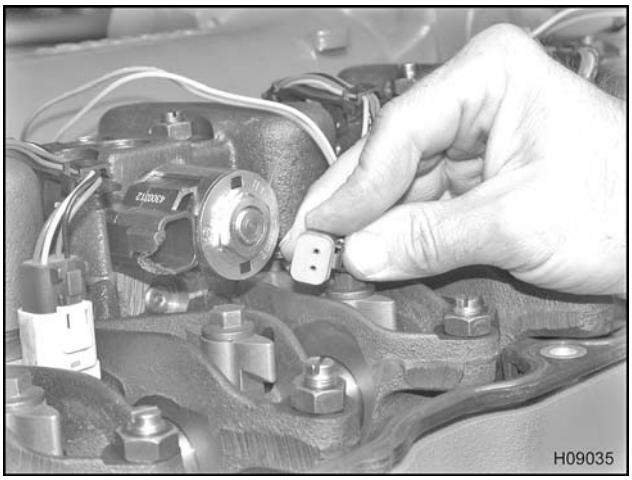


**Figure 650 Brake shutoff valve assembly electrical connector**

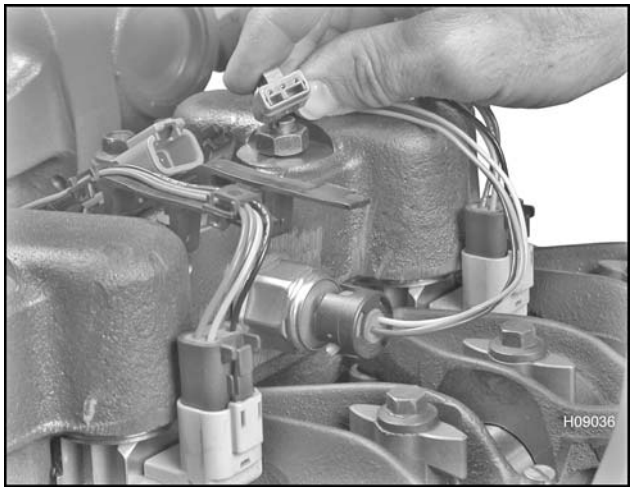


**Figure 651 BCP sensor electrical connector**

3. Connect brake shutoff valve electrical connector to valve cover gasket pass-through connector and clip harness to high-pressure oil rail.
4. Connect the BCP sensor electrical connector to the valve cover gasket pass-through connector (front) and clip harness to high-pressure oil rail.
5. Adjust brake actuator lash. See Brake Lash Adjustment (Steps 2-6) in Periodic Service in this “Diamond Logic® Engine Brake” section (page 392).
6. Install valve cover. See Valve Cover (Valve Cover, page 152) in the “Cylinder Head and Valve Train” section of this manual.


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## Specifications

**Table 54 Engine Brake Specifications**

| | |
|---|---|
| Brake actuator lash (cold) | 0.48 mm (0.019 in) |
| Engine exhaust valve lash (cold) | See (Adjusting Valve Lash, page150) |

## Special Torque

**Table 55 Engine Brake Special Torques**

| | |
|---|---|
| Brake Control Pressure (BCP) sensor | 20-30 N·m (15-22 lbf·ft) |
| Brake piston adjustment locknut | 27 N·m (20 lbf·ft) |
| Brake shutoff solenoid Tinnermann nut | 7 - 11 N·m (5 - 8 lbf·lb) |
| Brake shutoff valve | 24-30 N·m (18-22 lbf·ft) |
| High-pressure oil rail bolts (M8 x 90) | 27 N·m (20 lbf·ft) |
| Plug assembly, M10 | 12 N·m (108 lbf·in) |
| Plug assembly, M12 | 12 N·m (108 lbf·in) |
| Injection Control Pressure (ICP) sensor | 20-30 N·m (15-22 lbf·ft) |
| Oil pressure relief valve | 41-48 N·m (30-35 lbf·ft) |
| Rail End Plug Assembly or attenuator | 204 N·m (150 lbf·ft) |

## Special Tools

**Table 56 Engine Brake Special Service Tools**

| | |
|---|---|
| Feeler gauge (long) | Obtain locally |


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