SERVICE MANUAL

MaxxForce® 11 and 13

DIESEL ENGINE

Model Year 2010 and Up

EGES-465-1

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Engine Identification

Engine Serial Number

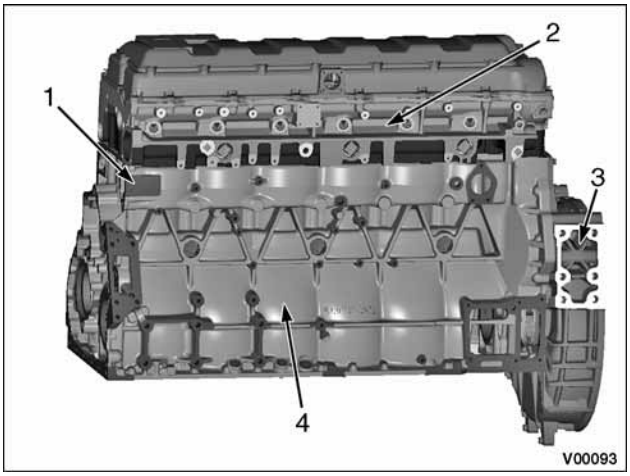

Figure 1 Engine serial number

1. Engine Serial Number (ESN) location
2. Cylinder head
3. Flywheel housing
4. Crankcase

The Engine Serial Number (ESN) is located on the front of the crankcase (left side), below the cylinder head.

Engine Serial Number Examples

MaxxForce® 11: 105HM2XXXXXXX

MaxxForce® 13: 124HM2XXXXXXX

MaxxForce® 11: 105HM2YXXXXXXX

MaxxForce® 13: 124HM2YXXXXXXX

Engine Serial Number Codes

105 – Engine displacement (10.5 L)
124 – Engine displacement (12.4 L)
H – Diesel, turbocharged, Charge Air Cooler (CAC), and electronically controlled
M2 – Motor truck
Y – Huntsville, Alabama
7 digit suffix – Engine serial number sequence

Engine Emission Label

Figure 2 2010 U.S. Environmental Protection Agency (EPA) exhaust emission label (example)

The U.S. Environmental Protection Agency (EPA) exhaust emission label is on top of the valve cover (front left side). The EPA label typically includes the following:

- Model year
- Engine family, model, and displacement
- Advertised brake horsepower and torque rating
- Emission family and control systems
- Valve lash specifications
- ESN
- EPA, Onboard Diagnostics (OBD), EURO, and reserved fields for specific applications

Airflow

Air flows through the air filter assembly and enters the low pressure turbocharger. The LP turbocharger increases the pressure and temperature of the before entering the LPCAC. Cooled and compressed air then flows from the LPCAC into the HP turbocharger (compressor inlet). Hot and highly compressed air flows from the HP turbocharger (compressor outlet) into the HPCAC where it is cooled, and into the intake throttle duct, and continues through the Engine Throttle Valve (ETV). The HP and LP turbochargers increase pressures up to 345 kPa (50 psi).

If the EGRV is open, exhaust gases pass through the EGR cooler and into the intake throttle duct where it is mixed with filtered air. This mixture flows into the intake manifold, and then the cylinder head. The intake manifold is an integral part of the cylinder head casting.

During cold weather, the cold start assist system rapidly activates the heater element, vaporizing and igniting small quantities of fuel into the air inlet duct.

After combustion, exhaust gases exit through the cylinder head exhaust valves and ports. The exhaust gas is forced through the exhaust manifold where, depending on EGRV position, it is split between the EGR system and the exit path through the HP turbocharger, LP turbocharger, and EBPV.

The EBPV is operated by a pneumatic actuator. When the ACV is applied, the EBPV restricts flow and increases exhaust back pressure. Operation of the EBPV is controlled by the ECM using the ACV and the Turbocharger 1 Turbine Outlet Pressure (TC1TOP) sensor. When the EBPV is opened, exhaust back pressure is released.

Exhaust gases exiting the engine systems flow through the EBPV, then through the vehicle Aftertreatment (AFT) system, and out the exhaust tail pipe.

Downstream Injection (DSI) Unit

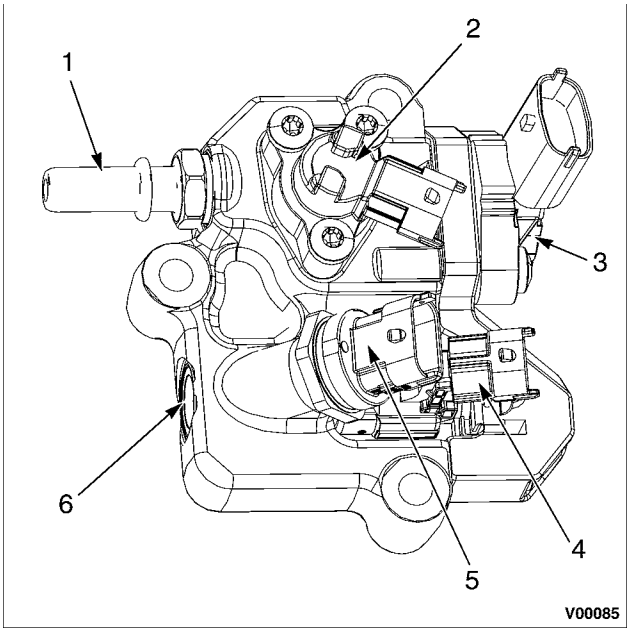

Figure 14 Downstream Injection (DSI) unit

1. Fuel supply from fuel filter assembly
2. Aftertreatment Fuel Inlet (AFTFIS) sensor
3. Aftertreatment Fuel Pressure 2 (AFTFP2) sensor
4. High pressure fuel outlet electrical connector to AFI
5. Fuel out electrical connector to AFI
6. Fuel outlet port to AFI

The DSI unit is connected to the clean side of the low pressure fuel system, and will provide a metered amount of fuel to the AFI. The DSI unit provides pressurized fuel injection pulses to the AFI. The AFI is a mechanical poppet type injector, and will only inject fuel when fuel line pressure is increased above a specific pressure. The DSI unit is installed on the left side of the engine, to the rear of the fuel module.

The AFTFIS and AFTFP2 sensors monitor fuel pressure and temperature in the DSI system, and provide constant feedback to the ECM.

Aftertreatment Fuel Injector (AFI)

The AFI is located on the right side of the engine, and is installed in the turbocharger exhaust pipe after the exhaust O2S.

Pressurized fuel is supplied to the injector by the DSI unit using the AFTFD valve. When the conditions required for regeneration are met, the ECM sends a PWM voltage to the AFTFD. During operation, the AFTFD increases fuel pressure to the AFI, causing injection of fuel into the exhaust pipe.

To protect the AFI internal components, continuous engine coolant flow through the AFI is maintained by external coolant supply and return lines.

Oil Flow and Components

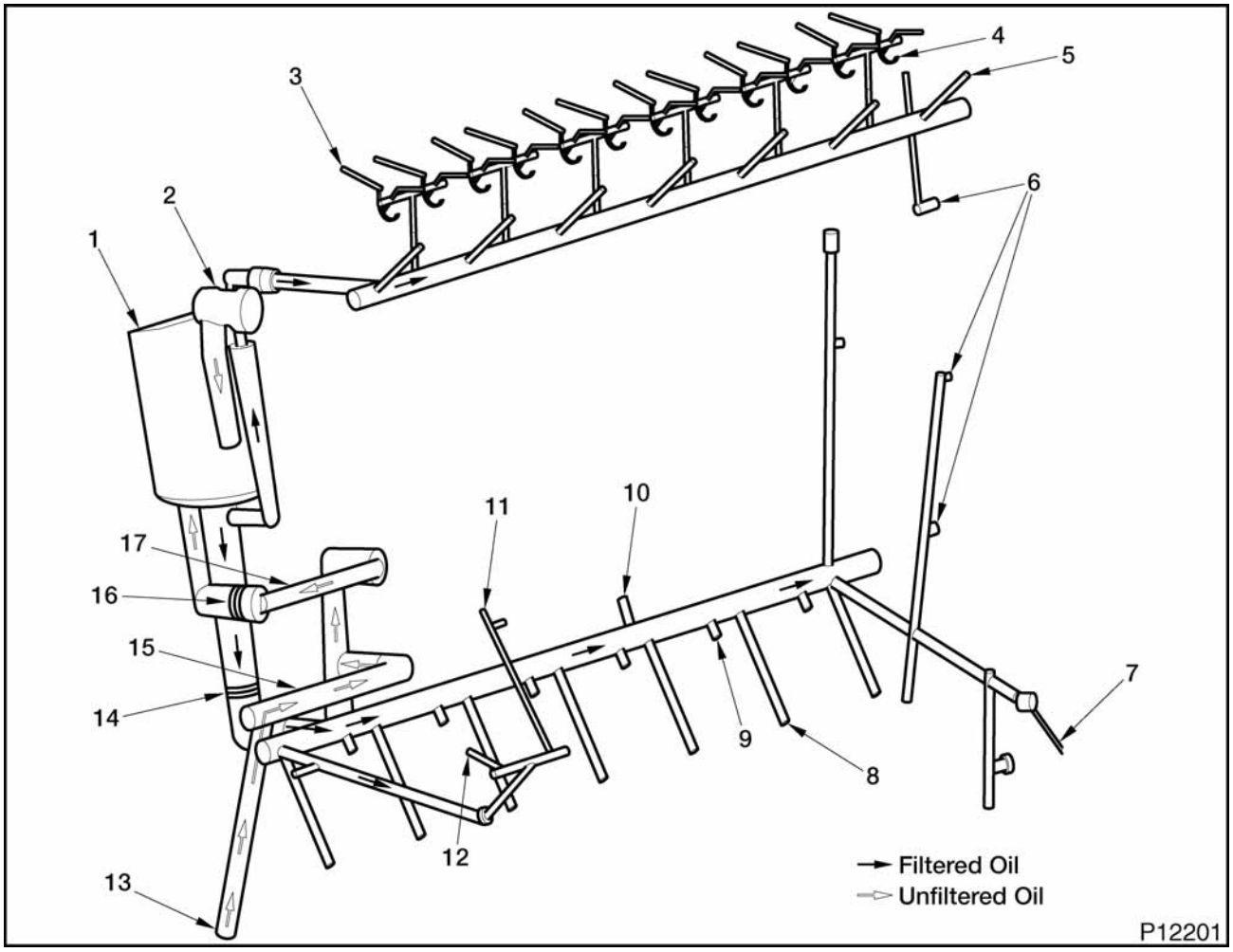

Figure 22 Oil flow

1. Oil filter element
2. Oil return from cylinder head
3. Oil supply to exhaust valve bridge
4. Oil supply to rocker gear
5. Oil supply to camshaft bearings
6. Oil supply to intermediate gears
7. Oil supply to air compressor
8. Oil supply to crankshaft main bearings
9. Oil supply to piston oil sprayer nozzles
10. Oil supply to turbochargers
11. Oil supply to drive housing
12. Oil supply to front cover
13. Oil pump output
14. Oil pressure relief valve
15. Oil supply to oil module
16. Oil return shutoff valve
17. Oil cooler

Unfiltered oil is drawn from the oil pan through the pickup tube and front cover passage by the crankshaft driven gerotor pump. The pressurized oil is moved through a vertical crankcase passage and into the oil module.

Inside the oil module, unfiltered oil flows through plates in the oil cooler heat exchanger. Engine coolant flows around the plates to cool the surrounding oil. An oil return shutoff valve installed at the exit from the oil cooler prevents oil from draining through the oil pump and back into the oil pan when the engine is stopped. If oil pressure coming out of the oil pump is too high, a pressure relief valve allows the excess oil to return through the crankcase and into the oil pan before entering the oil cooler.

The CSR delivers battery voltage (VBAT) to the heater element for a set time, depending on engine coolant temperature and altitude. The ground circuit is supplied directly from the battery ground at all times. The relay is controlled by switching on a voltage source from the ECM, and is installed to the rear of the ECM.

Cold Start Solenoid (CSS) Valve

The CSS valve controls fuel flow to the CSFI during cold start assist operation.

When cold start assist is required, the ECM provides voltage to open the CSS valve during cranking.

The CSS valve is mounted on the intake throttle duct, on the top left side of the engine.

Engine Throttle Valve (ETV)

The ETV controls the flow of fresh air (boosted and cooled) into the engine's air intake path through the CAC to help heat the exhaust aftertreatment during regeneration, and to assist when heavy EGR is requested. The electronic portion of the ETV contains a microprocessor that monitors valve position, electronic chamber temperature, controls the electric motor, and reports diagnostic faults to the ECM. The ETV changes position in response to ECM signals.

The ETV is integrated into the intake throttle duct, on the top left side of the engine.

Fuel Pressure Control Valve (FPCV)

The FPCV is a variable position actuator that controls the flow of fuel to the suction side of the high pressure pump.

The FPCV changes valve position through pulse width modulated signals from the ECM.

The FPCV is mounted on the upper side of the high pressure pump. The FPCV and fuel pump are serviced as an assembly.

Aftertreatment Fuel Doser (AFTFD)

The AFTFD is used to provide HP fuel flow to the aftertreatment fuel injector. The AFTFD is controlled through an PWM signal sent by the ECM. The AFTFD is housed in the DSI unit, which is located to the rear of the fuel filter assembly.

Aftertreatment Shutoff Valve (AFTSV)

The AFTSV is used to prevent fuel flow to the aftertreatment fuel injector (AFI), and prevents all uncontrolled fuel delivery for the aftertreatment system during a AFTFD valve malfunction. The AFTSV is controlled through an on-off signal sent by the ECM. The AFTSV is housed in the DSI unit, which is located to the rear of the fuel filter assembly.

Engine and Vehicle Sensors

Thermistor Sensors

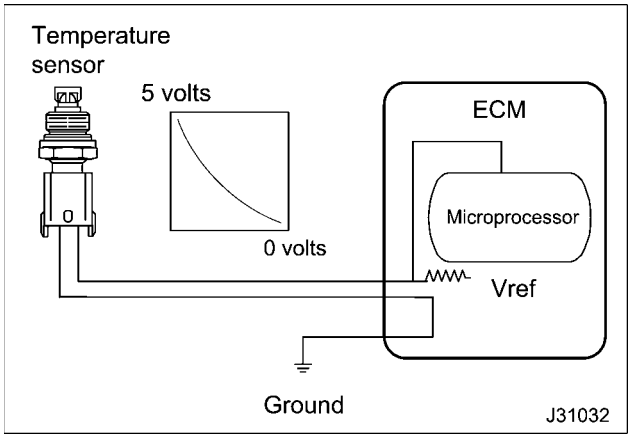

Figure 26 Thermistor

A thermistor sensor changes electrical resistance with changes in temperature. As temperature changes at the thermistor, voltage at the ECM will change accordingly. Thermistors work with the control module to produce a voltage signal directly proportional to temperature values.

WARNING: To prevent personal injury or death, use metric class 10.9 or SAE grade 8 bolts when mounting Engine Stand Adapter Plate to engine and engine stand. See instructions included with engine stand and Engine Stand Adapter Plate.

NOTE: See manufacturer's safety instructions included with engine stand and Engine Stand Adapter Plate.

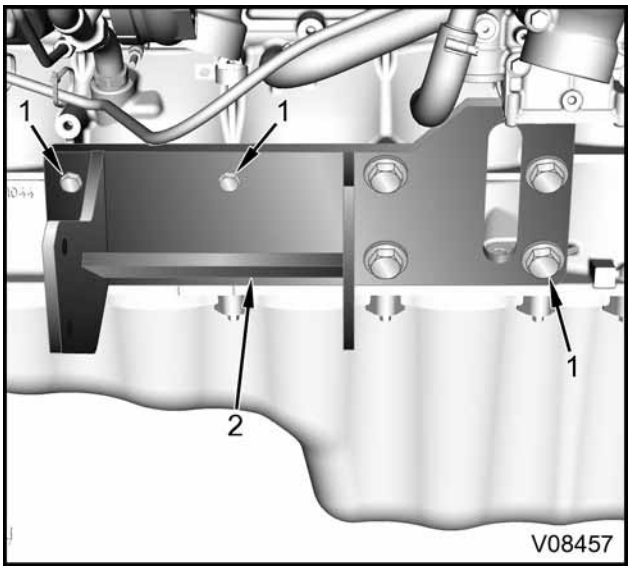

Figure 34 Engine Stand Adapter Plate (mounting bracket)

1. Hex bolt (part of ZTSE4789)
2. Engine Stand Adapter Plate (mounting bracket)

13. Position Engine Stand Adapter Plate (page 58) on right side of engine. Secure adapter plate with six mounting bolts and washers (part of Engine Stand Adapter Plate). Tighten bolts to standard torque (page 471).
14. Mount engine on engine stand using four 5/8 x 1.5 inch grade 8 mounting bolts. Tighten bolts to standard torque (page 471) .

Rail Fuel Pressure (RFP) Sensor

Figure 49 RFP sensor

The RFP sensor is a variable capacitance sensor that monitors the fuel pressure in the high-pressure fuel rail. The sensor measures the fuel pressure just before injection.

The RFP sensor is mounted in the front of the fuel rail on the left side of the engine.

Intake Manifold Temperature (IMT) Sensor

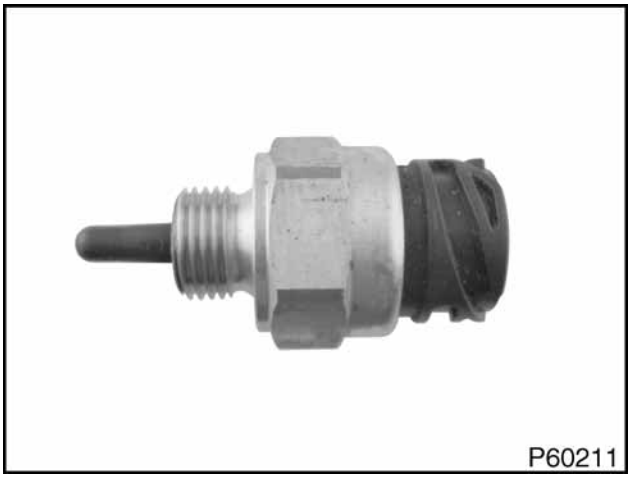

Figure 50 IMT sensor

The IMT sensor is a thermistor sensor that monitors the temperature of the mixture of recirculated exhaust gas and fresh intake air.

EGR system operation is shut down under certain temperature conditions, to prevent acids from condensing under cold charge-air temperatures and to protect the engine from excessively hot intake air in the event of an EGR fault.

The IMT sensor is installed in the intake channel of the cylinder head, on the left side of the engine.

Oxygen Sensor (O2S)

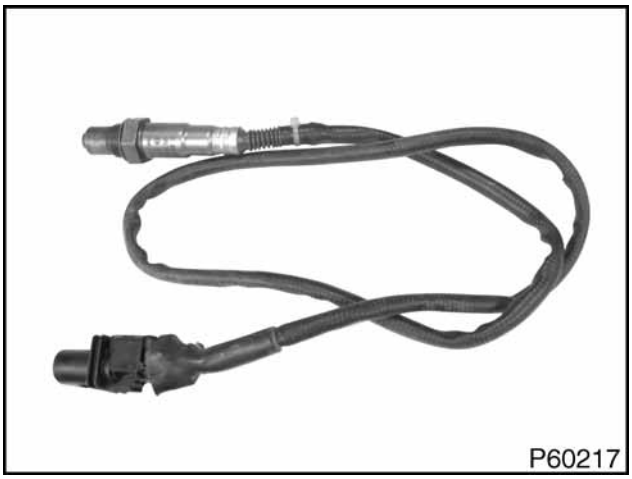

Figure 51 O2S

The O2S monitors oxygen levels in exhaust gases. It is used to tune engine operation by monitoring the level of unused oxygen in the exhaust stream.

The O2S compares oxygen levels in the exhaust stream with oxygen levels in the outside air. The sensor generates an analog voltage and is monitored by the ECM. The level of voltage generated by the O2S corresponds to the oxygen levels in the exhaust stream.

The O2S is installed in the exhaust back pressure valve housing.

Intake Manifold Pressure (IMP) Sensor

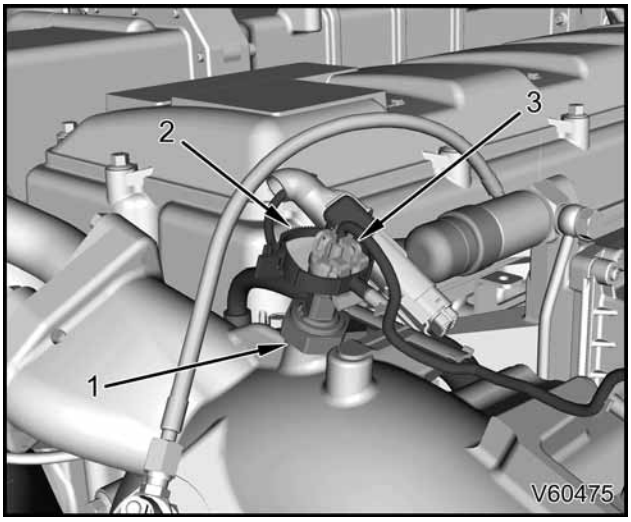

Figure 70 IMP sensor

1. IMP sensor
2. Standoff tie strap
3. Harness connector

1. Press release tab to loosen tie strap and remove standoff bracket securing harness connector lead to IMP sensor.
2. Press release tab to disconnect harness from IMP sensor.
3. Remove IMP sensor from ETV housing. Discard O-ring.

Rail Fuel Pressure (RFP) Sensor

Figure 71 RFP sensor (typical)

1. Pull out yellow locking tab on RFP sensor harness connector.
2. Press release lever and disconnect harness connector from RFP sensor installed in front of fuel rail on left side of engine.
3. Remove sensor from fuel rail.
4. Cover exposed fuel rail opening using Disposable Air and Fuel Caps (page 106).

Engine Control Module (ECM) and Support

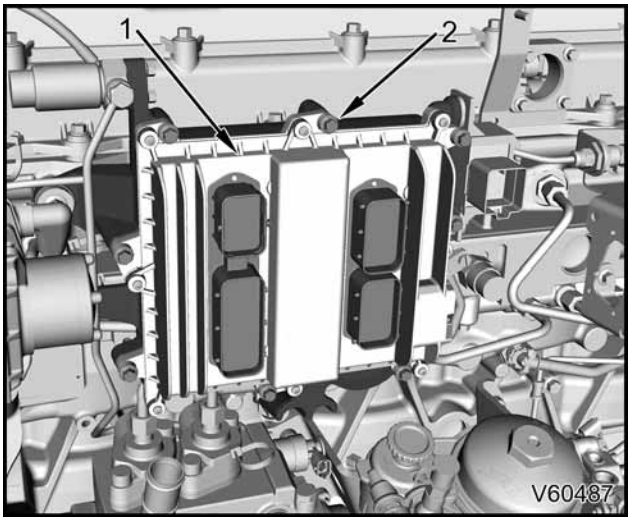

Figure 86 ECM mounting bolts

1. ECM
2. M6 x 30 bolt (8)

1. Remove eight M6 x 30 bolts and remove ECM from support.

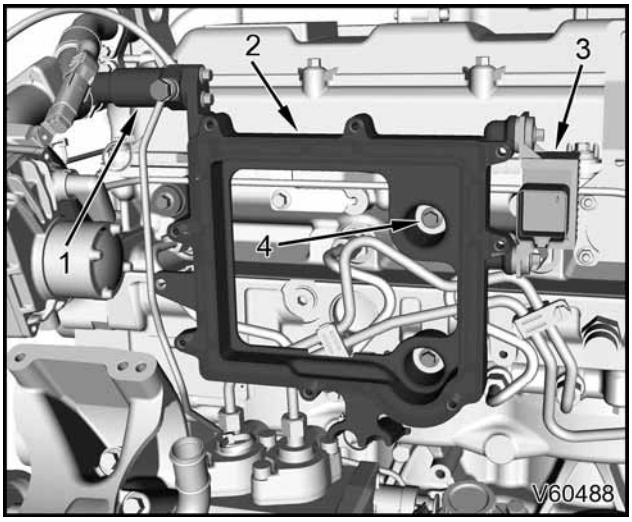

Figure 87 ECM support

1. Cold Start Solenoid (CSS)
2. ECM support
3. Cold Start Relay (CSR)
4. M8 x 40 bolt (3) with EDC bracket insulators (6)

2. Remove CSR from ECM support. See (Relay Assembly, page 110) in “COLD START ASSIST” section to remove CSR.
3. Remove CSS from ECM support. See (Fuel Supply Solenoid Hose, page 111) in “COLD START ASSIST” section to remove CSS.
4. Remove three M8 x 40 bolts, six EDC bracket insulators (three on each side of support) and ECM support from cylinder head.

Exhaust Gas Recirculation (EGR) Valve

1. Install dual flap EGR valve. For EGR valve installation see (EGR Dual Flap Valve, page 261) in “EXHAUST GAS RECIRCULATION (EGR) SYSTEM” for procedure.

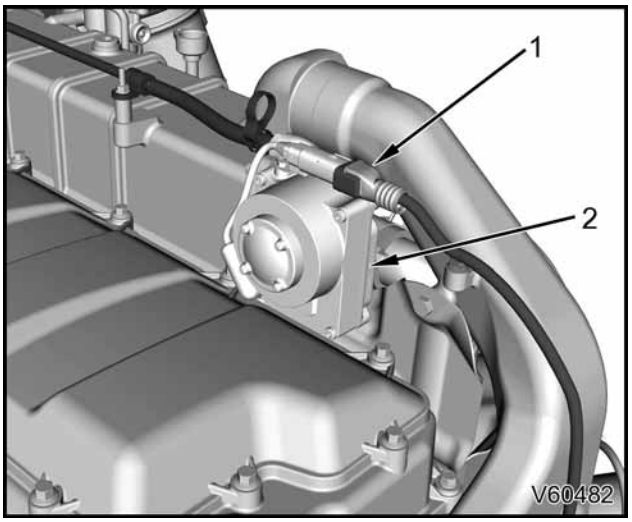

Figure 101 EGR valve harness connector

1. Harness connector
2. EGR valve

2. Connect harness to EGR valve terminal by pushing in on connector until a click is heard.
3. Engage release tab.

Air Control Valve (ACV)

1. Install ACV. For air control valve installation see (Air Control Valve, page 143) in “EXHAUST BACK PRESSURE CONTROL” for procedure.

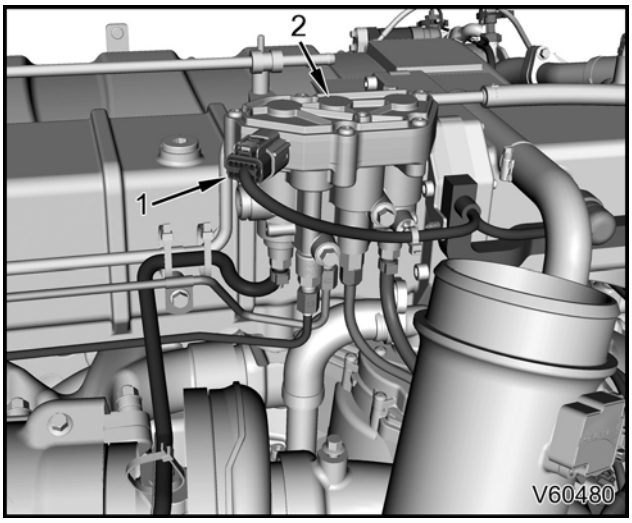

Figure 102 ACV

1. Harness connector
2. ACV assembly

2. Connect harness to ACV terminal by pushing in on connector until a click is heard.

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Special Torque

Table 5 Cold Start Assist

Banjo 6 (M10 x 1) and 8 (M12 x 1.5) bolts	15 N·m (11 lbf·ft)
Banjo M8 x 1 bolt	8 N·m (71 lbf·in)
Fuel supply cold start hose fitting nut	10 N·m (11 lbf·ft)
Glow plug locking nut	25 N·m (18 lbf·ft)
Relay assembly M6 x 20 bolts	10 N·m (89 lbf·in)
Solenoid valve M6 x 20 bolts	6 N·m (53 lbf·in)

HCI Coolant Supply Tube Assembly

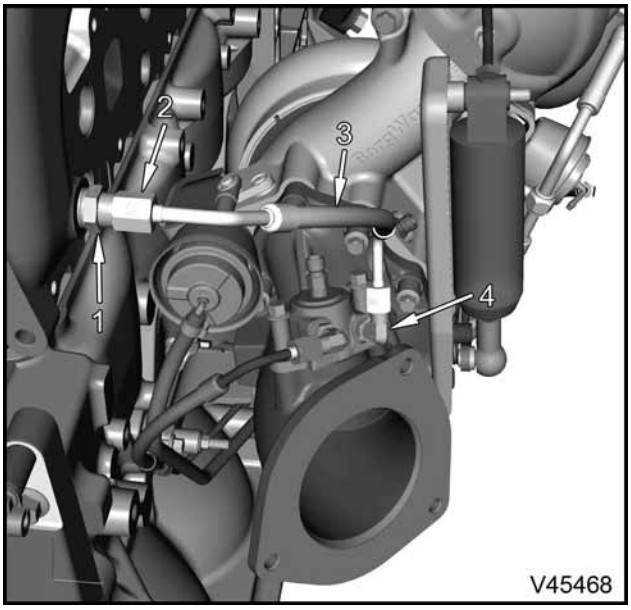

Figure 143 HCI coolant supply tube assembly

1. Straight fitting
2. HCI coolant supply tube nut (at coolant manifold)
3. HCI coolant supply tube assembly
4. Tube M10 elbow fitting

1. Loosen the HCI coolant supply tube assembly nut and disconnect tube from tube M10 elbow fitting.
2. Loosen coolant supply tube nut and disconnect tube from straight fitting at coolant manifold. Remove HCI coolant supply tube.
3. If necessary, remove straight fitting from coolant manifold.

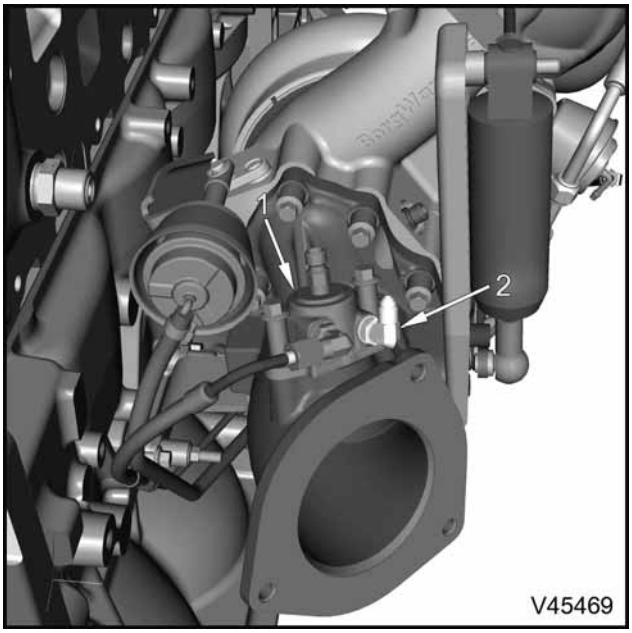

Figure 144 Hydrocarbon injector connection

1. Hydrocarbon injector
2. Tube M10 elbow fitting

NOTE: Perform step 4 only if tube M10 elbow fitting is leaking or if hydrocarbon injector is being replaced.

4. Remove tube M10 elbow fitting from hydrocarbon injector.

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Low-pressure Charge Air Cooler (LPCAC) Coolant Tube and Hoses

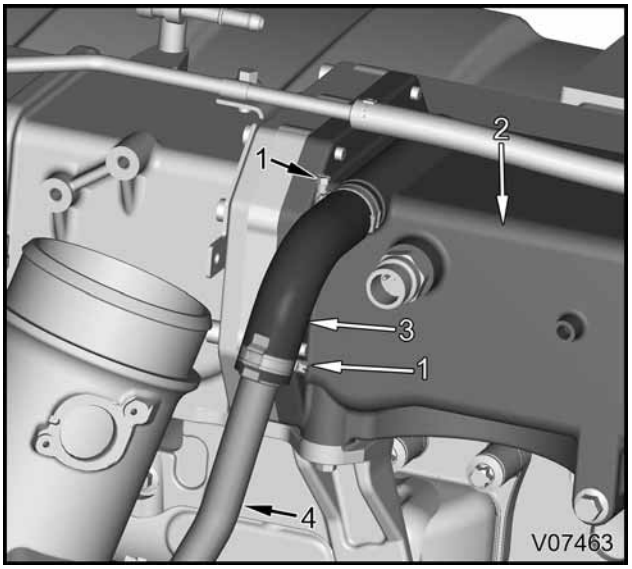

Figure 179 Coolant return hose

1. 3/4 inch constant torque hose clamp (2)
2. Low temperature housing (EGR cooler)
3. Coolant return hose
4. Coolant tube

1. Loosen two 3/4 inch hose clamps.
2. Disconnect coolant return hose from low temperature housing and coolant tube.

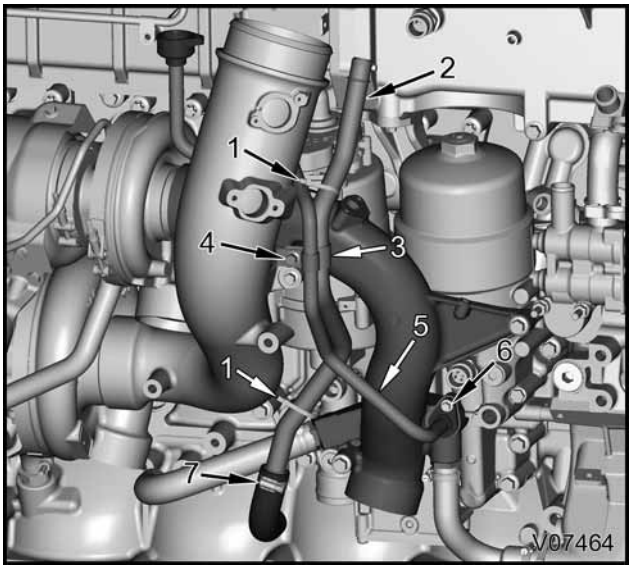

Figure 180 Coolant and cab heater tubes

1. Cable lock strap (2)
2. Coolant tube
3. Tube support
4. M8 x 20 bolt
5. Cab heater return tube assembly
6. M6 x 20 bolt
7. 3/4 inch constant torque hose clamp

3. Cut two cable lock straps from coolant tube.
4. Remove M8 x 20 bolt to release coolant tube support and cab heater return tube assembly retainer.
5. Remove M8 x 16 bolt and tube support behind air inlet duct. Remove M6 x 20 bolt to release cab heater return tube assembly and remove tube. Remove and discard O-ring.
6. Loosen 3/4 inch hose clamp and disconnect coolant tube from coolant hose. Remove coolant tube.

Installation

Turbocharger Mounting

WARNING: To prevent personal injury or death, use suitable lifting equipment and get help to remove or install the turbochargers.

WARNING: To prevent personal injury or death, do not allow the turbochargers to hang by the lower stud and nut alone. Support the assembly until the upper sleeves and nuts are installed.

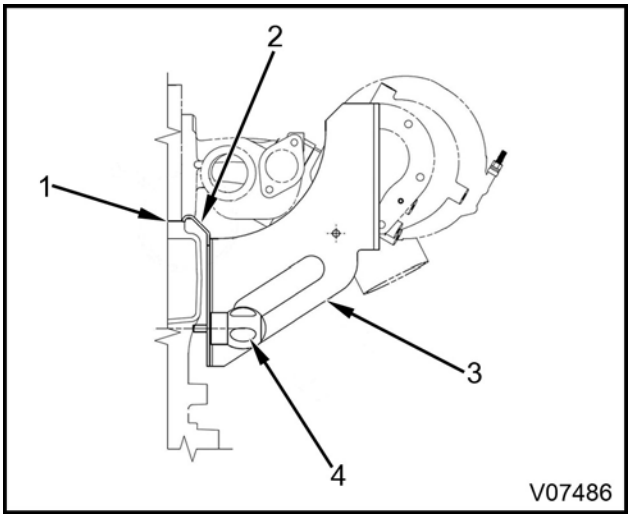

Figure 197 Turbocharger alignment tool installation

1. Crankcase-to-cylinder head deck
2. Tab
3. Turbo Alignment Bracket (ZTSE6041)
4. Hand screw

1. Install Turbo Alignment Bracket ZTSE6041 on engine with tabs seated on crankcase-to-cylinder head deck. Thread tool hand screw into crankcase boss and tighten to secure bracket in place.

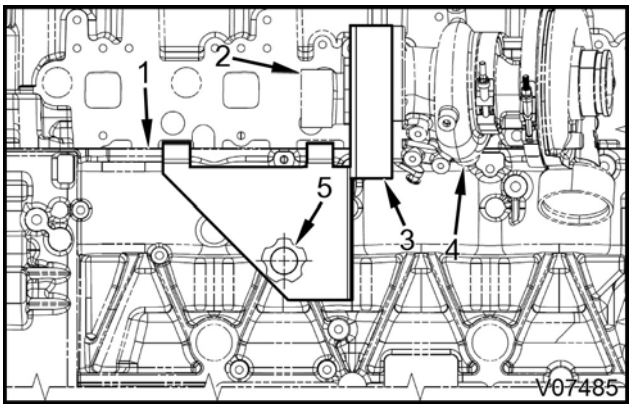

Figure 198 HP turbocharger alignment check

1. Crankcase-to-cylinder head deck
2. Middle exhaust manifold
3. Turbo Alignment Bracket (ZTSE6041)
4. HP turbocharger
5. Hand screw

2. With help of an assistant, align three studs and position HP turbocharger to middle exhaust manifold. Check that turbine exhaust outlet flange is aligned square with Turbo Alignment Bracket.

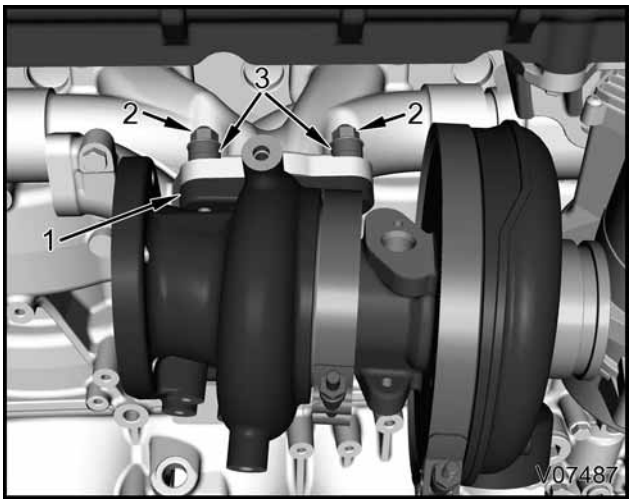

Figure 199 HP turbocharger mounting (upper nuts and sleeves)

1. HP turbocharger mounting flange
2. M10 nut (2)
3. 10.5 x 20 x 15 sleeve (2)

High-pressure (HP) and Low-pressure (LP) Wastegate Hoses

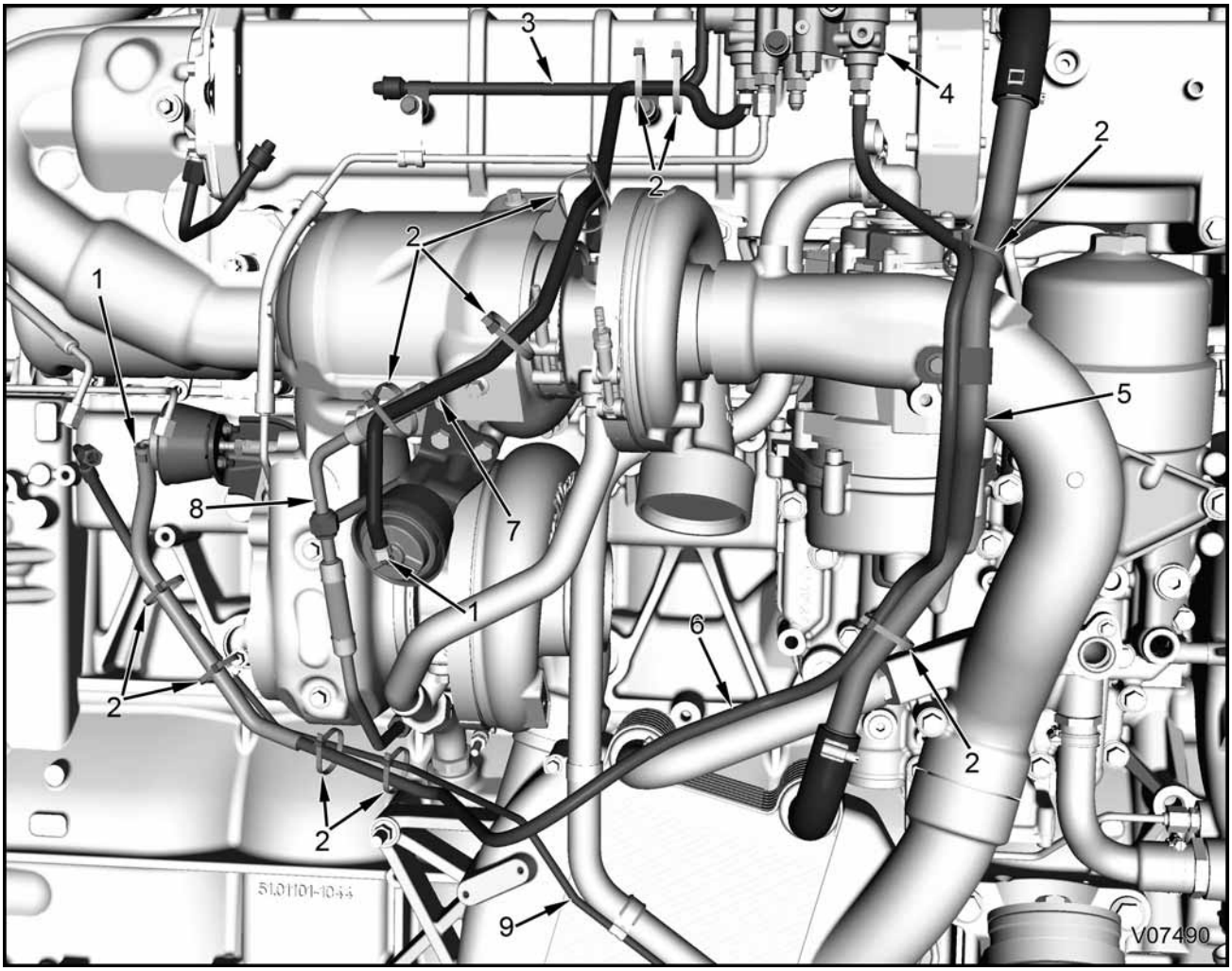

Figure 217 HP and LP wastegate hoses

1. 12.3 x 7 crimp clamp (2)
2. Cable lock strap (11)
3. EGRV coolant supply tube
4. Air control valve assembly
5. Coolant tube (EGR cooler to LPCAC)
6. LP wastegate hose
7. HP wastegate hose
8. Turbocharger oil supply tube
9. HCI coolant return tube

Power Steering Pump

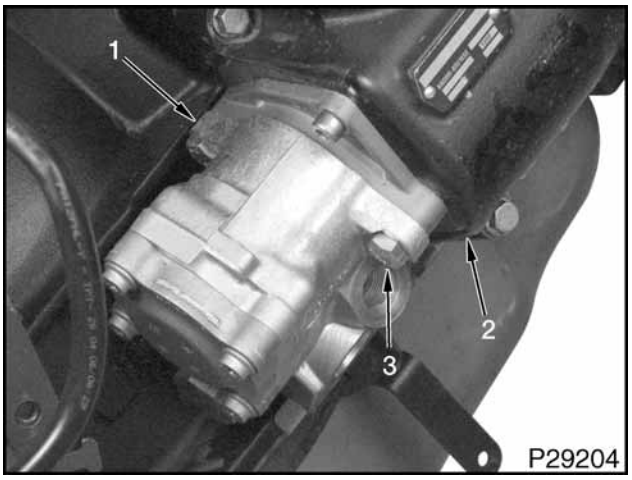

Figure 223 Power steering pump

1. Power steering pump
2. Air compressor
3. M10 x 40 bolt and lock washer (2)

1. Remove two M10 x 40 bolts, lock washers and power steering pump.
2. Check pump collar O-ring for damage and replace as necessary.

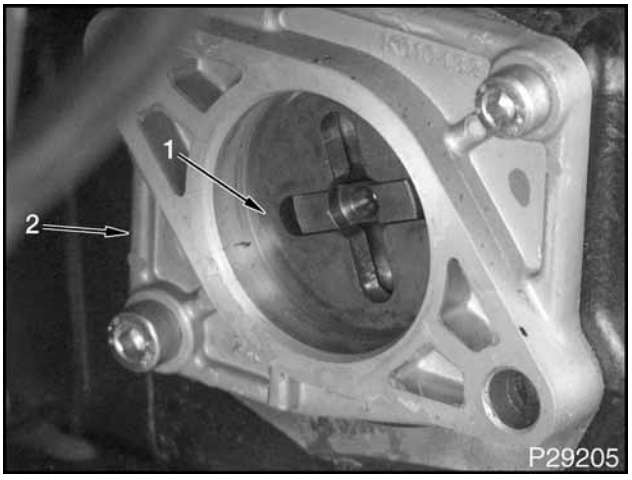

Figure 224 Power steering pump adapter

1. Power steering pump adapter
2. Air compressor

3. Remove power steering pump adapter from air compressor bore.

Air Compressor Coolant Hoses

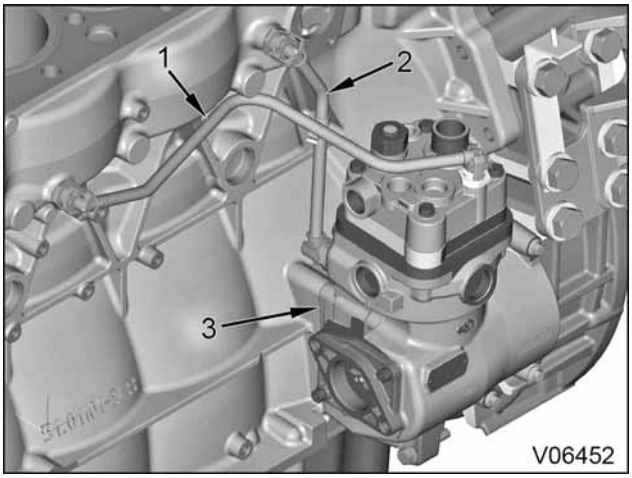

Figure 225 Air compressor coolant hoses

1. Coolant return hose
2. Coolant return tube (one cylinder air compressor) or Coolant supply hose (two cylinder air compressor)
3. Air compressor

1. Place suitable container under air compressor to collect any residual coolant.

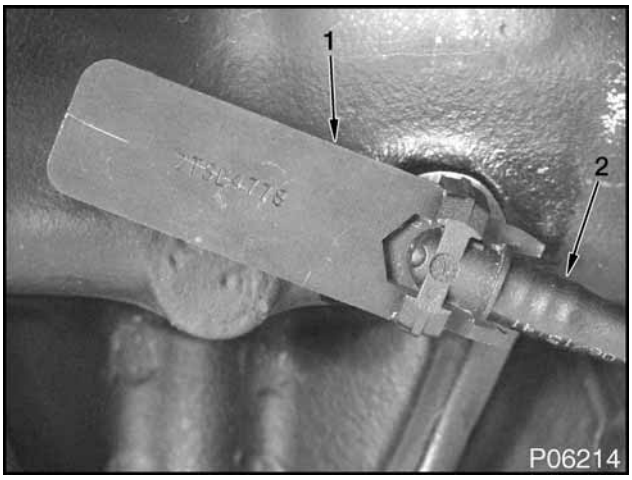

Figure 226 Air compressor coolant hose removal

1. Coolant Line Release Tool
2. Coolant hose

2. Insert Coolant Line Release Tool (page 193) into retaining clips of air compressor coolant hose and remove from crankcase.

Exploded Views

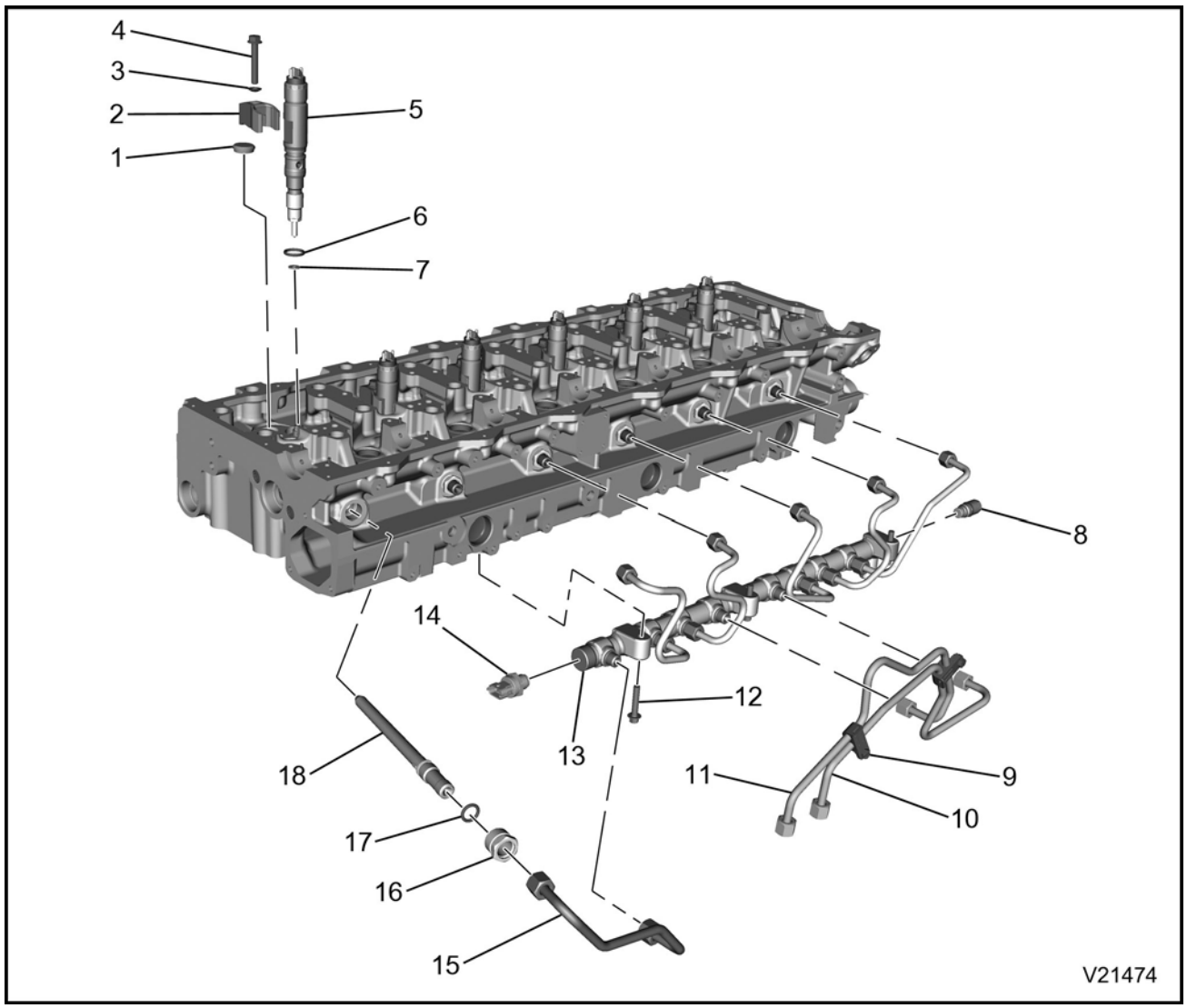

Figure 235 High-pressure fuel lines

1. Thrust washer (6)
2. Injector hold-down clamp (6)
3. Rounded washer (6)
4. M8 x 50 bolt (6)
5. Injector (6)
6. 3 x 20.9 ID O-ring (6)
7. Combustion washer (6)
8. Pressure limiting valve (fuel rail)
9. Fuel to rail supply clamp assembly (2)
10. High-pressure pump to rail tube assembly 2
11. High-pressure pump to rail tube assembly 1
12. M8 x 40 bolt (3)
13. Fuel rail
14. Rail fuel pressure sensor
15. High-pressure rail to injector tube assembly (6)
16. High-pressure connector retaining nut (6)
17. 13.5 x 3 O-ring (6)
18. High-pressure connector body (6)

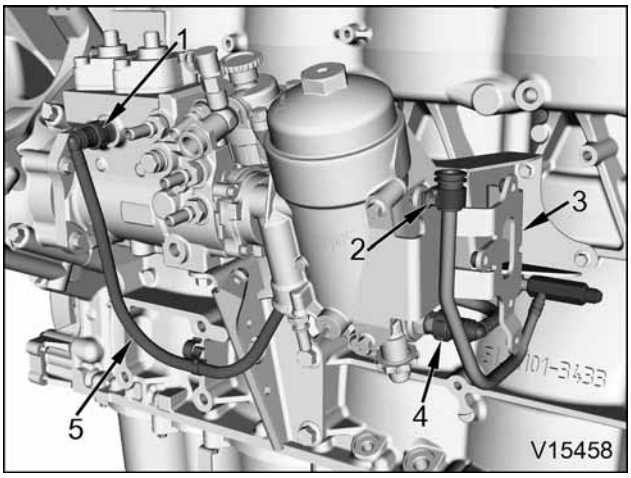

Figure 253 Fuel drain hose connections

1. Quick-connect 90° fitting (at high-pressure fuel pump)
2. M6 x 16 bolt and closed (P) clamp
3. Metering unit bracket
4. Quick-connect 90° fitting (at filter housing)
5. Fuel drain hose

5. Remove M6 x 16 bolt and closed (P) clamp attaching fuel drain hose to metering unit bracket.
6. Disconnect fuel drain hose assembly quick-connect 90° fittings at high-pressure fuel pump and at fuel filter housing. Cap openings.

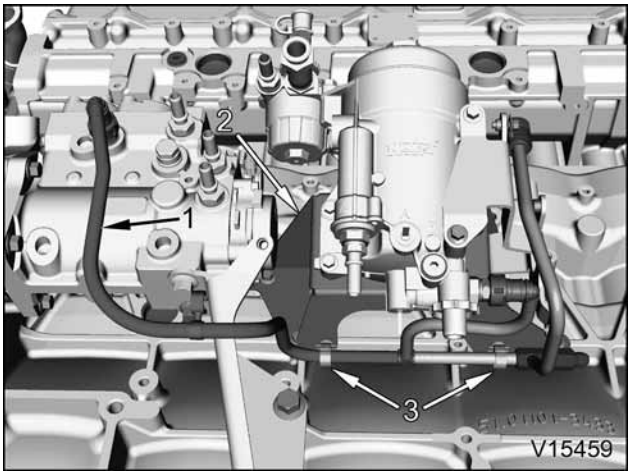

Figure 254 Fuel drain hose retainers

1. Fuel drain hose
2. Fuel filter bracket
3. 8 x 13 single retainer (2)

7. Disconnect 8 x 13 single retainers and remove fuel drain hose from engine.

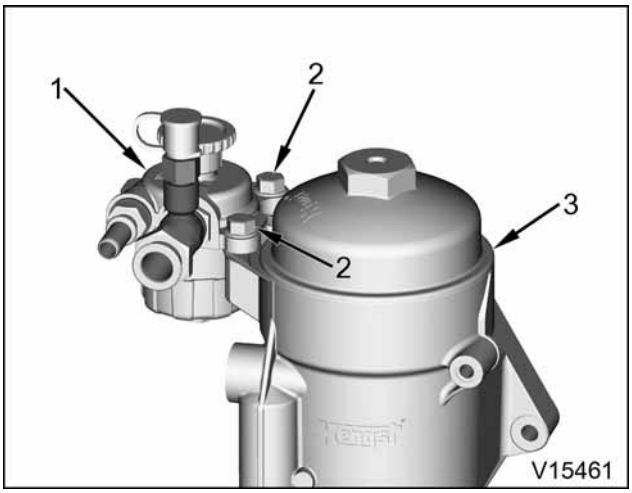

Figure 255 Fuel primer pump

1. Fuel primer pump assembly
2. M8 x 25 bolt (2)
3. Fuel filter housing

NOTE: The fuel primer pump can be removed as an assembly along with the fuel filter housing. If the primer pump is to be replaced, remove two M8 x 25 bolts and remove pump assembly from filter housing.

8. Remove two M8 x 25 bolts.
9. Remove fuel primer pump from fuel filter housing.

4. Slide injector into hold-down clamp with injector fuel inlet opening on opposite side of hold-down clamp.

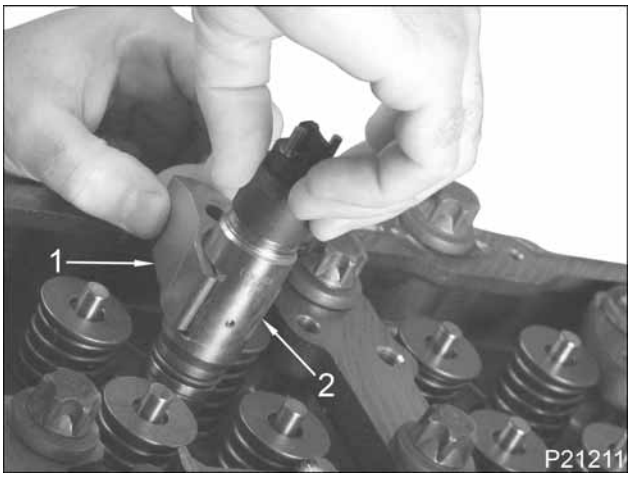

Figure 278 Injector and injector hold-down clamp installation (typical)

1. Injector hold-down clamp
2. Injector

CAUTION: To prevent engine damage, align injector and hold-down clamp correctly with cylinder head; do not twist injector when inserting injector into cylinder head.

NOTE: Make sure injector bore in cylinder head is clean and no old combustion washer remains inside the bore.

5. Install injector by lowering injector and hold-down clamp as one unit into injector bore.

6. Using Injector Installer (page 234), firmly press injector and hold-down clamp and make sure injector is fully seated into cylinder head.

CAUTION: To prevent engine damage, six new high-pressure connector bodies must be installed and aligned before tightening M8 x 50 bolts for six fuel injectors.

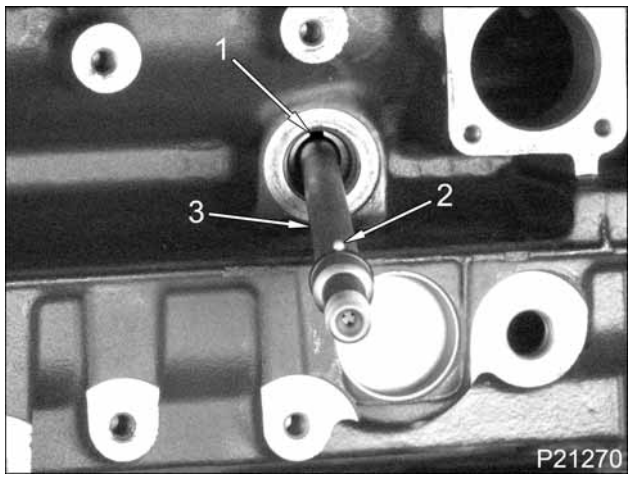

Figure 279 Alignment of high-pressure connector body (typical)

1. Notch in cylinder head
2. Locating ball
3. High-pressure connector body

7. Align locating ball on each new high-pressure connector body with notch in cylinder head and install six new high-pressure connector bodies.

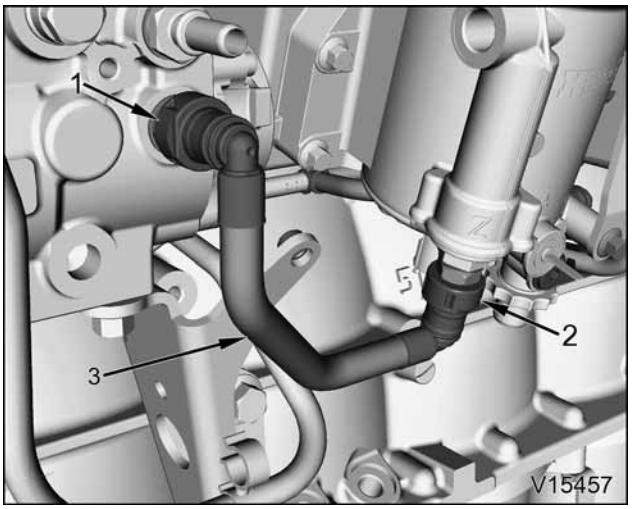

Figure 298 Pre-filter fuel supply hose assembly

1. Quick-connect 90° fitting (at high-pressure fuel pump)
2. Quick-connect 90° fitting (at filter housing)
3. Pre-filter fuel supply hose

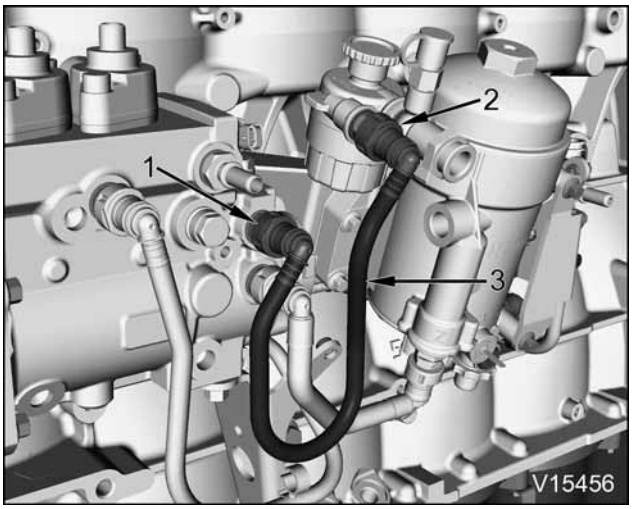

Figure 299 Pre-pump fuel supply hose assembly

1. Quick-connect 90° fitting (at high-pressure fuel pump)
2. Quick-connect 90° fitting (at primer pump)
3. Pre-pump fuel supply hose

7. Check that O-rings are in place in pre-filter fuel supply quick-connect 90° fittings and not damaged. Replace as necessary.
8. Install pre-filter fuel supply hose. Push on quick-connect 90° fitting at high-pressure fuel pump until an audible click is heard. Pull quick-connect fitting to make sure it is seated. Repeat the procedure for the quick-connect 90° fitting at fuel filter housing.
9. Check that O-rings are in place in pre-pump fuel supply hose quick-connect 90° fittings and not damaged. Replace as necessary.
10. Install pre-pump fuel supply hose. Push on quick-connect 90° fitting at high-pressure fuel pump until an audible click is heard. Pull quick-connect fitting to make sure it is seated. Repeat the procedure for the quick-connect 90° fitting at primer pump.

Exploded Views

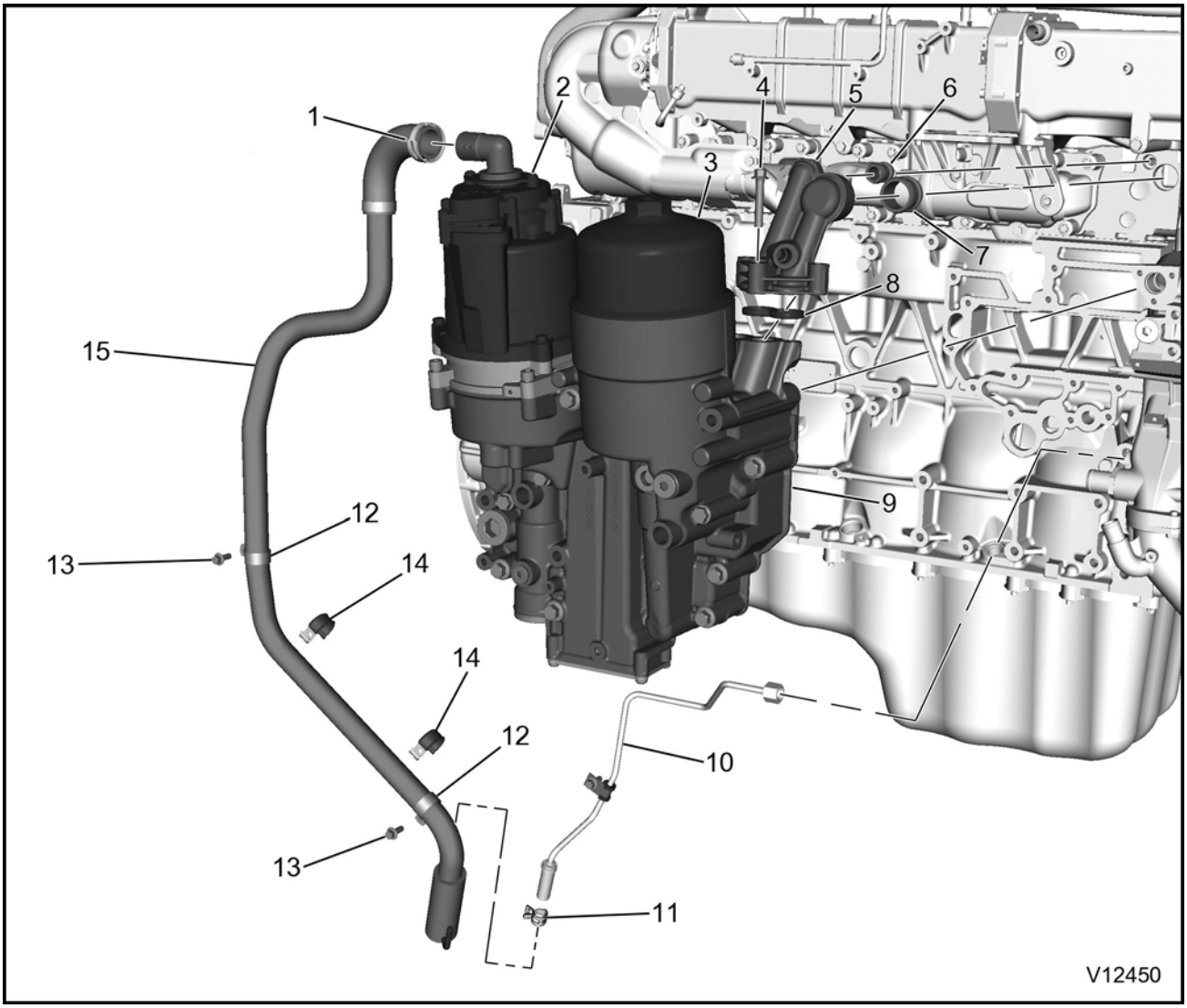

Figure 311 Oil module assembly

1. Clamp (spring)
2. Oil centrifuge
3. Filter cover
4. M8 x 45 bolt (3)
5. Oil module flange
6. Extension tube (DMR20 x DN14)
7. Extension tube (DMR37 x DN29)
8. Seal (formed)
9. Oil module assembly
10. Heater return tube assembly
11. Hose clamp (spring)
12. Tube clamp (2)
13. M6 x 16 bolt (2)
14. Tube clamp (2)
15. Open breather tube assembly

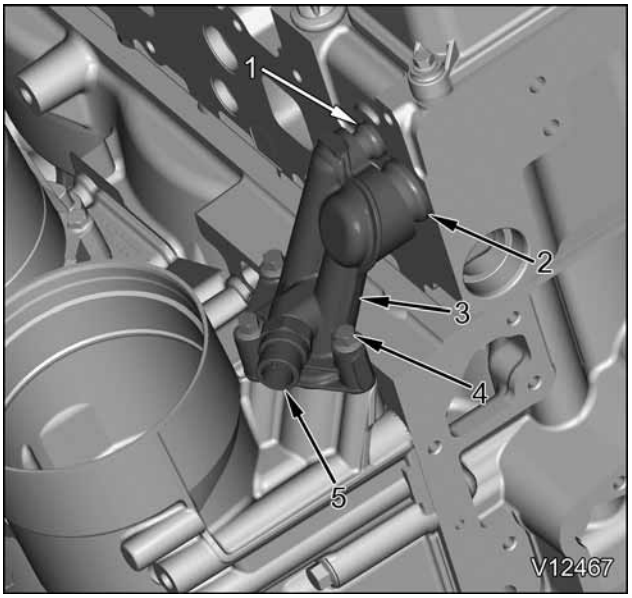

Figure 331 Oil module flange

1. Extension tube (DMR20 x DN14)
2. Extension tube (DMR37 x DN29)
3. Oil module flange
4. M8 x 45 bolt (3)
5. Engine oil temperature sensor

6. Lubricate sealing surfaces of DMR20 x DN14 and DMR37 x DN29 extension tubes with P-80® rubber lubricant or equivalent (page 250) and insert into oil module flange.
7. Install extension tubes into oil module flange using Extension Tube Installer Large and Extension Tube Installer Small (page 250).
8. Position oil module with new formed seal onto oil module while gently pushing extension tubes into cylinder head. Install three M8 x 45 bolts. Tighten bolts to special torque (page 250).
9. If not previously done, install engine oil temperature sensor into oil module flange if needed. See "ENGINE ELECTRICAL" for procedure. Connect temperature sensor electrical connector.

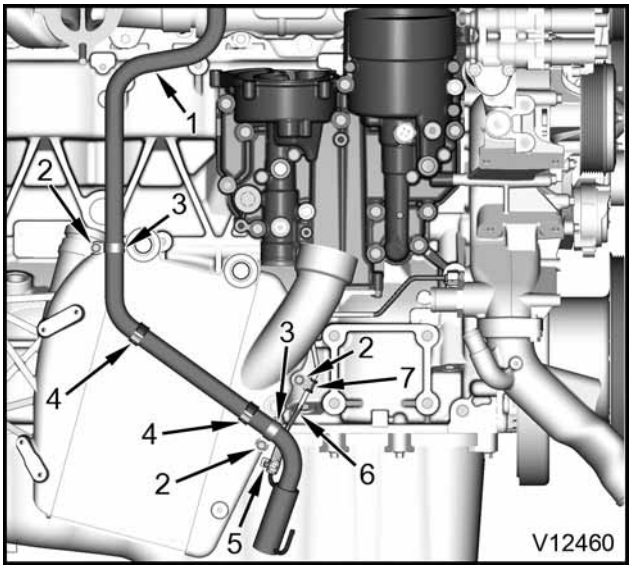

Figure 332 Open breather tube and heater return tube

1. Open breather tube assembly
2. M6 x 16 bolt (3)
3. Tube clamp (2)
4. Tube clamp (2) (for HCI coolant return tube assembly)
5. Hose clamp (spring type)
6. Heater return tube assembly
7. Pipe single cushioned clamp

10. Install two tube clamps onto open breather tube. Position open breather tube assembly to LPCAC and install two M6 x 16 bolts. Tighten bolts to special torque (page 250).
11. If not previously done, snap two tube clamps over open breather tube assembly and HCI coolant return tube assembly.
12. If not previously done, install HCI coolant return tube onto open breather tube assembly and install hose clamp (spring type). See "AFTERTREATMENT SYSTEM" for procedure.
13. Position heater return tube assembly to straight fitting on water distribution housing and loosely tighten tube nut.
14. Install pipe single cushioned clamp onto heater return tube assembly and install M6 x 16 bolt into LPCAC and tighten to special torque (page 250).

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, make sure the engine has cooled before removing 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: Refer to the following service sections for information on removal of components prior to this section.

- Engine Electrical
- Front Cover, Fan Drive, Cooling System and Related Components
- Turbochargers
- Oil Cooler, Filter Housing and Crankcase Ventilation

Coolant Manifold

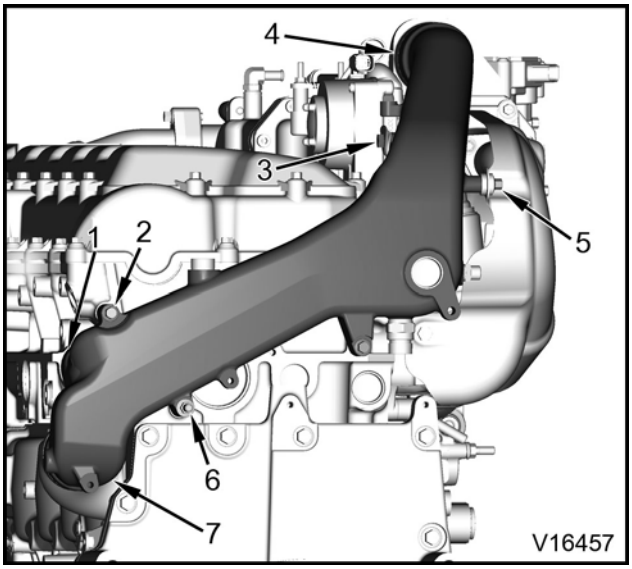

Figure 340 Coolant manifold

1. Extension tube (DMR44 x 35)
2. M8 x 45 bolt (2)
3. M8 x 12 bolt
4. Extension tube (DMR62 x 51)
5. M8 x 25 heat-resistant bolt
6. M8 x 50 x 16 stud bolt
7. Extension tube (DMR62 x 51)

1. Remove M8 x 12 bolt securing heat protection EGR shield to coolant manifold.
2. Remove heat protection (cylinders 4-6) shield M8 x 25 heat-resistant bolt.
3. Remove two M8 x 45 bolts, one M8 x 50 x 16 stud bolt and coolant manifold.

CAUTION: To prevent engine damage, do not remove extension tubes by grabbing sealing surface.

4. Remove two DMR62 x 51 and one DMR44 x 35 extension tubes. Pry the tubes out using a wood or plastic hammer handle or similar tool. Inspect extension tube sealing surfaces for damage. Replace as needed.

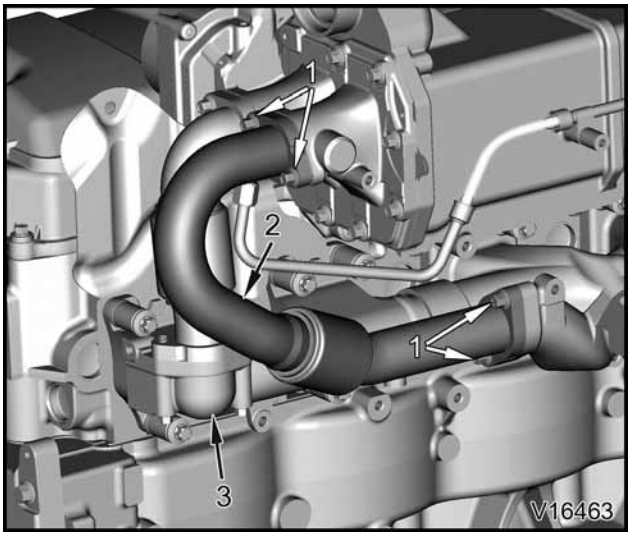

Figure 358 EGR inlet (cylinders 1-3) tube

1. M8 x 25 heat-resistant bolt (4)
2. EGR inlet (cylinders 1-3) tube
3. Rear exhaust manifold

3. Position two new EGR inlet (cylinders 1-3) tube gaskets, one to EGR valve and one to middle exhaust manifold.
4. Install EGR inlet (cylinders 1-3) tube and four M8 x 25 heat-resistant bolts. Tighten bolts to special torque (page 270).

EGR Outlet Tubes

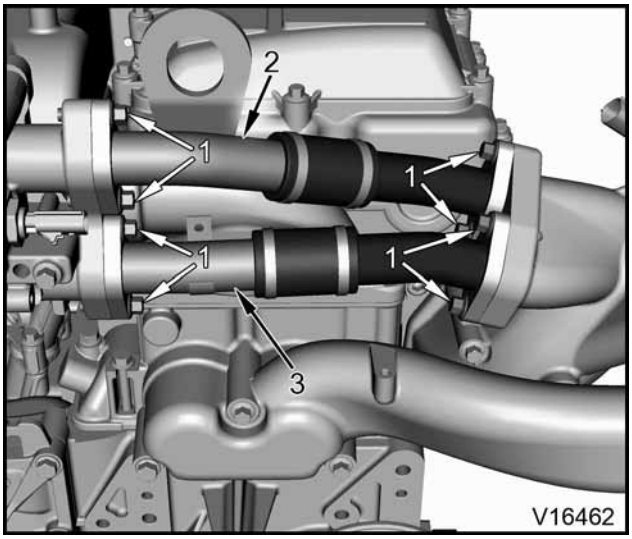

Figure 359 EGR outlet tubes

1. M8 x 30 bolt (8)
2. EGR outlet (cylinders 1-3) tube
3. EGR outlet (cylinders 4-6) tube

1. Install EGR outlet (cylinders 4-6) tube, two new tube gaskets and four M8 x 30 bolts. Tighten bolts to standard torque (page 471).
2. Install EGR outlet (cylinders 1-3) tube, two new tube gaskets and four M8 x 30 bolts. Tighten bolts to standard torque (page 471).
3. Check EGR outlet tube hose clamps for looseness. Tighten tube hose clamps to special torque (page 270).

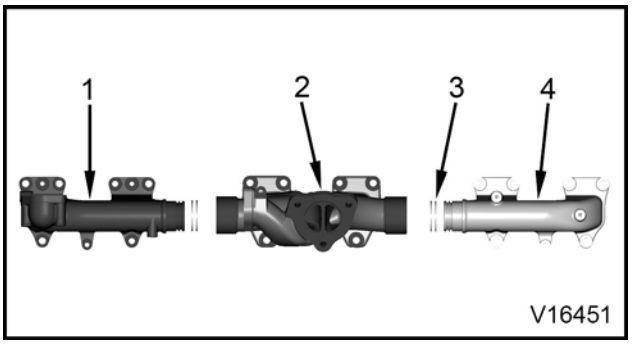

Figure 368 Exhaust manifolds

1. Rear exhaust manifold
2. Middle exhaust manifold
3. Multipiece oil (FEY) ring (4)
4. Front exhaust manifold

4. Separate front and rear exhaust manifold sections from middle exhaust manifold.
5. Remove and discard multipiece oil (FEY) rings from front and rear exhaust manifolds.

Air Intake Throttle Duct

CAUTION: To prevent engine damage, make sure gasket debris and dirt do not enter cylinder head opening.

1. Remove glow plug from air intake throttle duct. See “COLD START ASSIST” for procedure.
2. Remove temperature sensor and air pressure sensor from air intake throttle duct. See “ENGINE ELECTRICAL” for procedures.

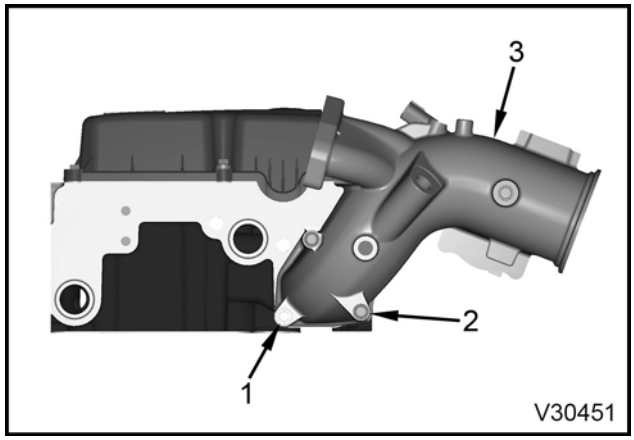

Figure 369 Air intake throttle horizontal duct

1. M8 x 50 bolt
2. M8 x 100 bolt (2)
3. Air intake throttle horizontal duct

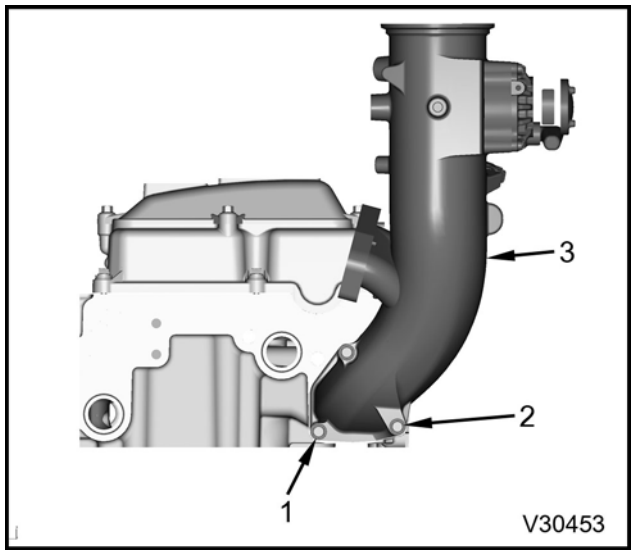

Figure 370 Air intake throttle vertical duct

1. M8 x 50 bolt
2. M8 x 100 bolt (2)
3. Air intake throttle vertical duct

3. Remove M8 x 50 bolt and two M8 x 100 bolts.
4. Depending on application, remove either air intake throttle horizontal or vertical duct.

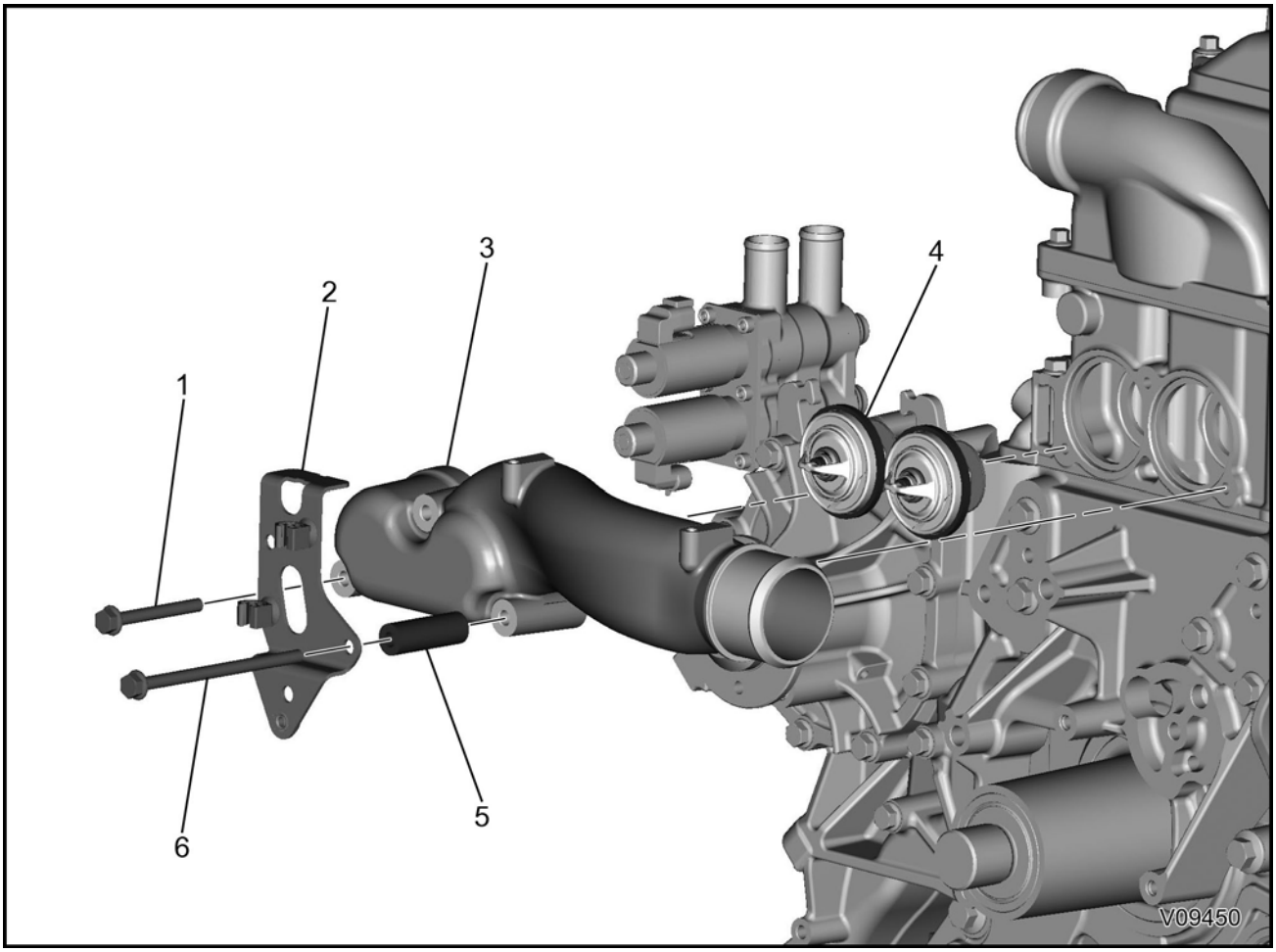

Figure 380 Thermostat assembly and coolant outlet manifold (low mount fan)

1. M8 x 70 bolt
2. Fan coupling bracket assembly
3. Coolant outlet manifold
4. Thermostat assembly (2)
5. Bushing (2)
6. M8 x 130 bolt (2)

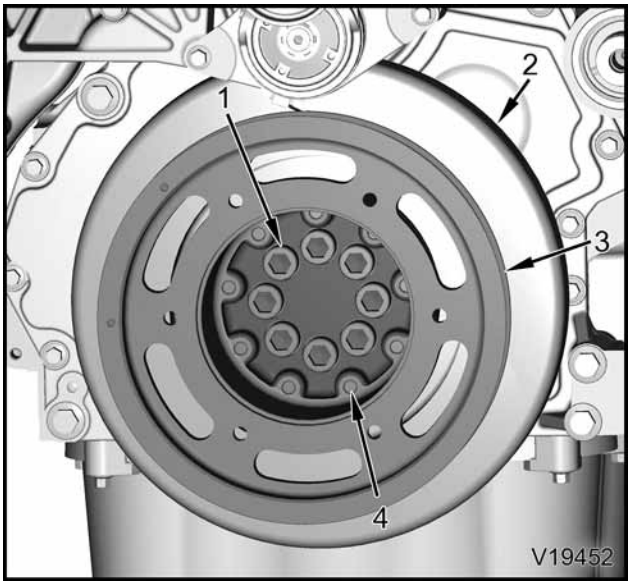

Figure 396 Vibration damper (high mount fan with fan drive pulley)

1. M16 x 85 socket-head cap screw (8)
2. Vibration damper
3. Fan drive pulley
4. M10 x 35 bolt (9)

WARNING: To prevent personal injury or death, support the vibration damper when removing bolts. The damper can easily slide off the crankshaft.

NOTE: If equipped with high mount fan, remove fan drive pulley and vibration damper together. If equipped with low mount fan, remove damper hub and vibration damper together.

1. Remove eight M16 x 85 socket-head cap screws.
2. Remove vibration damper with damper hub or fan drive pulley as an assembly.
3. For vibration damper replacement only, remove damper hub or fan drive pulley by removing nine M10 x 35 bolts.

Coolant Control Valve (CCV) Assembly

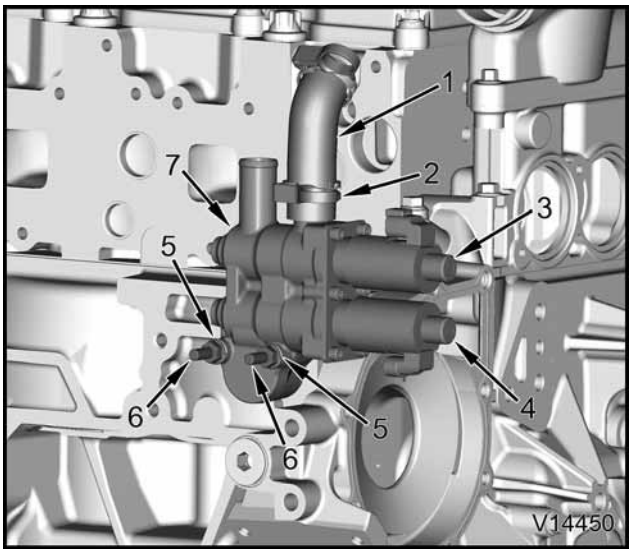

Figure 397 CCV assembly

1. Low temperature hose assembly
2. Hose clamp (spring type)
3. Coolant Mixer Valve (CMV)
4. Coolant Flow Valve (CFV)
5. Lock washer (2)
6. M8 x 60 stud bolt (2)
7. CCV assembly

1. Release hose clamp (spring type) and remove low temperature hose assembly from CCV assembly.
2. Remove two M8 x 60 stud bolts, two lock washers, CCV assembly and O-ring. Discard O-ring.

Vibration Damper

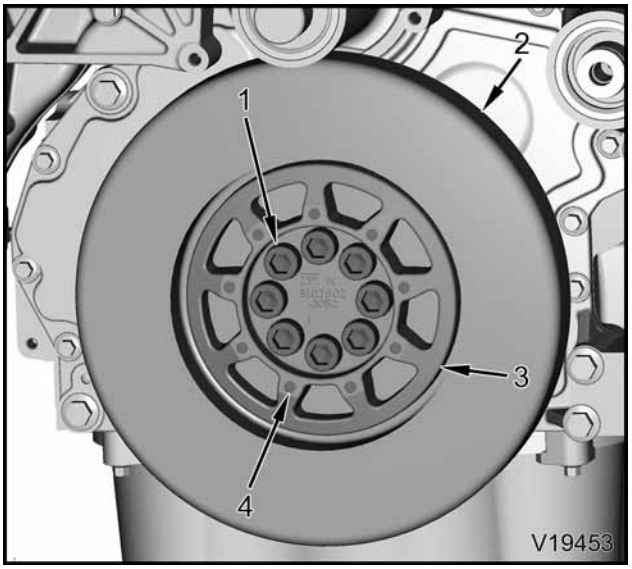

Figure 417 Vibration damper (low mount fan with damper hub)

1. M16 x 85 socket-head cap screw (8)
2. Vibration damper
3. Damper hub
4. M10 x 35 bolt (9)

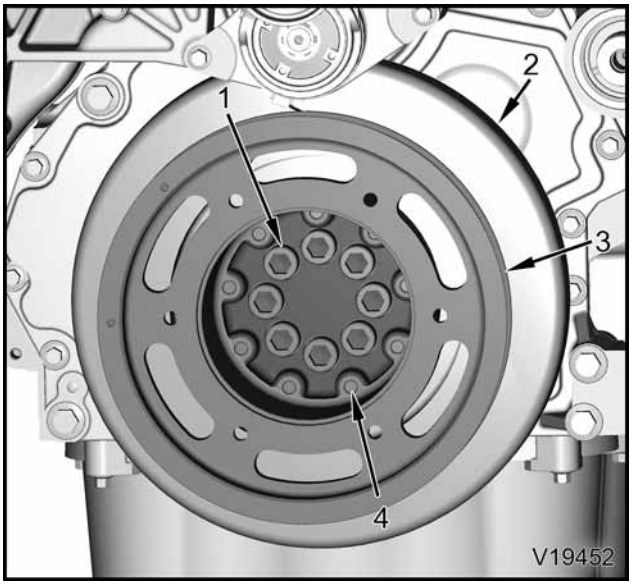

Figure 418 Vibration damper (high mount fan with fan drive pulley)

1. M16 x 85 socket-head cap screw (8)
2. Vibration damper
3. Fan drive pulley
4. M10 x 35 bolt (9)

NOTE: Install damper hub or fan drive pulley and vibration damper together as an assembly.

1. If previously disassembled, assemble damper hub or fan drive pulley to vibration damper with nine M10 x 35 bolts. Tighten bolts to special torque (page 312).
2. Install vibration damper assembly.
3. Install eight M16 x 85 socket-head cap screws. Using a crisscross pattern, tighten screws as follows.
   a. Tighten socket-head cap screws to 150 N·m (111 lbf·ft).
   b. Angle-tighten socket-head cap screws an additional 90°.

Exploded Views

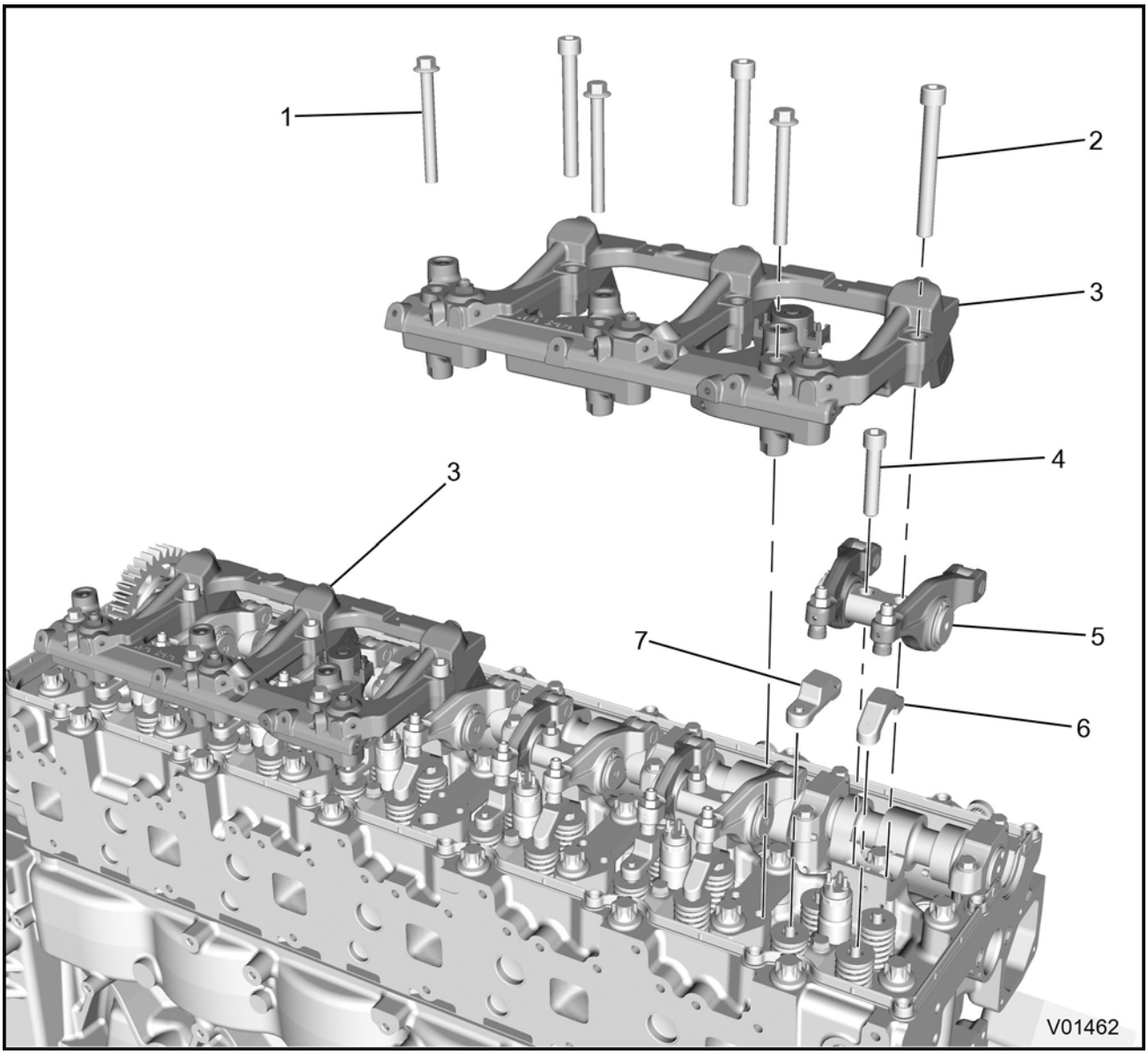

Figure 429 MaxxForce® engine brake assembly installation

1. M10 x 90 bolt (6)
2. M12 x 100 (socket-head) screw (6)
3. Engine brake housing assembly (2)
4. M12 x 60 (socket-head) screw (6)
5. Intake and exhaust rocker arm assembly (6)
6. Valve bridge (intake) (6)
7. Valve bridge (exhaust) (6)

Control Valve

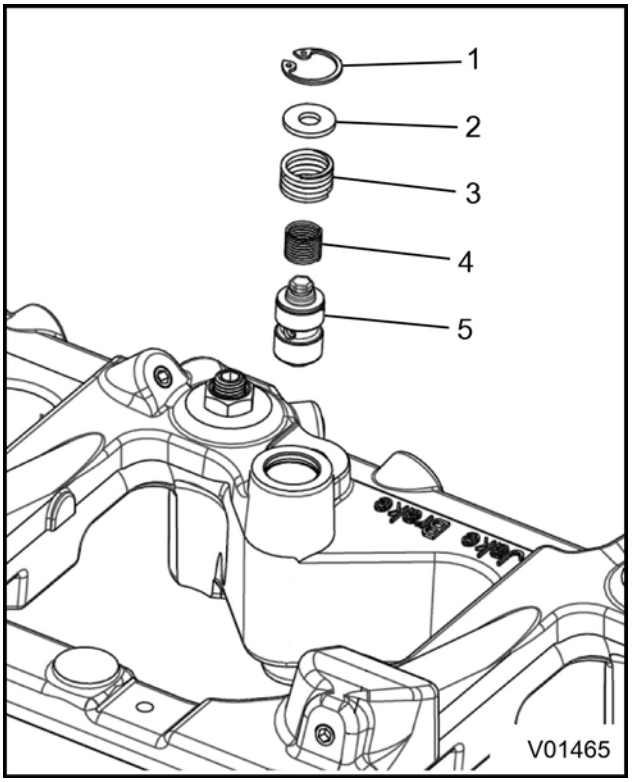

Figure 444 Control valve

1. Control valve retaining ring
2. Control valve cover
3. Outer spring
4. Inner spring
5. Control valve assembly

1. Check that housing control valve bore is clean, free of any residue and debris.
2. Lubricate control valve assembly and springs with clean engine oil.
3. With hex stud end up, insert control valve assembly into housing bore. Ensure control valve assembly moves smoothly and freely down bore.
4. Insert inner and outer springs into bore. Make sure that springs are properly seated with inner spring on control valve and outer spring on step of control valve bore.
5. Install control valve cover over springs.

WARNING: To prevent personal injury or death, wear safety glasses with side shields.

6. Using snap-ring pliers, install control valve retaining ring in housing bore to contain control valve assembly. Ensure retaining ring is installed with sharp side up (away from control valve cover). Rotate retaining ring to insure that it is properly seated in groove.

Solenoid

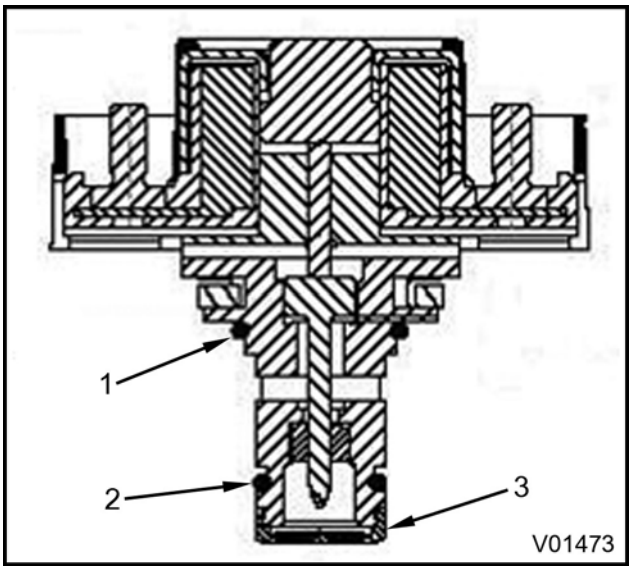

Figure 445 Solenoid seal rings

1. Upper seal ring
2. Lower seal ring
3. Solenoid screen

1. Install new upper and lower seal rings in ring grooves on solenoid stem. Lubricate seal rings with clean engine oil.
2. Clip solenoid screen on bottom of solenoid stem.

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 the transmission to park or neutral, set parking brake, and block wheels before doing diagnostic or service procedures.

WARNING: To prevent personal injury or death, make sure the engine has cooled before removing components.

WARNING: To prevent personal injury or death, remove the ground cable from the negative terminal of the main battery before disconnecting or connecting electrical components. Always connect the ground cable last.

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.

Valve Lash Adjustment

NOTE: Valve lash must be set with engine cold and cylinder head assembled to crankcase.

1. Remove the upper valve cover and base. See (Upper Valve Cover and Base, page 341).

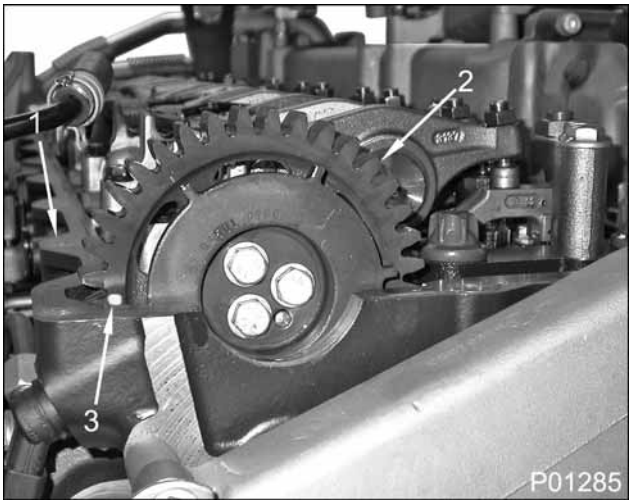

Figure 453 Camshaft gear timing mark

1. Valve cover surface
2. Camshaft gear
3. Timing mark

2. Rotate crankshaft in direction of engine rotation until the camshaft timing gear mark aligns with the valve cover surface on the intake side of the engine.

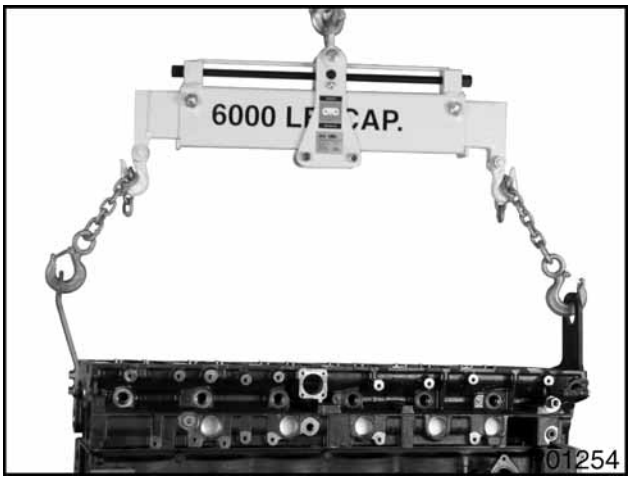

Figure 470 Cylinder head removal

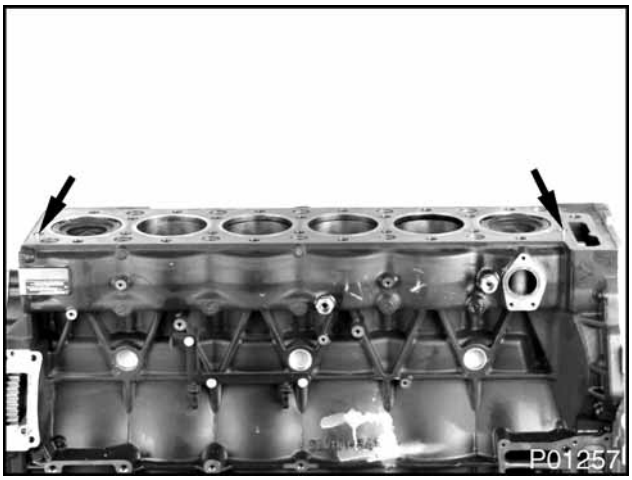

Figure 471 8 mm dowel pin (2)

5. Lift cylinder head using a suitable lifting device.

WARNING: To prevent personal injury or death, use a hoist rated for the weight of the cylinder head and follow the manufacturer's operative and safety instructions. Attach safety lifting hooks to the cylinder head lifting bracket and lifting eye.

CAUTION: To prevent engine damage, do not scratch gasket surface of cylinder head.

CAUTION: To prevent engine damage, carefully set cylinder head on wooden blocks to protect the cylinder head idler gear.

6. Place cylinder head on a clean, non-metallic surface.
7. Remove four M8 x 20 class 10.9 bolts and Cylinder Head Lifting Bracket (page 362).
8. Remove and discard cylinder head gasket.
9. If damaged, remove two 8 mm dowel pins.

Cylinder Head Idler Gear

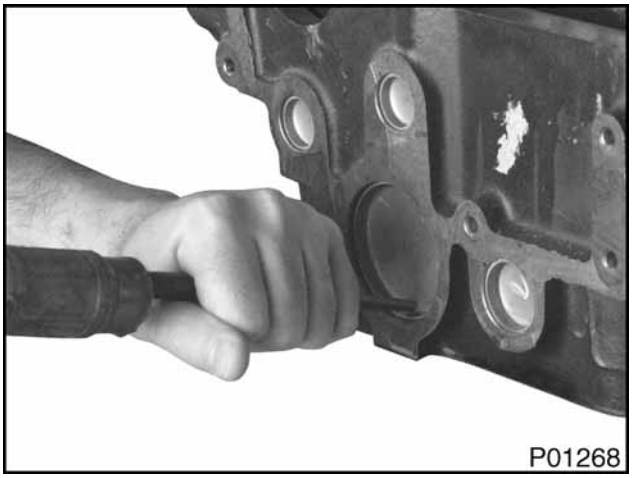

Figure 472 DMR 63.10 cup plug removal

1. Use a punch to knock in bottom of DMR 63.10 cup plug. Remove and discard cup plug.

7. Verify timing mark on flywheel is aligned with flywheel housing timing index at bottom of flywheel housing.

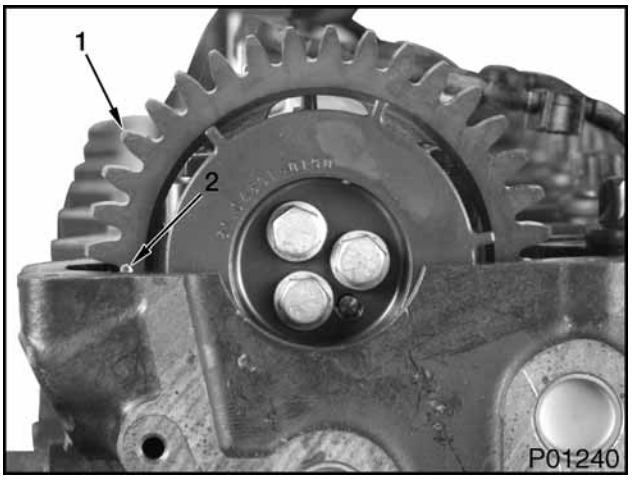

Figure 489 Camshaft timing mark (typical)

1. Camshaft gear
2. Timing mark

8. Lower camshaft on cylinder head and make sure timing mark on camshaft gear is aligned with cylinder head surface.

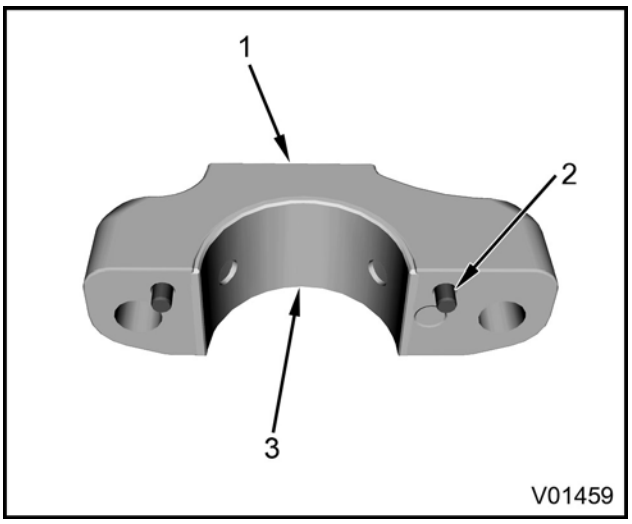

Figure 490 Camshaft bearing cap and bearing shell

1. Camshaft bearing cap
2. 4H x 8 x 10 dowel pin (2)
3. Bearing shell

NOTE: Make sure that each bearing cap has the two dowel pins installed.

9. If previously removed, install 14 – 4H x 8 x 10 dowel pins into seven camshaft bearing caps.

NOTE: If original bearings are installed, make sure each is placed as previously marked in its original location and orientation.

10. Install seven new or previously marked bearing shells on camshaft bearing caps.

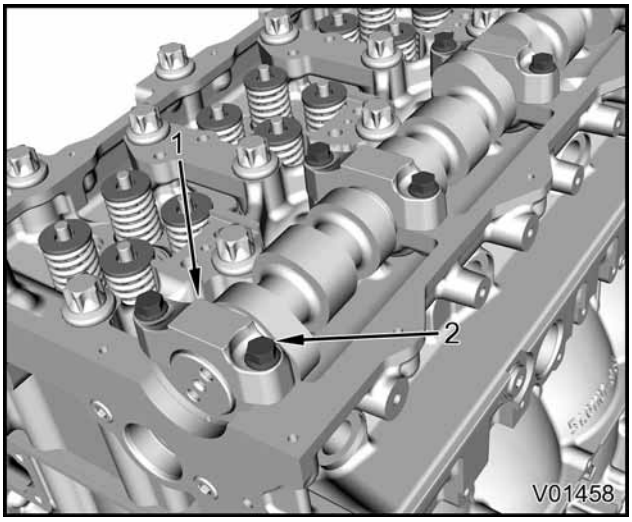

Figure 491 Camshaft bearing caps

1. Camshaft bearing cap (7)
2. M8 x 35 bolt (14)

11. Install seven previously marked camshaft bearing caps with each placed in its original location and orientation.
12. Install 14 M8 x 35 bolts. Tighten bolts to special torque (page 361).

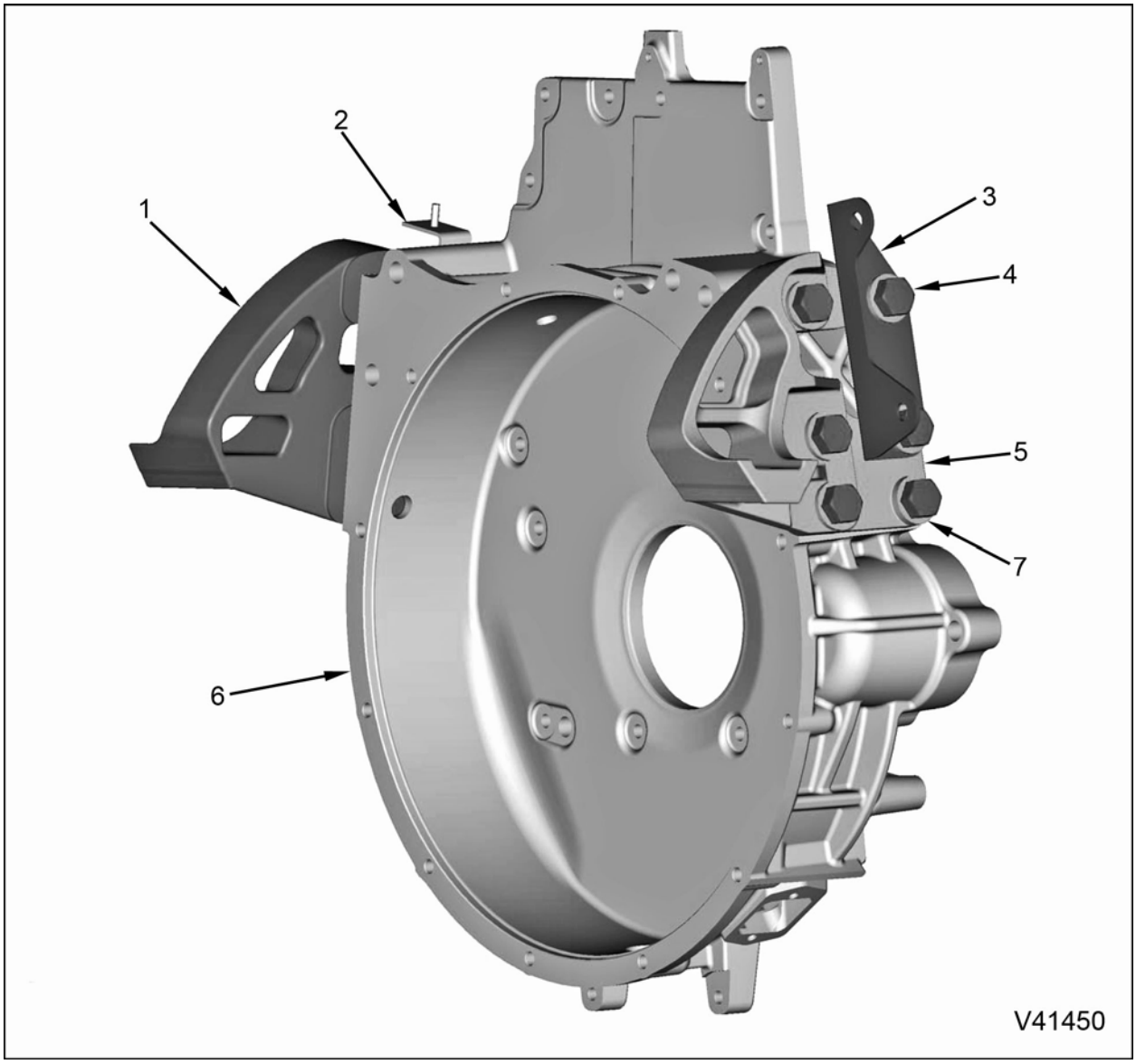

Figure 500 Rear engine mounts

1. Left offset engine mounting support
2. Extension assembly
3. PDO base bracket
4. 3/4” x 2” bolt (12)
5. Right offset engine mounting support
6. Flywheel housing
7. 3/4” washer (12)

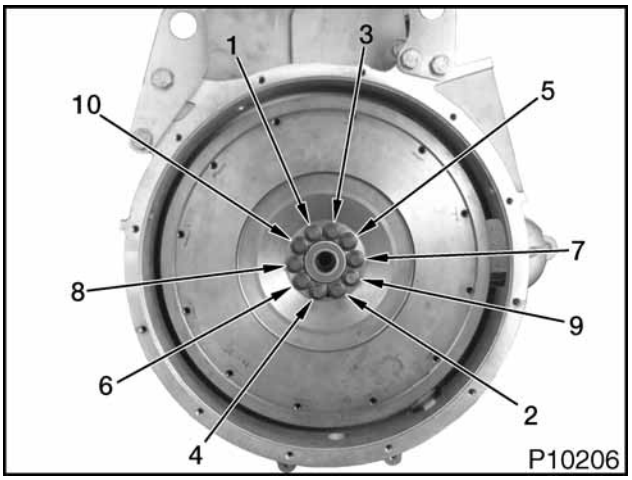

Figure 517 Flywheel bolt tightening sequence

NOTE: For proper flywheel installation, follow the correct tightening sequence while keeping the crankshaft from turning.

5. Tighten 12PT flange bolts using sequence indicated above as follows:
   a. Tighten bolts to 110 N·m (81 lbf·ft).
   b. Angle tighten bolts 90°.
   c. Angle tighten bolts an additional 90°.

Pilot Bearing (Flywheel)

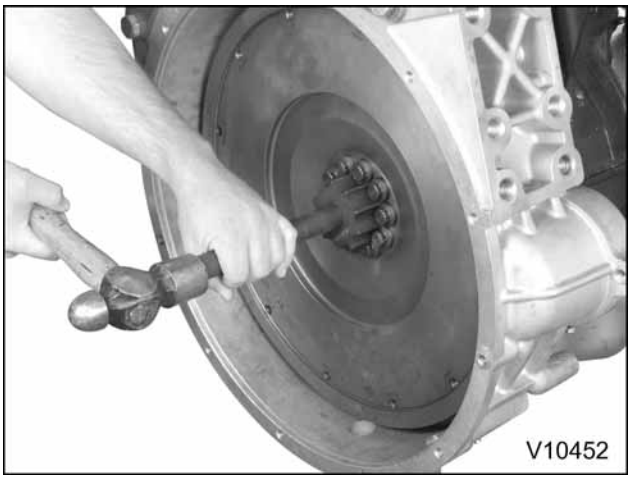

Figure 518 Pilot Bearing Installation Tool

1. Place pilot bearing in flywheel bore.
2. Using Pilot Bearing Installation Tool (page 379), tap pilot bearing into flywheel. When tool bottoms out, pilot bearing is fully installed.

Flywheel and Flexplate Assembly (Automatic Transmission)

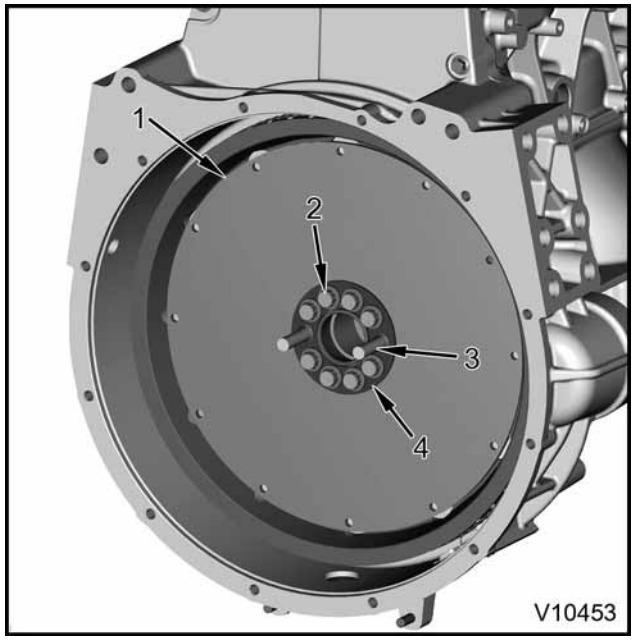

Figure 519 Flywheel and flexplate assembly

1. Flexplate and flywheel assembly
2. 12PT flange bolt (10)
3. Guide pin (2)
4. Wear plate (reinforcement ring)

1. Install two guide pins (made locally) into crankshaft flange 180° apart (approximately 3 o'clock and 9 o'clock positions).
2. Align crankshaft timing gear pin hole in flywheel assembly with crankshaft gear pin and slide flywheel onto guide pins.

CAUTION: To prevent engine damage, always install new flywheel mounting bolts.

CAUTION: To prevent engine damage, do not use anti-seize compounds or grease on new flywheel or flexplate mounting bolts.

NOTE: The individual components of the flexplate assembly are non-servicable. Replace the flexplate as an assembly.

Oil Pickup Tube — Rear Sump

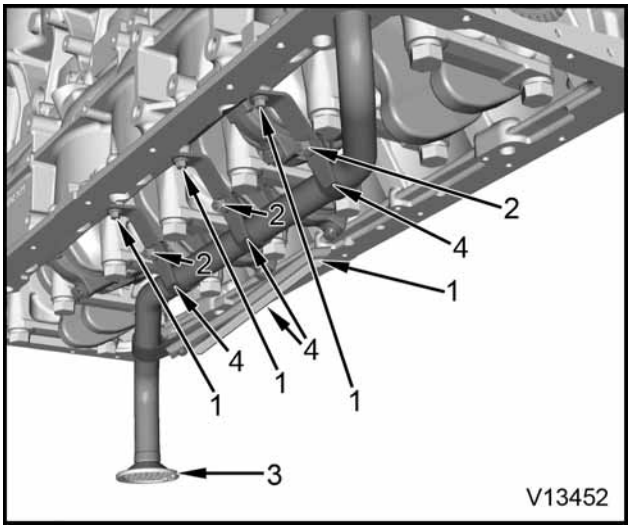

Figure 527 Oil pickup tube (rear sump)

1. M8 x 16 bolt (4)
2. M8 x 25 bolt (3)
3. Oil pickup tube
4. Tube support

1. Remove four M8 x 16 bolts holding oil pickup tube supports to crankcase.
2. Remove oil pickup tube and supports as an assembly.
3. Only if required, remove M8 x 25 bolts, prevailing torque nuts and D9/19/4 washers and supports.

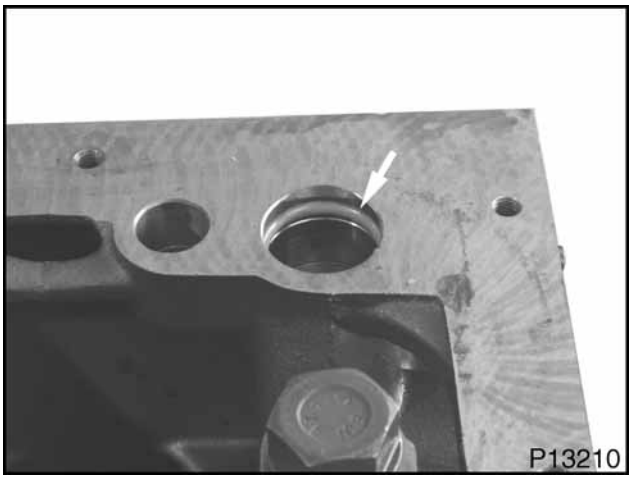

Figure 528 Oil pickup tube O-ring

4. Remove and discard oil pickup tube O-ring.

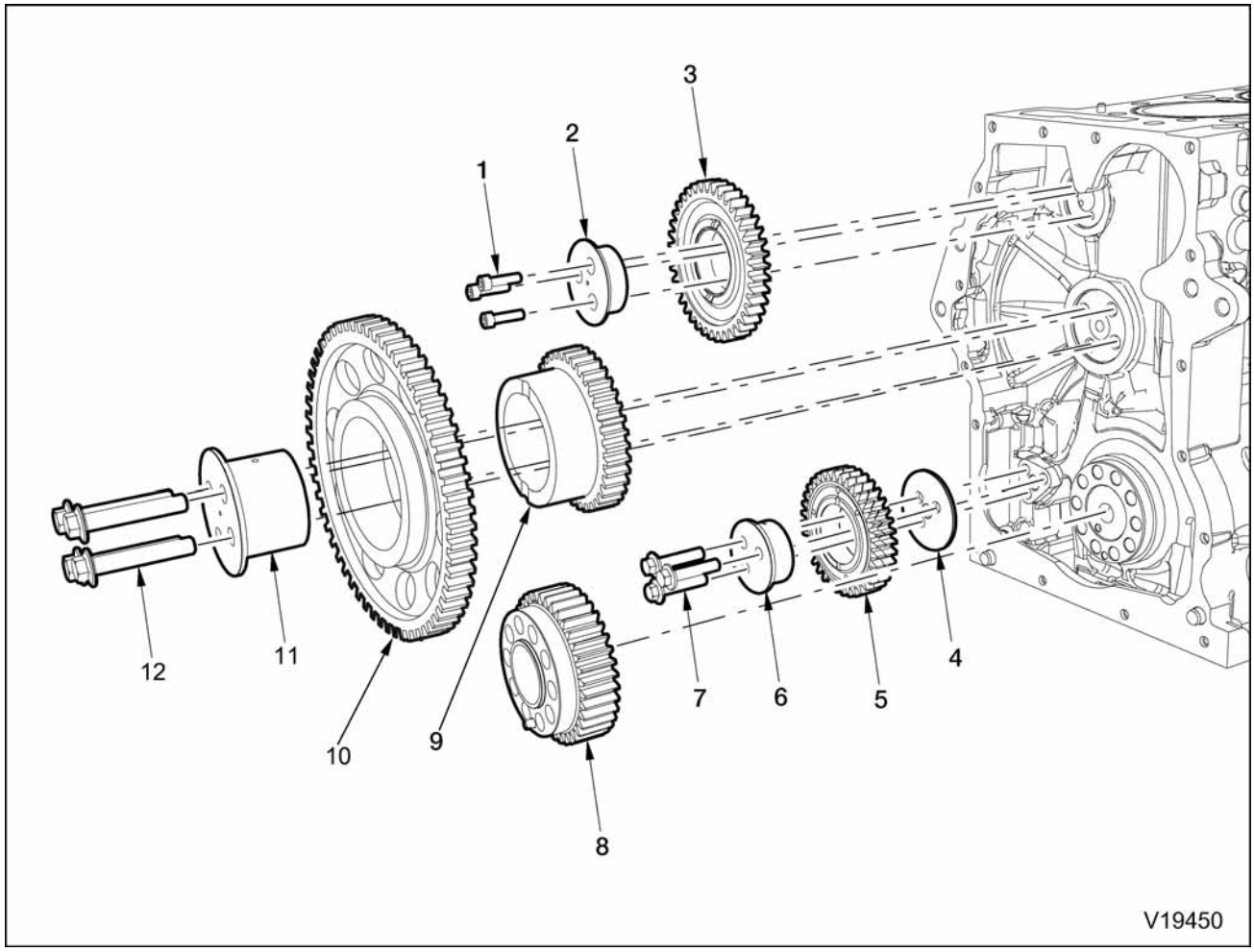

Figure 538 Rear timing gears

1. M8 x 30 socket-head cap screw (3)
2. Gear stud small
3. Crankcase idler gear
4. Thrust washer (for gear stud air compressor)
5. Air compressor coupled idler gear assembly
6. Air compressor gear stud
7. M12 x 55 bolt (3)
8. Rear crank gear assembly
9. Small idler gear
10. Large idler gear
11. Gear stud big
12. M14 x 80 bolt (4)

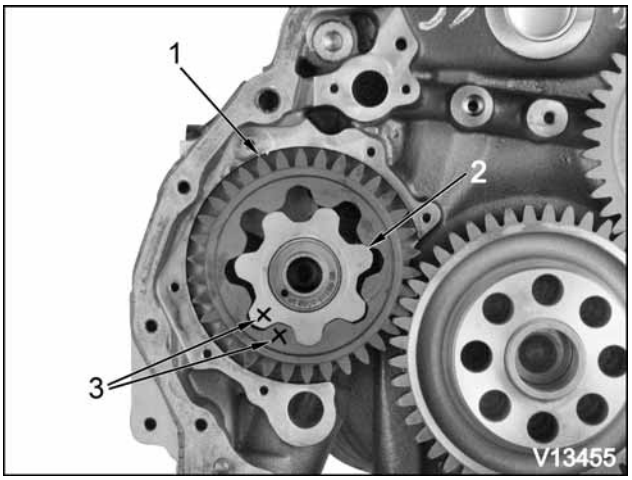

Figure 560 Pinion (gear) for oil pump and ring gear

1. (Oil pump) ring gear
2. Pinion (gear) for oil pump
3. Marks for reassembly (toward front)

3. Lubricate pinion (gear) for oil pump and ring gear with clean engine oil.
4. Install pinion gear and ring gear with previously made index marks facing towards front.
5. Lubricate new oil pump cover O-ring with clean engine oil and install on cover.

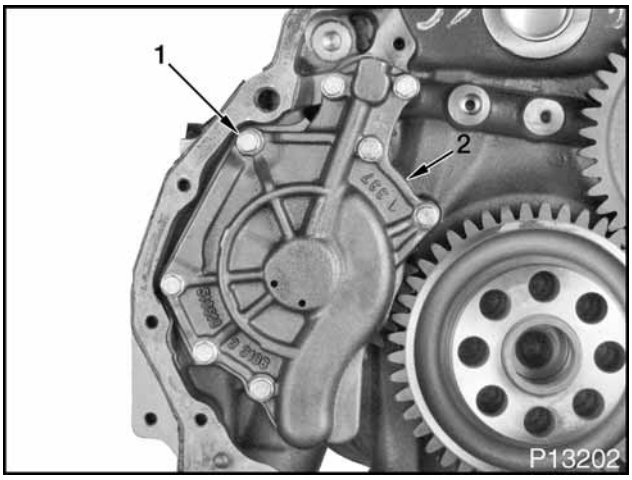

Figure 561 Oil pump cover (typical)

1. M6 x 20 bolt (8)
2. Oil pump cover

6. Install oil pump cover.
7. Install eight M6 x 20 bolts. Tighten bolts to standard torque (page 471).

Cleaning and Inspection

Cleaning

CAUTION: To prevent engine damage, do not use caustic solvents, wire brushes or bead blasting media to clean aluminum pistons.

CAUTION: To prevent engine damage, do not use solvents or a wire brush to clean the fractured mating surface of connecting rods.

1. Use a soap and water solution to clean pistons. Soak piston first and then clean with a non-metallic brush.
2. Clean piston ring grooves thoroughly.
3. The following disassembled components may be cleaned using a suitable solvent:
   - Piston pins
   - Piston pin retainers
4. Thoroughly clean connecting rod bolt holes and threads.

Piston Inspection

1. Inspect pistons for scuffed or scored skirts, cracked or worn ring lands and cracked or scuffed pin bores. Replace damaged pistons.

Figure 570 Second and third ring groove clearance check (typical)

NOTE: It is not possible to measure side clearance of top compression ring groove.

2. Check side clearance of taper face compression ring groove as follows:
   a. Place edge of a new taper face compression ring in its respective ring groove. Roll taper face compression ring all around ring groove to ensure ring is free in its groove.
   b. With edge of taper face compression ring in taper face compression ring groove, use a feeler gauge (page 427) to measure side clearance between ring and groove.
   c. Compare taper face compression ring side clearance to specification (page 425). Excessive side clearance indicates ring groove wear and requires piston replacement.
3. Check side clearance of bevelled oil ring groove as follows:
   a. Place edge of a new bevelled oil ring in its respective ring groove. Roll bevelled oil ring all around ring groove to ensure ring is free in its groove.
   b. With edge of bevelled oil ring in the bevelled oil ring groove, use a feeler gauge (page 427) to measure side clearance between ring and groove.
   c. Compare bevelled oil ring side clearance to specification (page 425). Excessive side clearance indicates ring groove wear and requires piston replacement.

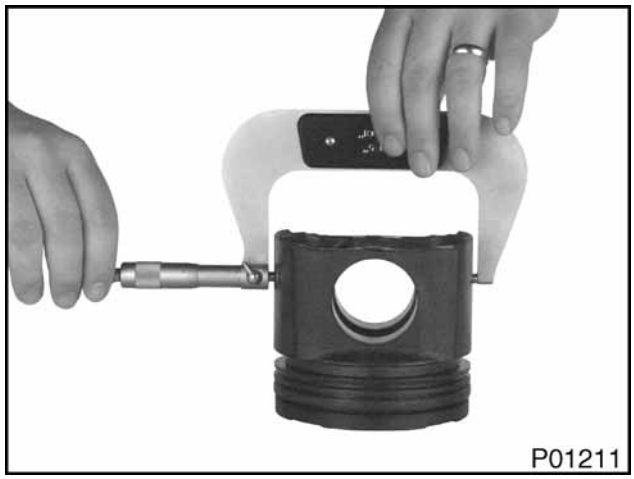

Figure 571 Piston skirt diameter measurement

Special Service Tools

Table 42 Power Cylinders

Description	Tool Number
2 - 3 inch micrometer	Obtain locally
3 - 4 inch micrometer	Obtain locally
4 - 5 inch micrometer	Obtain locally
Connecting Rod Bolt Torx® Socket	ZTSE4843
Cylinder Sleeve Puller	ZTSE2536
Dial bore gauge	Obtain locally
Dial indicator with magnetic base	Obtain locally
Feeler gauge	Obtain locally
Piston ring compressor	Obtain locally
Piston ring expansion pliers	Obtain locally
Sleeve Protrusion Hold Down Clamps	ZTSE4825
Telescoping gauge	Obtain locally

h. Turn remaining collar bolts an additional 90° clockwise.

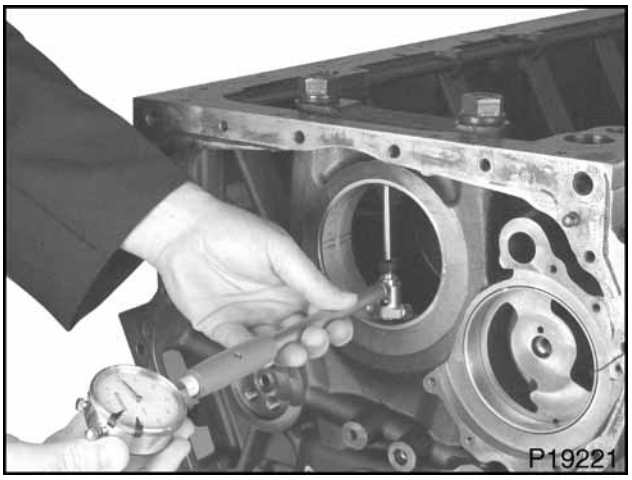

Figure 594 Main bearing installed diameter measurement

9. Using a dial bore gauge (page 441), measure main bearing installed inside diameter. If measurement does not meet specification (page 441), replace main bearings.
10. Remove 14 M18 x 160.5 collar bolts, seven main bearing caps, upper main bearings and lower main bearings. Discard used collar bolts.

Piston Cooling Jets

1. Hold each piston cooling jet under running water. Water should stream from jet end.

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

2. Clear blocked piston cooling jets using filtered compressed air. Replace piston cooling jet if blockage cannot be cleared.
3. Replace any cracked or bent jets.

IGN – Ignition
ILO – Injector Leak Off
IMP – Intake Manifold Pressure
IMT – Intake Manifold Temperature
in – Inch
inHg – Inch of mercury
inH_2O – Inch of water
INJs – Injectors
IPR – Injection Pressure Regulator
IPR PWR – Injection Pressure Regulator Power
ISC – Interstage Cooler
ISIS – International® Service Information System
IST – Idle Shutdown Timer
ITP – Internal Transfer Pump
J1939H – J1939 Data Link High
J1939L – J1939 Data Link Low
JCT – Junction (electrical)
kg – Kilogram
km – Kilometer
km/h – Kilometers per hour
km/l – Kilometers per liter
KOEO – Key-On Engine-Off
KOER – Key-On Engine-Running
kPa – Kilopascal
L – Liter
L/h – Liters per hour
L/m – Liters per minute
L/s – Liters per second
lb – Pound
lbf – Pounds of force
lb/s – Pounds per second
lbf ft – Pounds of force per foot
lbf in – Pounds of force per inch
lbm – Pounds of mass
LSD – Low Sulfur Diesel
m – Meter
m/s – Meters per second
MAF – Mass Air Flow
MAF GND – Mass Air Flow Ground
MAG – Magnetic
MAP – Manifold Absolute Pressure
MAT – Manifold Air Temperature
mep – Mean effective pressure
mi – Mile
MIL – Malfunction Indicator Lamp
mm – Millimeter
mpg – Miles per gallon
mph – Miles per hour
MPR – Main Power Relay
MSDS – Material Safety Data Sheet
MSG – Micro Strain Gauge
MSM – Multiplex System Module
MY – Model Year
NC – Normally closed (electrical)
NETS – Navistar Electronics Technical Support
Nm – Newton meter
NO – Normally Open (electrical)
NO_x – Nitrogen Oxides
O2S – Oxygen Sensor
O2SH – Oxygen Sensor Heater
OAT – Organic Acid Technology
OCC – Output Circuit Check
OCP – Overcrank Protection
OD – Outside Diameter
OL – Over Limit
ORH – Out-of-Range High
ORL – Out-of-Range Low
OSHA – Occupational Safety and Health Administration
OWL – Oil/Water Lamp
PID – Parameter Identifier
P/N – Part Number
PDOC – Pre-Diesel Oxidation Catalyst
ppm – Parts per million
PROM – Programmable Read Only Memory
psi – Pounds per square inch
psia – Pounds per square inch absolute
psig – Pounds per square inch gauge
pt – Pint
PTO – Power Takeoff
PWM – Pulse Width Modulate
PWR – Power (voltage)
qt – Quart
RAM – Random Access Memory
RAPP – Remote Accelerator Pedal Position
RAS – Resume / Accelerate Switch (speed control)
REPTO – Rear Engine Power Takeoff
RFI – Radio Frequency Interference
rev – Revolution
rpm – Revolutions per minute
RPRE – Remote Preset Power Take Off
RSE – Radiator Shutter Enable
RVAR – Remote Variable
SAE – Society of Automotive Engineers®
SCA – Supplemental Cooling Additive
SCCS – Speed Control Command Switches
SCS – Speed Control Switch
SHD – Shield (electrical)
SID – Subsystem Identifier
SIG GND – Signal Ground
SIG GNDB – Signal Ground Body
SIG GNDC – Signal Ground Chassis

Oxides of Nitrogen (NOx) – Nitrogen oxides formed by a reaction between nitrogen and oxygen at high temperatures.

Oxygen Sensor (O2S) – A sensor that monitors oxygen levels in the exhaust.

pH – A measure of the acidity or alkalinity of a solution.

Particulate matter – Particulate matter includes mostly burned particles of fuel and engine oil.

Piezometer – An instrument for measuring fluid pressure.

Power – Power is a measure of the rate at which work (force x distance) is done during a specific time. Compare with Torque.

Power TakeOff (PTO) – Accessory output, usually from the transmission, used to power a hydraulic pump for a special auxiliary feature (garbage packing, lift equipment, etc).

Pulse Width Modulation (PWM) – Succession of digital electrical pulses, rather than an analog signal. Efficient method of providing power between fully on and fully off.

Random Access Memory (RAM) – Computer memory that stores information. Information can be written to and read from RAM. Input information (current engine speed or temperature) can be stored in RAM to be compared to values stored in Read Only Memory (ROM). All memory in RAM is lost when the ignition switch is turned off.

Rated gross horsepower – Engine gross horsepower at rated speed as declared by the manufacturer. (SAE J1995 JUN90)

Rated horsepower – Maximum brake horsepower output of an engine as certified by the engine manufacturer. The power of an engine when configured as a basic engine. (SAE J1995 JUN90)

Rated net horsepower – Engine net horsepower at rated speed as declared by the manufacturer. (SAE J1349 JUN90)

Rated speed – The speed, as determined by the manufacturer, at which the engine is rated. (SAE J1995 JUN90)

Rated torque – Maximum torque produced by an engine as certified by the manufacturer.

Ratiometric Voltage – In a Micro Strain Gauge (MSG) sensor, pressure to be measured exerts force on a pressure vessel that stretches and compresses to change resistance of strain gauges bonded to the surface of the pressure vessel. Internal sensor electronics convert the changes in resistance to a ratiometric voltage output.

Reference voltage (V_{REF}) – A 5 volt reference supplied by the ECM to operate the engine sensors.

Reserve capacity – Time in minutes that a fully charged battery can be discharged to 10.5 volts at 25 amperes.

Return Fuel System – The return fuel system moves unused fuel from the fuel injectors to the fuel cooler. Excess fuel out of the FVCV and the FPCV mix with fuel from the fuel injectors on the way to the fuel cooler.

ServiceMaxx™ software – Diagnostics software for engine related components and systems.

Signal Conditioner – The signal conditioner in the internal microprocessor converts analog signals to digital signals, squares up sine wave signals, or amplifies low-intensity signals to a level that the ECM microprocessor can process.

Signal ground – The common ground wire to the ECM for the sensors.

Speed Control Command Switches (SCCS) – A set of switches used for cruise control, Power TakeOff (PTO), and remote hand throttle system.

Steady state condition – An engine operating at a constant speed and load and at stabilized temperatures and pressures. (SAE J215 JAN80)

Strategy – A plan or set of operating instructions that the microprocessor follows for a desired goal. Strategy is the computer program itself, including all equations and decision making logic. Strategy is always stored in ROM and cannot be changed during calibration.

Stroke – The movement of the piston from Top Dead Center (TDC) to Bottom Dead Center (BDC).

Substrate – Material that supports the wash coating or catalytic materials.

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Fuel System

Table 61 Fuel System

Banjo bolt, M14	30 N·m (22 lbf·ft)
Check valve	35 N·m (26 lbf·ft)
Fuel drain line fitting nut	26 N·m (19 lbf·ft)
Fuel filter bracket M8 x 30 bolt	35 N·m (26 lbf·ft)
Fuel filter housing assembly M8 x 45 bolt	35 N·m (26 lbf·ft)
Fuel filter cap	25 N·m (18 lbf·ft)
Fuel filter stand pipe	12 N·m (106 lbf·in)
Fuel primer pump M8 x 25 bolt	30 N·m (22 lbf·ft)
Fuel rail M8 x 40 bolt	35 N·m (26 lbf·ft)
Fuel strainer cover	10 N·m (89 lbf·in)
Fuel supply adapter	30 N·m (22 lbf·ft)
High-pressure connector (body) retaining nut	See tightening steps in procedure
High-pressure fuel pump drive housing M12 x 40, M12 x 90, M12 x 130 bolt	105 N·m (77 lbf·ft)
High-pressure fuel pump M10 x 40 bolt	62 N·m (46 lbf·ft)
High-pressure fuel pump M24 jam nut	285 N·m (210 lbf·ft)
High-pressure fuel pump support M14 x 30 bolt	172 N·m (126 lbf·ft)
High-pressure pump to rail tube assembly line fitting nuts	See tightening steps in procedure
High-pressure rail to injector line fitting nut	See tightening steps in procedure
High-pressure pump pulley housing M10 x 40 bolt	62 N·m (46 lbf·ft)
High-pressure pump pulley M16 x 40 LH bolt	280 N·m (207 lbf·ft)
Injector harness nut	1.5 N·m (13 lbf·in)
Injector hold-down clamp M8 x 50 bolt	See tightening steps in procedure
Quick-connect M16 x 1.5 connector	30 N·m (22 lbf·ft)
Threaded unions (M14 x 1.5)	30 N·m (22 lbf·ft)

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