SERVICE MANUAL

INTERNATIONAL® DT 466, DT 570, HT 570

DIESEL ENGINE

SERVICE MANUAL

FORM EGES-265-2

SERVICE MANUAL

INTERNATIONAL® DT 466, DT 570, HT 570

DIESEL ENGINE (S/N 2000001 AND ABOVE)

FORM EGES-265-2

2004 MODEL YEAR AND ABOVE

Table of Contents

Read all safety instructions in the "Safety Information" section of this manual before doing any procedures.
Follow all warnings, cautions, and notes.

Foreword

Navistar, Inc. is committed to continuous research and development to improve products and introduce technological advances. Procedures, specifications, and parts defined in published technical service literature may be altered.

This *Engine Service Manual* provides a general sequence of procedures for out-of-chassis engine overhaul (removal, inspection, and installation). For in-chassis service of parts and assemblies, the sequence may vary.

NOTE: Photo illustrations identify specific parts or assemblies that support text and procedures; other areas in a photo illustration may not be exact.

See vehicle manuals and Technical Service Information (TSI) bulletins for additional information.

Technical Service Literature

1171809R5	*DT 466, DT 570 and HT 570 Engine Operation and Maintenance Manual*
EGES-265–2	*DT 466, DT 570 and HT 570 Engine Service Manual*
EGES-270	*DT 466, DT 570 and HT 570 Engine Diagnostic Manual*
EGED-285	*DT 466, DT 570 and HT 570 Electronic Control Systems Diagnostic Form (Pad of 50)*
EGED-290	*DT 466, DT 570 and HT 570 Diagnostics Form (Pad of 50)*

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Service Diagnosis

Service diagnosis is an investigative procedure that must be followed to find and correct an engine application problem or an engine problem.

If the problem is engine application, see specific vehicle manuals for further diagnostic information.

If the problem is the engine, see specific *Engine Diagnostic Manual* for further diagnostic information.

Prerequisites for Effective Diagnosis

- Availability of gauges, diagnostic test equipment, and diagnostic software
- Availability of current information for engine application and engine systems
- Knowledge of the principles of operation for engine application and engine systems
- Knowledge to understand and do procedures in diagnostic and service publications

Technical Service Literature required for Effective Diagnosis

- *Engine Service Manual*
- *Engine Diagnostic Manual*
- Diagnostics Forms
- Electronic Control Systems Diagnostics Forms
- Service Bulletins

Safety Information

This manual provides general and specific maintenance procedures essential for reliable engine operation and your safety. Since many variations in procedures, tools, and service parts are involved, advice for all possible safety conditions and hazards cannot be stated.

Read safety instructions before doing any service and test procedures for the engine or vehicle. See related application manuals for more information.

Disregard for Safety Instructions, Warnings, Cautions, and Notes in this manual can lead to injury, death or damage to the engine or vehicle.

Safety Terminology

Three terms are used to stress your safety and safe operation of the engine: Warning, Caution, and Note

Warning: A warning describes actions necessary to prevent or eliminate conditions, hazards, and unsafe practices that can cause personal injury or death.

Caution: A caution describes actions necessary to prevent or eliminate conditions that can cause damage to the engine or vehicle.

Note: A note describes actions necessary for correct, efficient engine operation.

Safety Instructions

Work Area

- Keep work area clean, dry, and organized.
- Keep tools and parts off the floor.
- Make sure the work area is ventilated and well lit.
- Make sure a First Aid Kit is available.

Safety Equipment

- Use correct lifting devices.
- Use safety blocks and stands.

Protective Measures

- Wear protective safety glasses and shoes.
- Wear correct hearing protection.
- Wear cotton work clothing.
- Wear sleeved heat protective gloves.
- Do not wear rings, watches or other jewelry.
- Restrain long hair.

Vehicle

- Make sure the vehicle is in neutral, the parking brake is set, and the wheels are blocked before servicing engine.
- Clear the area before starting the engine.

Engine

- The engine should be operated or serviced only by qualified individuals.
- Provide necessary ventilation when operating engine in a closed area.
- Keep combustible material away from engine exhaust system and exhaust manifolds.
- Install all shields, guards, and access covers before operating engine.
- Do not run engine with unprotected air inlets or exhaust openings. If unavoidable for service reasons, put protective screens over all openings before servicing engine.
- Shut engine off and relieve all pressure in the system before removing panels, housing covers, and caps.
- If an engine is not safe to operate, tag the engine and ignition key.

Fire Prevention

- Make sure charged fire extinguishers are in the work area.

NOTE: Check the classification of each fire extinguisher to ensure that the following fire types can be extinguished.

1. Type A — Wood, paper, textiles, and rubbish
2. Type B — Flammable liquids
3. Type C — Electrical equipment

Batteries

- Always disconnect the main negative battery cable first.
- Always connect the main negative battery cable last.
- Avoid leaning over batteries.
- Protect your eyes.

- Do not expose batteries to open flames or sparks.
- Do not smoke in workplace.

Compressed Air

- Use an OSHA approved blow gun rated at 207 kPa (30 psi).
- Limit shop air pressure to 207 kPa (30 psi).
- Wear safety glasses or goggles.
- Wear hearing protection.
- Use shielding to protect others in the work area.
- Do not direct compressed air at body or clothing.

Tools

- Make sure all tools are in good condition.
- Make sure all standard electrical tools are grounded.
- Check for frayed power cords before using power tools.

Fluids Under Pressure

- Use extreme caution when working on systems under pressure.
- Follow approved procedures only.

Fuel

- Do not over fill the fuel tank. Over fill creates a fire hazard.
- Do not smoke in the work area.
- Do not refuel the tank when the engine is running.

Removal of Tools, Parts, and Equipment

- Reinstall all safety guards, shields, and covers after servicing the engine.
- Make sure all tools, parts, and service equipment are removed from the engine and vehicle after all work is done.

Table of Contents

Engine Identification

Engine Serial Number

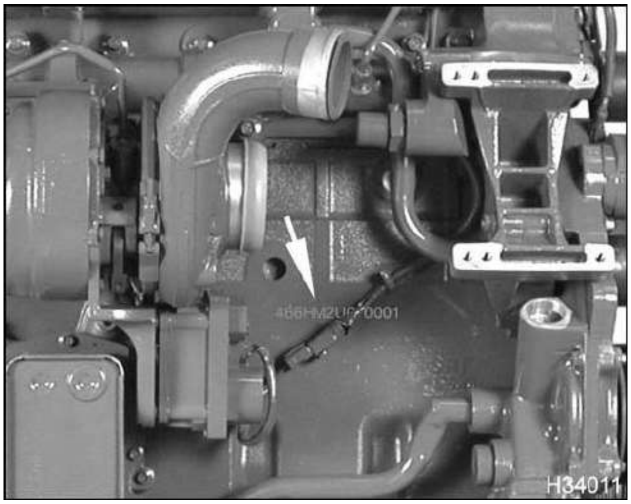


Figure 1 Engine serial number (right side front)

Figure 2 Engine serial number (right side rear)

Engine Serial Number Locations

- The engine serial number is stamped on a crankcase pad on the right side of the crankcase (front for earlier model years and rear for later model years).
- The engine serial number is also on the engine emission label.

Engine Serial Number Examples

DT 466 engine: 466HM2UXXXXXXX

DT 570 engine: 570HM2UXXXXXXX

Engine Serial Number Codes

466 – Engine displacement
570 – Engine displacement
H – Diesel, turbocharged, Charge Air Cooler (CAC), and electronically controlled
M2 – Motor truck
U – United States
7 digit suffix – Engine serial number sequence beginning with 2,000,000

Engine Emission Label

A common emission label is issued for the International® DT 466 and DT 570 diesel engines.

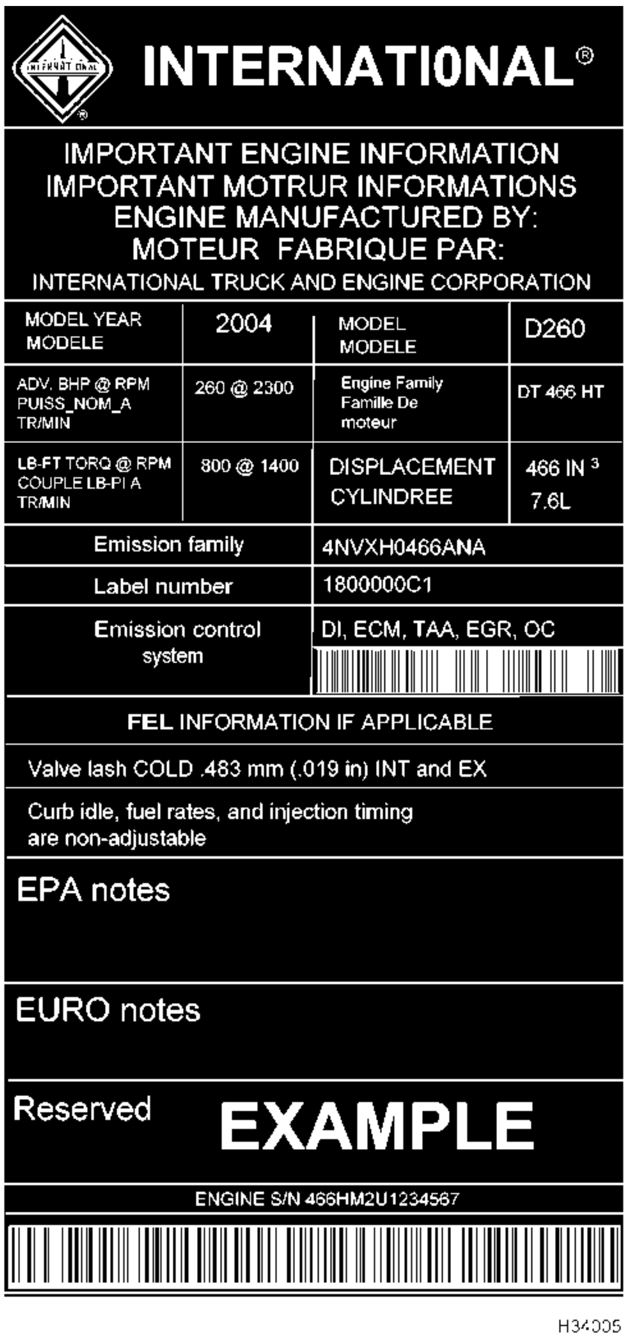


Figure 3 Engine emission label (Example)

The Environmental Protection Agency (EPA) emission label is on top of the valve cover. The engine label includes the following:

- Model year
- Engine family, model, and displacement
- Advertised brake horsepower and torque rating
- Emission family and control systems
- U.S. Family Emission Limits (FEL), if applicable
- Valve lash specifications
- Engine serial number
- EPA, EURO, and reserved fields for specific applications

Engine Accessories

The following engine accessories may have manufacturer's labels or identification plates:

- Air compressor (for brake or suspension system)
- Air conditioning compressor
- Alternator
- Cooling fan clutch
- EVRT® electronically controlled turbocharger – International's version of a Variable Geometry Turbocharger (VGT)
- Power steering pump
- Starter motor

Labels or identification plates include information and specifications helpful to vehicle operators and technicians.

Engine Description

Table 1 International® DT 466 and DT 570 Features and Specifications

Engine	4 stroke, in-line six cylinder diesel
Configuration	Four valves per cylinder
Displacement	7.6 L (466 in^3)
Displacement	9.3 L (570 in^3)
Bore (sleeve diameter)	116.6 mm (4.59 in)
Stroke	
DT 466	119 mm (4.68 in)
DT 570	146 mm (5.75 in)
Compression ratio	
DT 466	16.5 : 1
DT 570	17.5 : 1
Aspiration	VGT turbocharged and Charge Air Cooled (CAC)
Rated power @ rpm	
DT 466*	210 bhp @ 2600 rpm
DT 570**	285 bhp @ 2200 rpm
Peak torque @ rpm	
DT 466*	520 lbf•ft @ 1400 rpm
DT 570**	800 lbf•ft @ 1200 rpm
Engine rotation (facing flywheel)	Counterclockwise
Combustion system	Direct injection turbocharged
Fuel system	International® electro-hydraulic generation 2 injection
Total engine weight (dry without accessories)	
DT 466	671 kg (1,480 lbs)
DT 570	708 kg (1,560 lbs)
Cooling system capacity (engine only)	12.8 L (13.5 qts US)
Lube system capacity (including filter)	28 L (30 qts US)
Lube system capacity (overhaul only, with filter)	34 L (36 qts US)
Firing order	1-5-3-6-2-4

* Base rating shown. See Appendix A in the *Engine Diagnostics Manual*.

**Base rating shown. See Appendix B in the *Engine Diagnostics Manual*.

Engine Features

Table 2

Standard Features	Optional Features
Four valves per cylinder	Air compressor
Dual timing sensors	Power steering pump
Replaceable piston and sleeve configuration	Front cover PTO access
Gerotor lube oil pump	Engine Fuel Pressure (EFP) sensor
International® common rail high-pressure injection system	Diamond Logic® engine brake
Variable Geometry Turbocharger (VGT)	Diamond Logic® exhaust brake
Exhaust Gas Recirculation (EGR)	Fuel heater
Water supply housing (Freon® compressor bracket)	Oil pan heater
Alternator bracket	Coolant heater assembly
Control modules	
Water In Fuel (WIF) separation	
Water In Fuel (WIF) sensor	
Inlet Air Heater (IAH) – single or dual element	

Standard Features

DT 466, DT 570, and HT 570 are in-line six cylinder engines (medium range). Engine displacements are 7.6 liters (466 cubic inches) for the DT 466 and 9.3 liters (570 cubic inches) for the DT 570, and HT 570. The firing order of the cylinders is 1–5–3–6–2–4.

The cylinder head has four valves per cylinder for improved air flow. Each fuel Injector is centrally located between the four valves and directs fuel over the piston bowl for improved performance and reduced emissions. The overhead valve train includes mechanical roller lifters, push rods, rocker arms, and dual valves that open using a valve bridge.

A one piece crankcase withstands high-pressure loads during diesel operation.

The lower end of the DT 570 and HT 570 engines (for ratings above 300 hp) includes a crankcase ladder designed to absorb additional loads generated by increased horsepower. Seven main bearings support the crankshaft for DT 466, DT 570, and HT 570 engines. Fore and aft thrust are controlled at the rear bearing. Four insert bushings support the camshaft for each engine. The rear oil seal carrier is part of the flywheel housing. The open crankcase breather assembly uses a road draft tube to vent crankcase pressure and an oil separator that returns oil to the crankcase.

The crankshaft (CKP) and camshaft (CMP) sensors are used by the ECM and IDM to calculate rpm, fuel timing, fuel quantity, and duration of fuel injection.

Two different kinds of pistons are used in the in-line engines:

- The DT 466 engine has one piece aluminum alloy pistons.
- The DT 570 and HT 570 engines have two piece articulated pistons with a steel crown.

All pistons are mated to fractured cap joint connecting rods. Replaceable wet cylinder sleeves are used with the pistons.

A gerotor lube oil pump, mounted to the front cover, is driven directly by the crankshaft. All engines use an oil cooler and spin-on oil filter.

A low-pressure fuel supply pump draws fuel from the fuel tank through a fuel filter assembly that includes a strainer, filter element, primer pump, drain valves, and Water In Fuel (WIF) sensor. After filtering, fuel is pumped to the cylinder head fuel rail.

The International® common rail high-pressure injection system includes a cast iron oil manifold, fuel injectors, and a high-pressure oil pump.

The key feature of the VGT is actuated vanes in the turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing. The benefit is the ability to control boost pressure for various engine speeds and load conditions. An additional benefit is lower emissions.

An EGR control valve regulates cooled exhaust gases entering the inlet air stream. Cool exhaust gas increases engine tolerance for EGR, while reducing smoke formed by gas dilution in the mixture. Three EGR coolers are available depending on applications.

A water supply housing (Freon® compressor bracket) is a coolant supply housing that includes an auxiliary water connection.

Three control modules monitor and control the electronic engine systems:

- Diamond Logic® engine controller – Electronic Control Module (ECM)
- Injector Drive Module (IDM)
- Exhaust Gas Recirculation (EGR) drive module

Water In Fuel (WIF) separation occurs when the filter element repels water molecules and water collects at the bottom of the element cavity in the fuel filter housing.

A Water In Fuel (WIF) sensor in the element cavity of the fuel filter housing detects water. When enough water accumulates in the element cavity, the WIF sensor sends a signal to the Electronic Control Module (ECM). A fuel drain valve handle on the housing can be opened to drain water from the fuel filter housing.

An Inlet Air Heater (IAH) – a single or dual element – warms the intake air entering the cylinder head.

Optional Features

An air compressor is available for applications requiring air brakes or air suspension.

A hydraulic power steering pump can be used with or without an air compressor.

The front cover includes a mounting flange for Power Take Off (PTO) accessories. The air compressor drive gear train, used with a spline adapter, provides power for front mounted PTO accessories.

An optional Engine Fuel Pressure (EFP) sensor detects low pressure caused by high fuel filter restriction and sends a signal to the ECM; the ECM illuminates the amber FUEL FILTER lamp on the instrument panel.

The Diamond Logic® engine brake is new for medium range diesel engines. This compression braking system uses a high-pressure rail assembly and the VGT for additional braking. The operator controls the engine brake for different operating conditions.

The Diamond Logic® exhaust brake system uses only the VGT to restrict exhaust flow for additional braking. The operator controls the exhaust brake for different operating conditions.

Options for vehicles and applications used in cold climates include the following:

- **Oil pan heater**

  The oil pan heater warms engine oil in the pan and ensures oil flow to the injectors.

- **Coolant heater**

  The coolant heater raises the temperature of coolant surrounding the cylinders for improved performance and fuel economy during start-up.

- **Fuel heater**

  The fuel heater (a 300 watt element) in the base of the fuel filter assembly heats the fuel for improved performance.

Engine Component Locations

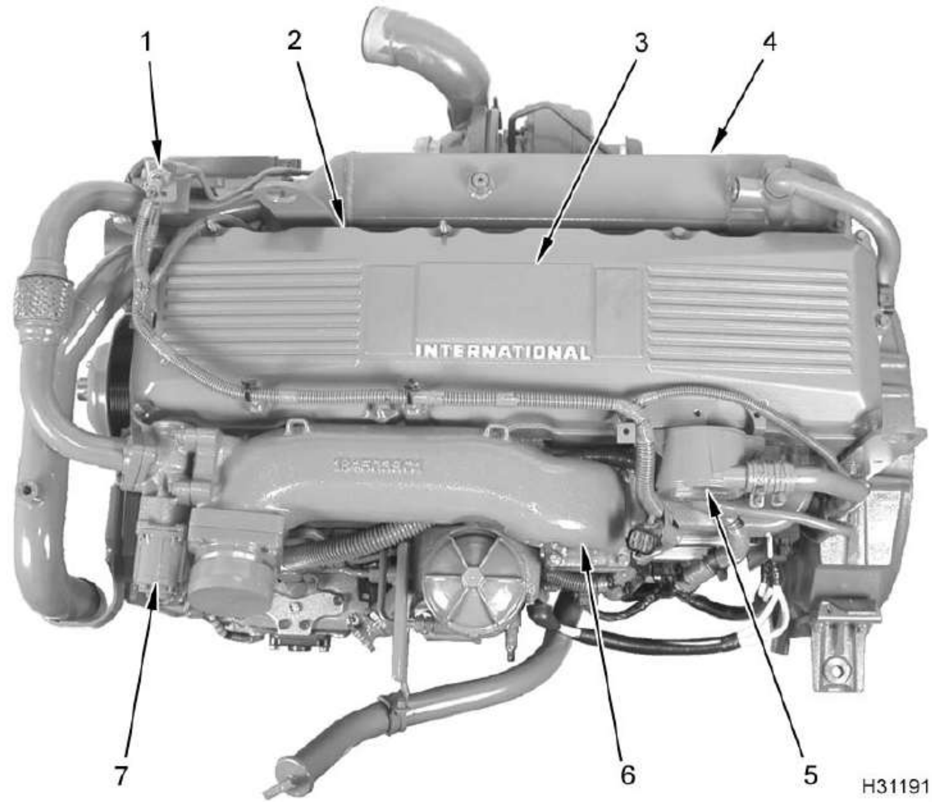


Figure 4 Component location – top

1. Exhaust Back Pressure (EBP) sensor
2. Valve cover
3. Exhaust emission label (location)
4. EGR cooler assembly
5. Breather assembly
6. Inlet and EGR mixer duct
7. EGR control valve

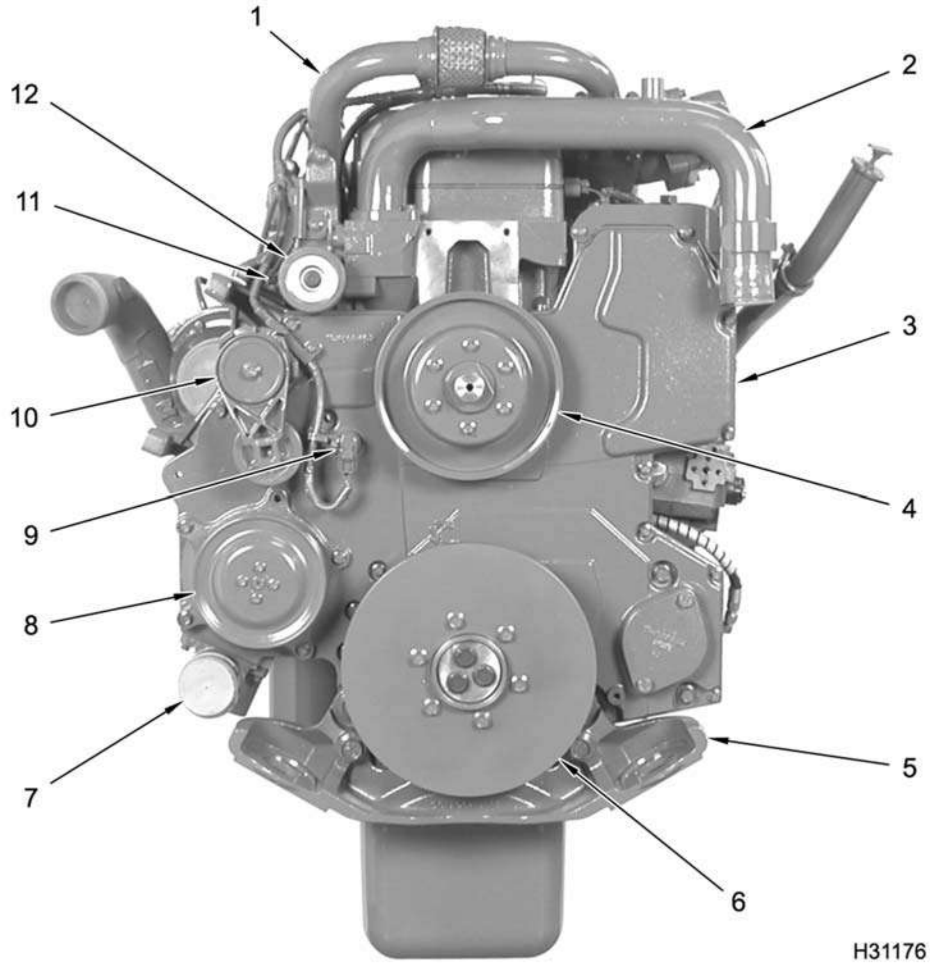


Figure 5 Component location – front

1. Exhaust gas crossover (EGR cooler to EGR valve)
2. Water outlet tube assembly (thermostat outlet)
3. Front cover (front half)
4. Fan drive pulley
5. Engine mounting bracket (front)
6. Vibration damper
7. Water inlet elbow
8. Water pump pulley
9. Camshaft Position (CMP) sensor
10. Auto tensioner assembly (belt)
11. ECT sensor (location)
12. Flat idler pulley assembly

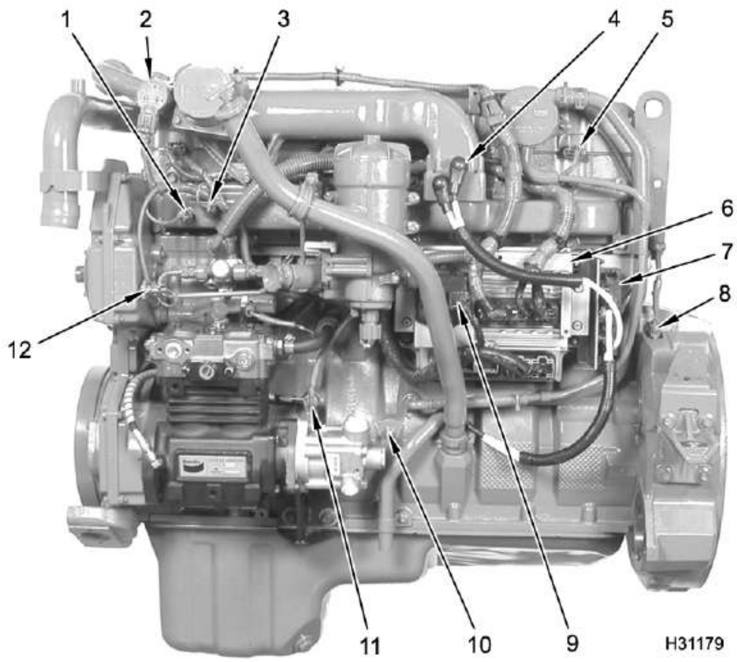


Figure 6 Component location, electrical– left

1. Manifold Absolute Pressure (MAP) sensor
2. EGR control valve
3. Manifold Air Temperature (MAT) sensor
4. Inlet Air Heater (IAH) cable – dual element
5. Valve cover gasket pass-through connector
   a. (Six) four wire connectors for fuel injectors
   b. (One) three wire connector for ICP sensor
   c. Engine brake application – (one) three wire connector for the BCP sensor and (one) three wire connector for the brake valve.
6. ECM and IDM module assembly
7. IAH relay
8. Crankshaft Position (CKP) sensor
9. EGR drive module
10. Ground stud
11. Engine Oil Pressure (EOP) sensor
12. Engine Oil Temperature (EOT) sensor

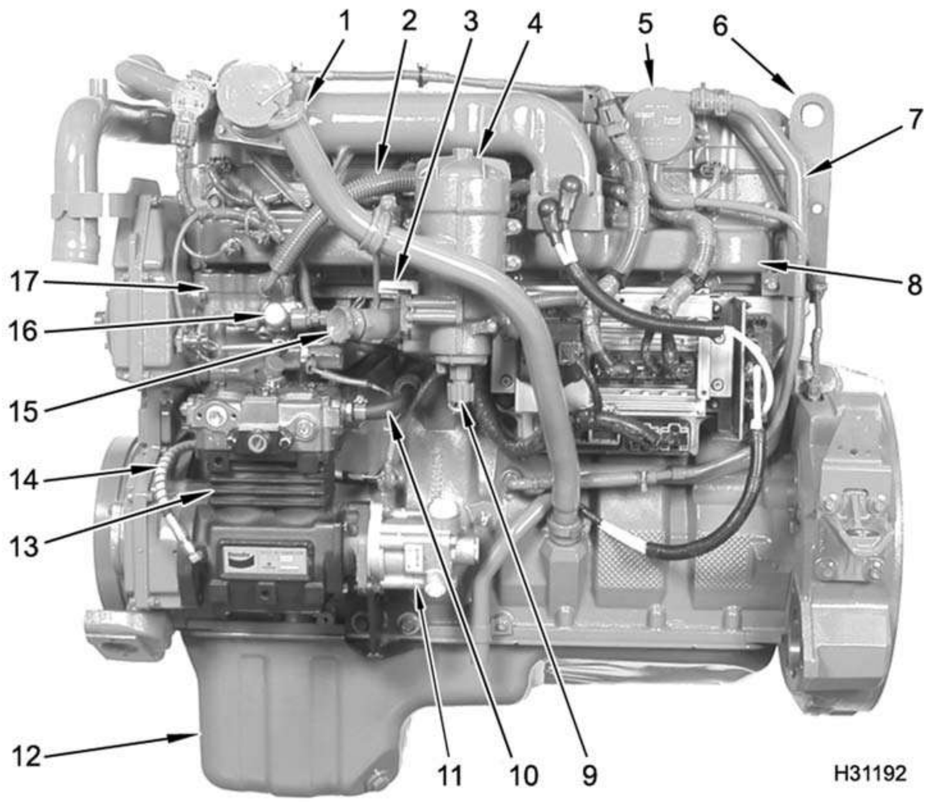


Figure 7 Component location, mechanical – left

1. Oil level gauge tube
2. High-pressure oil hose
3. Water drain valve (fuel)
4. Fuel filter header assembly
5. Breather assembly
6. Lifting eye
7. Vent and drain tube assembly
8. Intake manifold
9. Drain valve (fuel strainer)
10. Coolant line
11. Power steering pump
12. Oil pan assembly
13. Air compressor
14. Oil supply line
15. Fuel primer pump assembly
16. Low-pressure fuel supply pump
17. High-pressure oil pump assembly

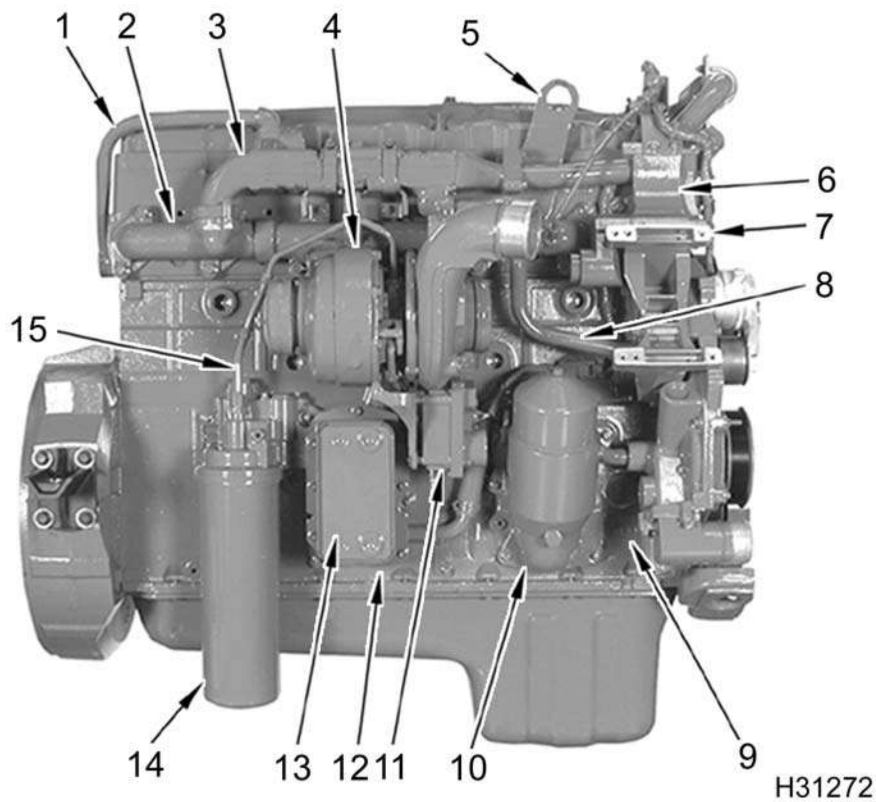


Figure 8 Component location – right

1. EGR cooler return tube assembly
2. Exhaust manifold assembly
3. EGR cooler assembly
4. Variable Geometry Turbocharger (VGT)
5. Engine lifting eye
6. Water supply housing (Freon® compressor bracket)
7. Alternator bracket
8. EGR cooler supply tube assembly
9. Crankcase
10. Secondary filtration filter (optional)
11. Turbocharger control module
12. Coolant drain plug (underneath location)
13. Oil cooler
14. Oil filter
15. Turbo oil inlet tube (supply)

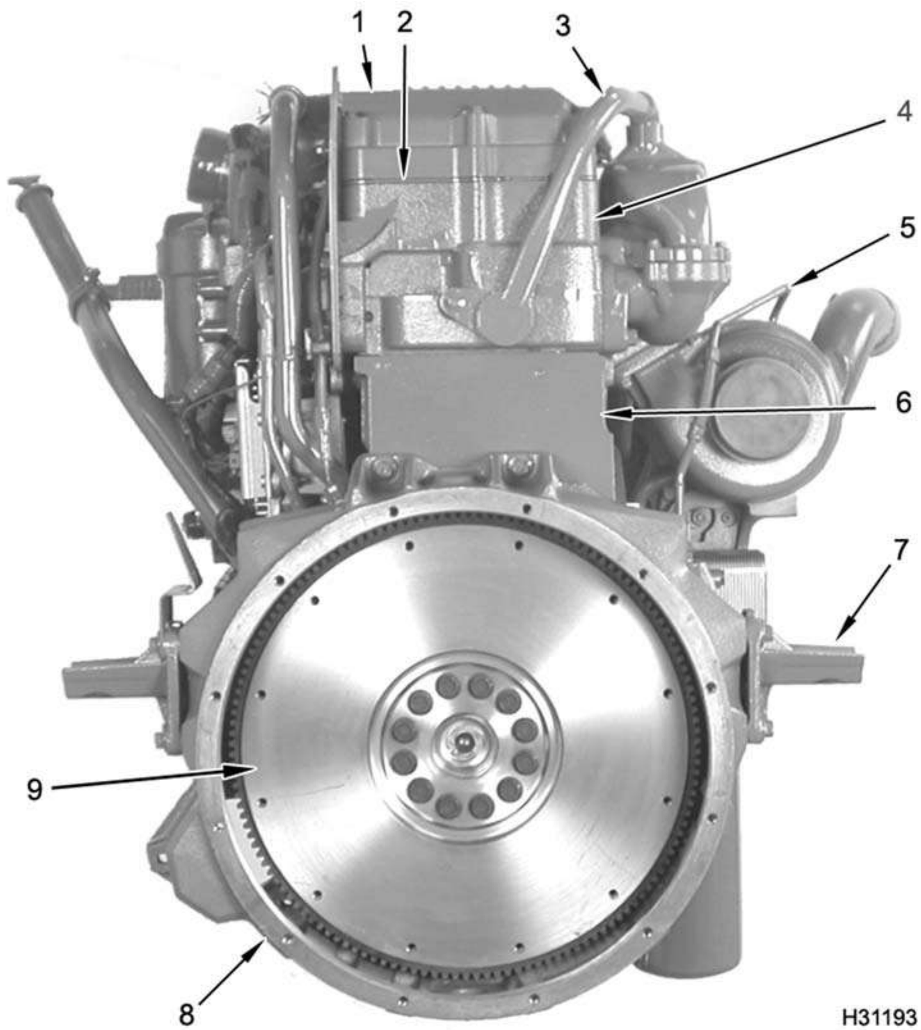


Figure 9 Component location – rear

1. Valve cover
2. Valve cover gasket with pass-through connectors
3. EGR cooler return tube assembly
4. Cylinder head assembly
5. Turbo oil inlet tube (supply)
6. Crankcase
7. Rear engine mount brackets (2)
8. Flywheel housing
9. Flywheel or flexplate assembly

Engine Systems

Engine System Diagram

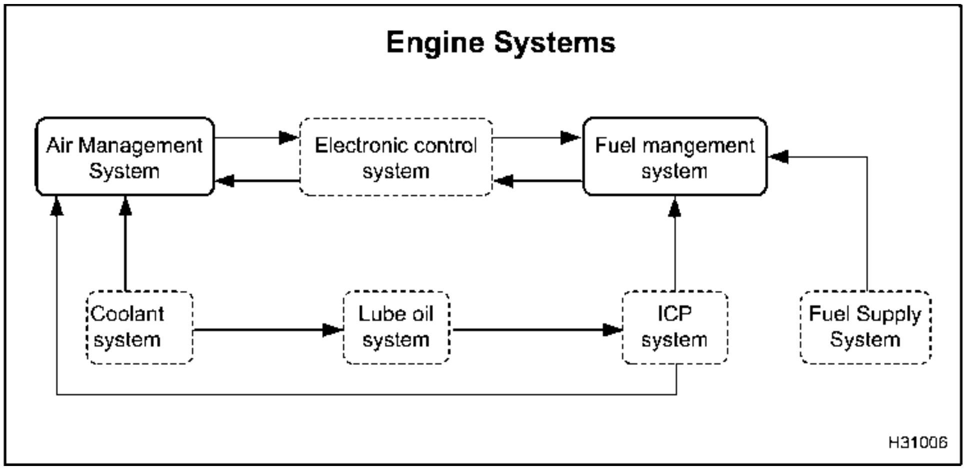


Figure 10 Engine systems

The primary engine systems are Air Management and Fuel Management which share some subsystems or have a subsystem that contributes to their operation.

- The Electronic Control system controls the Air Management System and Fuel Management System.
- The Coolant System provides heat transfer for EGR gases and lubrication oil.
- The Lube Oil System provides lubrication and heat transfer to engine components.
- The ICP system uses lube oil for hydraulic fluid to actuate the fuel injectors.
- The Fuel Supply System pressurizes fuel for transfer to the fuel injectors.

Air Management System

Air Management Components and Air Flow

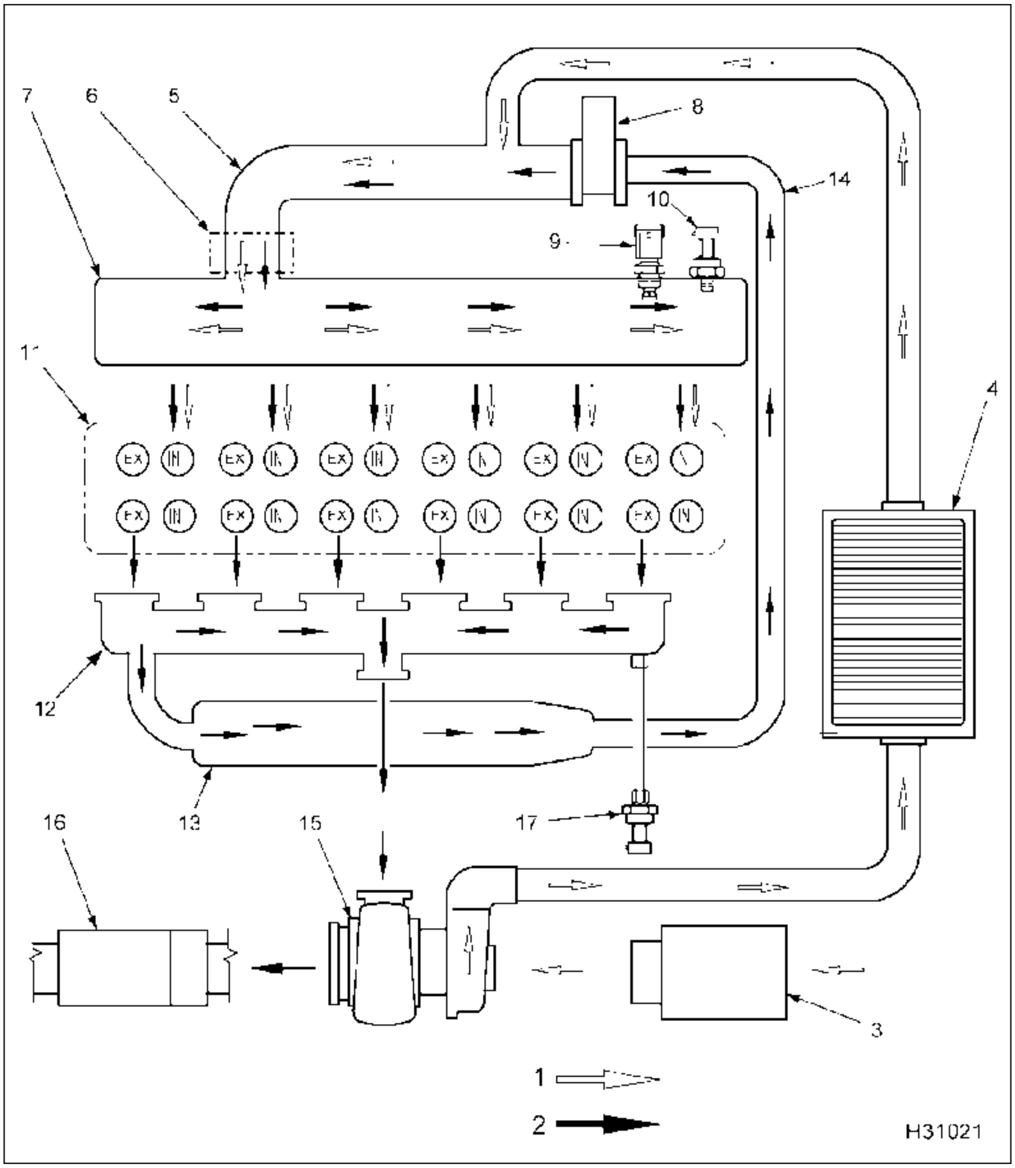


Figure 11 Air Management System (AMS)

1. Intake air
2. Exhaust gas
3. Air cleaner
4. Charge Air Cooler (CAC)
5. Inlet and EGR mixer duct
6. Inlet Air Heater (IAH) assembly – single or dual element
7. Intake manifold
8. EGR valve
9. Manifold Absolute Pressure (MAP) sensor
10. Manifold Air Temperature (MAT) sensor
11. Cylinder head
12. Exhaust manifold
13. EGR cooler
14. Exhaust gas crossover
15. Variable Geometry Turbocharger (VGT)
16. Muffler
17. Exhaust Back Pressure (EBP) sensor

The Air Management system includes the following:

- Air filter assembly
- Chassis mounted Charged Air Cooler (CAC)
- Variable Geometry Turbocharger (VGT)
- Inlet Air Heater (IAH) assembly – single or dual element
- Intake manifold
- Exhaust Gas Recirculation (EGR) system
- Exhaust system
- Inlet and EGR mixer duct
- Diamond Logic® engine brake
- Catalytic converter– dependent on application
- Catalyzed Diesel Particulate Filter (CDPF) – dependent on application

Air Flow

Air flows through the air filter assembly and enters the Variable Geometry Turbocharger (VGT). The compressor in the VGT increases the pressure, temperature, and density of the intake air before it enters the Charge Air Cooler (CAC). Cooled compressed air flows from the CAC into the EGR mixer duct.

- If the EGR control valve is open, exhaust gas will mix with filtered intake air and flow into the intake manifold.
- If the EGR control valve is closed, only filtered air will flow into the intake manifold.

After combustion, exhaust gas is forced through the exhaust manifold to the EGR cooler and VGT.

- Some exhaust gas is cooled in the EGR cooler and flows through the EGR control valve to the EGR mixer duct. When exhaust gas mixes with filtered air, nitrogen oxide (NOx) emissions and noise are reduced.
- The rest of the exhaust gas flows to the VGT, spins and expands through the turbine wheel, varying boost pressure.
- The VGT compressor wheel, on the same shaft as the turbine wheel, compresses the mixture of filtered air.

The VGT responds directly to engine loads. During heavy load, an increased flow of exhaust gases turns the turbine wheel faster. This increased speed turns the compressor impeller faster and supplies more air or greater boost to the intake manifold. Conversely, when engine load is light, the flow of exhaust gas decreases and less air is directed into the intake manifold.

Charge Air Cooler (CAC)

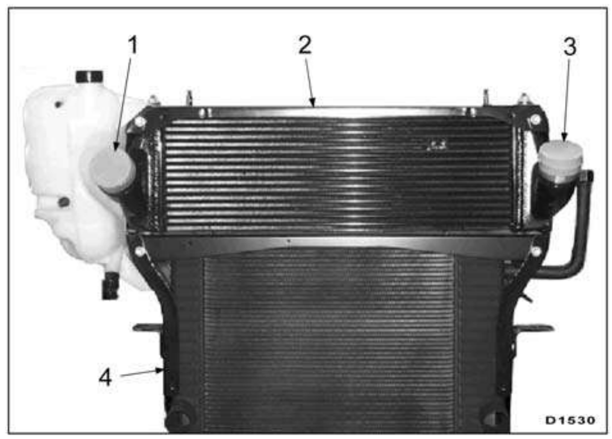


Figure 12 Charge Air Cooler (typical)

1. Air outlet
2. Charge Air Cooler (CAC)
3. Air inlet
4. Radiator

The CAC is mounted on top of the radiator. Air from the turbocharger passes through a network of heat exchanger tubes before entering the EGR mixer duct. Outside air flowing over the tubes and fins cools the charged air. Charged air is cooler and denser than the uncooled air; cooler and denser air improves the fuel-to-air ratio during combustion, resulting in improved emission control and power output.

Variable Geometry Turbocharger (VGT)

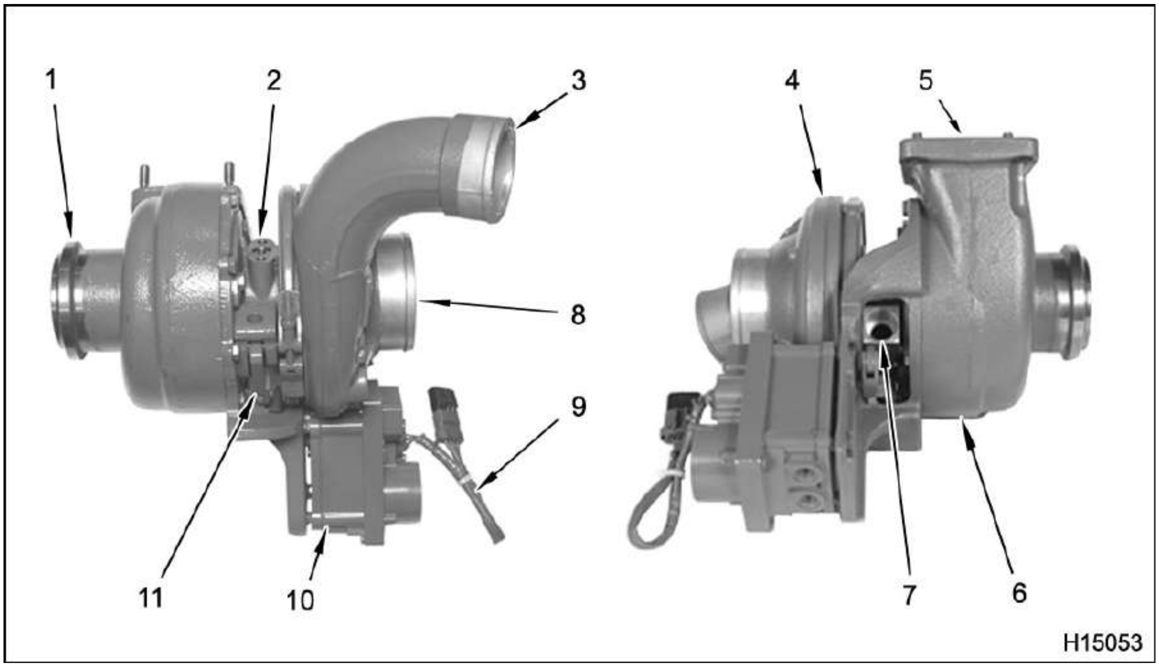


Figure 13 Variable Geometry Turbocharger (VGT)

1. Turbine outlet
2. Oil supply port
3. Compressor outlet
4. Compressor housing
5. Turbine inlet
6. Turbine housing
7. Oil drain port
8. Compressor inlet
9. Electrical connector and wire
10. Turbocharger control module
11. VGT linkage

The Variable Geometry Turbocharger (VGT) has actuated vanes in the turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing. The benefit is the ability to control boost pressure for various engine speeds and load conditions. An additional benefit is lower emissions.

VGT Closed Loop System

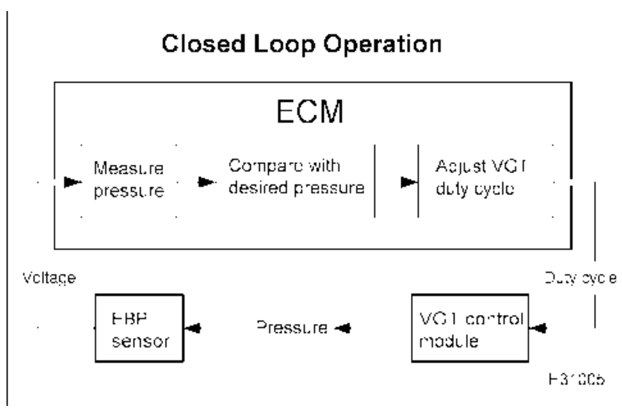


Figure 14 VGT closed loop system

The Variable Geometry Turbocharger (VGT) is a closed loop system that uses the Exhaust Back Pressure (EBP) sensor to provide feedback to the ECM. The ECM uses the EBP sensor to continuously monitor EBP and adjust the duty cycle to the VGT to match engine requirements.

VGT Control

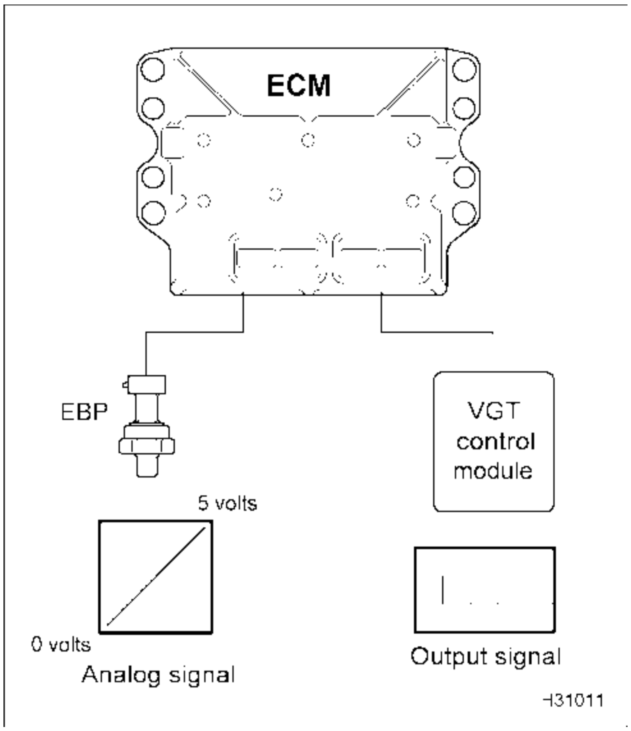


Figure 15 VGT control

The VGT actuator is a control module that contains a microchip and a DC motor. The VGT actuator is located below the turbocharger. The microchip operates a DC motor which rotates a crank lever controlling the vane position in the turbine housing. The position of the vanes is based off the pulse-width modulated signal sent from the ECM.

Actuated vanes are mounted around the inside circumference of the turbine housing. A unison ring links all the vanes. When the unison ring moves, all vanes move to the same position. Unison ring movement occurs when the crank lever in the control module moves.

Exhaust gas flow can be regulated depending on required exhaust back pressure for engine speed and load. As demand for EBP increases, the ECM increases the pulse-width modulation to the VGT control module. When EBP demand decreases, the ECM decreases the duty cycle to the control module.

Exhaust Gas Recirculation (EGR) System

The EGR system includes the following:

- EGR control valve
- EGR cooler
- Intake manifold
- Inlet and EGR mixer duct
- Exhaust manifold
- Exhaust gas crossover

The Exhaust Gas Recirculation (EGR) system reduces Nitrogen Oxide (NOx) emissions.

NO_x forms during a reaction between nitrogen and oxygen at high temperature during combustion. Combustion starts when fuel is injected into the cylinder before or slightly after the piston reaches top-dead-center.

EGR Flow

Some exhaust from the exhaust manifold flows into the EGR cooler. Exhaust from the EGR cooler flows through the exhaust gas crossover to the EGR valve.

When EGR is commanded, the EGR control valve opens allowing cooled exhaust gases to enter the EGR mixer duct to be mixed with filtered intake air.

EGR Control Valve

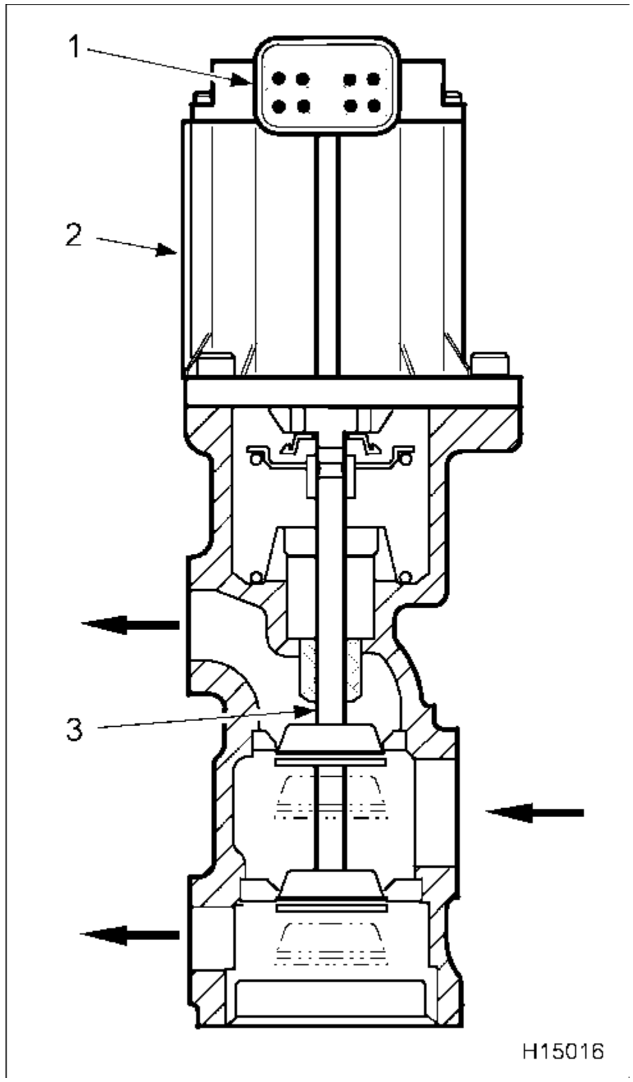


Figure 16 EGR control valve

1. Connector
2. DC motor with position sensor
3. Valve assembly

The EGR valve uses a DC motor to control the position of the valve assembly. The motor pushes directly on the valve assembly. The valve assembly has two valve heads on a common shaft.

The EGR actuator consists of three major components, a valve, an actuator motor, and Integrated Circuit (IC). The IC has three Hall effect position sensors to monitor valve movement. The

EGR actuator is located at the front of the engine on the intake manifold.

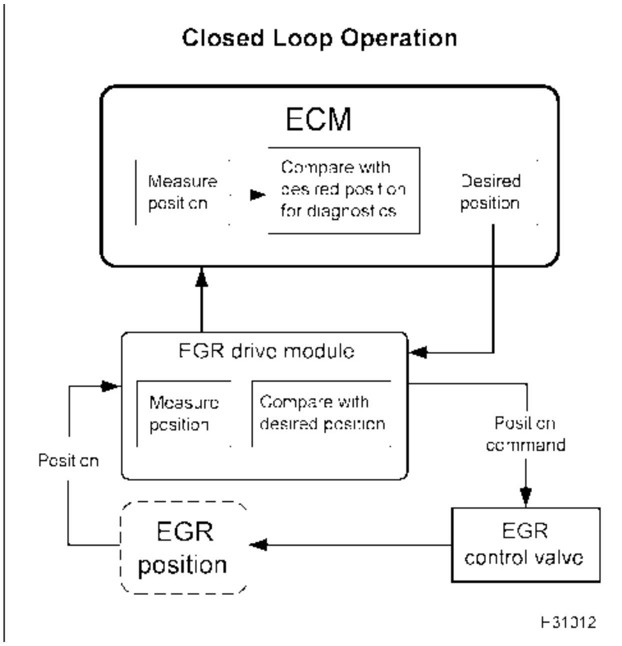


Figure 17 EGR closed loop operation with fault management

The EGR drive module controls the EGR actuator and is located on the left side of the engine on the ECM and Injector Driver Module (IDM).

The EGR drive module receives the desired EGR actuator position from the ECM across the CAN 2 datalink to activate the valve for exhaust gas recirculation. The EGR drive module provides feedback to the ECM on the valve position. The EGR drive module interprets the ECM command and sends the command using three pulse-width modulated signals to the valve actuator.

The system is closed loop control using the EGR position signals.

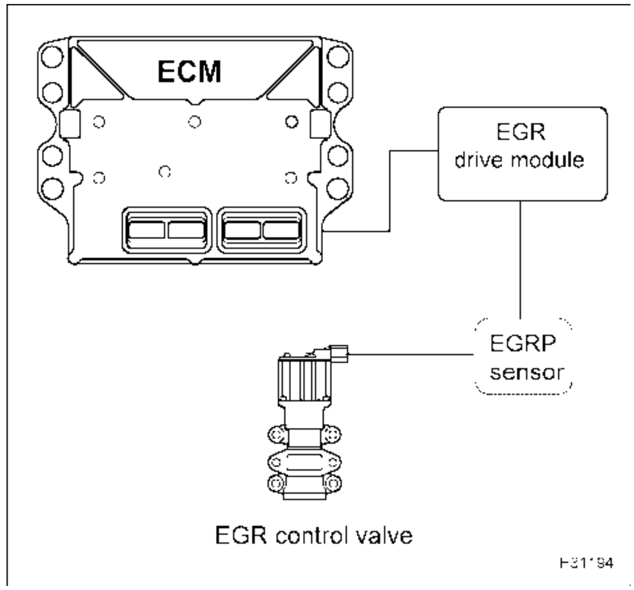


Figure 18 EGR control

Exhaust System

The exhaust system includes the following:

- Exhaust valves
- Exhaust manifold
- Diamond Logic® engine brake
- Variable Geometry Turbocharger (VGT)
- Exhaust piping
- Muffler and catalytic converter – dependent on application
- Catalyzed Diesel Particulate Filter (CDPF) – dependent on application

The exhaust system removes exhaust gases from the engine. Exhaust gases exit from exhaust valves, through exhaust ports, and flow into the exhaust manifold. Expanding exhaust gases are directed through the exhaust manifold. The exhaust manifold directs some exhaust gases into the Exhaust Gas Recirculation (EGR) cooler. Exhaust gases flowing into the turbocharger drive the turbine wheel. Exhaust gases exit the turbocharger and flow into the exhaust piping, through the muffler and catalytic converter or CDPF, depending on application, and out the discharge pipe to the atmosphere.

Fuel Management System

Fuel Management Components

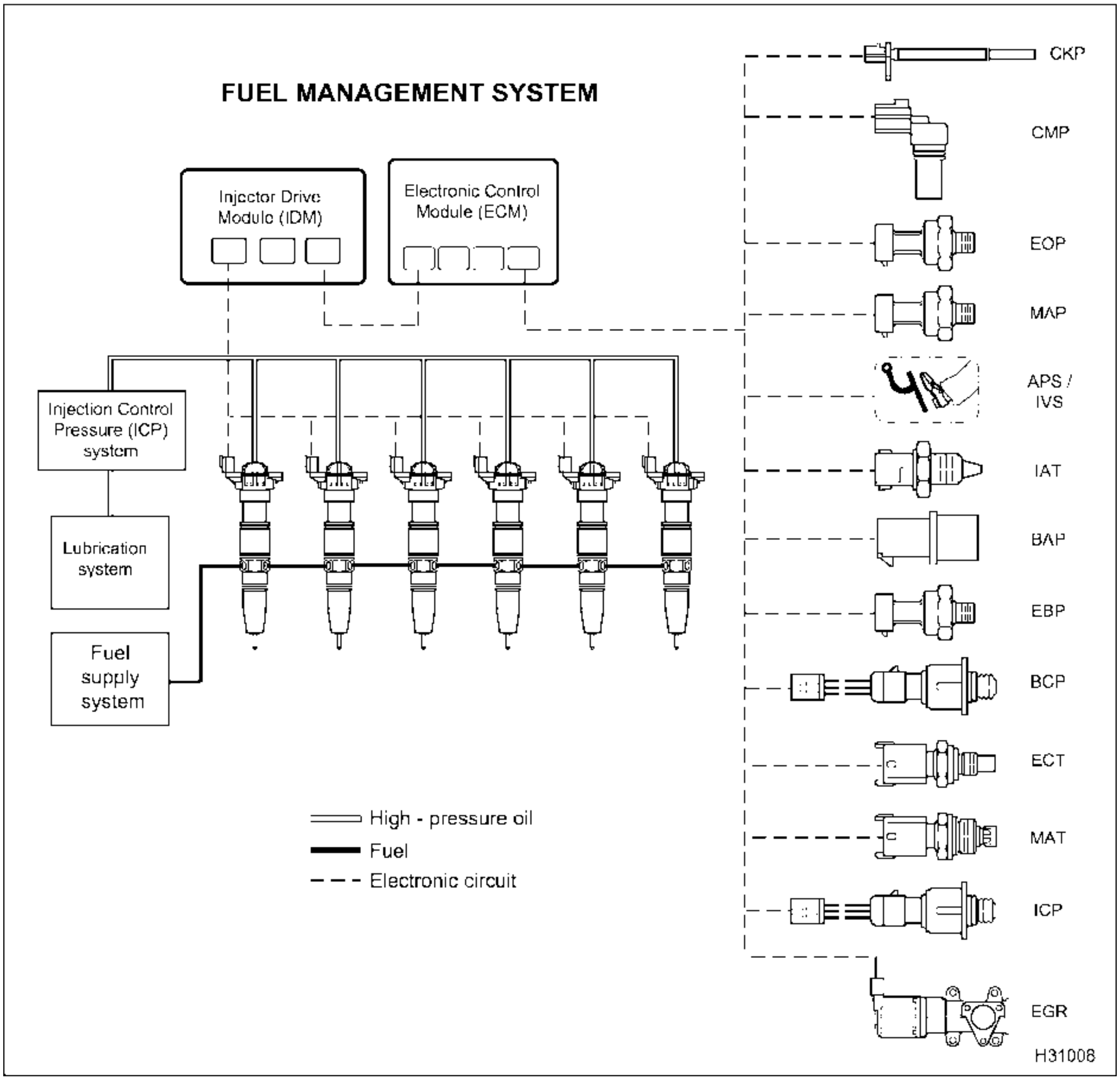


Figure 19 Fuel management system

The fuel management system includes the following:

- Injection Control Pressure (ICP) system
- Fuel supply system
- Fuel injectors
- Lubrication system
- Electronic control system

Injection Control Pressure (ICP) System Components and High-pressure Oil Flow

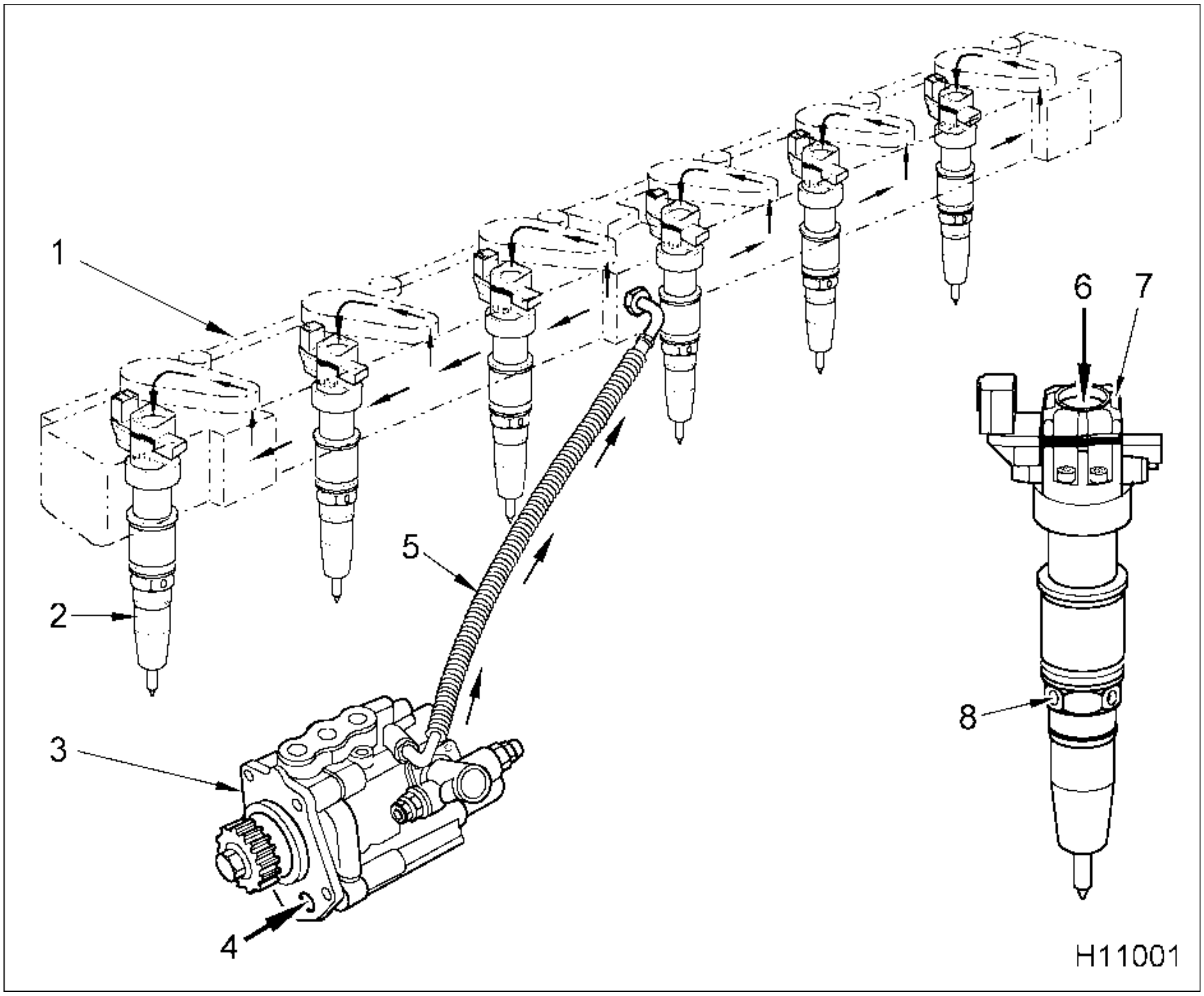


Figure 20 Injection Control Pressure (ICP) system

1. High-pressure oil manifold assembly
2. Fuel injector
3. High-pressure pump assembly
4. High-pressure oil inlet (pump)
5. High-pressure oil hose
6. High-pressure oil inlet (injector)
7. Oil exhaust port (2)
8. Fuel inlet (4)

High-pressure Oil Flow

The oil reservoir in the front cover provides a constant supply of oil to a high-pressure oil pump mounted to the backside of the front cover. Oil drawn from the oil reservoir is constantly refilled by the engine lubrication system.

The gear-driven, high-pressure oil pump delivers oil through a high-pressure oil hose, through a cylinder head passage into the high-pressure oil manifold beneath the valve cover. The manifold distributes to the top of each fuel injector.

When the OPEN coil for each injector is energized, the injectors use high-pressure oil to inject and atomize fuel in the combustion chambers. To end injection, the CLOSE coils are energized. Exhaust oil exits through two ports in the top of the fuel injectors, then drains back to sump.

Injection Control Pressure (ICP) Closed Loop System

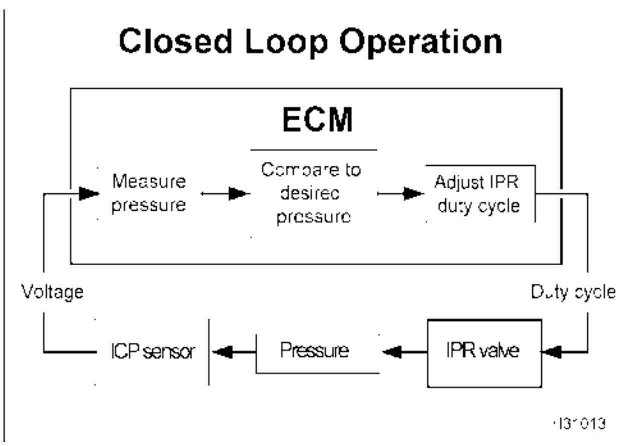


Figure 21 ICP closed loop system

The ICP is a closed loop system that uses the ICP sensor to provide feedback to the ECM. The ECM uses the ICP sensor to continuously monitor injection control pressure and adjust the duty cycle of the IPR valve to match engine requirements.

ICP System Control

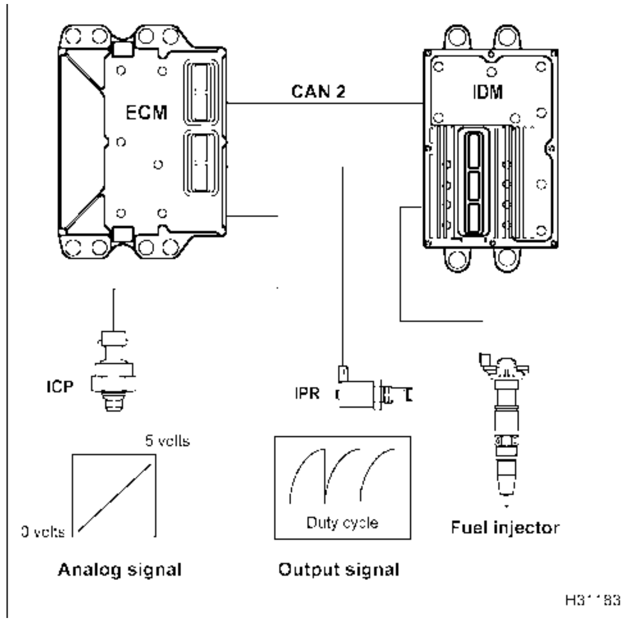


Figure 22 ICP control

ICP Operation

The IPR solenoid receives a pulse width modulated signal from the ECM that indicates the on and off time the control valve is energized. The pulse is calibrated to control ICP pressure in a range from 5 MPa (725 psi) up to 28 MPa (4,075 psi). Maximum pressure relief occurs at about 32 MPa (4,600 psi).

The IPR valve is mounted in the body of the high-pressure pump. The IPR valve maintains the desired ICP by dumping excess oil back to the crankcase sump.

As demand for ICP increases, the ECM increases the pulse - width modulation to the IPR solenoid. When ICP demand decreases, the ECM decreases the duty cycle to the solenoid, allowing more oil to flow from the drain orifice.

The ECM sets Diagnostic Trouble Codes (DTCs), if the ICP electrical signal is out of range. DTCs are also set if an ICP signal corresponds to an out of range value for injection control pressure for a given operating condition.

The ECM will ignore ICP signals that are out of range and the IPR valve will operate from programmed default values. This is called Open Loop operation.

The ICP sensor is installed under the valve cover, forward of the No. 6 fuel injector in the high-pressure oil rail.

Fuel Injectors

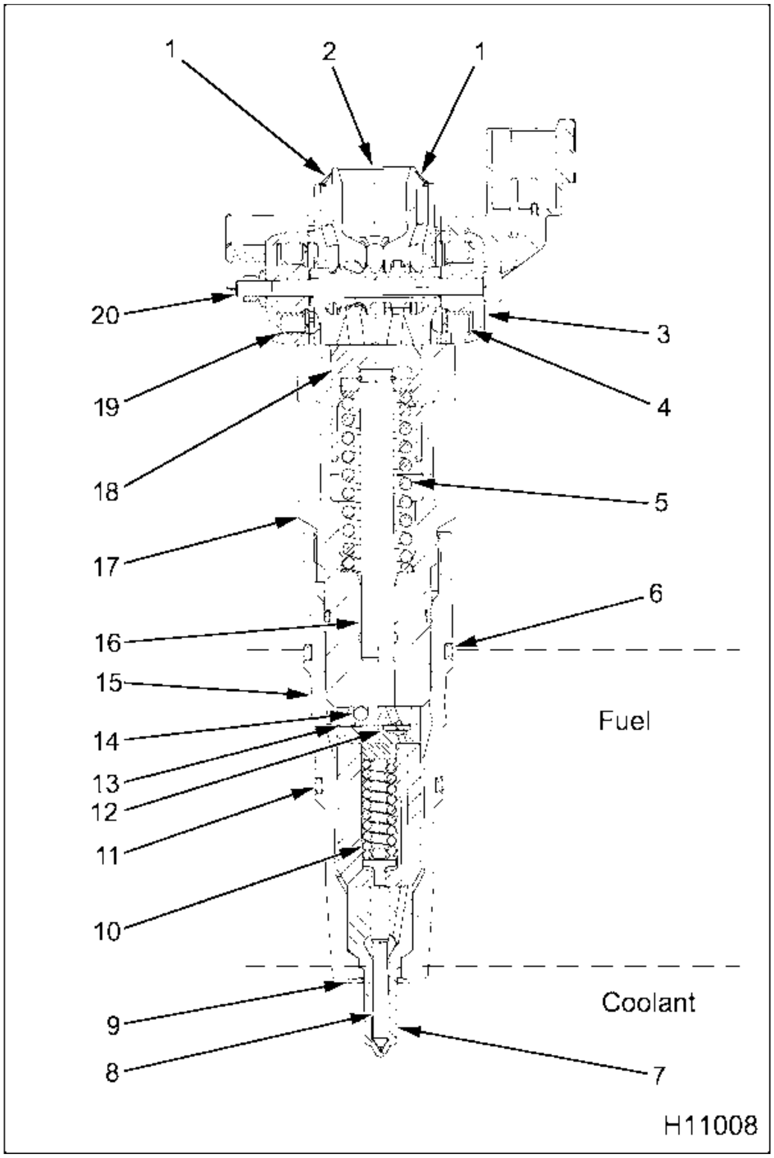


Figure 23 Fuel injector assembly

1. Exhaust port (oil)
2. Inlet port (oil)
3. Control valve body
4. OPEN coil
5. Intensifier piston spring
6. Upper O-ring
7. Nozzle assembly
8. Needle
9. Nozzle gasket
10. Valve Opening Pressure (VOP) spring
11. Lower O-ring
12. Reverse flow check
13. Edge filter
14. Fuel inlet check ball
15. Fuel inlet (4)
16. Plunger
17. Barrel
18. Intensifier piston
19. CLOSE coil
20. Spool valve (control valve)

Fuel Injector Features

Two 48 volt 20 amp coils control a spool valve that directs oil flow in and out of the injector. The injector coils are turned on for approximately 800 µs (microseconds or millionths of a second). Each injector has a single four pin connector that couples to the valve cover gasket assembly.

Injector Coils and spool valve

An OPEN coil and a CLOSE coil on the injector move the spool valve from side to side using magnetic force. The spool has two positions:

- When the spool valve is open, oil flows into the injector from the high-pressure oil rail.
- When the spool valve is closed oil exhausts from the top of the fuel injector and drains back to the crankcase.

Intensifier piston and plunger

When the spool valve is open, high-pressure oil enters the injector pushing down the intensifier piston and plunger. Since the intensifier piston is 7.1 times greater in surface area than the plunger, the injection pressure is also 7.1 times greater than ICP pressure on the plunger.

Plunger and barrel

Fuel pressure builds at the base of the plunger in the barrel. When the intensifier piston pushes the plunger down, the plunger increases fuel pressure in the barrel 7.1 times greater than ICP. The plunger has tungsten carbide coating to resist scuffing.

Injector needle

The injector needle opens inward, off its seat when fuel pressure overcomes the Valve Opening Pressure (VOP) of 28 MPa (4,075 psi). Fuel is atomized at high pressure through the nozzle tip.

Fuel Injector Operation

The injection operation has three stages:

- Fill stage
- Main injection
- End of main injection

Fill stage

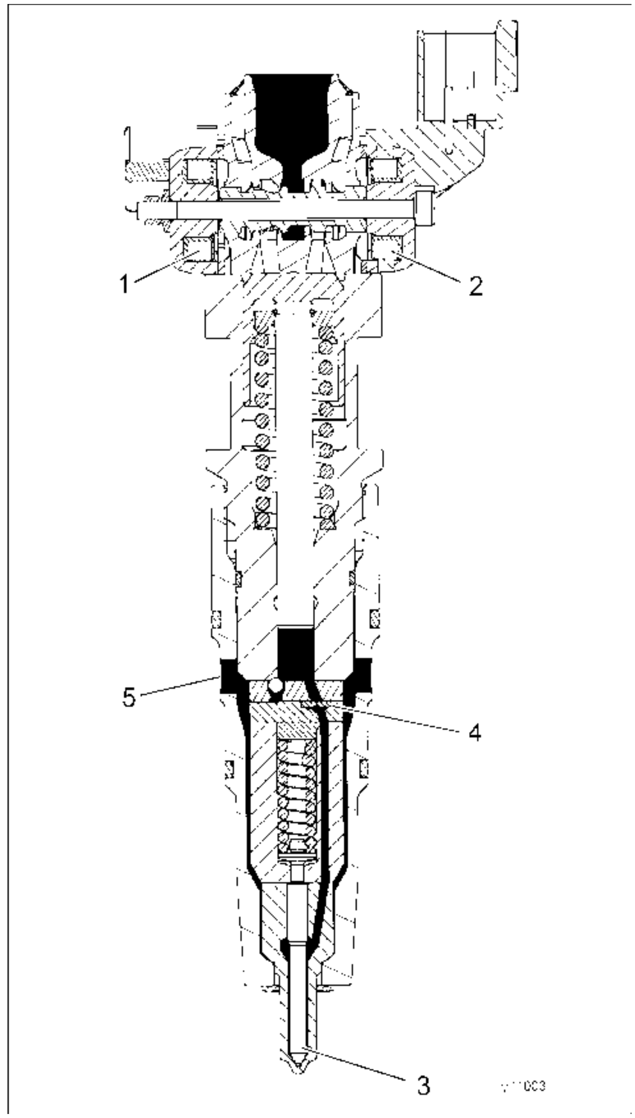


Figure 24 Fill stage

1. CLOSE coil (off)
2. OPEN coil (off)
3. Needle (seated)
4. Disk check (seated)
5. Fuel inlet (4)

During the fill stage both coils are de-energized and the spool valve is closed. High-pressure oil from the high-pressure oil rail is deadheaded at the spool valve.

Low-pressure fuel fills the four ports and enters through the edge filter on its way to the chamber beneath the plunger. The needle control spring holds the needle onto its seat to prevent fuel from entering the combustion chamber.

Main injection (Step 1)

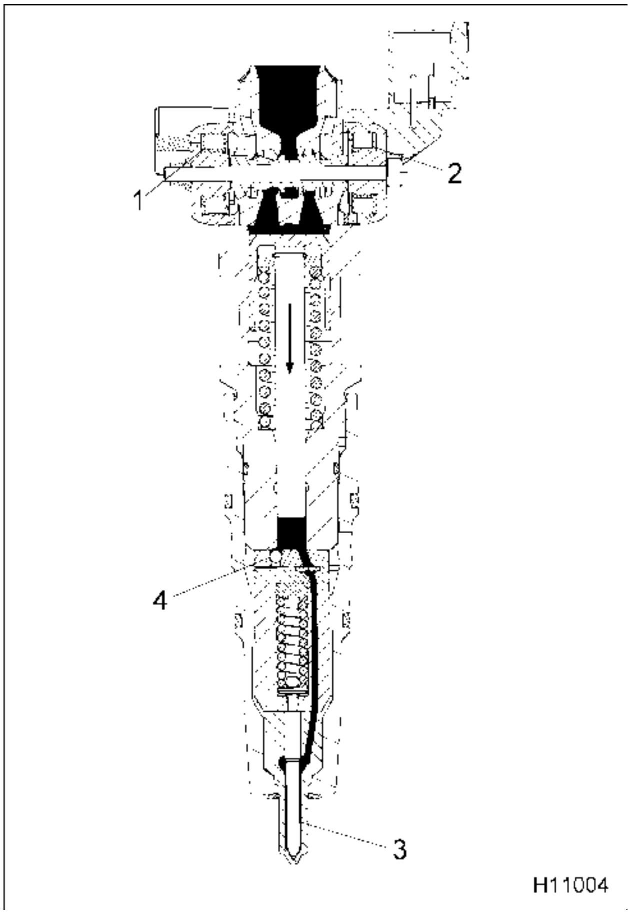


Figure 25 Main injection (Step 1)

1. CLOSE coil (off)
2. OPEN coil (on)
3. Needle (seated)
4. Fuel inlet check ball (seated)

A pulse width current energizes the OPEN coil. Magnetic force moves the spool valve open. High-pressure oil flows past the spool valve and onto the top of the intensifier piston. Oil pressure overcomes the force of the intensifier piston spring and the intensifier starts to move down. An increase in fuel pressure under the plunger seats the fuel inlet check ball, and fuel pressure starts to build on the needle.

Main injection (Step 2)

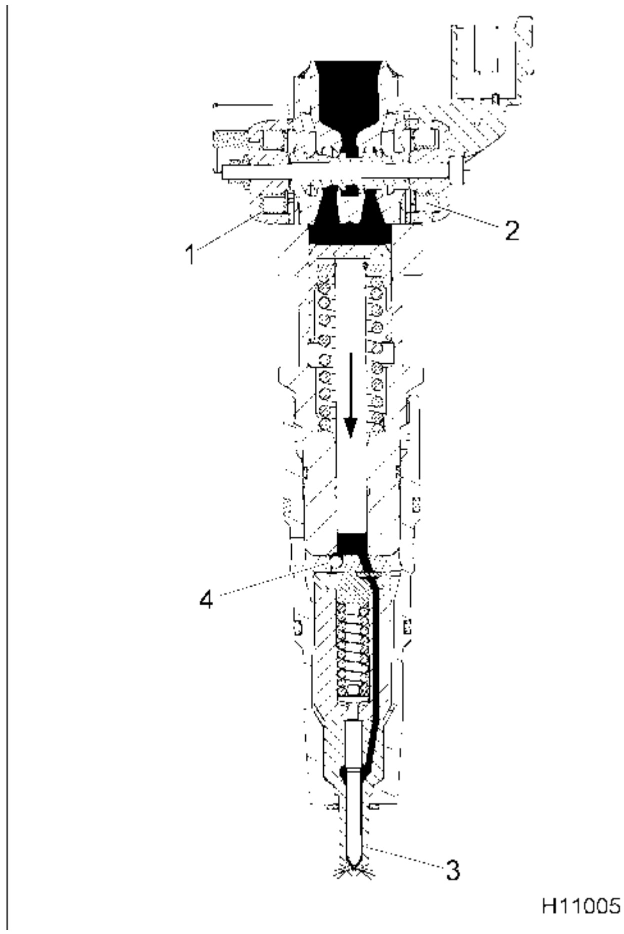


Figure 26 Main injection (Step 2)

1. CLOSE coil (off)
2. OPEN coil (off)
3. Needle (unseated – VOP)
4. Fuel inlet check ball (seated)

The pulse-width controlled current to the OPEN coil is shut off, but the spool valve remains open. High pressure oil from high pressure oil rail continues to flow past the spool valve. The intensifier piston and plunger continue to move and fuel pressure increases in the barrel. When fuel pressure rises above the VOP - about 28 MPa (4,075 psi) - the needle lifts of its seat and injection begins.

End of main injection (Step 1)

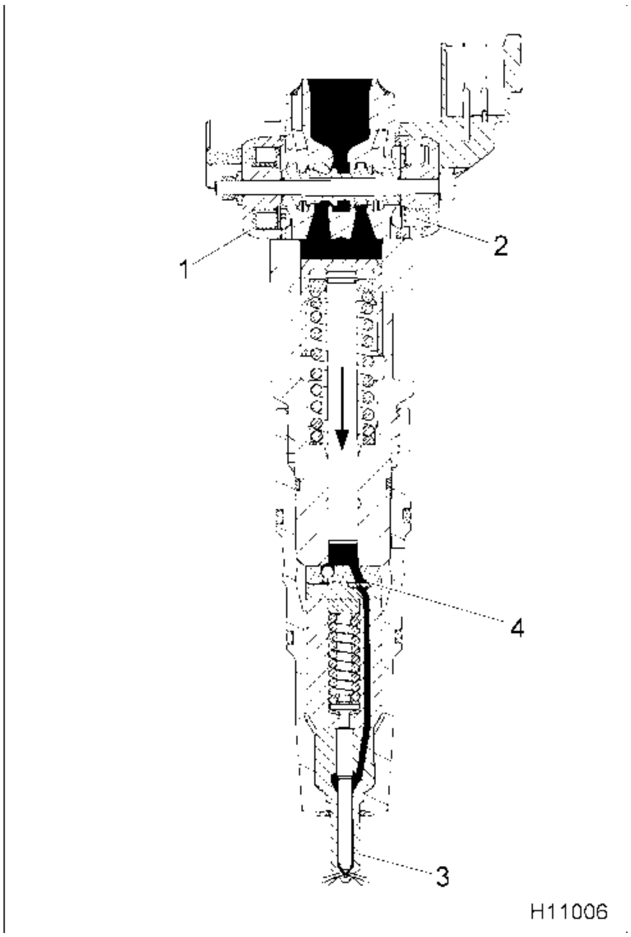


Figure 27 End of main injection (Step 1)

1. CLOSE coil (on)
2. OPEN coil (off)
3. Needle (unseated / closing)
4. Check disk (seated)

When the Injector Drive Module (IDM) determines that the correct injector on-time has been reached (the correct amount of fuel has been delivered), the IDM sends a pulse width controlled current to the CLOSE coil of the injector. The current energizes the CLOSE coil and magnetic force closes the spool valve. High-pressure oil is deadheaded against the spool valve.

End of main injection (Step 2)

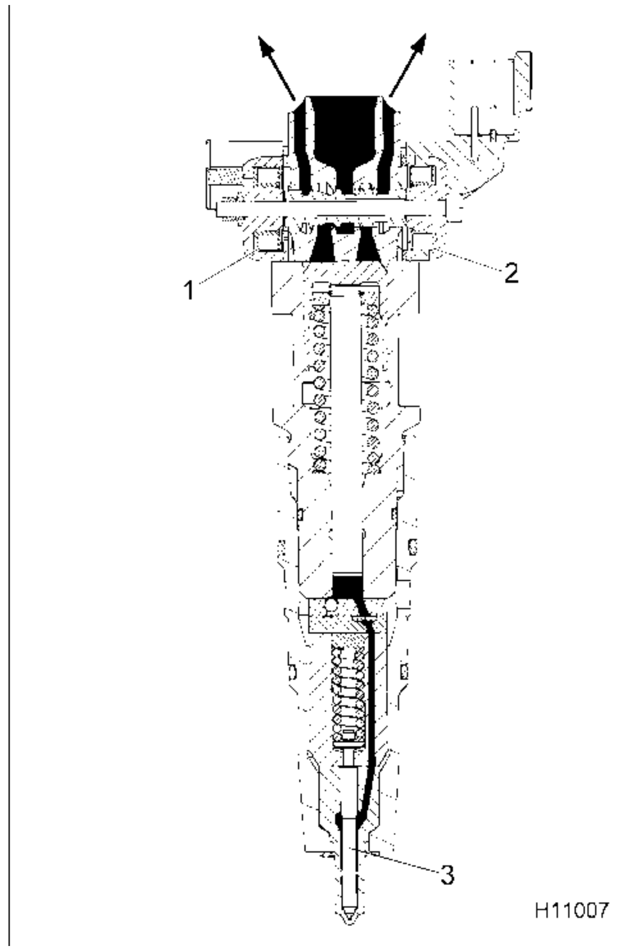


Figure 28 End of main injection (Step 2)

1. CLOSE coil (off)
2. OPEN coil (off)
3. Needle (seated)

The pulse width controlled current to close the coil is shut off, but the spool valve remains closed. The intensifier piston and plunger return to their initial positions. Oil above the intensifier piston flows past the spool valve through the exhaust ports. Fuel pressure decreases until the needle control spring forces the needle back onto its seat.

Fuel Supply System

Fuel System Components and Fuel Flow

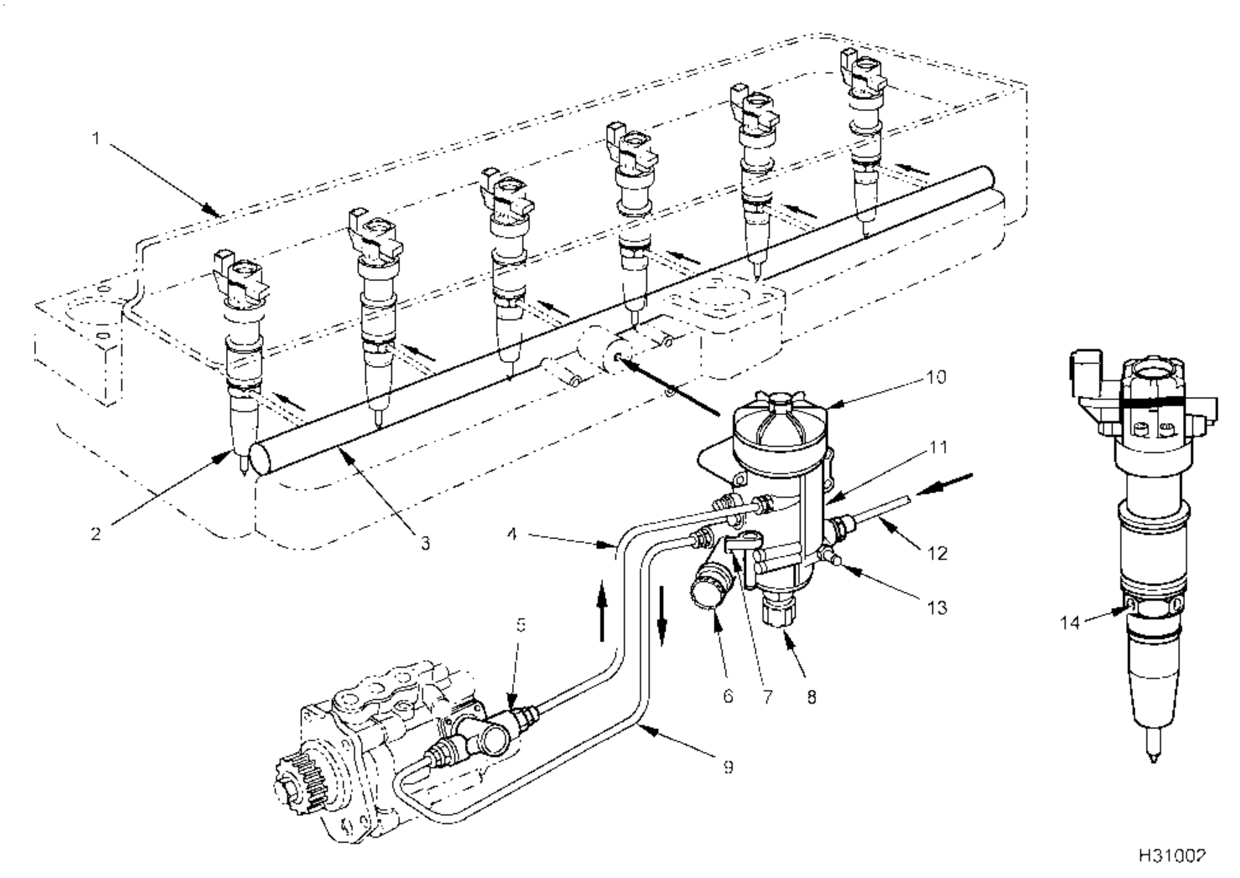


Figure 29 Fuel supply system

1. Cylinder head assembly
2. Fuel injector
3. Low-pressure fuel rail
4. Transfer pump outlet tube assembly
5. Low-pressure fuel supply pump
6. Primer pump assembly
7. Water drain valve
8. Drain valve (fuel)
9. Transfer pump inlet tube assembly
10. Fuel filter access cap
11. Fuel filter assembly
12. Fuel line from tank
13. Test fitting
14. Fuel inlet (4)

Fuel Flow Schematic

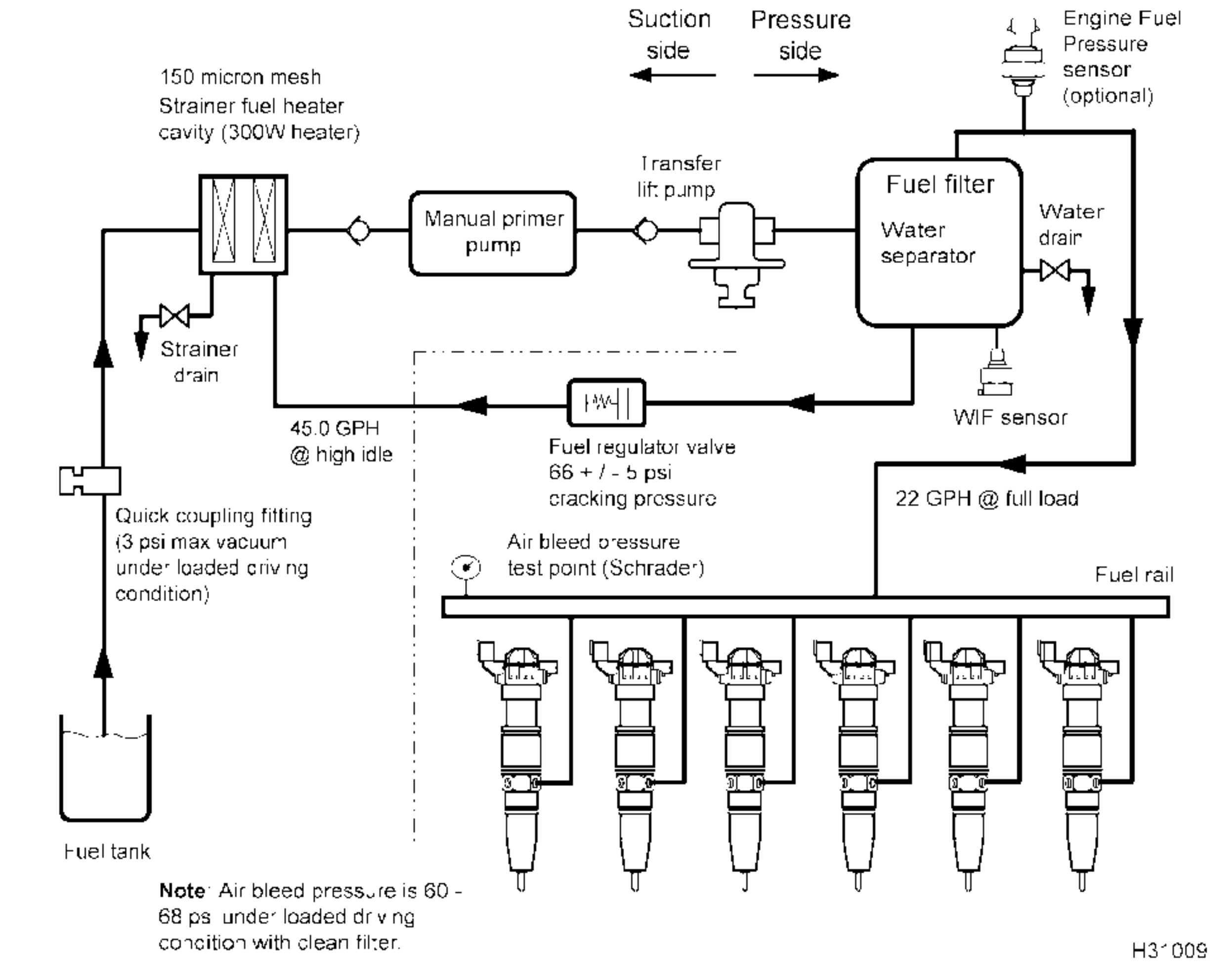


Figure 30 Fuel flow

The fuel filter housing includes the following components:

- 150 micron fuel strainer
- 300W fuel heating element (optional)
- Primer pump assembly
- Fuel filtering element
- Water separator
- Water In Fuel (WIF) sensor
- Water drain valve
- Fuel pressure regulator
- Engine Fuel Pressure (EFP) sensor (optional)

Fuel Flow

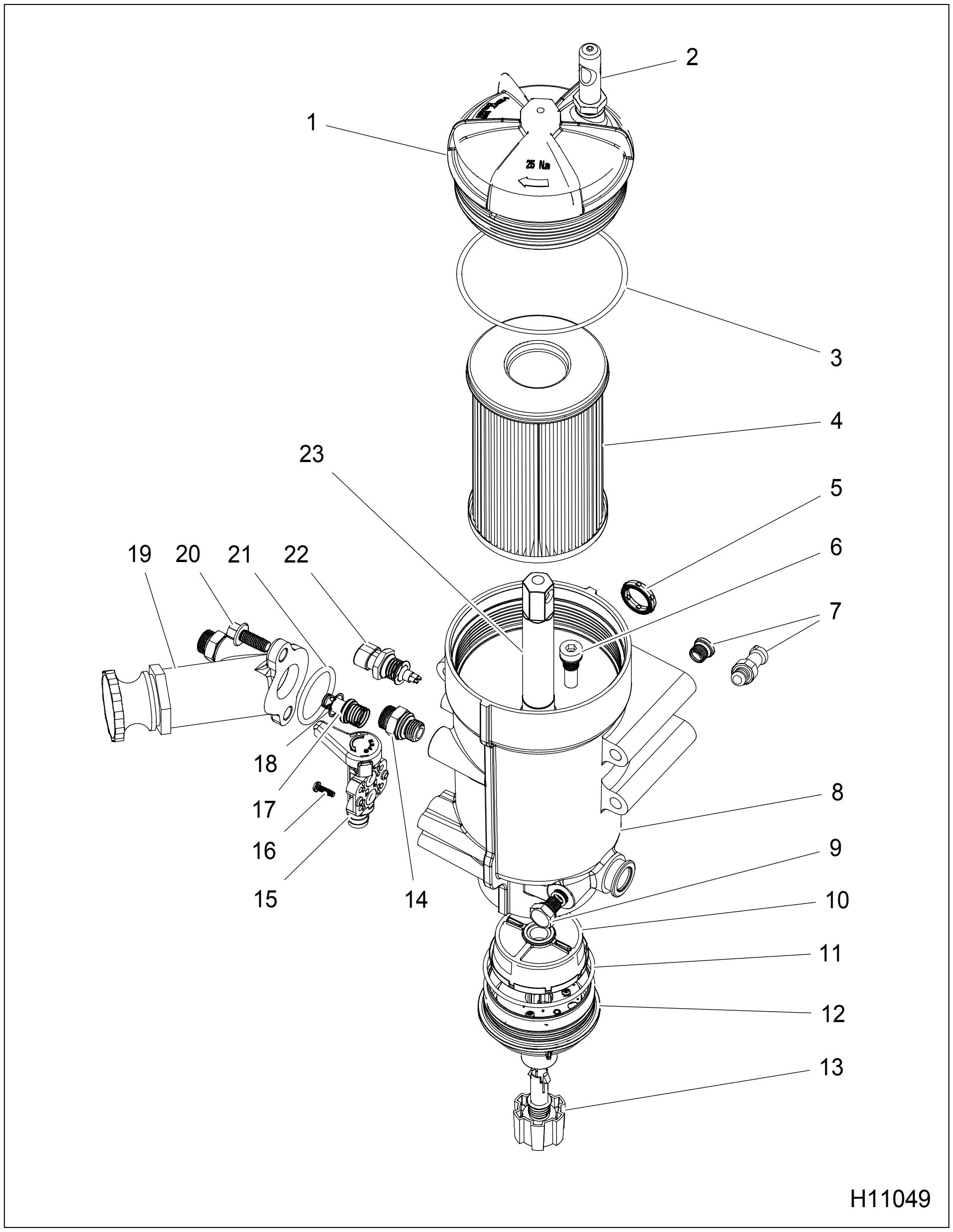


Figure 31 Fuel filter assembly

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, ⅜ 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

NOTE: Early fuel filter assemblies may have an M10 Plug assembly (item 2) in the location of M12 port fitting (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.

The low-pressure fuel supply pump draws fuel from the fuel tank through a 150 micron strainer in the fuel filter assembly.

An optional electric heating element in the fuel filter housing warms incoming fuel to prevent waxing.

If water is in the fuel, the filter element repels water molecules, water collects at the bottom of the element cavity in the fuel filter housing, and a Water In Fuel (WIF) sensor in the element cavity detects water in the fuel. When enough water accumulates in the element cavity, the WIF sensor sends a signal to the Electronic Control Module (ECM); the ECM illuminates the amber WATER IN FUEL lamp on the instrument panel. A fuel drain valve handle on the housing can be opened to drain contaminants (usually water) from the fuel filter housing. Another drain valve in the bottom of the housing drains strainer cavity.

A built-in fuel regulator valve, calibrated to open at about 414 - 482 kPa (60 - 70 psi), regulates and relieves excessive pressure. During idle and light engine loads, when injector demand is low, most of the fuel is cycled between the fuel filter housing and low-pressure fuel pump. When engine demand increases, engine fuel consumption increases resulting in less fuel cycling. Under heavy loads fuel flows through the filter with little or no cycling.

Fuel is conditioned as it flows through a main filter and central post. The post prevents fuel from draining from the fuel rail during servicing.

An optional Engine Fuel Pressure (EFP) sensor detects low pressure caused by high fuel filter restriction and sends a signal to the ECM; the ECM illuminates the amber FUEL FILTER lamp on the instrument panel.

Fuel flows from the fuel filter housing into the fuel rail, through the fuel rail into six drilled holes (one for each injector) to each injector.

When the fuel injectors are activated, fuel flows (from fuel rail) into four inlets in each injector.

Engine Lubrication System

Lubrication System Components and Oil Flow

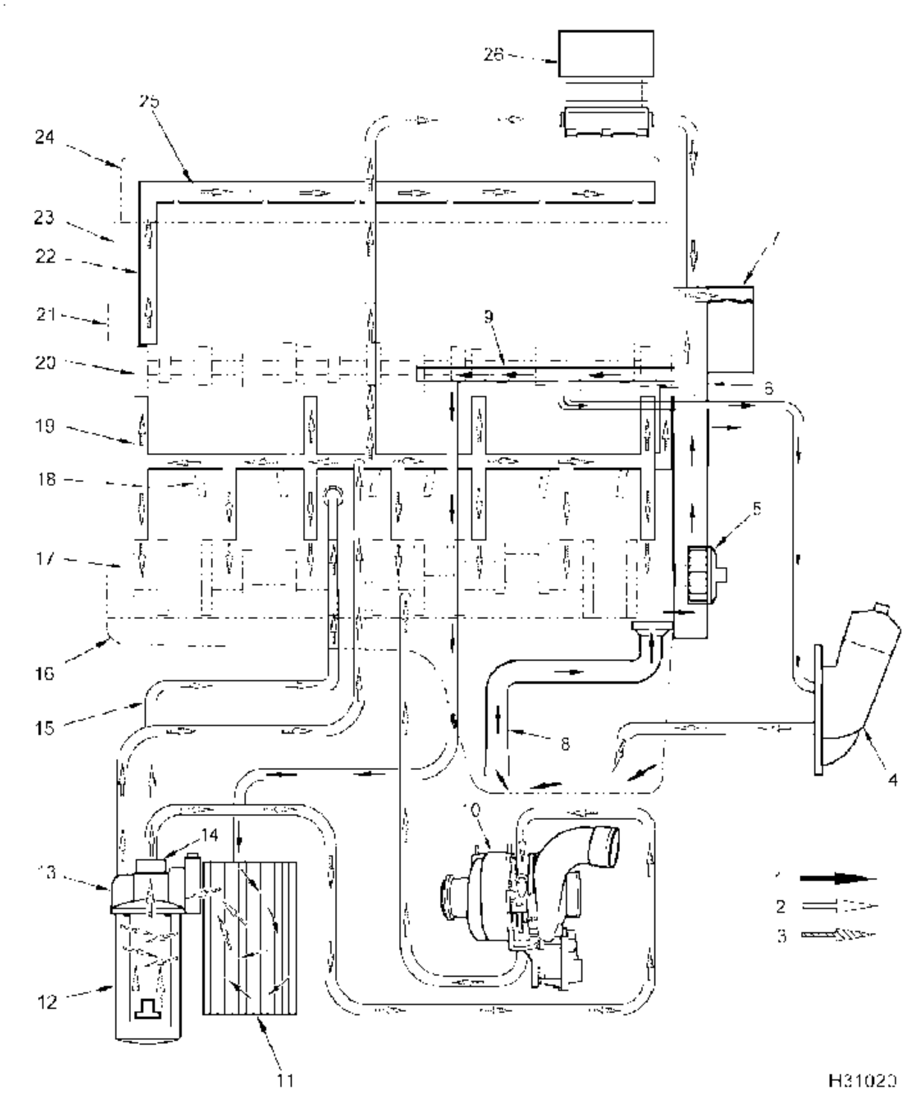


Figure 32 Lubrication system

1. Unfiltered oil
2. Cooled unfiltered oil
3. Filtered oil
4. Secondary filtration filter (optional)
5. Gerotor oil pump
6. Front cover
7. Reservoir for high-pressure oil pump
8. Pick-up tube
9. Unfiltered oil gallery
10. Variable Geometry Turbocharger (VGT)
11. Oil cooler
12. Oil filter
13. Oil cooler / filter header assembly
14. Oil pressure regulator relief valve
15. Regulator relief valve drain to crankcase
16. Oil pan assembly
17. Crankshaft
18. Piston cooling jet (6)
19. Main filtered oil gallery
20. Camshaft
21. Crankcase
22. Vertical gallery
23. Cylinder head
24. Valve cover
25. Rocker arm assembly
26. Air compressor

Oil Flow Diagram

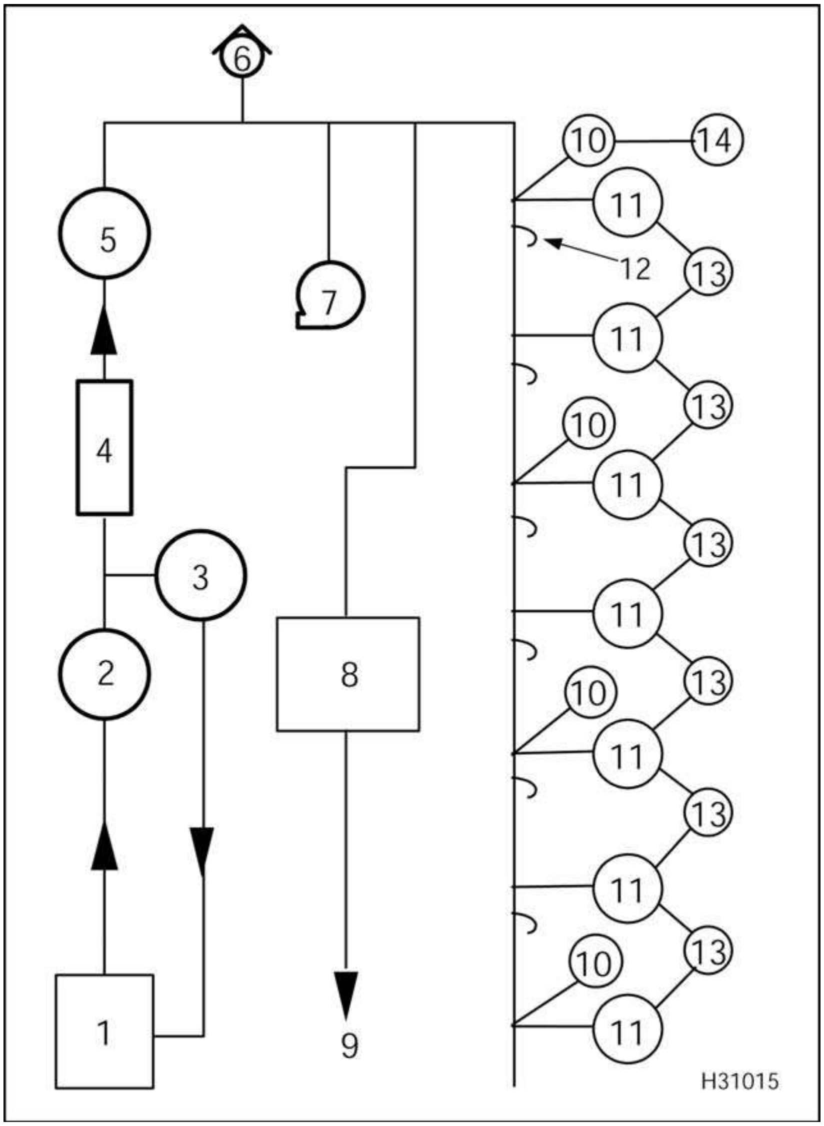


Figure 33 Lubrication system

1. Sump
2. Oil pump
3. Secondary filtration filter (optional)
4. Oil cooler
5. Oil filter
6. Regulator valve
7. Variable Geometry Turbocharger (VGT)
8. Oil reservoir for high-pressure pump
9. To high-pressure oil system
10. Cam bearings
11. Main bearings
12. Piston cooling tubes (6)
13. Connecting rods
14. Rocker arm shaft

The gerotor oil pump, driven by the engine crankshaft, draws unfiltered oil from the oil pan through an oil pick-up tube into the inlet port of the front cover. Unfiltered oil (under pressure) flows through the outlet port in the front cover into the unfiltered oil gallery in the crankcase.

The unfiltered oil gallery has one exit port to the header of the oil cooler. The oil is then internally diverted to the oil cooler plate stack or bypassed in the oil cooler/filter module.

An oil temperature control valve, in the oil cooler/filter header, senses inlet oil temperature. During engine start-up, when the oil is cold the oil temperature control valve allows unfiltered oil to bypass the oil cooler plate stack. When the unfiltered oil reaches engine operating temperature, the oil temperature control valve routes unfiltered oil to the oil cooler. Oil flows through both the oil cooler core and bypass gallery when the valve is partially open.

Unfiltered oil at full flow moves through plates in the oil cooler. Engine coolant flows through the plates to cool the surrounding oil.

The cooled, unfiltered oil leaving the oil cooler stack mixes with the uncooled, unfiltered oil (that bypassed the oil cooler). The oil mixture flows through the oil filter (from element outside to element inside). The oil filter bypass valve in the header ensures full flow of oil to the engine should the filter element become plugged. Oil bypass occurs within the module when differential filter pressure reaches 345 kPa (50 psi) .

Cooled, filtered oil flows to and past the oil pressure regulator valve, in the oil cooler module. The oil pressure regulator valve maintains correct operating oil pressure.

The pressure regulator valve opens at 379 kPa (55 psi) and dumps excess oil into the crankcase. The filtered oil continues to the main oil gallery for distribution throughout the engine.

Connecting rod bearings are fed through drilled passages in the crankshaft from main to rod journals, receiving pressurized oil from the main bearings.

Camshaft journals are fed through passages drilled vertically in the main bearing webs. Pressurized oil from the main gallery, through piston cooling jets, lubricates and cools the pistons.

Valve rocker arms are lubricated through an annulus on the outside of the rear camshaft bushing. The oil passes up and through the vertical gallery in the rear of the crankcase, through a passage in the cylinder head. Oil continues through rocker arm shaft pedestal and into the rocker arm shaft. Oil continues flowing through drillings in the rocker arm shaft to the rocker arms. The oil then drains to the oil pan through push rod holes.

Filtered oil from the main gallery flows up through a passage in the front of the crankcase and front cover into the oil reservoir for the high-pressure oil pump.

The turbocharger receives filtered oil through an external tube connected to the oil cooler header. Oil drains back to the oil pan through a tube connected to the crankcase.

The air compressor (if equipped) receives filtered oil from the main oil gallery through an external tube connected to the left side of the crankcase. Oil drains to the front cover and back to the oil pan.

The front gear train is splash lubricated with oil draining from the high-pressure reservoir and the air compressor (if equipped).

Cooling System

Cooling System Components and Coolant Flow

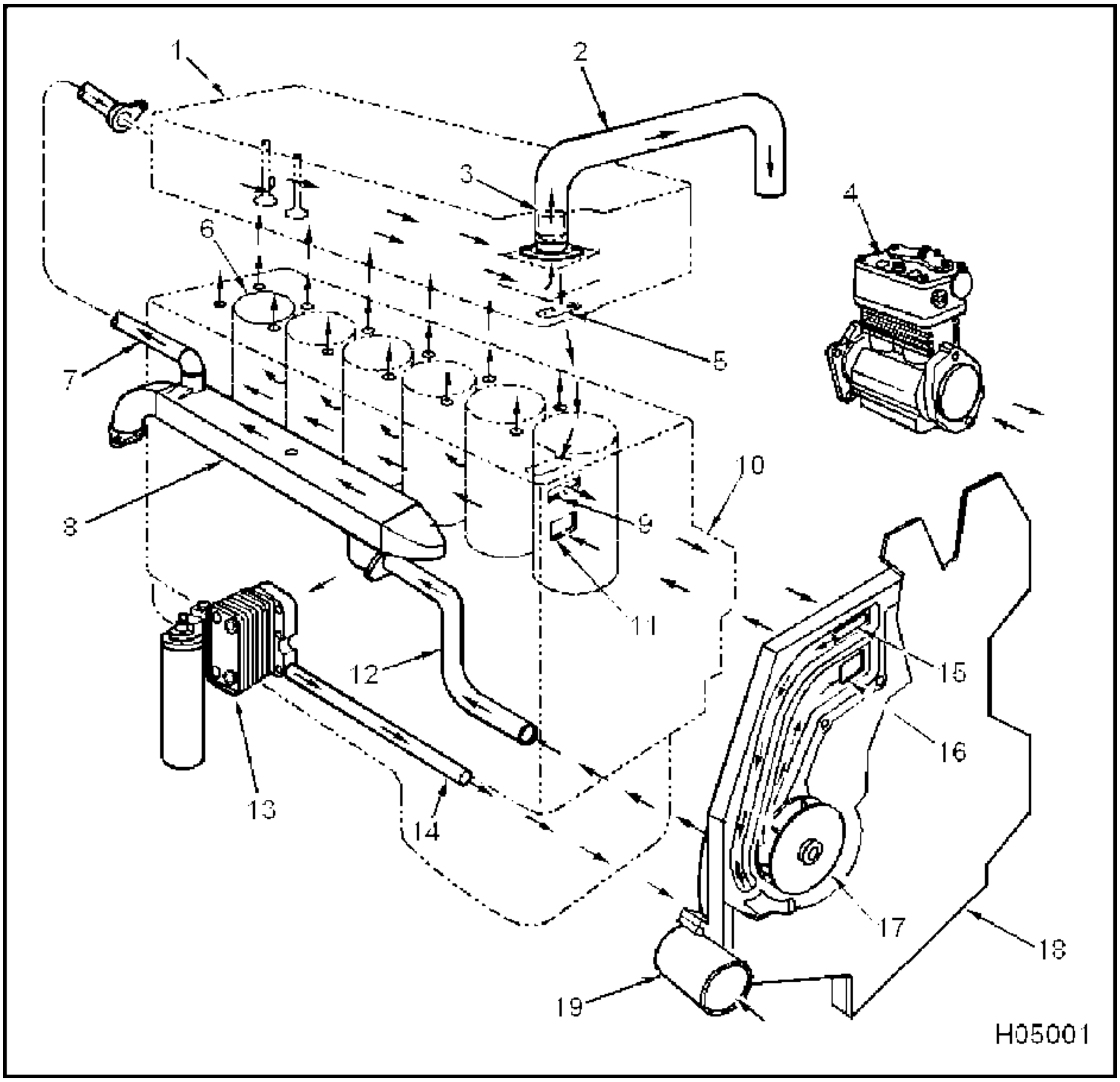


Figure 34 Engine cooling system

1. Cylinder head assembly
2. Water outlet tube assembly (thermostat outlet)
3. Thermostat assembly
4. Air compressor
5. Water return from cylinder head to crankcase
6. Cylinder sleeve
7. EGR coolant return tube assembly
8. EGR cooler
9. Water outlet from crankcase to front cover
10. Crankcase
11. Water inlet to crankcase
12. EGR cooler supply tube
13. Oil system module assembly
14. Oil cooler tube
15. Water inlet to front cover and water pump
16. Water supply from front cover to crankcase
17. Water pump impeller assembly
18. Front cover
19. Water inlet elbow

Cooling System Flow

The cooling system keeps the engine within a designated temperature range. The major components of the cooling system include the following:

- Radiator and fan combination (chassis components)
- Water pump assembly
- Thermostat assembly
- Oil system module assembly
- EGR cooler assembly

A belt-driven, centrifugal water pump set into the front cover has three passages. One passage channels coolant from the water pump to the crankcase, the second returns coolant to the water pump, and the third (a bypass) channels coolant back to the water pump when the thermostat is closed.

Incoming coolant flows from the bottom of the radiator through a water inlet elbow to the front cover and water pump. Coolant is pumped to the crankcase through a passage in the front cover and crankcase.

Water jackets in the crankcase direct coolant from front to rear, distributing coolant evenly to the lower sections of the cylinder sleeves. Coolant flow is directed tangent to each cylinder sleeve, causing a swirling motion up to the cylinder head. The swirling action improves heat absorption.

Coolant flows from the cylinder sleeve areas in three ways:

- Coolant flows into the oil system module assembly through the right side of the crankcase, passes through the oil system module, and returns through a tube to the front cover.
- Coolant is routed through hoses to and from the air compressor on the left side of the crankcase.
- Coolant exits the crankcase at the upper end of each cylinder sleeve bore, distributed evenly through metering holes in the cylinder head. Coolant then flows through the cylinder head (back to front) to the thermostat.

The EGR cooler receives coolant from the front cover. Coolant flows from the front of the cooler and exits the rear of the cooler into the rear of the cylinder head. A deaeration port is on top of the EGR cooler.

Thermostat Operation

The thermostat has two outlets. One directs coolant to the radiator when the engine is at operating temperature. The other directs coolant to the water pump until the engine reaches operating temperature. The thermostat begins to open at 88 °C (190 °F) and is fully open at 96 °C (205 °F).

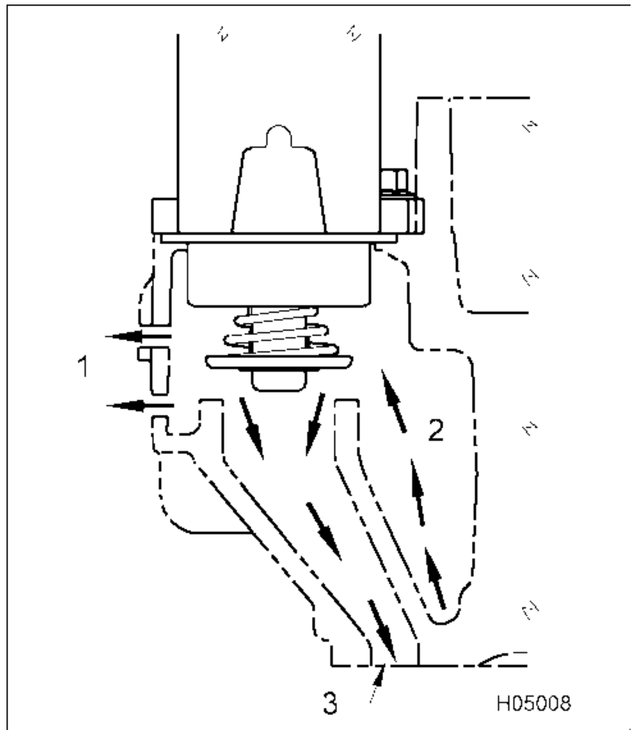


Figure 35 Thermostat closed

1. Coolant flow to heater port
2. Coolant in from engine
3. Bypass to water pump

When engine coolant is below 88 °C (190 °F), the thermostat is closed, blocking flow to the radiator. Coolant is forced to flow through a bypass port back to the water pump.

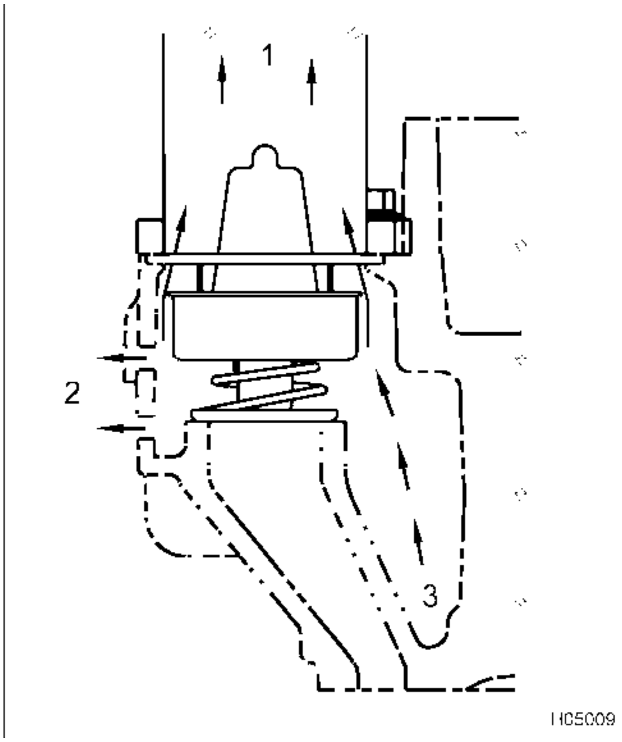


Figure 36 Thermostat open

1. Coolant out to radiator
2. Coolant flow to heater port
3. Coolant in from engine

When coolant temperature reaches the nominal opening temperature at 88 °C (190 °F), the thermostat opens allowing some coolant to flow to the radiator. When coolant temperature exceeds 96 °C (205 °F), the lower seat blocks the bypass port directing full coolant flow to the radiator.

Electronic Control System

Electronic Control System Components

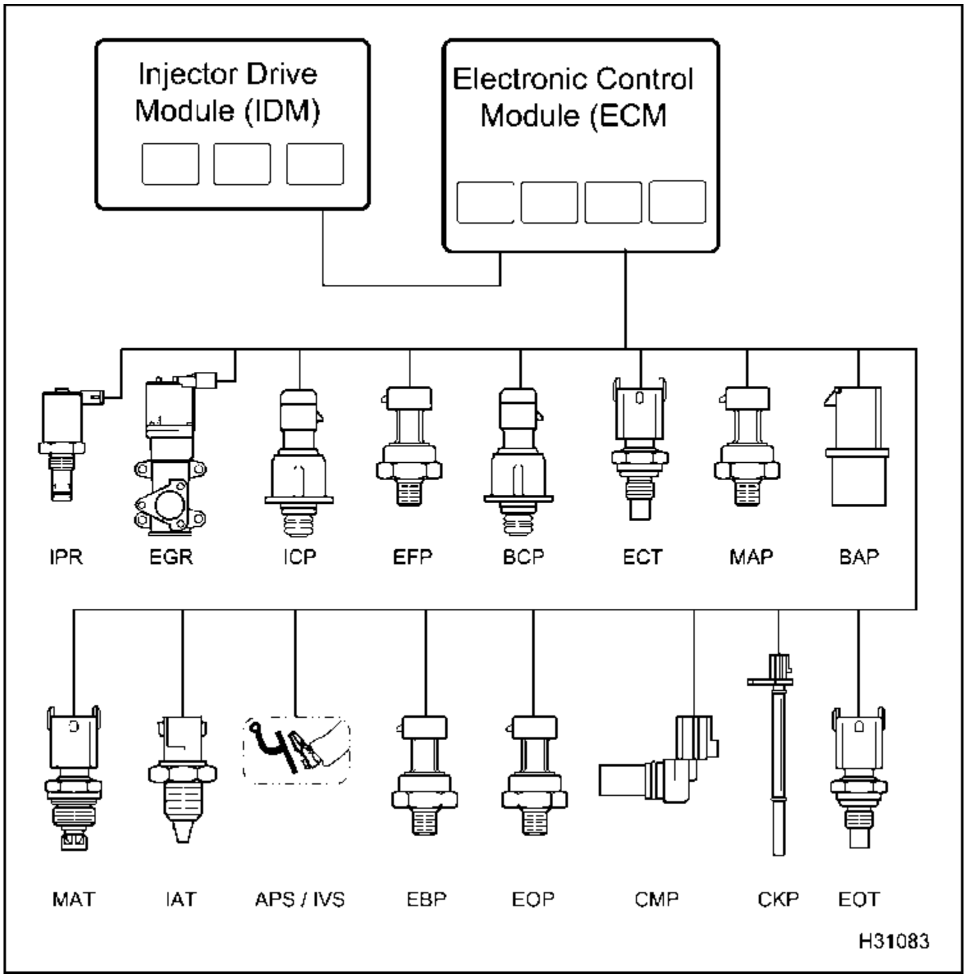


Figure 37 Electronic Control System

Operation and Function

The Electronic Control Module (ECM) monitors and controls engine performance to ensure maximum performance and adherence to emissions standards. The ECM has four primary functions:

- Provides Reference Voltage (V_{REF})
- Conditions input signals
- Processes and stores control strategies
- Controls actuators

1. Reference voltage (V_{REF})

The ECM supplies a 5 volt V_{REF} signal to input sensors in the electronic control system. By comparing the 5 volt V_{REF} signal sent to the sensors with their respective returned signals, the ECM determines pressures, positions, and other variables important to engine and vehicle functions.

The ECM supplies two independent circuits for V_{REF}:

- V_{REF} A supplies 5 volts to engine sensors
- V_{REF} B supplies 5 volts to vehicle sensors

2. 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.

3. Microprocessor

The ECM microprocessor stores operating instructions (control strategies) and value tables (calibration parameters). The ECM compares stored instructions and values with conditioned input values to determine the correct operating strategy for all engine operations.

Continuous calculations in the ECM occur at two different levels or speeds: Foreground and Background.

- Foreground calculations are much faster than background calculations and are normally more critical for engine operation. Engine speed control is an example.
- Background calculations are normally variables that change at a slower rates. Engine temperature is an example.

Diagnostic Trouble Codes (DTCs) are generated by the microprocessor, if inputs or conditions do not comply with expected values.

Diagnostic strategies are also programmed into the ECM. Some strategies monitor inputs continuously and command the necessary outputs to achieve the correct performance of the engine.

Microprocessor memory

The ECM microprocessor includes Read Only Memory (ROM) and Random Access Memory (RAM).

ROM

ROM stores permanent information for calibration tables and operating strategies. Permanently stored information cannot be changed or lost by turning the ignition key OFF or when ECM power is interrupted. ROM includes the following:

- Vehicle configuration, modes of operation, and options
- Engine Family Rating Code (EFRC)
- Engine warning and protection modes

RAM

RAM stores temporary information for current engine conditions. Temporary information in RAM is lost when the ignition key is turned to OFF or when ECM power is interrupted. RAM information includes the following:

- Engine temperature
- Engine rpm
- Accelerator pedal position

4. Actuator control

The ECM controls the actuators by applying a low level signal (low side driver) or a high level signal (high side driver). When switched on, both drivers complete a ground or power circuit to an actuator.

Actuators are controlled in three ways, determined by the kind of actuator.

- A duty cycle (percent time on/off)
- A controlled pulse width
- Switched on or off

ECM Control of Engine Operation

The ECM controls engine operation with the following:

- Variable Geometry Turbocharger (VGT) control module
- EGR control module and control valve
- Diamond Logic® engine brake
- IPR valve
- Inlet Air Heater (IAH) assembly

Variable Geometry Turbocharger (VGT) control module

The VGT control module controls vane position in the turbine housing. Vane position is controlled by a switching voltage source in the ECM. The ground circuit is supplied directly from the battery ground at all times.

The actuator control is set by a pulse width modulated signal in response to engine speed, desired fuel quantity, boost or exhaust back pressure and altitude.

Exhaust Gas Recirculation (EGR) Control Valve

The EGR valve controls the flow of exhaust gases into the inlet and EGR mixer duct.

The EGR drive module controls the EGR actuator.

The EGR drive module receives the desired EGR actuator position from the ECM across the CAN 2 datalink to activate the valve for exhaust gas recirculation. The EGR drive module provides feedback to the ECM on the valve position.

The EGR drive module constantly monitors the EGR actuator. When an EGR control error is detected, the EGR drive module sends a message to the ECM and a DTC is set.

Brake Shut-off Valve

The brake shut-off valve controls pressure in the oil gallery of the high-pressure oil rail. When the engine brake is activated, the ECM provides power to activate the brake shut-off valve to allow oil from the injector oil gallery to flow to the brake oil gallery. High oil pressure activates the brake actuator pistons to open the exhaust valves.

Injection Pressure Regulator (IPR)

The IPR valve controls pressure in the Injection Control Pressure (ICP) system. The IPR valve is a variable position valve controlled by the ECM. This regulated pressure actuates the fuel injectors. The valve position is controlled by switching the ground circuit in the ECM. The voltage source is supplied by the ignition switch.

Inlet Air Heater (IAH)

The IAH system warms the incoming air supply prior to cranking to aid cold engine starting and reduce white smoke during warm-up.

The ECM is programmed to energize the IAH elements through the IAH relays while monitoring certain programmed conditions for engine coolant temperature, engine oil temperature, and atmospheric pressure.

Injection Drive Module (IDM)

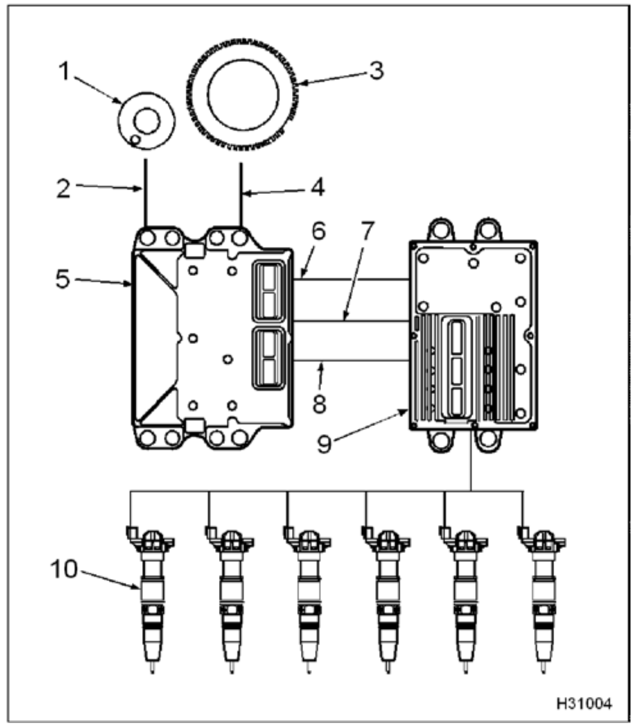


Figure 38 Injection Drive Module (IDM)

1. Camshaft with peg
2. Camshaft Position (CMP) signal
3. Crankshaft position sensor timing disk
4. Crankshaft Position (CKP) signal
5. Electronic Control Module (ECM)
6. Camshaft Position Output (CMPO) signal
7. Crankshaft Position Output (CKPO) signal
8. Controller Area Network (CAN 2) communication
9. Injection Drive Module (IDM)
10. Fuel injectors

The IDM has three functions:

- Electronic distributor for injectors
- Power source for injectors
- IDM and injector diagnostics

Electronic Distributor for Injectors

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

The ECM uses CMP and CKP input signals to calculate engine speed and position. The ECM conditions both input signals and supplies the IDM with CMP and CKP output signals. The IDM uses CMP and CKP output signals to determine the correct sequence for injector firing.

The ECM sends information (fuel volume, EOT, and ICP) through the CAN 2 link to the IDM; the IDM uses this information to calculate the injection cycle.

Injector power source

The IDM creates a constant 48 volt (DC) supply to all injectors by making and breaking a 12 volt source across a coil in the IDM. The 48 volts created by the collapsed field is stored in capacitors until used by the injectors.

The IDM controls when the injector is turned on and how long the injector is active. The IDM first energizes the OPEN coil, then the CLOSE coil. The low side driver supplies a return circuit to the IDM for each injector coil (open and close). The high side driver controls the power supply to the injector. During each injection event, the low and high side drivers are switched on and off for each coil.

IDM and injector diagnostics

The IDM determines if an injector is drawing enough current. The IDM sends a fault to the ECM, indicating potential problems in the wiring harness or injector, and the ECM will set a DTC. The IDM also does self-diagnostic checks and sets a DTC to indicate failure of the IDM.

On demand tests can be done using the Electronic Service Tool (EST). The EST sends a request to the ECM and the ECM sends a request to the IDM to do a test. Some tests generate a DTC when a problem exists. Other tests require the technician to evaluate parameters, if a problem exists.

Engine and Vehicle Sensors

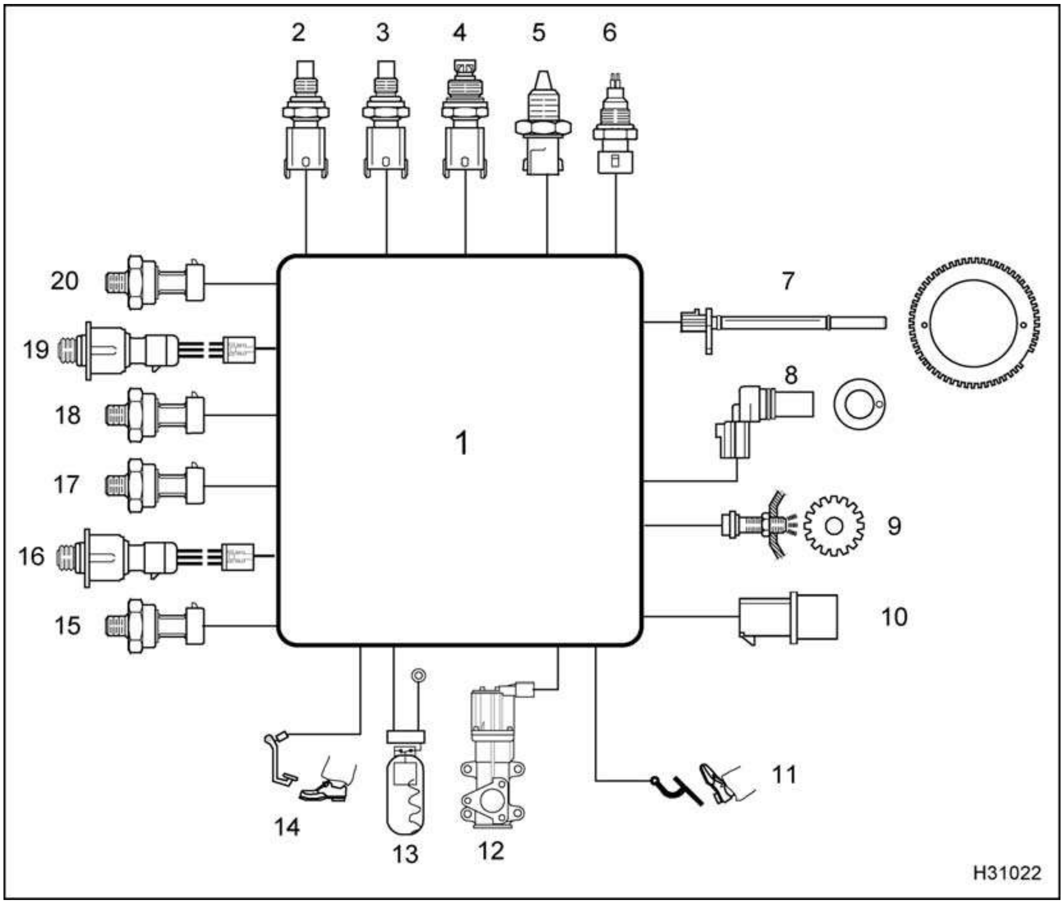


Figure 39 Engine and vehicle sensors

1. Electronic Control Module (ECM)
2. Engine Oil Temperature (EOT)
3. Engine Coolant Temperature (ECT)
4. Manifold Air Temperature (MAT)
5. Intake Air Temperature (IAT)
6. Water In Fuel (WIF) sensor
7. Crankshaft Position (CKP)
8. Camshaft Position (CMP)
9. Vehicle Speed Sensor (VSS)
10. Barometric Absolute Pressure (BAP)
11. Accelerator Position Sensor (APS)
12. Exhaust Gas Recirculation valve Position (EGRP)
13. Engine Coolant Level (ECL)
14. Driveline Disengagement Switch (DDS)
15. Manifold Absolute Pressure (MAP)
16. Brake Control Pressure (BCP)
17. Engine Oil Pressure (EOP)
18. Engine Fuel Pressure (EFP) sensor
19. Injection Control Pressure (ICP)
20. Exhaust Back Pressure (EBP)

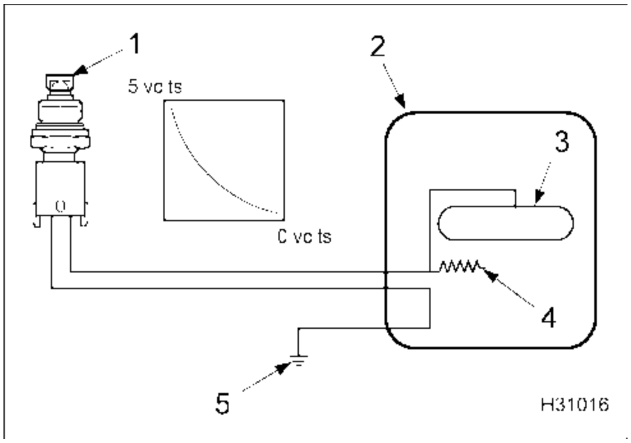


Figure 40 Thermistor

1. Temperature sensor
2. Electronic Control Module (ECM)
3. Microprocessor
4. Voltage Reference (Vref)
5. Ground

Thermistors

- ECT
- EOT
- IAT
- MAT

A thermistor sensor changes its electrical resistance with changes in temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors work with a resistor that limits current in the ECM to form a voltage signal matched with a temperature value.

The top half of the voltage divider is the current limiting resistor inside the ECM. A thermistor sensor has two electrical connectors, signal return and ground. The output of a thermistor sensor is a nonlinear analog signal.

Engine Coolant Temperature (ECT)

The ECM monitors the ECT signal and uses this information for the instrument panel temperature gauge, coolant compensation, Engine Warning Protection System (EWPS), and intake heater operation. The ECT is a backup, if the EOT is out of range. The ECT sensor is installed in the water supply housing (Freon® compressor bracket), left of the flat idler pulley assembly.

Engine Oil Temperature (EOT)

The ECM monitors the EOT signal to control fuel quantity and timing when operating the engine. The EOT signal allows the ECM and IDM to compensate for differences in oil viscosity for temperature changes. This ensures that power and torque are available for all operating conditions. The EOT sensor is installed in the rear of the front cover, outboard of the high-pressure oil pump assembly.

Intake Air Temperature (IAT)

The ECM monitors the IAT signal to control timing and fuel rate during cold starts. The IAT sensor is chassis mounted on the air filter housing.

Manifold Air Temperature (MAT)

The ECM monitors the MAT signal for EGR operation. The MAT sensor is installed right of the MAP sensor in the intake manifold.

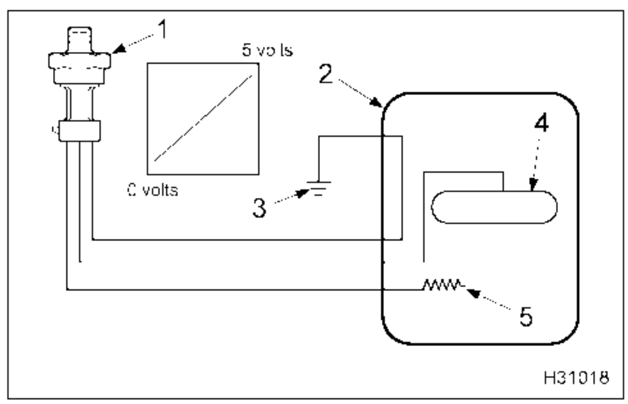


Figure 41 Variable capacitance sensor

1. Pressure sensor
2. Electronic Control Module (ECM)
3. Ground
4. Microprocessor
5. Voltage reference (V_{REF})

Variable Capacitance Sensors

- BAP
- EBP
- EFP

- EOP
- MAP

Variable capacitance sensors measure pressure. The pressure measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

The sensor is connected to the ECM by three wires:

- V_{REF}
- Signal return
- Signal ground

The sensor receives the V_{REF} and returns an analog signal voltage to the ECM. The ECM compares the voltage with pre-programmed values to determine pressure.

The operational range of a variable capacitance sensor is linked to the thickness of the ceramic disk. The thicker the ceramic disk the more pressure the sensor can measure.

Barometric Absolute Pressure (BAP)

The ECM monitors the BAP signal to determine altitude, adjust timing, fuel quantity, and inlet air heater operation. The BAP sensor is located in the cab.

Exhaust Back Pressure (EBP)

The EBP sensor measures exhaust back pressure so that the ECM can control the VGT and EGR systems. The sensor provides feedback to the ECM for closed loop control of the Variable Geometry Turbocharger (VGT). The EBP sensor is installed in a bracket mounted on the water supply housing (Freon® compressor bracket).

Engine Fuel Pressure (EFP)

The ECM uses the EFP sensor signal to monitor engine fuel pressure and give an indication when the fuel filter needs to be changed. The EFP sensor is installed in the rear of the fuel filter assembly (crankcase side).

Engine Oil Pressure (EOP)

The ECM monitors the EOP signal, and uses this information for the instrument panel pressure gauge and EWPS. The EOP sensor is installed in the left side of the crankcase below and left of the fuel filter housing.

Manifold Absolute Pressure (MAP)

The ECM monitors the MAP signal to determine intake manifold pressure (boost). This information is used to control fuel rate and injection timing. The MAP sensor is installed left of the MAT sensor in the intake manifold.

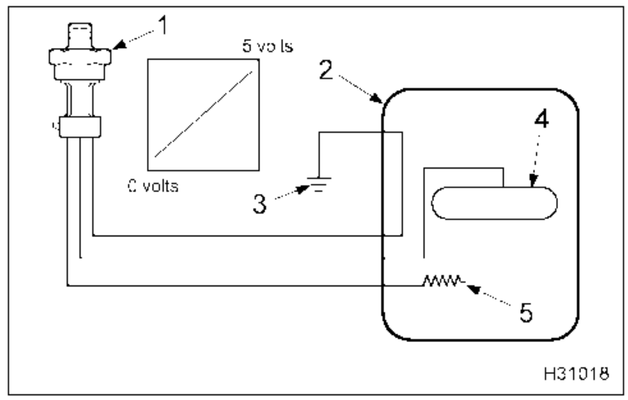


Figure 42 Micro Strain Gauge sensor

1. Pressure sensor
2. Electronic Control Module (ECM)
3. Ground
4. Microprocessor
5. Voltage reference (V_{REF})

Micro Strain Gauge (MSG) Sensors

- BCP
- ICP

A Micro Strain Gauge (MSG) sensor measures pressure. 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.

The sensor is connected to the ECM by three wires:

- V_{REF}
- Signal return
- Signal ground

The sensor receives the V_{REF} and returns an analog signal voltage to the ECM. The ECM compares the voltage with pre-programmed values to determine pressure.

Brake Control Pressure (BCP)

The ECM monitors the BCP signal to determine the oil pressure in the brake gallery of the high-pressure oil rail. The BCP sensor is under the valve cover, forward of the No. 2 fuel injector in the high-pressure oil rail.

Injection Control Pressure (ICP)

The ECM monitors the ICP signal to determine the injection control pressure for engine operation. The ICP signal is used to control the IPR valve. The ICP sensor provides feedback to the ECM for Closed Loop ICP control. The ICP sensor is under the valve cover, forward of the No. 6 fuel injector in the high-pressure oil rail.

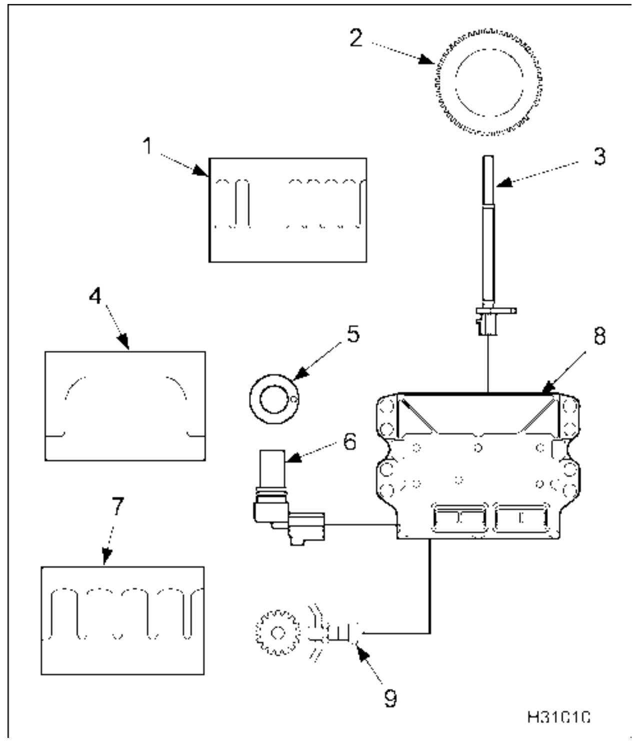


Figure 43 Magnetic pickups

1. Crankshaft Position (CKP) signal
2. Crankshaft position sensor timing disk
3. Crankshaft Position (CKP) sensor
4. Camshaft position (CMP) signal
5. Camshaft with peg
6. Camshaft position (CMP) sensor
7. Vehicle speed signal
8. Electronic Control Module (ECM)
9. Vehicle Speed Sensor (VSS)

Magnetic pickup sensors

- CKP
- CMP
- VSS

A magnetic pickup sensor generates an alternating frequency that indicates speed. Magnetic pickups have a two wire connection for signal and ground. This sensor has a permanent magnetic core surrounded by a wire coil. The signal frequency is generated by the rotation of gear teeth that disturb the magnetic field.

Crankshaft Position (CKP) sensor

The CKP sensor provides the ECM with a signal that indicates crankshaft speed and position. As the crankshaft turns the CKP sensor detects a 60 tooth timing disk on the crankshaft. Teeth 59 and 60 are missing. By comparing the CKP signal with the CMP signal, the ECM calculates engine rpm and timing requirements. The CKP is installed in the top left side 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.

Camshaft Position (CMP)

The CMP sensor provides the ECM with a signal that indicates camshaft position. As the cam rotates, the sensor identifies the position of the cam by locating a peg on the cam. The CMP 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.

Vehicle Speed Sensor (VSS)

The VSS provides the ECM with transmission tail shaft speed by sensing the rotation of a 16 tooth gear on the rear of the transmission. The detected sine wave signal (AC), received by the ECM, is used with tire size and axle ratio to calculate vehicle speed. The VSS is on left side of the transmission.

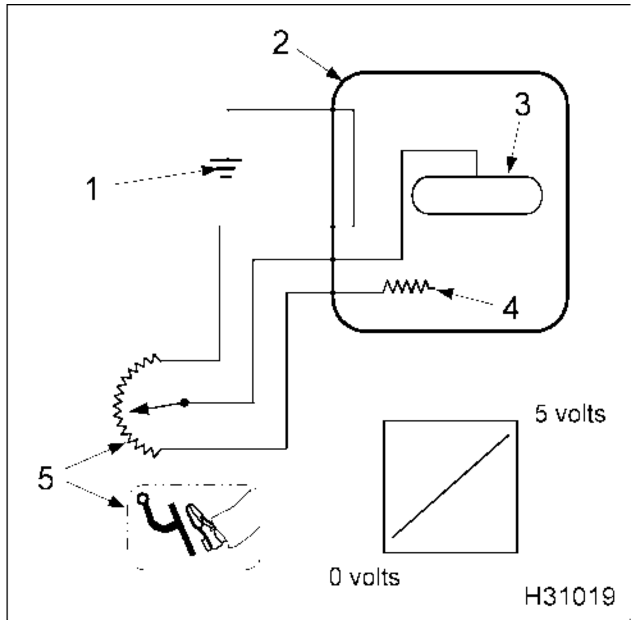


Figure 44 Potentiometer

1. Ground
2. Electronic Control Module (ECM)
3. Microprocessor
4. Voltage reference (V_{REF})
5. Accelerator Position Sensor (APS)

Potentiometers

- APS

A potentiometer is a variable voltage divider that senses the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical rotary or linear motion moves the wiper along the resistance material, changing voltage at each point along the resistive material. Voltage is proportional to the amount of mechanical movement.

Accelerator Position Sensor (APS)

The APS provides the ECM with a feedback signal (linear analog voltage) that indicates the operator’s demand for power. The APS is mounted in the accelerator pedal. A remote accelerator or throttle device can be used in addition to the accelerator pedal.

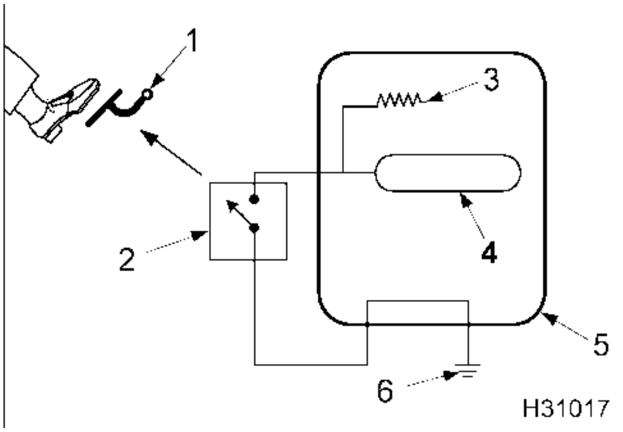


Figure 45 Switch

1. Accelerator pedal
2. Idle Validation Switch (IVS)
3. Voltage source with current limiting resistor
4. Microprocessor
5. ECM
6. Ground

Switches

- DDS
- ECL
- IVS
- WIF

Switch sensors indicate position. They operate open or closed, allowing or preventing the flow of current. A switch sensor can be a voltage input switch or a grounding switch. A voltage input switch supplies the ECM with a voltage when it is closed. A grounding switch grounds the circuit when closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

Driveline Disengagement Switch (DDS)

The DDS determines if a vehicle is in gear. For manual transmissions, the clutch switch serves as the DDS. For automatic transmissions, the neutral indicator switch functions as the DDS.

Engine Coolant Level (ECL)

ECL is part of the Engine Warning Protection System (EWPS). The ECL switch is used in plastic deaeration tank. When a magnetic switch is open, the tank is full.

If engine coolant is low, the red ENGINE lamp on the instrument panel is illuminated.

Idle Validation Switch (IVS)

The IVS is a redundant switch that provides the ECM with a signal that verifies when the APS is in the idle position.

Water In Fuel (WIF)

A Water In Fuel (WIF) sensor detects water in the fuel. When enough water accumulates at the bottom of the housing, the WIF sensor sends a signal to the Electronic Control Module (ECM); the ECM sets a Diagnostic Trouble Code (DTC) and illuminates the amber WATER IN FUEL lamp on the instrument panel. The WIF is installed in the base of the fuel filter housing.

Diamond Logic® Engine Brake System

The Diamond Logic® engine brake system is available for all engine displacements.

Engine Brake Components

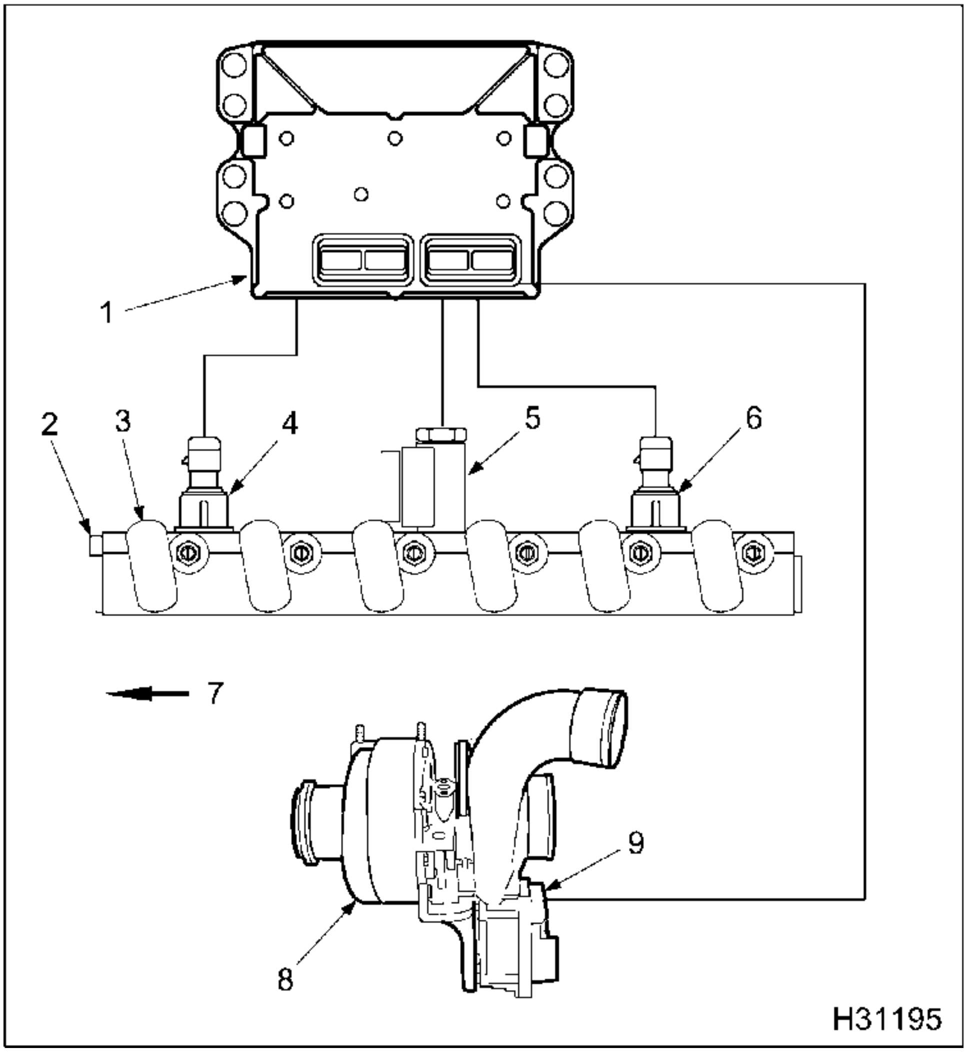


Figure 46 Diamond Logic® engine brake – system

1. ECM
2. Brake pressure relief valve
3. High-pressure oil rail
4. Brake Control Pressure (BCP) sensor
5. Brake shutoff valve assembly
6. Injection Control Pressure (ICP) sensor
7. Front of engine
8. Variable Geometry Turbocharger (VGT)
9. Turbocharger control module

The Diamond Logic® engine brake, a compression release brake system, provides the following:

- Significant noise reduction
- Improved engine braking
- High durability
- Compatibility with cruise control system
- Lower operating cost and longer service life for brake shoes

The Diamond Logic® engine brake is available for all engine displacements. The operator can select one of three brake settings, depending on terrain and driving conditions. See vehicle *Operator's Manual* for complete operating instructions.

Engine Brake Concept

The engine brake system retards vehicle speed during deceleration or braking. During deceleration and braking, the vehicle wheels drive the engine; the engine acts as an energy absorber.

Engine Brake Operation

To absorb energy, the Diamond Logic® engine brake combines bleeding off compressed intake air, VGT controlling exhaust back pressure, and vehicle driven piston movement.

- Energy is absorbed during the compression stroke, when intake air is compressed and forced through a slightly open exhaust valve, providing compressed air flow to the VGT.
- VGT turbine vanes create the desired energy absorbing, back pressure and intake boost.
- At the top of the compression stroke energy dissipates, pressure to force the piston down is eliminated, and energy is absorbed by the vehicle drive pulling the piston down.

Engine Brake Control

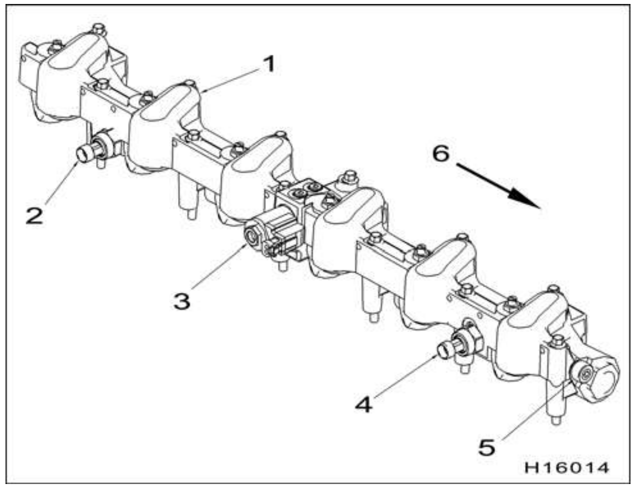


Figure 47 High-pressure oil rail

1. High-pressure oil rail
2. ICP sensor
3. Brake shutoff valve assembly
4. BCP sensor
5. Brake pressure relief valve
6. Front of engine

The high-pressure oil rail uses high-pressure oil from the injection control pressure system to open exhaust valves.

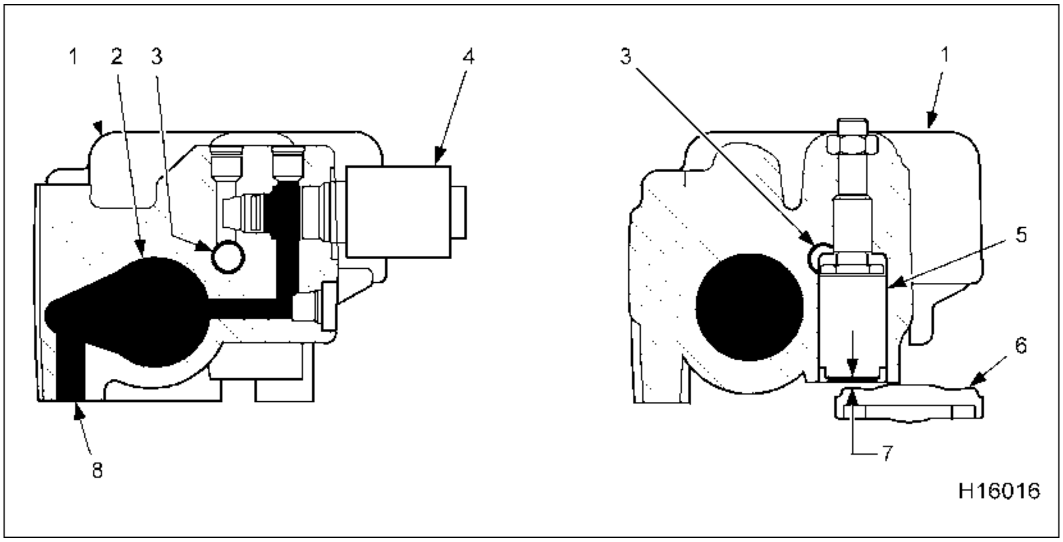


Figure 48 Brake shutoff valve and brake actuator– OFF

1. High-pressure oil rail
2. Injector oil gallery
3. Brake oil gallery
4. Brake shutoff valve assembly
5. Brake actuator piston assembly
6. Exhaust valve bridge
7. Valve lash (actuator retracted)
8. Oil inlet

During normal engine operation, oil in the high-pressure rail goes to the fuel injectors only. A brake shutoff valve, mounted in the high-pressure oil rail, is closed to prevent oil from entering the brake gallery.

Operation of Diamond Logic® Engine Brake in Braking Mode

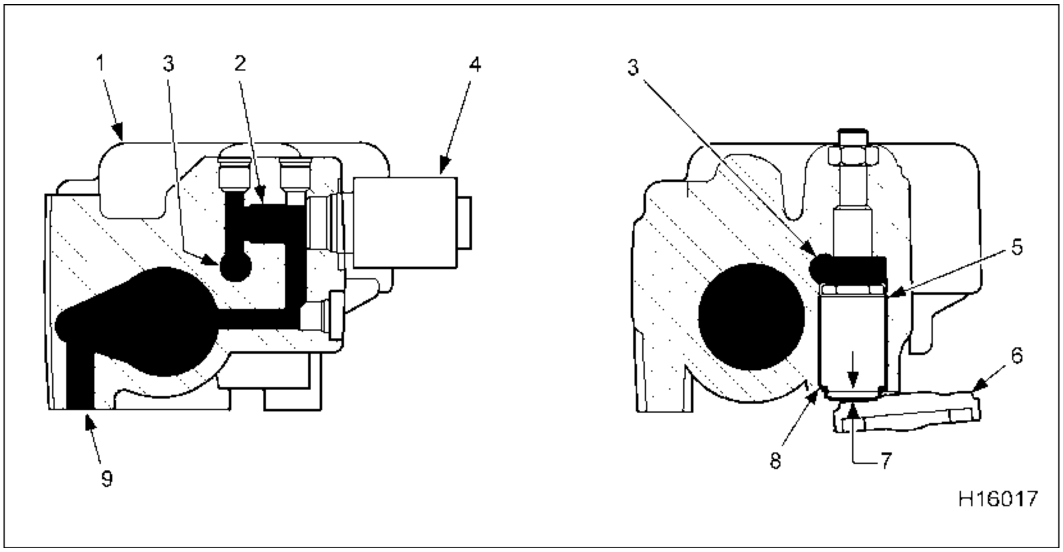


Figure 49 Brake shutoff valve and brake actuator– ON

1. High-pressure oil rail
2. High-pressure oil flow to brake oil gallery
3. Brake oil gallery
4. Brake shutoff valve assembly
5. Brake actuator piston assembly
6. Exhaust valve bridge
7. Valve lash (actuator deployed)
8. Normal oil seepage
9. Oil inlet

The ECM monitors the following criteria to make sure certain conditions are met.

- ABS (inactive)
- RPM (greater than 1200)
- APS (less than 5%)
- Idle validation
- EOT (greater than or equal to 60 °C [140 °C])
- Operator input switches (On/Off) (power selection – Low, Med, High)

If On is selected, and the above criteria is met, the engine brake will activate.

When the engine brake is activated, the ECM provides the power to activate the brake shutoff valve to allow oil from the injector oil gallery to flow to the brake oil gallery. High oil pressure activates the brake actuator pistons to open the exhaust valves.

During an ABS event, the engine brake is deactivated. The engine brake is activated once the ABS event is over.

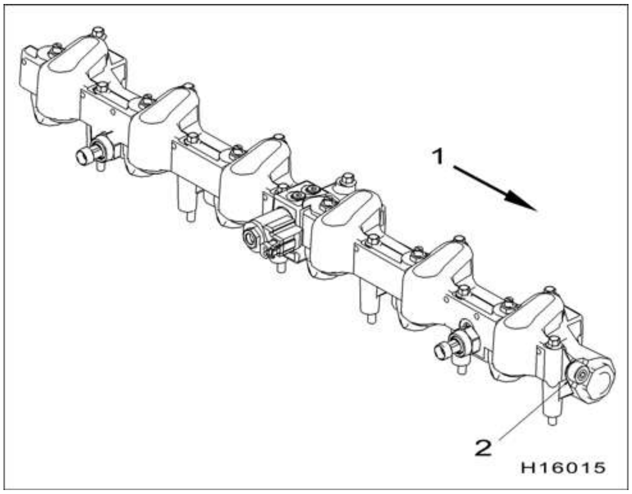


Figure 50 Brake pressure relief valve in high-pressure oil rail

1. Front of engine
2. Brake pressure relief valve

The ECM removes the ground source from the brake shutoff valve to deactivate the engine brake. Residual brake gallery pressure initially bleeds from the actuator bore. When brake gallery pressure reaches 1000 psi, the brake pressure relief valve opens, and oil drains back to sump.

Table of Contents

Engine Preparation

Cleaning the Engine

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 ground (-) cable from battery before doing service or diagnostic procedures.

WARNING: To prevent personal injury or death, allow engine to cool before working with 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.

1. Cap all openings to prevent water and degreased agents from entering any engine components internally.
2. Cover any exposed electrical pin connectors and ECM, IDM, and EGR modules using plastic and duct tape.
3. Use an appropriate detergent mixed in the correct ratio of water and apply to engine using a hot water pressure washer or similar cleaning equipment.

Draining Engine Fluids

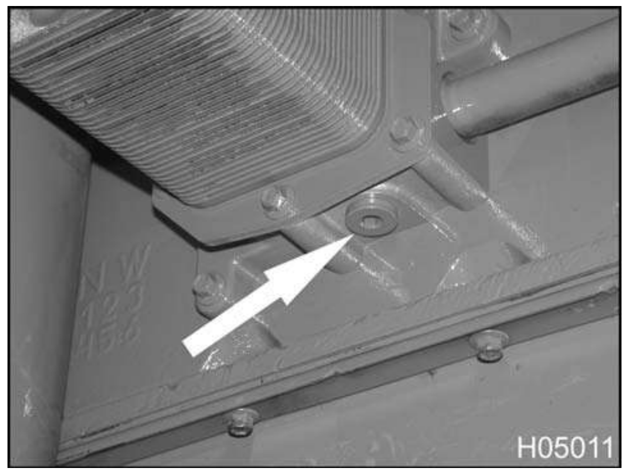


Figure 51 Coolant drain plug location

1. Place a coolant drain pan beneath the coolant drain plug. Remove coolant drain plug (M18) and O-ring from the bottom of the oil system module. Discard O-ring. Open radiator cap to allow system to drain quicker.
2. After draining coolant, install new O-ring on plug and install in module. Torque plug to the standard torque value (General Torque Guidelines, page 445). Dispose of used coolant according to applicable laws

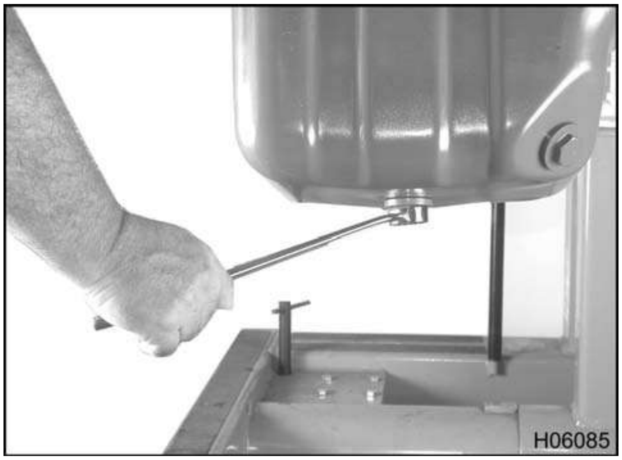


Figure 52 Draining the oil

3. Place a oil drain pan beneath the oil drain plug to collect the oil.
4. Remove oil pan drain plug (M25) and O-ring. Drain engine oil and dispose of used engine oil according to applicable laws.
5. Discard O-ring, inspect drain plug and replace if necessary. Place a new O-ring onto drain plug and install to oil pan. See special torque value (Table 3).

Component Removal

Turbocharger Oil Inlet Tube

1. Loosen turbocharger oil inlet tube assembly nut from fitting on top of oil filter header.
2. Remove two mounting bolts (M8 x 20) securing the turbocharger and oil inlet tube assembly to the top of the turbocharger central housing. Remove turbocharger oil inlet tube assembly. Discard flange O-ring.
3. Remove turbocharger oil drain tube bracket and bolt (M8 x 16) at crankcase.

Turbocharger

WARNING: To prevent personal injury or death, inspect turbocharger with engine off, and turbocharger not spinning. Turbocharger components may be extremely hot. Turbocharger wheels are very sharp and spin at high speeds.

WARNING: To prevent personal injury or death, support turbocharger assembly during removal and installation.

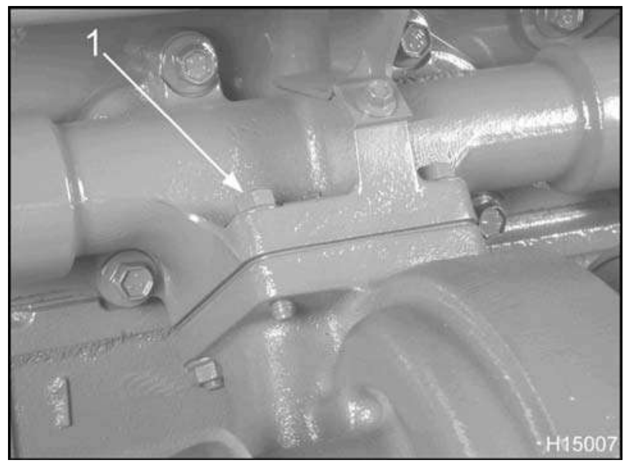


Figure 53 Turbocharger mounting nuts

1. Nut, M10 (4)

NOTE: To aid in the disassembly of the turbocharger, loosen four nuts (M10) between 1/8 and 1/4 of a turn then tap each nut using a socket or flat punch and hammer. This will knock the “peaks” of the stud threads off the “ramps” of the special Spiralock® nuts, thus allowing the nuts to unthread with considerable ease.

NOTE: Remove turbocharger and oil drain tube as an assembly. The oil drain tube is trapped between the turbocharger and crankcase.

1. Remove four nuts (M10 flange head) securing turbocharger assembly to exhaust manifold flange.

2. Remove turbocharger assembly, oil drain tube, and turbo mounting O-ring from engine. Discard oil drain tube O-rings.
3. Cap all openings on turbocharger assembly.

NOTE: If plastic caps are not available, use duct tape to cover openings.

Oil Filter

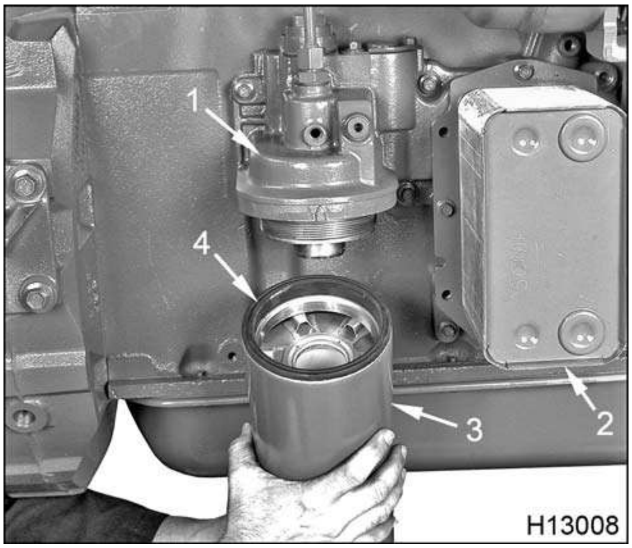


Figure 54 Removing the oil filter

1. Oil filter header
2. Oil cooler
3. Oil filter (spin-on)
4. Oil filter gasket

Remove oil filter from oil cooler filter header. Discard oil filter.

Oil System Module

1. Remove one bolt (M8 x 16) securing oil cooling drain tube assembly to crankcase.
2. Remove eight bolts (M8 x 30) securing oil system module to crankcase.
3. Remove oil system module and oil cooler drain tube as an assembly from crankcase and discard O-rings. The oil cooler drain tube is trapped between the oil system module and the front cover.

Mounting Adapter Plate and Engine

Adapter Plate

WARNING: To prevent personal injury or death, use a chain hoist rated for the weight of the engine, follow manufacturer's installation and safety instructions, and attach safety latch lifting hooks to lifting eyes on the engine.

WARNING: To prevent serious personal injury, possible death or damage to the engine or vehicle, use only metric grade 10.9 or SAE grade 8 bolts when mounting adapter plate to engine as well as the engine stand. See instructional literature included with adapter plate for specific directions of its safe use.

1. Match Engine Mounting Plate (Table 4) with bolt holes on right side of engine to determine adapter plate orientation to the Engine Stand (Table 4).

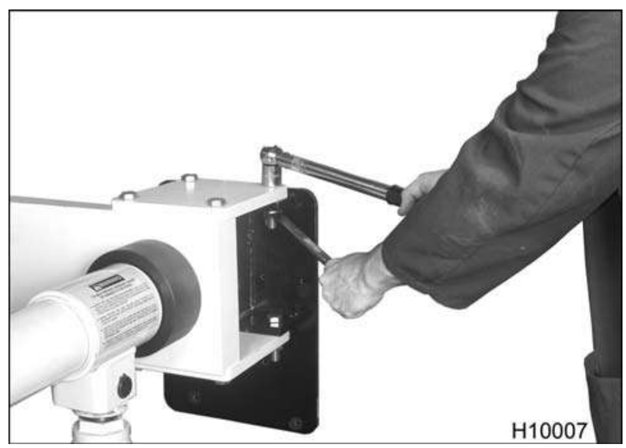


Figure 55 Installing the adapter plate to engine stand

2. Install recommended Engine Mounting Plate (Table 4) to engine stand and secure by using eight (grade 8) bolts and nuts. Tighten bolts to the standard torque value (General Torque Guidelines, page445).

Engine

1. Remove oil system module and oil cooler drain tube as an assembly from crankcase and discard O-rings. The oil cooler drain tube is trapped between the oil system module and the front cover.
2. Raise or lower engine to approximate height of Engine Stand (Table 4).
3. Align engine stand and Engine Mounting Plate (Table 4) to engine, rotating stand and / or raising engine to match adapter plate. Secure one bolt and rotate stand if necessary to thread remaining bolts.
4. Use metric grade 10.9 bolts to secure engine to Engine Mounting Plate (Table 4). Tighten bolts to the standard torque value (General Torque Guidelines, page445).

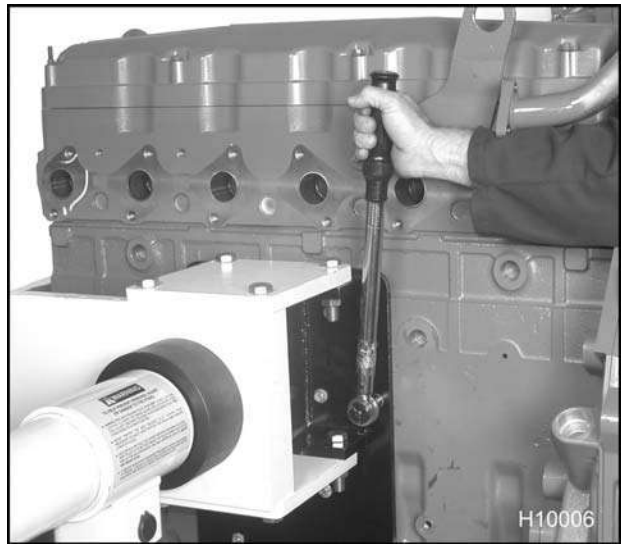


Figure 56 Torquing engine mounting bolts

5. Slowly release tension from engine hoist.
6. remove hoist safety chain hooks from engine lifting eyes.

Special Torque

Table 3 Engine Mounting Special Torques

Oil pan drain plug (M25)	68 N·m (50 lbf·ft)

Special Service Tools

Table 4 Special Tools

Engine Mounting Plate	ZTSE4649
Engine Stand	OTC1750A

Table of Contents

Description

For the procedures in this manual, the term Variable Geometry Turbocharger (VGT) will be used. See (Variable Geometry Turbocharger (VGT), page 21) for complete description of the EVRT® electronically controlled turbocharger.

This "EVRT® Electronically Controlled Turbocharger" section is for basic removal, exterior inspection and cleaning, and installation of the complete VGT assembly. See additional specific procedures in Appendix E for the following VGT components: turbocharger actuator, turbocharger actuator linkage, turbocharger actuator flange and pivot shaft, and turbine vane assembly

Instruction Sheets in Appendix E

- Installation of Turbocharger Actuator (1171855R1 Turbo Actuator Service Kit (SRA), page 497). This service kit provides instructions for replacement of the turbocharger actuator without removal of the turbocharger from the engine.
- Installation of Turbocharger Actuator Linkage (1171908R1 Turbocharger VGT Linkage Kit, page 499). This service kit provides instructions for replacement of the turbocharger actuator linkage without removal of the turbocharger from the engine.
- Installation of Turbocharger Actuator Flange and Pivot Shaft (1171915R2 Turbocharger Actuator Flange and Pivot Shaft Kit, page 508). This service kit provides instructions for replacement of internal turbocharger actuator flange and pivot shaft. These procedures require removal of the turbocharger from the engine.
- Cleaning Turbine Vane Assembly (1171913R1 Turbine Vane Assembly Cleaning Kit, page 503). This service kit provides instructions for cleaning the turbine vane area inside the housing when vanes become stuck due to excessive oil deposits. These procedures require removal of the turbocharger from the engine.

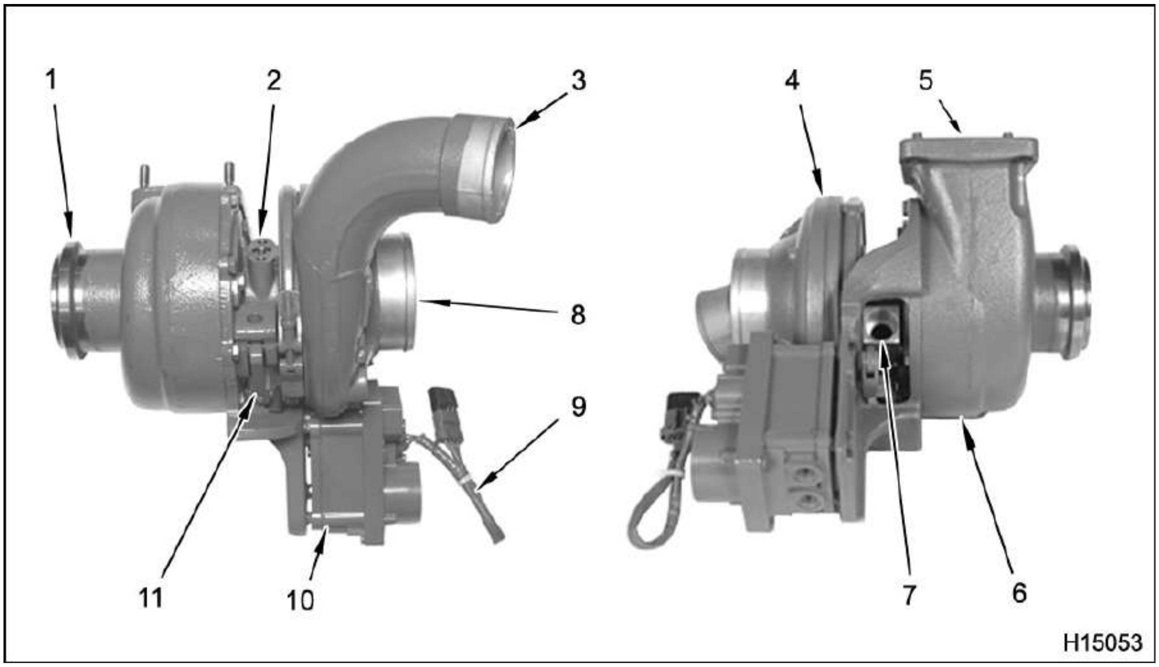


Figure 57 Variable Geometry Turbocharger (VGT) components

1. Turbine outlet
2. Oil supply port
3. Compressor outlet
4. Compressor housing
5. Turbine inlet
6. Turbine housing
7. Oil drain port
8. Compressor inlet
9. Electrical connector and wire
10. Turbocharger control module
11. VGT linkage

Removal

Variable Geometry Turbocharger (VGT) 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, allow engine to cool before working with components.

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, wear safety glasses with side shields. Limit compressed air pressure to 207 kPa (30 psi).

WARNING: To prevent personal injury or death, support turbocharger assembly during removal and installation.

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.

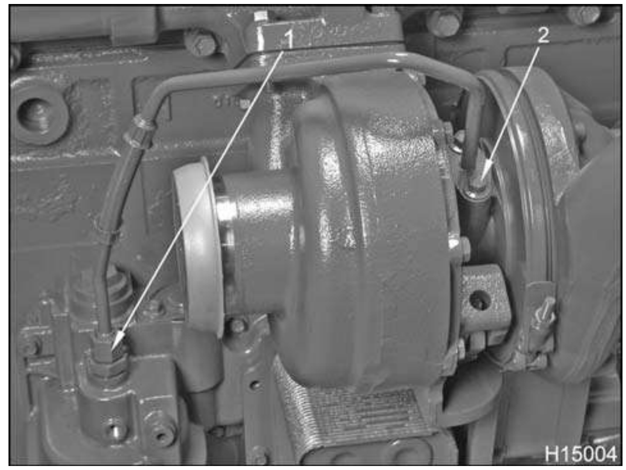


Figure 58 Oil inlet tube assembly

1. Nut
2. Bolt, M8 x 20 (2)

1. Remove turbo oil inlet tube assembly nut from fitting on top of oil filter header.
2. Remove two M8 x 20 bolts from turbo oil inlet tube assembly. Remove tube assembly, and discard O-ring.

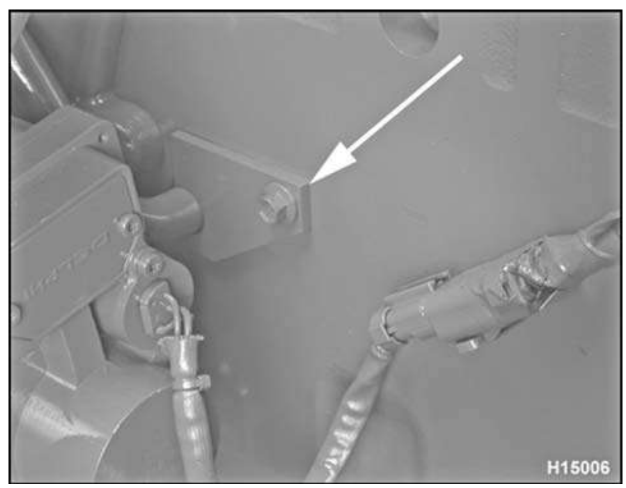


Figure 59 Oil drain tube bracket and bolt

3. Remove the M8 x 16 bolt from the turbo oil drain tube bracket.
4. Disconnect electrical harness from VGT actuator.

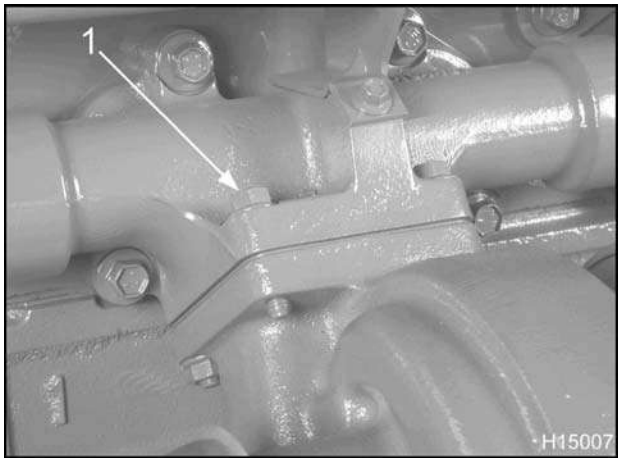


Figure 60 VGT mounting

1. M10 Spiralock® nut (4)

NOTE: To aid removal of the turbocharger, loosen four M10 nuts 1/4 turn then tap each nut using a socket or flat punch and a hammer. This will knock the “peaks” of the threads down, allowing the nuts to unthread easily.

WARNING: To prevent personal injury or death, support turbocharger assembly during removal and installation.

5. Remove three of four M10 Spiralock® nuts holding the VGT assembly to the exhaust manifold.
6. Support the VGT assembly, remove the fourth M10 nut, and remove the VGT assembly and turbocharger oil drain tube as a combined unit.
7. Remove the oil drain tube from VGT assembly and discard the oil drain tube O-rings.
8. Remove and discard the turbocharger mounting gasket.
9. Discard used M10 Spiralock® nuts.

Cleaning

Turbocharger and Related Parts

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

1. Use soap and water to clean piping between VGT and air cleaner assembly. Use filtered compressed air to dry piping.
2. Use filtered compressed air to clean the air inlet piping and connecting hoses.
3. Use a suitable solvent and a nylon brush to clean the oil inlet tube and oil drain tube. Use filtered compressed air to dry the tubes. Replace any damaged tubes.
4. Clean remaining gasket material from mounting surface of the turbine housing and exhaust manifold.

Inspection

Checking Turbine and Compressor

WARNING: To prevent personal injury or death, inspect turbocharger with engine off, and turbocharger not spinning. Turbocharger components may be extremely hot. Turbocharger wheels are very sharp and spin at high speeds.

1. Position VGT on a workbench so that the shaft is horizontal.

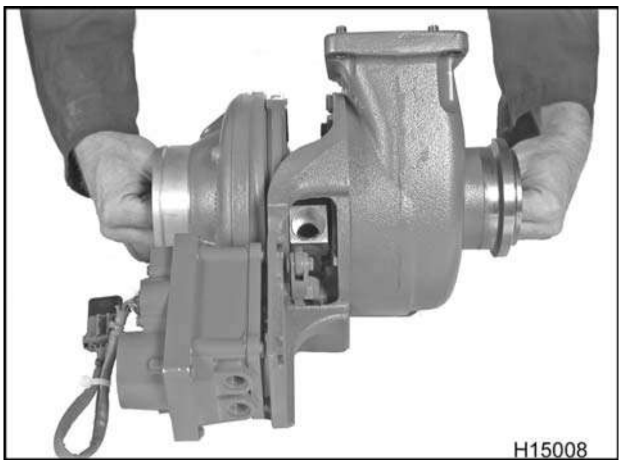


Figure 61 Checking shaft rotation

2. Turn shaft by hand and check for wheel rub within each housing.

   The wheels must rotate freely. If there is any rubbing or interference, replace the VGT assembly.

NOTE: Do not straighten bent blades.

3. Check the compressor impeller and turbine wheel. If there are deposits on the blades or any blades are bent, broken or eroded, replace the VGT assembly.

Checking Rotation of Actuator Shaft

1. Place VGT assembly onto a clean workbench.
2. Position VGT assembly so that actuator linkage can be easily accessed and viewed.
3. Move the actuator shaft through its entire travel. The actuator shaft should rotate 90° and return under spring tension (Table 5).

Installation

Variable Geometry Turbocharger (VGT) Assembly

1. Position VGT on a workbench so the oil supply port faces up.
2. Prelube the VGT assembly by adding oil to the oil supply port while rotating the turbine shaft. Continue to add oil until oil comes out the oil drain port.
3. Place a new turbocharger mounting gasket onto turbocharger flange studs.
4. Place a new O-ring onto each end of the turbocharger oil drain tube and lubricate with clean engine oil.

CAUTION: To prevent serious personal injury, possible death, or damage to the engine or vehicle, exercise special care not to cut or damage oil drain tube O-rings.

5. Install oil drain tube into turbocharger side and then move turbocharger and oil drain tube into cylinder block as a unit.

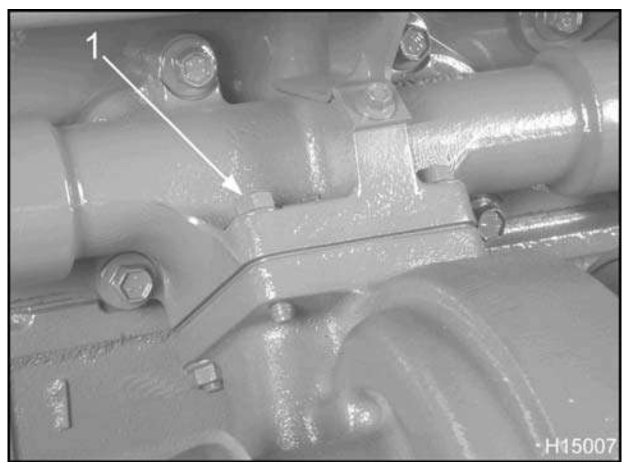


Figure 62 VGT mounting

1. M10 Spiralock® nut (4)

WARNING: To prevent personal injury or death, support turbocharger assembly during removal and installation.

6. Lift VGT assembly onto engine and insert VGT mounting studs into the exhaust manifold flange.

Install two new M10 Spiralock® nuts on the VGT mounting studs.

7. Install two new M10 Spiralock® nuts on the exhaust manifold studs.
8. Verify the oil drain tube is seated in the crankcase oil drain port.
9. Tighten four M10 Spiralock® nuts to the special torque (Table 6).

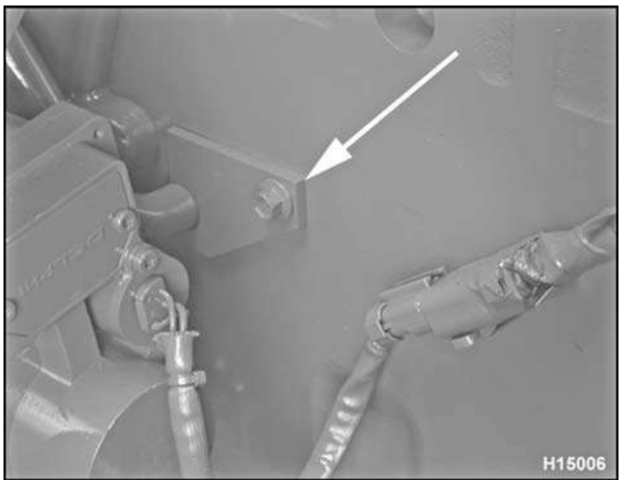


Figure 63 Oil drain tube bracket and bolt

10. Align oil drain tube bracket with bolt (M8 x 16) and hole and tighten bolt to the standard torque value (General Torque Guidelines, page445).
11. Place a new turbo oil inlet O-ring over oil inlet flange located on top of the VGT central housing.

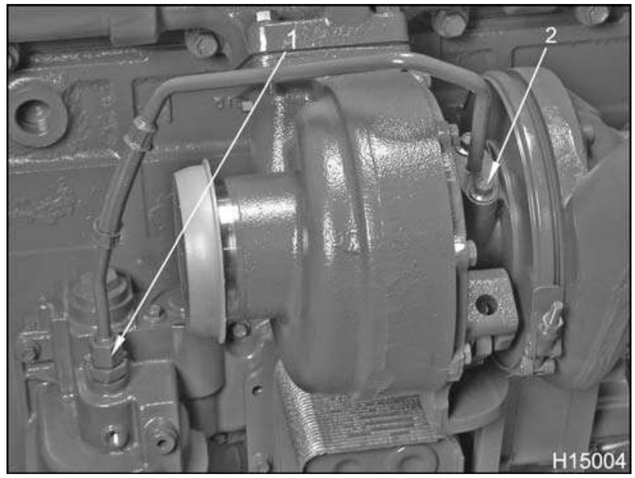


Figure 64 Oil inlet tube assembly

1. Nut
2. Bolt, M8 x 20 (2)

12. Thread two bolts (M8 x 20) through turbo oil inlet tube assembly at the top of the VGT. Do not tighten these bolts yet.
13. Thread oil inlet tube assembly nut onto fitting located on top of oil filter header.
14. Tighten two bolts (M8 x 20) at the top of the oil inlet tube assembly to the standard torque value (General Torque Guidelines, page445).
15. Tighten oil inlet tube assembly nut to the standard torque value (General Torque Guidelines, page 445).
16. Connect electrical harness to VGT actuator.

Specifications

Table 5 VGT Specifications

VGT axial linkage shaft	Must strike open and closed stops in actuator, 90° rotation

Special Torque

Table 6 VGT Special Torques

VGT Spiralock® nuts (M10)	71 N·m (52 lbf·ft)

Table of Contents

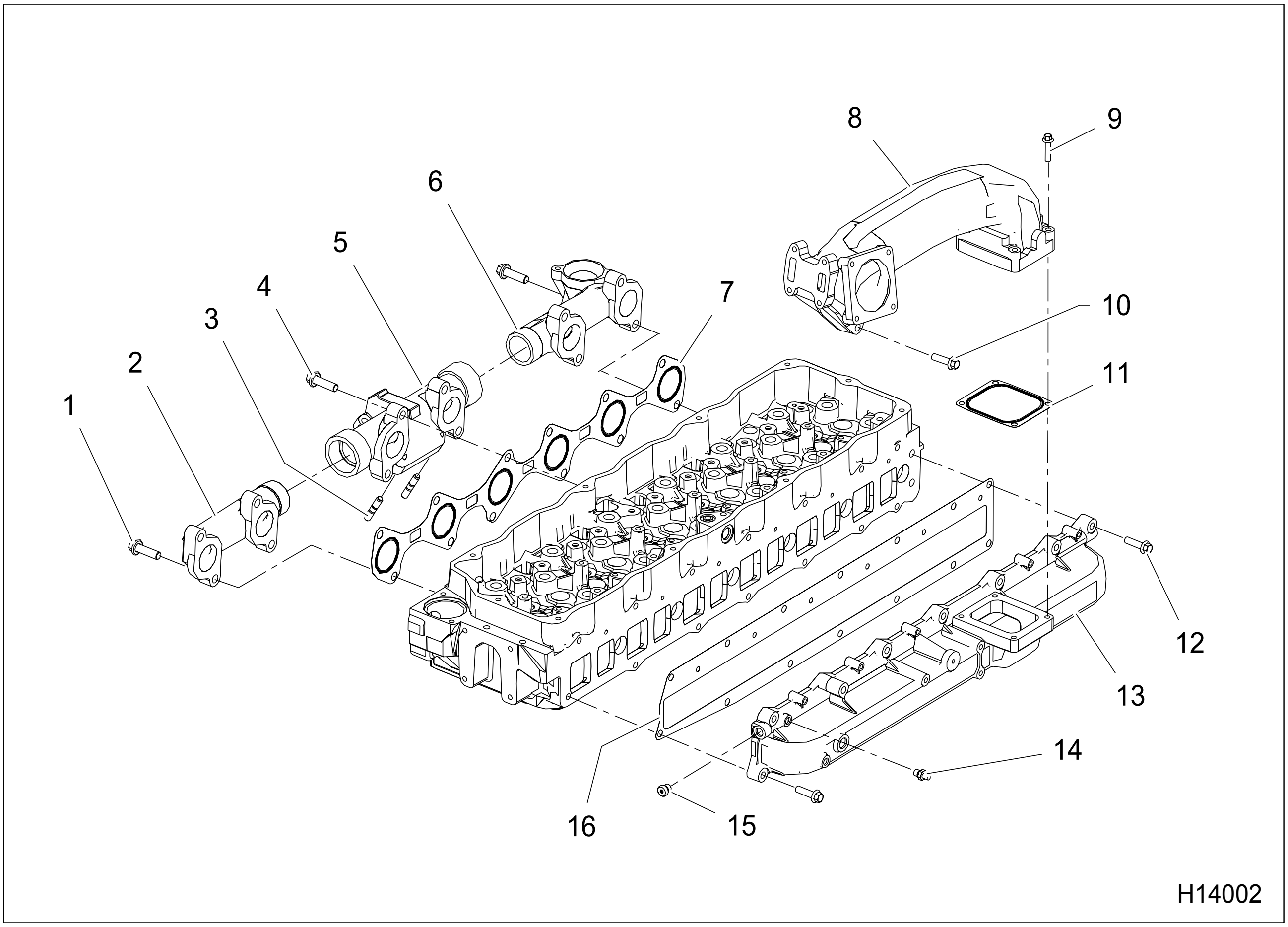


Figure 65 Intake manifold, inlet and EGR mixer, and exhaust manifold assemblies

1. Exhaust manifold flange head bolt, M12 x 35 (11)
2. Manifold, exhaust front
3. Stud, M10 (2)
4. Manifold, exhaust center (low or high mount turbo versions)
5. Exhaust manifold and EGR bracket flange head bolt, M12 x 120 (1)
6. Manifold, exhaust rear (short or long EGR cooler version)
7. Exhaust manifold gasket
8. Inlet and EGR mixer duct
9. EGR mixer flange bolt, M8 x 60 (4)
10. EGR mixer support bolt, M10 x 90
11. Intake manifold to mixer gasket
12. Intake manifold bolt, M10 x 35 (13)
13. Intake manifold
14. Fuel (Schrader) valve
15. Intake manifold plug (2)
16. Intake manifold gasket

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, allow engine to cool before working with 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 smoke and keep fuel away from flames and sparks.

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: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- VGT turbo
- EGR valve
- Fuel filter assembly
- Crankcase breather
- Oil fill tube assembly

Exhaust Manifold

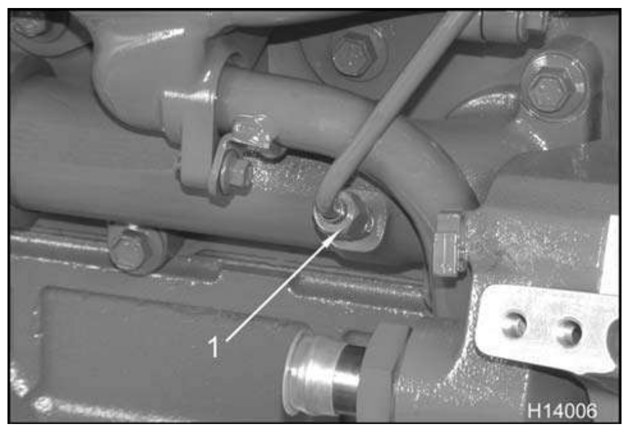


Figure 66 EBP tubing nut

1. EBP tubing nut

1. Disconnect the EBP tubing nut at exhaust manifold.

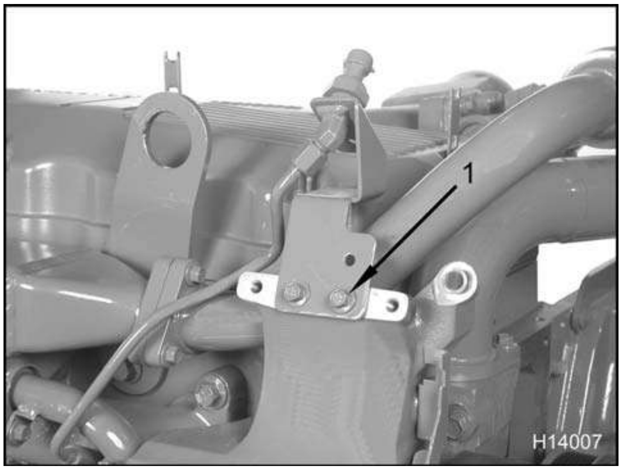


Figure 67 Removing EBP tubing bracket

1. EBP tubing bracket bolt (2)

2. Remove EBP tubing bracket bolts at water housing (Freon® compressor bracket).
3. Lift the EBP tubing and bracket assembly from the engine.

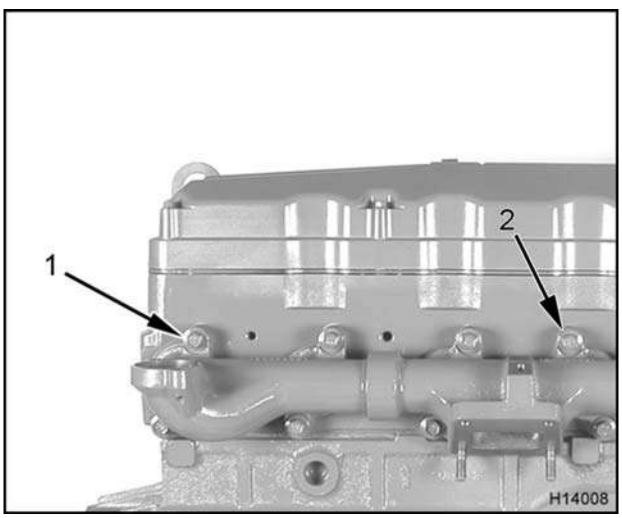


Figure 68 Exhaust manifold mounting bolts

1. Exhaust manifold mounting bolt, M12 x 35 (11)
2. Exhaust manifold mounting bolt, M12 x 120

4. Remove 11 mounting bolts (M12 x 35) and one mounting bolt (M12 x 120) securing the three-piece exhaust manifold to the cylinder head.

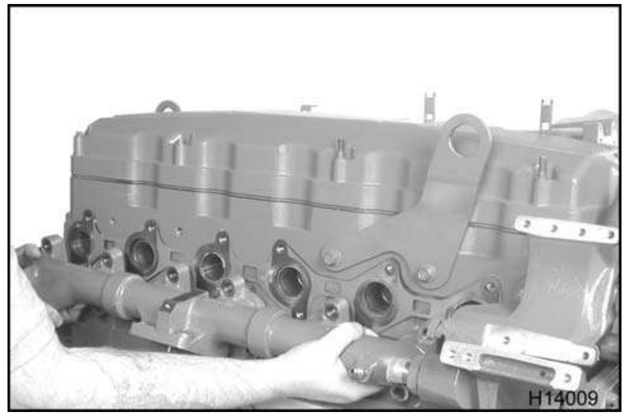


Figure 69 Removing exhaust manifold

5. Remove exhaust manifold from the engine and discard the one piece gasket.

Inlet and EGR Mixer Duct

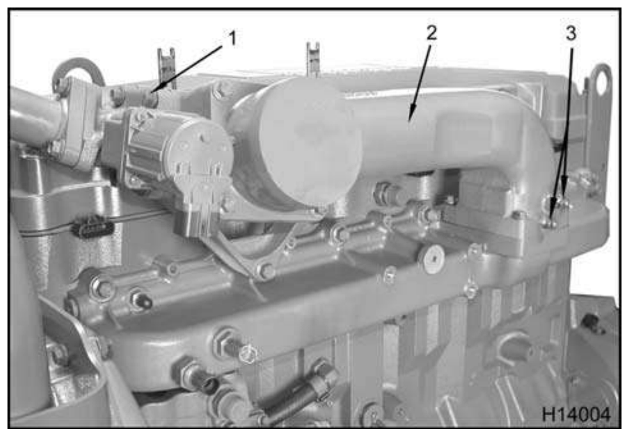


Figure 70 Inlet and EGR mixer duct related components

1. EGR valve mounting bolt (4)
2. Inlet and EGR mixer duct
3. Inlet Air Heater (IAH) connections

1. Remove four EGR valve mounting bolts at the EGR valve to mixer duct connection.
2. Remove EGR valve and discard gasket.

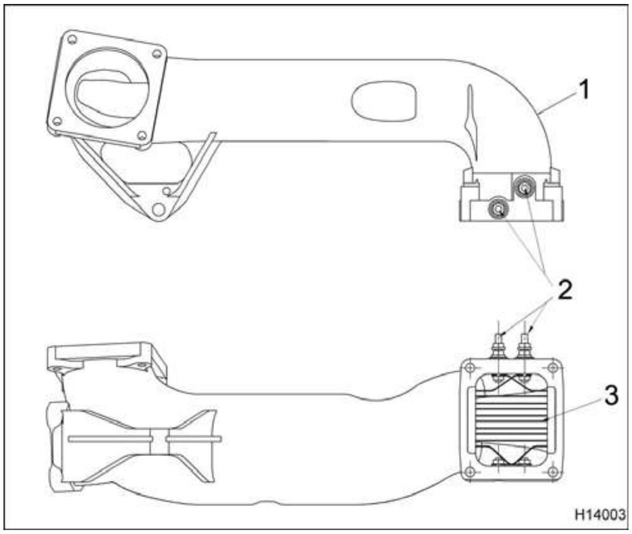


Figure 71 Intake air heater – dual element

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, page466).

3. Disconnect Inlet Air Heater (IAH) cable(s).

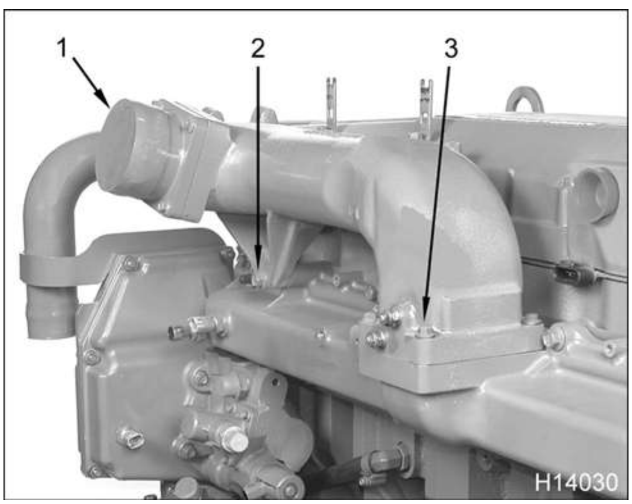


Figure 72 Inlet and EGR mixer duct bolts

1. Inlet adapter
2. Inlet and EGR mixer support bolt, M10 x 90
3. Inlet mixer bolt, M8 x 60 (4)

4. Remove the inlet and EGR mixer duct bolts.

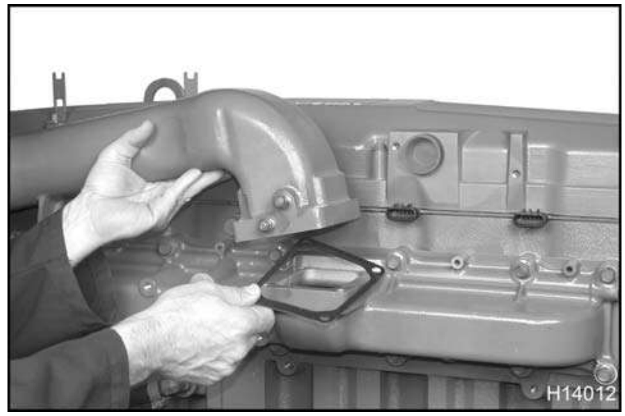


Figure 73 Inlet and EGR mixer duct gasket

5. Lift inlet and EGR mixer duct away from the intake manifold. Remove gasket and discard.

Aluminum Air Inlet Adapter and Inlet Air Heater Option

See (1171846R1 Aluminum Air Inlet Adapter, page 492).

Intake Manifold

1. Disconnect wire from MAP and MAT sensor connectors.
2. Disconnect injector harness anchor points.
3. Pull out wiring harness and connectors.
4. Disconnect the high-pressure oil hose at pump.

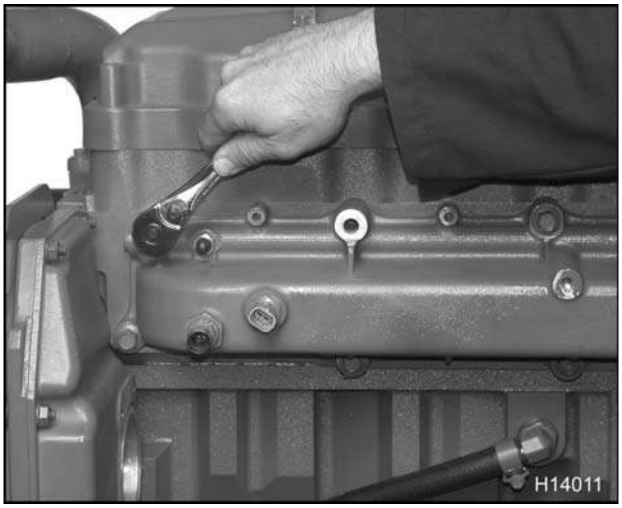


Figure 74 Intake manifold mounting bolts

5. Remove 13 intake manifold mounting bolts (M10 x 35).
6. Remove intake manifold and gasket from the engine. Discard gasket.

Cleaning and Inspection

Exhaust Manifold

1. Clean exhaust manifold thoroughly with a suitable non-caustic solvent. Scrape off excess scale and rust from manifold surfaces.

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

2. After cleaning, blow dry exhaust manifold using filtered compressed air.
3. Inspect manifold for cracks or damage. Replace manifold as necessary.
4. Check for warpage as follows:
   a. Install exhaust manifold without the gasket to a cleaned cylinder head mating surface. Torque 12 mounting bolts (M12 x 35) to the special torque value (Table 8).

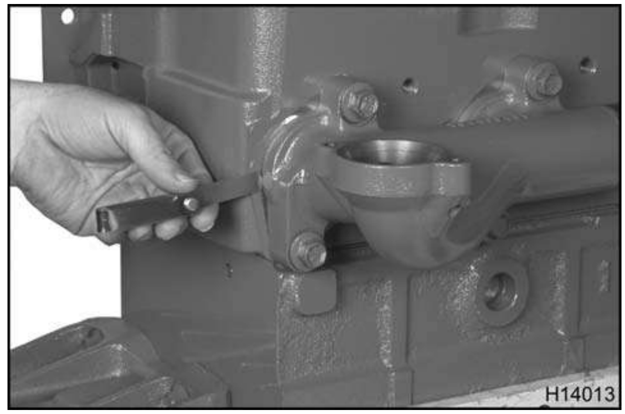


Figure 75 Checking exhaust manifold for cracks and warpage

   b. Use a 0.25 mm (0.010 in) feeler gauge to measure the gap between the mating surfaces of the manifold and engine. If the feeler gauge passes through the gap, the manifold must be resurfaced.

      NOTE: A maximum of 0.64 mm (0.025 in) of material can be ground off to correct warpage.

   c. Remove 12 bolts (M12 x 35) and manifold.
   d. If the warpage cannot be corrected by grinding manifold mating surface, replace manifold.

Intake Manifold

CAUTION: To prevent engine damage, do not attempt to grind or machine the intake manifold to compensate for a warped condition.

1. Clean intake manifold thoroughly with a suitable non-caustic solvent.

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

2. After cleaning, blow dry using filtered compressed air.
3. Check manifold for cracks and damage. Replace intake manifold as necessary.

Installation

Exhaust Manifold

CAUTION: To prevent engine damage, make sure exhaust manifold gasket and exhaust manifold are aligned before tightening bolts to the specified torque value.

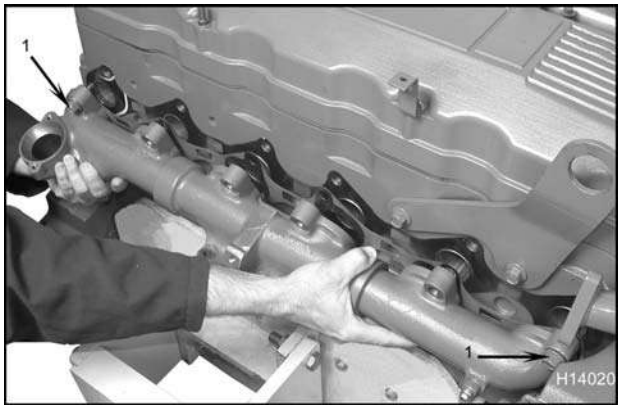


Figure 76 Installing exhaust manifold

1. Bolts installed holding gasket

1. Apply anti-seize compound to all 11 bolt (M12 x 35) threads and one bolt (M12 x 120) used with the EGR cooler bracket.
2. Insert an exhaust manifold bolt (M12 x 35) at each end of the assembled exhaust manifold. Place the exhaust manifold gasket over these two bolts. This will ensure a proper alignment of the exhaust manifold and gasket.

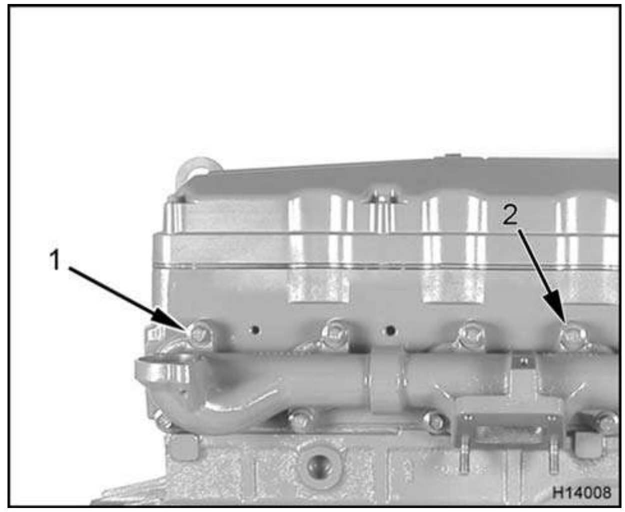


Figure 77 Exhaust manifold mounting bolts

1. Exhaust manifold mounting bolt, M12 x 35 (11)
2. Exhaust manifold mounting bolt, M12 x 120

3. Install assembled exhaust manifold with a new gasket to cylinder head.

NOTE: Refer to the EGR Cooler and Tubing Section for instructions assembling the EGR cooler.

4. Torque the exhaust manifold bolts in the following three step sequence.

Exhaust Manifold Torque Sequence

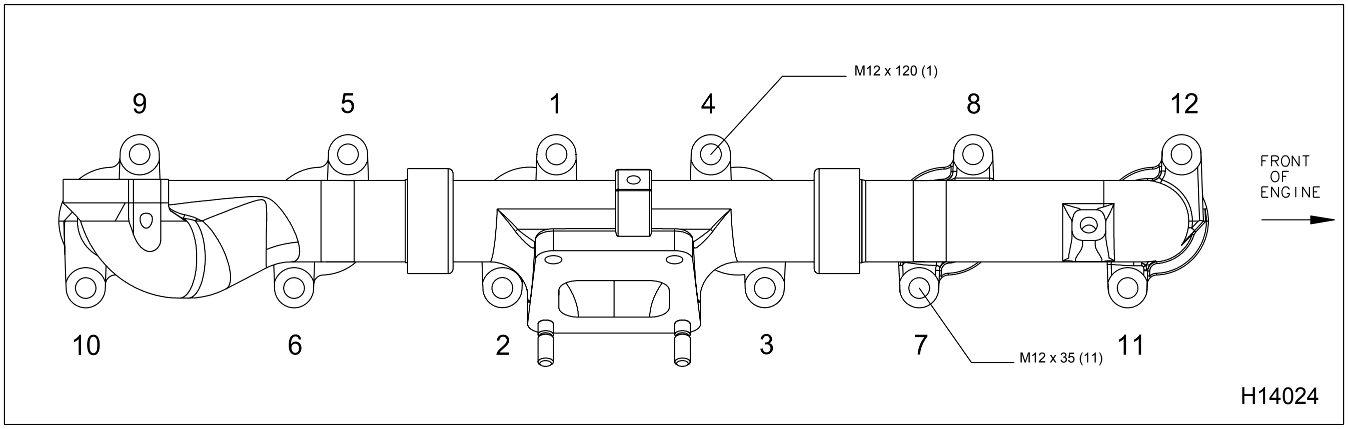


Figure 78 Exhaust manifold torque sequence

a. Torque all bolts in sequence 1 through 12 to 27 N·m (20 lbf·ft).

b. Torque all bolts in sequence 1 through 12 to 54 N·m (40 lbf·ft).

c. Torque all bolts in sequence 1 through 12 to 109 N·m (80 lbf·ft).

CAUTION: To prevent engine damage, make sure that the EGR cooler bracket bolt (M12 x 120) has a final torque value of 116 N·m (85 lbf·ft). This applies only to this bolt (number 4 in the sequence).

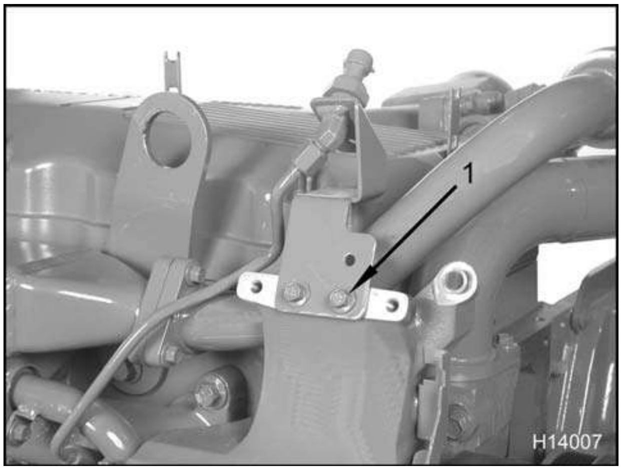


Figure 79 Installing EBP tubing bracket

1. EBP tubing bracket bolts, M8 x 20 (2)

5. Install EBP tubing bracket assembly and bolts onto the water supply housing (Freon® compressor bracket) and finger tighten.

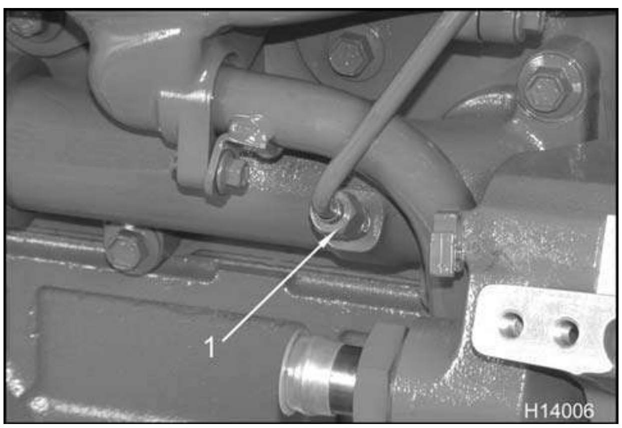


Figure 80 Installing EBP tubing nut

1. EBP tubing nut

6. Torque tubing nut to the standard torque value (General Torque Guidelines, page 445).
7. Torque EBP tubing bracket bolts to the standard torque value (General Torque Guidelines, page 445).
8. Install the EBP sensor connector.

Intake Manifold

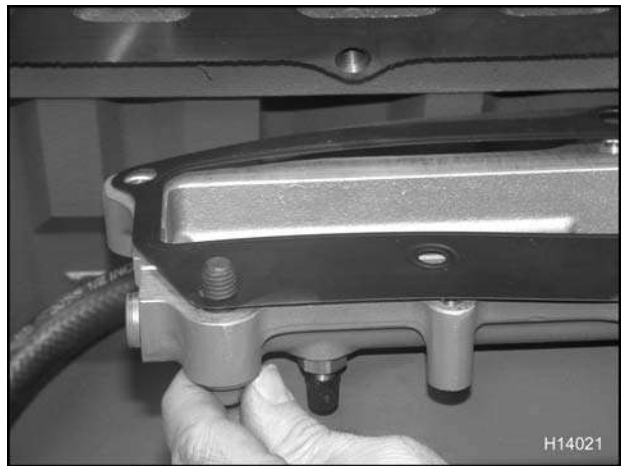


Figure 81 Aligning intake gasket to manifold

1. Insert an intake manifold bolt (M10 x 35) into each end of the intake manifold (both top holes). Place intake manifold gasket over these two bolts to ensure proper alignment between the manifold and gasket.
2. Install the intake manifold and gasket to the cylinder head by starting the two top end bolts by hand.

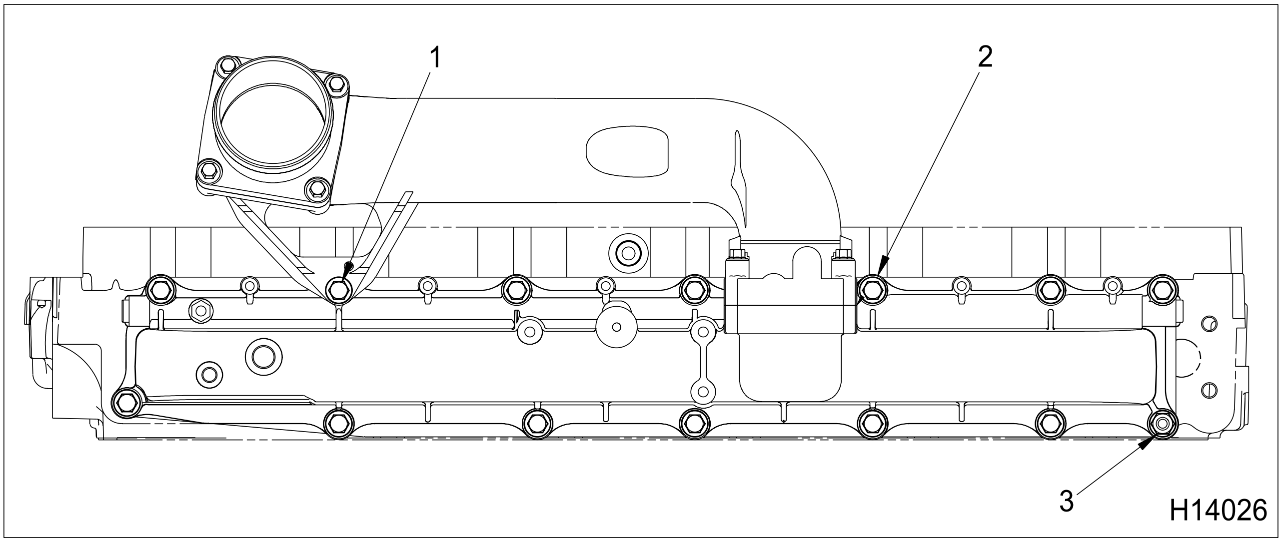


Figure 82 Intake manifold and inlet duct bolt configuration

1. Inlet and EGR mixer support bolt, M10 x 90
2. Bolt, M10 x 35 (12)
3. Bolt / Stud, M10 x 35 / 20

3. Place bolt / stud, (M10 x 35 / 20) into the rear most bolt hole along the bottom finger tight.
4. Install the remaining short intake manifold mounting bolts (M10 x 35) finger tight, in their correct positions. One bolt hole should remain open for later installation of the inlet and EGR mixer support and bolt.
5. Connect injectors and anchor harness.
6. Connect harness to MAP and MAT sensors.

Inlet and EGR Mixer Duct

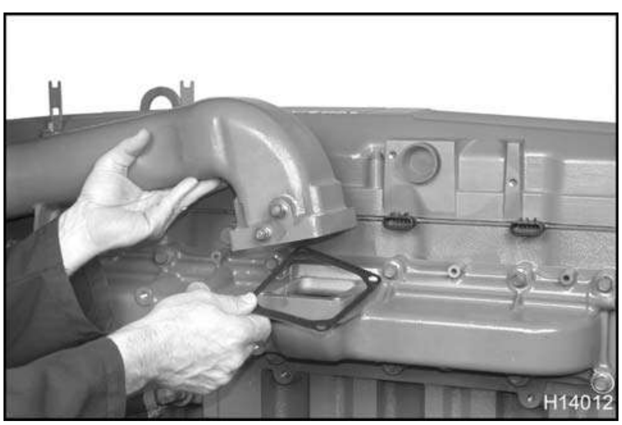


Figure 83 Inlet and EGR mixer gasket

1. Install inlet and EGR mixer with new gasket.

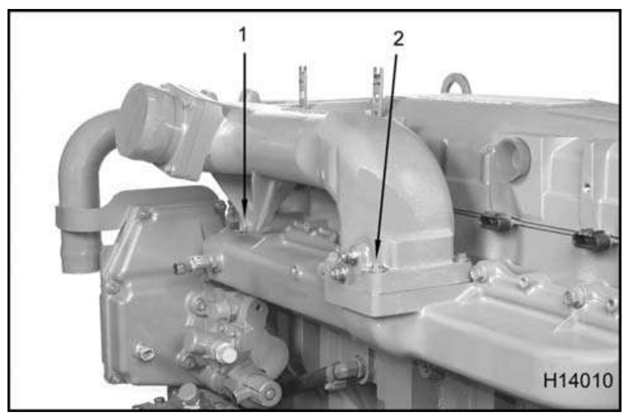


Figure 84 Mounting the inlet and EGR mixer

1. Inlet and EGR mixer support bolt, M10 x 90
2. Inlet mixer bolts, M8 x 60 (4)

2. Install four bolts (M8 x 60) that hold the inlet and EGR mixer to the intake manifold, but do not tighten.
3. Thread the inlet and EGR mixer duct support bolt (M10 x 90) finger tight.

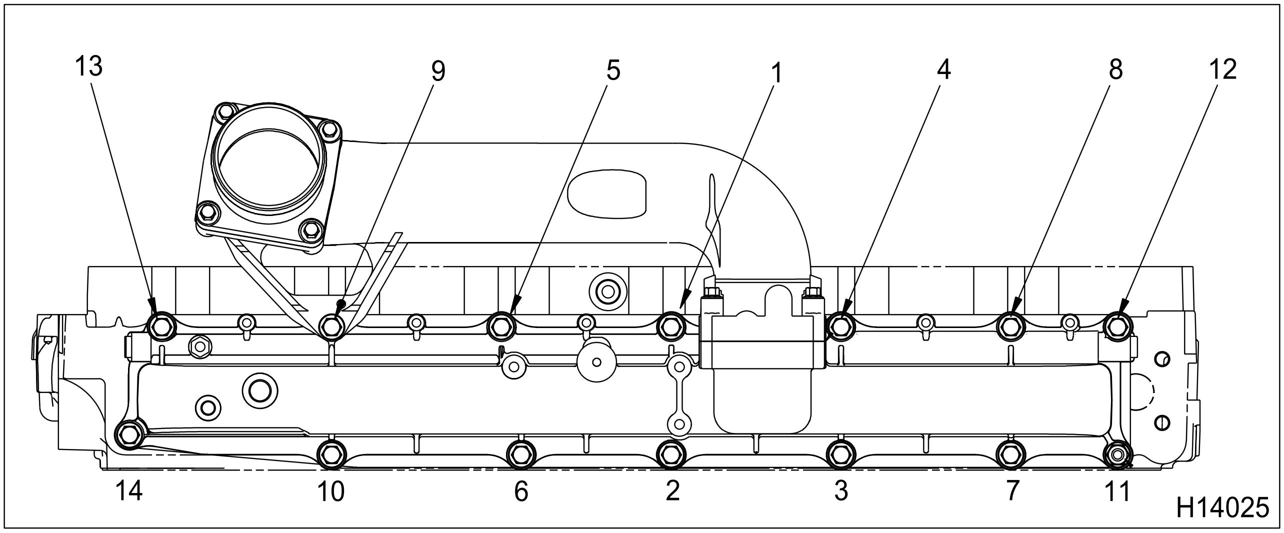


Figure 85 Intake manifold torque sequence

4. Torque intake manifold bolts including the inlet and EGR mixer support bolt (M10 x 90) to the standard torque value (General Torque Guidelines, page 445) and in the recommended sequence.

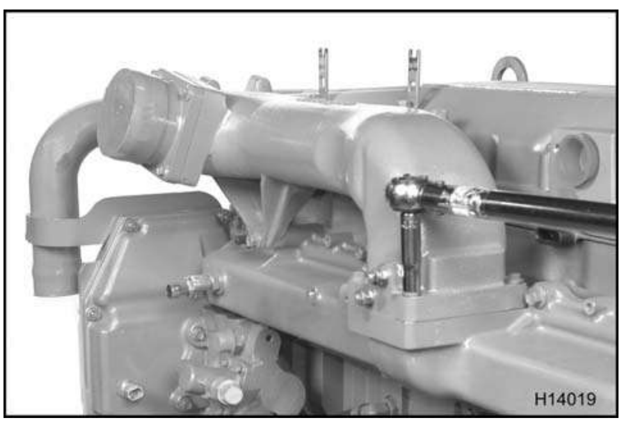


Figure 86 Torque the inlet and EGR mixer bolts

5. Torque four inlet mixer bolts (M8 x 60) to the standard torque value (General Torque Guidelines, page 445).
6. Install fuel assembly valve if removed, and tighten to the special torque value (Table 8).
7. Install intake plug assemblies, if removed (M12) and tighten to the special torque value (Table 8).

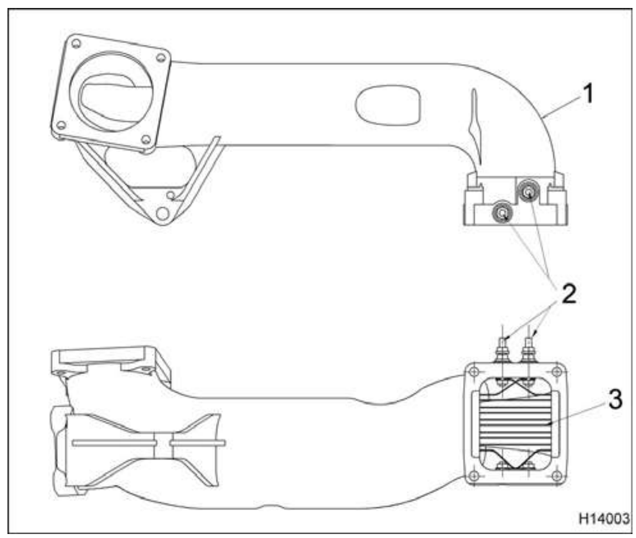


Figure 87 Intake air heater – dual element

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, page 466).

8. Connect Inlet Air Heater (IAH) cable(s).

Specifications

Table 7 Exhaust Manifold Specifications

Allowable warpage (max.)	0.10 mm (0.004 in) overall
Flange thickness (min.)	21.59 mm (0.850 in)

Special Torque

Table 8 Intake Manifold, Inlet and EGR Mixer, and Exhaust Manifold Special Torques

Exhaust manifold mounting torque and sequence.	See "Exhaust manifold torque sequence" (page 85).
Fuel assembly valve	15 N·m (132 lbf·in)
Intake manifold mounting bolts	40 N·m (30 lbf·ft)
Intake plug assembly	25 N·m (18 lbf·ft)

Table of Contents

Description

EGR COOLANT SYSTEM

The original production version of the complete EGR coolant system and first EGR cooler return configuration, beginning model year 2004, starts at the front of this section.

Over the production life of the International® DT 466, DT 570 and HT 570 Diesel Engines, the EGR coolant return system was modified according to the following EGR cooler return configurations:

- Deeper O-ring location in EGR coolant return tube plus retaining clip
- EGR coolant return tube adapter and EGR coolant hose
- Round EGR coolers and EGR coolant hose
- Service kits to convert from original or first modification of EGR coolant return tube design changes to a more robust EGR coolant return hose design.

See specific EGR coolant return system modifications, listed in the Table of Contents in this section for service procedures.

EGR System Components (Beginning Model Year 2004)

Removal of EGR System Components

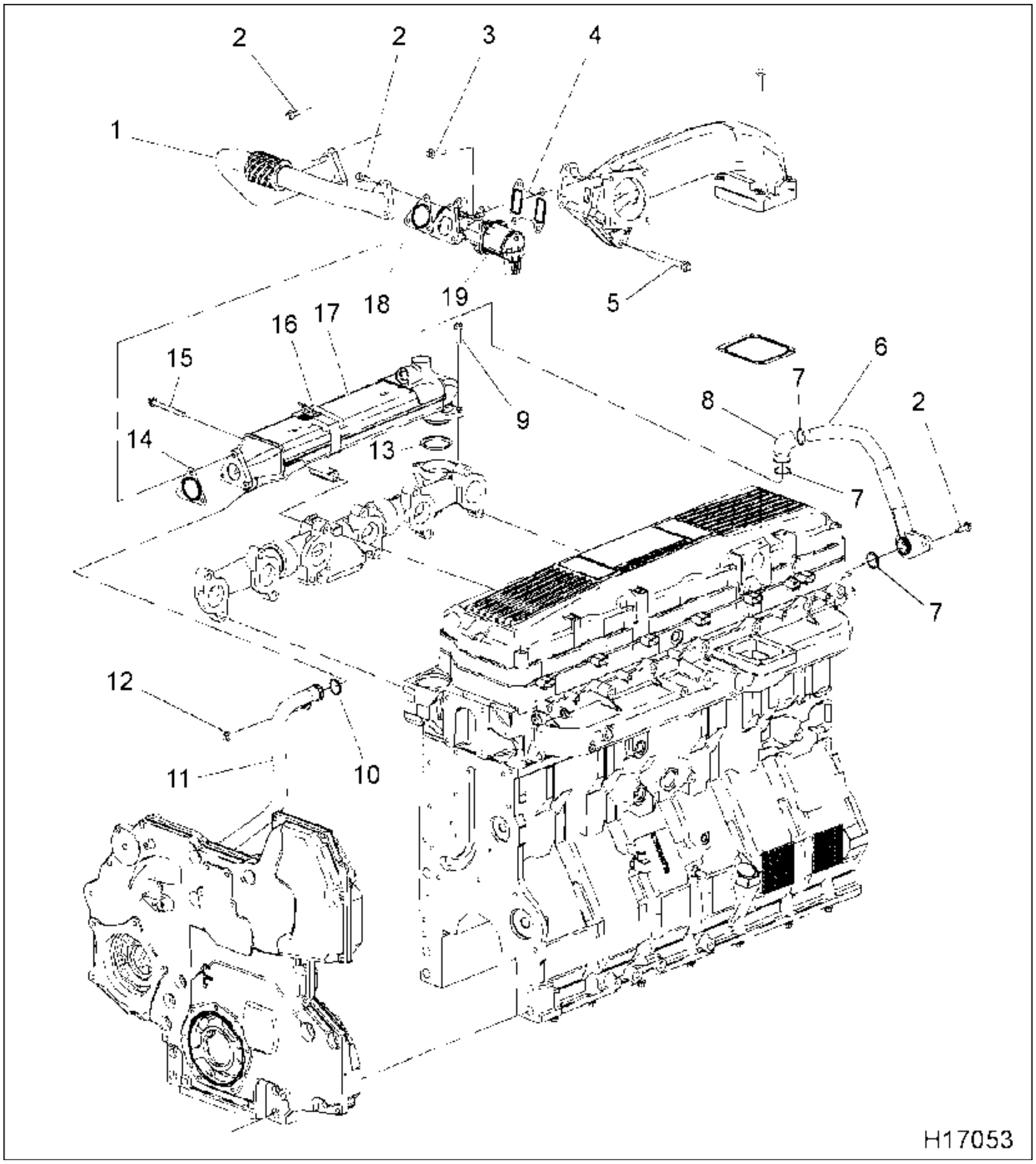


Figure 88 EGR system

1. EGR tube assembly
2. Bolt, M8 x 25 (7)
3. Bolt, M8 x 35 (4)
4. Gasket
5. Bolt, M10 x 90
6. EGR cooler return tube
7. O-ring (3)
8. EGR cooler return elbow
9. Bolt, M8 x 30 (2)
10. O-ring (2)
11. EGR cooler supply tube
12. EGR cooler supply tube retaining bolt, M8 x 16
13. Gasket, hot side
14. Gasket, cool side
15. Bolt, M12 x 120
16. EGR cooler bracket clamp
17. EGR cooler assembly
18. EGR cooler assembly gasket
19. EGR valve assembly

Table 9 EGR Cooler – Applications

EGR Cooler Length (inches)	Engine Model	Rated Brake Horsepower (bhp)
11.5	DT 466	225 and below
17.0	DT 466	245 and above
	DT and HT 570	295 and below
21.0	DT and HT 570	300 and above

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 that 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.

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

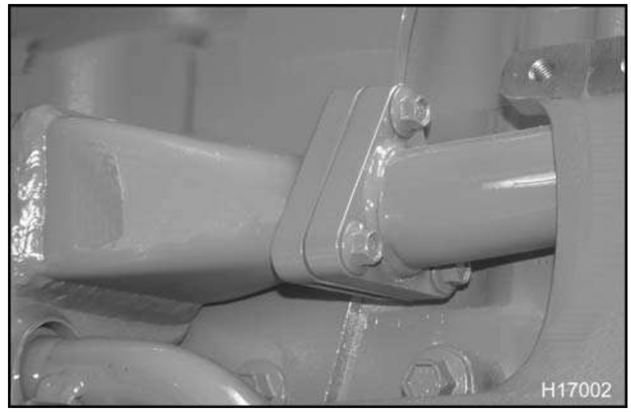


Figure 89 EGR tube assembly at EGR cooler

1. Remove three bolts (M8 x 25) from the EGR tube assembly at the EGR cooler assembly.

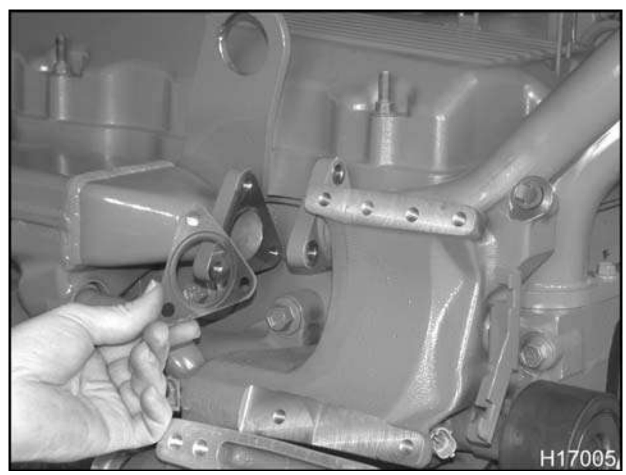


Figure 90 Removing the gasket

2. Pull tube assembly away and discard gasket.

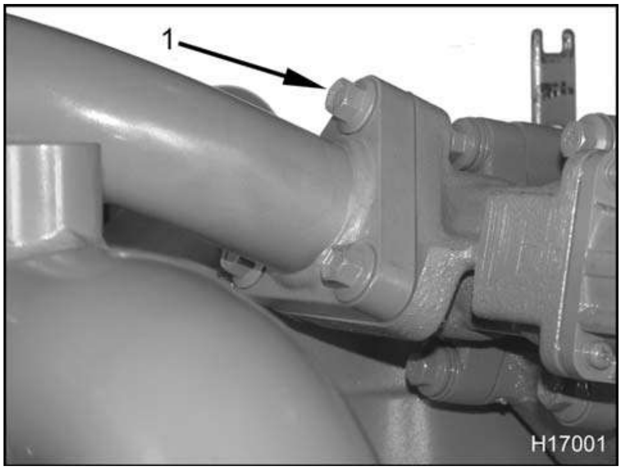


Figure 91 EGR tube assembly at EGR valve

1. Bolt, M8 x 25 (3)

3. Remove three bolts (M8 x 25) securing the EGR tube assembly at the EGR valve assembly.

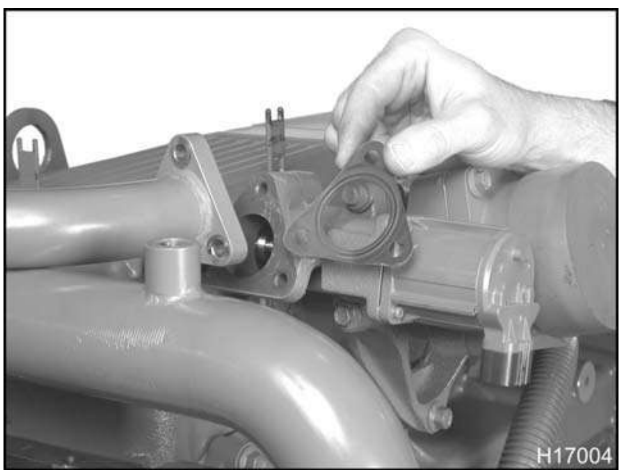


Figure 92 Removing the EGR tube assembly gasket

4. Remove EGR tube assembly and discard gasket.
5. Disconnect wiring harness connector at EGR valve assembly.

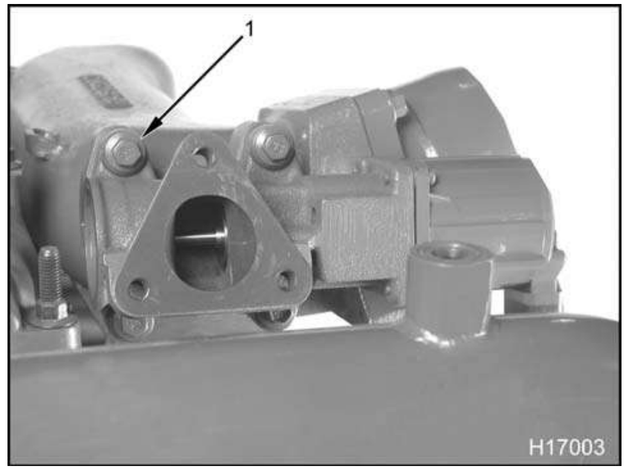


Figure 93 EGR valve retaining bolts

1. Bolt, M8 x 35 (4)

6. Remove four bolts (M8 x 35) securing the EGR valve assembly to the EGR mixer duct.

Figure 94 Removing the EGR valve to EGR mixer gasket

7. Remove and discard gasket between EGR valve assembly and EGR mixer.

NOTE: Do not attempt to remove the EGR cooler supply tube from the engine until the EGR cooler assembly has been removed. The EGR cooler supply tube is trapped between the EGR cooler and the rear half of the front cover.

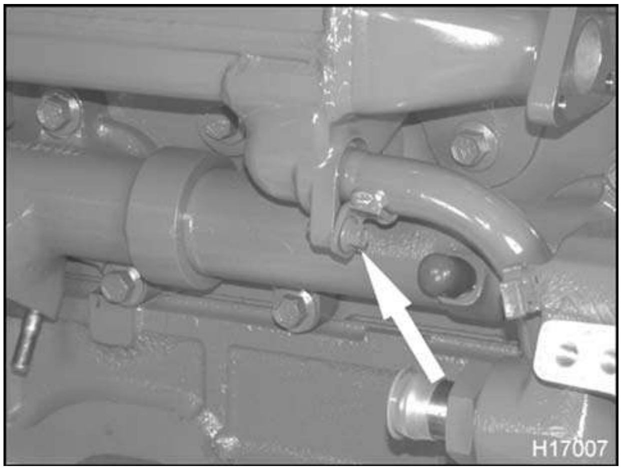


Figure 95 EGR cooler supply tube assembly retaining bolt

8. Remove the EGR cooler supply tube assembly retaining bolt (M8 x 16).

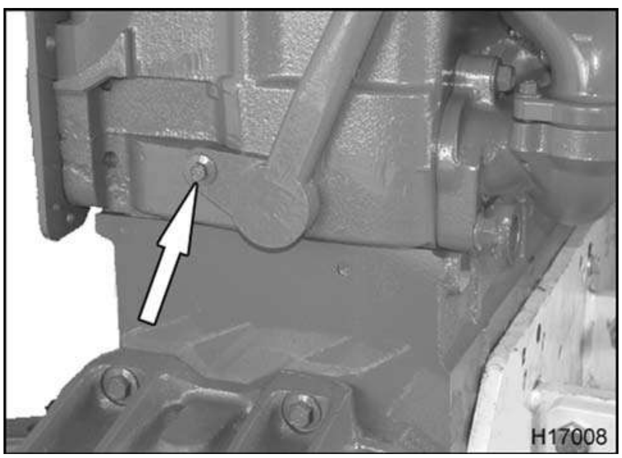


Figure 96 EGR cooler return tube assembly retaining bolt

9. Remove the EGR cooler return tube assembly retaining bolt (M8 x 25).

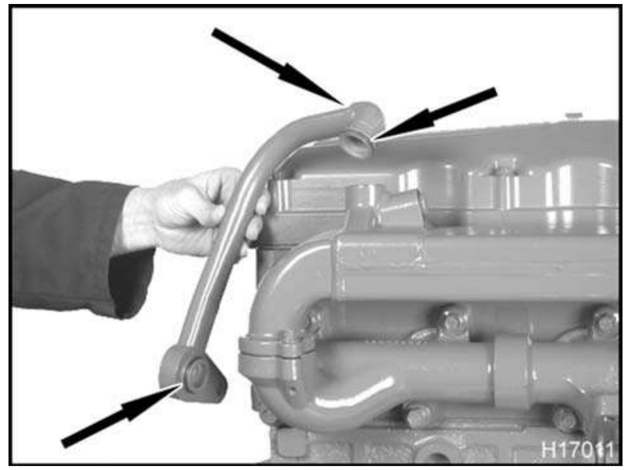


Figure 97 EGR cooler return tube and elbow O-rings

10. Remove the EGR cooler return tube assembly and elbow from engine and discard all O-rings.

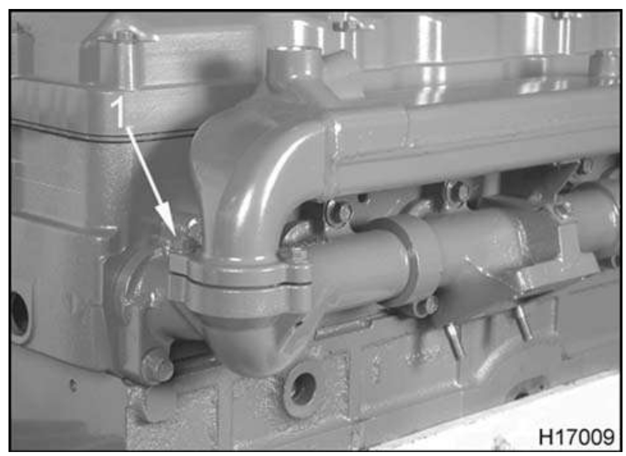


Figure 98 EGR cooler retaining bolts at exhaust manifold

1. Bolt, M8 x 30 (2)

11. Remove two bolts (M8 x 30) retaining the EGR cooler to the exhaust manifold.

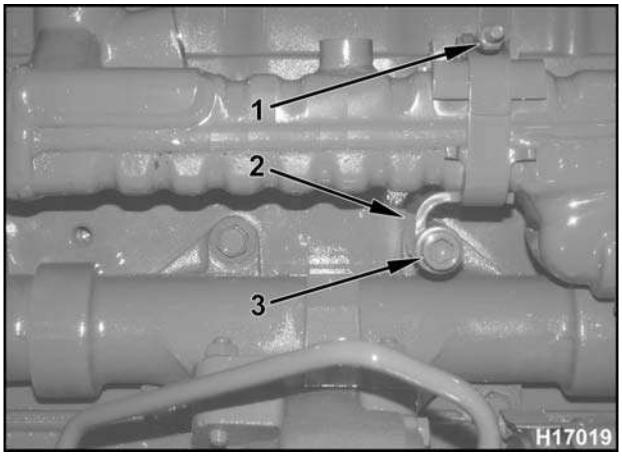


Figure 99 EGR cooler mounting bracket hardware

1. EGR cooler bracket clamp
2. EGR cooler mounting bracket
3. Bolt, M12 x 120

12. Remove M12 x 120 bolt from EGR cooler mounting bracket and exhaust manifold.
13. Remove the EGR cooler bracket clamp.

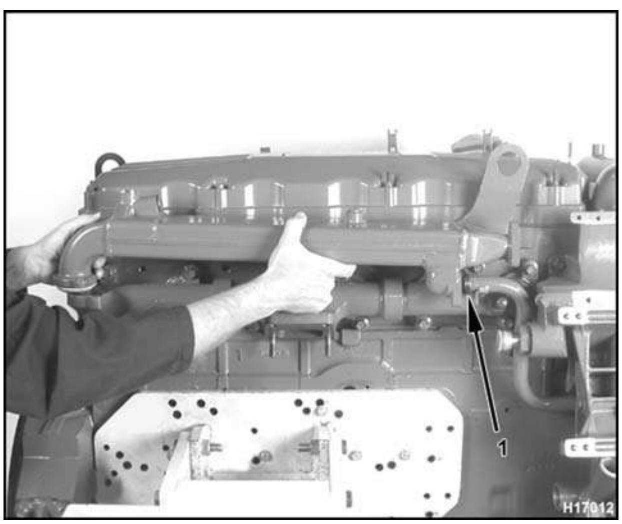


Figure 100 Removing the EGR cooler assembly

1. O-ring gasket

14. Remove the EGR cooler assembly by pulling out from EGR cooler supply tube and discard O-ring gasket.
15. Discard gasket between EGR cooler assembly and exhaust manifold.

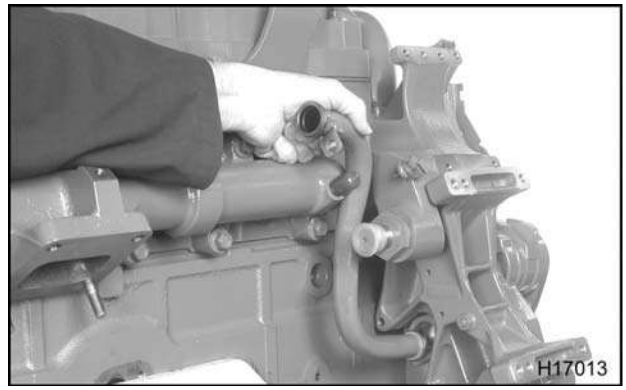


Figure 101 EGR cooler supply tube

16. Remove EGR cooler supply tubing from rear half of front cover. Discard O-ring from end of tube.

Cleaning EGR System Components

1. Clean off any gasket material and carbon deposits between the EGR cooler and exhaust manifold mating surfaces.
2. Clean mating surfaces between EGR cooler and exhaust gas crossover.
3. Clean mating surfaces between exhaust gas crossover and EGR valve.
4. Clean mating surfaces between EGR valve and intake mixer duct.

Inspection of EGR Cooler

1. Bolt EGR cooler pressure test plates (Table 11) to each end of the EGR cooler assembly.

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

2. Connect air pressure to EGR cooler pressure test plate and regulate pressure to not more than 207 kPa (30 psi).

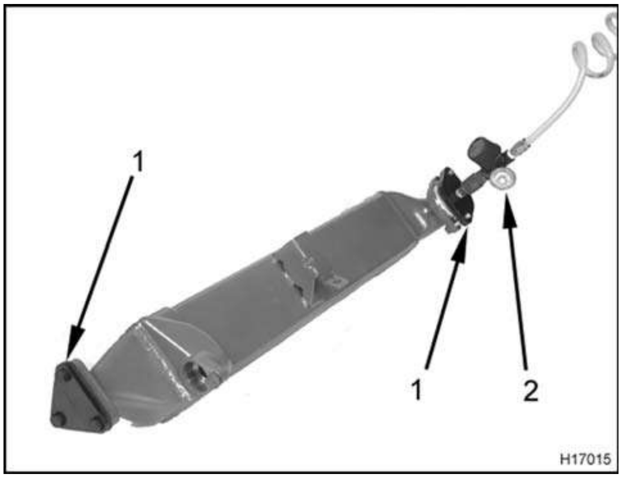


Figure 102 EGR cooler pressure test

1. EGR cooler pressure test plates (2)
2. Air pressure regulator

3. Submerge assembly into a tank of water. Watch for air bubbles coming out of the coolant ports. Discard EGR cooler if any air bubbles are produced from any ports.

Installation EGR System Components

NOTE: Assemble the following parts in order, but do not torque any bolts until all components have been installed and bolts threaded finger tight.

1. Install new O-rings onto each end of the EGR cooler supply tube.

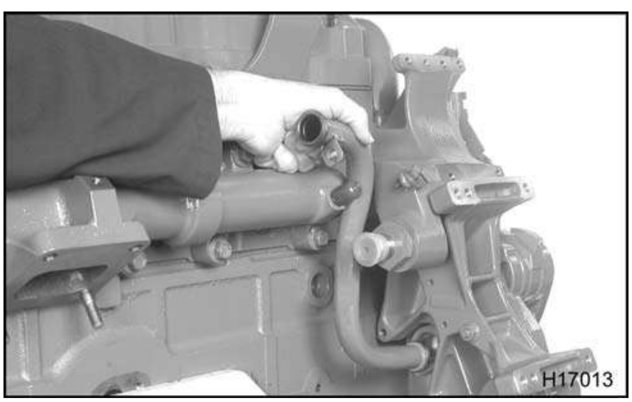


Figure 103 EGR cooler supply tube

2. Install the EGR cooler supply tube into the open port in rear half of front cover.

3. Install a new gasket between the EGR cooler assembly and exhaust manifold.

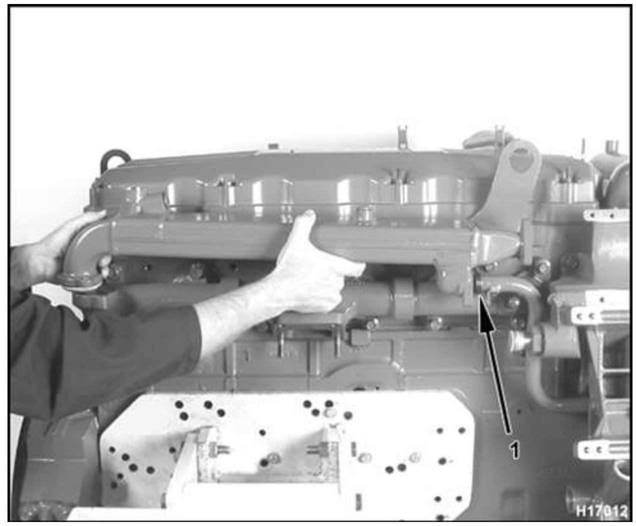


Figure 104 Installing the EGR cooler assembly

1. O-ring gasket

4. Install EGR cooler assembly by pushing in towards the EGR cooler supply tube. Make sure EGR cooler supply tube fully engages the EGR cooler assembly. The cooler tube should be trapped between the EGR cooler and the rear half of the front cover.

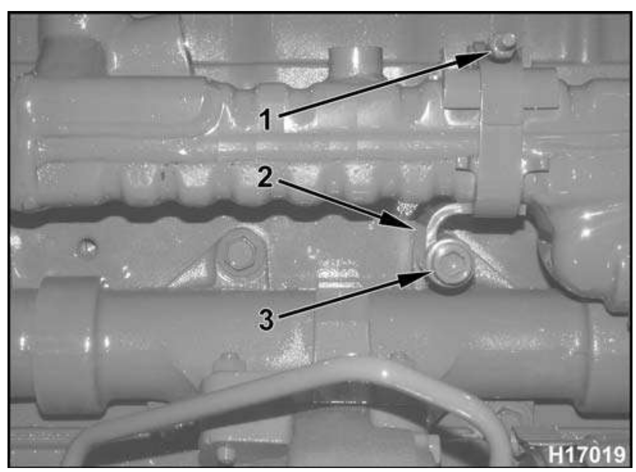


Figure 105 EGR cooler support bracket retaining bolt

1. EGR cooler bracket clamp
2. EGR cooler mounting bracket
3. Bolt, M12 x 120

5. Install M12 x 120 bolt through the EGR cooler support bracket and exhaust manifold to support and secure the EGR cooler assembly. Hand tighten bolt.
6. Install the EGR cooler into the mounting bracket and close EGR cooler bracket clamp.

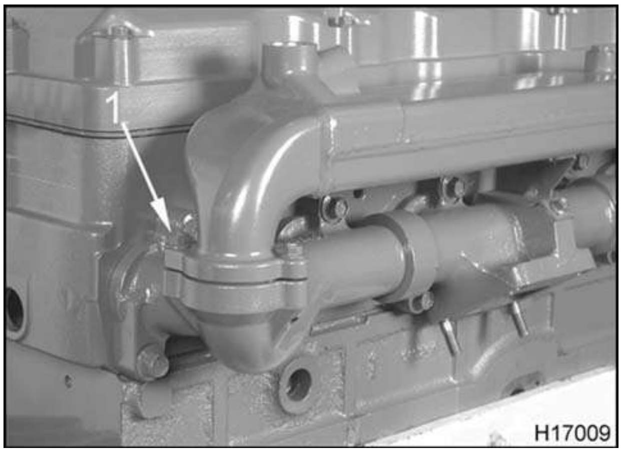


Figure 106 EGR cooler retaining bolts at exhaust manifold

1. Bolt, M8 x 30 (2)

7. Place EGR gasket between EGR cooler and exhaust manifold.
8. Install two EGR cooler retaining bolts (M8 x 30). Thread bolts finger tight at the exhaust manifold.

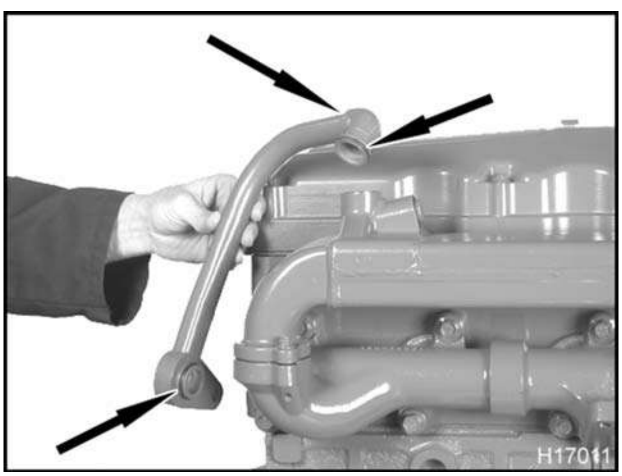


Figure 107 EGR cooler return tube O-rings

9. Install new O-rings onto each end of the EGR cooler return tube. Lubricate O-rings with P-80 or equivalent.

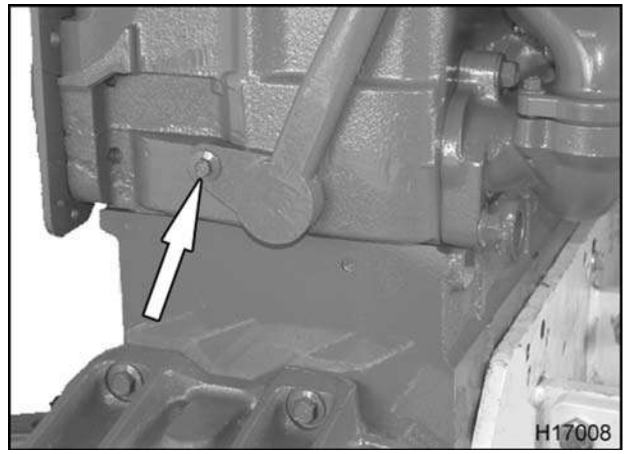


Figure 108 EGR cooler return tube assembly retaining bolt

10. Position the EGR cooler return tube assembly into place and install retaining bolt (M8 x 25) finger tight.

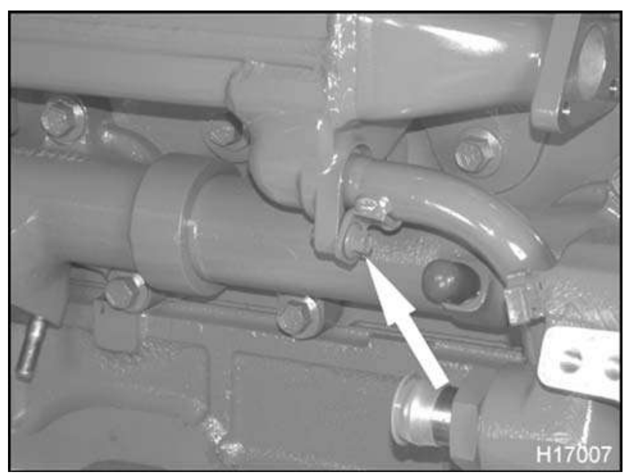


Figure 109 EGR cooler supply tube assembly retaining bolt

11. Install the EGR cooler supply tube assembly retaining bolt (M8 x 16) finger tight.

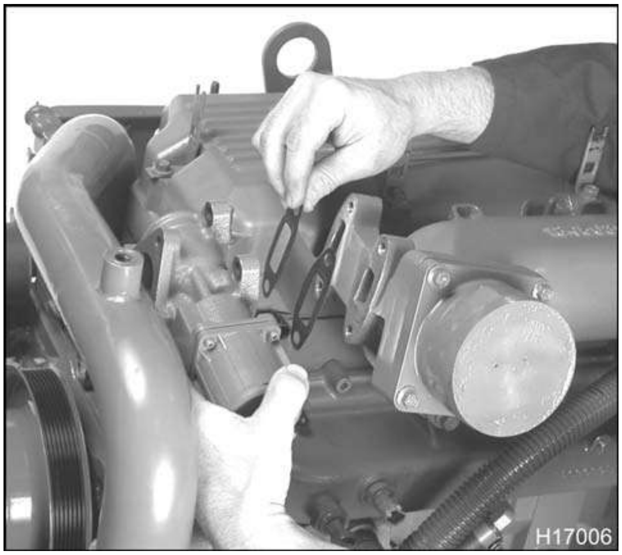


Figure 110 EGR valve gasket at EGR mixer duct

12. Place a new gasket between the EGR mixer duct and EGR valve assembly.

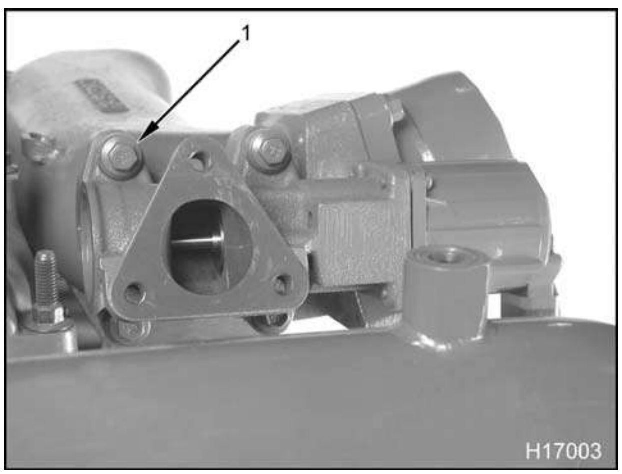


Figure 111 EGR valve mounting bolts

1. Bolt, M8 x 35 (4)

13. Secure EGR valve assembly with four bolts (M8 x 35) finger tight.

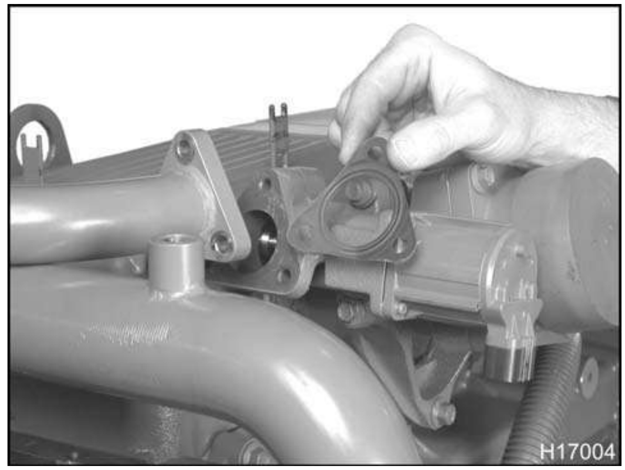


Figure 112 EGR gasket at EGR valve

14. Position a new gasket between the EGR tube assembly and EGR valve assembly.

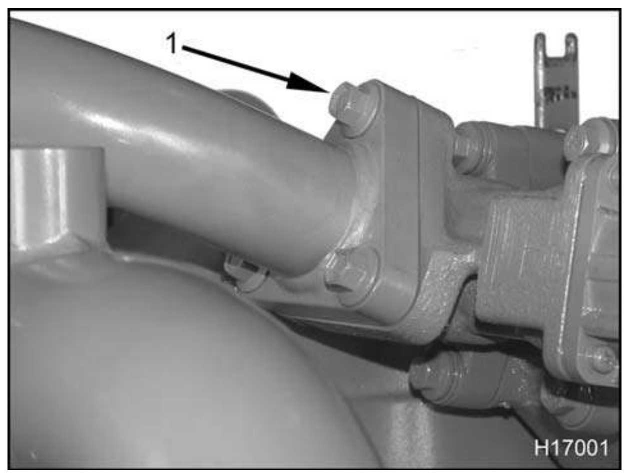


Figure 113 EGR tube assembly at EGR valve

1. Bolt, M8 x 25 (3)

15. Install three EGR tube assembly bolts (M8 x 25) finger tight.

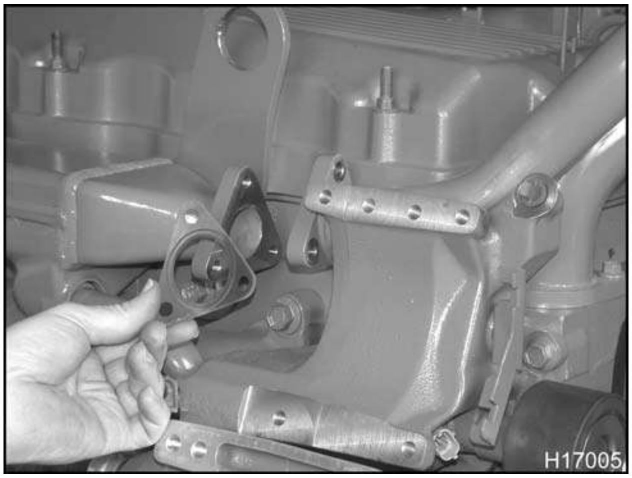


Figure 114 Installing a new gasket

16. Position a new gasket between the EGR tube assembly and EGR cooler.

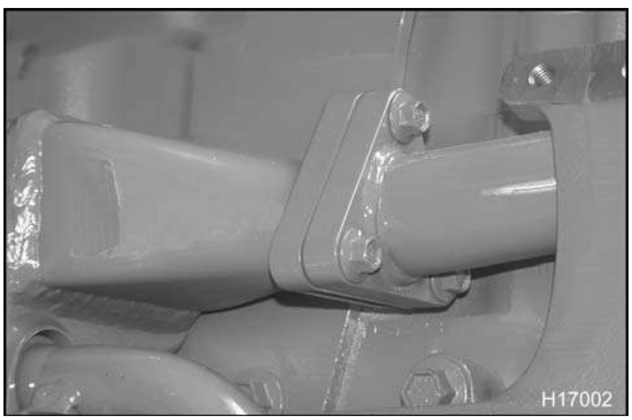


Figure 115 EGR tube assembly at EGR cooler

17. Install three bolts (M8 x 25) finger tight to join the EGR tube assembly at the EGR cooler assembly.
18. Tighten all EGR system component bolts to the standard torque (General Torque Guidelines, page445) in the following order:
    a. EGR cooler at exhaust manifold
    b. EGR tube assembly at EGR cooler
    c. EGR valve mounting bolts
    d. EGR tube assembly at EGR valve
    e. EGR cooler return tube assembly retaining bolt
    f. EGR cooler supply tube assembly retaining bolt
    g. EGR cooler support bracket retaining bolt

Modification 1 – Deeper O-ring Location into EGR Coolant Return Tube plus Retaining Clip

Removal of EGR Coolant Return Tube and Elbow

CAUTION: To prevent engine damage, do not mix the new longer leg EGR coolant return tube elbow with the original short adapter end EGR cooler return tube.

The EGR coolant return tube and mating elbow were redesigned as a production running change to locate the elbow O-ring one inch deeper into the EGR coolant return tube. Both the EGR coolant return tube and EGR coolant return elbow were redesigned to accomplish this. The EGR coolant return tube has a one inch longer arm to locate the O-ring one inch deeper into the EGR coolant return tube adapter end.

1. Drain coolant to a level below the cylinder head.
2. Remove bolt from EGR return tube located at back of cylinder head. Retain bolt for reuse with new EGR cooler return tube assembly.
3. If applicable, remove two set screws or retaining clip retaining the EGR cooler elbow.
4. Remove EGR return tube and elbow as an assembly by lifting it out of the EGR cooler.

Installation of EGR Coolant Return Tube and Elbow

1. Install two O-rings onto EGR cooler elbow and one O-ring onto pilot of EGR coolant return tube assembly.

CAUTION: To prevent engine damage, do not use engine oil or any other petroleum based products on EGR coolant return tube or elbow O-rings. These O-rings are not compatible with petroleum based lubricants.

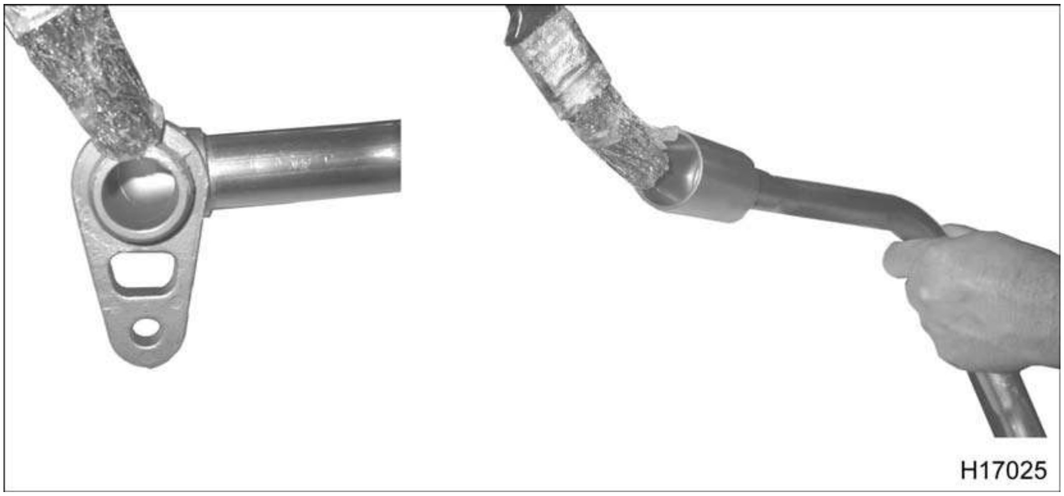


Figure 116 Brushing lubricant and sealant onto pilot end (left) and adapter end of EGR coolant return tube (right)

2. Using P-80 or equivalent, lubricate the pilot O-ring on one end and the adapter on the other end.

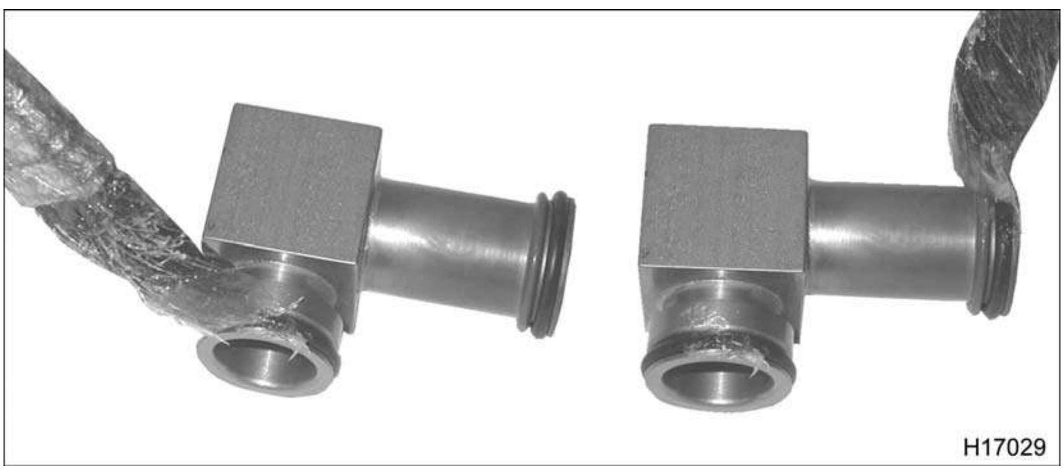


Figure 117 Lubricating both ends of the EGR cooler elbow

3. Using P-80 or equivalent, lubricate both O-rings on the EGR cooler elbow.

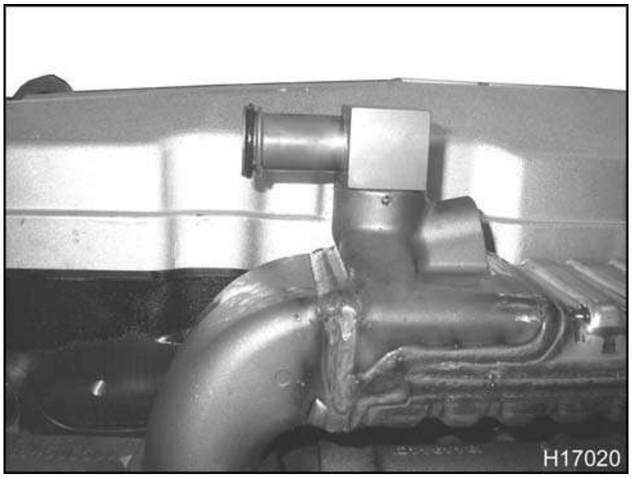


Figure 118 EGR cooler return elbow

4. Install EGR cooler return elbow into the EGR cooler assembly without wire retaining clip. The shorter arm of the elbow goes into EGR cooler.

Figure 119 EGR cooler return tube

5. Assemble EGR cooler return tube at the elbow end, pushing in until O-ring is well into tube adapter.

Figure 120 Installing the EGR cooler return tube

6. While holding the elbow and tube with one hand, swivel the EGR cooler return tube into position as needed, aligning the O-ring pilot into the cylinder head.
7. With palm of left hand, forcefully push the flange face forward into the cylinder head, fully engaging both ends while also maintaining alignment of elbow and return tube with right hand.

Figure 121 Installing the EGR return tube mounting bolt

8. Install EGR return tube mounting bolt (M8 x 25) into cylinder head (finger tight).

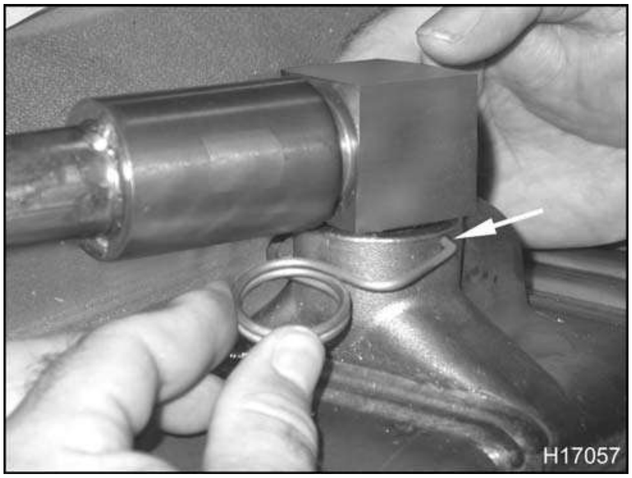


Figure 122 Installing the retaining clip (outboard hole first)

9. Ensure that EGR cooler elbow and return tube are straight. Hand seat elbow downward as far as possible and install wire retaining clip into outboard hole of EGR cooler and slide retaining clip around into remaining hole.

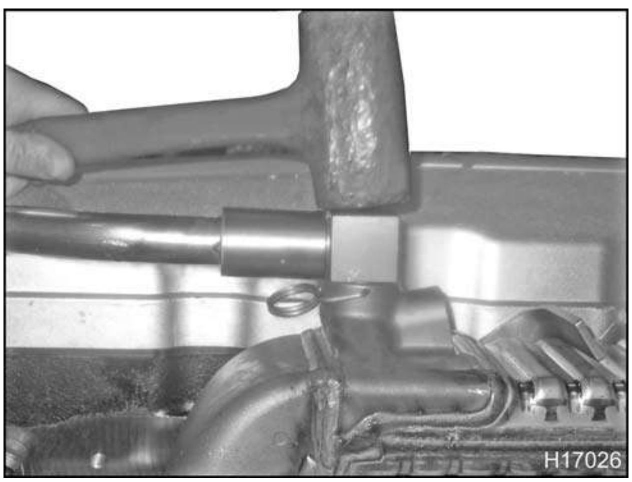


Figure 123 Seating the EGR cooler elbow and retaining clip

10. Tap top of EGR cooler elbow with rubber mallet to ensure retaining clip is fully engaged in elbow.

Figure 124 Torquing the EGR cooler return tube mounting bolt

11. Torque EGR cooler return tube mounting bolt to the standard torque value (General Torque Guidelines, page445).

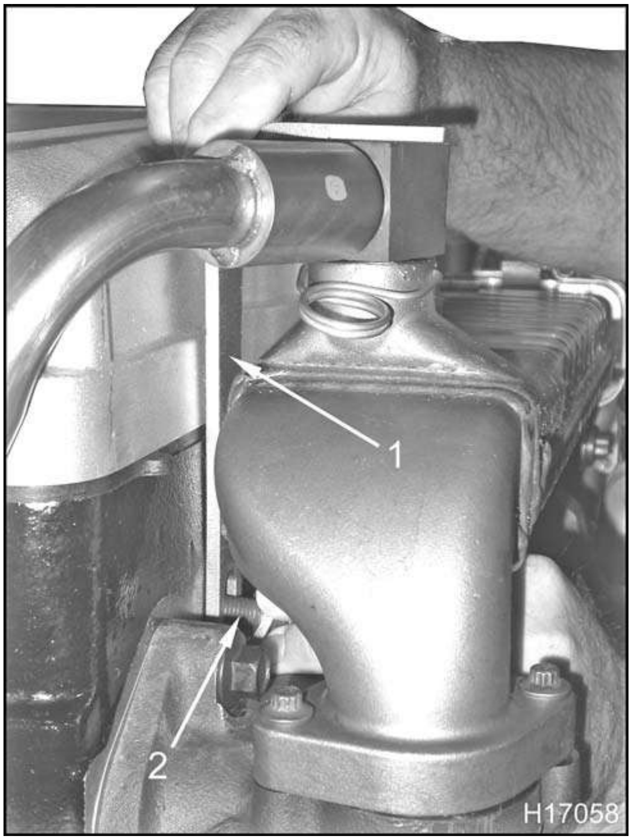


Figure 125 Installing the EGR elbow bracket and mounting hardware

1. Bracket
2. M10 x 25 Bolt and 3/8 flat washer

12. If equipped, slide elbow retaining bracket between cylinder head and EGR cooler assembly. Install flat washer and M10 x 25 bolt. Tighten bolt to the standard torque (General Torque Guidelines, page 445).

Modification 2 – EGR Coolant Return Tube Adapter and EGR Coolant Hose

Removal of EGR Coolant Return Tube Adapter and EGR Coolant Hose

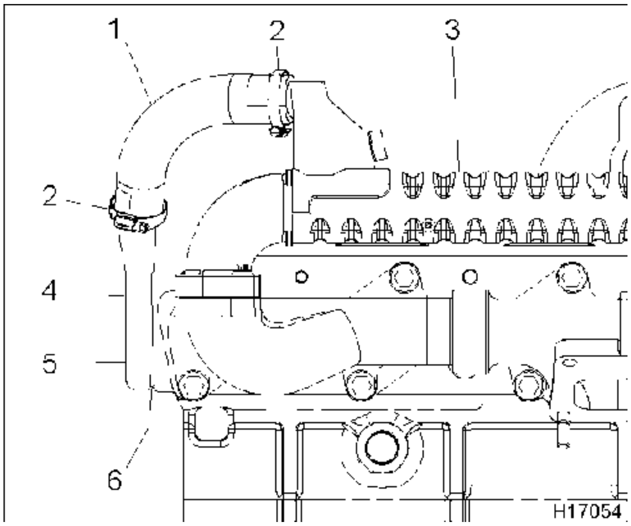


Figure 126 EGR coolant return tube adapter and EGR coolant hose

1. EGR coolant hose
2. Constant tension EGR hose clamp (2)
3. EGR cooler
4. EGR coolant return tube adapter
5. Bolt, M8 x 25 (in flange)
6. O-ring seal

1. Drain coolant.
2. Loosen two constant tension EGR hose clamps and remove EGR coolant hose from EGR coolant return tube adapter and EGR cooler.
3. Remove M8 x 25 EGR coolant return tube adapter bolt and pull EGR coolant return tube adapter straight out of the cylinder head. Discard O-ring.

Installation of EGR Coolant Return Tube Adapter and EGR Coolant Hose

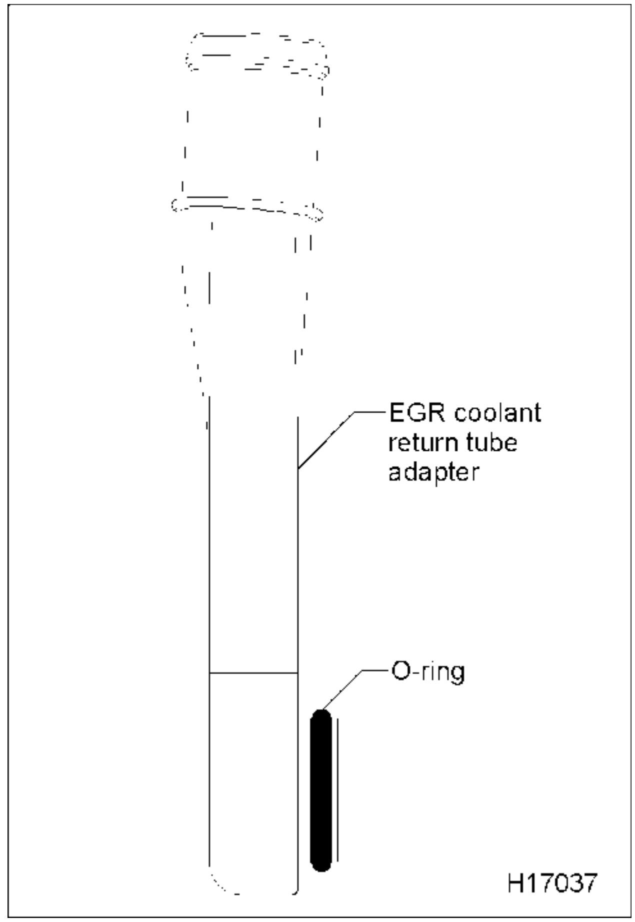


Figure 127 EGR cooler return tube adapter

1. Install a new O-ring onto new EGR cooler return tube adapter.

   CAUTION: To prevent engine damage, do not use engine oil or any other petroleum based products on EGR cooler return tube adapter O-ring. This O-ring is not compatible with petroleum based lubricants.

2. Using P-80 or equivalent, lubricate O-ring on adapter.

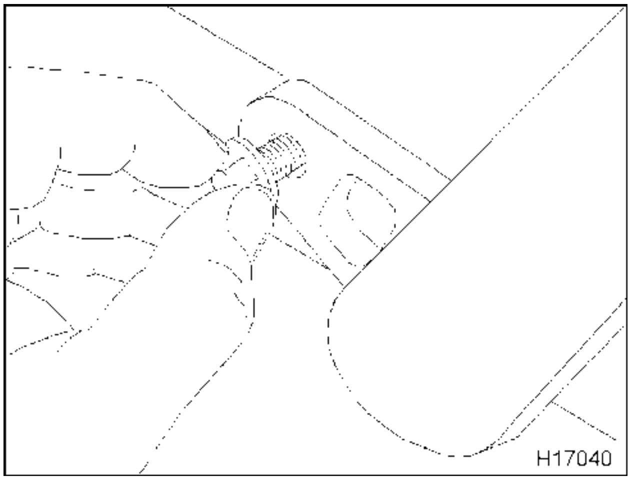


Figure 128 Installing the EGR return tube adapter mounting bolt

3. Position adapter into cylinder head coolant port and install EGR coolant return tube adapter bolt (M8 x 25). Tighten bolt to the standard torque (General Torque Guidelines, page445).

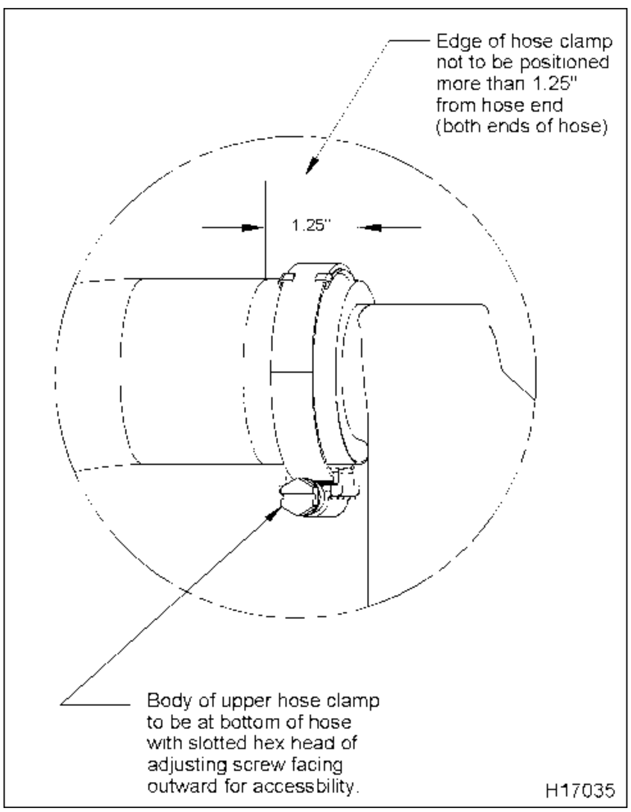


Figure 129 EGR upper hose clamp details

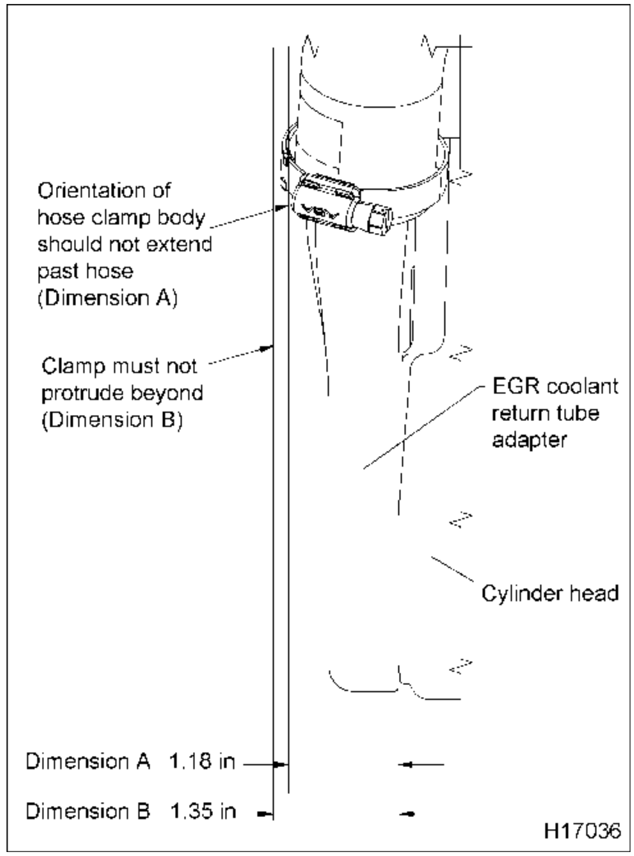


Figure 130 EGR lower hose clamp details

4. Position EGR coolant hose and two constant tension EGR hose clamps between EGR cooler and EGR cooler return tube adapter.
5. Tighten constant tension EGR hose clamps to the special torque (Table 10).
6. Fill engine with coolant and check for leaks.
7. Start engine and let engine warm up to operating temperature.
8. Shut down engine and let engine cool to ambient air temperature.
9. Retighten constant tension EGR hose clamps to the special torque (Table 10).

Modification 3 – Round EGR Cooler and EGR Return Hose

Removal

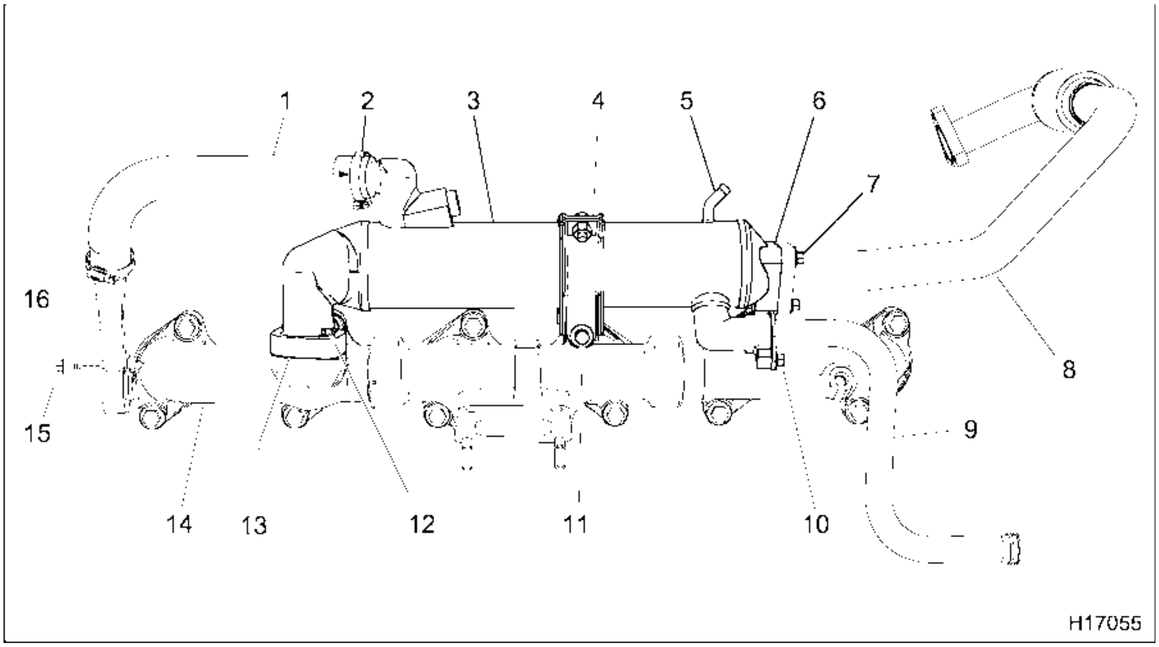


Figure 131 Round EGR cooler

1. EGR return hose
2. Constant tension EGR hose clamp (2)
3. EGR cooler
4. EGR cooler mounting bracket
5. Deaeration hose fitting
6. EGR tube to EGR valve gasket
7. EGR tube assembly bolt (M8 x 25) (3)
8. EGR tube assembly
9. EGR cooler supply tube assembly
10. EGR cooler supply tube retaining bolt (M8 x 16)
11. EGR cooler mounting bracket lower bolt (M12 x 120)
12. EGR rear mounting bolt (M8 x 30) (2)
13. EGR hot side gasket
14. Exhaust manifold
15. EGR coolant return adapter tube retaining bolt (M8 x 25)
16. EGR coolant return adapter tube

1. Drain engine cooling system.
2. Loosen and remove EGR cooler supply tube retaining bolt.
3. Loosen and remove three bolts holding EGR tube assembly to EGR cooler.
4. Loosen EGR return hose clamp and pull EGR return hose off of EGR cooler.
5. Loosen clamp holding deaeration hose to the deaeration hose fitting and pull hose off of EGR cooler.
6. Remove EGR rear mounting bolts.
7. Loosen and remove EGR cooler mounting bracket lower bolt.
8. Pull EGR cooler and mounting bracket away from exhaust manifold, EGR cooler supply tube, and EGR tube assembly.
9. Remove EGR cooler supply tube assembly from rear half of front cover. Remove and discard O-rings from ends of cooler supply tube and clean tube ends.
10. Remove old gaskets and clean gasket surfaces of EGR tube assembly and exhaust manifold.

Installation

1. Clean port in rear half of front cover which EGR cooler supply tube fits into.

   CAUTION: To prevent engine damage, do not use engine oil or any other petroleum based products on EGR cooler supply tube O-rings. These O-rings are not compatible with petroleum based lubricants.

2. Install new O-ring seals on EGR cooler supply tube assembly ends and reinstall tube into port in rear half of front cover.
3. Install new EGR hot side gasket on new EGR cooler.
4. Position EGR cooler on the engine and install two new EGR rear mounting bolts. Finger tighten bolts.
5. Reinstall EGR cooler mounting bracket lower bolt and finger tighten.
6. Push EGR cooler supply tube assembly into EGR cooler and finger tighten retaining bolt.
7. Install new EGR tube to EGR valve gasket and finger tighten three bolts holding EGR tube to EGR cooler.
8. Tighten EGR rear mounting bolts (M8 x 30) to the standard torque (General Torque Guidelines, page445).
9. Tighten EGR cooler mounting bracket lower bolt (M12 x 120) to the special torque (Table 10).
10. Tighten EGR cooler mounting bracket to the special torque (Table 10).
11. Tighten three bolts (M8 x 25) holding EGR tube assembly to EGR cooler to the standard torque (General Torque Guidelines, page445).
12. Tighten EGR cooler supply tube retaining bolt (M8 x 16) to the special torque (Table 10).
13. Push EGR return hose onto EGR cooler and tighten constant tension EGR hose clamps to the special torque value (Table 10).
14. Push deaeration hose onto EGR cooler deaeration fitting and tighten clamp.
15. Refill engine cooling system.
16. Start engine and let engine warm up to operating temperature.
17. Shut down engine and let engine cool to ambient air temperature.
18. Retighten constant tension EGR hose clamps to the special torque value (Table 10).

EGR Coolant Return Kits (Conversion from EGR Cooler Return Tube to Hose)

Removal of EGR Coolant Return

NOTE: See Technical Service Information (TSI) bulletin (TSI-07-12-12 EGR Coolant Return Kit, page 477) for Exhaust Gas Recirculation (EGR) kits.

1. Drain coolant to a level below the cylinder head.
2. Remove and save bolt from EGR cooler return tube flange.
3. Remove spring clip or set screws from EGR return tube elbow.
4. Remove old EGR return tube and elbow.

Installation of EGR Coolant Return Kit

CAUTION: To prevent engine damage, do not use engine oil or other petroleum products on EGR coolant return hose or O-rings.

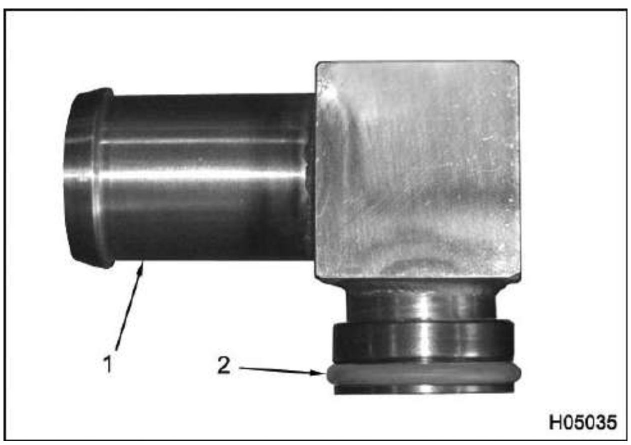


Figure 132 EGR coolant return elbow

1. EGR coolant return elbow
2. O-ring seal

1. Put O-ring seal on new EGR coolant return elbow.
2. Put O-ring seal on new EGR coolant return adapter tube.
3. Lubricate both O-rings with P-80 or equivalent.

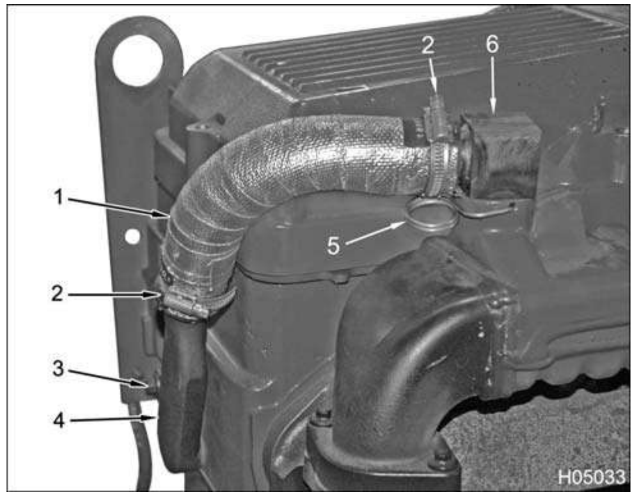


Figure 133 EGR coolant return

1. EGR coolant return hose
2. Constant tension EGR hose clamp
3. M8 x 25 bolt
4. EGR cooler return adapter tube
5. EGR elbow retaining clip
6. EGR coolant return elbow

4. Install EGR coolant return elbow.
5. Slide new EGR coolant return hose onto coolant return elbow and position hose clamp.
6. Put hose clamp on EGR coolant return hose, insert EGR cooler return adapter tube into hose, and position clamp.
7. Install M8 x 25 bolt (finger tight) to secure EGR cooler return adapter tube to cylinder head.
8. Install EGR elbow retaining clip (outboard hole first). Tap top of elbow with rubber mallet to ensure retaining clip is fully engaged.
9. Tighten M8 x 25 bolt to the standard torque (General Torque Guidelines, page 445).
10. Tighten constant tension EGR hose clamps to the special torque (Table 10).

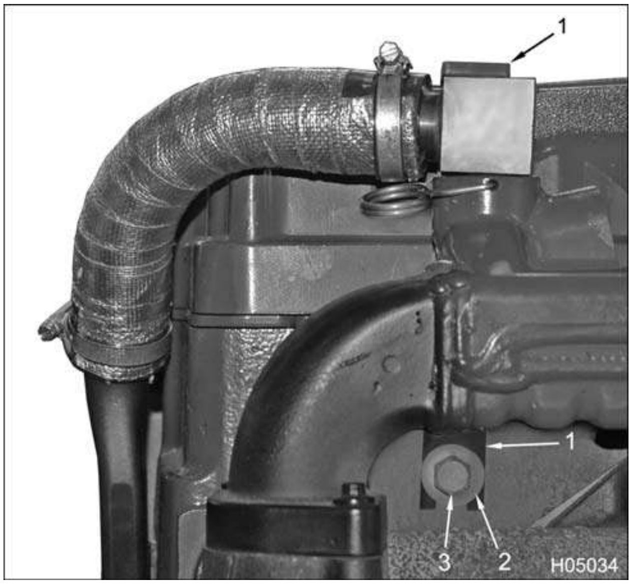


Figure 134 EGR cooler return bracket

1. EGR tube bracket
2. Flat washer, 3/8 in
3. Bolt, M10 x 1.5 x 25 mm

11. Position EGR cooler return bracket between cylinder head and EGR cooler.
12. Install 3/8 in flat washer and M10 Bolt.
13. Tighten M10 bolt to the standard torque (General Torque Guidelines, page445).
14. Refill engine cooling system.
15. Start engine and let engine warm up to operating temperature.
16. Shut down engine and let engine cool to ambient air temperature.
17. Retighten constant tension EGR hose clamps to special torque (Table 10).

Special Torque

Table 10 EGR Cooler Special Torques

Constant tension EGR hose clamps (if equipped)	3.4 N·m (30 lbf·in)
EGR cooler mounting bracket lower bolt, M12 x 120	116 N·m (85 lbf·ft)
EGR cooler mounting bracket	116 N·m (85 lbf·ft)
EGR cooler supply tube retaining bolt	15-22 N·m (11.3-16.2 lbf·ft)

Special Service Tools

Table 11 EGR System Special Service Tools

EGR cooler pressure test plates	ZTSE4636

Table of Contents

Read all safety instructions in the "Safety Information" section of this manual before doing any procedures.
Follow all warnings, cautions, and notes.

Description

The DT 466 and DT 570 cylinder heads are cast iron and feature four valves per cylinder.

The design of the cylinder head valve train focuses on component commonality between the intake and exhaust sides of the head. Shared parts include: valve bridges, guides, springs, retainer keys, rotators, and valve stem seals. These parts are also compatible between the 466 and 570 engine families.

The valve rotators create positive valve rotation for increased valve face life.

The valve stem seals are one piece design, easy to install, and have a hardened washer for valve spring seating.

The valve guides and valve seats are replaceable.

The bridge can be installed on the intake or exhaust in either direction, and still allow compression brake operation through the pad on top.

A single roller tappet transfers lifting forces through a push rod, rocker arm, and then onto a valve bridge where both valves are opened and closed simultaneously. This allows for a greater quantity of air to flow through the engine than comparably sized engines using only two valves per cylinder.

Phosphate coating has been carried over from past production to rocker arms for initial break-in and to extend life.

Pressurized oil is fed from the crankcase through the head at cylinder number 6 exhaust lower support. Oil then enters shaft and is distributed to all rocker arms.

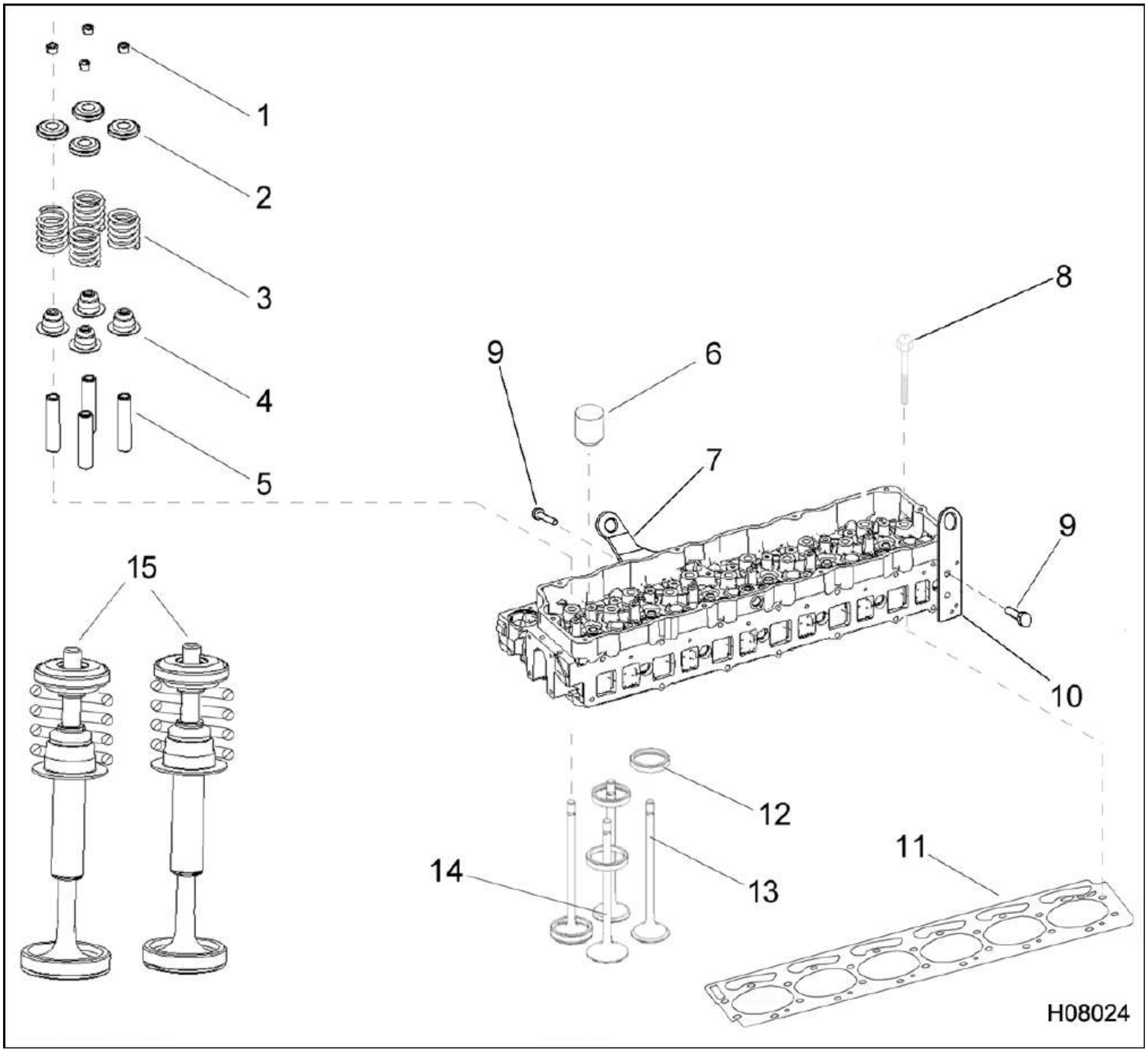


Figure 135 Cylinder head and valve train components

1. Valve spring retainer keys
2. Valve rotators
3. Valve springs
4. Valve stem seals
5. Valve guide inserts
6. Fuel injector sleeve
7. Front lifting eye
8. Cylinder head bolt, (26)
9. Bolt, M12 x 25 (4)
10. Rear lifting eye
11. Cylinder head gasket
12. Valve seat insert
13. Exhaust valve
14. Intake valve
15. Valve assemblies

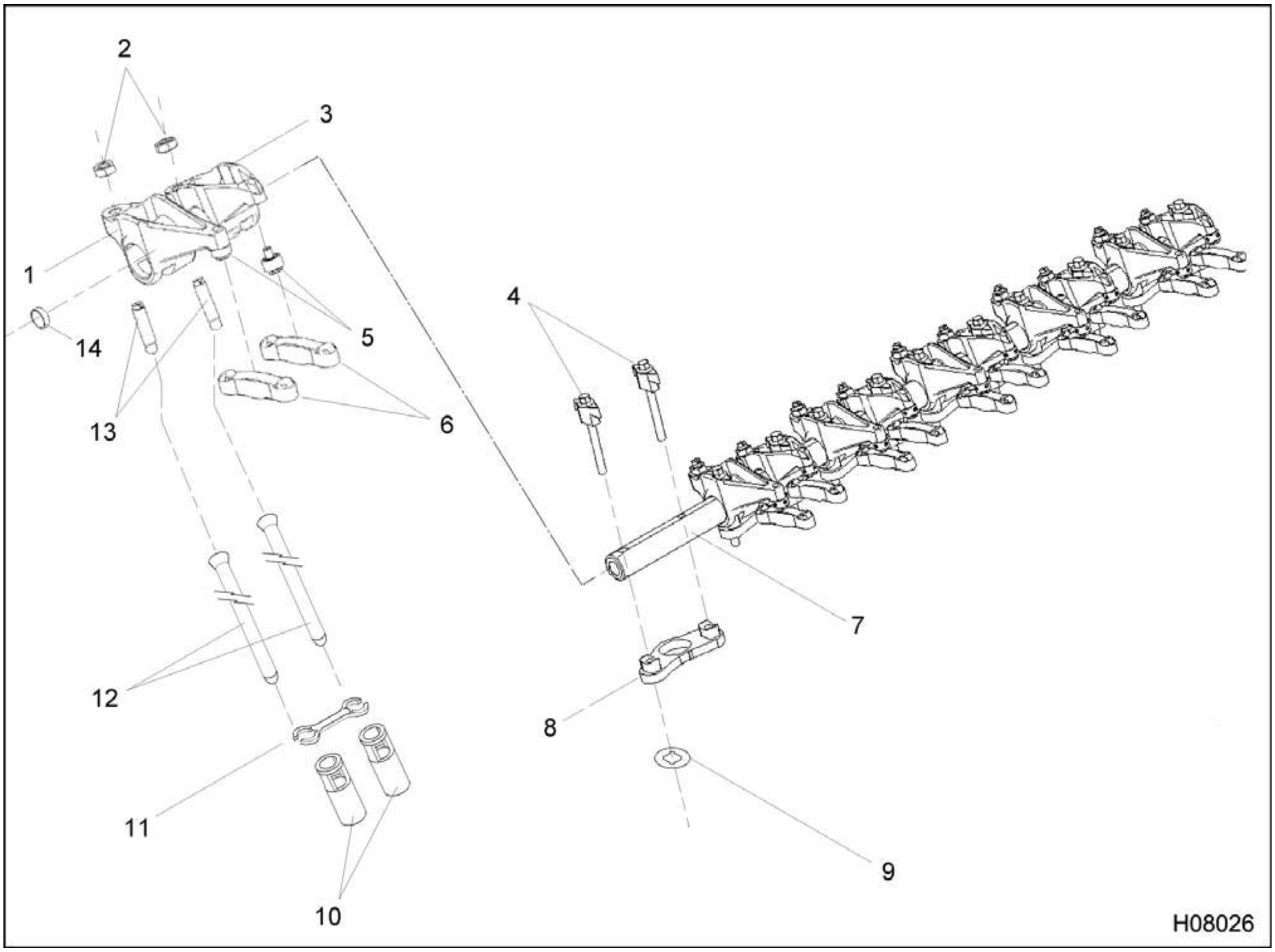


Figure 136 Valve train components

1. Intake rocker arm (6)
2. Valve lash adjustment nuts, M10 (12)
3. Exhaust rocker arm (6)
4. Rocker shaft clamp assembly (12)
5. Rocker pivots (12)
6. Valve bridge (12)
7. Rocker arm shaft
8. Rocker shaft support (6)
9. Lower support washer (6)
10. Roller tappets (12)
11. Roller tappet guide (6)
12. Push rods (12)
13. Valve lash adjuster screw, M10 (12)
14. Rocker shaft plug (2)

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, allow engine to cool before working with components.

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, 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.

CAUTION: To prevent engine damage, do not reuse cylinder head bolts; install new bolts.

NOTE: For information regarding the removal or installation of adjacent components, refer to the following service procedures located in other sections of this manual:

- VGT turbocharger
- Intake and exhaust manifolds
- EGR system components
- High-pressure oil manifold or Diamond Logic® Engine Brake (if equipped)
- Fuel filter assembly
- Fuel injector assembly
- Crankcase breather assembly
- Coolant outlet tube assembly
- Water supply housing

Valve Cover

1. If cylinder head is to be removed in chassis, drain coolant to a level below the head gasket joint.
2. Disconnect crankcase ventilation and drain tubing from breather assembly. The breather assembly can remain attached to the valve cover during the valve cover removal (Crankcase Ventilation System, page253).

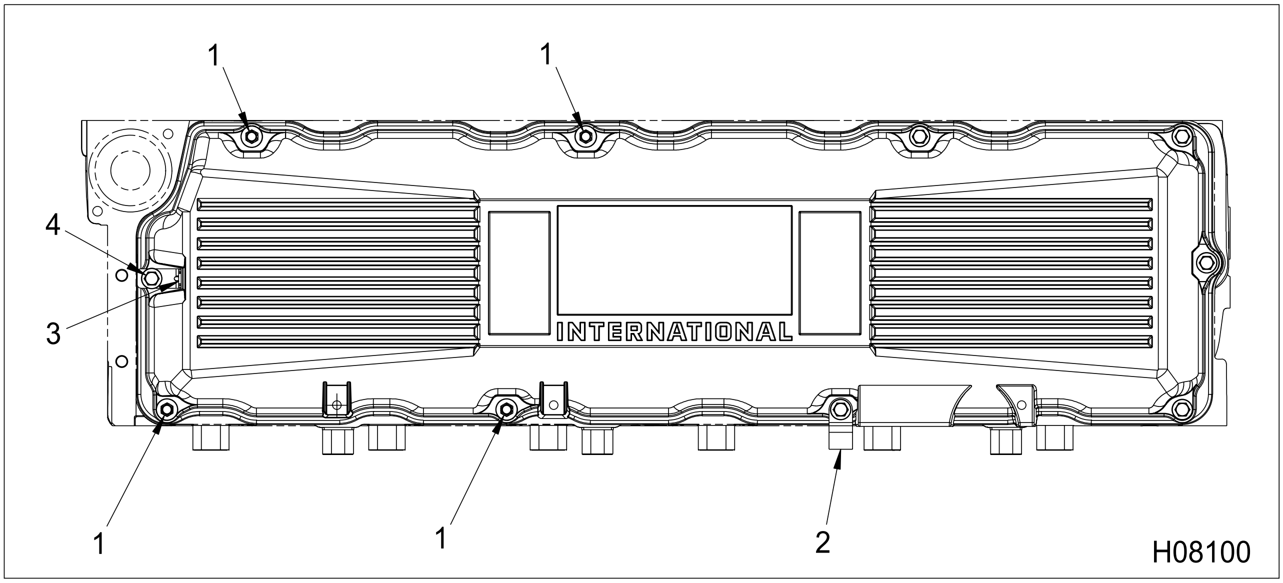


Figure 137 Valve cover assembly detail

1. Bolt / stud, M8 x 80 / 19 (4)
2. Extension bracket
3. Valve cover harness mounting bracket
4. Bolt, M8 x 80 (6)

3. Remove four valve cover bolt / studs (M8 x 80 / 19).
4. Remove six valve cover bolts (M8 x 80).
5. Lift valve cover off of cylinder head.

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

6. Disconnect all electrical and injector connectors at valve cover gasket.
7. Remove valve cover gasket.

Removing Rocker Arm Assembly

1. Remove high-pressure oil rail. See (Figure 640) .

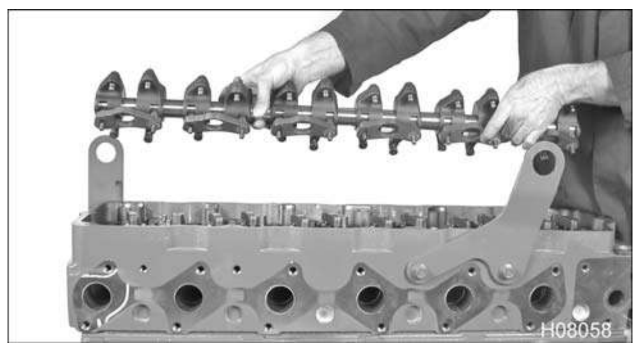


Figure 138 Removing rocker arm assembly

2. Loosen all rocker arm adjusting screws and nuts. This will avoid possible valve train damage during installation.
3. Loosen but do not remove 12 rocker shaft clamp bolts.
4. Lift the rocker arm shaft assembly up and away from the cylinder head and set aside.

   NOTE: There are six nylon washers, one for each rocker shaft support, that are for assembly purposes. Make sure that you have these washers for installing the rocker arm shaft.

Figure 139 Removing the valve bridge

5. If removing valve bridges, mark all valve bridges for installation (original orientation) later on.

Measuring Camshaft Lift

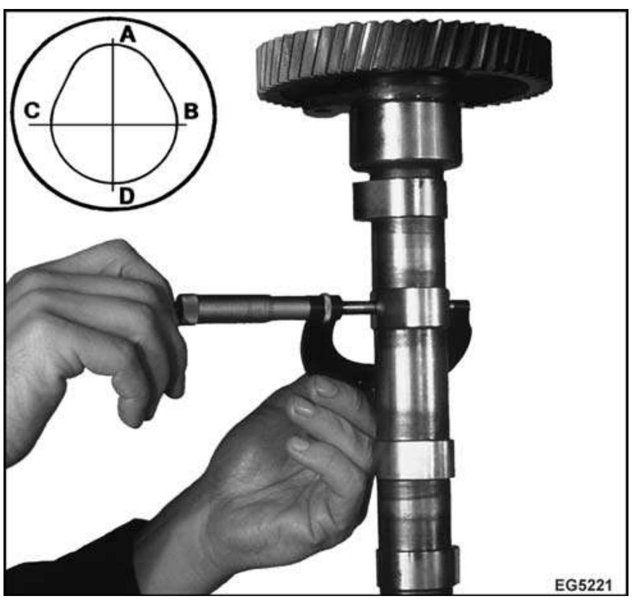


Figure 140 Measuring cam lobes with micrometer

NOTE: If a complete engine overhaul is scheduled, camshaft lobe wear can be determined by measuring lobes (Checking Camshaft Lobes and Journals, page 263) with a micrometer after the camshaft is removed.

At this stage of disassembly, determine the appropriate stage of camshaft inspection. If this is not a complete engine overhaul, measure camshaft lobe lift now using the following procedure.

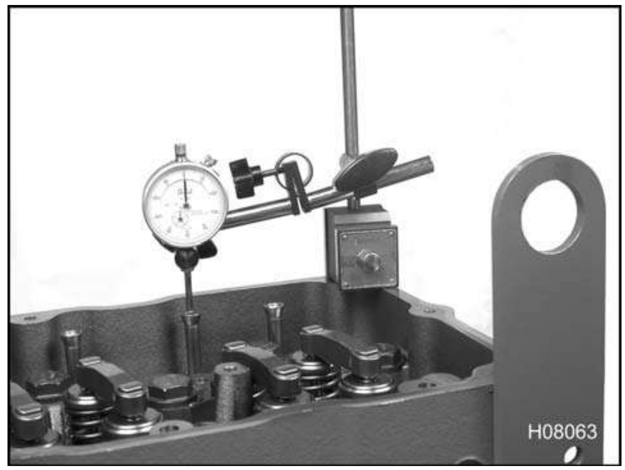


Figure 141 Mounting magnetic base dial indicator

1. Mount a magnetic base dial indicator onto the cylinder head.
2. Place dial indicator tip on top of push rod and rotate engine until push rod is at its lowest point of travel (base circle), then “zero” indicator.

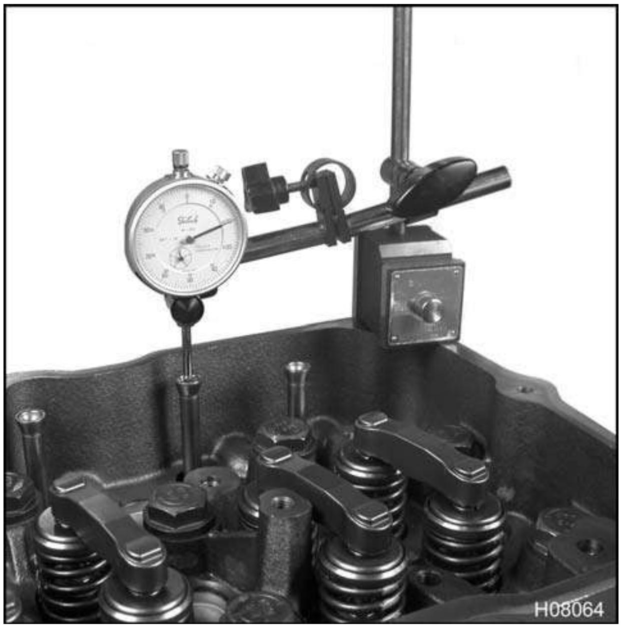


Figure 142 Recording camshaft lobe reading

3. Rotate the crankshaft and bring push rod to its highest point of travel. Record indicator reading.
4. Repeat this procedure for all lobes.
5. For specifications on camshaft lobe (Table 13).

Removing Rocker Arms

NOTE: Mark rocker arms and rocker shaft supports for location to ensure correct placement for later reassembly.

1. Place the rocker arm assembly on a clean flat surface. Mark each rocker arm before removal to aid in assembly of the rocker arm shaft later on.
2. Remove the 12 rocker shaft clamps.

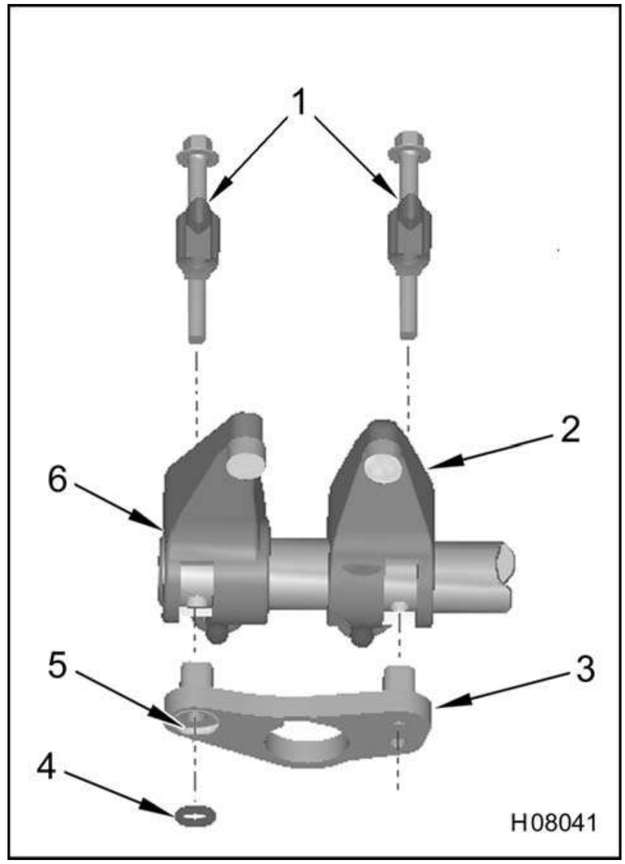


Figure 143 Rocker arm configuration

1. Clamp bolt assembly
2. Exhaust rocker arm
3. Rocker arm shaft support
4. Lower support washer
5. Machined recessed
6. Intake rocker arm

3. Slide rocker arm assembly components off shaft.
4. Tag all pushrods with cylinder number and valve association (intake or exhaust).
5. Remove all pushrods.

Removing Cylinder Head

CAUTION: To prevent engine damage, remove injectors before cylinder head removal (High-pressure Oil Rail Assembly, page346).

1. Remove and discard 26 cylinder head mounting bolts (M15 x 180).

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, chain must be equipped with safety hooks. See safety section in front of manual.

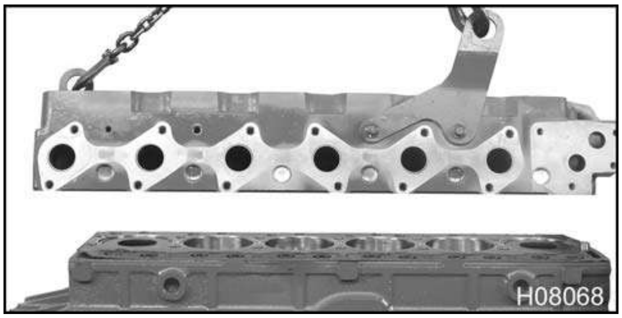


Figure 144 Removing cylinder head from crankcase

2. Attach appropriate hoist and lifting hooks to lifting eyes. Carefully lift the cylinder head from the crankcase.
3. After cylinder head been placed on a workbench surface, remove both lifting eyes and four bolts (M12 x 25) from cylinder head.

Figure 145 Removing cylinder head gasket

NOTE: Place the cylinder head on wood blocks to protect the valves and bottom deck surface.

4. Remove the cylinder head gasket from the crankcase. Discard the gasket.

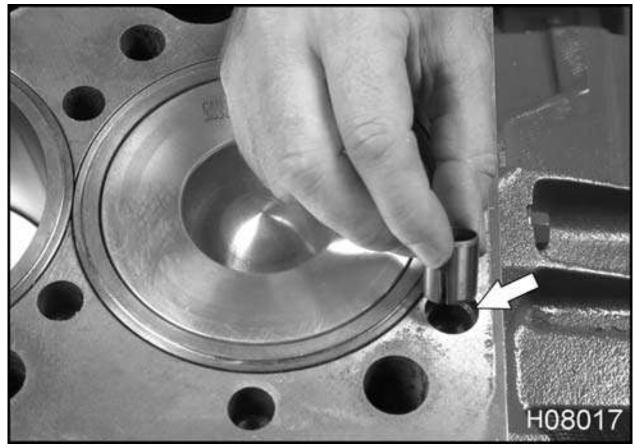


Figure 146 Removing alignment dowels

5. Remove the alignment dowels from the top of the crankcase, only if damaged.

Roller Tappets

Figure 147 Roller tappets and guide

Remove each roller tappet and guide from tappet bore and mark with cylinder number, valve association (intake or exhaust), and roller orientation.

Cleaning

Cylinder Head

CAUTION: To prevent engine damage, leave the valves installed within the cylinder head. This protects the valve seats during the cleaning process.

1. Use a rotary wire brush or a sanding block with mineral spirits to remove any deposits and gasket material from the gasket surface of the cylinder head.
2. Use an appropriately sized brush to clean all mounting bolt holes in the cylinder head.
3. Wash rocker arm assemblies, hydraulic lifters, and push rods in a suitable solvent and dry them thoroughly. Replace any bolts that have damaged threads.

CAUTION: To prevent engine damage, do not use chlorinated solvents on bolts or crankcase tapped holes. Parts should be clean, dry, and free of any chemical residuals other than engine oil.

Inspection

Valve Train Components

Engine valve train load carrying requirements have resulted in the release of several different push rod and tappet configurations. The main differences are improved geometry designs and materials.

For information on push rod and tappet compatibility for different engine model year configurations, see (TSI-06-12-14 Update Valve Train Components – Push Rod and Tappet Compatibility, page469) .

Push Rods

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

1. Thoroughly clean each push rod using a suitable solvent and dry rods using filtered compressed air .
2. Inspect each push rod for wear at both ends. If push rod is worn, install new push rod.

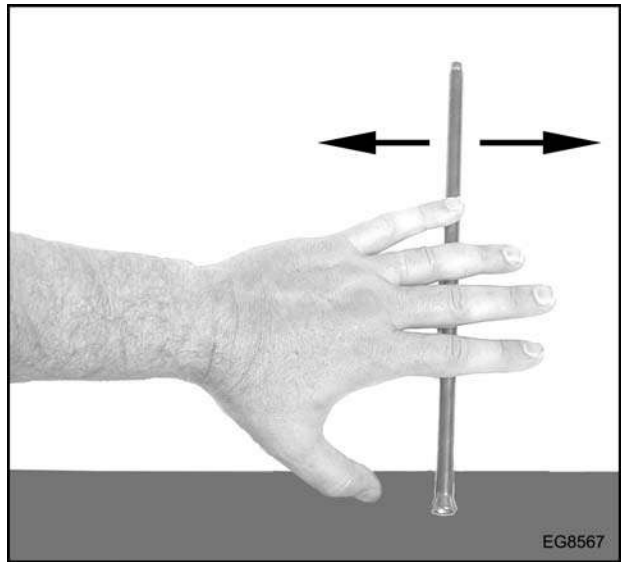


Figure 148 Check push rods for straightness

3. Check all push rods for straightness by rolling push rods on a flat surface with the cap end over the edge of the flat surface.
4. Measure push rod runout with a feeler gauge (page156) between the flat surface and push rod.
5. If specifications (page 154) are exceeded, install new push rod.

Rocker Shaft

CAUTION: To prevent engine damage, if it is necessary to replace the rocker shaft, all of the rocker arms must be replaced. Reusing rocker arms on a new shaft will not allow for an adequate break-in period, causing premature failure of the rocker arm assembly.

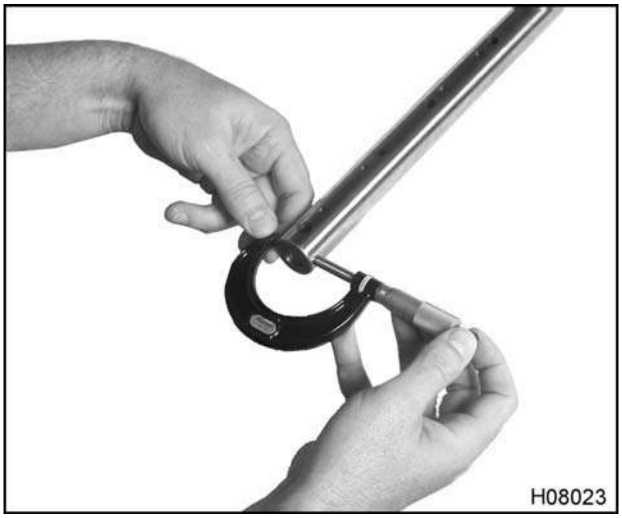


Figure 149 Measuring rocker arm shaft

1. Check the rocker shaft for scoring, pitting and wear. Replace rocker shaft and all of the rocker arms as required.

NOTE: It is normal to see a slight polishing at the rocker arm area.

2. Use an outside micrometer to measure a non-contact area of the rocker shaft. This dimension will be used as a baseline for the shaft diameter.
3. Use an outside micrometer to measure each of the 12 lever contact areas of the rocker shaft. If the difference between the baseline and any of the measurements is greater than 0.03 mm (0.001 in), replace the rocker shaft and all of the rocker arms.
4. To ensure that oil supply holes are open, insert a small wire or another suitable tool.
5. Check the cup plugs at each end of the rocker shaft. Do not disturb the cup plugs unless they are damaged. If replacement is required, pry out the plugs and press in new plugs.

Rocker Arms

1. Inspect arms for scoring, pitting, or signs of excessive wear. If the bore has visible damage, replace the rocker arm. Be sure to inspect the lower half of the rocker arm. The most significant wear will occur at this location. Rocker arms may be reused in their original locations if the phosphate coating is worn off and the shaft was not replaced.

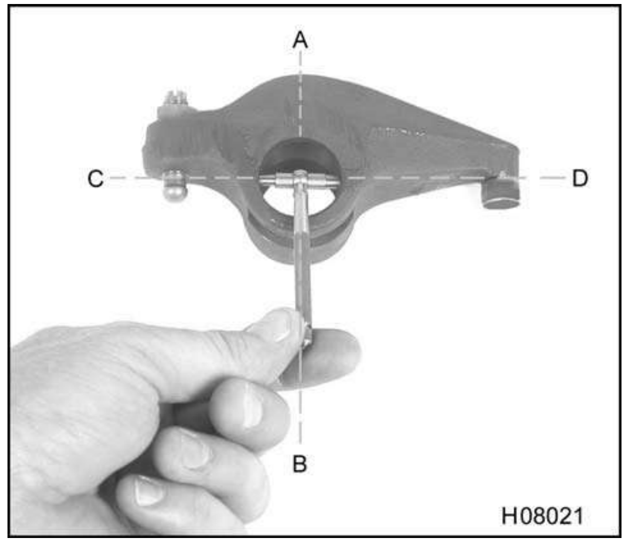


Figure 150 Measuring the rocker arm bore

NOTE: The purpose of the black phosphate coating on the rocker arm is to provide a break-in lubricant between the rocker shaft and rocker arm bore. It is normal to see the black phosphate coatings worn off of the bottom of the lever arm in the shaft and bore contact area. Rocker arms must be labeled and installed in their original locations to maintain the proper wear pattern.

2. Use a telescoping gauge and outside micrometer to measure the rocker arm bore diameter at two locations. Measure the diameter at **A-B** and **C-D**. If the difference between the diameters is greater than or equal to 0.03 mm (0.001 in), replace the rocker arm.
3. Inspect the valve bridge contact pivot on the rocker arm for scoring, pitting, or signs of excessive wear.
4. Inspect the valve lash adjuster for signs of wear. Replace the adjuster screw if excessive wear is found.

Cylinder Head Warpage

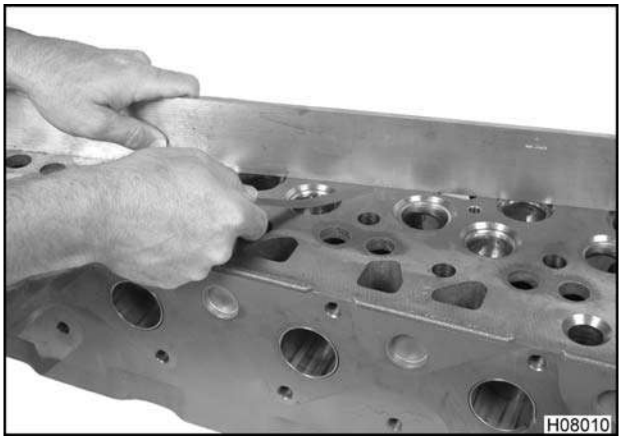


Figure 151 Checking for warpage

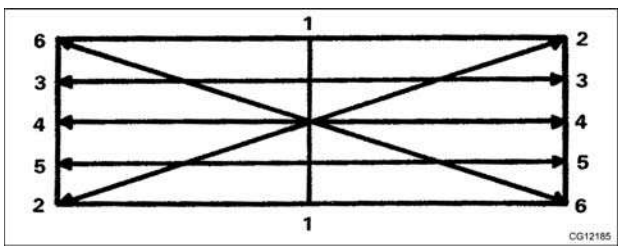


Figure 152 Checking pattern

Use a straightedge and feeler gauge to check the gasket surface of the cylinder head for warpage. Use the checking pattern that is shown. If warpage is present as indicated by a feeler gauge measurements exceeding cylinder head gasket surface flatness specifications, check thickness of cylinder head.

Cylinder Head Thickness

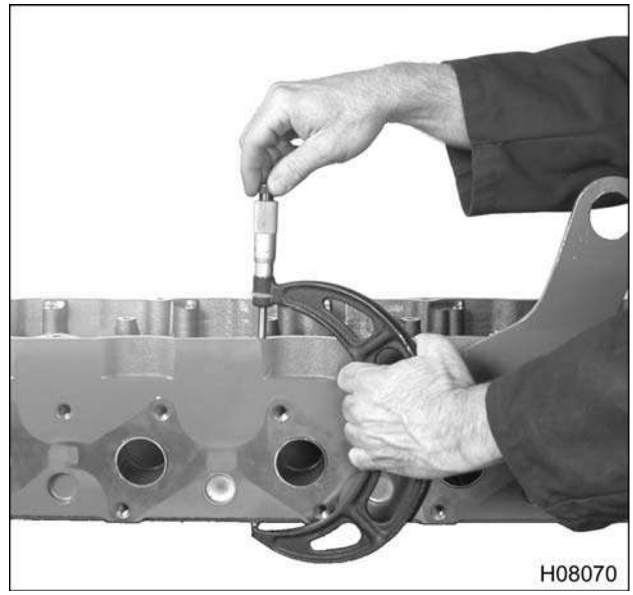


Figure 153 Checking cylinder head thickness

Use a 6-7 inch outside micrometer to measure the thickness of the cylinder head at six locations (four corners and two center points). Cylinder head thickness must equal or exceed the minimum specification after resurfacing. If the minimum specification after resurfacing cannot be met, replace cylinder head.

Valve Seat Leakage

NOTE: This test does not check for the condition of the valve guides or the valve stem-to-valve guide clearance.

1. Position the cylinder head on wood blocks with the gasket surface facing down.
2. Squirt mineral spirits into the intake and exhaust valve ports and wait 5 minutes.
3. Use an inspection mirror to check valve seat area for leakage of the mineral spirits past the valve seats.

   NOTE: If leakage occurs, the valves must be reconditioned.

Cylinder Head Cracking

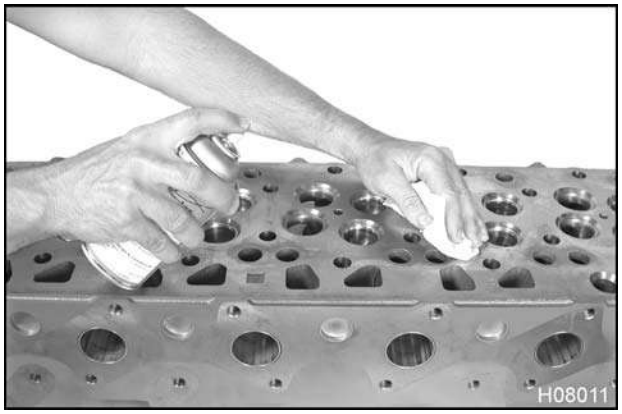


Figure 154 Spraying brake cleaner on cylinder head

NOTE: The cylinder head cracking inspection can be performed with or without valves installed.

1. Spray brake cleaner on the gasket surface of the cylinder head and wipe it dry.

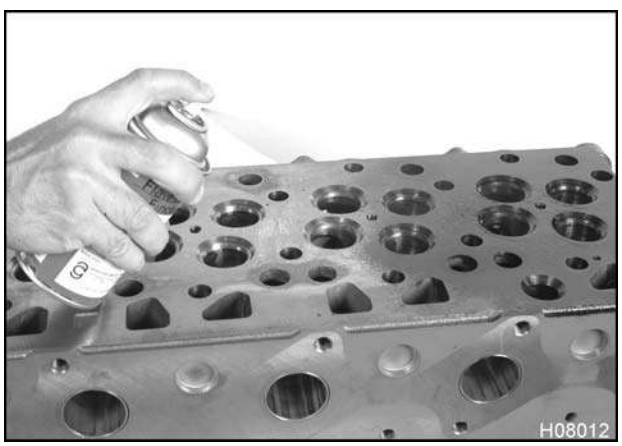


Figure 155 Spraying dye penetrant on cylinder head

2. Spray dye penetrant on the gasket surface of the cylinder head. Leave the dye penetrant on for 1-10 minutes.

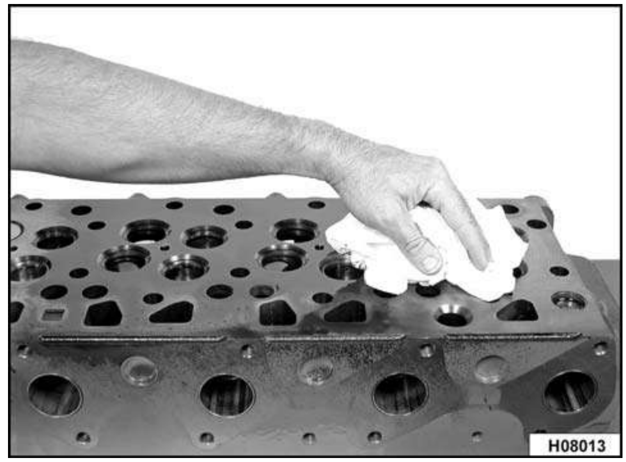


Figure 156 Wiping dye penetrant off cylinder head

3. Wipe off dye penetrant. The dye will remain in any cracks in the cylinder head.

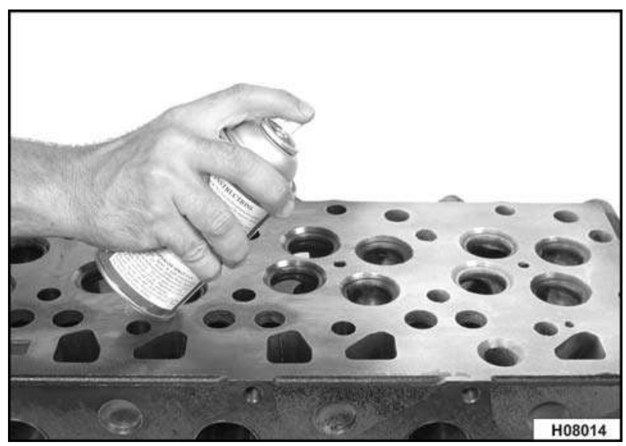


Figure 157 Spraying developer on cylinder head

4. Spray developer on the gasket surface of the cylinder head. Allow the developer to dry for 5-15 minutes.

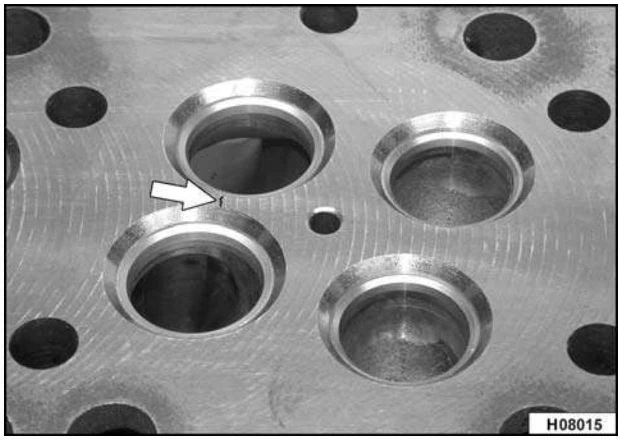


Figure 158 Crack in cylinder head

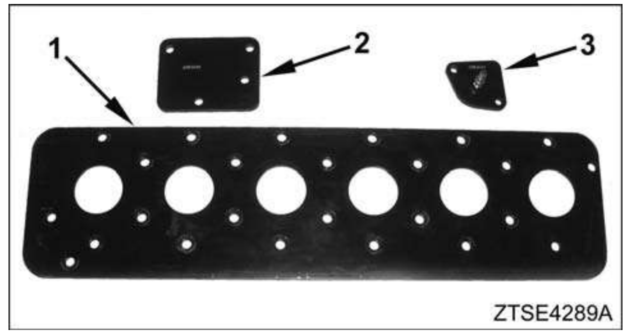


Figure 159 Cylinder head pressure test tools

1. Cylinder head test plate (bolts not shown)
2. Water supply housing pressure adapter
3. Thermostat opening pressure adapter- cylinder head

NOTE: Any cracks will show up as purple lines against the white developer. If any cracks are present, replace the cylinder head.

Pressure Check Cylinder Head

Pressure testing the cylinder head will reveal cracks in ports or sleeve leakage which cannot be observed using dye penetrant. Pressure-test the cylinder head as follows:

1. Install fuel injectors into cylinder head injector bores and secure. Refer to Fuel Injectors (Fuel Injectors, page352) for installation procedure.
2. Remove the valves, using a valve spring compressor. See “Reconditioning” in this section for valve removal instructions.
3. Pressure test the cylinder head using the cylinder head pressure test tools (Table 17).
4. Fasten the pressure plate to the cylinder head gasket surface using the 24 mounting bolts and nuts supplied with the kit.

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

5. Remove thermostat and install air regulator. Secure to cylinder head with two mounting bolts.
6. Remove the pipe plug next to the thermostat opening. Fill cylinder head with hot water and reinstall pipe plug
7. Install a hose fitting to the cylinder head at the removed plug. Apply 124–138 kPa (18–20 psi) air pressure and inspect for leaks at the:
   - Fuel injector nozzle sleeve area
   - Ports
   - Upper deck
   - Lower deck

If leakage is observed at any port or the upper and lower deck, replace the cylinder head.

Reconditioning

Removing Valves from Cylinder Head

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, wear safety glasses when removing valves or valve spring retainer keys.

1. Install a valve spring compressor tool over the valve, see Cylinder head and valve special service tools (Table 17). Compress the valve spring.

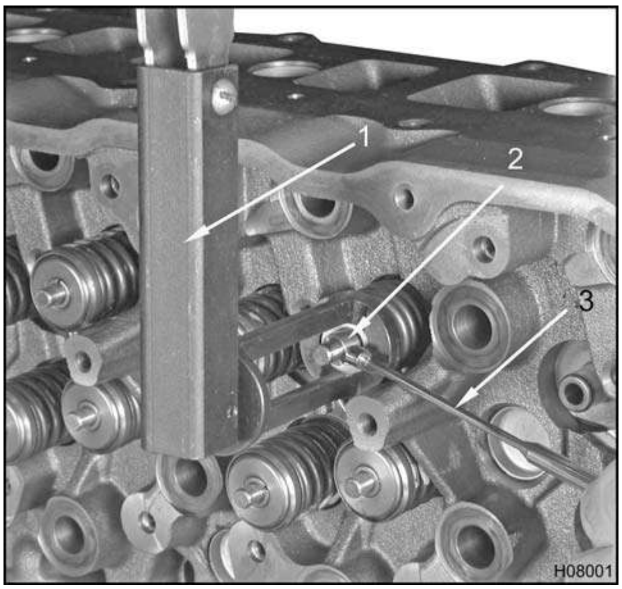


Figure 160 Removing valve spring retainer keys

1. Valve spring compressor tool
2. Valve spring retainer key
3. Magnet

2. Use a magnet to remove the valve spring retainer keys.

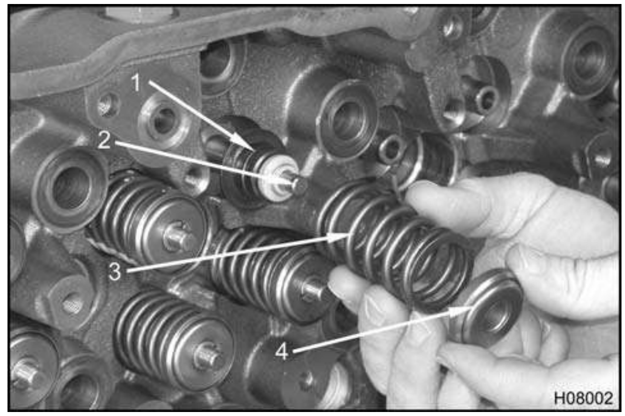


Figure 161 Removing valve rotator, spring, and valve stem seal

1. Valve stem seal
2. Valve stem
3. Valve spring
4. Valve rotator

3. Remove valve spring compression tool, valve rotator, and spring.
4. Remove and discard valve stem seal.
5. Remove valve from the cylinder head.
6. Repeat steps 1-5 for all 24 valve locations.

Inspecting Valve Guides

Figure 162 Cleaning valve guides

1. After removing valves, use soap, water, and a nylon brush to clean valve guides.

2. Position an inspection light at the bottom of the valve guide bores. Inspect bores for signs of burning or cracking. Replace any valve guides that are damaged.

Figure 163 Measuring valve guide with ball gauge

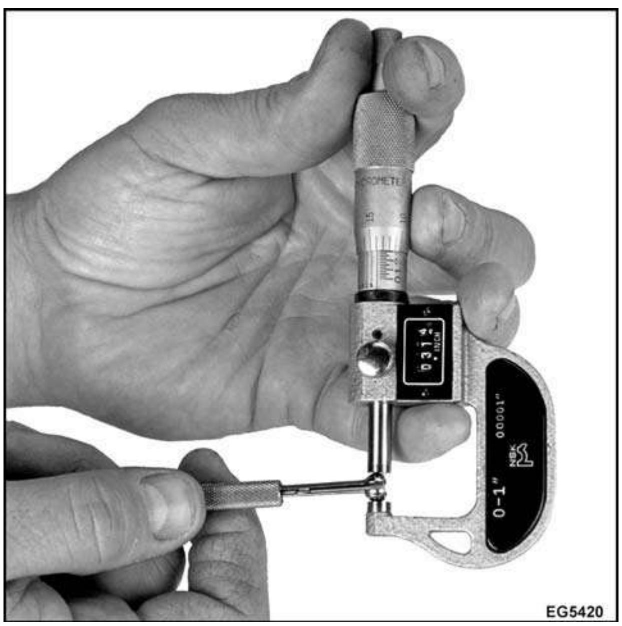


Figure 164 Measuring ball gauge with an outside micrometer

3. Use a ball gauge and an outside micrometer to measure the inside diameter of each valve guide.

   If inside diameter of valve guide exceeds specifications, replace valve guide.

4. Measure the valve guides within 0.64 mm (0.025 in) of each end and 90 degrees from the crankshaft center line. Record the readings in order to determine the valve-to-guide running clearance later.

Replacing Valve Guides

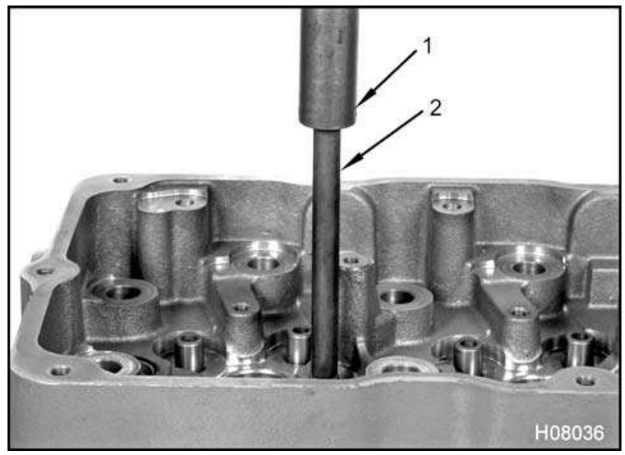


Figure 165 Pressing out valve guide insert

1. Arbor press ram
2. Valve guide removal tool

1. Secure the cylinder head on a press table. Align the valve guide to be replaced with the center of the press ram.
2. Insert the valve guide removal tool into the valve guide from the top side of the cylinder head. Press out the valve guide insert.

CAUTION: To prevent engine damage, do not use a hammer or any other tool to remove or install the valve guide inserts into the cylinder head.

NOTE: Chilling the valve guide inserts first may facilitate installation.

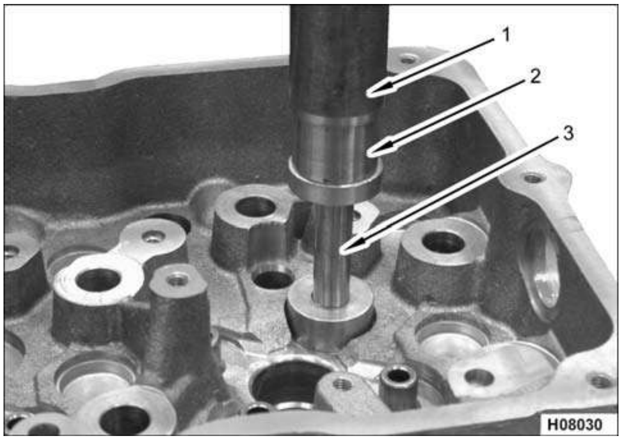


Figure 166 Pressing in the valve guide insert

1. Arbor press ram
2. Valve guide installation tool
3. Valve guide insert

3. Lubricate a new valve guide insert with clean engine oil. Use the valve guide installation sleeve to install the valve guide insert until the installation sleeve bottoms out against the cylinder head.

NOTE: Do not ream the inside diameter of the valve guide after installation. Service valve guides are provided in a finish reamed condition.

4. After installing the valve guide insert, debur the valve guide by using the valve guide deburring tool.

Inspecting Valves

1. Remove all carbon deposits from the valve stems and valve heads.
2. Inspect each valve for burn marks, warpage, scuffing and bending. Replace any damaged valves.

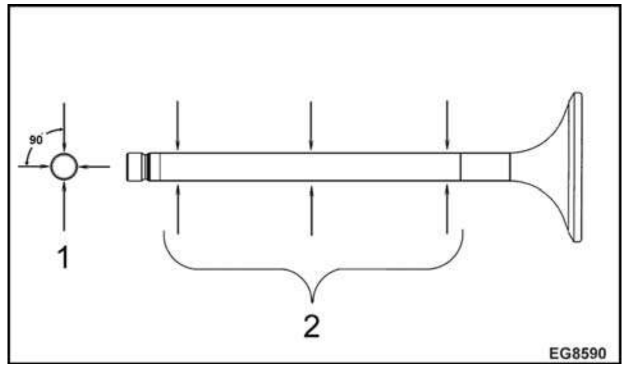


Figure 167 Measuring valve stem diameter

1. Two measurements 90 degrees apart
2. Valve stem diameter measurement locations

3. To check for wear, use a micrometer to measure the diameter of each valve stem.
4. Measure the valve stem diameter at two locations that are approximately equidistant. At each location, take two measurements that are 90 degrees apart. Average the two measurements at each location and record the readings.

   If the average of measurements at any of the two locations exceed the valve stem diameter specification, replace the valve.
5. Inspect the valve stem tip for scoring, pitting, or signs of excessive wear.
6. Using the valve stem diameter and valve guide inside diameter measurements, recorded earlier (see “Inspecting Valve Guides”) determine valve stem-to-guide running clearance. See “Specifications”. Replace the valve or valve guides as required.

NOTE: Subtract the average valve stem diameter from the average valve guide inner diameter (determined earlier).

Valve Guide – Valve Stem = Running Clearance.

Refacing Valves

Valve Face

NOTE: If the valves are in serviceable condition, they may be refaced to the specified angles, as required.

CAUTION: To prevent engine damage, maintain the minimum valve face margin across the entire valve face. An insufficient valve face margin will not provide proper heat dissipation, ultimately causing the valve to warp or break.

NOTE: Make sure that there is sufficient coolant in the valve grinding machine reservoir. Turn coolant pump on before grinding.

1. Use the dressing stud attachment on the grinder to dress the cutting stone.

Figure 168 Grinding valve face

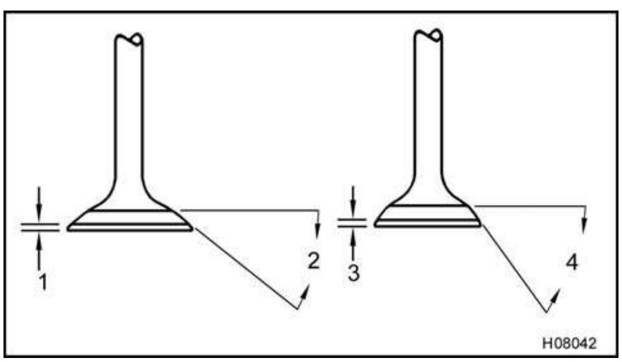


Figure 169 Valve face angles

1. Intake margin
2. Intake valve angle
3. Exhaust margin
4. Exhaust valve angle

NOTE: Intake valves and exhaust valves have different valve face margins.

2. Install valve in the grinder and set the grinder to the specified angle.
3. Turn on coolant and grinder.

NOTE: Removal of too much material may reduce the margin below minimum specifications.

4. Grind the valve face. Only remove the minimum amount of material necessary.

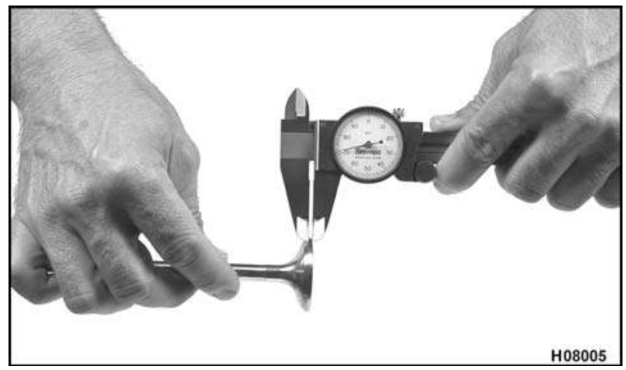


Figure 170 Measuring valve face margin

5. Use a caliper to measure the valve face margin at four locations. If any of the measurements are less than the minimum specification (Table 13), replace valve.

Valve Stem Tip

CAUTION: To prevent engine damage, leave a sufficient amount of material so that the valve bridge does not contact the valve retainer keys or valve rotator during operation. Refacing the tip of the valve stem provides a new wear surface for the valve bridge.

1. Use the dressing stud attachment on the grinder to dress the cutting stone.

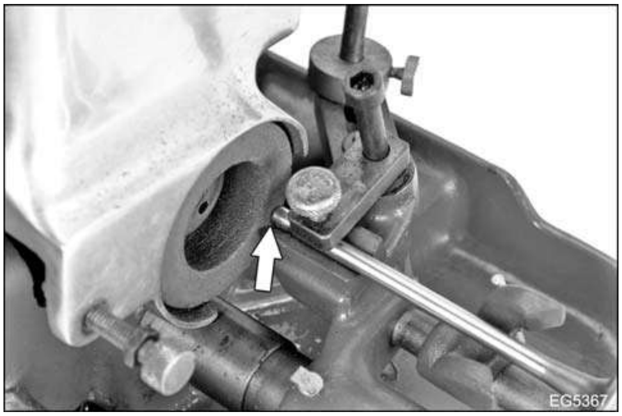


Figure 171 Grinding valve stem

2. Install the valve in the grinder so that the tip of the valve stem is close to the grinding stone.
3. Briefly touch the tip of the valve stem to the grinding stone. Only remove the minimum amount of material that is necessary.

Checking Valve Face-to-Valve Seat Contact

Figure 172 Applying Prussian Blue® to valve face

1. After refacing a valve, spread a thin film of Prussian Blue® on the valve face and insert the valve in the valve guide.

Figure 173 Turning valve on valve seat

2. Apply pressure on the center of the valve head while turning the valve 90 degrees on the valve seat.
3. Remove the valve from the cylinder head. Check the impression that was made on the valve seat and valve face. Prussian Blue should appear around the entire contact surface of the valve seat and valve face.
4. Perform this check several times to rule out any errors. If the Prussian Blue® contact impression is good, proceed to valve installation. If the Prussian Blue® contact impression is not good, continue with resurfacing valve seats.

Resurfacing Valve Seats

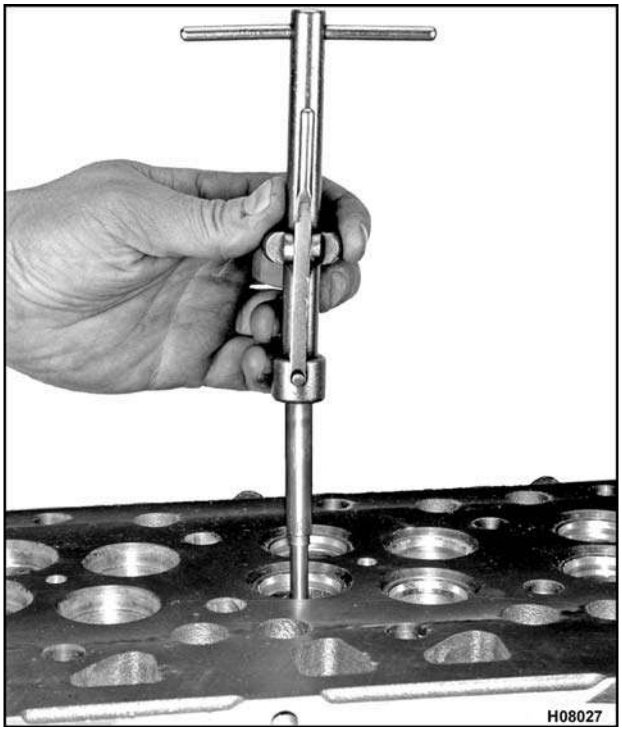


Figure 174 Installing valve guide pilot

1. Lightly lubricate the correct size of grinding pilot. Install the pilot into the valve guide.
2. Choose the correct angle grinding stone and dress the stone. See “Specifications” for the correct valve seat angle.
3. Install the grinding stone over the pilot.

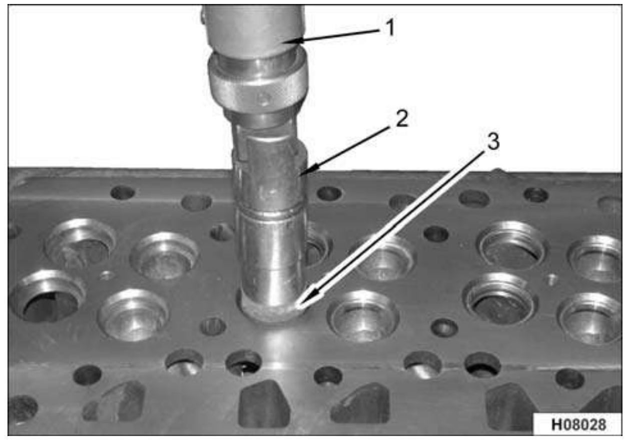


Figure 175 Grinding the valve seat

1. Motor and drive
2. Holder
3. Grindstone

4. Turn on the power and gently apply the weight of the grinding motor to the grindstone. Raise the grinding stone frequently to prevent overheating. Grind the valve seat to a smooth even finish, paying attention to achieving an acceptable uniform width (Table 15).

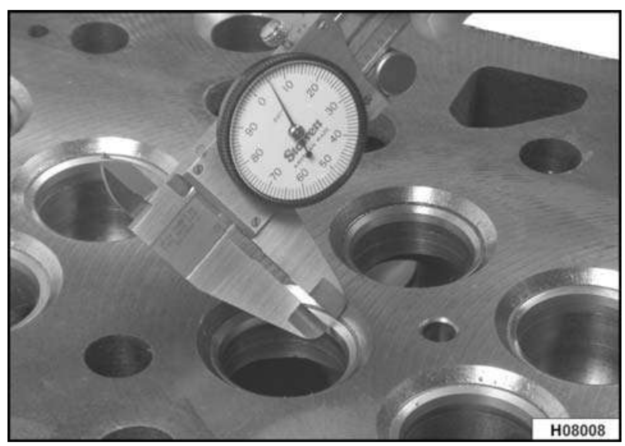


Figure 176 Checking valve seat width

5. Use a caliper to check the valve seat width. If the valve seat width exceeds specifications, the valve seat may be corrected by grinding with a 15 degree or smaller angle stone.

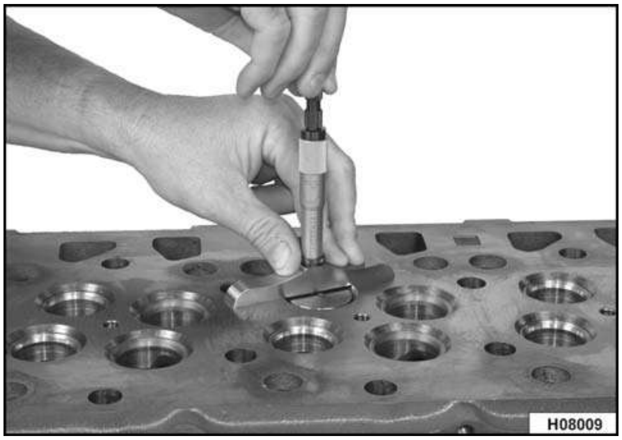


Figure 177 Checking valve recession

6. Install valve in guide. Use a depth micrometer to check valve recession. If valve recession is excessive, install a new valve or replace valve seat as necessary. If the valve protrudes above the surface of the cylinder head, regrind the valve seat. After grinding the valve seat, check valve seat width again. Also check the valve face-to-valve seat contact (Checking Valve Face-to-Valve Seat Contact, page 134).
7. Use an appropriate dial indicator to check the valve seat runout. If runout exceeds specifications, replace valve seat.

Replacing Valve Seats

Removal

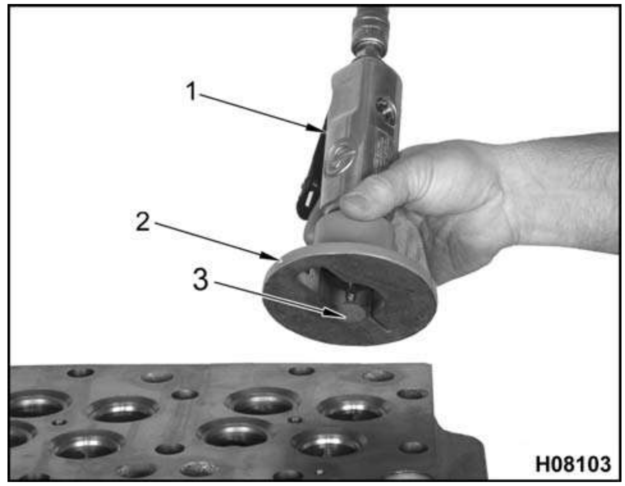


Figure 178 Grinding group tool

1. Air motor
2. Grinding base
3. Grinding wheel

1. Use grinding group tool (Table 17) to cut a groove in the valve seat insert.

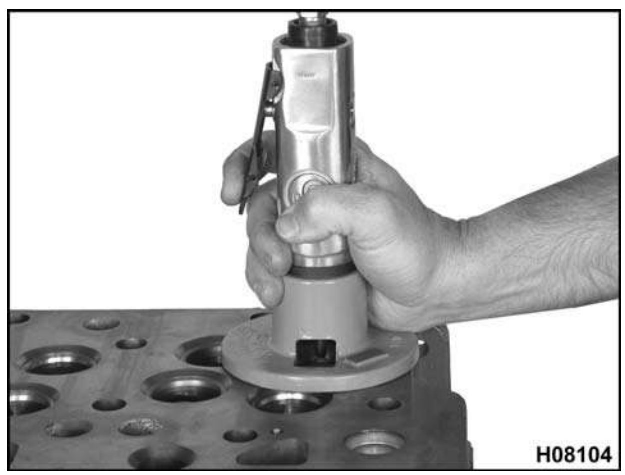


Figure 179 Grinding groove in valve seat

2. Position the appropriate size extractor in the valve seat.

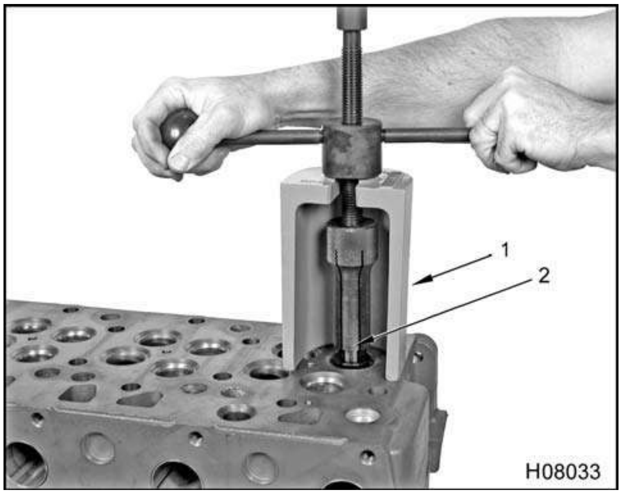


Figure 180 Removing the valve seat insert

1. Lifting bridge
2. Valve seat remover (collet)

3. Expand collet by threading the shaft into the valve seat remover until it is tight inside the valve seat. Turn T-handle on shaft to pull the valve seat insert from cylinder head.

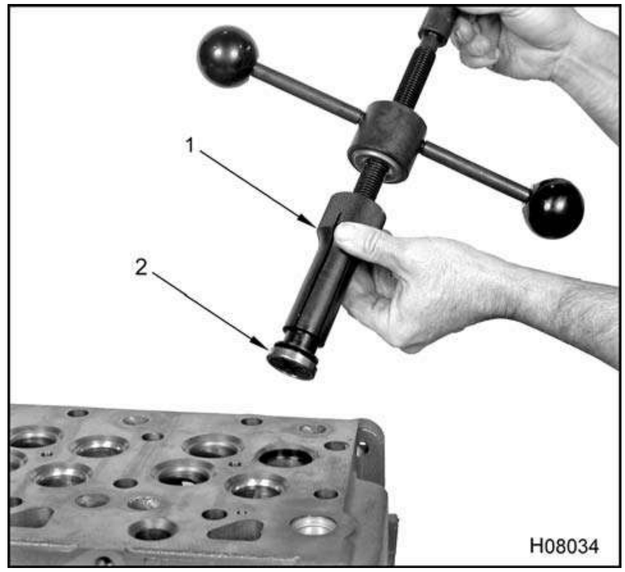


Figure 181 Valve seat insert removed

1. Collet
2. Valve seat insert

4. Unlock the collet by loosening the threaded shaft. Discard valve seat insert.

Installation

1. Use a micrometer to measure the diameter of the valve seat insert counterbore at two locations, 90° apart. Average the two measurements to determine the appropriate size valve seat insert to install.

Table 12 Valve Seat Insert Selection Chart

Available inserts (int. and exh.)	Ave. dia. of intake counterbore	Ave. dia. of exhaust counterbore
Standard	40.119 - 40.170 mm (1.5795 - 1.5815 in)	37.478 - 37.529 mm (1.4755 - 1.4775 in)
Oversize - 0.05 mm (0.002 in)	40.170 - 40.221 mm (1.5815 - 1.5835 in)	37.529 - 37.579 mm (1.4775 - 1.4795 in)

2. Chill the valve seat insert in a freezer for 30 minutes. This will prevent the outer layer of metal from being shaved off during installation.

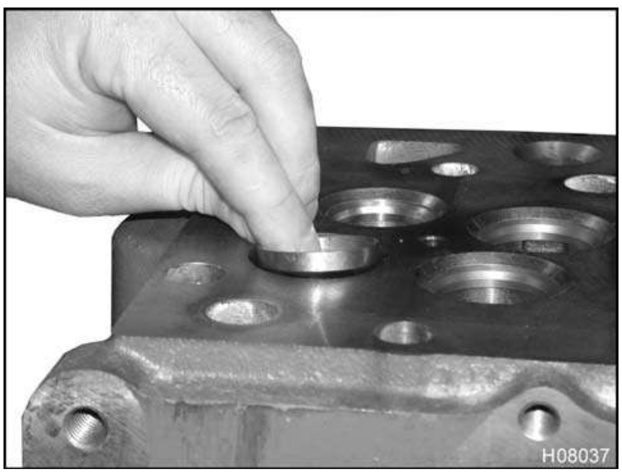


Figure 182 Placing chilled valve seat into head

3. Align insert over counterbore to avoid misalignment.

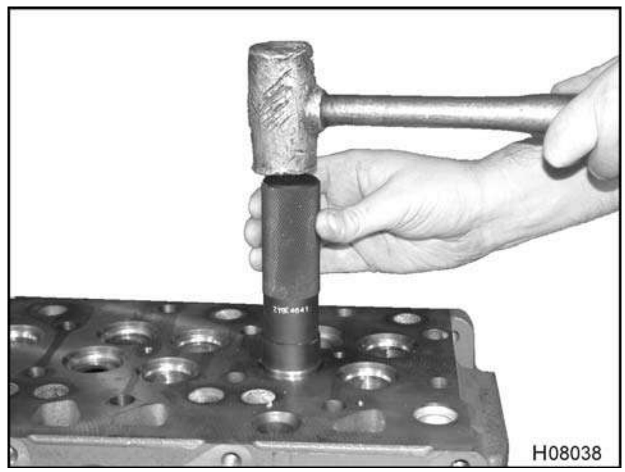


Figure 183 Driving valve seat into place

4. Using a hammer and valve seat installation tool drive the valve seat into place until it is fully seated. See Cylinder head and valve special service tools (Table 17).
5. Grind new valve seats to the specified angles and widths, see Cylinder Head Specifications (Table 15) in this section.

Inspecting Valve Springs

1. Clean all of the valve springs in a suitable solvent.

CAUTION: To prevent engine damage, do not wire brush or grind valve springs. Disruption of surface may result in fatigue cracks and spring failure.

2. Check the valve springs for rust, cracks, and pitting. Replace any damaged valve springs.

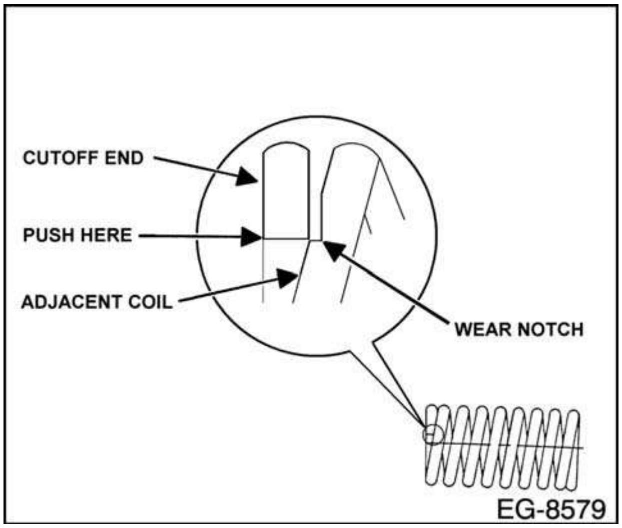


Figure 184 Valve spring inspection

3. Check both ends of each valve spring at the contact point between the cutoff end of the last coil and the adjacent coil. If the cutoff end has worn a notch in the adjacent coil, replace the spring.

NOTE: These wear notches can also be detected by compressing the spring and listening for a clicking sound.

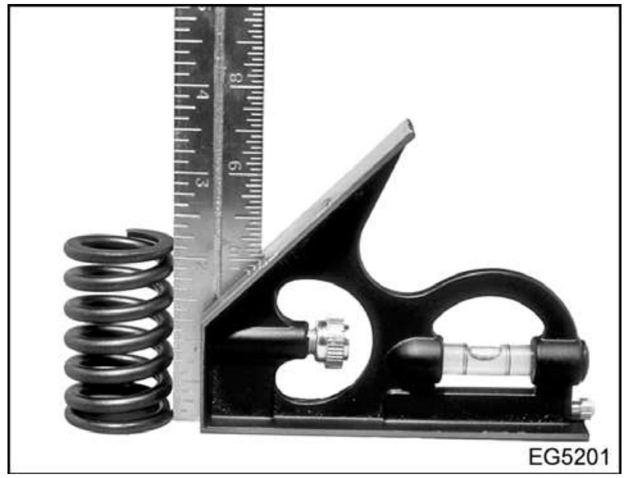


Figure 185 Checking perpendicularity and flatness of valve spring

NOTE: Valve springs that are not perpendicular to a flat surface place an unequal lateral load on the valve stem during operation, causing premature valve guide wear.

4. Use a square to check flatness and perpendicularity of spring ends. If the end of any valve spring is not flat and square, replace spring.

Figure 186 Measuring valve spring tension

5. Use a Valve Spring Compressor (Table 17) to measure the valve spring tension. Measure the maximum and minimum lengths of the spring at the appropriate test loads (valve closed and valve open). Replace any valve spring that does not meet valve spring specifications (Table 14).

Inspecting Valve Rotators

1. Clean all valve rotators in a suitable solvent.

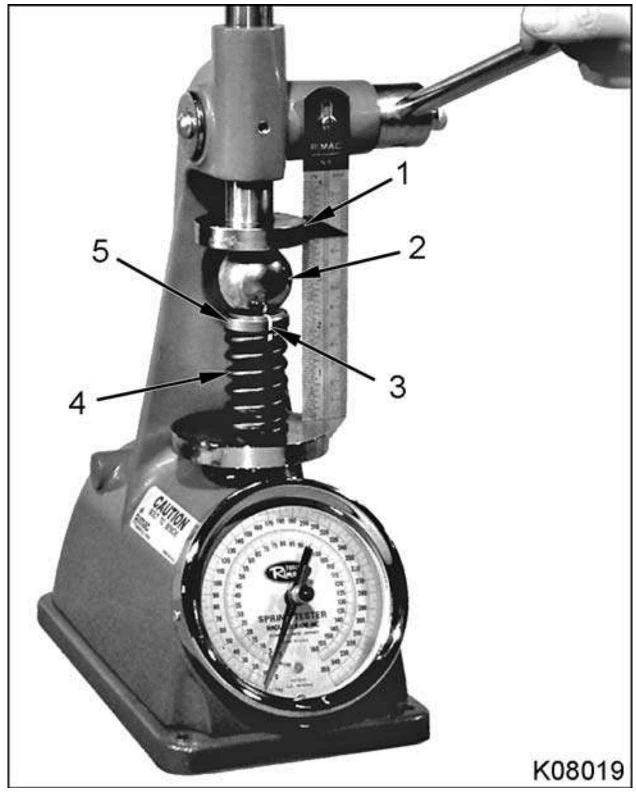


Figure 187 Checking valve rotator

1. Ram
2. Steel ball bearing
3. Paint reference line
4. Spring
5. Valve rotator

2. Lubricate the valve rotator with clean engine oil. Place the valve spring and rotator in spring tester.
3. Place a ball bearing between the valve rotator and the ram of the spring tester. The ball bearing must be large enough to prevent the ram from touching any part of the rotator.
4. Paint a reference line on the valve rotator and spring.
5. Compress the valve spring rapidly with even pressure and observe the valve rotator as it turns. Replace any valve rotator that does not turn.

Inspecting Valve Spring Retainer Keys

1. Clean all valve spring retainer keys with a suitable solvent.
2. Check the inside and outside of the valve spring retainer keys for wear. Replace any worn retainer keys.

Replacing Fuel Injector Sleeves

Removal

NOTE: If the fuel injector sleeve is being removed while the engine is in-chassis, place a cup plug in the bore before removal to prevent debris from entering the cylinder bore.

1. Insert the fuel injector sleeve removal tool into the fuel injector bore.
2. Turn the removal tool to cut threads into the fuel injector sleeve. Remove the tool from the bore.
3. Install the fuel injector sleeve puller tool into the bore and tighten. Make sure that the puller tool is threaded all the way into the fuel injector sleeve.
4. Install a slide hammer onto the puller tool. Remove the fuel injector sleeve from the bore.

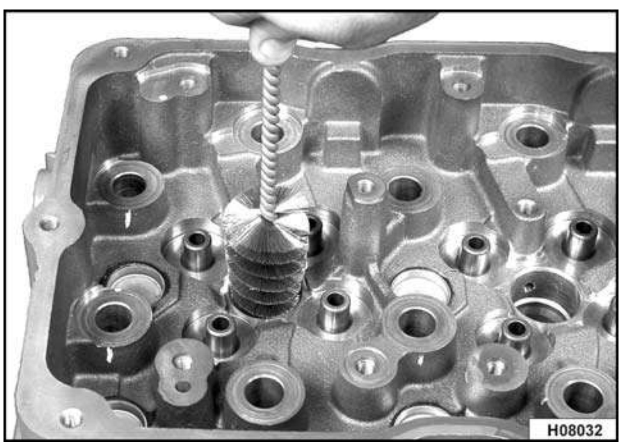


Figure 188 Cleaning fuel injector bore

5. Use a stiff wire brush to clean deposits and hardened sealant from the fuel injector bore.
6. Insert a small stiff nylon brush tool into oil gallery for cleaning.

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

7. Use compressed air to clean out all fuel and oil galleries of debris.

Installation

1. Inspect installation tool for a bent pilot shaft or any nicks where sleeve will seat

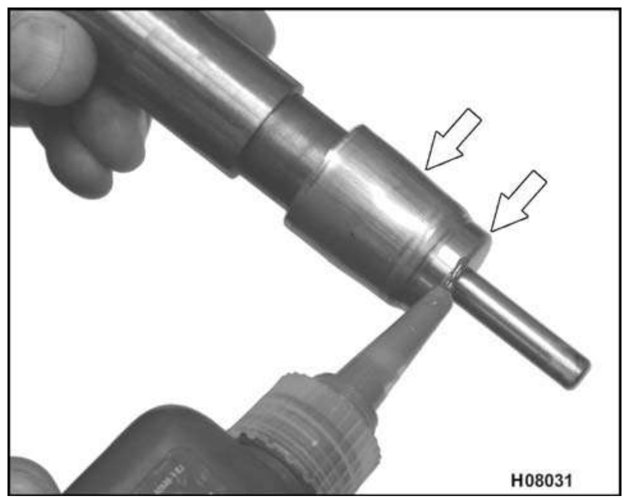


Figure 189 Applying Loctite® 620 sealant to fuel injector sleeve

2. Place a new fuel injector sleeve on the end of the installation tool. See cylinder head and valve special service tools (Table 17).

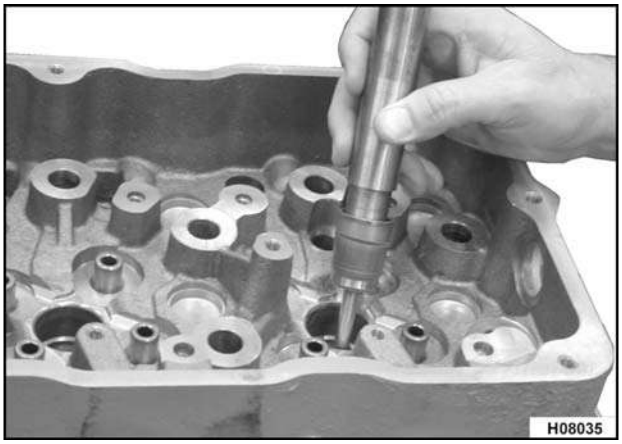


Figure 190 Installing fuel injector sleeve into bore

3. Apply Loctite® 620 around the outside diameter at the bottom of the sleeve and around the beginning of the taper at the middle of the sleeve.

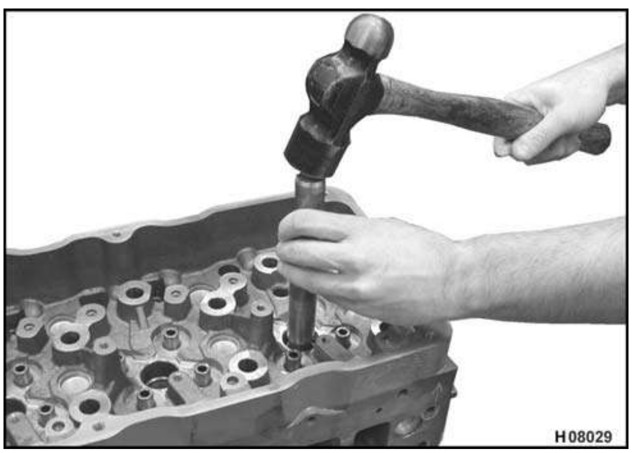


Figure 191 Installing fuel injector sleeve

4. Install the sleeve and installation tool into the fuel injector bore.
5. Use a hammer to drive the fuel injector sleeve into the bore. Remove the installation tool when the sleeve is seated.
6. Use a soft nylon brush to clean the fuel injector sleeve after installation.
7. Inspect the inside surfaces of the installed fuel injector sleeve. If nicks and scratches are evident, replace the sleeve again. Make sure that the installation tool is not causing such damage. Use a different installation tool, if necessary.

Installing Valves

Cleaning

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

1. Clean the valve faces and seats with a suitable cleaning solvent. Dry all components using filtered compressed air.
2. To clean valve guides, coat a brush with soap and water. Insert the brush into each valve guide bore and rotate in one direction with an up and down motion. Dry the valve guide bores using filtered compressed air.
3. Insert a large nylon brush in the rear of the fuel rail gallery to loosen any dirt and deposits. Blow out any debris using filtered compressed air.

Assembly

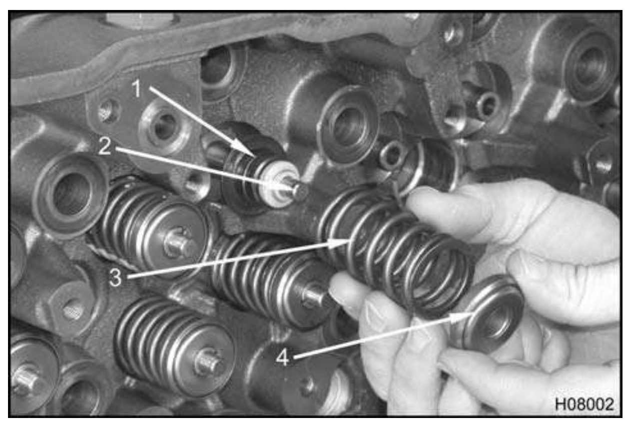


Figure 192 Installing valve stem seal, spring, and valve rotator

1. Valve stem seal
2. Valve stem
3. Valve spring
4. Valve rotator

1. Lubricate the valve stems with clean engine oil and insert into the valve guides.

2. Lubricate the inside diameter of the new valve stem seals with clean engine oil. Install the seals over the valve stems and valve guides. Make sure that the seals are completely seated against the cylinder head spring pockets.
3. Install the valve springs over the valve stem seals.
4. Then install the valve rotators on top of the valve springs.

WARNING: To prevent serious personal injury or possible death, wear safety glasses before using the valve spring compressor.

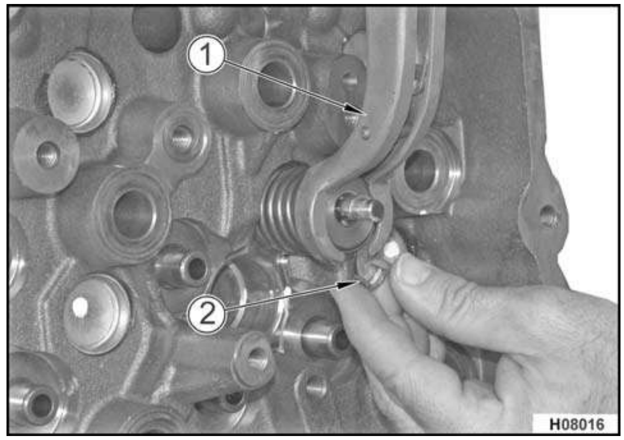


Figure 193 Installing valve spring retainer keys

1. Valve spring compressor tool
2. Valve spring retainer key

5. Install a valve spring compressor tool over the valve. See cylinder head and valve special service tools (Table 17). Compress the valve spring.
6. Install the valve spring retainer keys.

Installation

Roller Tappets

Figure 194 Roller tappets and guide

1. Lubricate roller tappets with clean engine oil.
2. Install each roller tappet and guide into tappet bore. Install used roller tappets in their original locations, revolving in the same direction as before removal.

Installing the Cylinder Head

NOTE: Before cylinder head installation, check cylinder sleeve protrusion (Checking Cylinder Sleeve Protrusion, page229).

1. Install two lifting eyes with four bolts (M12 x 25) onto cylinder head. Tighten bolts to the standard torque value (General Torque Guidelines, page 445).
2. Clean and dry the cylinder head gasket surface. Also use the correct size tap to clean head bolt holes in the crankcase.

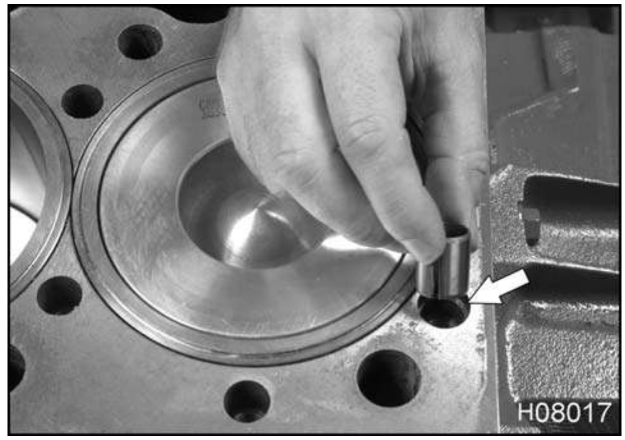


Figure 195 Installing alignment dowels

3. Install or verify that alignment dowels are in the top of the crankcase.

Figure 196 Installing cylinder head gasket

1. Alignment dowels

4. Install a new cylinder head gasket over the alignment dowels.

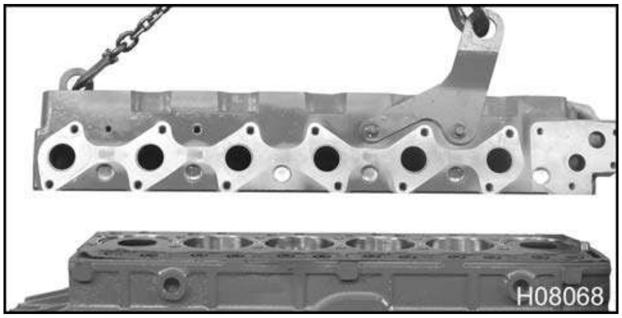


Figure 197 Lowering cylinder head onto crankcase

5. Attach an appropriate hoist and lifting hooks to the lifting eyes. Carefully lower the cylinder head onto the crankcase.

Torque-to-Yield Procedure for Cylinder Head Bolts

CAUTION: To prevent engine damage, do not reuse cylinder head bolts; install new bolts.

NOTE: Do not use chlorinated solvents on cylinder head bolts. Parts should be clean, dry, and free of chemicals other than engine oil.

1. Lightly lubricate threads and bolt flange of new 26 cylinder head bolts with clean engine oil.
2. Install all new cylinder head bolts finger tight.

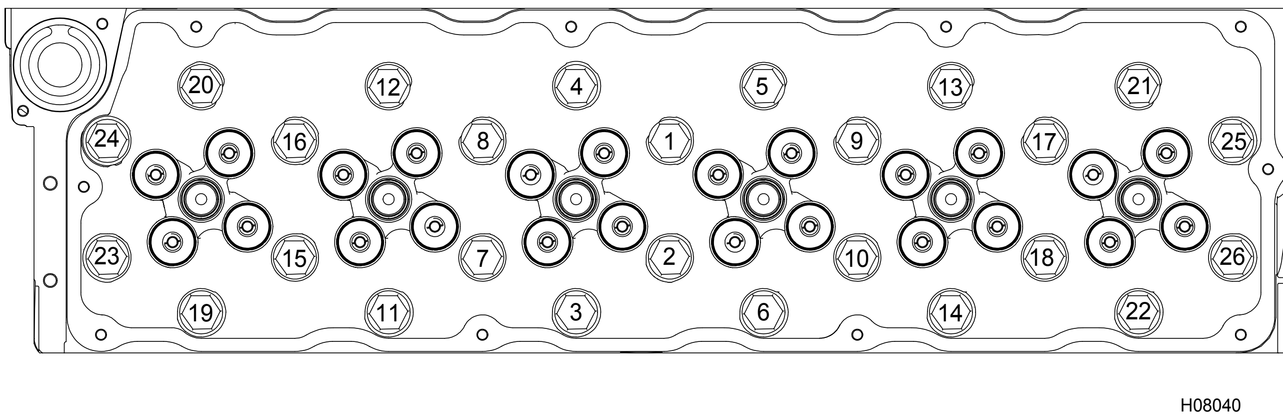


Figure 198 Torque sequence A for cylinder head bolts

3. Tighten each cylinder head bolt to 204 N·m (150 lbf·ft) in cylinder head torque sequence A.

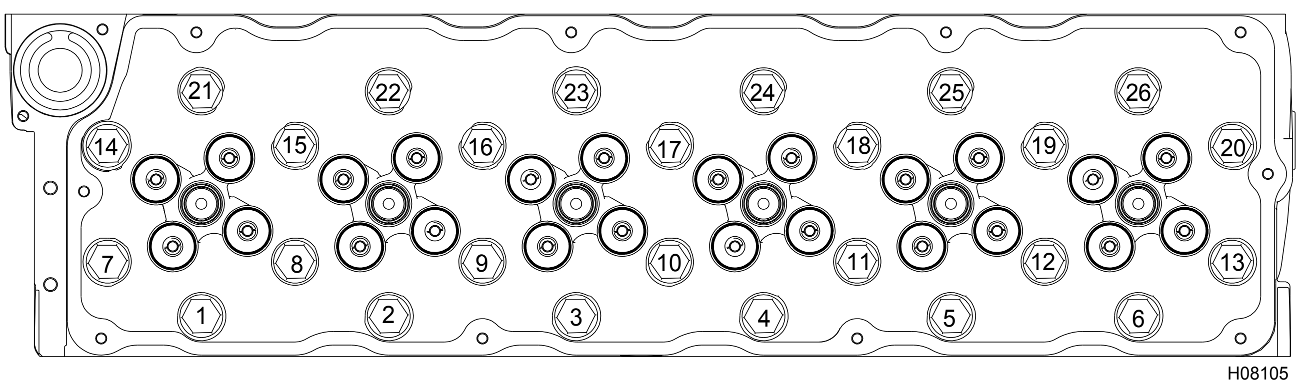


Figure 199 Torque sequence B for cylinder head bolts

4. Tighten each cylinder head bolt to 204 N·m (150 lbf·ft) in cylinder head torque sequence B.

NOTE: It is necessary to tighten cylinder head bolts in both sequence A and B to obtain uniform head bolt torque.

CAUTION: To prevent engine damage, use permanent marker to identify internal engine components and their orientation. Do not use paint or temporary markers.

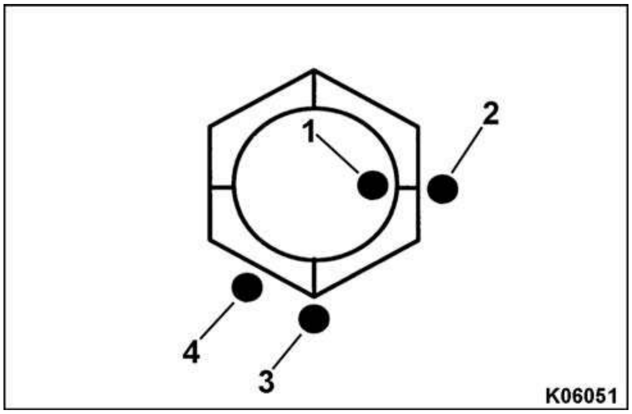


Figure 200 Cylinder head and head bolt torque markings

1. Mark on cylinder head bolt
2. Mark on cylinder head surface next to head bolt mark
3. Mark on cylinder head surface 90° CW from head bolt mark
4. Mark on cylinder head surface 120° CW from head bolt mark

5. Using permanent marker, place a mark on each head bolt and put another mark on the head bolt socket directly in line with the mark on each head bolt. Put another mark on the cylinder head surface next to the head bolt mark. (Figure 200) Items 1 and 2
6. Place a mark on the cylinder head surface 90 degrees clockwise (CW) from each head bolt mark. (Figure 200) Item 3
7. Place a mark on the cylinder head surface 120 degrees (two hex flats) CW from each head bolt mark. (Figure 200) Item 4
8. Install head bolt socket on head bolt to be torqued (Cylinder head bolt torque sequence B) and align mark on socket with the mark on the head bolt.

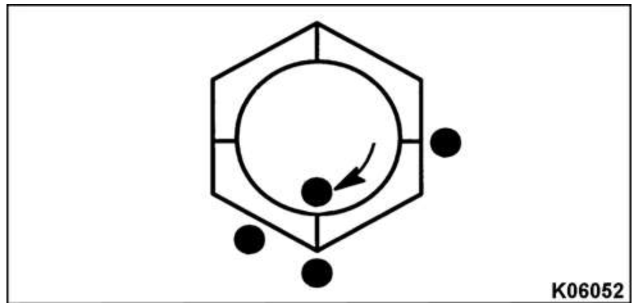


Figure 201 Head bolt rotated 90° CW

9. Rotate cylinder head bolt 90 degrees CW (1/4 turn). The marks on the head bolt socket, head bolt, and cylinder head surface should align.
10. Repeat steps 8 and 9 for each cylinder head bolt in cylinder head bolt torque sequence B.

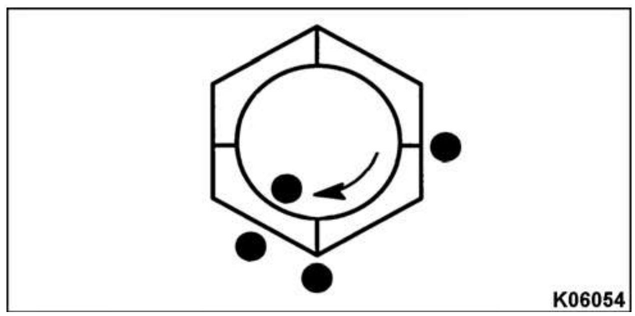


Figure 202 Head bolt rotated 120° CW

11. Rotate each cylinder head bolt an additional 30 degrees CW in cylinder head bolt torque sequence B for a total of 120 degrees (two hex flats). The marks on the head bolt socket, head bolt, and cylinder head surface should align.

Valve Train Components

Engine valve train load carrying requirements have resulted in different push rod and tappet configurations. The main differences are noted by improved geometry designs and materials.

For information on push rod and tappet compatibility for different engine model year configurations, see (TSI-06-12-14 Update Valve Train Components – Push Rod and Tappet Compatibility, page469).

A small geometry adjuster kit provides a replacement large geometry rocker shaft assembly with small geometry adjuster screws that can be used with existing small geometry push rods and tappets. See (TSI-06-12-21 Update Valve Train Components – Adjuster Screws, page474).

Installing Rocker Arms

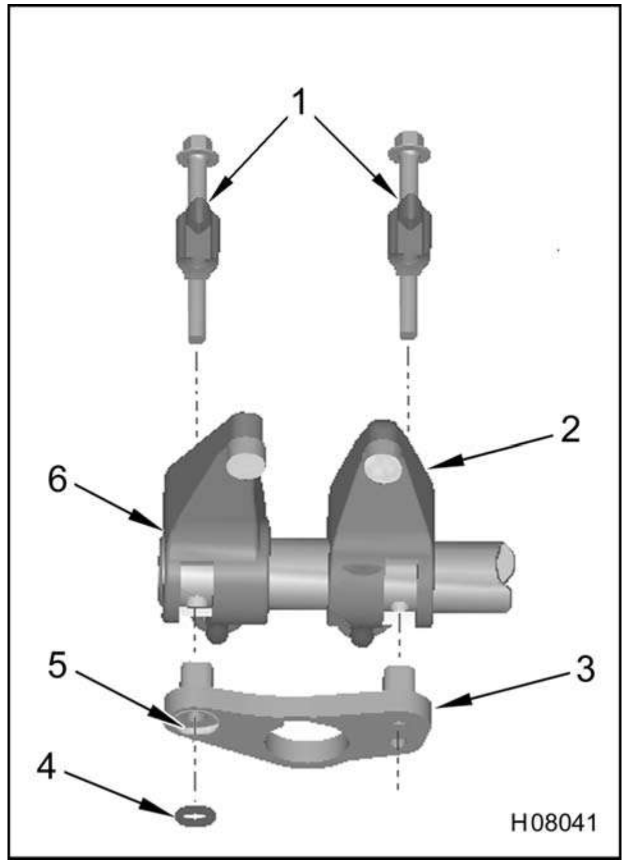


Figure 203 Rocker arm configuration

1. Clamp bolt assembly
2. Exhaust rocker arm
3. Rocker arm shaft support
4. Lower support washer
5. Machined recessed
6. Intake rocker arm

1. Install push rods.
2. Slide each of the 12 rocker arms onto the rocker shaft in the order they were removed (rocker arms should have been marked for this occasion).

NOTE: Ensure that the rocker arm shaft has the big **T** stamped facing up (Figure 204).

3. Place a bolt and clamp assembly through each rocker arm shaft support and align shaft with bolt hole in cylinder head (Figure 203).
4. Install plastic washer (assembly aid) onto each intake rocker arm retaining bolt.

Installing the Rocker Arm Assembly

1. Place valve bridges across each set of valves. These should be marked if removed. The recessed holes set over the valve stems.

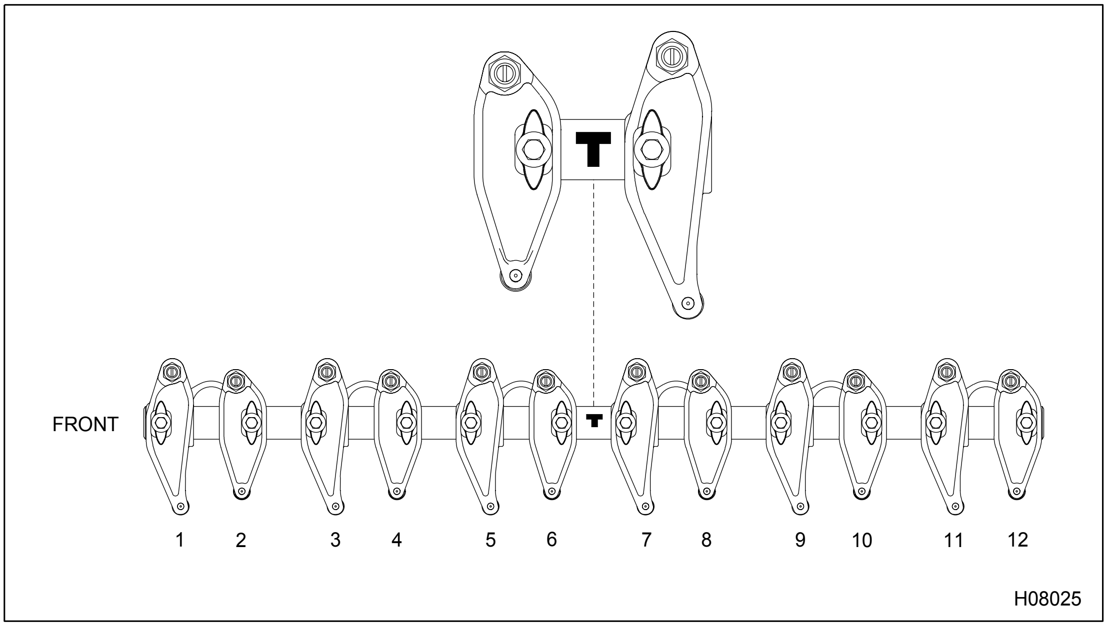


Figure 204 Rocker arm orientation

2. Align rocker arm assembly with bolts over mounting holes and thread hand tight.

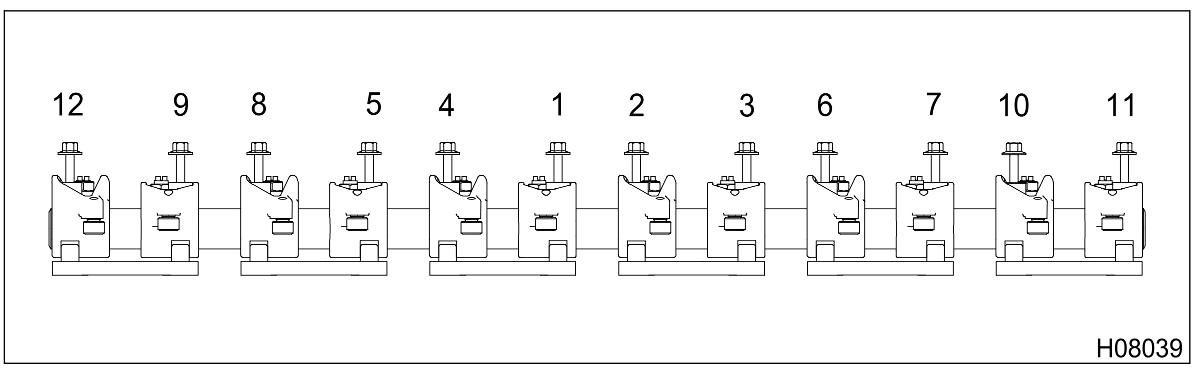


Figure 205 Rocker arm torque sequence

3. Torque bolts in two passes in the sequence illustrated above and to the specified value.
   a. Torque rocker arm clamp assembly bolts to 27 N·m (20 lbf·ft) for the first pass.
   b. Torque rocker arm clamp assembly bolts to 37 N·m (27 lbf·ft) for the final pass.

Valve Lash for Intake and Exhaust Valves

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

- Six adjustments are made when piston 1 is at Top Dead Center (TDC) compression.
- Six adjustments are made when piston 6 is at Top Dead Center (TDC) compression.

If the engine is equipped with the Diamond Logic® engine brake, corresponding brake actuator lash (Adjusting Valve Lash, page 150) can be adjusted before and after rotating the crankshaft the second time.

Adjusting Valve Lash

1. Remove valve cover (Valve Cover, page 120).
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 1 (page 151) and do steps 4 and 5 for cylinders 1, 3, and 5.

Chart 1

Valve and brake lash adjustments (inches) with piston 1 at TDC compression (Chart 1)											
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			

Valve and brake lash adjustments with piston 1 at TDC compression

Chart 2

Valve and brake lash adjustments (inches) with piston 6 at TDC compression (Chart 2)											
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	

Valve and brake lash adjustments with piston 6 at TDC compression

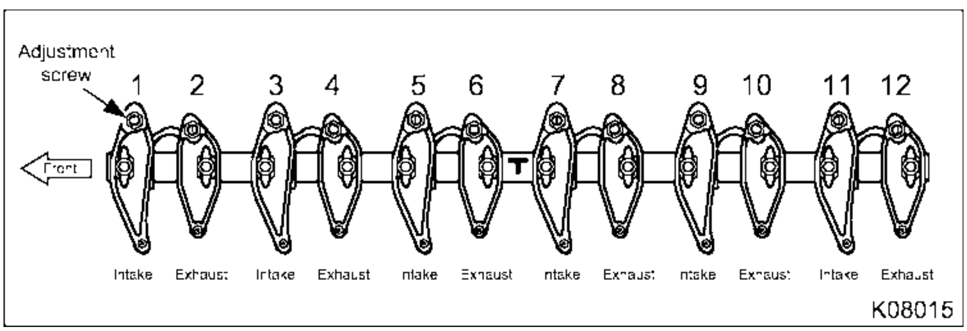


Figure 206 Valve lash adjustment

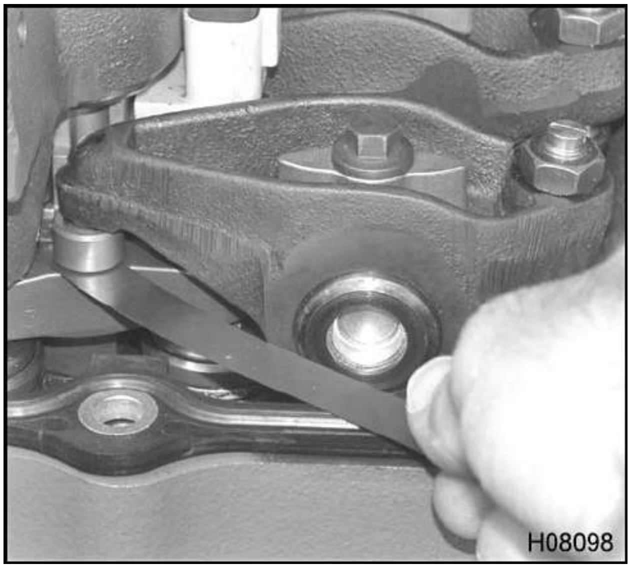


Figure 207 Feeler gauge between the pivot foot and valve bridge

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

   If engine is equipped with a Diamond Logic® engine brake, corresponding brake actuator lash can be adjusted before rotating crankshaft.
6. Turn crankshaft 360° in the direction of engine rotation to remove gear lash. Position piston 6 at TDC compression by observing cylinder 1 rocker arms in overlap as the vibration damper timing mark approaches the TDC mark on the front cover.
7. If piston 6 is at TDC compression, see Chart 2 (page151) and do steps 4 and 5 for cylinders 2, 4, and 6.

High-pressure Oil Rail Assembly

1. Install high-pressure oil rail assembly. See (High-pressure Oil Rail Assembly, page353).

Valve Cover

1. Install valve cover gasket.
2. Connect all electrical and injector connectors to the valve cover gasket, if disconnected.
3. Install valve cover onto cylinder head.

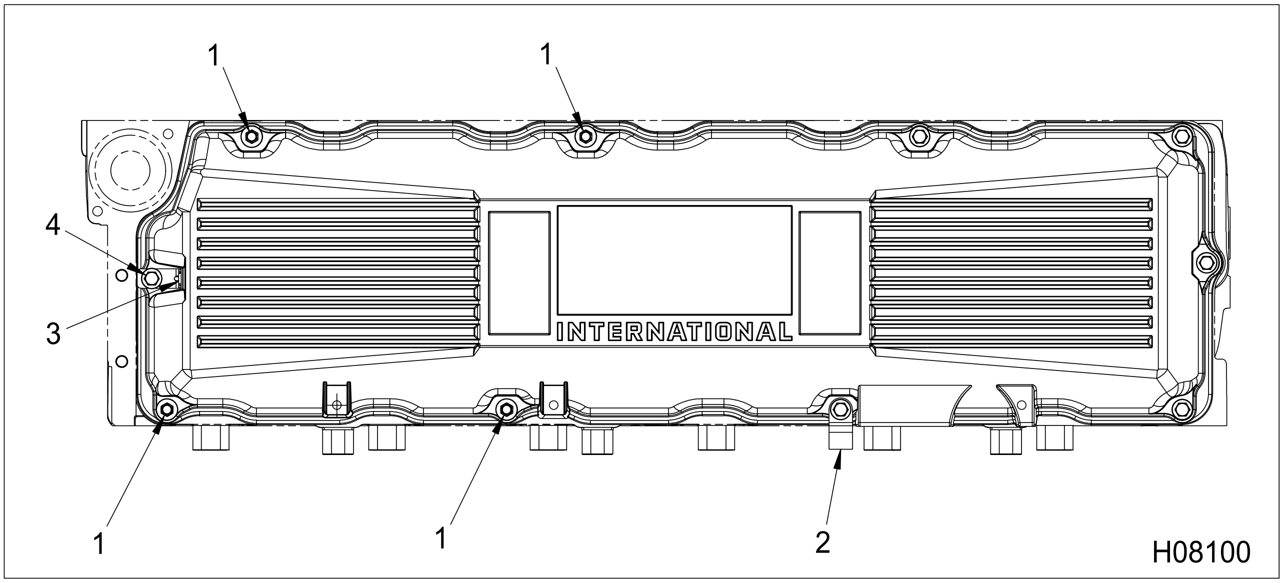


Figure 208 Valve cover assembly detail

1. Bolt / stud, M8 x 80 / 19 (4)
2. Extension bracket
3. Valve cover harness mounting bracket
4. Bolt, M8 x 80 (6)

4. Install four valve cover bolt / studs (M8 x 80 / 19) finger tight.
5. Install six valve cover bolts (M8 x 80) finger tight.
6. Tighten all bolts and studs to the standard torque value (General Torque Guidelines, page445).
7. Add any necessary brackets to the appropriate studs.
8. Connect crankcase ventilation piping (Crankcase Ventilation System, page274).
9. Add coolant (if cylinder head was removed in chassis).

Specifications

Table 13 Valve Specifications

Camshaft lobe lift	**Intake:** 6.68 mm (0.263 in)
	Exhaust: 6.91 mm (0.272 in)
Valve face angle	**Intake:** 59.75 - 60.00°
	Exhaust: 44.75 - 45.00°
Valve face margin (min.)	**Intake:** 1.32 mm (0.052 in)
	Exhaust: 1.16 mm (0.046 in)
Valve face-to-valve stem runout (max.)	0.038 mm (0.0015 in)
Valve lash (cold), intake and exhaust	0.48 mm (0.019 in)
Valve stem diameter (new condition)	**Intake:** 7.928 ± 0.0089 mm (0.3121 ± 0.00035 in)
	Exhaust: 7.908 ± 0.0089 mm (0.3113 ± 0.00035 in)
Valve stem-to-valve guide clearance (max.)	**Intake:** 0.10 mm (0.004 in)
	Exhaust: 0.11 mm (0.005 in)

Table 14 Valve Spring Specifications

Intake and Exhaust Valve Springs	
Free length	52.35 mm (2.061 in)
Solid height (max.)	27.43 mm (1.080 in)
Valve closed test length @ 410.1 ± 24.5 N (92.2 ± 5.5 lbf) test load	40 mm (1.575 in)
Valve closed test length @ 764.2 ± 48.9 N (171.8 ± 11.0 lbf) test load	29.3 mm (1.155 in)

Table 15 Cylinder Head Specifications

Cylinder head gasket surface flatness	0.10 mm (0.004 in.) per 229 mm (9.0 in)
Cylinder head thickness	**New:** 160.48 mm (6.318 in)
	Minimum: 159.97 mm (6.298 in)
Exhaust valve seat insert counterbore diameter	**Standard:** 37.503 ± 0.003 mm (1.477 ± 0.001 in)
	Oversize: 0.05 mm (0.002 in) 37.55 ± 0.03 mm (1.478 ± 0.001 in)
Exhaust valve seat outside diameter	**Standard:** 37.56 mm (1.479 in)
	Oversize: 0.05 mm (0.002 in) 37.61 mm (1.481 in)
Intake valve seat insert counterbore diameter	**Standard:** 33.50 ± 0.03 mm (1.319 ± 0.001 in)

Table 15 Cylinder Head Specifications (cont.)

	Oversize: 0.05 mm (0.002 in) 35.55± 0.03 mm (1.321 ± 0.001 in)
Intake valve seat outside diameter	**Standard:** 40.20 mm (1.583 in)
	Oversize: 0.05 mm (0.002 in) 40.25 mm (1.585 in)
Push rod runout (maximum)	0.508 mm (0.020 in)
Valve guide bore diameter	14.308 ± 0.017 mm (0.5633 ± 0.0007 in)
Valve guide bore out-of-round (max.)	0.005 mm (0.0002 in)
Valve guide bore taper (max.)	0.013 mm (0.0005 in)
Valve guide height from cylinder head spring pocket (intake)	16.53 ± 0.13 mm (0.651 ± 0.005 in)
Valve guide insert inside diameter (installed)	7.98 - 8.00 mm (0.314 - 0.315 in)
Valve guide insert interference fit dimension	0.043 mm (0.0017 in)
Valve guide insert outside diameter	14.351 ± 0.010 mm (0.5650 ± 0.0004 in)
Valve guide length (overall)	65.71 mm (2.587 in)
Valve recession	**Intake:** 1.02 mm (0.040 in)
	Exhaust: 1.40 mm (0.055 in)
Valve seat angles	**Intake:** 59.75 - 60°
	Exhaust: 44.75 - 45°
Valve seat runout (max.)	0.05 mm (0.002 in)
Valve seat width	1.91 - 2.16 mm (0.075 - 0.085 in)

Special Torque

Table 16 Cylinder Head and Valve Train Special Torques

BCP sensor	20 - 30 N·m (15 - 22 lbf·ft)
Cylinder head mounting bolts torque and sequence	
Fuel injector mounting bolt	41 N·m (30 lbf·ft)
High-pressure oil hose fitting	46 N·m (34 lbf·ft)
ICP sensor	20 - 30 N·m (15 - 22 lbf·ft)
Rocker arm bolts torque and sequence	(Installing Rocker Arms, page148)
Valve adjustment locknut	27 N·m (20 lbf·ft)

Special Service Tools

Table 17 Cylinder Head Special Service Tools

Cylinder head test plate	ZTSE4289A
Dye penetrant kit	Obtain locally
Feeler gauge	Obtain locally
Injector sleeve brush set (set of 2)	ZTSE4304
Injector sleeve installer	ZTSE4642
Injector sleeve remover	ZTSE4643
Pressure regulator	Obtain locally
Slide hammer puller set	ZTSE1879
Small hole gauge set	Obtain locally
Straightedge	Obtain locally
Thermostat opening pressure adapter	ZTSE4647
Valve guide deburring tool	ZTSE4393
Valve guide installer	ZTSE1943
Valve guide remover	ZTSE4377
Valve seat extractor kit (universal)	ZTSE1951C
Valve seat grinder	ZTSE1631A
Valve seat grinding stones 45° (exhaust)	Obtain locally
Valve seat grinding stones 60° (intake)	Obtain locally
Valve seat installer	ZTSE4641
Valve seat remover (collet)	ZTSE4640
Valve spring compressor	ZTSE1846
Valve spring compressor jaws	ZTSE4652
Water supply housing pressure adapter	ZTSE4648

Table of Contents

Description

FRONT COVER ASSEMBLIES

The front cover assembly was modified as a production running change from Generation 1 to Generation 2 for International® DT 466, DT 570 and HT 570 Diesel Engines.

- Generation 1 front cover assemblies include a water pump wear plate; Generation 2 front cover assemblies do not have a water pump wear plate.
- Generation 2 front cover assemblies have additional bolts to secure the front cover (front half) to the front cover (rear half).
- Generation 1 and Generation 2 front cover assemblies are not interchangeable.
- Some Generation 2 front covers are equipped with a sound shield. When replacing a front cover equipped with a sound shield, replace it only with a cover equipped with a sound shield, to ensure that noise reduction requirements are maintained.

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

See removal and installation procedures for Generation 1 (Mounting Bolts) and Generation 2 (Mounting Bolts), listed in the Table of Contents in this section.

GEROTOR OIL PUMP ASSEMBLY

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Removal, inspection, and installation procedures for the Gerotor oil pump assembly, show the 8 lobe gerotor oil pump. Removal, inspection, and installation procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

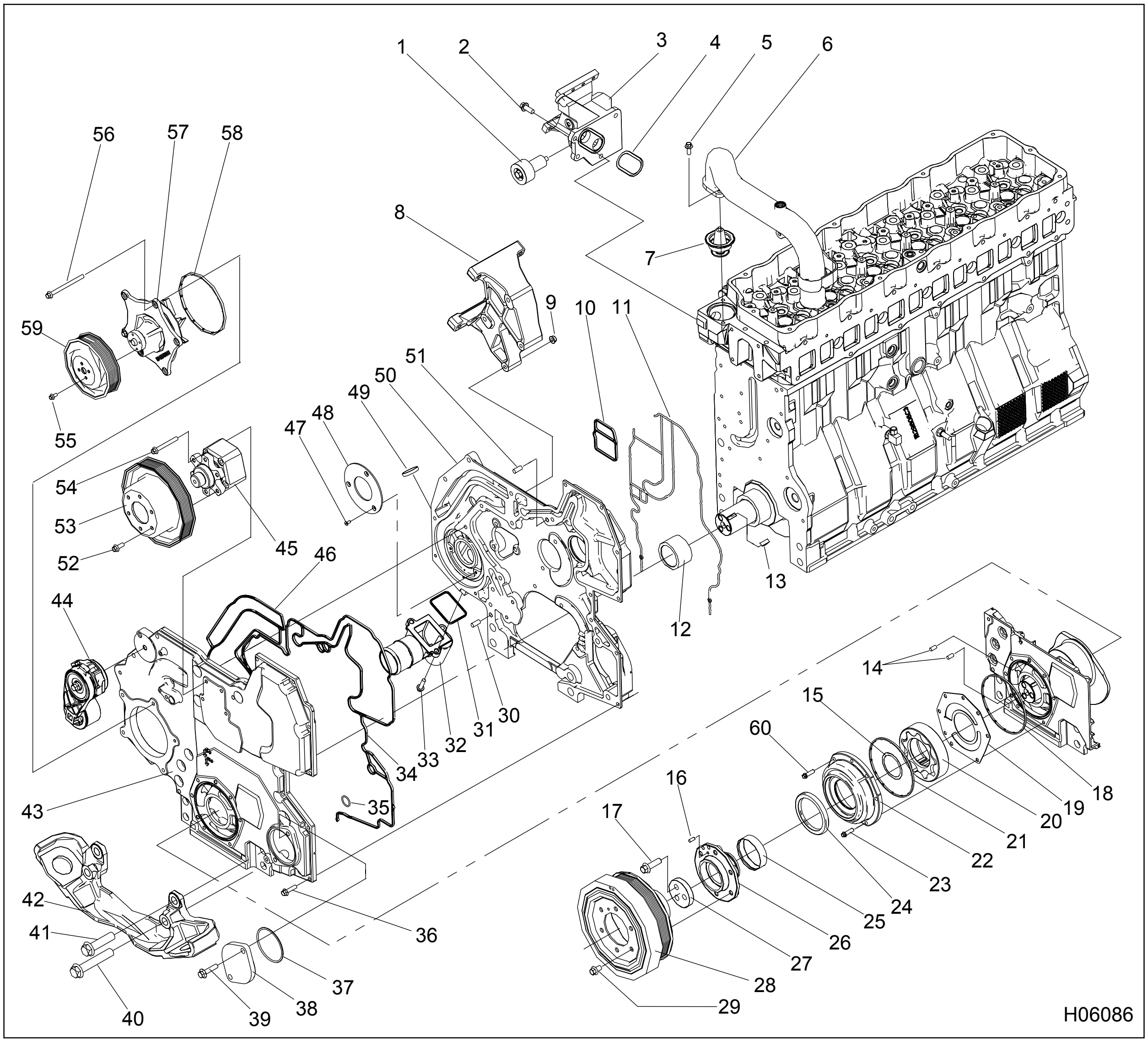


Figure 209 Front cover related components (less gear train)

1. Flat idler pulley assembly
2. Bolt, M10 x 25 (4)
3. Water supply housing
4. Coolant port seal
5. Bolt, M8 x 25 (2)
6. Water outlet tube assembly
7. Thermostat assembly
8. Alternator bracket
9. Nut, M8
10. Coolant gasket
11. Oil gasket
12. Oil pump drive
13. Vibration damper key
14. Dowels (2)
15. Washer, seal
16. Pin, 6 mm x 16 mm
17. Bolt, M12 x 40 (3)
18. Oil pump (housing plate) seal
19. Oil pump housing plate
20. Gerotor oil pump assembly
21. Oil pump (housing) seal
22. Oil pump housing
23. Bolt, M8 x 25 (4) See bolt locations (Figure 228)
24. Front oil seal
25. Wear sleeve
26. Damper hub
27. Damper retaining plate
28. Vibration damper
29. Bolt, M10 x 16 (6)
30. Dowel
31. Water inlet gasket
32. Water inlet elbow
33. Bolt, M8 x 30 (3)
34. Front cover gasket (oil)
35. O-ring seal
36. Bolt, M8 x 30 see bolt locations (Figure 252)
37. O-ring seal (#235), PTO equipped only
38. End cover adapter, PTO equipped only
39. Bolt, M10 x 40 (2), PTO equipped only
40. Bolt, M18 x 100 (2)
41. Bolt, M18 x 70 (2)
42. Front engine mount
43. Cover, front half (PTO equipped)
44. Auto tensioner
45. Fan drive assembly
46. Coolant gasket
47. Flat head socket screw, M5 (3)
48. Water pump wear plate (Generation 1 front covers only)
49. Cup plug
50. Cover, rear half
51. Dowel
52. Bolt, M8 x 20 (6)
53. Fan drive pulley
54. Bolt, (4) see bolt sizes (Table 18)
55. Bolt, M6 x 12 (4)
56. Bolt, (5) see water pump (Figure 272)
57. Water pump assembly
58. Water pump seal
59. Water pump pulley
60. Bolt, M8 x 60 (2) see bolt locations (Figure 228)

Checking Gear Train Timing without Removing Front Cover

Valve train failures from broken or bent push rods, valves, rocker arms and worn valve keepers and/or rotators in many instances could be caused by improper timing of the gear train. Depending on valve lash setting, if the camshaft gear is improperly timed by one tooth early, the engine pistons will strike the intake valve heads or if the timing is set one tooth late, the exhaust valves may contact pistons.

NOTE: Before attempting to check gear train timing, it will be necessary to remove the valve cover, valve cover gasket, and high-pressure oil manifold or Diamond Logic® engine brake. See the appropriate sections of this manual regarding removal and installation procedures.

DT 466 Engines Only

Method One – Using a Feeler Gauge

1. Rotate the engine to approximately TDC (Top Dead Center) compression on No. 1 cylinder (no valves open). Set the lash on the No. 1 intake valve to the nominal lash setting of 0.48 mm (0.019 in).

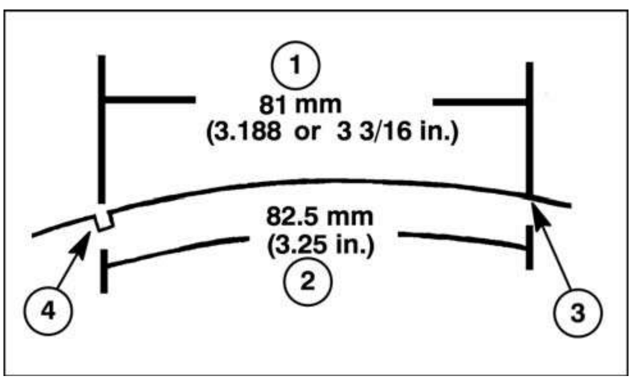


Figure 210 Checking Engine Gear Train Timing

1. Straight line dimension
2. Radial distance dimension
3. Scribe mark
4. Damper timing notch

2. Scribe a mark on the damper pulley at a radial distance of 82.5 mm (3.25 in) or a straight line distance of 81 mm (3.188 in) clockwise from the timing notch as viewed from the front of the engine.
3. Place a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve. Slowly rotate the engine forward (clockwise) until the intake valve starts to lift and the feeler gauge becomes tight. The mark should line up with the TDC arrow on the front cover or be within 3.5 crankshaft degrees of it. 3.5 degrees is equivalent to a radial (or straight) line distance of 6.8 mm (0.27 in) at the damper pulley.

NOTE: One tooth “out of time” on the gear train equals approximately 11 degrees of movement or 21.4 mm (27/32 in) of radial distance of damper pulley.

4. If the timing on the No. 1 valve is within specifications, the other valves, barring extreme camshaft lobe wear or poor adjustment, will also be in time. If timing is found to be incorrect, removal of the front cover is required to inspect the punch marks on the gear train.

Method Two – Using a Dial Indicator

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke to 0.48 mm (0.019 in). Install a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve.
2. Position the magnetic base dial indicator on the valve cover fence of the cylinder head rail with the indicator tip on the No. 1 intake rocker arm tip.
3. Zero the dial indicator.
4. Rotate the engine approximately one full revolution in either direction to a position 360 degrees from starting point.
5. The dial indicator should read within the range of 0.13-0.25 mm (0.005-0.010 in) from the starting position for proper gear train timing.
6. If dial indicator readings are found to be outside of this range, removal of the front cover is required to inspect the punch marks on the gear train.

DT 570 and HT 570 Engines Only

Method One – Using a Feeler Gauge

1. Rotate the engine to approximately TDC (Top Dead Center) compression on No. 1 cylinder (no valves open). Set the lash on the No. 1 intake valve to the nominal lash setting of 0.48 mm (0.019 in).

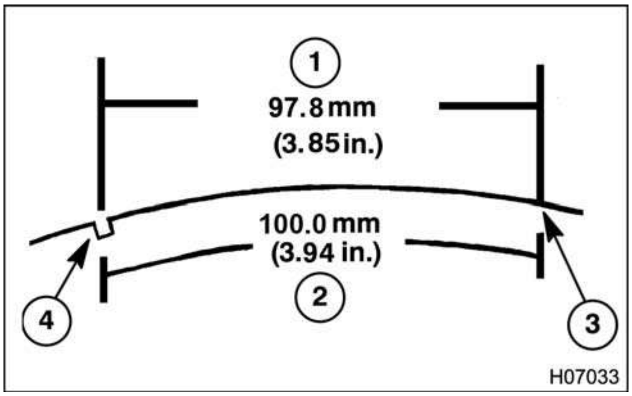


Figure 211 Checking Engine Gear Train Timing

1. Straight line dimension
2. Radial distance dimension
3. Scribe mark
4. Damper timing notch

2. Scribe a mark on the damper pulley at a radial distance of 100.0 mm (3.94 in) or a straight line distance of 97.8 mm (3.85 in) clockwise from the timing notch as viewed from the front of the engine.
3. Place a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve. Slowly rotate the engine forward (clockwise) until the intake valve starts to lift and the feeler gauge becomes tight. The mark should line up with the TDC arrow on the front cover or be within 3.5 crankshaft degrees of it. 3.5 crank degrees is equivalent to a radial (or straight) line distance of 8.1 mm (0.32 in) at the damper pulley.

NOTE: One tooth "out of time" on the gear train equals approximately 11 degrees of movement or 21.4 mm (27/32 in) of radial distance of damper pulley.

4. If the timing on the No. 1 valve is within specifications, the other valves, barring extreme camshaft lobe wear or poor adjustment, will also be in time. If timing is found to be incorrect, removal of the front cover is required to inspect the punch marks on the gear train.

Method Two – Using a Dial Indicator

1. Adjust the No. 1 intake valve with the No. 1 piston set at TDC (Top Dead Center) compression stroke to 0.48 mm (0.019 in). Install a 0.28 mm (0.011 in) feeler gauge between the rocker arm and the valve bridge of the No. 1 intake valve.
2. Position the magnetic base dial indicator on the valve cover fence of the cylinder head rail with the indicator tip on the No. 1 intake rocker arm tip.
3. Zero the dial indicator.
4. Rotate the engine approximately one full revolution in either direction to a position 360 degrees from starting point.
5. The dial indicator should read within the range of 0.13-0.25 mm (0.005-0.010 in) from the starting position for proper gear train timing.
6. If dial indicator readings are found to be outside of this range, removal of the front cover is required to inspect the punch marks on the gear train.

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 engine has cooled before removing components.

WARNING: To prevent personal injury or death, do not open pressurized Freon® lines.

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.

Alternator Bracket

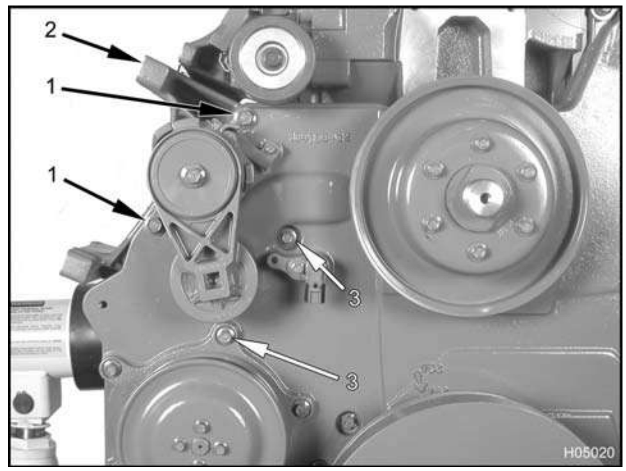


Figure 212 Alternator bracket bolts

1. Bolt, M10 x 120 (2)
2. Alternator bracket
3. Bolt, M8 x 100 (2)

1. Remove M8 bolt and harness routing guide.
2. Remove two hex flange bolts and nuts (M10 x 120).
3. Remove two hex flange bolts and nuts (M8 x 100).
4. Remove alternator bracket.

Flat Idler Pulley and Automatic Belt Tensioner

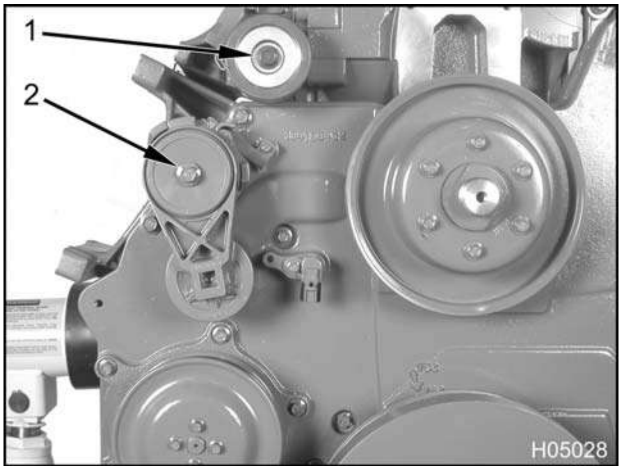


Figure 213 Flat idler pulley and automatic belt tensioner

1. Flat idler pulley assembly mounting bolt, M10 x 80
2. Automatic belt tensioner assembly mounting bolt, M10 x 80

1. Remove flat idler pulley mounting bolt (M10 x 80) and assembly from the water supply housing.
2. Remove automatic belt tensioner mounting bolt (M10 x 80) and assembly from the front cover assembly.

Water Supply Housing

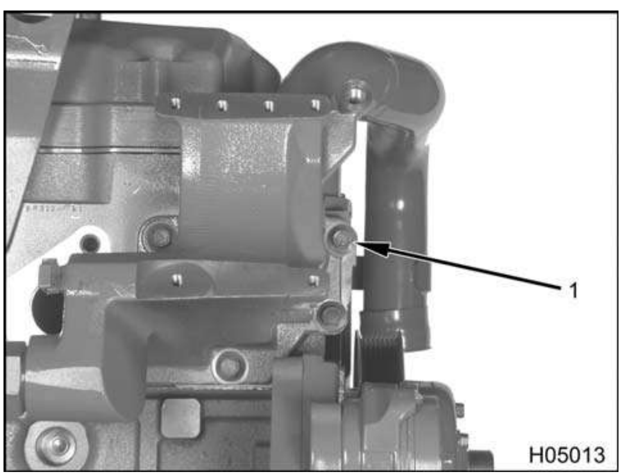


Figure 214 Water supply housing bolts

1. Bolt, M10 x 25 (4)

1. Support water supply housing and remove four water supply housing bolts (M10 x 25).

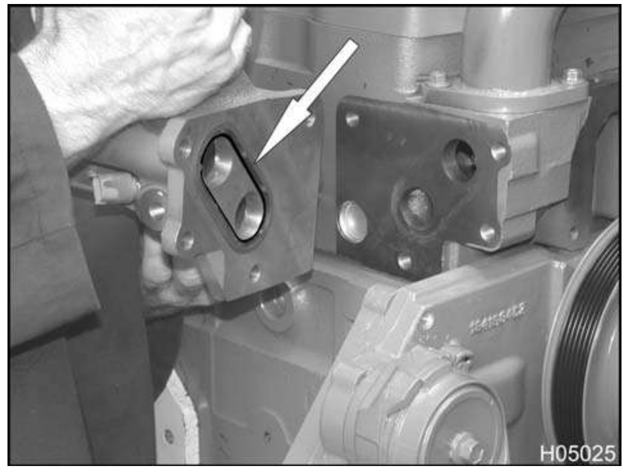


Figure 215 Water supply housing and coolant port seal

2. Tap water supply housing with a hammer to break coolant seal. Remove housing and discard coolant port seal.

Water Inlet Elbow, Water Outlet Tube, and Thermostat

1. Remove three hex flange bolts (M8 x 30) securing water inlet elbow to front cover.

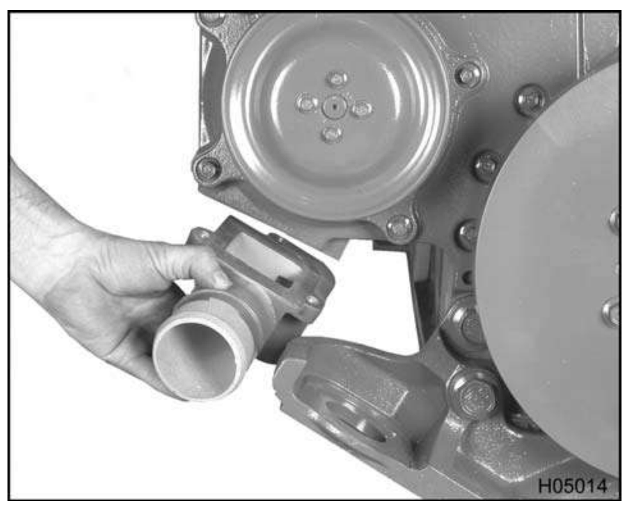


Figure 216 Water inlet elbow

2. Tap water inlet elbow with a hammer to break coolant seal. Remove water inlet elbow and discard gasket seal.

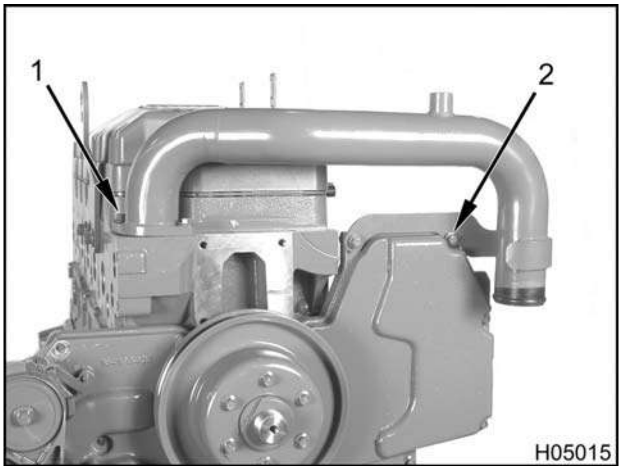


Figure 217 Water outlet tube assembly

1. Bolt, M8 x 25 (2)
2. Hex flange nut, M8 (2)

3. Remove two water outlet tube assembly bolts (M8 x 25) at the cylinder head.
4. Remove two hex flange nuts (M8) retaining the water outlet tube assembly to front cover and remove tube assembly.

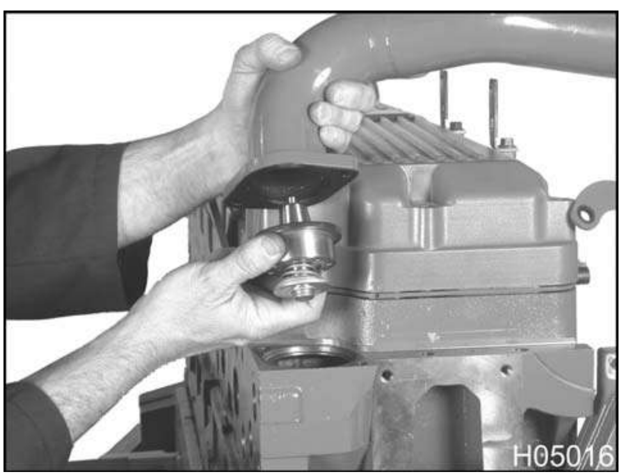


Figure 218 Thermostat assembly

5. Lift thermostat out of cylinder head.

NOTE: The thermostat seal cannot be purchased separately. It is only available with the thermostat assembly.

Fan Drive Hub

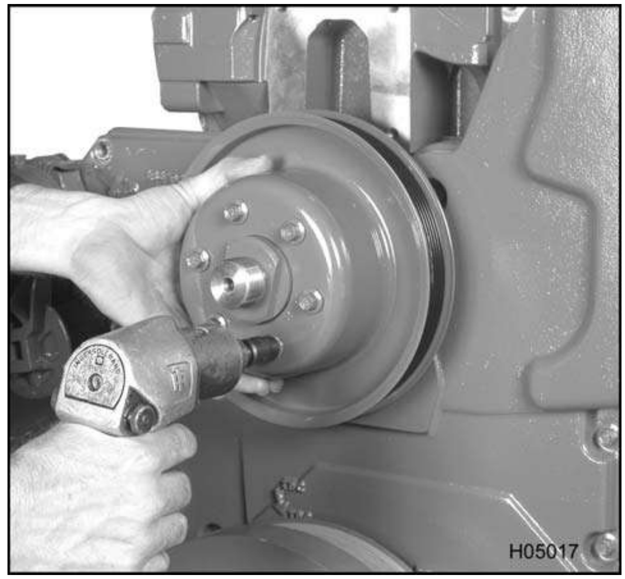


Figure 219 Removing the fan drive pulley

1. Remove six hex flange bolts (M8 x 20) and the fan drive pulley.

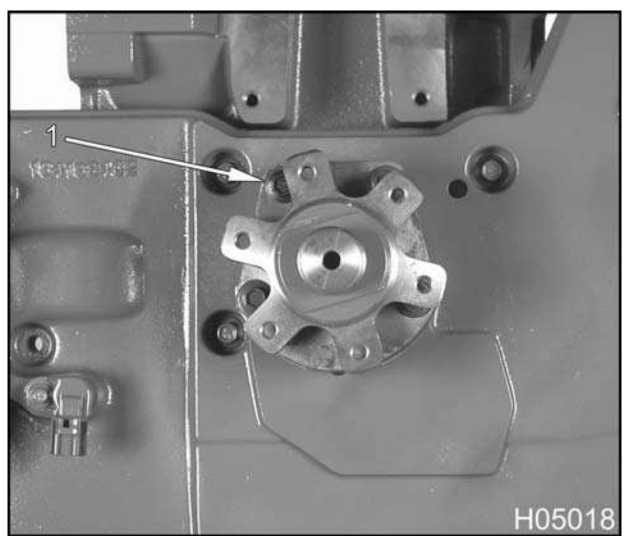


Figure 220 Fan hub assembly (typical)

1. Bolt, M8 x 65 (4)

2. Remove four hex flange bolts. See fan drive applications (Table 18).
3. Remove fan hub assembly.

Water Pump Assembly

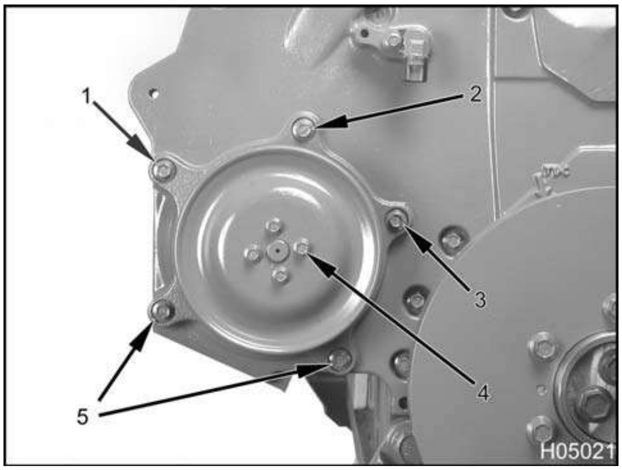


Figure 221 Water pump assembly

1. Bolt, M8 x 55 , nut, M8 (1)
2. Bolt, M8 x 100, nut, M8 (1)
3. Bolt, M8 x 16 (1)
4. Bolt, M6 x 12 (4)
5. Bolt, M8 x 40 (2)

1. Remove four pulley bolts (M6 x 12).
2. Remove water pump pulley.
3. Remove one water pump assembly nut (M8) and bolt (M8 x 55).
4. Remove one water pump assembly nut (M8) and bolt (M8 x 100).
5. Remove one water pump assembly bolt (M8 x 16).
6. Remove two water pump assembly bolts (M8 x 40).

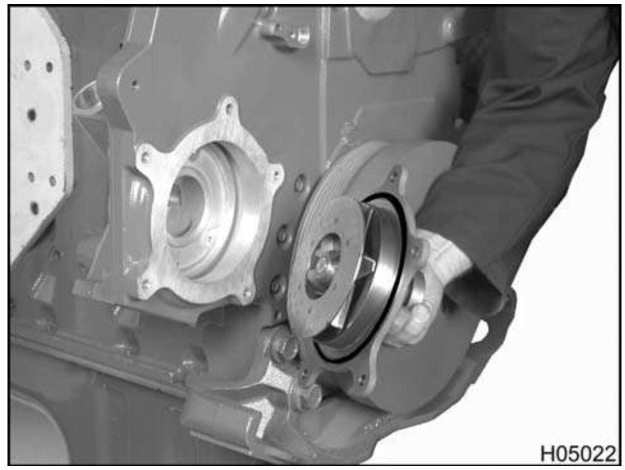


Figure 222 Water pump assembly

7. Remove water pump assembly. Remove and discard seal.

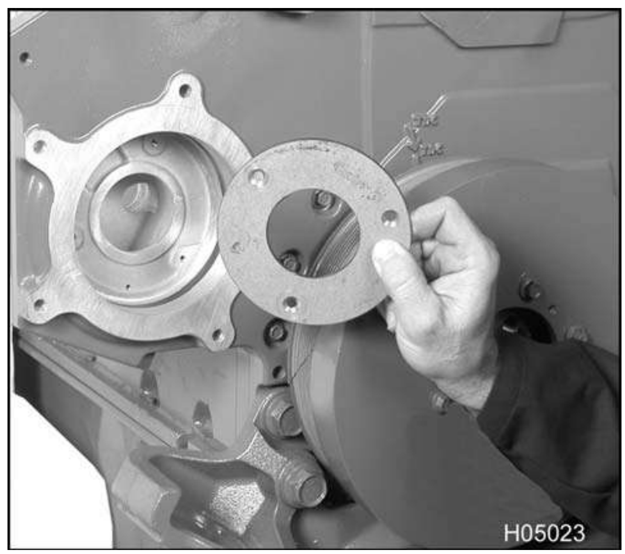


Figure 223 Water pump wear plate (Generation 1 front covers only)

8. If applicable, remove three flat head hex socket screws (M5) securing the water pump wear plate to the rear half of the front cover and remove water pump wear plate.

Vibration Damper, Damper Hub, and Wear Sleeve

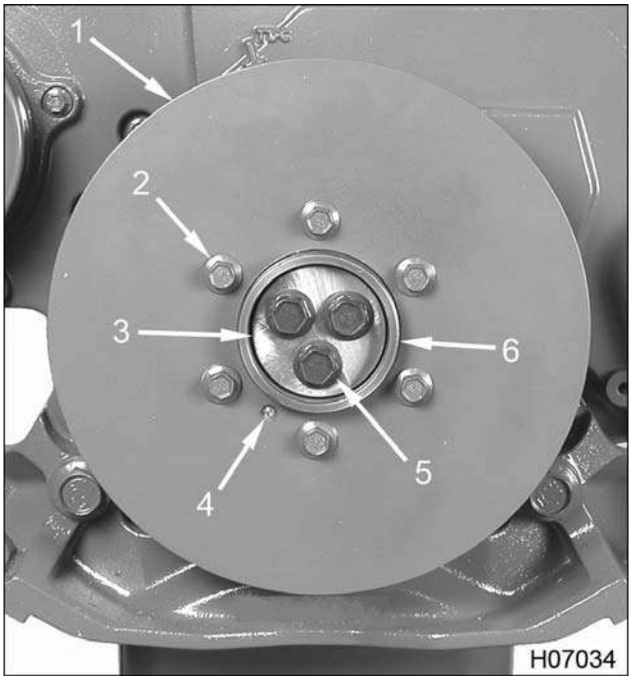


Figure 224 Vibration damper assembly

1. Vibration damper
2. Bolt, M10 x 16 (6)
3. Damper retaining plate
4. Dowel
5. Bolt, M12 x 40 (3)
6. Damper hub assembly

1. Remove six M10 x 16 bolts securing the vibration damper to the damper hub assembly and remove the vibration damper.
2. Remove and discard three M12 x 40 bolts securing the damper retaining plate.
3. Remove and discard damper retaining plate.

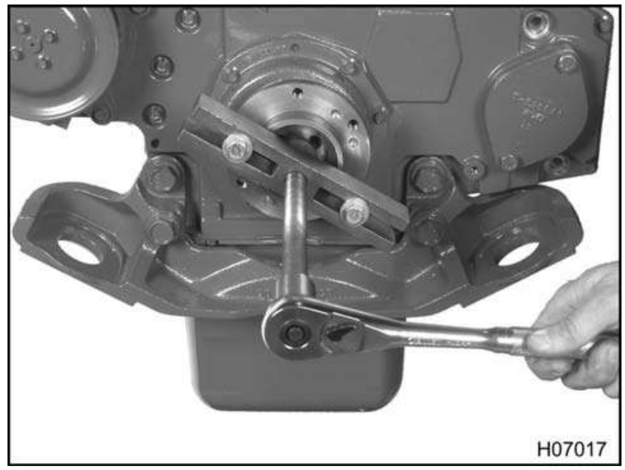


Figure 225 Removing the damper hub assembly

4. Install two M10 x 80 bolts and washers through H-bar puller (Table 21) and into the damper hub. Install M10 x 80 bolt heads at equal lengths from the vibration damper mounting surface.
5. Tighten H-bar center shaft to pull damper hub off of crankshaft and remove damper hub.

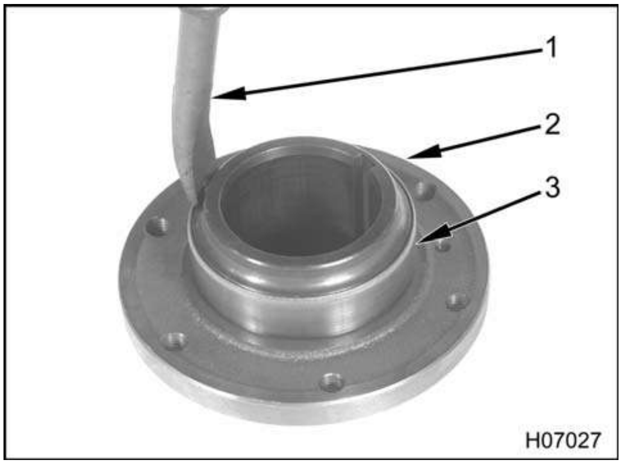


Figure 226 Removing the wear sleeve with a muffler chisel

1. Muffler Chisel
2. Vibration damper hub
3. Wear Sleeve

CAUTION: To prevent engine damage, do not damage or distort damper hub while removing wear sleeve.

6. Split the wear sleeve with a muffler chisel to remove it from the damper. Be careful not to damage the vibration damper hub.

Gerotor Assembly Oil Pump and Front Oil Seal

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Removal procedures for the gerotor oil pump assembly, show the 8 lobe gerotor oil pump. Removal procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

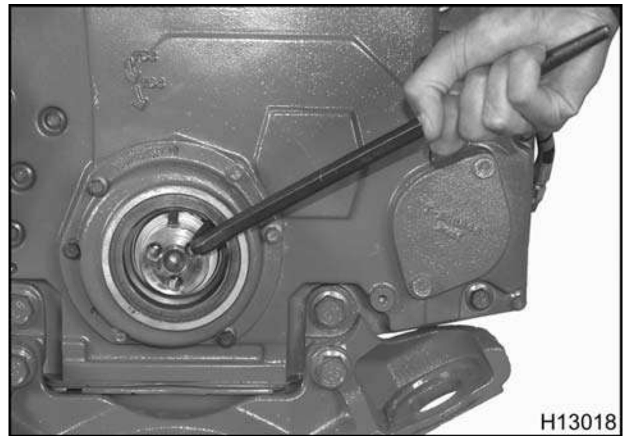


Figure 227 Removing front oil seal

NOTE: Be careful not to damage the crankshaft or front oil seal mounting surface while removing the front oil seal.

1. Remove front oil seal with a heel bar while oil pump housing assembly is still attached to front cover. Discard the front oil seal.

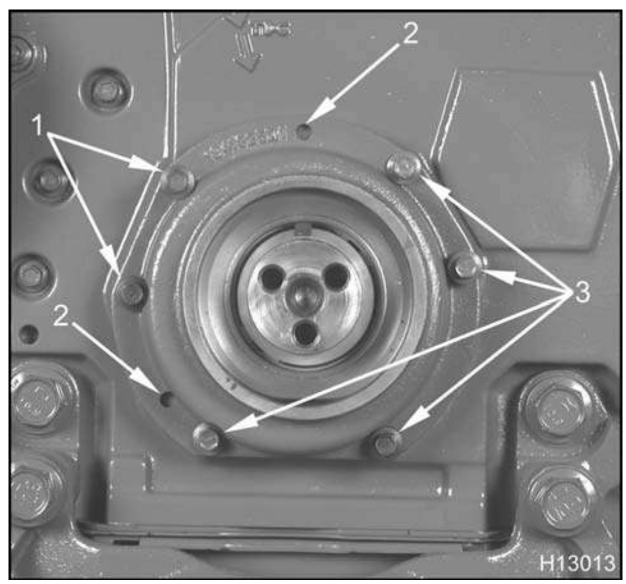


Figure 228 Oil pump housing mounting bolts

1. Bolt, M8 x 60 (2)
2. Dowels (2)
3. Bolt, M8 x 25 (4)

2. Remove two bolts (M8 x 60) retaining the oil pump housing cover.

3. Remove four bolts (M8 x 25) retaining the oil pump housing cover.

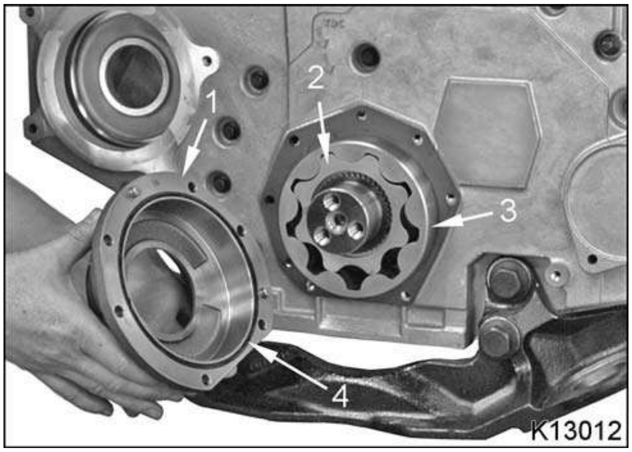


Figure 229 Oil pump housing, rotors, and oil pump (housing) seal

1. Oil pump and rotor housing
2. Inner rotor
3. Outer rotor
4. Oil pump (housing) seal

4. Remove oil pump housing cover and discard oil pump (housing) seal.

CAUTION: To prevent engine damage, use permanent marker to identify internal engine components and their orientation. Do not use paint or temporary markers.

5. Mark inner and outer rotors with a permanent marker, if oil pump is to be reused. Mark will indicate rotor turning direction and orientation to front cover.

6. Remove outer rotor.

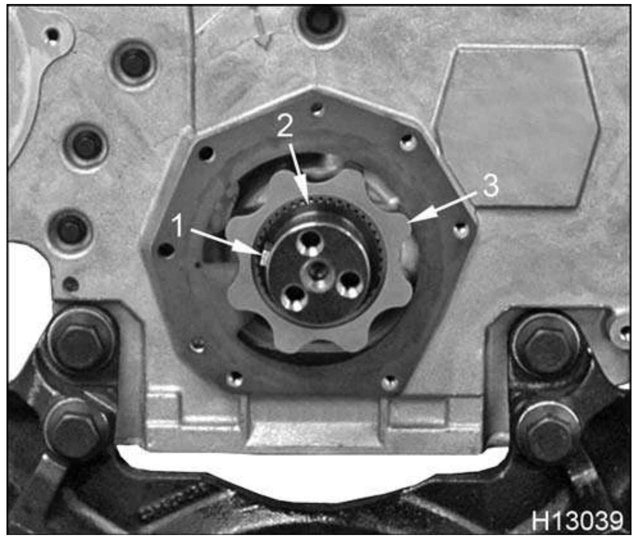


Figure 230 Vibration damper key, washer seal, and inner rotor

1. Vibration damper key
2. Washer seal
3. Inner rotor

CAUTION: To prevent engine damage, do not damage or distort the crankshaft keyway groove during vibration damper key removal.

7. Carefully tap the vibration damper key out of the crankshaft with a hammer and chisel.

8. Remove washer seal and inner rotor from crankshaft.

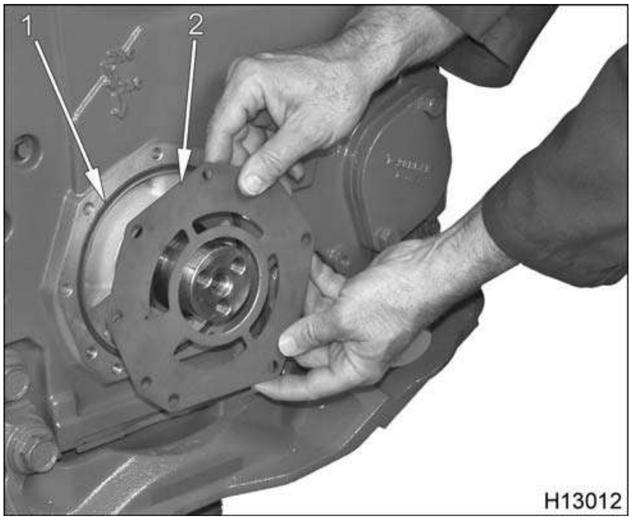


Figure 231 Oil pump housing plate and seal

1. Oil pump (housing plate) seal
2. Oil pump housing plate

9. Remove oil pump housing plate and discard oil pump (housing plate) seal.
10. See disassembly of crankshaft oil pump drive (spline) (Crankshaft Disassembly, page 256) for procedure relating to oil pump drive.

Front Engine Mount

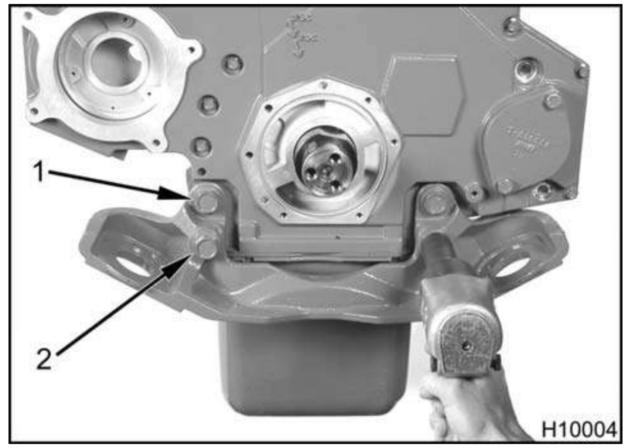


Figure 232 Front engine mounting bracket

1. Bolt, M18 x 70 (2)
2. Bolt, M18 x 100 (2)

1. Remove two upper bolts (M18 x 70).
2. Support engine mounting bracket and remove two lower bolts (M18 x 100).
3. Remove front engine mounting bracket.

Front Cover (Front Half)

Generation 1 (Mounting Bolts)

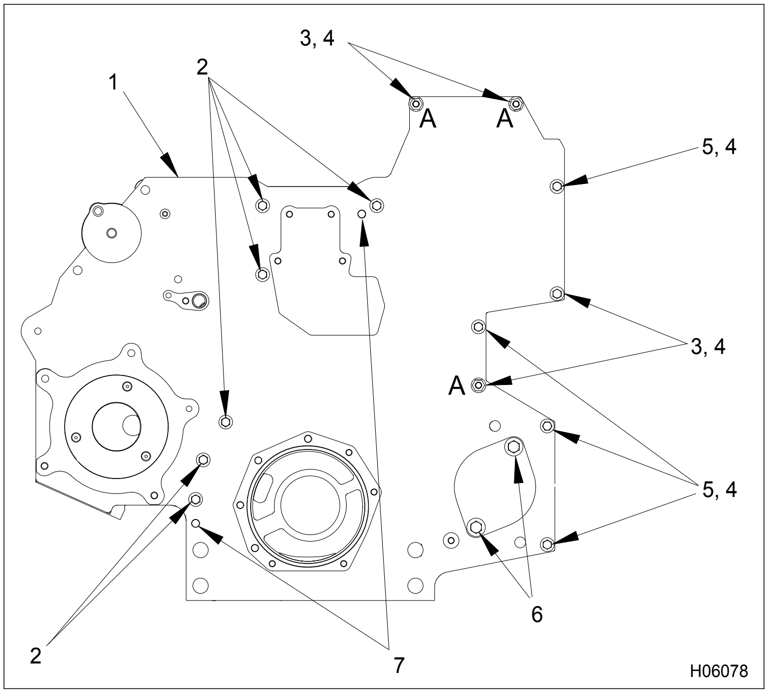


Figure 233 Front cover mounting bolts – front half (Generation 1)

1. Front cover (front half)
2. Hex flange bolt, M8 x 45 (6)
3. Hex flange bolt, M8 x 40 (4)
4. Hex flange nut, M8 (8)
5. Hex flange bolt, M8 x 30 (4)
6. Heavy hex flange bolt, M10 x 25 (2) (PTO equipped engines only)
7. Dowel hole

CAUTION: To prevent engine damage, the oil pan and oil suction tube must be removed before the front cover can be removed.

1. Remove six hex flange bolts (M8 x 45).
2. Remove four hex flange bolts (M8 x 40) and nuts (M8).
3. Remove four hex flange bolts (M8 x 30) and nuts (M8).
4. Remove front cover (front half) by sliding off the two dowel pins.
5. Remove the oil and coolant gaskets and O-ring seal from the inside of the front cover, as required and discard.

Generation 2 (Mounting Bolts)

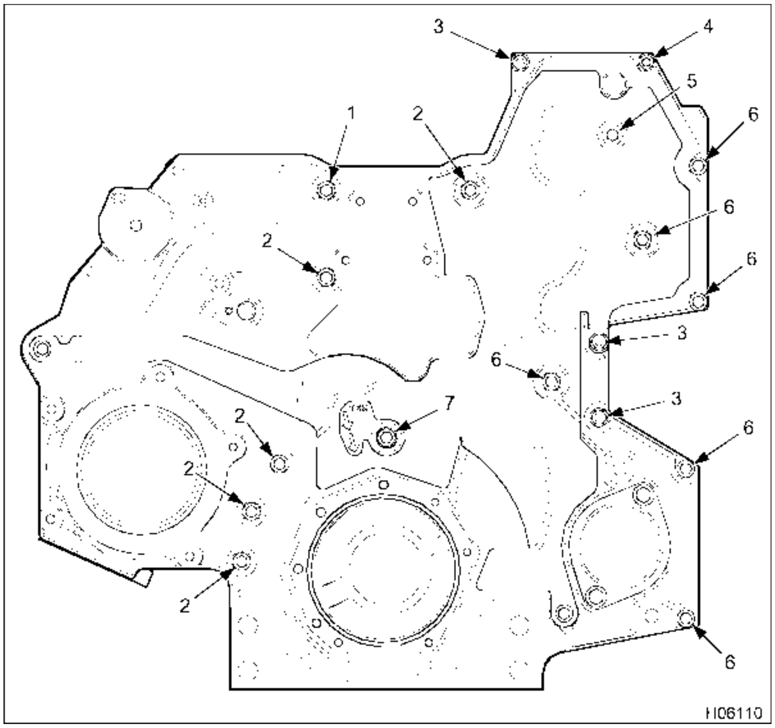


Figure 234 Front cover mounting bolts – front half (Generation 2)

1. M8 x 45 hex flange bolt (patch bolt)
2. M8 x 45 bolt (5)
3. M8 x 50 special bolt (nut on front) (3)
4. M8 x 73 stud bolt (nut on back)
5. M8 x 75 bolt – dog point (nut on back)
6. M8 x 50 bolt (nut on back) (6)
7. Seal assembly – M8 x 50 bolt and seal washer
8. Dowel hole

CAUTION: To prevent engine damage, the oil pan (Removing the Oil Pan, page 206) and oil suction tube (Removing the Oil Suction Tube, page 207) must be removed before the front cover can be removed.

1. Remove M8 x 75 bolt – dog point and nut (nut on back).
2. Remove Seal Assembly – M8 x 50 bolt and seal washer.
3. Remove six M8 x 50 special bolts and nuts.
4. Remove M8 x 73 stud bolt and nut (nut on back).
5. Remove M8 x 45 mm hex flange patch bolt.
6. Remove five M8 x 45 bolts.
7. Remove front cover (front half) by sliding off the two dowel pins.
8. Remove the oil and coolant gaskets and O-ring seal from the inside of the front cover, as required and discard.

Idler Gears

NOTE: Before removing any gears from the gear train, check the backlash between each gear and the camshaft end play. See the inspection procedures (Inspection, page177) in this section.

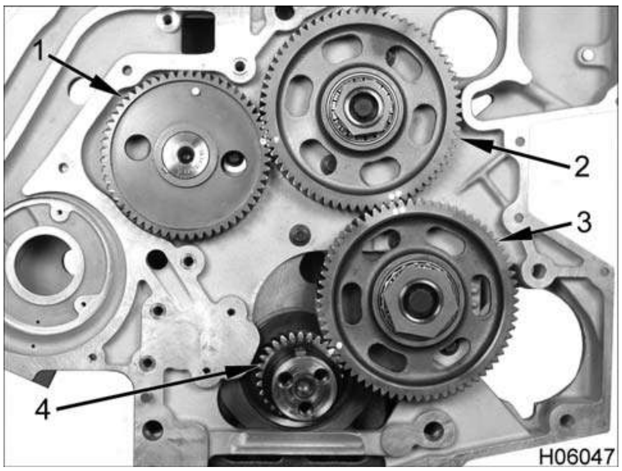


Figure 235 Gear train locations

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

Figure 236 Removing the lower idler gear

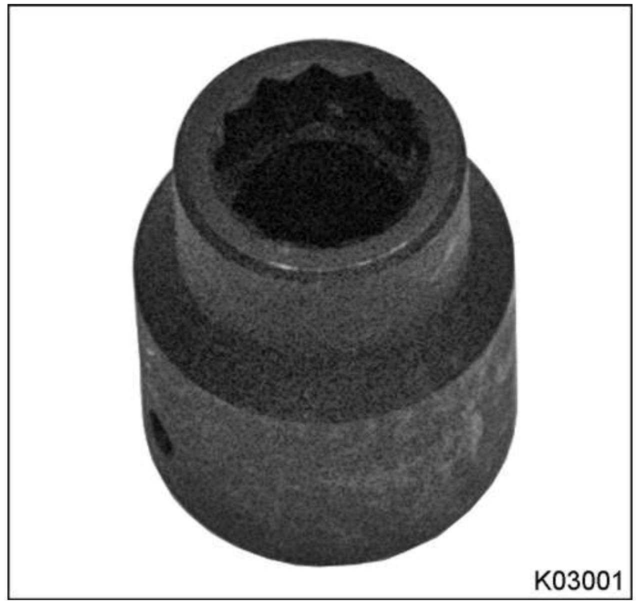


Figure 237 Lower Idler Gear Socket

1. Remove M20 x 70 lower idler gear mounting bolt using Lower Idler Gear Socket (Table 21) and a 3/4 inch drive breaker bar.
2. Remove lower idler gear.

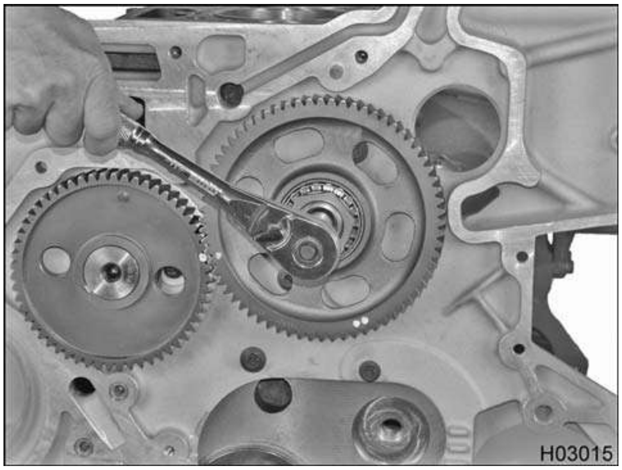


Figure 238 Removing the upper idler gear

3. Remove M16 x 65 upper idler gear mounting bolt using a 16 mm 12 point impact socket (Table 21) and a 1/2 inch drive breaker bar.
4. Remove upper idler gear.

NOTE: If required, Measure Camshaft End Play (page 267) after removing the upper idler gear.

Front Cover (Rear Half)

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

NOTE: Generation 1 (rear half) front covers include a water pump wear plate.

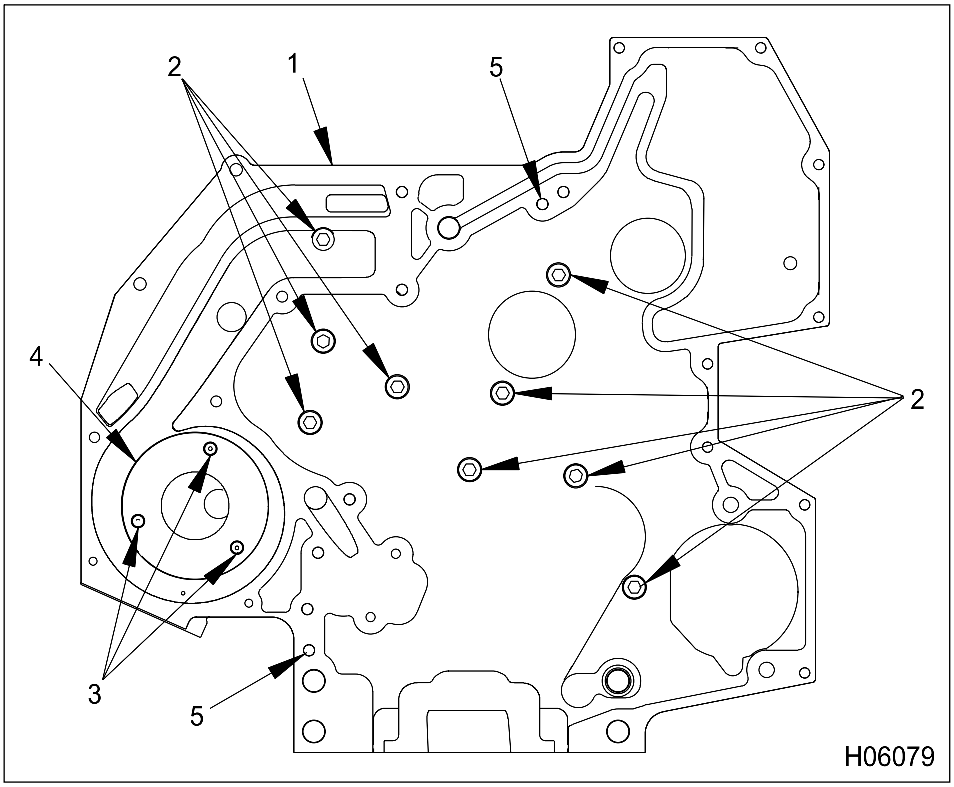


Figure 239 Front cover mounting bolts – rear half (Generation 1)

1. Front cover assembly (rear half)
2. Special hex flange bolt, M8 x 20 (9)
3. Flat head hex socket, M5 (3)
4. Wear plate
5. Dowel pin locations

1. Remove the camshaft or camshaft assembly before removing front cover (rear half). See “Crankcase, Crankshaft, and Camshaft” section in this manual for removal procedure.
2. Remove nine mounting bolts (M8 x 20) that secure the rear half of the front cover to the crankcase. Pull cover straight outward to slide dowels out of the crankcase. These dowels are retained in the rear half of the front cover.
3. Remove the oil and coolant gaskets from the rear half of the front cover and discard.

Inspection

Checking Lower Idler Gear Backlash

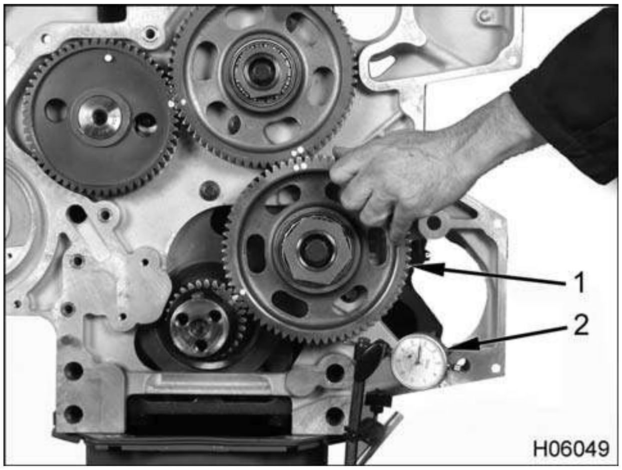


Figure 240 Checking lower idler gear backlash

1. Lower idler gear
2. Dial indicator

1. Clamp a dial indicator onto the front cover.
2. Place the tip of the dial indicator as tangent as possible to a gear tooth, and zero dial indicator.
3. Rock lower idler gear back and forth. Record the reading on the dial indicator face. If the backlash exceeds specifications, replace lower idler gear.

Checking Upper Idler Gear Backlash

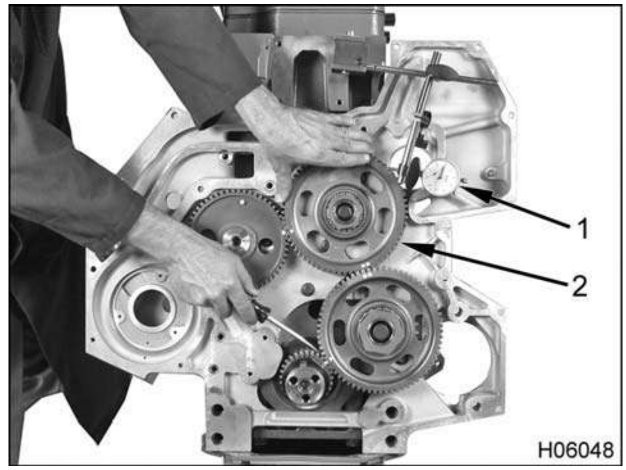


Figure 241 Checking upper idler gear backlash

1. Dial indicator
2. Upper idler gear

1. Mount a dial indicator on top of the crankcase.
2. Place the tip of the dial indicator as tangent as possible to a gear tooth and zero dial indicator.
3. Place a screwdriver between the crankshaft and the lower idler gear to keep the lower idler gear from rotating.
4. Rock upper idler gear back and forth. Record the reading on the dial indicator. If the backlash exceeds specifications, replace upper idler gear.

Checking Camshaft Gear Backlash

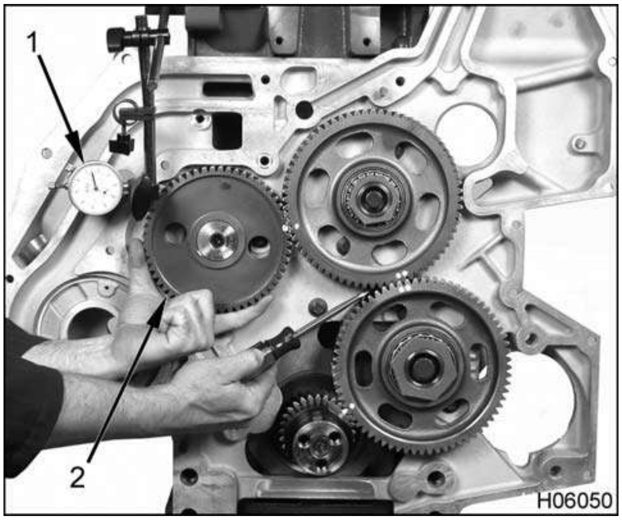


Figure 242 Checking camshaft gear backlash

1. Dial indicator
2. Camshaft gear

NOTE: Pressure exerted by the valve train must be relieved before doing the following procedure.

1. Clamp a dial indicator on the front cover or the cylinder head if the dial indicator stand is magnetic
2. Place the tip of the dial indicator as tangent as possible to a gear tooth and zero dial indicator.
3. Place a screwdriver between the upper idler gear and the lower idler gear to keep the upper idler gear from rotating.
4. Rotate the camshaft gear back and forth. Record reading on the dial indicator face. If the backlash exceeds specifications, replace camshaft gear.

Gerotor Oil Pump Clearance

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Inspection procedures for the gerotor oil pump assembly show the 8 lobe gerotor oil pump. Inspection procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

Measuring Oil Pump Side Clearance

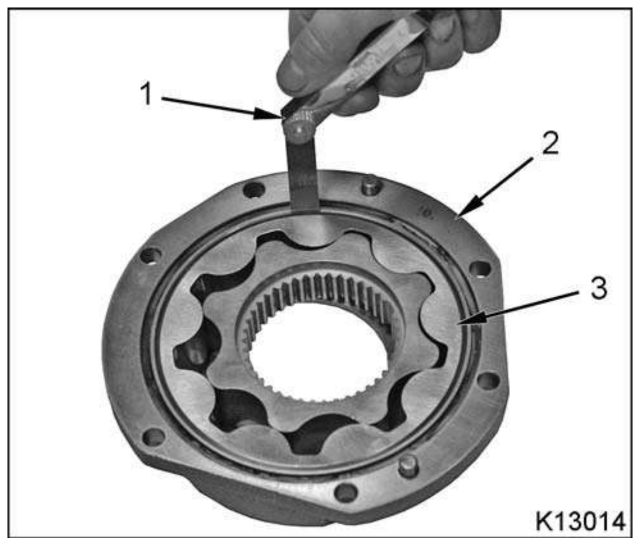


Figure 243 Oil pump side clearance measurement

1. Feeler gauge
2. Oil pump and rotor housing
3. Outer rotor

1. Coat outer rotor with oil and install rotor in oil pump and rotor housing.
2. Check oil pump side clearance Specification (Table 19) and choose the appropriate thickness feeler gauge (Table 21).
3. Insert feeler gauge between the oil pump and rotor housing and outer rotor.
4. Replace oil pump and rotor assembly if not within specification.

Measuring Oil Pump End Clearance

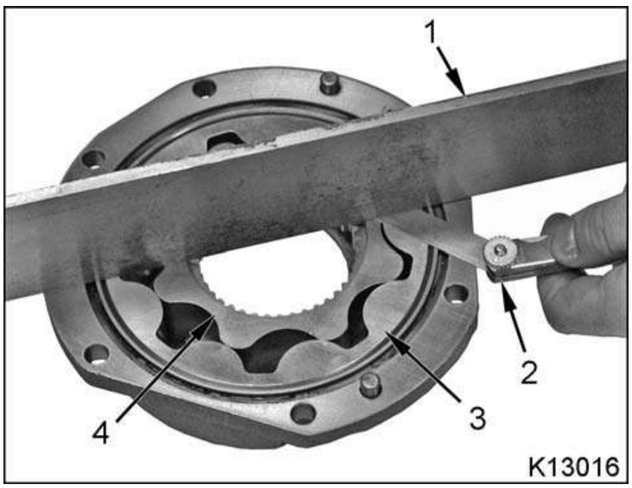


Figure 244 Oil pump end clearance measurement

1. Straightedge
2. Feeler gauge
3. Outer rotor
4. Inner rotor

1. Place a straightedge (Table 21) across the oil pump mounting surface.
2. Check oil pump end clearance Specification (Table 19) and choose the appropriate thickness feeler gauge (Table 21).
3. Slide feeler gauge between the straightedge and the oil pump inner and outer rotors.
4. Replace oil pump and rotor assembly if not within specification.

Installation

Front Cover

NOTE: If the (rear half) of a Generation 1 front cover assembly needs to be replaced, install a new Generation 2 front cover assembly (front and rear half). The (rear half) of the Generation 1 front cover assembly is not available for service.

Gaskets

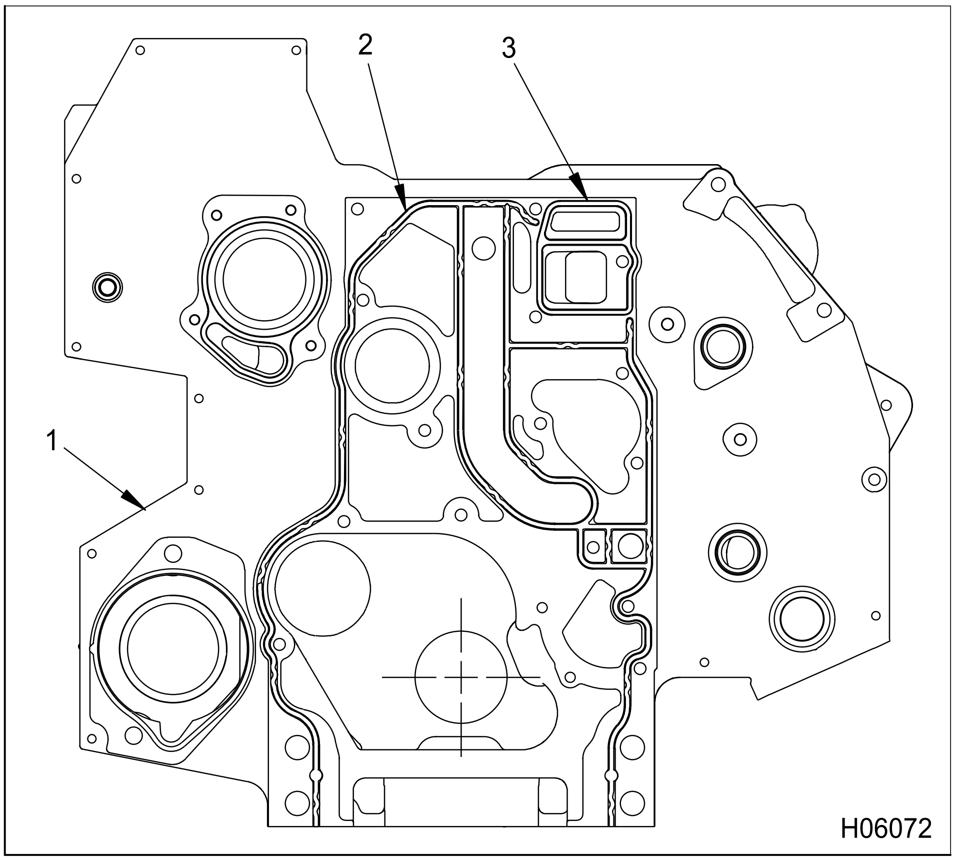


Figure 245 Front cover gaskets – rear half, crankcase side

1. Front cover assembly (rear half, crankcase side)
2. Oil gasket
3. Coolant gasket

1. Install a new oil gasket onto the crankcase side of the front cover (rear half).
2. Install a new coolant gasket onto the crankcase side of the front cover (rear half).

Mounting Bolts (Rear Half)

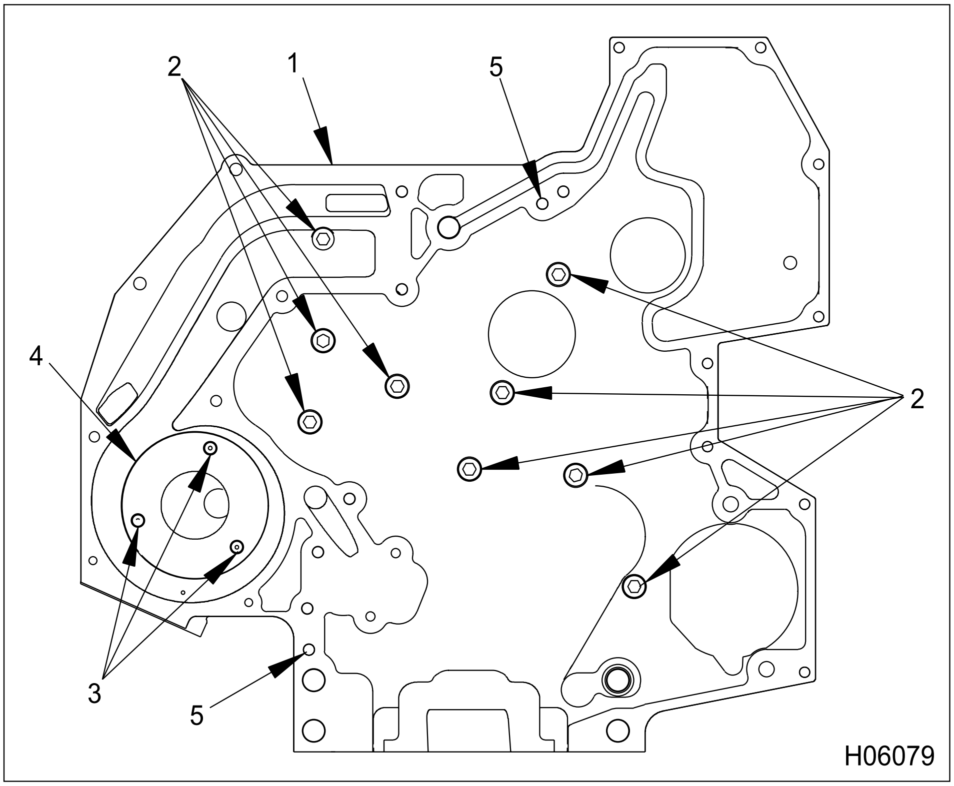


Figure 246 Front cover mounting bolts – rear half

1. Front cover assembly (rear half)
2. Special hex flange bolt, M8 x 20 (9)
3. Flat head hex socket, M5 (3)
4. Wear plate
5. Dowel pin

1. Position the rear half of the front cover onto the crankcase and install all nine mounting bolts finger tight. Then tighten the mounting bolts to the special torque value (Table 20).
2. Install the camshaft or camshaft assembly after installing front cover (rear half). See “Crankcase, Crankshaft, and Camshaft” section in this manual for removal procedure.

Idler Gears

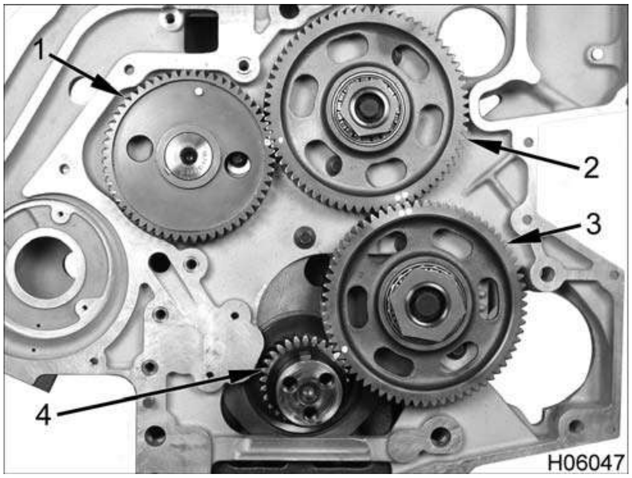


Figure 247 Gears and timing marks

1. Camshaft gear
2. Upper idler gear
3. Lower idler gear
4. Crankshaft gear

NOTE: When installing the gears in the gear train, the timing marks on the edge of each gear must be correctly aligned and oriented (facing outward). Once the gears are properly installed, the crankshaft will require 34 revolutions to align the timing marks again.

- The upper idler gear and camshaft gear are matched with one dimple on each gear
- The upper idler gear and lower idler gear are matched with two dimples on each gear
- The lower idler gear and crankshaft gear are matched with one dimple on each gear

Figure 248 Installing the lower idler gear mounting bolt

1. Install and hand tighten the lower idler gear and mounting bolt (M20 x 70) with timing marks facing outward. Align single timing marks between the crankshaft and lower idler gear.

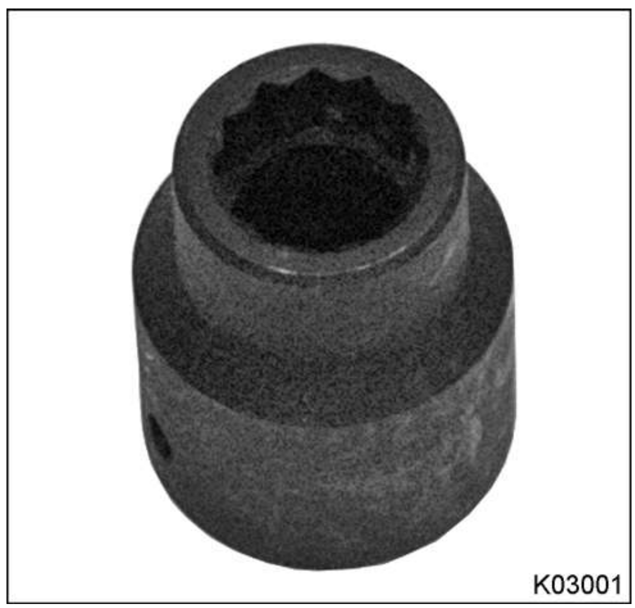


Figure 249 Lower Idler Gear Socket

2. Tighten the M20 x 70 bolt to the special torque value (Table 20) using Lower Idler Gear Socket (Table 21).

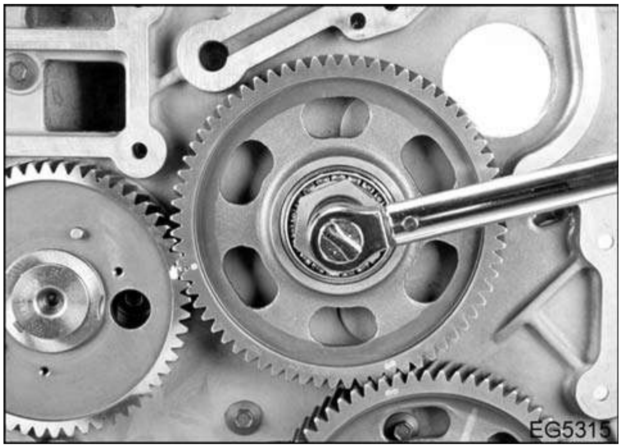


Figure 250 Installing the upper idler gear mounting bolt

3. Install the upper idler gear and mounting bolt (M16 x 65) with timing marks facing outward. Align the single marks on the camshaft gear and upper idler gear and the dual marks on the lower idler gear with those on the upper gaer. Tighten M16 x 65 bolt to the special torque value (Table 20), using a 16 mm 12 point impact socket (Table 21).
4. Check gear backlash between upper idler gear and camshaft gear. See Checking Camshft Gear Backlash.
5. Check gear backlash between high-pressure pump and upper idler gear (Table 19).
6. Check high-pressure pump end play.
7. Check camshaft end play.

NOTE: If equipped with an air compressor, check gear backlash between air compressor drive gear and lower idler gear.

8. If a Generation 1 front cover (rear half) is reused, install wear plate onto the front cover (rear half) and insert three flat head hex socket screws (M5). Tighten screws to the special torque value (Table 20).

Front Cover (Front Half)

Gaskets

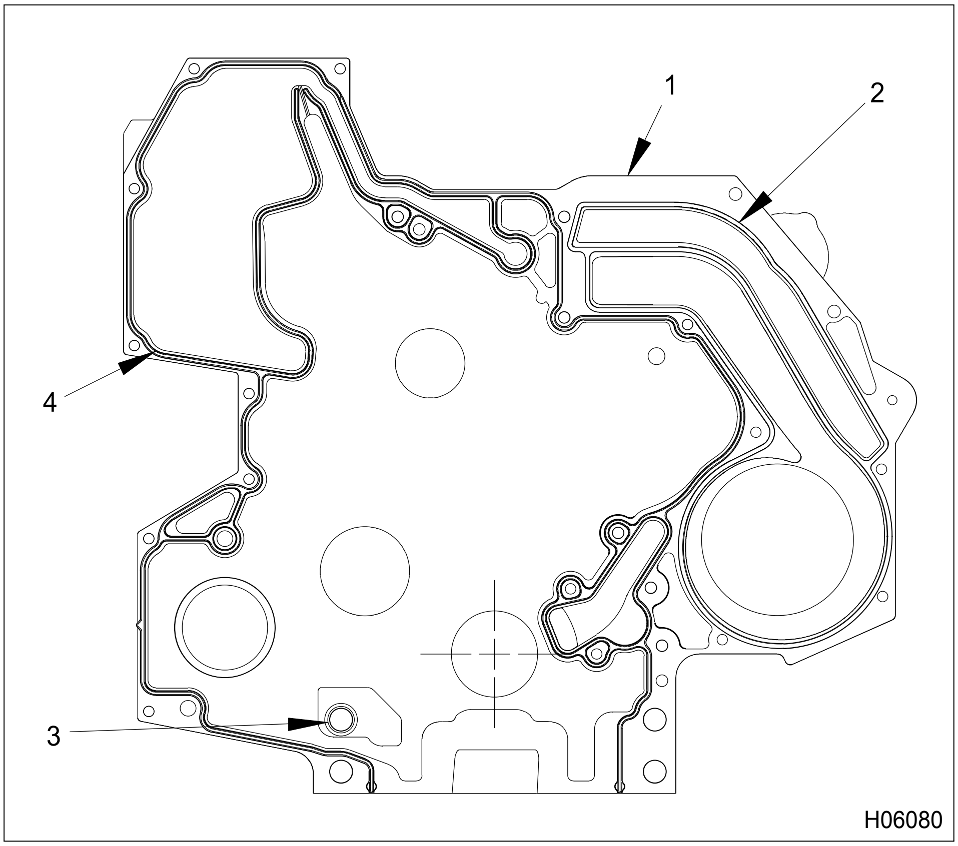


Figure 251 Front cover gaskets – front half

1. Front cover (front half)
2. Front cover gasket (coolant)
3. O-ring seal
4. Front cover gasket (oil)

1. Install new front cover coolant and oil gaskets into the front half of the front cover.
2. Install a new O-ring seal into the front half of the front cover

Generation 1 (Mounting Bolts)

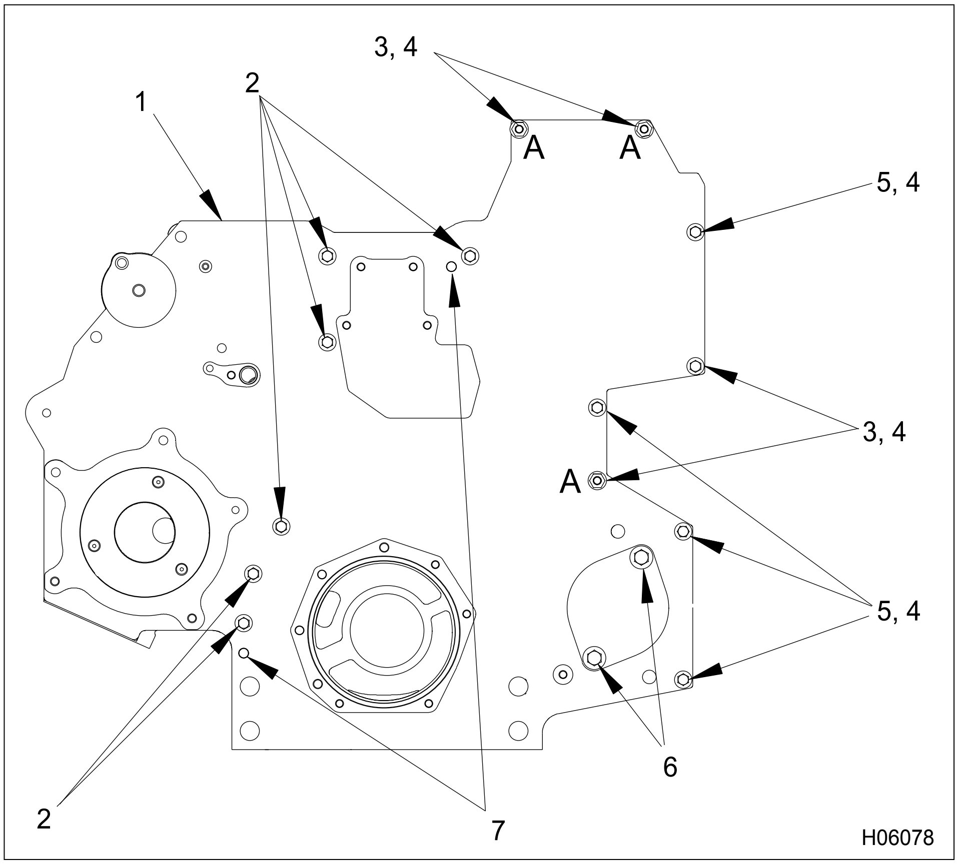


Figure 252 Front cover mounting bolts – front half (Generation 1)

1. Front cover (front half)
2. Hex flange bolt, M8 x 45 (6)
3. Hex flange bolt, M8 x 40 (4), **Note:** Bolts marked **A** to be inserted from rear side of cover.
4. Hex flange nut, M8 (8)
5. Hex flange bolt, M8 x 30 (4)
6. Heavy hex flange bolt, M10 x 25 (2) (PTO equipped engines only)
7. Dowel hole

1. Position the forward half of the front cover onto the rear half of the front cover using the two dowels as a guide.

Thread all mounting bolts finger tight, then tighten bolts to the standard torque value (General Torque Guidelines, page445).

Generation 2 (Mounting Bolts)

NOTE: Generation 2 front cover assemblies have additional bolts to secure the front cover half to the rear half.

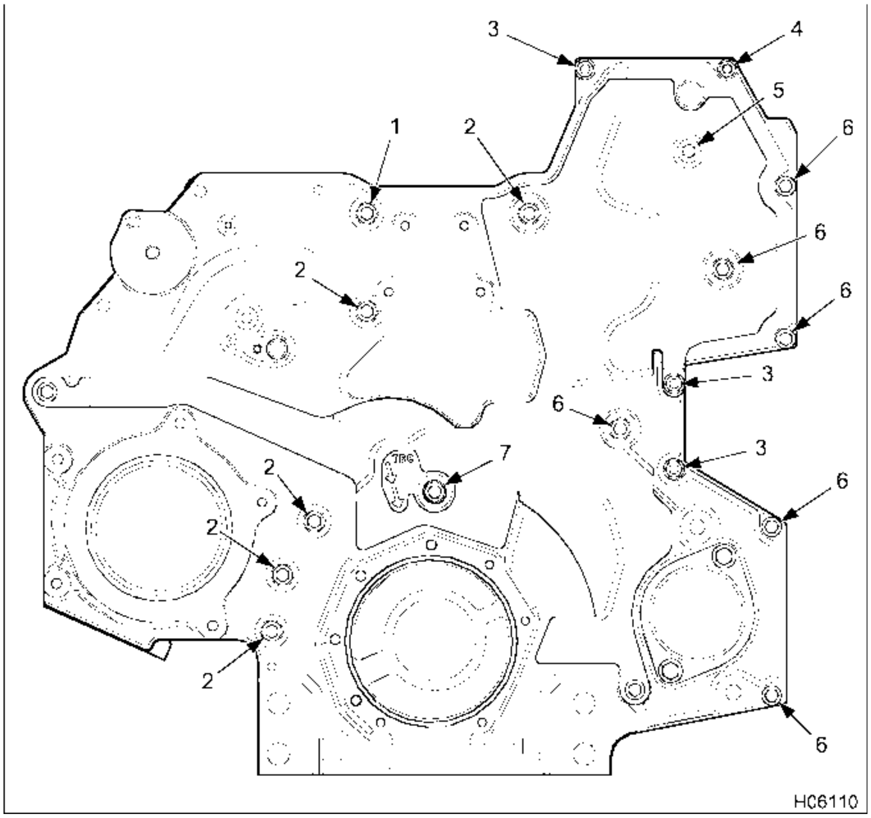


Figure 253 Front cover mounting bolts – front half (Generation 2)

1. M8 x 45 hex flange bolt (patch bolt)
2. M8 x 45 bolt (5)
3. M8 x 50 special bolt (nut on front) (3)
4. M8 x 73 stud bolt (nut on back)
5. M8 x 75 bolt – dog point (nut on back)
6. M8 x 50 bolt (nut on back) (6)
7. Seal assembly – M8 x 50 bolt and seal washer
8. Dowel hole

1. Align dowel holes in front cover (front half) with dowel pins in rear half of front cover, and install front cover (front half).
2. Install new M8 x 75 bolt – dog point and nut (nut on back) finger tight.
3. Install new Seal Assembly – M8 x 50 bolt and seal washer finger tight.
4. Install six M8 x 50 special bolts and nuts finger tight.
5. Install M8 x 73 stud bolt and nut (nut on back) finger tight.
6. Install new M8 x 45 mm hex flange patch bolt finger tight.
7. Install five M8 x 45 bolts finger tight.
8. Tighten all mounting bolts to the standard torque value (General Torque Guidelines, page445) .

Front Engine Mount

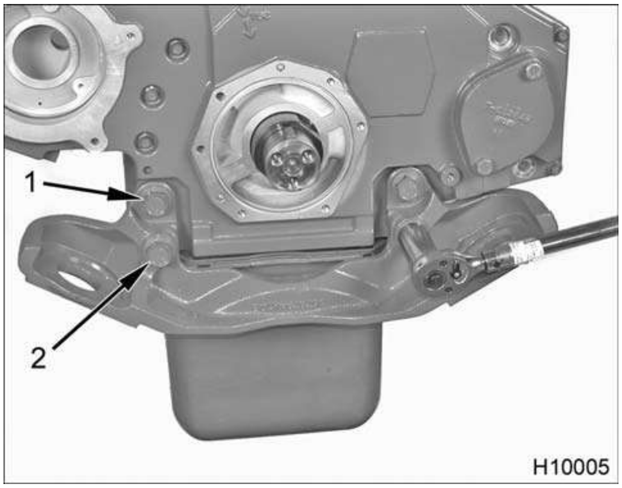


Figure 254 Front engine mount

1. Bolt, M18 x 70 (2)
2. Bolt, M18 x 100 (2)

1. Position front engine mount onto front cover assembly.
2. Install two upper bolts (M18 x 70) finger tight.
3. Install two lower bolts (M18 x 100) finger tight.
4. Tighten all four bolts to the special torque value (Table 20) .

Gerotor Oil Pump Assembly and Front Oil Seal

Up to late Model Year 2006, all International® DT 466, DT 570 and HT 570 Diesel Engines were equipped with an 8 lobe gerotor oil pump.

Later in Model Year 2006, International® DT 466 (210 to 245 horsepower) Diesel Engines were equipped with a 10 lobe gerotor oil pump.

NOTE: Installation procedures for the gerotor oil pump assembly show the 8 lobe gerotor oil pump. Installation procedures for the 10 lobe gerotor oil pump are the same as for the 8 lobe gerotor oil pump.

1. If removed, install new oil pump drive (spline) onto the crankshaft, (Crankshaft Assembly, page268).

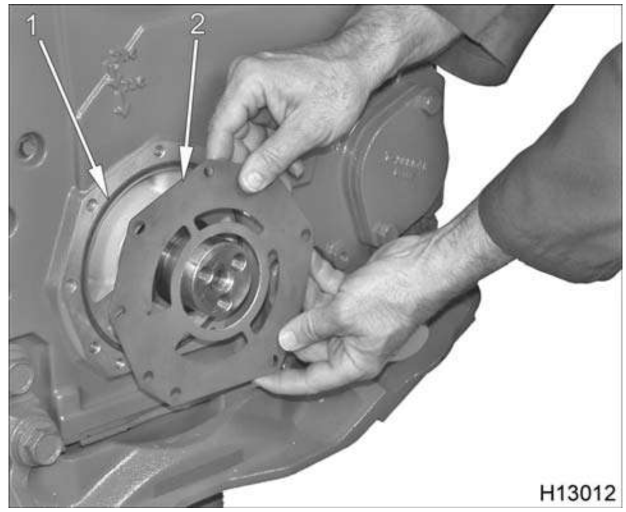


Figure 255 Oil pump housing plate and seal

1. Oil pump (housing plate) seal
2. Oil pump housing plate

2. Place oil pump (housing plate) seal into front cover recess. Align oil pump housing plate with dowels.

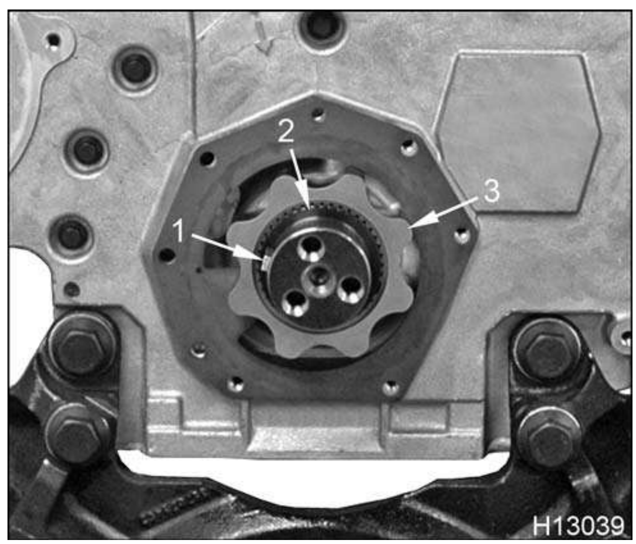


Figure 256 Vibration damper key, washer seal, and inner rotor

1. Vibration damper key
2. Washer seal
3. Inner rotor

NOTE: If reusing the original gerotor oil pump assembly, make sure the marks added during the removal process are properly oriented for installation.

3. Slide oil pump inner rotor onto oil pump drive (spline).
4. Install the washer seal with outer bevel oriented towards the front.

   CAUTION: To prevent engine damage, do not mark or distort the crankshaft keyway groove during vibration damper key installation.

5. Carefully tap the vibration damper key into place on the crankshaft with a hammer.

Figure 257 Applying Loctite® hydraulic sealant to front oil seal

6. Apply Loctite® hydraulic sealant to the outside edge of the front oil seal.

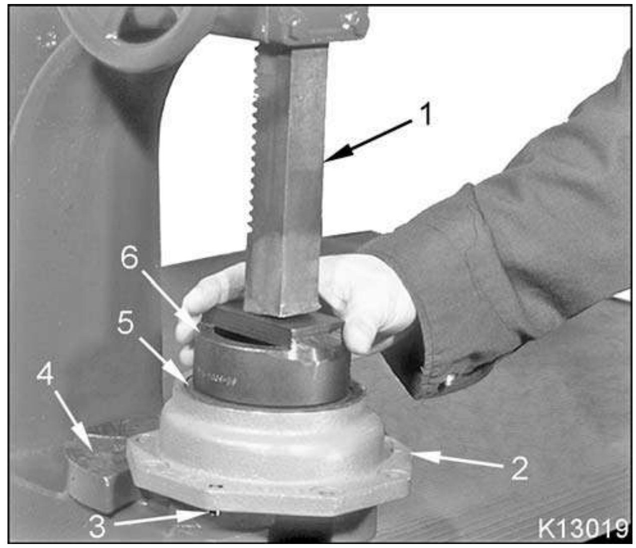


Figure 258 Front oil seal installation

1. Press ram
2. Oil pump and rotor housing
3. Dowel pin (2)
4. Press table
5. Front oil seal
6. Front Seal and Wear Sleeve Installer

7. Place oil pump and rotor housing, new front oil seal, and Front Seal and Wear Sleeve Installer (Table 21) on press table.
8. Position oil pump housing on press table so housing mating surface is level and supported. Dowel pins should be recessed in press table openings.
9. Position press ram on the center of the Front Seal and Wear Sleeve Installer and carefully press the front oil seal into the oil pump housing until seal is fully seated.

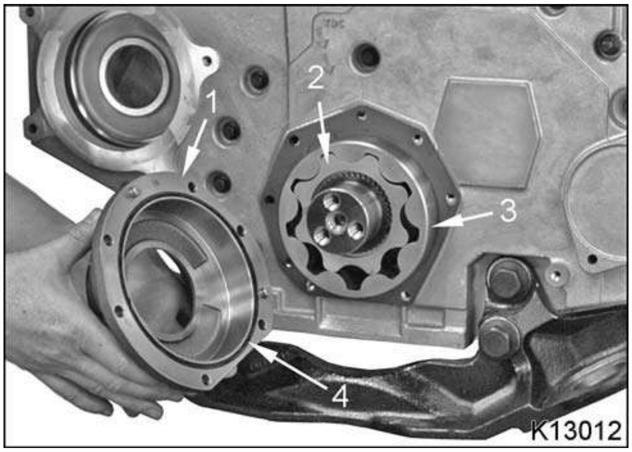


Figure 259 Oil pump housing, rotors, and oil pump (housing) seal

1. Oil pump and rotor housing
2. Inner rotor
3. Outer rotor
4. Oil pump (housing) seal

10. Install a new oil pump (housing) seal in the oil pump and rotor housing groove.
11. Coat the outer rotor with clean engine oil.

CAUTION: To prevent engine damage, make sure used oil pump inner and outer rotors rotate in the same direction as before removal. See marks added during removal for proper rotor orientation.

12. Install the outer rotor on the inner rotor.
13. Lightly coat the inside sealing surface of the front oil seal with clean engine oil.
14. Align two oil pump and rotor housing dowels with two front cover dowel holes and install oil pump and rotor housing.

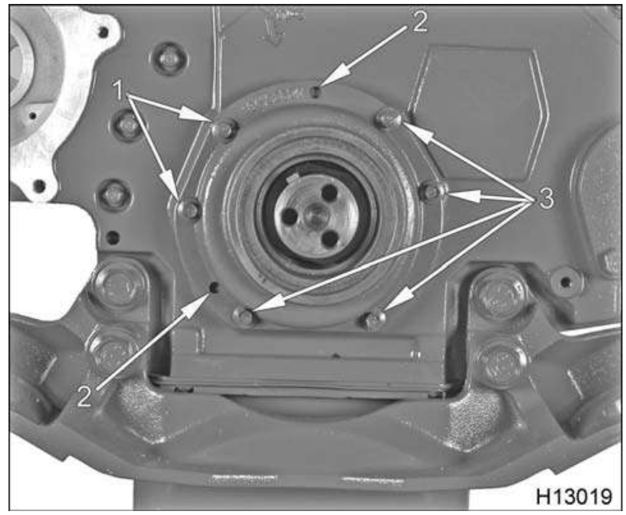


Figure 260 Oil pump housing mounting bolt locations

1. Bolt, M8 x 60 (2)
2. Dowels (2)
3. Bolt, M8 x 25 (4)

15. Install four M8 x 25 bolts finger tight.
16. Install two M8 x 60 bolts finger tight.
17. Tighten four M8 x 25 bolts and two M8 x 60 bolts to special torque (Table 20).

POSE Dust Seal and Wear Sleeve

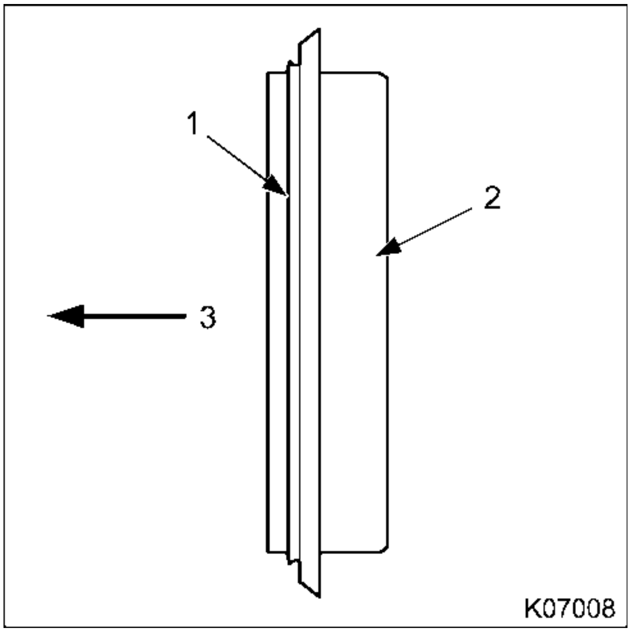


Figure 261 Wear sleeve with POSE dust seal

1. POSE dust seal
2. Wear sleeve
3. Front of engine

NOTE: DT 466 engines equipped with an 8 lobe oil pump use a wear sleeve without a POSE dust seal. DT 466 engines equipped with a 10 lobe oil pump use a wear sleeve with a POSE dust seal. All DT 570 and HT 570 engines equipped with an 8 lobe oil pump use a wear sleeve with a POSE dust seal.

NOTE: If service kit contains more than one wear sleeve, use sleeve that has the same width as the current wear sleeve.

CAUTION: A new front oil seal and wear sleeve (with a POSE dust seal) must be installed as a set for engines equipped with a 10 lobe oil pump.

NOTE: The chamfer (rounded edge) of the wear sleeve outside diameter must face in, toward the engine.

1. Apply Loctite® 569 Hydraulic Sealant (Table 21) to the inside diameter of a new wear sleeve.

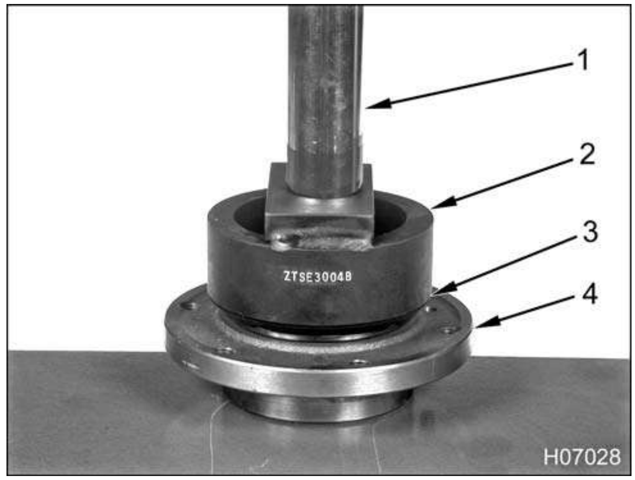


Figure 262 Front seal and wear sleeve installation

1. Press ram
2. Front Seal and Wear Sleeve Installer
3. POSE dust seal
4. Damper hub

2. Center the damper hub, new wear sleeve (with or without a POSE dust seal as appropriate for application), and Front Seal and Wear Sleeve Installer (Table 21) under press ram.
3. Carefully press the new wear sleeve on the damper hub until sleeve is fully seated.
4. Wipe any excess sealant off the outside diameter of the wear sleeve.

Vibration Damper Hub and Damper Retaining Plate

1. Mark damper hub with 100 °C (212 °F) Thermo-melt crayon (Table 21).

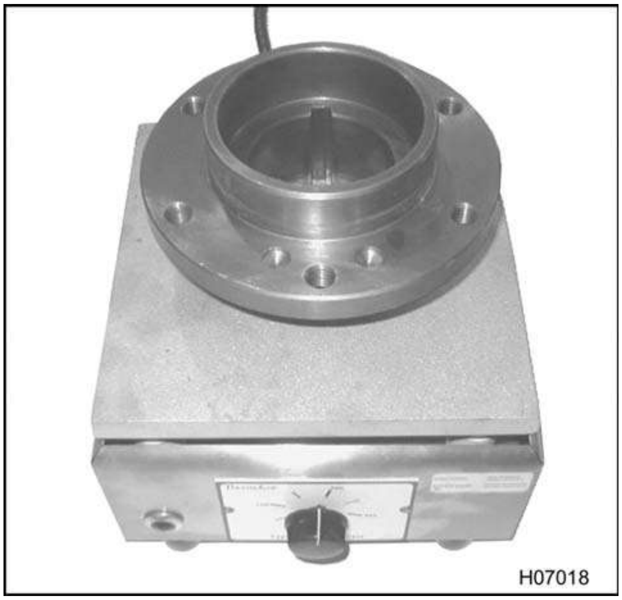


Figure 263 Heating the vibration damper hub

2. Heat vibration damper hub on a hot plate (Table 21) . Do not heat to more than 212 °F.

WARNING: To prevent serious personal injury, possible death, do not pick up the vibration damper hub with exposed hands. Wear heat protective gloves due to the extremely hot vibration damper hub.

Figure 264 Installation of vibration damper hub

WARNING: To prevent personal injury or death, wear heat insulated gloves when handling heated components.

WARNING: To prevent personal injury or death, damper hub must be completely seated on the crankshaft.

3. Install heated vibration damper hub onto the crankshaft. Use Heat Insulated Gloves (Table 21) specifically designed for extremely hot objects.

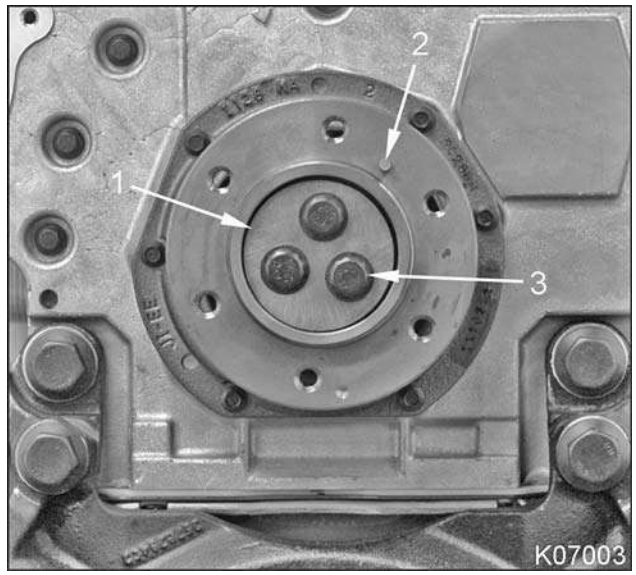


Figure 265 Damper retaining plate

1. Damper retaining plate
2. Dowel pin
3. Bolt M12 x 40 (3)

CAUTION: To prevent engine damage, only use 15.2 mm (0.60) in thick damper retainer and Class 12.9 damper bolts.

4. Verify that new damper retainer is 15.2 mm (0.60) in thick and new M12 x 40 damper bolts are Class 12.9.
5. Position new damper retaining plate and install three new M12 x 40 bolts.
6. Tighten three M12 x 40 damper bolts to special torque (Table 20).

7. Retighten three M12 x 40 damper bolts in sequence to special torque (Table 20) several times until each bolt has no movement.

Vibration Damper assembly

Three Rubber Vibration Damper Kits are available for International® DT 570 and HT 570 Diesel Engines. See (TSI-08-12-20 Rubber Vibration Damper Replacement Kits, page480).

CAUTION: To prevent engine damage, verify damper hub dowel pin is aligned with dowel hole of the vibration damper assembly.

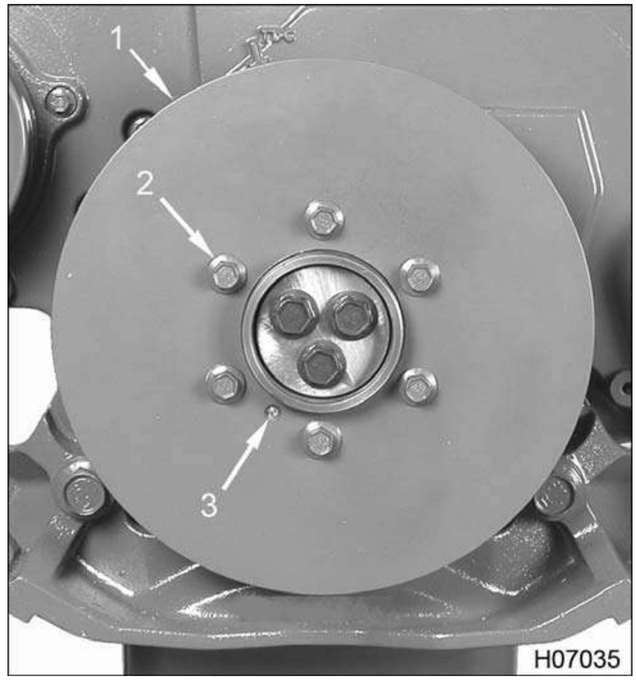


Figure 266 Vibration damper assembly

1. Vibration damper
2. Bolt, M10 x 16 (6)
3. Dowel pin

1. Align dowel hole in vibration damper with dowel pin on damper hub and install six M10 x 16 bolts finger tight.
2. Torque bolts to special torque (Table 20).

Fan Drive

Table 18 Fan Drive Mounting Bolt Sizes

Fan drive mounting configuration	Bolt size	Torque	Quantity
High-mount, Horton (20 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
High-mount, Horton (18.3 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
Mid-mount, Horton (16.2 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
Low-mount (Horton 12.2 in)	M8 x 1.25 x 30	26 N·m (19 lbf·ft)	4
High-mount (spin-on)	M8 x 1.25 x 30	Standard	2
	M8 x 1.25 x 65	Standard	2
Mid-mount (spin-on)	M8 x 1.25 x 30	Standard	2
	M8 x 1.25 x 65	Standard	2
Low-mount (bolt-on and spin-on)	M8 x 1.25 x 65	Standard	4

NOTE: The table located at the back of this section covers fan drive configurations diameters and ratios (Table 19).

1. Install fan hub assembly.

NOTE: The standard fan hub assembly is serviced as a unit. The assembly is made up of the following nonserviceable items:

- Fan and pulley mounting hub
- Fan bearing hub
- Bearing assembly
- M10 x 70 bolt
- Fan bearing retainer

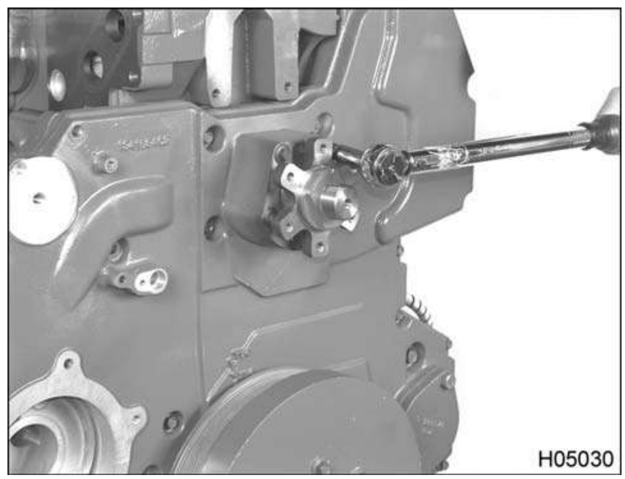


Figure 267 Torquing the fan drive mounting bolts (typical)

2. Install the hex flange bolts required (Table 18) and tighten to the standard torque value (General Torque Guidelines, page 445), unless otherwise noted (Table 20).

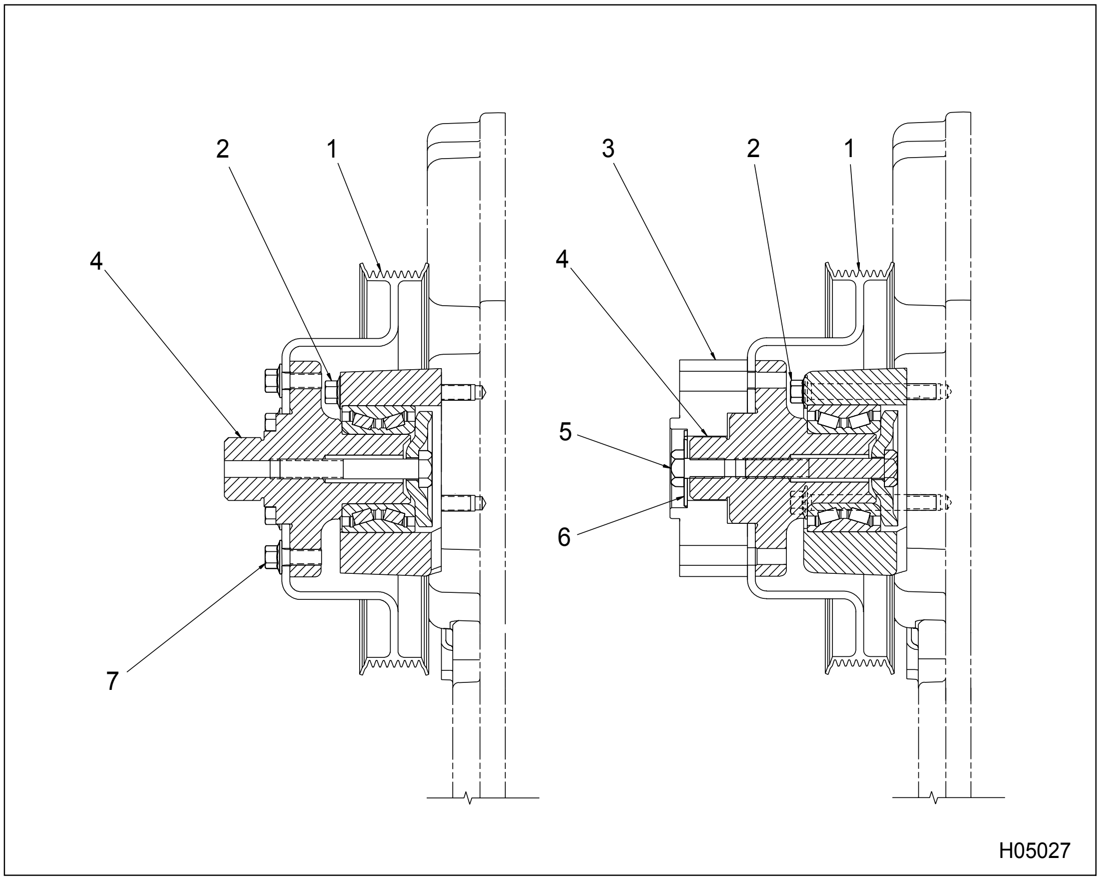


Figure 268 Spin-on fan drive (left) and bolt-on fan drive (right)

1. Fan pulley
2. Bolt, M8 x 65 (4)
3. Fan spacer
4. Fan hub assembly (cross-hatched)
5. Bolt, M10 x 20
6. Spacer retainer washer
7. Bolt, M8 x 20 (6)

3. Install the fan pulley and spacer as required for application.

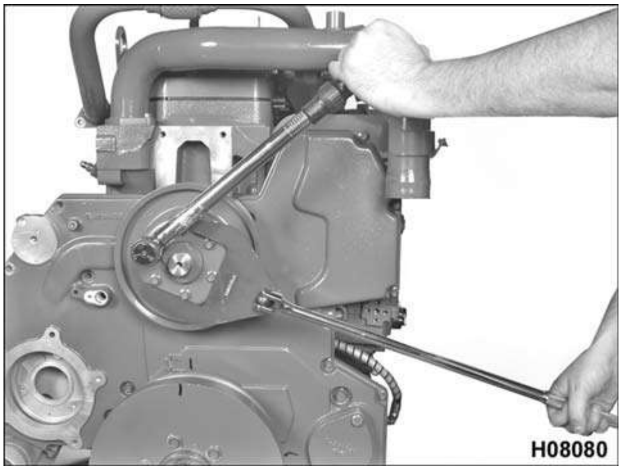


Figure 269 Torquing the fan drive pulley bolts

4. Install six M8 x 20 hex flange bolts to the fan pulley and tighten to the standard torque value (General Torque Guidelines, page445) .

Horton DriveMaster

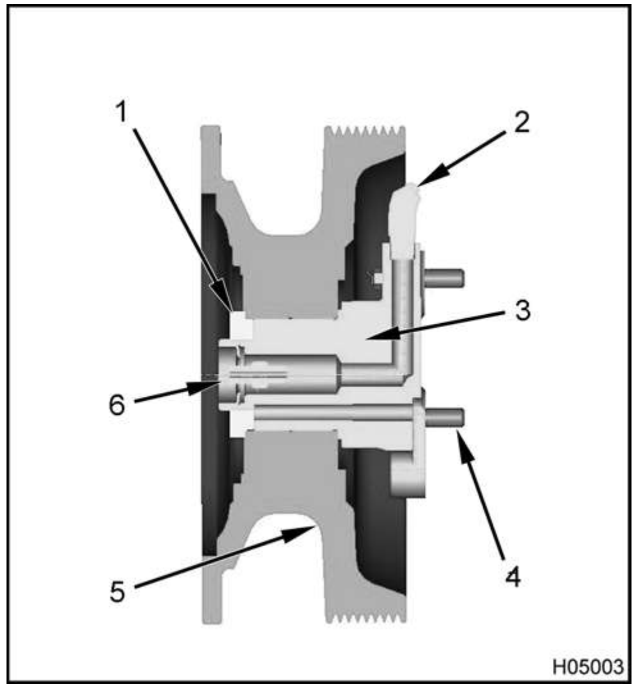


Figure 270 Horton DriveMaster (low mount version)

1. Bearing retainer nut assembly (shoulder relief faces engine)
2. Air channel inlet
3. Bracket assembly
4. Bolt, M8 x 30 (4)
5. Fan pulley
6. Air cartridge (Note: Horton service part only)

1. Install bracket assembly and four M8 X30 hex flange bolts . Torque bolts to the standard torque value (General Torque Guidelines, page445).
2. Slide fan pulley onto bracket with clutch mounting flange facing front.
3. Install bearing nut, making sure bearing nut shoulder relief is facing towards engine.
4. Tighten bearing retainer nut to the special torque (Table 20).

Water Pump Assembly

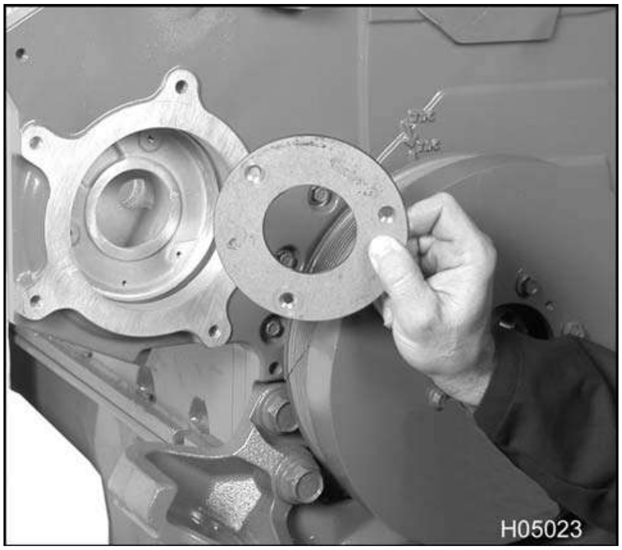


Figure 271 Water pump wear plate (Generation 1 front covers only)

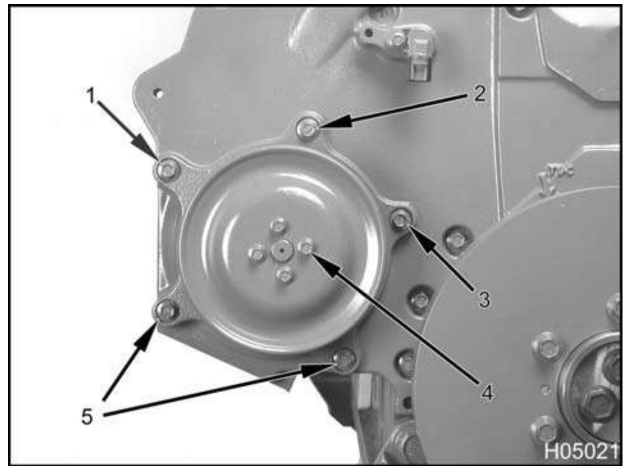


Figure 272 Water pump assembly

1. Bolt, M8 x 55, nut M8 (1)
2. Bolt, M8 x 100, Nut, M8
3. Bolt, M8 x 16 (1)
4. Bolt, M6 x 12 (4)
5. Bolt, M8 x 40 (2)

1. If applicable, install three flat head hex socket screws (M5) to secure the water pump wear plate to the rear half of the front cover, if not done previously during front cover installation.
2. Tighten M5 hex socket screws to the special torque (Table 20).
3. Install the water pump seal into the water pump seal recess.
4. Position water pump assembly into front cover.
5. Install one water pump assembly bolt (M8 x 100) from the raer half of the front cover. Thread nut (M8) on finger tight.
6. Install one water pump assembly bolt (M8 x 55) from the rear half of the front cover. Thread nut (M8) on finger tight.
7. Install one water pump assembly bolt (M8 x 16) finger tight.
8. Install two water pump assembly bolts (M8 x 40) finger tight.
9. Tighten all water pump bolts to the standard torque value (General Torque Guidelines, page 445) .
10. Install water pump pulley and secure with four pulley bolts (M6 x 12). Tighten bolts to the standard torque value (General Torque Guidelines, page445) .

Water Supply Housing

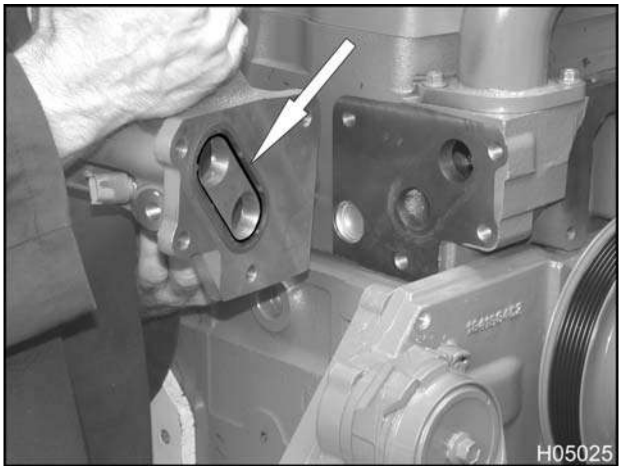


Figure 273 Water supply housing and coolant port seal

1. Position coolant port seal into machined recess at water supply housing.

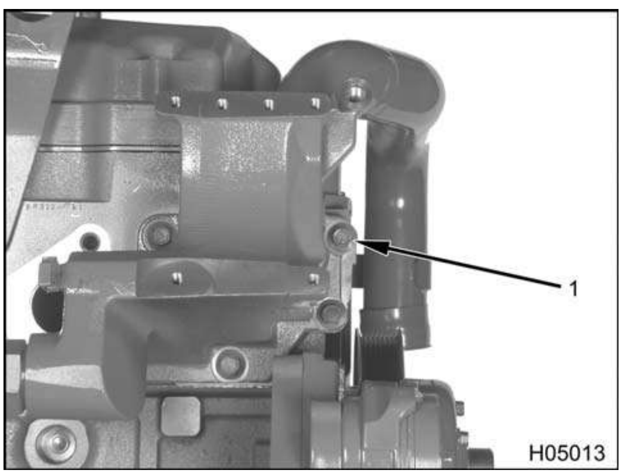


Figure 274 Water supply housing bolts

1. Bolt, M10 x 25 (4)

2. Install water supply housing and secure with four water supply housing bolts (M10 x 25).

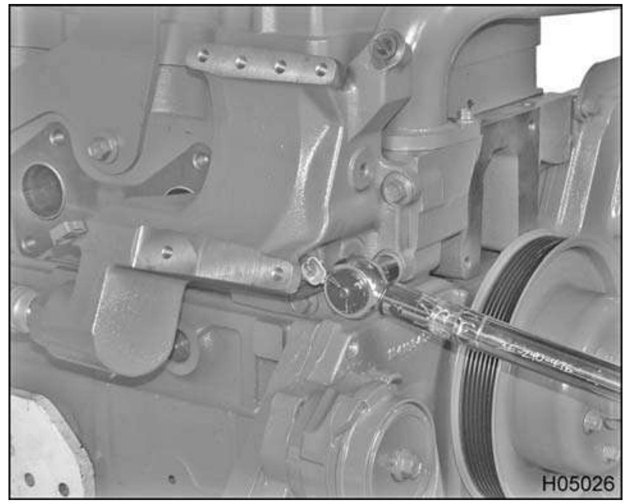


Figure 275 Torquing the water supply housing bolts

3. Tighten all bolts to the standard torque value (General Torque Guidelines, page445) .

Alternator Bracket

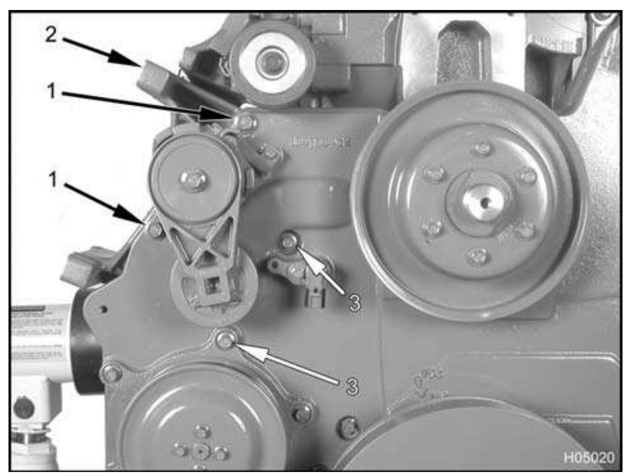


Figure 276 Alternator bracket

1. Bolt, M10 x 120 (2)
2. Alternator bracket
3. Bolt, M8 x 100 (2)

1. Position alternator bracket to backside of front cover and install two bolts (M10 x 120) and hex flange nuts (M10) finger tight.
2. Install the two remaining bolts (M8 x 100) and hex flange nuts (M8) finger tight.

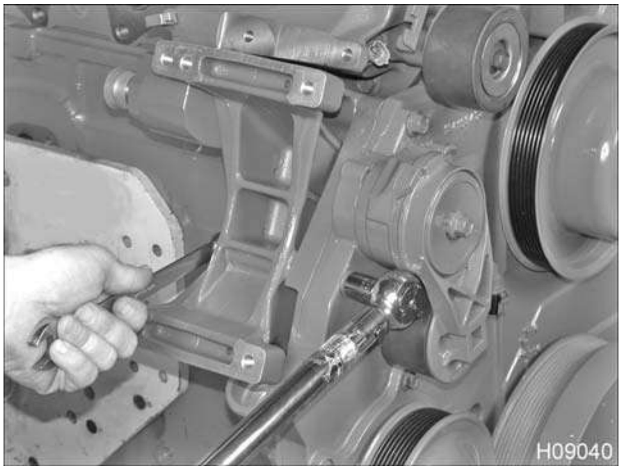


Figure 277 Torquing the alternator bracket bolts

3. Tighten all alternator bracket bolts to the standard torque value (General Torque Guidelines, page 445) .
4. Install harness routing guide and secure guide with an M8 bolt.

Flat Idler Pulley and Automatic Belt Tensioner

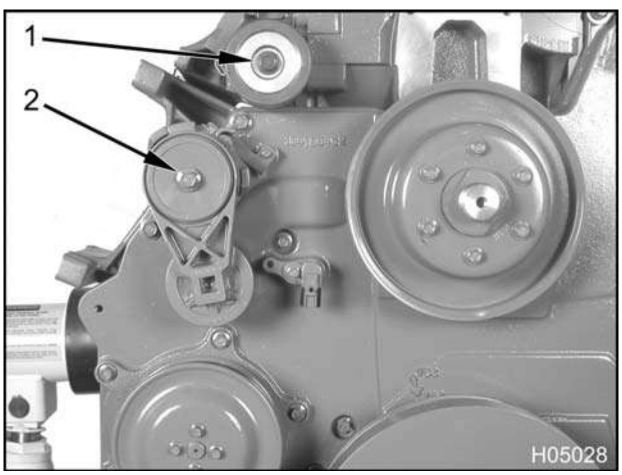


Figure 278 Flat idler pulley and automatic belt tensioner

1. Flat idler pulley assembly mounting bolt, M10 x 80
2. Automatic belt tensioner assembly mounting bolt, M10 x 80

1. Install M10 x 80 bolt through flat idler pulley assembly and into the water supply housing. Tighten bolt to the standard torque value (General Torque Guidelines, page445).
2. Install M10 x 80 bolt through the automatic belt tensioner assembly to the front cover assembly and tighten to the special torque (Table 20).

Water Inlet Elbow, Water Outlet Tube, and Thermostat

1. Install a water inlet gasket into the machined recess at the front cover.

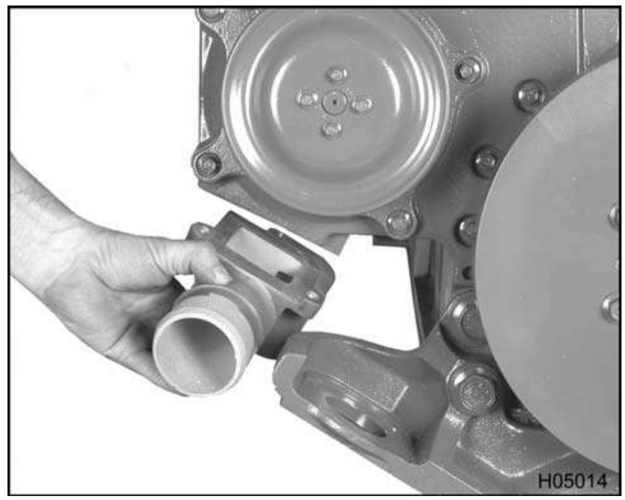


Figure 279 Water inlet elbow

2. Install water inlet (side port) elbow.
3. Install and tighten three hex flange bolts (M8 x 30) to the standard torque value (General Torque Guidelines, page445) .

NOTE: The thermostat seal cannot be purchased separately. It is only available with the thermostat assembly.

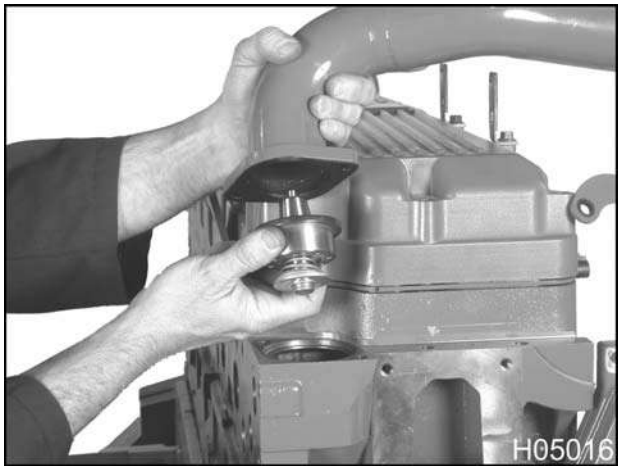


Figure 280 Thermostat assembly

4. Install a new thermostat and gasket into cylinder head.

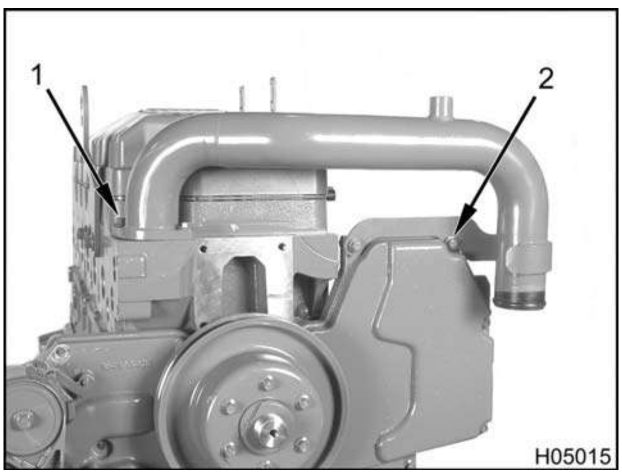


Figure 281 Water outlet tube assembly

1. Bolt, M8 x 25 (2)

5. Install water outlet tube assembly and secure with two water outlet tube assembly bolts (M8 x 25) at the cylinder head. Tighten to the special torque value (Table 20) .

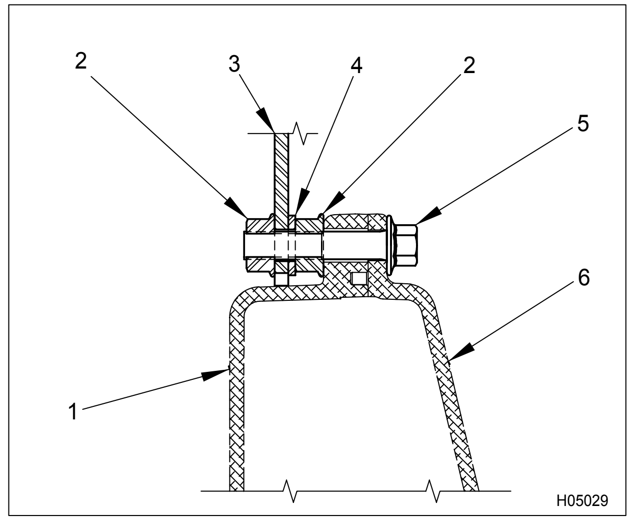


Figure 282 Water outlet tube assembly connection at front cover

1. Front cover (front half)
2. Hex flange nut, M8 (4)
3. Water outlet tube assembly (bracket)
4. Washer (2)
5. Hex flange bolt, M8 x 40 (2)
6. Front cover (rear half)

6. Install nuts, bolts and washers to secure the water outlet tube assembly at the front cover. Tighten nuts and bolts to the special torque value (Table 20).

Specifications

Table 19 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications

Camshaft gear end play	0.33 mm (0.013 in)
Camshaft gear-to-upper idler gear backlash	0.46 mm (0.018 in)
High-pressure pump end play	0.45 -1.22 mm (0.018 - 0.48 in)
Lower idler gear-to-air compressor gear backlash	0.508 mm (0.020 in)
Lower idler gear-to-crankshaft gear backlash	0.36 mm (0.014 in)
Oil pump end clearance	0.05 -0.13 mm (0.002-0.005 in)
Oil pump side clearance	0.36 - 0.48 mm (0.014 - 0.019 in)
Upper idler gear-to-high-pressure oil pump gear backlash	0.48 mm (0.019 in)
Upper idler gear-to-lower idler gear backlash	0.48 mm (0.019 in)
Vibration damper face runout (max.)	1.52 mm (0.060 in)
Vibration damper maximum allowable member misalignment	1.50 mm (0.060 in)

Fan Drive Configurations Diameters and Ratios

Engine fan drive configuration	Fan CL to Crankshaft CL, mm (in)	Pulley Diameter OBD, mm (in)	Drive Ratio
466 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	0.894 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	1.08 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	219.4 (8.636)	1.2 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	1.2 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	0.99 : 1
466 mid-mount, (Horton DriveMaster)	411 (16.2)	201.2 (7.92)	1.08 : 1
466 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.08 : 1
570 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 mid-mount, (spin-on)	411 (16.2)	201.2 (7.92)	1.08 : 1

Table 19 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications (cont.)

466 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
466 low-mount, Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.3 : 1
570 low-mount, (Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.3 : 1
466 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.3 : 1

NOTE: The high-mount and mid-mount fan drives share the same part number, however the fan drive is inverted depending upon application.

Special Torque

Table 20 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Special Torques

Automatic belt tensioner assembly	50 N·m (37 lbf·ft)
Damper retaining plate bolts	163 N·m (120 lbf·ft) Retorque all bolts until no movement
End cover adapter (PTO equipped engines only)	52 N·m (38 lbf·ft)
Fan drive, high-mount, Horton DriveMaster (20, 18.3 in.)	26 N·m (19 lbf·ft)
Fan drive, mid-mount, Horton DriveMaster (16.2 in.)	26 N·m (19 lbf·ft)
Fan drive, low-mount, Horton DriveMaster (12.2 in.)	26 N·m (19 lbf·ft)
Fan spacer retaining bolt, M10 x 20 (bolt-on drive only)	52 N·m (38 lbf·ft)
Front cover mounting bolts (rear half)	26 N·m (19 lbf·ft)
Front engine mounting bracket bolts (4)	386 N·m (284 lbf·ft)
Horton DriveMaster bearing retainer nut	177 N·m (130 lbf·ft)
Lower idler gear mounting bolt	639 N·m (470 lbf·ft)
Oil pump and rotor housing M8 bolts	25 N·m (18 lbf·ft)
Upper idler gear mounting bolt	326 N·m (240 lbf·ft)
Viscous or rubber vibration damper mounting bolts	54 N·m (40 lbf·ft)
Water outlet tube assembly at cylinder head	33 N·m (24 lbf·ft)
Water outlet tube assembly at front cover	33 N·m (24 lbf·ft)
Wear plate (water pump)	7 N·m (60 lbf·in)

Special Service Tools

Table 21 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mounts, and Gear Train Special Service Tools

Dial indicator set	Obtain locally
Feeler gauge	Obtain locally
Front seal and wear sleeve installer	ZTSE3004B
Heat Insulated Gloves	Obtain locally
H-bar puller	Obtain locally
Hot plate	Obtain locally
Loctite® 569 Hydraulic Sealant	Obtain locally
Lower Idler Gear Socket	ZTSE4383
Slide hammer puller set	ZTSE1879
Straightedge	Obtain locally
Thermo-melt crayon, 100 °C (212 °F)	Obtain locally
16 mm 12 point impact socket	Obtain locally

Table of Contents

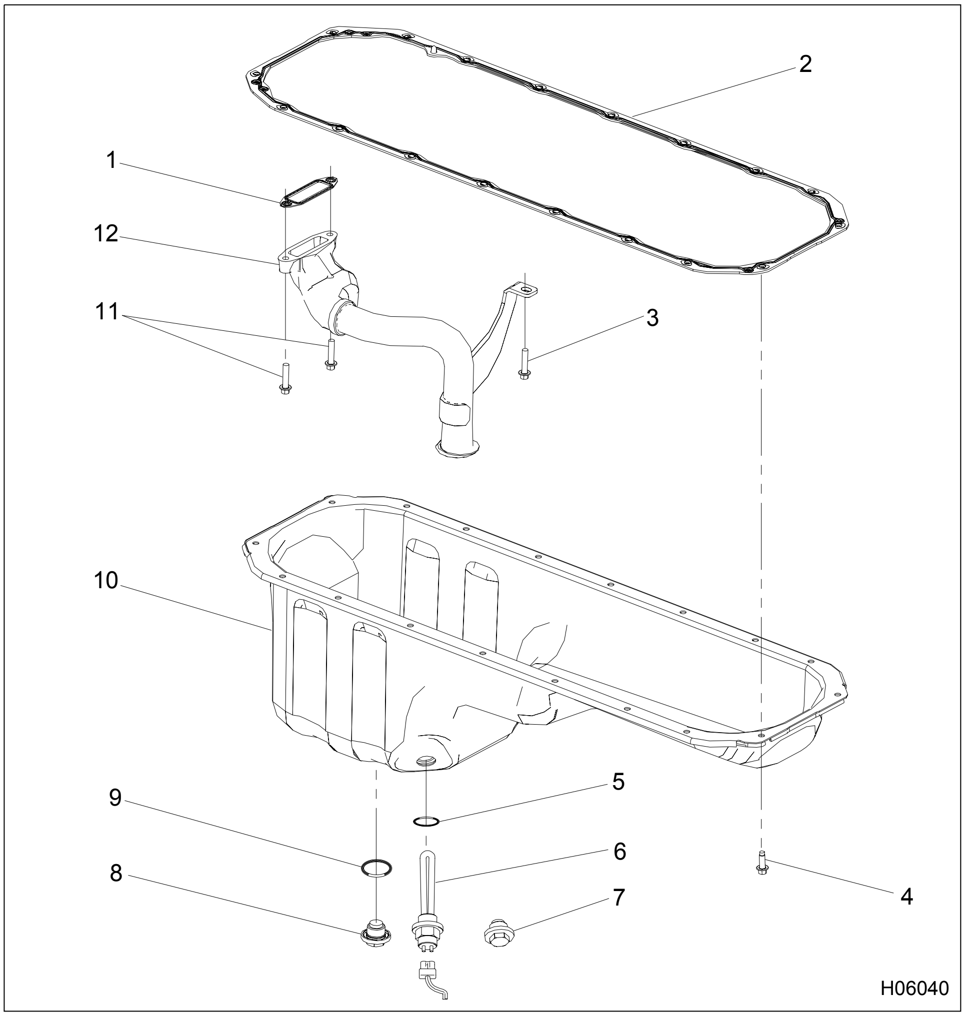


Figure 283 Oil pan and oil suction tube components

1. Oil suction tube gasket
2. Oil pan gasket
3. Bolt, M10 x 25 (1)
4. Bolt, M8 x 24 (18)
5. Heater element gasket
6. Oil heating element assembly (optional)
7. Plug (without oil pan heater)
8. Oil drain plug
9. Oil drain plug gasket
10. Oil pan (typical)
11. Bolt, M8 x 35 (2)
12. Oil suction tube assembly (typical)

Removal

Removing the Oil Pan

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 serious personal injury, possible death, or damage to the engine or vehicle, read all safety instructions in the "Safety Information" section of this manual.

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle.

WARNING: To prevent personal injury or death, allow engine to cool before working with 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.

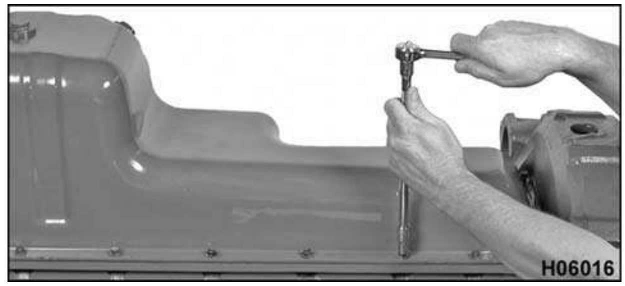


Figure 284 Removing the oil pan mounting bolts

1. Remove 18 (M8 x 24) oil pan mounting bolts.

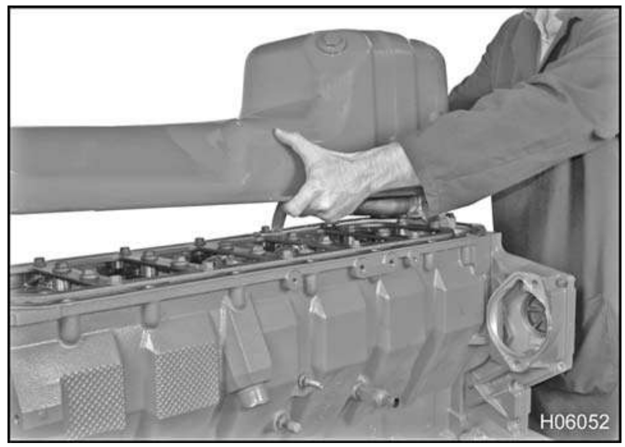


Figure 285 Removing the oil pan

2. Lift the oil pan from the engine.

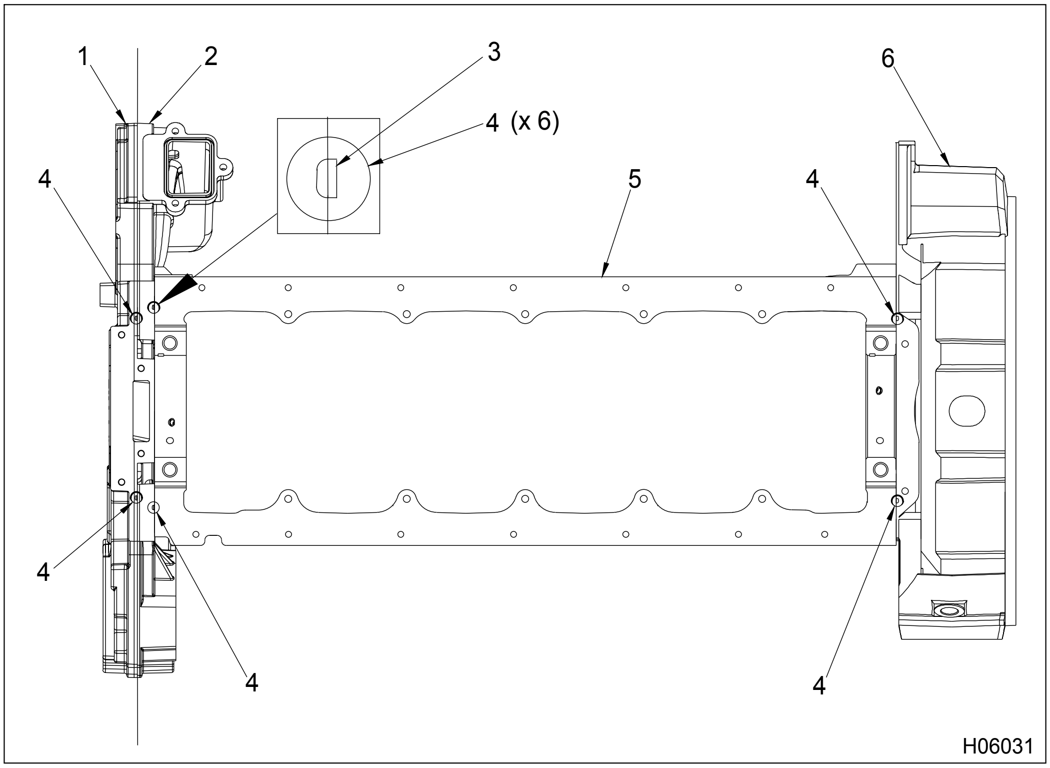


Figure 286 RTV sealant locations

1. Front cover (front half)
2. Front cover (rear half)
3. Gasket
4. RTV sealant locations
5. Crankcase
6. Flywheel housing

3. Use a knife or scraper to cut through the RTV sealant under the oil pan gasket at six locations on the crankcase mounting surface.

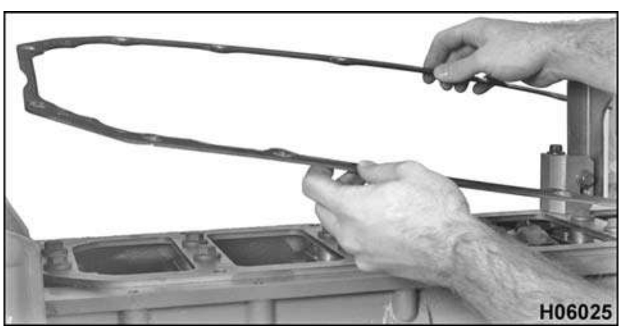


Figure 287 Removing the oil pan gasket

4. Remove the oil pan gasket from the crankcase mounting surface and discard.

Removing the Oil Suction Tube

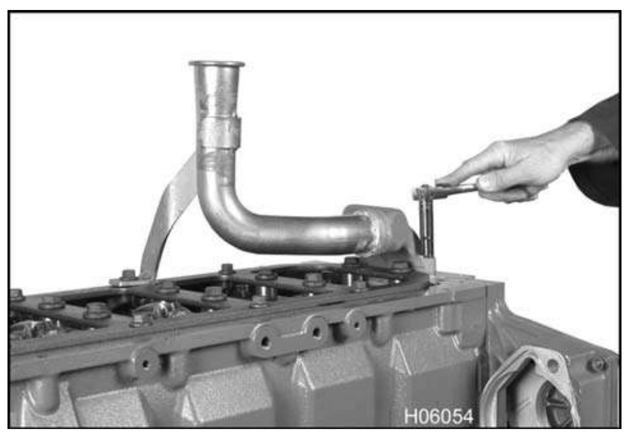


Figure 288 Removing the oil suction tube

1. Remove two (M8 x 35) mounting bolts from the oil suction tube.

2. Remove mounting bolt (M10 x 25) from the oil suction tube bracket.

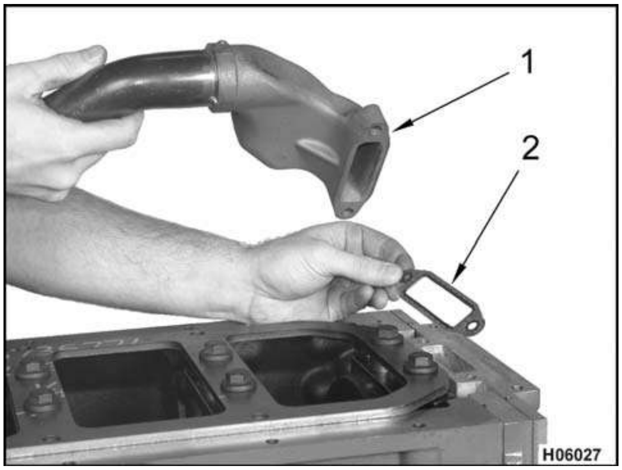


Figure 289 Removing the oil suction tube and gasket

1. Oil suction tube assembly
2. Gasket

3. Remove the oil suction tube assembly and gasket from the front cover and discard gasket.

Cleaning and Inspection

Oil Pan

1. Remove any used RTV sealant from the crankcase, oil pan, and oil pan gasket.
2. Clean the oil pan, front cover, flywheel housing and crankcase mating surfaces thoroughly with a suitable solvent.
3. Make sure that the oil suction tube is free of any obstructions.
4. Check the oil pan and oil suction tube for cracks and damage. Replace components as necessary.
5. Inspect oil pan heating element (if equipped) for an open circuit.

Installation

Installing the Oil Suction Tube

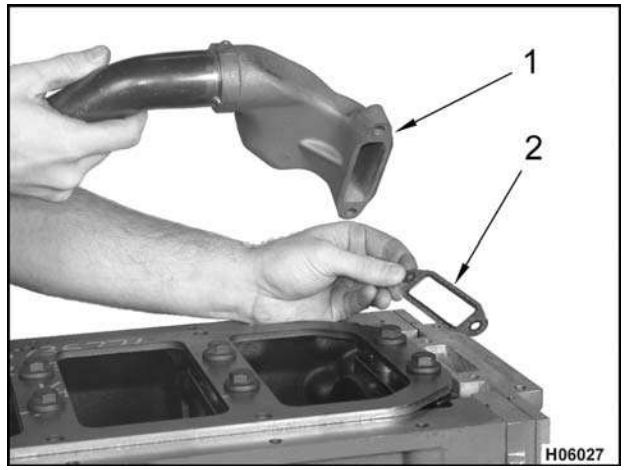


Figure 290 Installing the oil suction tube and gasket

1. Oil suction tube assembly
2. Gasket

1. Place a new gasket onto the front cover and install the oil suction tube assembly.

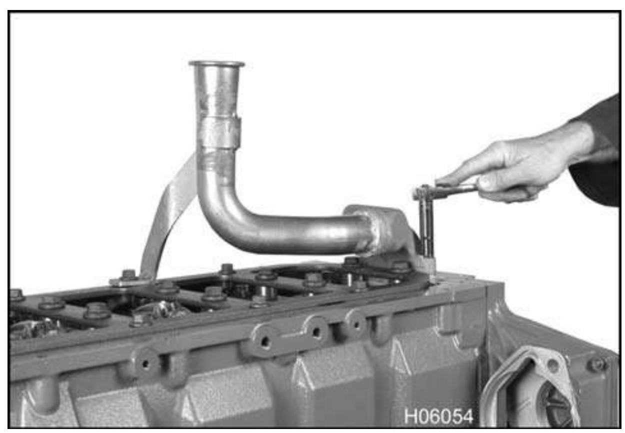


Figure 291 Installing the oil suction tube

2. Install two mounting bolts (M8 x 35) for the oil suction tube and one mounting bolt (M10 x 25) to hold down bracket.
3. Torque both bolts (M8 x 35) to the special torque value (Table 23).

4. Torque bracket bolt (M10 x 25) to the special torque value (Table 23).

Installing the Oil Pan

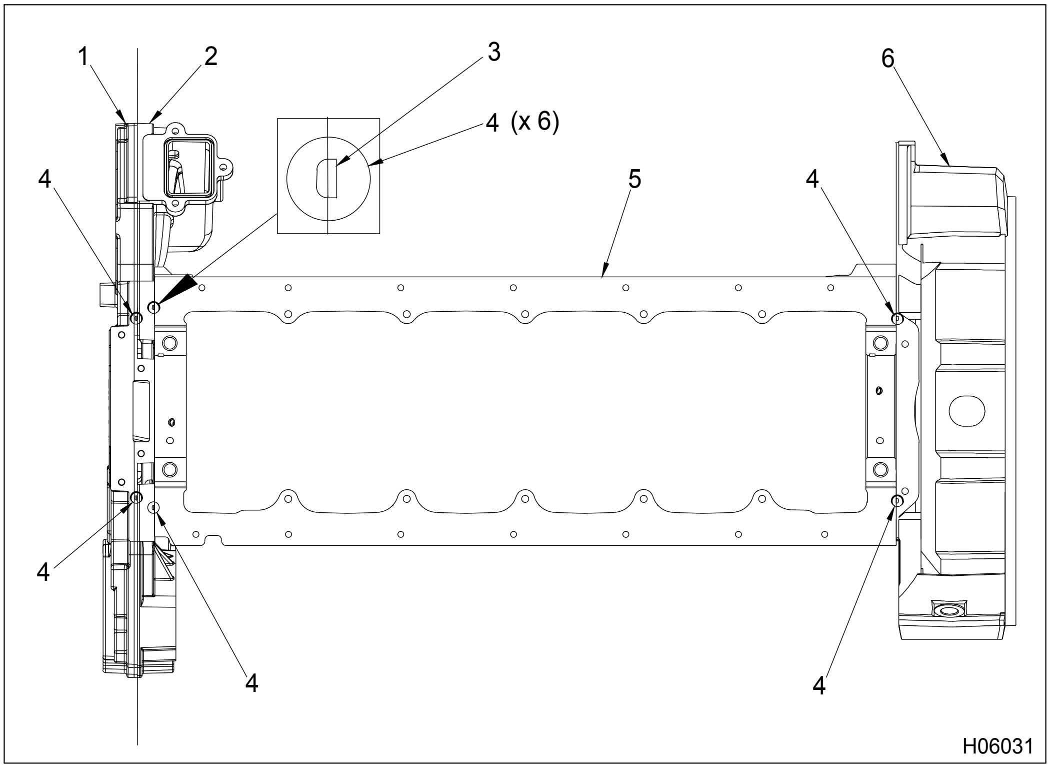


Figure 292 RTV sealant locations – see inset (typical)

1. Front cover (front half)
2. Front cover (rear half)
3. Gasket
4. Sealant, Wacker T-442, (6 locations)
5. Crankcase
6. Flywheel housing

1. Apply a circular dab of T-442 Wacker RTV sealant (Table 24) approximately 19 mm (0.75 in) in diameter to the six locations on the crankcase mounting surface. These locations coincide with gasket joints between the front cover halves, crankcase, and flywheel housing.

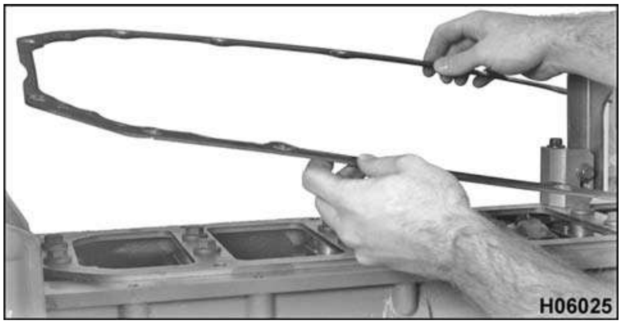


Figure 293 Installing the oil pan gasket

2. Before the RTV sealant dries (tack free), install a new oil pan gasket on the crankcase mounting surface. Make sure that the dowel on the gasket is aligned with the hole on the crankcase mounting surface.

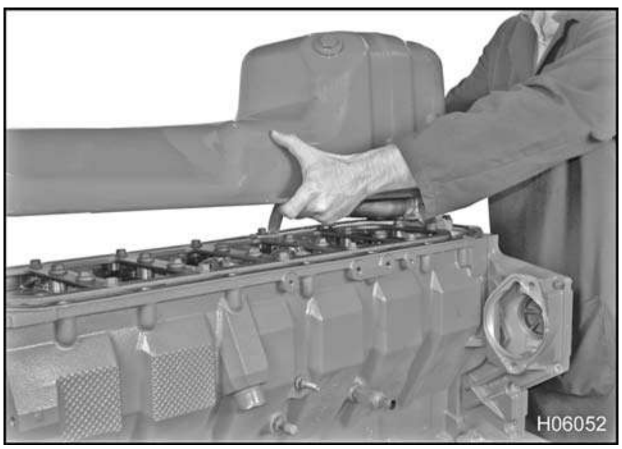


Figure 294 Installing the oil pan

3. Install the oil pan onto the crankcase.

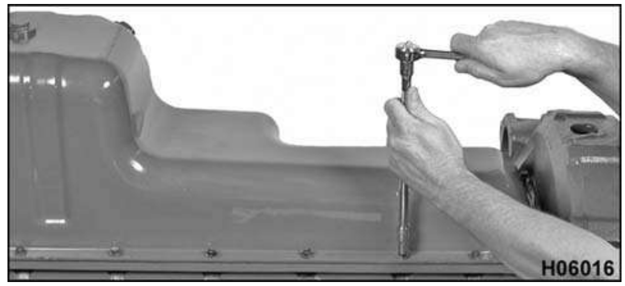


Figure 295 Installing oil pan mounting bolts

4. Install 18 oil pan mounting bolts (M8 x 24). Tighten all bolts to the special torque value (Table 23).

300 Watt Oil Pan Heater (Optional)

An optional 300 Watt Oil Pan Heater is available for service. See (1171848R1 300 Watt Oil Pan Heater Kit, page495) for installation procedure.

Specifications

Table 22 Oil Fill Specifications

Dry engine (after rebuild and new filter)	34 L (36 quarts US)
Wet engine (after oil drain and filter change)	28 L (30 quarts US)

Special Torque

Table 23 Oil Pan and Oil Suction Tube Special Torques

Oil pan drain plug	68 N·m (50 lbf·ft)
Oil heating element assembly (optional)	68 N·m (50 lbf·ft)
Oil pan heater plug	68 N·m (50 lbf·ft)
Oil pan mounting bolts	32 N·m (24 lbf·ft)
Oil suction tube bracket, M10 x 25	63 N·m (46 lbf·ft)
Oil suction tube, M8 x 35	27 N·m (20 lbf·ft)

Special Service Tools

Table 24 Special Tools

Wacker T – 442 RTV sealant	Obtain locally

Table of Contents

Description

A few changes were made for model year 2004:

- Piston skirts for DT 466 and 570 cubic inch displacements have a notch cast into each side of the skirt for piston cooling tube clearance.
- The combustion bowl has been centered within the piston crown. The pistons are symmetrical, and therefore do not require orientation.
- Connecting rods have a fractured surface at the cap and rod bolted joint. These are mated parts and are not interchangeable with other connecting rods. It is important that serial numbers on the connecting rod and connecting rod cap must match and appear together.

Additional changes running changes were made after model year 2004:

- New piston cooling tubes were released for service.
- New connecting rod assemblies were released for service.

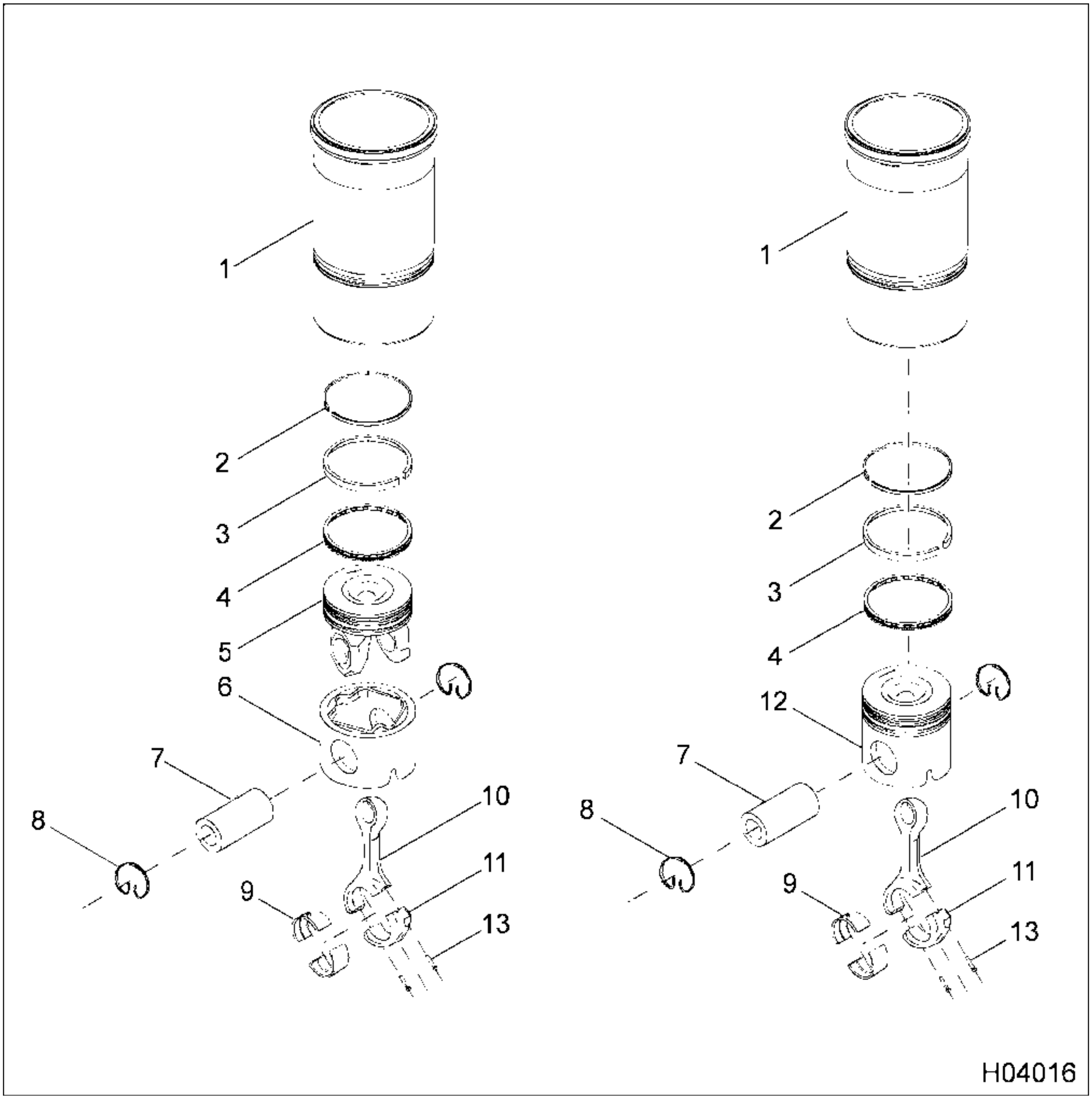


Figure 296 Connecting rods, pistons, and rings

1. Cylinder sleeve
2. Top compression ring
3. Intermediate compression ring
4. Oil control ring
5. Piston crown (570)
6. Piston skirt (570)
7. Piston pin
8. Retaining ring (2)
9. Bearing shells (2)
10. Connecting rod
11. Connecting rod cap
12. Piston, one-piece aluminum (466)
13. Connecting rod bolt (2)

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, allow engine to cool before working with components.

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, 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, keep the fractured mating surfaces of the connecting rod and cap clean and free of lint and debris. Do not allow the mating surfaces to rest on any surface. Do not bump the mating surfaces or drop the connecting rod or cap. This could cause chipping and wear on the mating surface, resulting in improper mating during installation and possible engine damage.

CAUTION: If a carbon ridge has developed at the top of the cylinder sleeve, use a razor knife to scrape it off before removing the piston assemblies. Care must be taken not to damage the sleeve bore surface when removing the carbon.

Piston Cooling Tubes

NOTE: Old piston cooling tubes and bolts can be reused or replaced with new piston cooling tubes and bolts.

Old Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

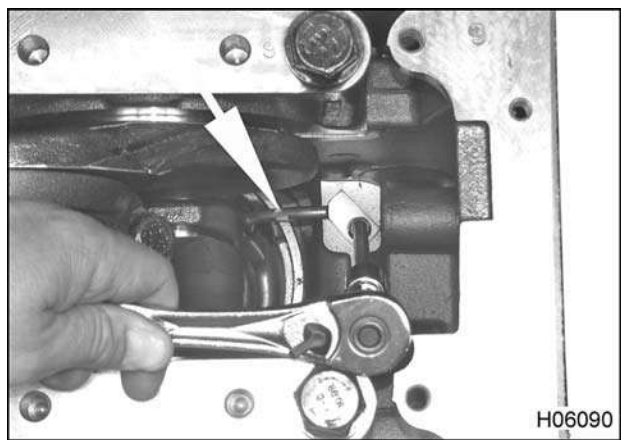


Figure 297 Old piston cooling tube

1. Remove M6 x 16 patch type bolt from piston cooling tubes.

Figure 298 Old piston cooling tube

2. Remove six old piston cooling tubes only if replacing with new.

New Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

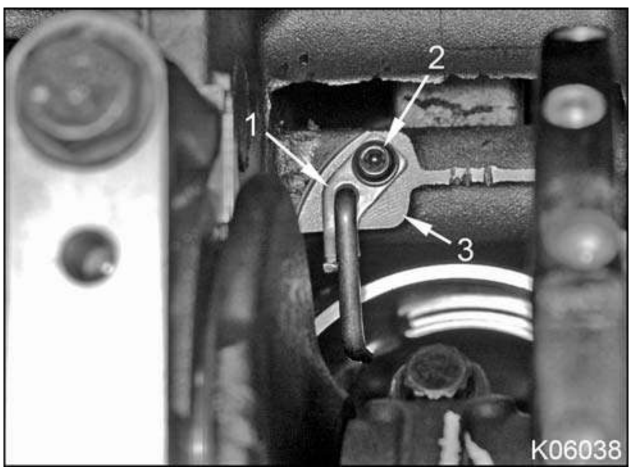


Figure 299 New piston cooling tube

1. Piston cooling tube (6)
2. M6 x 12 bolt (6)
3. Mounting pad (6)

1. Remove M6 x 12 bolt from piston cooling tubes and bolts.

Figure 300 O-ring (underside) of new piston cooling tube

2. Remove and discard O-rings.

Removing Piston and Connecting Rod Assembly

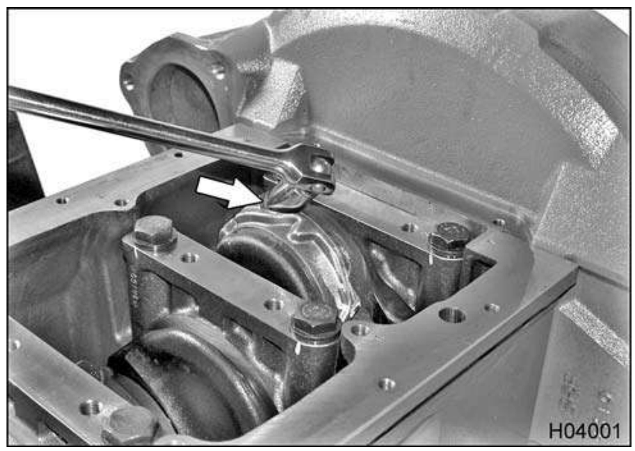


Figure 301 Loosening connecting rod bolts

1. Loosen both connecting rod bolts two turns.
2. Rock the two bolts on the rod cap to loosen.
3. Repeat procedure for all other connecting rods.
4. Rotate the engine to a vertical position with the front end up.

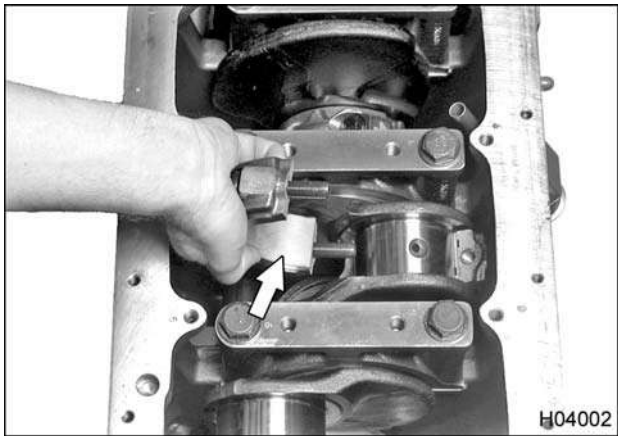


Figure 302 Removing connecting rod cap and bolts

5. Unscrew the bolts completely. Remove the cap and bolts as a unit.
6. Discard connecting rod cap bolts.

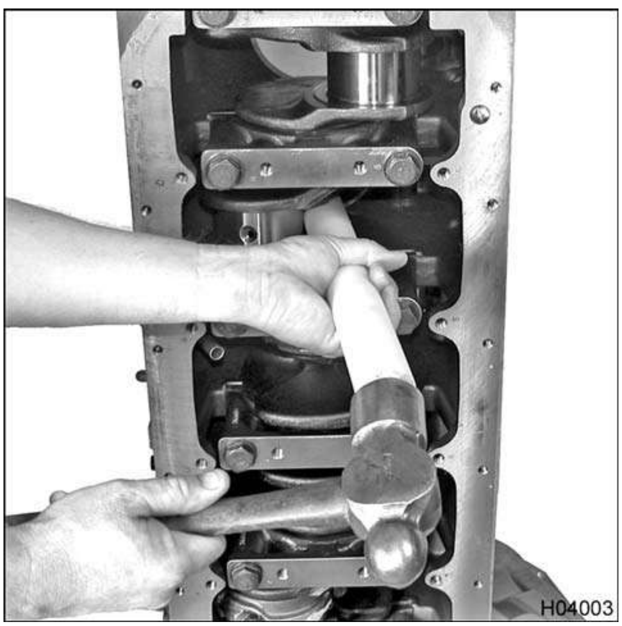


Figure 303 Pushing out piston and connecting rod assembly

7. Do not push on rod fractured surface. Use a hammer with a plastic or wooden handle or a non-marring punch to push the piston out of the cylinder sleeve.

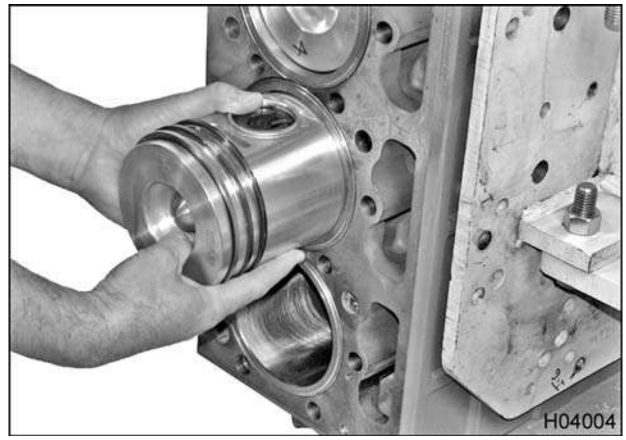


Figure 304 Removing piston and connecting rod assembly from cylinder sleeve

8. Once the piston rings are free of the cylinder sleeve, remove the assembly from the top of the crankcase.
9. For installation purposes, mark each piston, connecting rod, and cap with the cylinder number from which it was removed. Also mark the front of each piston as it was installed in the engine.

Disassembling Piston and Connecting Rod Assembly

WARNING: To prevent serious personal injury or possible death, wear safety glasses when removing piston pin retaining rings.

Figure 305 Removing piston pin retaining rings

1. Use pliers to remove the two piston pin retaining rings.

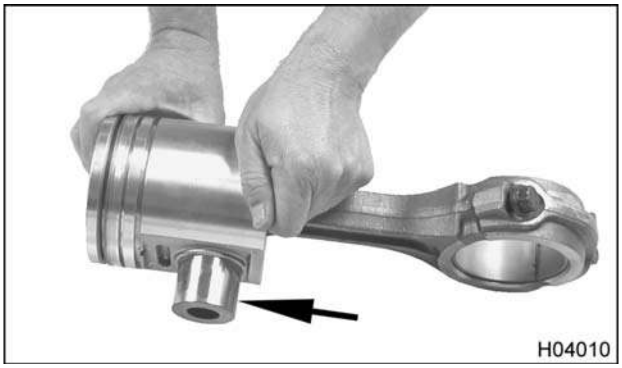


Figure 306 Removing piston pin

2. Remove the piston pin from the bore by hand. Separate the piston from the connecting rod. Mark the front of the piston pin with the cylinder number from which it was removed.

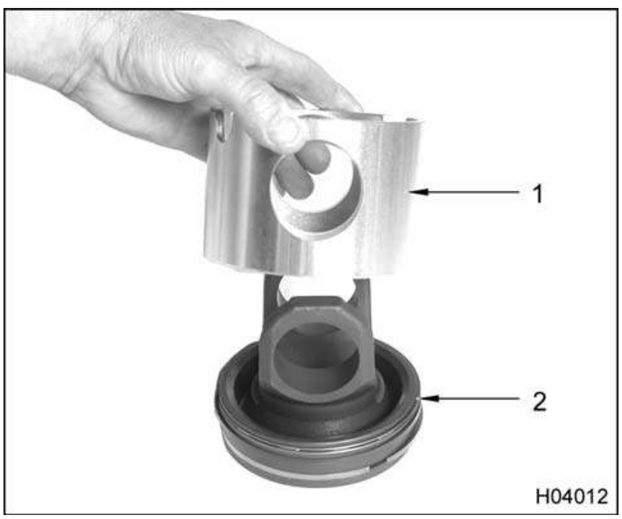


Figure 307 Removing piston skirt from crown (570 engine only)

1. Skirt
2. Crown

3. **For 570 engines only:** Mark the orientation of the piston skirt to the crown for installation purposes. Remove the piston skirt from the crown.

Figure 308 Removing piston rings (DT 466 piston shown)

4. Use a piston ring expander tool (Table 34) to remove the piston rings.

Cylinder Sleeve Removal

NOTE: Before installing the puller, bar the engine over so the crankshaft journal is located at the bottom (low point) of its travel. This prevents possible damage to the journal by the puller lifting jaws during puller installation.

NOTE: When you remove the sleeve from puller, mark the sleeve with its cylinder bore number. Also mark the sleeve position in the engine block for the purposes of inspection and assembly.

1. Position the cylinder sleeve puller in the sleeve and spread the lifting jaws so the tangs grip the bottom of the sleeve (Figure 309).

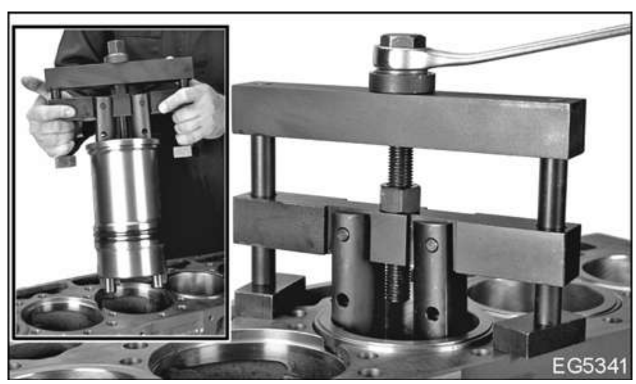


Figure 309 Removing cylinder sleeve from crankcase

2. With the lifting bridge firmly on the crankcase top deck, turn the forcing nut to break the cylinder sleeve loose from the crankcase.
3. Lift sleeve and puller from the crankcase.
4. Use a pick to remove the crevice seal at the lower counterbore area of each cylinder sleeve. Discard crevice seal.

Cleaning

Pistons and Related Components

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

1. Soak aluminum pistons and skirts in a soap and water solution. Use a non-metallic brush to clean the pistons.
2. Scrub the piston ring grooves thoroughly. Make sure that the four oil drain holes in the oil ring grooves are not blocked.

CAUTION: To prevent engine damage, do not clean the fractured mating surfaces of the connecting rods.

3. Use a suitable solvent and a non-metallic brush to clean the connecting rods and caps, piston rings, pins, retainers, and steel piston crowns. Thoroughly clean the connecting rod bolt holes and threads.
4. Clean crevice seal bore area of any scale, deposits, or sealant (located in crankcase.)

Inspection

Pistons

CAUTION: To prevent engine damage, when replacing only the steel piston crown, the original orientation of the reused aluminum piston skirt to the sleeve must be maintained upon reassembly.

Inspect the pistons for scuffed or scored skirts and worn ring lands. Replace damaged pistons as required. For two-piece pistons, the aluminum piston skirt or steel piston crown may be replaced individually.

Top and Intermediate Compression Ring Grooves

Table 25 DT 466 Piston Ring Gauge Selection

Engine Rating	Ring / Groove Type	Gauge Diameter, mm (in)
225 bhp and below	Top / keystone cross section	3.1 (0.122)
	Intermediate / rectangular	N/A
230 bhp and above	Top / keystone cross section	3.1 (0.122)
	Intermediate / keystone cross section	2.8 (0.110)

Table 26 DT 570 and HT 570 Piston Ring Gauge Selection

Engine Rating	Ring / Groove Type	Gauge Diameter, mm (in)
All 570 series engines	Top / keystone cross section	3.2 (0.126)
	Intermediate / rectangular	N/A

Figure 310 Measuring ring grooves with piston ring gauge pins

1. Install the piston ring gauge pins into the top compression ring groove. Make sure that the gauge pins are parallel.
2. Use an outside micrometer to measure the diameter of the piston over gauge pins. Record the reading.
3. Repeat the procedure for the intermediate compression ring groove, if its cross section is keystone-shaped. If the ring groove has a rectangular cross section, the height of the groove must be checked with gauge blocks.

   If either measurement exceeds specifications, the piston ring groove is worn, and the piston must be replaced. For two-piece pistons, replace only the steel piston crown.

Oil Control Ring Groove

Figure 311 Measuring side clearance of oil control ring groove

1. Place the edge of a new oil control ring in the groove. Roll the oil control ring entirely around the piston to ensure that the ring is free in its groove.
2. With the edge of the oil control ring still in the groove, use a feeler gauge to check the side

clearance between the ring and the top of its groove. Record the reading.

If the measurement exceeds the specification, the oil control ring groove is worn out. Replace the piston. For two-piece pistons, replace only the steel piston crown.

Piston-to-Cylinder Sleeve Running Clearance

Figure 312 Measuring piston skirt diameter

1. With the piston at room temperature, use an outside micrometer to measure the piston skirt diameter. Place the micrometer 90 degrees from the piston pin bore. For one-piece pistons (466 engine), measure at 28.58 mm (1.125 in) from the bottom of the piston. For two-piece pistons (570 engine), measure at 3.00 mm (0.118 in) from the bottom of the piston skirt. Record the reading.
2. Subtract the measurement from the inside diameter of the cylinder sleeve (Checking Cylinder Sleeves, page 227). The result is the running clearance between the piston and the cylinder sleeve.

   If the running clearance is not within the specification for the one-piece piston, replace the cylinder sleeve, piston and rings. For two-piece pistons, replace the cylinder sleeve, aluminum piston skirt, crown and rings.

Piston Rings

CAUTION: To prevent engine damage, whenever a piston is removed from a cylinder, replace the piston rings. Faulty piston rings cannot always be detected by visual inspection. Therefore, if the rings are replaced, the cylinder sleeves need to be replaced as well.

1. Inspect the new piston rings for cleanliness. Use a suitable solvent to clean the piston rings if necessary.

Figure 313 Checking piston ring end gap

2. Push the piston ring down into the cylinder bore. Make sure that the piston ring is perpendicular to the cylinder wall.
3. Use a feeler gauge to measure the end gap between the ends of each piston ring.

   Discard any piston ring that does not meet specifications.

Piston Pins

1. Inspect piston pins for corrosion, nicks, and obvious wear. Do not use pins with nicks or heavy scratches with the two-piece steel crown. Engine failure will result. Install new piston pins.

Figure 314 Measuring piston pin outside diameter

2. Use an outside micrometer to measure the outside diameter of each piston pin at two places.
3. If the outside diameter is less than minimum Specification (Table 31), install new piston pin.
4. Measure each piston pin bore.
5. Calculate piston pin clearance. Subtract the outside diameter of the piston pin from the inside diameter of the piston pin bore.

   NOTE: Piston pin clearance = (inside diameter of the piston pin bore) – (outside diameter of the piston pin)
6. If piston pin clearance in piston exceeds Specifications (Table 31), install new connecting rod.

Connecting Rods

Piston Pin Bushing

Figure 315 Measuring piston pin bushing inside diameter

Use a telescoping gauge and an outside micrometer to measure the inside diameter of the piston pin bushing at two locations that are 90 degrees apart. Record the readings.

Connecting Rod Cap Bolts

1. Inspect the connecting rod cap bolts for nicks and thread damage. Replace the bolts as required.
2. Lubricate the threads of the connecting rod cap bolts with clean engine oil. Install the cap without the bearing shells on the connecting rod and install the bolts by hand. Match serial numbers on the connecting rod and cap (on same side of fractured rod).

   If resistance is met, clean the bolt holes in the connecting rod and try installing new bolts. If the new bolts do not turn in freely, replace the connecting rod. The threads in the bolt holes cannot be tapped.
3. Tighten the connecting rod cap bolts to the special torque value (Table 33).

Connecting Rod Bearing Bore

1. Inspect the finished surface of the connecting rod bearing bore for nicks, burrs, and scoring. Replace connecting rod as required.

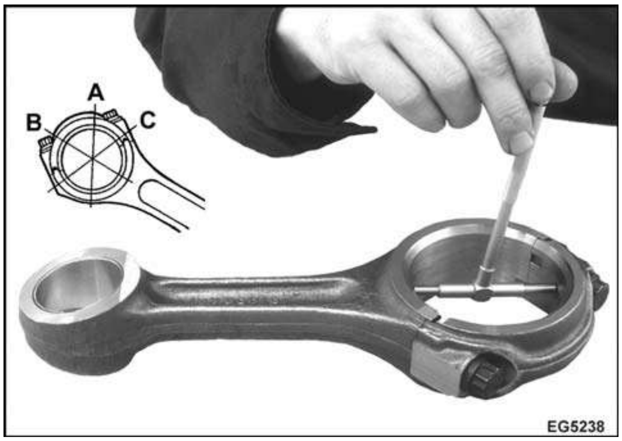


Figure 316 Connecting rod bearing bore for out-of-round

2. Use an inside micrometer to measure the inside diameter of the connecting rod bearing bore at three locations that are 60 degrees apart. Record the readings.

   If the difference between measurement **B** and the average of measurements **A** and **C** exceeds the specification for out-of-round, replace the connecting rod.

Figure 317 Measuring connecting rod bearing bore taper

3. Use a telescoping gauge and an outside micrometer to measure the inside diameter of the connecting rod bearing bore at the edge of each side of the bore. Record the readings.

   If the difference between the two measurements exceeds the bore taper specification, replace the connecting rod assembly.

Bend and Twist

Engine component wear patterns can often be identified and used to diagnose a problem. Some common examples of connecting rod wear patterns include the following:

- A shiny surface on the edge of the piston pin bushing usually indicates that a connecting rod is bent or a piston pin hole is not positioned properly in relation to the piston skirt and piston ring grooves.
- Abnormal wear on the connecting rod bearing may indicate that a connecting rod is bent or the bearing bore is too tapered.
- A twisted connecting rod will not create an easily identifiable wear pattern, although severely twisted connecting rods will disturb the action of the entire piston and connecting rod assembly and may be the cause of excessive oil consumption.

If any of these conditions exist, use a suitable alignment fixture to check the connecting rod for bends and twists. Follow the instructions of the alignment fixture manufacturer. If a bend or twist exceeds the specification, replace the connecting rod.

Bearing Fitting Procedures and Bearing Running Clearance

CAUTION: To prevent engine damage, do not attempt to reduce journal-to-bearing running clearance by reworking the bearing cap or the bearings. Grind the crankshaft to the next available under size or replace crankshaft.

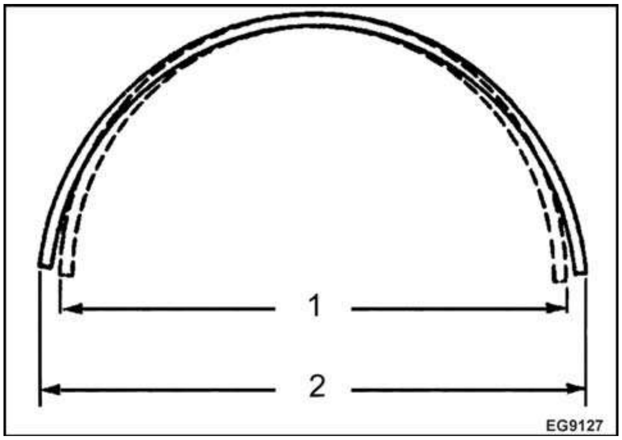


Figure 318 Effects of bearing crush

1. Diameter at open ends after bearing crush load
2. Diameter at open ends before bearing crush load

NOTE: Connecting rod bearings must fit tightly in the connecting rod bore. When bearings are inserted in the connecting rod and cap, they protrude slightly above the parting surface. This protrusion is required to achieve bearing crush. Bearing crush forces the ends inward at the parting line when a load is applied by tightening the bolts. Some snap may be lost in normal use, but bearing replacement is not required because of a nominal loss of snap.

When the connecting rod bearing is installed and the connecting rod cap bolts are tightened, the bearing is compressed, ensuring a positive contact between the backside of the bearing and the machined surface of the connecting rod bore.

Bearing Running Clearance

1. Install new bearings in the connecting rod and cap.

CAUTION: To prevent engine damage, install connecting rod cap and connecting rod with matching serial numbers on the same side. If the rod cap is reversed or not installed on its matching connecting rod, the fractured mating surfaces will be damaged. This can loosen the rod cap. A new connecting rod assembly must be installed.

2. Match serial numbers on the connecting rod and rod cap (on same side of fractured rod) and install the connecting rod and cap on the crankshaft. See Installing Piston and Connecting Rod Assembly (page237).
3. Remove the connecting rod cap. Wipe the oil from the face of the bearings in the cap and the exposed portion of the crankshaft.
4. Place a piece of undamaged Plastigage® across the full width of the connecting rod bearing, about 6 mm (0.25 in) from the center of the connecting rod cap.

CAUTION: To prevent engine damage, do not torque-to-yield connecting rod cap bolts while doing this measurement procedure.

CAUTION: To prevent engine damage, when torquing connecting rod bolts use a torque wrench that is known to be accurate. Correct torque of connecting rod cap bolts is important.

5. Install the connecting rod cap bolts and tighten to 109 N·m (80 lbf·ft).

NOTE: Do not turn the crankshaft. This will smear the Plastigage® making it unusable.

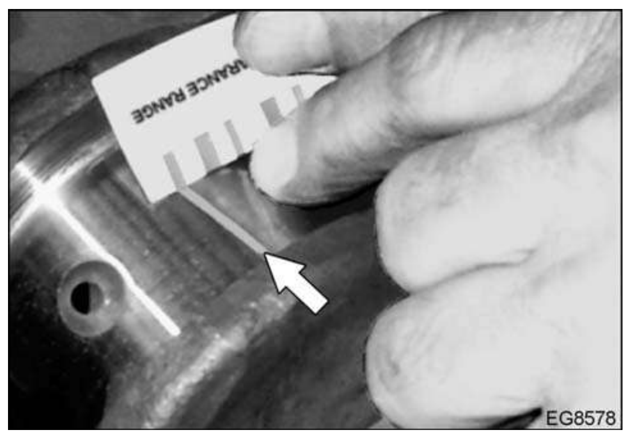


Figure 319 Measuring Plastigage® with scale

6. Remove the connecting rod cap. The Plastigage® material will adhere to the bearing shell or the crankshaft. Do not remove the Plastigage®.
7. Use the Plastigage® paper scale to measure the widest point of the flattened material. Numbers in the graduated marks on the scale indicate the running clearance in thousandths of an inch or millimeters.

NOTE: If running clearance is not to specification, it may be necessary to grind the crankshaft and install an undersized bearings. Check running clearance again before condemning the crankshaft.

8. Remove the Plastigage® material. Repeat the test for each connecting rod bearing.

Connecting Rod Side Clearance

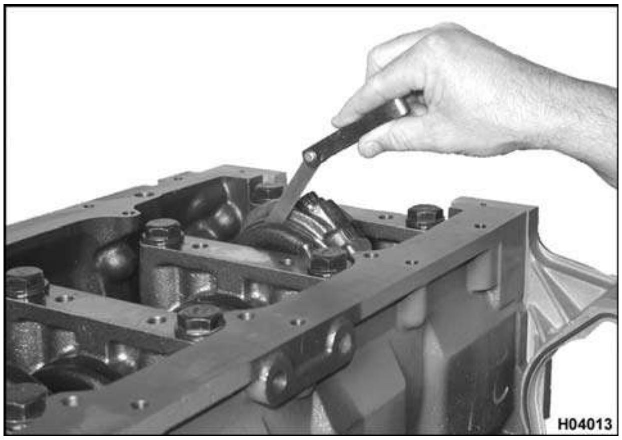


Figure 320 Measuring connecting rod side clearance

Place a feeler gauge between the connecting rod and crankshaft journal. This is the connecting rod side clearance.

If there is too little side clearance, the connecting rod may be damaged or the bearing may be out of position. If there is too much clearance, the connecting rod or crankshaft may be damaged.

Checking Cylinder Sleeves

1. Inspect the inside surface of the cylinder sleeves for scuffing, scoring and polishing. Inspect the outside surface for cavitation. Replace the cylinder sleeves with piston rings as required.
2. To check the cylinder sleeves for wear (taper), use one of the following methods:

Telescoping Gauge Method

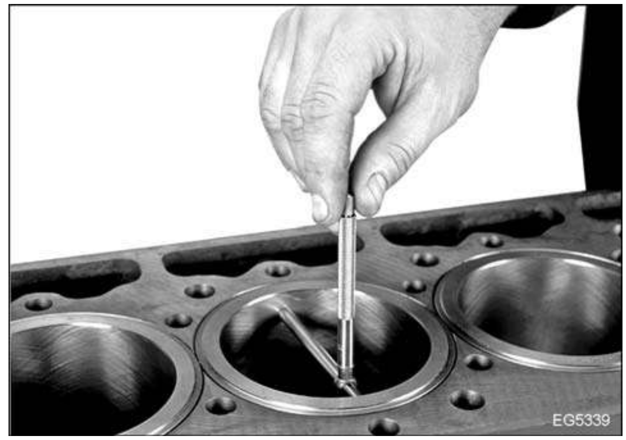


Figure 321 Checking cylinder sleeve inside diameter with telescoping gauge

Figure 322 Measuring telescoping gauge

a. Use a telescoping gauge and an outside micrometer to measure the inside diameter of each cylinder sleeve at the top of piston ring travel and below the area of piston ring travel. Record the readings.
b. Subtract the lower reading from the higher reading. The result is the cylinder sleeve taper.

   If the result exceeds the specification, replace the cylinder sleeve.

Dial Bore Gauge Method

Figure 323 Checking cylinder sleeve inside diameter with dial bore gauge

a. Use a dial bore gauge to measure the inside diameter of the each cylinder sleeve at the top of piston ring travel and below the area of piston ring travel. Record the readings.

b. Subtract the lower reading from the higher reading. The result is the cylinder sleeve taper.

   If the result exceeds the specification, replace the cylinder sleeve.

Feeler Gauge Method

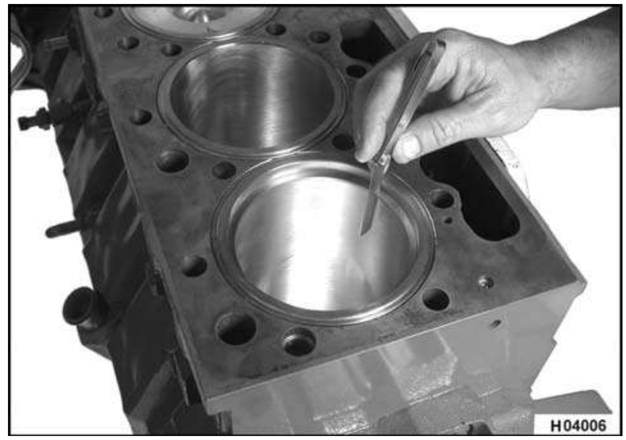


Figure 324 Checking cylinder sleeve piston ring end gap

a. Install a top compression ring squarely above the top of the piston ring travel area. Use a feeler gauge to measure the piston ring end gap. Record the measurement.

b. Move the top compression ring squarely below the bottom of the piston ring travel area. Use a feeler gauge to measure the piston ring end gap. Record the measurement.

   Every increase of 0.07 mm (0.003 in) between the measurements equals a 0.025 mm (0.001 in) increase in cylinder sleeve inside diameter. If the cylinder sleeve is worn beyond the specification, replace the cylinder sleeve.

Checking Counterbore Depth

Use one of the following methods to check the depth of the crankcase counterbore:

Surface Gauge Method

NOTE: Clean counterbore surface and remove existing shims if any before measuring counterbore depth.

Figure 325 Checking counterbore depth with surface gauge

1. Place the indicator tip of the surface gauge on the crankcase. Zero the dial indicator.
2. Move the indicator tip onto the counterbore ledge. Record the counterbore depth reading on the dial indicator.
3. Take counterbore depth measurements at four evenly spaced locations around the counterbore ledge.
4. Compare the counterbore depth variation between the four measurements with those listed in specifications (Table 32).

   If the maximum variation between the four measurements exceeds the specification, resurface the counterbore.

Depth Micrometer Method

NOTE: Clean counterbore surface and remove existing shims if any before measuring counterbore depth.

Figure 326 Checking counterbore depth with depth micrometer

1. Place a depth micrometer onto the counterbore ledge. Record the counterbore depth reading.
2. Take counterbore depth measurements at four evenly spaced locations around the counterbore ledge.
3. Compare the counterbore depth variation between the four measurements with specifications.

   If the maximum variation between the four measurements exceeds the specification, resurface the counterbore.

Checking Cylinder Sleeve Protrusion

CAUTION: To prevent engine damage, do not apply holding adapters to the "fire dam" ridge of the cylinder sleeve. Clamping forces should not be applied to this ridge as internal cracking could develop adjacent to the shim land.

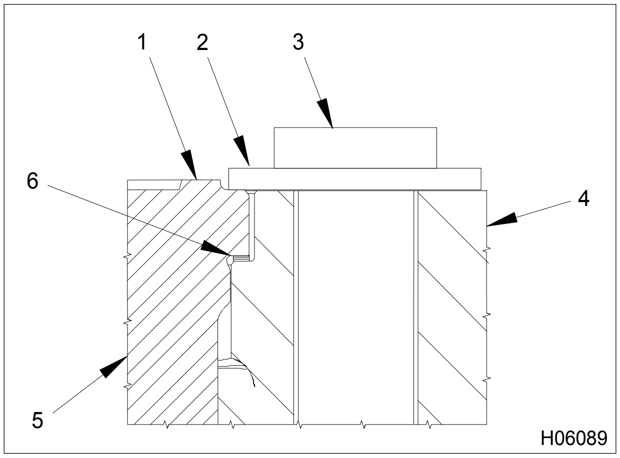


Figure 327 Cylinder sleeve clamping details

1. Fire dam (highest point on cylinder sleeve)
2. Clamping tool (washer)
3. Clamping bolt
4. Crankcase
5. Cylinder sleeve
6. Shim pack

1. Clean the cylinder sleeve, cylinder sleeve crevice bore, and crankcase counterbore surface.

   CAUTION: To prevent engine damage, do not "torque-to- yield" the holding adapter bolts (as when installing cylinder head bolts). This will prevent stretching the bolts and risking the indentation of tooling marks on the cylinder sleeve.

2. Install the cylinder sleeve in the cylinder bore without the crevice seal.

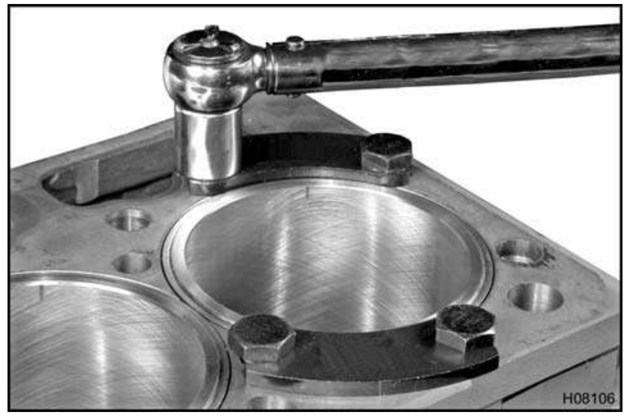


Figure 328 Installing the holding adapters

3. Install the cylinder sleeve holding adapters (Table 34) with 10.9 or higher grade bolts and hardened washers. Tighten bolts in two stages:

   A. 55 N·m (40 lbf·ft)

   B. 110 N·m (80 lbf·ft)

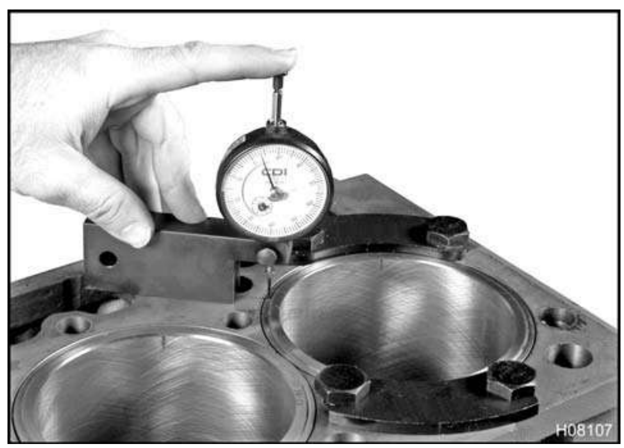


Figure 329 Measuring cylinder sleeve protrusion

4. Place the indicator tip of a surface gauge on the cylinder sleeve flange. Zero the dial indicator.
5. Move the surface gauge until the indicator tip slides off the flange to the surface of the crankcase. Record the cylinder sleeve protrusion reading on the dial indicator.

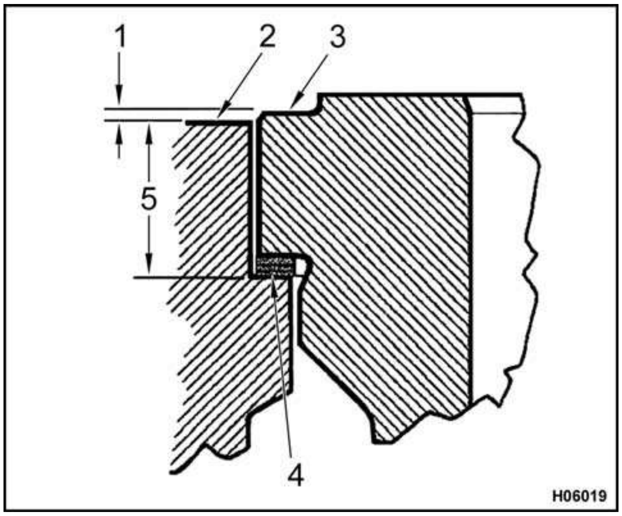


Figure 330 Checking cylinder sleeve protrusion

1. Cylinder sleeve protrusion
2. Top surface of crankcase
3. Cylinder sleeve flange
4. Shim to suit
5. Counterbore

6. Take cylinder sleeve protrusion readings from three evenly spaced locations around the cylinder sleeve. Average the three readings to determine the cylinder sleeve protrusion.

   If the cylinder sleeve protrusion does not meet the specification, remove the cylinder sleeve and install the necessary amount of shims to meet the specification.

NOTE: Shims are available as a package consisting of the following:

Table 27 Cylinder Sleeve Shim Sizes

Shim size (mm)	Shim size (in)
0.05	0.002
0.10	0.004
0.25	0.010
0.51	0.020
0.81	0.032

Reconditioning

Resurfacing the Counterbore

The following steps will require the use of the cylinder sleeve counterbore tool kit. See piston, piston ring, and connecting rod special service tools (Table 34).

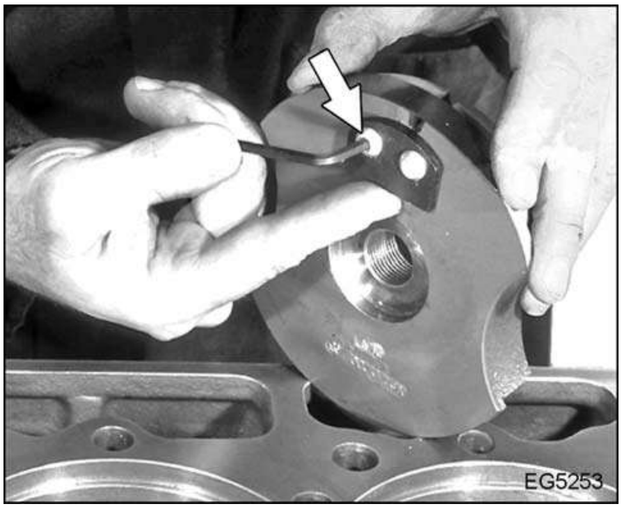


Figure 331 Setting tool bit

1. To set the tool bit for the counterbore cutting head (Table 34), place a 0.20-0.25 mm (0.008-0.010 in) feeler gauge on the outside diameter of the cutting head. Push the tool bit out until it touches the feeler gauge. Use a hex head wrench to lock the tool bit in place.

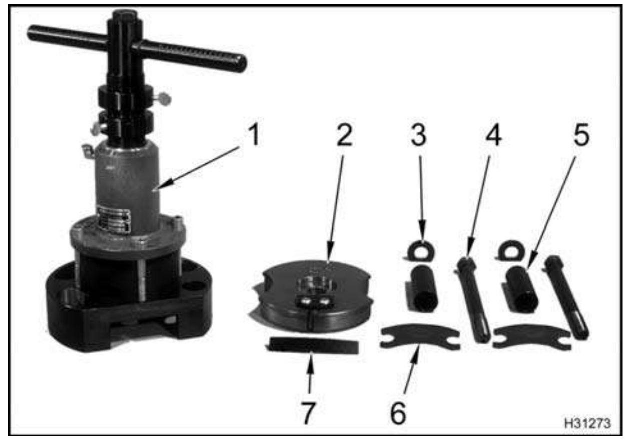


Figure 332 Counterboring tool components

1. Driver unit and adapter plate
2. Cutting head
3. Washer (2)
4. Mounting bolt (2)
5. Spacer (2)
6. Locking plate (2)
7. Feeler gauge

2. Install the cutting head on the driver unit and adapter plate of the counterboring tool.

Figure 333 Positioning counterboring tool

1. Turn knuckles
2. Locking screws
3. Mounting bolt (2)
4. Washer (2)
5. Spacer (2)
6. Locking plate (2)

3. Pull the plunger and lift up on the handle to raise the cutting head. Mount the counterboring tool on the crankcase. Install the washers and mounting bolts finger tight, then tighten the bolts to 45 N·m (33 lbf·ft).
4. To lower the cutting head, loosen the locking screws and the turn knuckles. Pull the plunger up to the desired height. Tighten the turn knuckles and locking screws.

NOTE: Do not remove more than 0.05 mm (0.002 in) of material at any one attempt.

5. To set the depth of the cut, use one of the following methods:

   Graduated Marks on Tool

   a. Loosen the locking screw and turn the adjusting nut counterclockwise until it contacts the housing of the driver unit.
   b. Back off the adjusting nut by the amount of the desired cut. Each graduated mark equals 0.03 mm (0.001 in).
   c. Tighten the locking screw.

   Feeler Gauge

   a. Loosen the locking screw on the upper turn knuckle and insert the correct size of feeler gauge between the turn knuckles.
   b. Rotate the upper turn knuckle until the feeler gauge is barely held between the turn knuckles.
   c. Tighten the locking screw and remove the feeler gauge.

CAUTION: To prevent engine damage, do not rotate the handle counterclockwise when the tool bit is in contact with the counterbore ledge as damage to the tool bit could result as well.

6. To cut the counterbore, rotate the handle smoothly in a clockwise direction until the driver unit turns freely and is bottomed out between the adjusting nut and the top of the driver unit housing.
7. Remove the counterboring tool and clean the counterbore area. Check the depth of the counterbore (Checking Counterbore Depth, page 229).

Installation

Cylinder Sleeve Installation

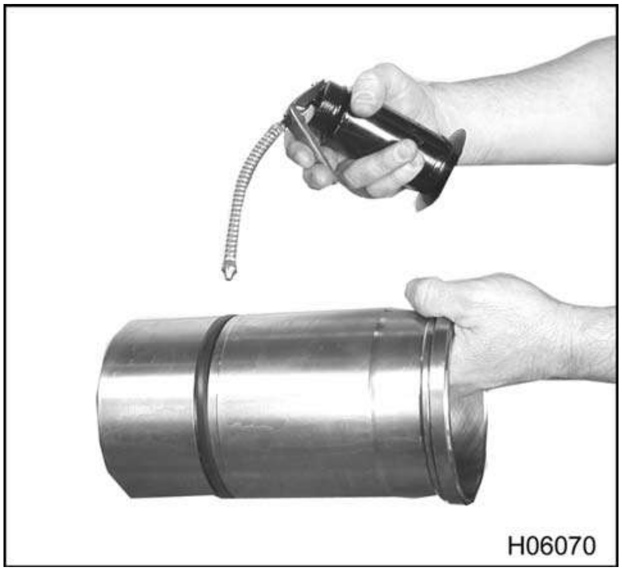


Figure 334 Lubricate cylinder sleeve crevice seal

1. Lubricate the crevice seal with clean engine oil and install into cylinder sleeve groove (without twisting).

   NOTE: Each cylinder sleeve has one crevice seal.

2. If required, ensure the proper shim(s) are installed in the crankcase counterbore necessary to bring the cylinder sleeve protrusion within specifications.
3. Make sure the crevice seal is properly aligned in the groove.

Figure 335 Lubrication of cylinder sleeve bore

4. Apply clean engine oil to the lower crankcase counterbore and crevice seal bore, then carefully install the cylinder sleeve.

Figure 336 Installation of cylinder sleeve

5. After installation, check cylinder sleeve protrusion (Checking Cylinder Sleeve Protrusion, page229).
6. Check cylinder sleeve bore dimensions and sleeve taper per specifications (Table 32). If the cylinder sleeve is not measuring up to specifications, check for an improperly aligned crevice seal.

Assembling Piston and Connecting Rod Assembly

Figure 337 Installing piston rings (466 piston shown)

NOTE: Make sure that the top side of both compression rings (marked with a dot) are facing up. The oil control ring may be installed with either side facing up, if new.

1. Use a piston ring expander tool (Table 34) to install the piston rings. Install the oil control ring first, then intermediate compression ring, and finally the top compression ring.

CAUTION: To prevent engine damage, orientation of a reused piston skirt is very important due to wear patterns. Install the skirt on the crown using the original skirt orientation.

NOTE: New piston skirts may be oriented in either direction due to piston skirt symmetry.

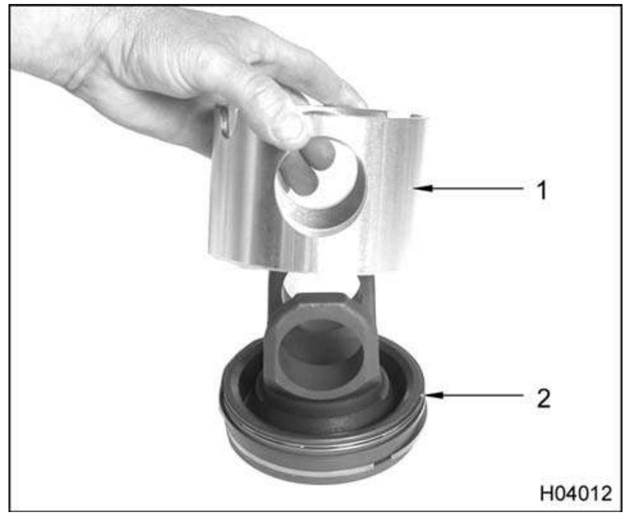


Figure 338 Installing piston skirt on crown (570 engine only)

1. Skirt
2. Crown

2. **For 570 engines only:** Install the piston skirt on the crown. Make sure that the oil jet cutouts on the skirt are facing away from the crown.
3. Lubricate the piston pin bore with clean engine oil.

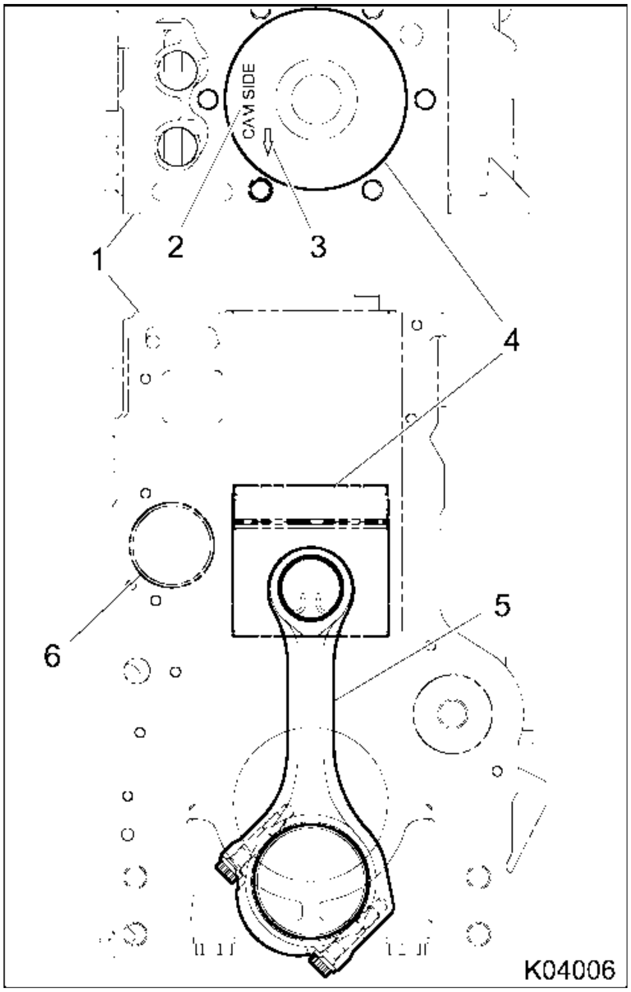


Figure 339 Piston and connecting rod orientation

1. Crankcase
2. CAM SIDE stamp
3. Arrow stamp
4. Piston
5. Connecting rod
6. Camshaft bore

NOTE: One piece pistons are stamped CAM SIDE or with an arrow.

- Install piston with CAM SIDE over short leg of the connecting rod.
- Install piston with arrow stamp (on left side of piston) over short leg of the connecting rod.

Figure 340 Installing piston pin

CAUTION: To prevent engine damage, do not mix connecting rods with M12 bolts and connecting rods with M11 bolts in the same engine. If one or more connecting rods must be replaced make sure all connecting rods in each engine are the same type.

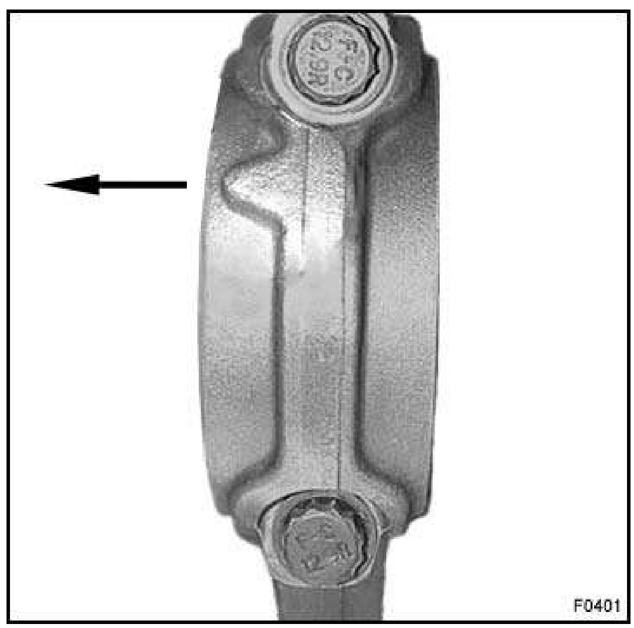


Figure 341 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

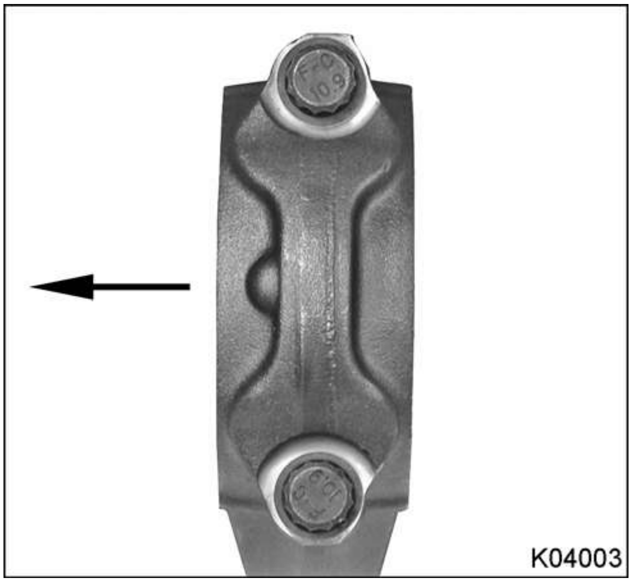


Figure 342 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

4. Align the bores in the connecting rod and piston and install the piston pin.

WARNING: To prevent serious personal injury or possible death, wear safety glasses when installing retaining rings.

Figure 343 Installing piston pin retaining rings

5. Use pliers to install the piston pin retaining rings.

Installing Piston and Connecting Rod Assembly

CAUTION: To prevent engine damage, do not allow the connecting rod or connecting rod cap fractured mating surfaces to contact any surface other then its matched fractured surface. Contacting any other surface can cause misalignment of the mating surface, resulting in connecting rod bearing and engine failure.

NOTE: Turn crankshaft so connecting rod journals 1 and 6 are at Bottom Dead Center (BDC). Install piston and connecting rod assemblies 1 and 6 first. Then repeat the procedure for piston and connecting rod assemblies 2 and 5. Finish with piston and connecting rod assemblies 3 and 4.

1. Install connecting rod bearings into connecting rods and connecting rod caps dry (without oil).
2. Lubricate piston rings with clean engine oil. Stagger piston ring gaps approximately 120 degrees from each other.
3. Install the piston ring compression tool (Table 34) over the piston rings.
4. Lubricate the cylinder sleeve and connecting rod bearing shell with clean engine oil.

CAUTION: To prevent engine damage, install each piston with the arrow to the front of the engine and the CAM SIDE mark toward the cam side of the engine.

CAUTION: To prevent engine damage, make sure that the longer side of the connecting rod bolted joint is oriented opposite the camshaft side of the engine.

5. Carefully install the piston and connecting rod assembly without rod cap into the cylinder sleeve with the arrow on the piston crown pointing to the front of the engine. Use a wooden or plastic handle to carefully push the assembly into the cylinder sleeve. Do not scratch the cylinder wall.

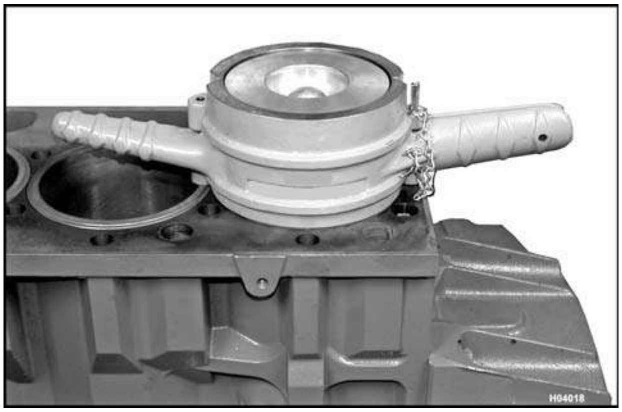


Figure 344 Installing the piston ring compression tool

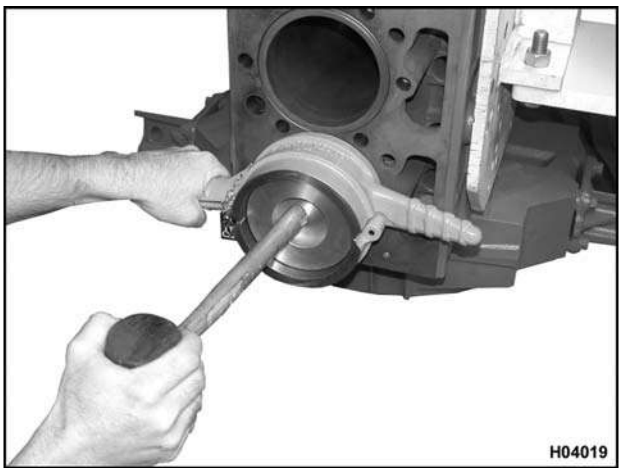


Figure 345 Installing the piston and connecting rod assembly

6. Carefully guide the piston and connecting rod assembly onto the crankshaft connecting rod journal.

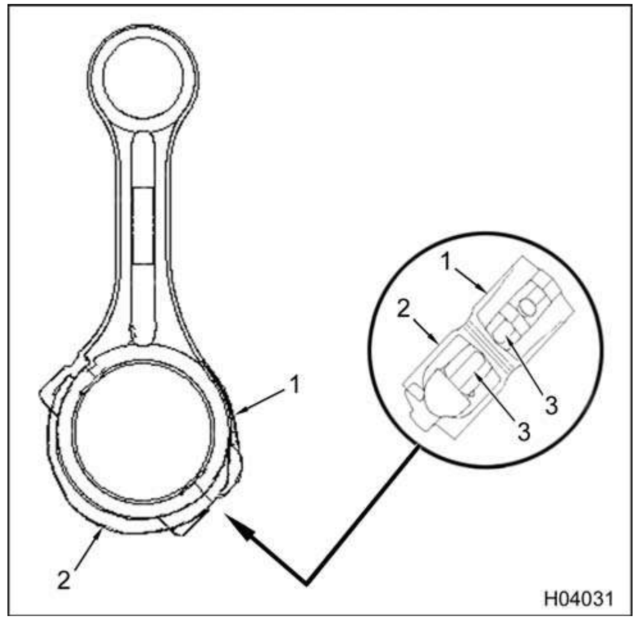


Figure 346 Matching serial number on connecting rod and connecting rod cap

1. Connecting rod
2. Connecting rod cap
3. Serial number

CAUTION: To prevent engine damage, install connecting rod cap and connecting rod with matching serial numbers on the same side. If the rod cap is reversed or not installed on its matching connecting rod, the fractured mating surfaces will be damaged. This can loosen the rod cap. A new connecting rod assembly must be installed.

The fractured mating surfaces of each rod and cap pair are precisely matched. Always keep each cap with its respective rod. If unsure, match the serial number on each connecting rod and connecting rod cap.

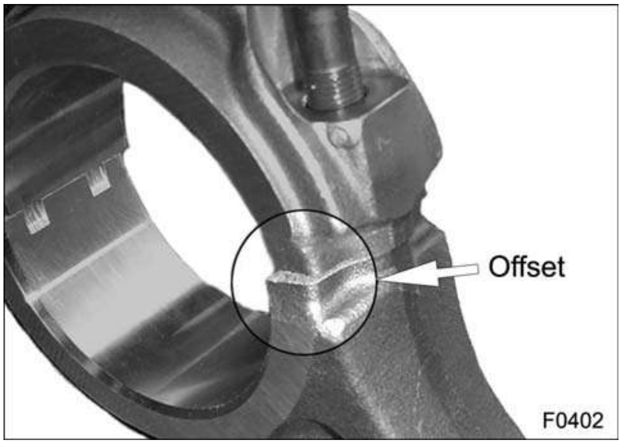


Figure 347 An offset indicates incorrect rod cap assembly

The rod cap can only be correctly installed on the connecting rod if it is oriented in the correct direction. If the rod cap is reversed during assembly of the connecting rod, an obvious offset will be seen at the mating surfaces. If the connecting rod assembly is installed on the crankshaft in this manner, the connecting rod must be replaced. Also check the crankshaft journal fillets for damage. Such damage will require replacement of the crankshaft.

7. Lubricate the inside diameter of the connecting rod cap bearing.

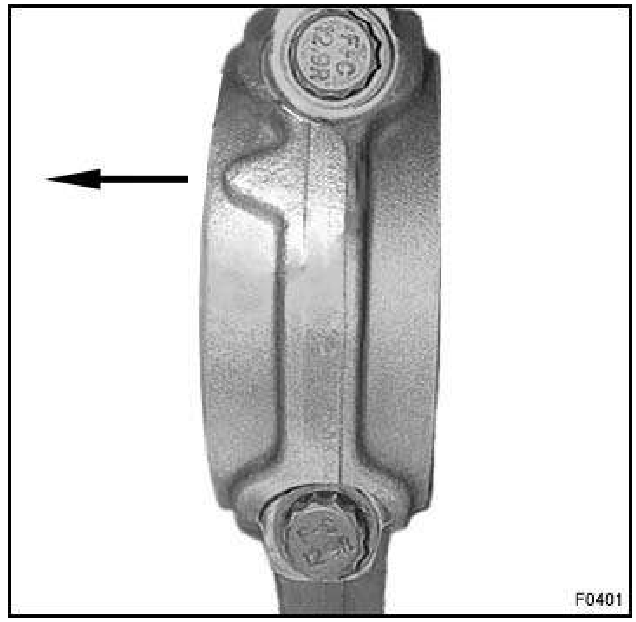


Figure 348 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

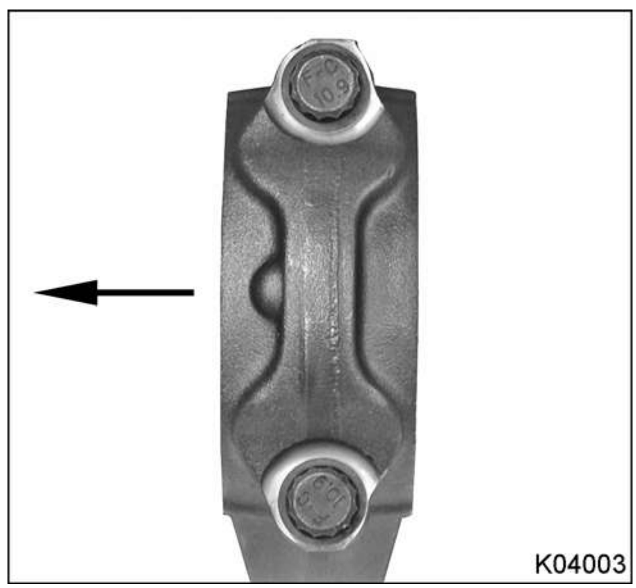


Figure 349 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

NOTE: Each rod end cap has a protrusion for correct orientation in the engine during installation. The protrusion must face toward the front of the engine.

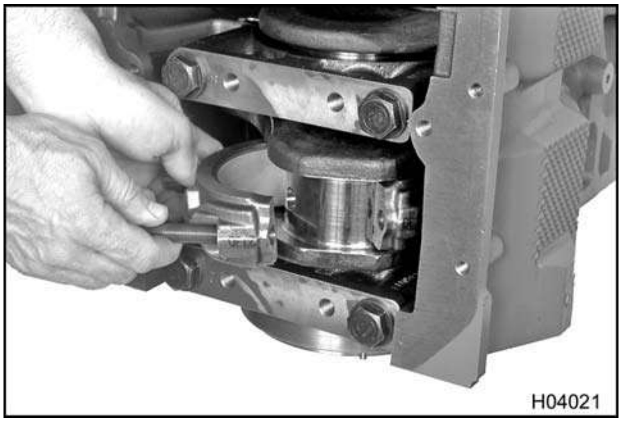


Figure 350 Installing the connecting rod cap

8. Carefully install connecting rod cap over the crankshaft journal and install two new M11 or M12 connecting rod cap bolts, depending on connecting rod version, finger tight.

Torque Procedure for Connecting Rods with M12 Bolts

CAUTION: To prevent engine damage, follow the connecting rod torque procedure for the specific connecting rods in the engine.

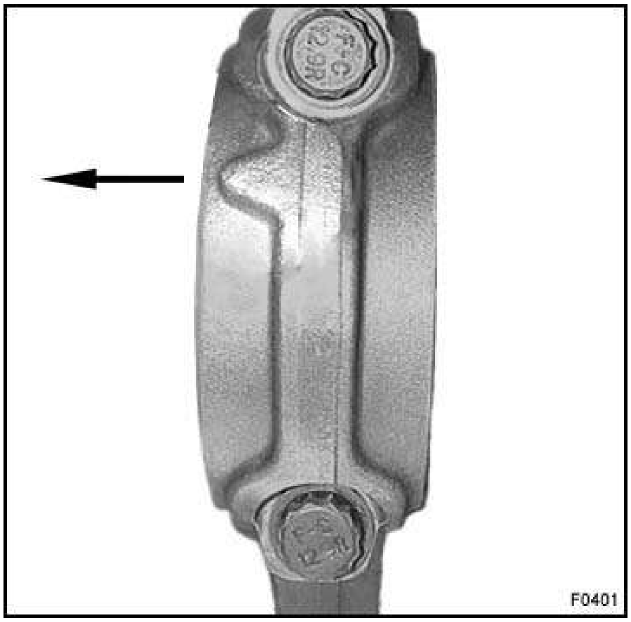


Figure 351 Connecting rod cap with M12 connecting rod cap bolts (protrusion points to front of engine)

NOTE: If doing a bearing fit procedure, (Bearing Fitting Procedures and Bearing Running Clearance, page 225) tighten new M12 connecting rod cap bolts to 109 N·m (80 lbf·ft).

For final assembly, tighten new M12 connecting rod cap bolts to 163 N·m (120 lbf·ft).

Torque-to-yield Procedure for New Connecting Rod with M11 Bolts

CAUTION: To prevent engine damage, follow the connecting rod torque procedure for the specific connecting rods in the engine.

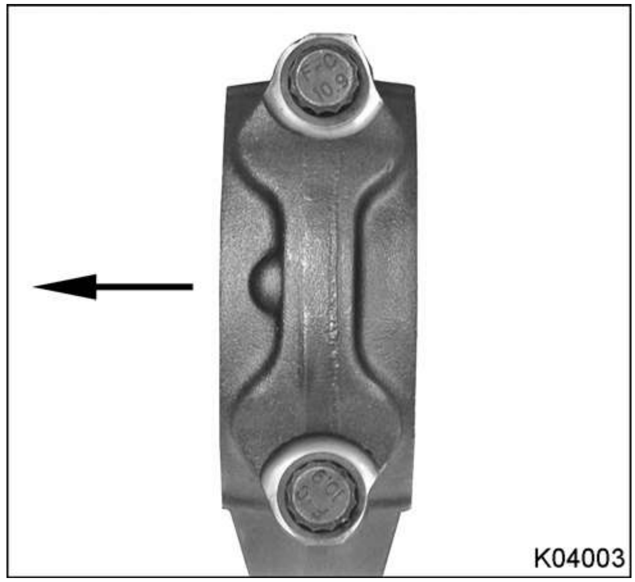


Figure 352 Connecting rod cap with M11 connecting rod cap bolts (protrusion points to front of engine)

NOTE: If doing a bearing fit procedure (Bearing Fitting Procedures and Bearing Running Clearance, page 225), do not torque-to-yield connecting rod cap bolts. Tighten new M11 connecting rod cap bolts to 109 N·m (80 lbf·ft)

1. For final assembly, tighten new M11 connecting rod cap bolts to 41 N·m (30 lbf·ft).

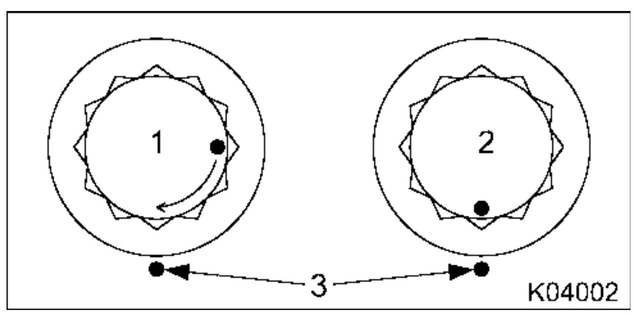


Figure 353 Torque-to-yield marks for M11 bolts

1. Connecting rod bolt with permanent marker spot (before torque-to-yield)
2. Connecting rod bolt with permanent marker spot (after torque-to-yield)
3. Permanent marker spot on connecting rod cap

CAUTION: To prevent engine damage, use permanent marker to identify internal engine components and their orientation. Do not use paint or temporary markers.

2. Using a permanent marker, mark each connecting rod bolt and put another mark on a 15 mm 12 point socket directly in line with the mark on each rod bolt.
3. Mark the surface of the connecting rod cap 90° clockwise from each mark on the rod bolt.
4. Align mark on socket with mark on the rod bolt and install socket on the rod bolt.
5. Torque-to-yield each M11 connecting rod cap bolt by rotating bolt exactly 90 degrees clockwise (1/4 turn). The mark on the socket and bolt should be aligned with the mark on the surface of the connecting rod cap.

Piston Cooling Tubes

Old Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

Figure 354 Old piston cooling tube

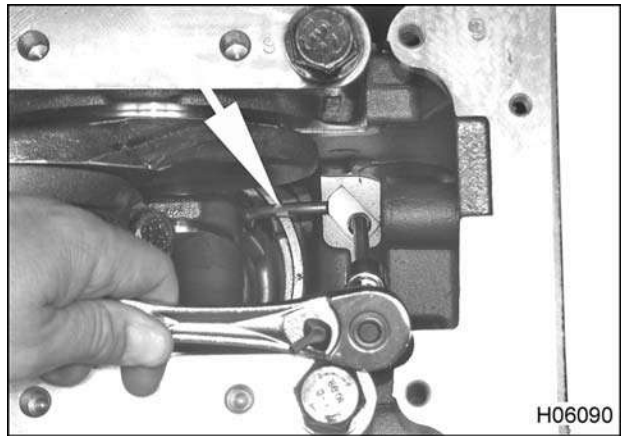


Figure 355 Old piston cooling tube

CAUTION: To prevent engine damage, the piston cooling tubes use a special patch type mounting bolt. Do not substitute.

NOTE: Piston cooling tubes are self aligning.

1. Place piston cooling tubes onto crankcase mounting pad.
2. When installing the piston cooling tube bolts (M6 x 16), do A or B below:
   - A. Install **new** piston cooling tube mounting bolts (patch type).
   - B. Remove oil residue, and apply Loctite® #242 to the threads of existing piston cooling tube mounting bolts (patch type), and install M6 x 16 bolts.
3. Tighten M6 x 16 bolts to the special torque value (Table 33).

New Piston Cooling Tubes

NOTE: The crankshaft may need to be rotated to access some piston cooling tubes.

CAUTION: To prevent engine damage, the correct piston cooling tubes must be installed.

NOTE: The non-knurled piston cooling tube is required for DT 466 engines. The knurled piston cooling tube is required for DT 570 and HT 570 engines.

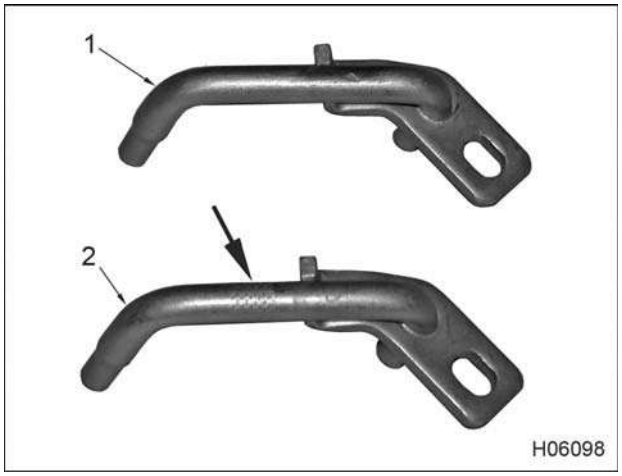


Figure 356 New piston cooling tubes

1. New piston cooling tube (non-knurled) – DT 466 engines
2. New piston cooling tube (knurled) – DT 570 and HT 570 engines

Figure 357 O-ring (underside) of new piston cooling tube

1. Put a new O-ring on each piston cooling tube.

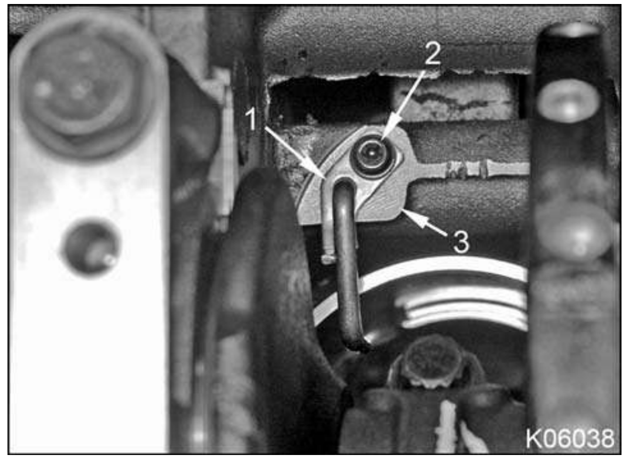


Figure 358 Installation of new piston cooling tube

1. Piston cooling tube (6)
2. M6 x 12 bolt (6)
3. Crankcase mounting pad (6)

NOTE: The new piston cooling tubes are self aligning.

2. Position piston cooling tubes on crankcase mounting pads.

CAUTION: To prevent engine damage, the piston cooling tubes use a special patch type mounting bolt. Do not substitute.

3. When installing the piston cooling tube bolts (M6 x 16), do do A or B below:
   A. Install **new** piston cooling tube mounting bolts (patch type).
   B. Remove oil residue, and apply Loctite® #242 to the threads of existing piston cooling tube mounting bolts (patch type), and install M6 x 12 bolts.
4. Tighten M6 x 16 bolts to the special torque value (Table 33).

Engine Run-In Procedure

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.

If new pistons or piston rings have been installed, do the following engine run-in procedure:

1. Run the engine at low idle with no load for 5 minutes. Check for leaks in the water, lube oil, fuel and air induction systems.
2. Check the turbocharger for any of the following conditions:
   - Unusual noise
   - Oil leaks
   - Air leaks
   - Excessive exhaust smoke
   - Excessive vibration
   - Loose mounting
3. Shut the engine off and correct any condition to prevent damage to the engine or turbocharger.
4. Start the engine and drive the vehicle (unloaded) for 25 minutes in city mode, then drive the vehicle (unloaded) for an additional 15 minutes in highway mode.
5. Return to idle and check for leaks.

Specifications

Table 28 Connecting Rod Specifications

Bend (max.)	0.06 mm (0.003 in)
Center-to-center distance between connecting rod bearing bore and piston pin bushing bore	219.4 - 219.5 mm (8.638 - 8.642 in)
Connecting rod bearing bore inside diameter	85.130 - 85.156 mm (3.3516 - 3.3526 in)
Connecting rod bearing inside diameter (installed)	80.05 - 80.10 mm (3.1518 - 3.1536 in)
Connecting rod bearing bore out-of-round (max.)	0.02 mm (0.00078 in)
Connecting rod bearing bore taper (max.)	0.02 mm (0.00078 in)
Connecting rod bearing running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod side clearance on crankshaft	0.13 - 0.48 mm (0.005 - 0.019 in)
Piston pin bushing inside diameter	46.393 - 46.401 mm (1.8265 - 1.8268 in)
Twist (max.)	0.05 mm (0.002 in)

Table 29 Piston Specifications

466 piston configuration	
Piston material	Aluminum alloy
Piston rings	
225 bhp and below	Top ring - keystone cross section Intermediate - rectangular cross section
230 bhp and above	Top ring - keystone cross section Intermediate - keystone cross section
570 piston configuration	
Piston crown	Steel crown, two-piece articulated
Piston skirt	Aluminum alloy
Piston rings	
All 570 series engines	Top ring – keystone cross section Intermediate – rectangular cross section
466 and 570 piston specifications	

Table 29 Piston Specifications (cont.)

Running clearance between piston and cylinder sleeve	**466 piston:** 0.076 - 0.128 mm (0.0030 - 0.0050 in)
	570 piston: 0.063 - 0.115 mm (0.0025 - 0.0045 in)
Skirt diameter	**466 piston:** 116.44 - 116.49 mm (4.584 - 4.586 in)
	570 piston: 116.48 - 116.51 mm (4.586 - 4.587 in)
Top compression ring groove width, 466 measure over 0.122 gauge pins	115.90 - 115.68 mm (4.563 - 4.554 in)
Top compression ring groove width, 570 measure over 0.126 gauge pins	116.74 - 116.50 mm (4.596 - 4.587 in)
Intermediate compression ring groove width (keystone shaped ring) measure over 0.110 gauge pins	115.92 - 115.73 mm (4.564 - 4.556 in)
Intermediate compression ring groove width (rectangular shaped ring), 466	3.05 - 3.03 mm (0.120 - 0.119 in)
Intermediate compression ring groove width (rectangular shaped ring), 570	3.05 - 3.03 mm (0.120 - 0.119 in)
Oil control ring, side clearance, 466	0.076 - 0.026 mm (0.0030 - 0.0010 in)
Oil control ring, side clearance, 570	0.080 - 0.030 mm (0.0031 - 0.0012 in)

Table 30 Piston Ring Specifications

Intermediate compression ring end gap	1.65 - 1.90 mm (0.065 - 0.075 in)
Oil control ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)
Top compression ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)

Table 31 Piston Pin Specifications

Clearance in piston	**466 piston:** 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	0.035 - 0.048 mm (0.0014 - 0.0019 in)
	570 skirt (vertical plane): 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	570 skirt (horizontal plane): 0.0280 - 0.0574 mm (0.00114 - 0.00226 in)
	570 crown: 0.038 - 0.053 mm (0.0015 - 0.0021 in)
Diameter	46.352 - 46.357 mm (1.8249 - 1.8251 in)
Length	96.57 - 96.82 mm (3.802 - 3.812 in)

Table 32 Cylinder Sleeve Specifications

Allowable variation of counterbore depth between four points (max.)	0.03 mm (0.001 in)
Counterbore depth before adding shims (max.)	10.49 mm (0.413 in)
Counterbore depth (including shims- if any)	8.84 - 8.89 mm (0.348 - 0.350 in)
Cylinder sleeve protrusion	0.05 - 0.13 mm (0.002 - 0.005 in)
Cylinder sleeve taper, at top of ring travel (max.)	0.10 mm (0.004 in)
Flange thickness	8.94 - 8.96 mm (0.352 - 0.353 in)
Inside diameter	114.50 - 116.60 mm (4.590 - 4.591 in)

Special Torque

Table 33 Connecting Rod Special Torque

Connecting rod bolts (verify connecting rod type)	See Torque Procedures for Connecting Rod with M12 Bolts (page241) or M11 Bolts (page241).
Piston cooling tube bolts, M6 x 12	13 N·m (115 lbf·in)
Piston cooling tube bolts, M6 x 16	13 N·m (115 lbf·in)

Special Service Tools

Table 34 Piston, Piston Ring, and Connecting Rod Special Service Tools

Counterbore cutting head	ZTSE25144A
Cylinder bore gauge	Obtain locally
Cylinder sleeve counterbore tool kit	ZTSE2514
Cylinder sleeve holding adapters (set of 3)	ZTSE4672
Cylinder sleeve puller	ZTSE2536
Dial indicator set	Obtain locally
EGR water coolant supply plate	ZTSE4648
Piston ring compressor tool	ZTSE4396
Piston ring expander	Obtain locally
Piston ring gauge pins (set of 3)	ZTSE4653
Telescoping gauge set	Obtain locally

Table of Contents

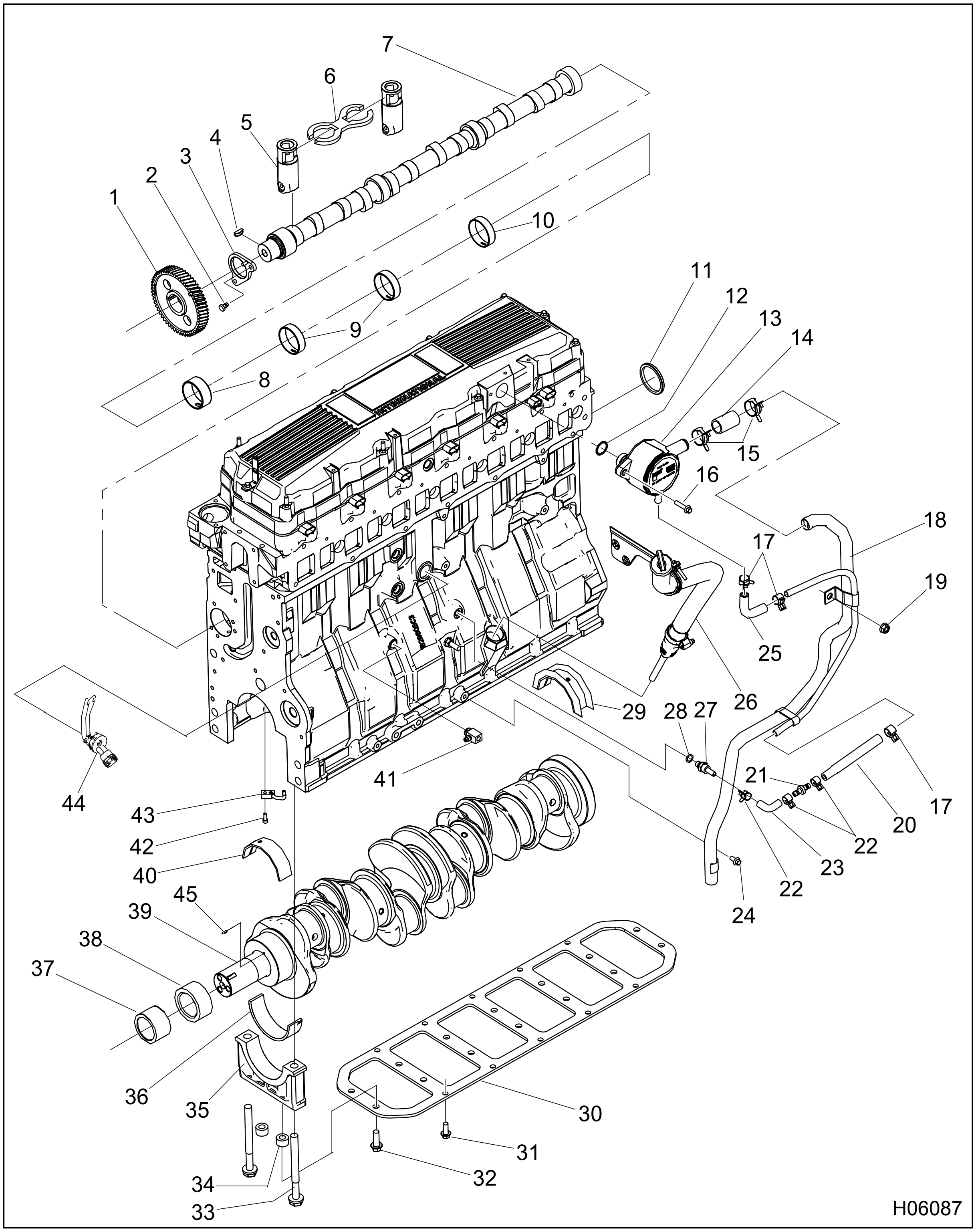


Figure 359 Crankcase, Crankshaft, and Camshaft

1. Camshaft gear assembly
2. Bolt, M8 x 20 (2)
3. Camshaft thrust plate
4. Key, 1/2 x 1/2
5. Roller tappet assembly (12)
6. Roller tappet guide (6)
7. Camshaft
8. Front camshaft bushing
9. Intermediate camshaft bushings (2)
10. Rear camshaft bushing
11. Camshaft seal ring, rear
12. O-ring, #214
13. Breather assembly
14. Hose, 1 in. I.D.
15. Clamp, 1 in. diameter (2)
16. Bolt, M8 x 35 (2)
17. Clamp, 1/2 in. diameter (3)
18. Vent and drain tube assembly
19. Nut, M10
20. Reducer hose
21. Check valve
22. Clamp (3)
23. Rubber elbow
24. Bolt, M8 x 16
25. Drain hose elbow
26. Oil level gauge assembly (Figure 361)
27. Fitting assembly, M12
28. O-ring seal
29. Main bearing, upper (#7 thrust)
30. Crankcase ladder (DT 570 >300 bhp)
31. Bolt, M10 x 25 (10)
32. Bolt, M12 x 35 (14)
33. Bearing cap bolt, M15 x 162 (14)
34. Spacer (14)
35. Main bearing cap (7)
36. Main bearing, lower (7)
37. Oil pump drive (spline)
38. Crankshaft gear
39. Crankshaft
40. Main bearing, upper (6)
41. Tee assembly, M12
42. Bolt, piston cooling tube (6)
43. Piston cooling tube assembly (6) (see “Power Cylinders”)
44. Block heater assembly (option)
45. Slotted pin, 5/32 x 5/16

Removal

Crankcase Ventilation System

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 working with components.

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, 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.

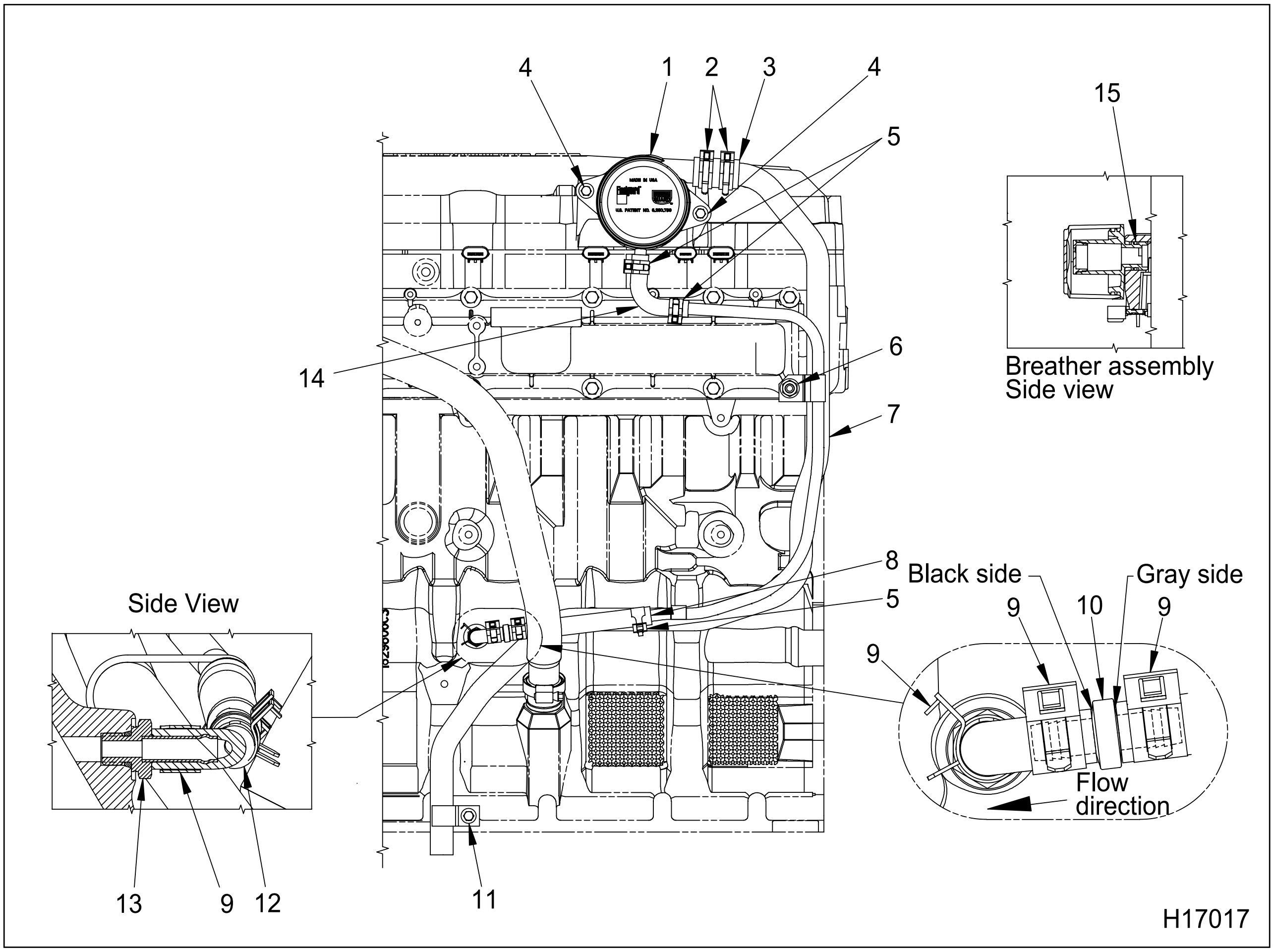


Figure 360 Crankcase ventilation system

1. Breather assembly
2. Clamp, 25.4 mm (1 in) diameter (2)
3. Hose, 25.4 mm (1 in) I.D.
4. Bolt, M8 x 35 (2)
5. Clamp, 1/2 in. diameter (3)
6. Nut, M10
7. Vent and drain tube assembly
8. Reducer hose
9. Clamp (3)
10. Check valve
11. Bolt, M8 x 16
12. Rubber elbow
13. Fitting assembly, M12
14. Drain hose elbow
15. O-ring, #214

NOTE: Have an oil pan handy before disconnecting the oil drain hose. It is possible for a column of oil to be maintained above the check valve, as the check valve does require a certain amount of pressure to allow passage of oil back to the crankcase.

To remove the crankcase ventilation system as an assembled unit, do the following steps.

1. Move clamp (1/2 in) out of way and remove reducer hose from vent and drain tube assembly. Allow tube and reducer hose to drain. Reconnect reducer hose and clamp.
2. Remove clamp and rubber elbow on the crankcase side of the check valve. Leave fitting assembly in crankcase unless evidence of leaking is occurring from fitting O-ring.
3. Remove the bolt (M8 x 16) securing the vent and drain tube assembly to the crankcase, located at the end of the vent tube.
4. Remove two bolts (M8 x 35) securing the breather assembly to the valve cover.

5. Remove the nut (M10) securing the vent and drain tube to the intake manifold.
6. Carefully pull breather assembly out of valve cover.
7. Remove breather and tubing assembly and place in solvent wash tank.

Oil Level Gauge

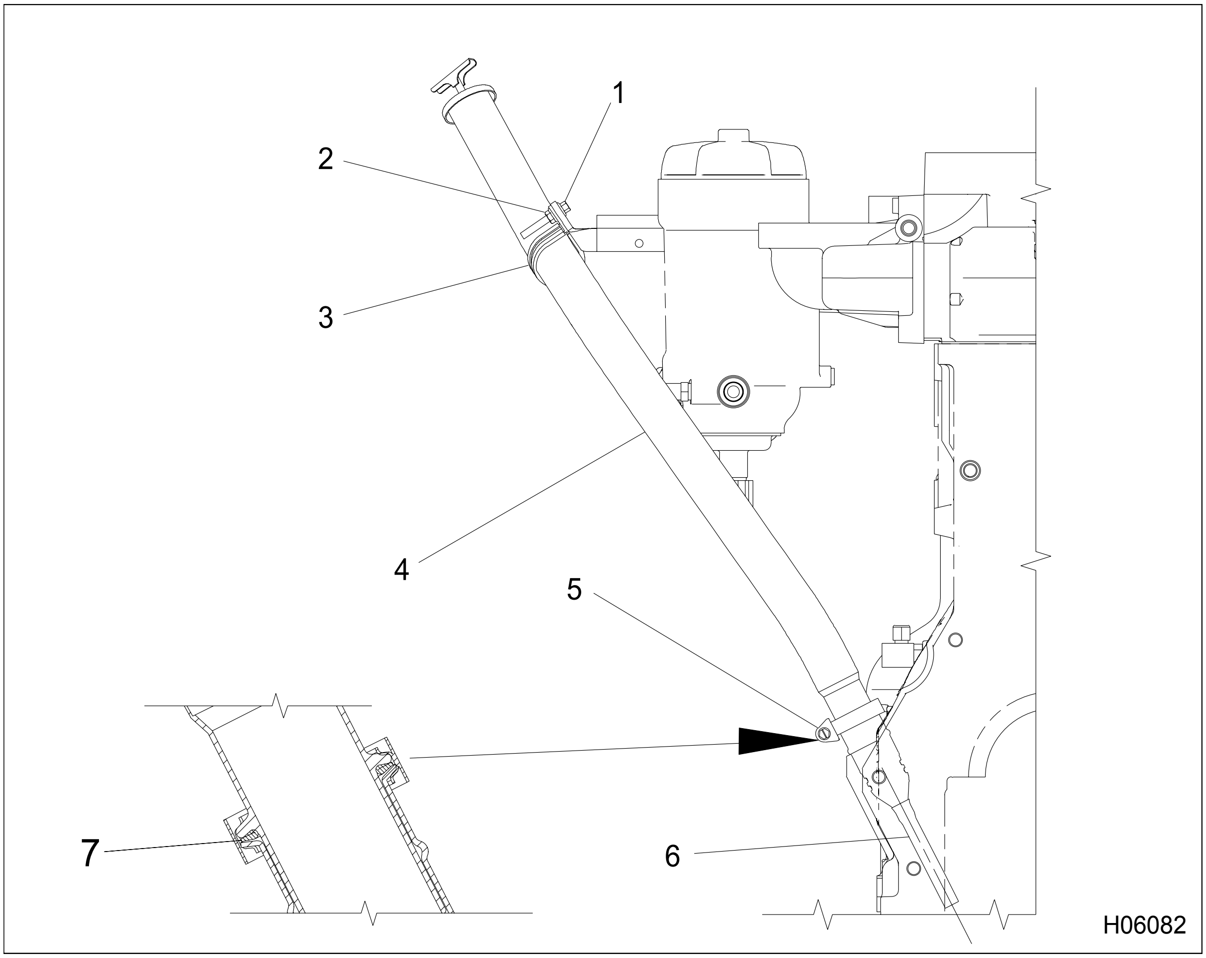


Figure 361 Oil level gauge assembly

1. Bolt, M6 x 40
2. Nut, M6
3. Cushioned clamp
4. Oil filler tube
5. Tube clamp
6. Oil level gauge tube
7. Oil dipstick tube seal

1. Remove the oil filler tube bolt (M6 x 40) and nut (M6) at the fuel filter bracket.
2. Remove the tube clamp at the crankcase and discard oil dipstick tube seal.
3. If necessary, remove oil level gauge tube from crankcase by using a brass drift and hammer.

Crankcase Ladder (DT 466 series – 225 hp and 245 hp @ 2600 rpm) and all 570 ratings

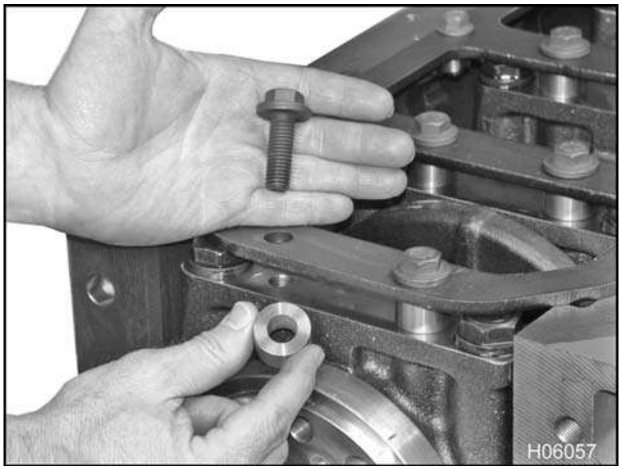


Figure 362 Crankcase ladder hardware

NOTE: Refer to the following for information regarding the removal or installation of these related components:

- Oil pan (Removing the Oil Pan, page 206)
- Oil suction tube (Removing the Oil Suction Tube, page 207)

1. Remove 14 crankcase ladder bolts (M12 x 35) and spacers.
2. Remove 10 crankcase ladder bolts (M10 x 25).

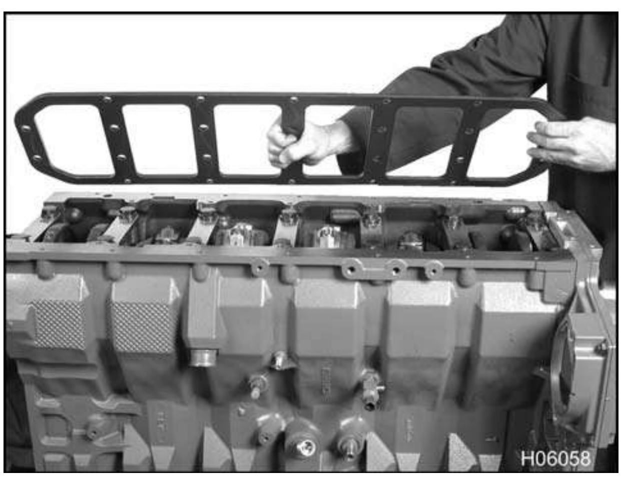


Figure 363 Removing the crankcase ladder

3. Remove the crankcase ladder.

Crankshaft Disassembly

NOTE: Before removing the crankshaft, it may be necessary to remove the piston assemblies (Removing Piston and Connecting Rod Assembly, page 218).

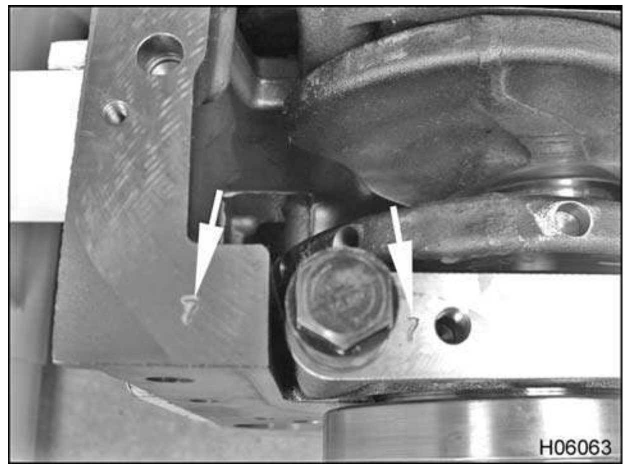


Figure 364 Main bearing cap identification stamps

1. Verify that the main bearing caps and crankcase are numbered. You may have to degrease accordingly to gain access to the stamped numbers.
2. Loosen all the main bearing bolts (M15 x 162).

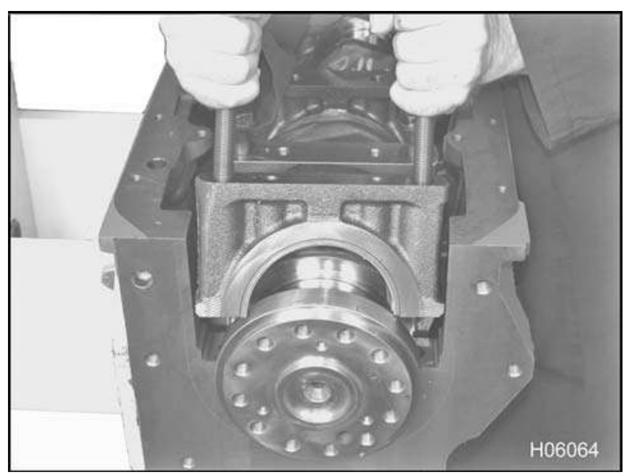


Figure 365 Removing the main bearings

3. Lift up both bolts until about half the threads are exposed. Use both bolts to rock main bearing cap free from crankcase.
4. Discard all of the removed main bearing bolts. These are not reusable due to the permanent stretch they received from “torque-to-yield”.

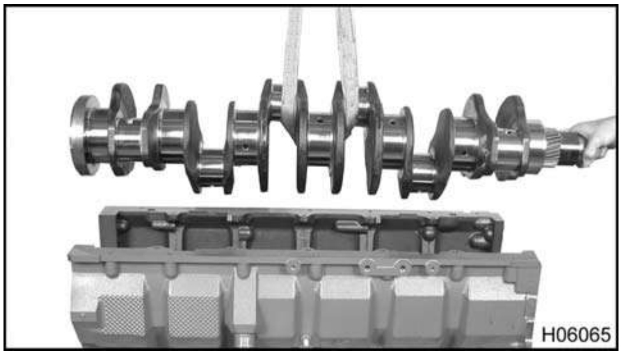


Figure 366 Removing the crankshaft assembly

5. Place an appropriately sized sling around the middle of the crankshaft and attach it to a hoist or crane. Lift crankshaft out of crankcase and place on workbench.
6. Visually inspect the crankshaft gears for chipping or wear. Replace as required.
7. Place a chisel between the gear teeth and strike the chisel with a hammer to split the gear.

Figure 367 Removing oil pump drive spline

8. Remove the oil pump drive first to access the crankshaft gear.
9. Be careful not to damage the crankshaft during gear removal.

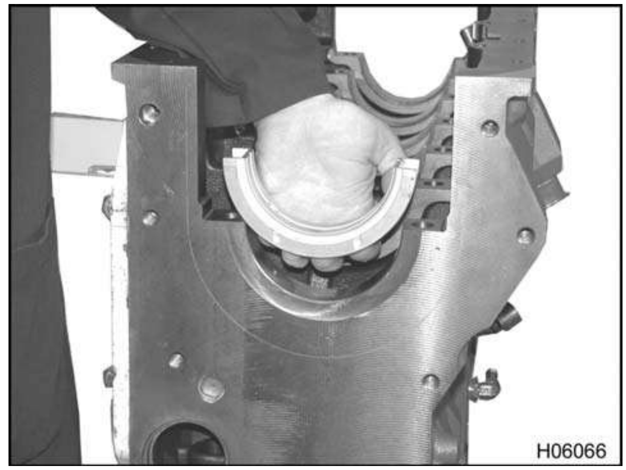


Figure 368 Removing the number seven upper thrust bearing

10. Remove upper main bearing shells by pushing them out of main bearing saddle with your thumbs. Mark the upper shells with bearing number and orientation. Set aside each upper bearing shell with the lower shells until a proper inspection can be done.

Cam Gear from Camshaft

NOTE: If removing the whole camshaft assembly, skip to next procedure.

1. Install gear puller making sure claws are positively engaged with cam gear and the threaded shaft is aligned with camshaft.

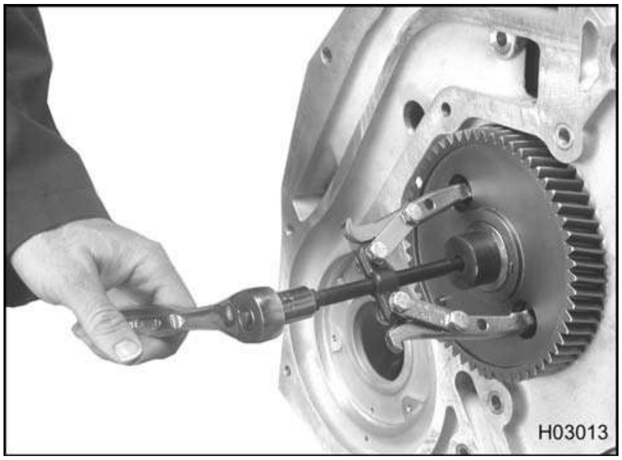


Figure 369 Removing camshaft gear

2. Using a socket or wrench apply force to tool until gear is just about off. Use both hands to remove cam gear and tool.

Camshaft Disassembly

NOTE: Use this procedure to remove the cam gear and camshaft as a unit.

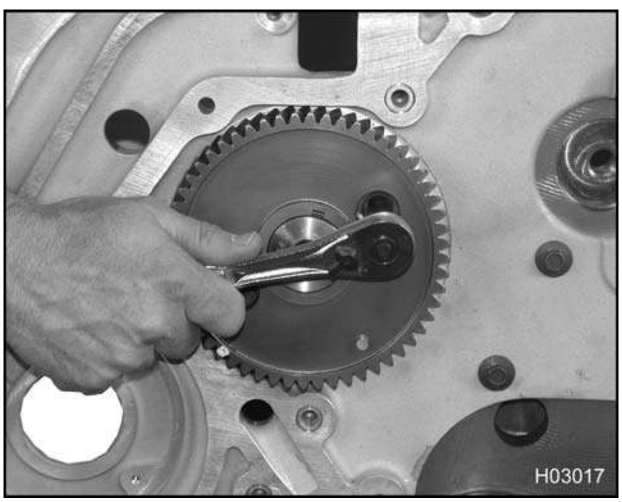


Figure 370 Removing camshaft thrust plate bolts

1. Remove the two camshaft thrust plate bolts (M8 x 20).

Figure 371 Removing the camshaft assembly

2. Carefully remove the camshaft assembly from the crankcase.

Camshaft Bushings

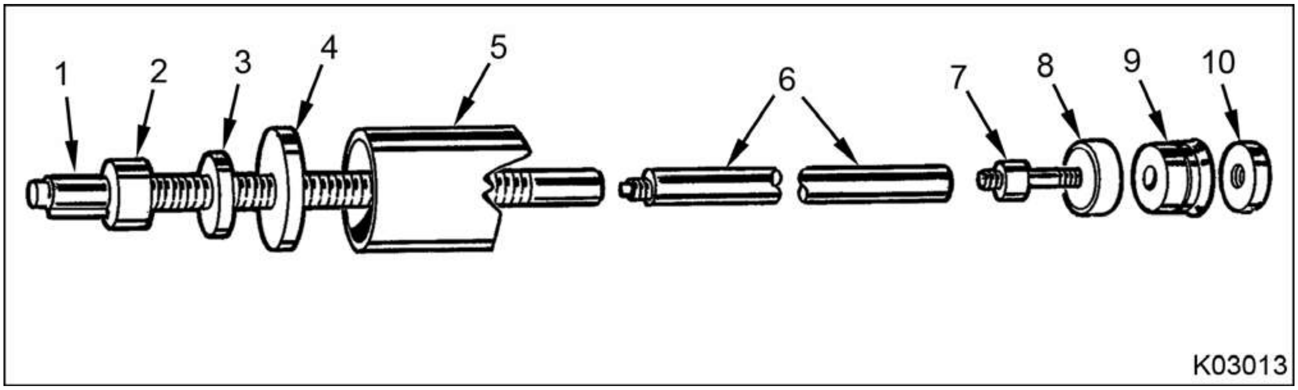


Figure 372 Camshaft Bushing Puller (installer)

1. Puller screw
2. Pulling nut
3. Thrust bearing
4. Pulling plate
5. Pulling spacer
6. Extension tube
7. Puller screw extension
8. Camshaft bearing (not part of tool)
9. Expanding collet
10. Backup nut

NOTE: Although the inside diameter of each camshaft bushing is the same, the outside diameters and widths are different depending on bearing location. The bearing diameters have changed from previous designs and this determines how bushing are removed and installed.

Table 35

Bushing Location	Outside Diameter (nominal)	Width (nominal)
Front	65.5 mm (2.50 in)	25.4 mm (1.00 in)
Rear	65.5 mm (2.50 in)	17.8 mm (0.70 in)
Intermediate	63.0 mm (2.48 in)	17.8 mm (0.70 in)

Remove the front and rear bushings (1) first. The rear bearing and camshaft seal ring **must** be removed from the rear of the crankcase. It is recommended that the intermediate bushings be removed according to the following illustration.

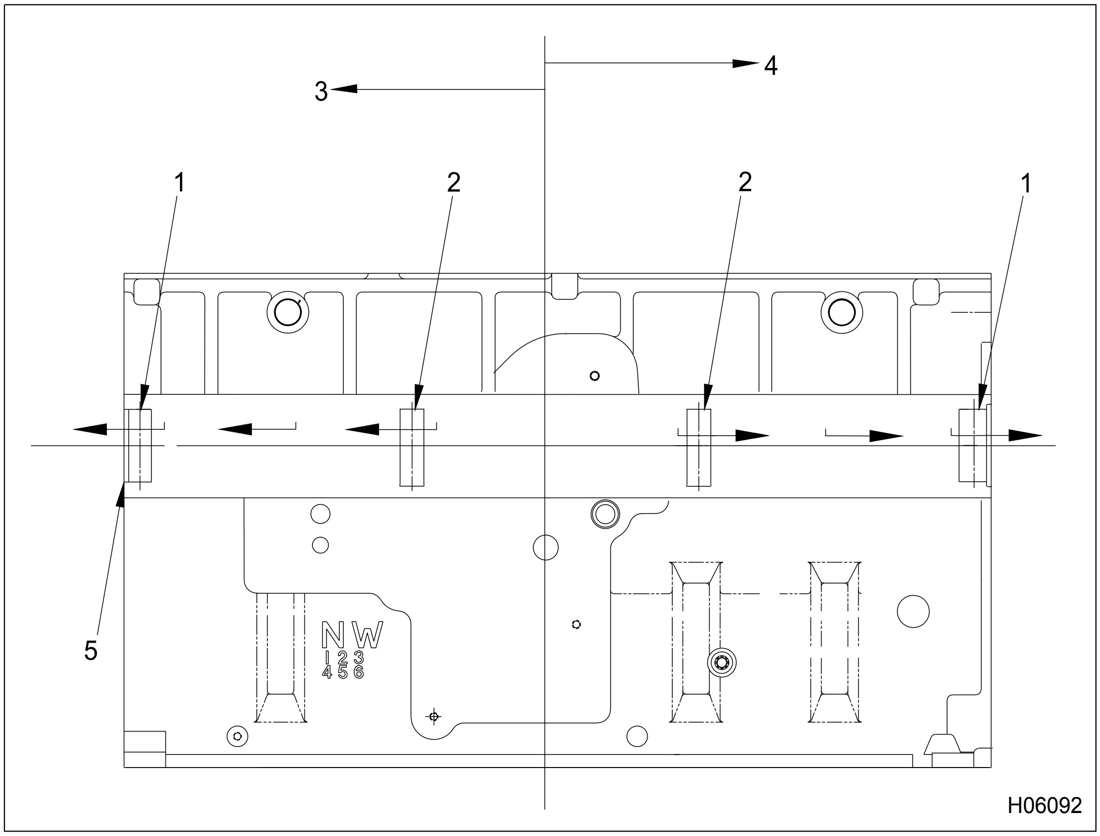


Figure 373 Pulling direction for camshaft bushing removal

1. Front and rear bushings
2. Intermediate bushings
3. Rear half of engine
4. Front half of engine
5. Camshaft seal ring

1. Assemble the correct expanding collet size and backup nut onto the expanding mandrel.
2. With the collet collapsed, install the collet assembly into the camshaft bushing. Tighten the backup nut onto the expanding mandrel until the collet fits the camshaft bearing.
3. Assemble the puller screw and extension, if necessary. Install the puller screw onto the expanding mandrel.
4. Hold the end of the puller screw with a wrench to keep it from turning. Tighten the pulling nut against the thrust bearing and the pulling plate until the camshaft bushing is removed.

Coolant Heater (if equipped)

1. Make sure coolant has been drained out of the engine or at least drained to a level below the coolant heater, if simply servicing the heater.
2. Loosen 5/32 in hex socket head cap screw sufficient to remove the coolant heater from the crankcase.
3. Clean out coolant heater cavity at crankcase.

Cleaning and Inspection

Cleaning the Crankcase

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.

NOTE: The best way to clean the crankcase during engine overhaul is in a chemical bath or hot tank. This removes all carbonaceous material and mineral deposits that collect in the cooling passages. If the hot tank is not available, use the following cleaning procedure.

1. Clean all old gasket material from the surfaces of the crankcase, if any.

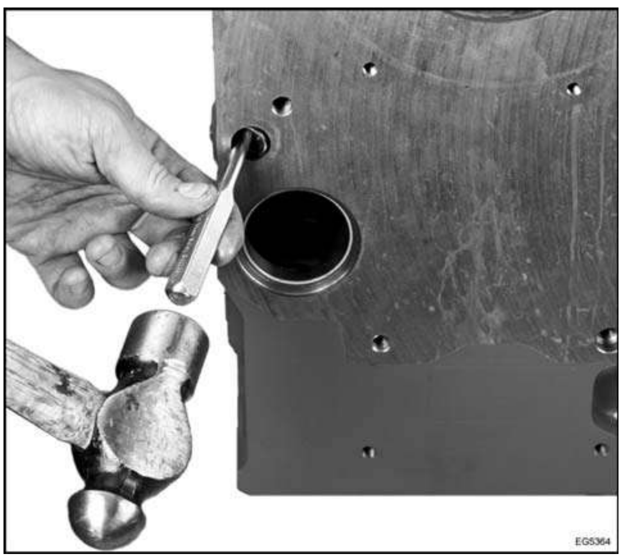


Figure 374 Removing crankcase plugs

2. Remove the main oil gallery cup plug, located at the rear of the crankcase by using a hammer and chisel. Knockout main oil gallery cup plug.

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

3. With the plugs removed from the crankcase, clean the crankcase as follows:
   a. Use a nylon brush (Table 40) with soap and water to clean oil galleries.
   b. Clean cross drillings using a nylon brush (Table 40) with soap and water.
   c. Use filtered compressed air to blow out oil galleries and cross drillings.
   d. Clean all threaded holes with an appropriately sized tap (Table 40).
4. Install a new main oil gallery cup plug as follows:
   a. Clean the mating surfaces of the plug and crankcase.
   b. Apply Loctite® 262 to the outside edge of the cup plug.
   c. Use an arbor to drive the cup plug in. The arbor must be approximately 6 mm (1/4 in) smaller in diameter than the plug that is being installed.
   d. Recess the cup plug 3.2 mm (1/8 in).
5. Install new plugs in the rear of the crankcase.

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

6. Inspect the piston cooling tubes for damage and blockage as follows:
   a. Inspect both ends of the tube. Verify that the flanged end next to the bearing saddle is intact and the orifice end protruding from the crankcase is not broken. Replace any tubes that are damaged.
   b. Hold tube under running water in a sink. Water should stream out of tube end. If not, blockage will have to be physically removed by compressed air or piston oil tube must be replaced.

Crankcase Ventilation

1. Place breather and tubing assembly (Figure 360) into a solvent parts cleaner and disassemble.
2. Thoroughly clean all hoses, clamps, tubing, check valve and breather assembly. Run solvent through each end of the check valve to confirm directional flow.

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

3. Blow dry with filtered compressed air.
4. Inspect all rubber hoses for cracking or deformation. Replace components as necessary.

Crankshaft and Main Bearings

Perform the following steps:

1. Clean the bearing inserts and caps thoroughly in solvent and dry with filtered compressed air . **Do not scrape gum or varnish deposits from bearing shells**.
2. Clean all the internal oil passages of the crankshaft using a stiff nylon brush (Table 40). Loosen all dirt, sludge and deposits which may have accumulated. Flush the oil passages with a suitable non-caustic solvent.

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

3. Blow passages dry with filtered compressed air .
4. Inspect the crankshaft journals (main and rod) for scratches, grooves and scoring. Use dye penetrant methods to check for cracks.
5. Inspect all bearing inserts. Replace bearings that are scored, chipped or worn.

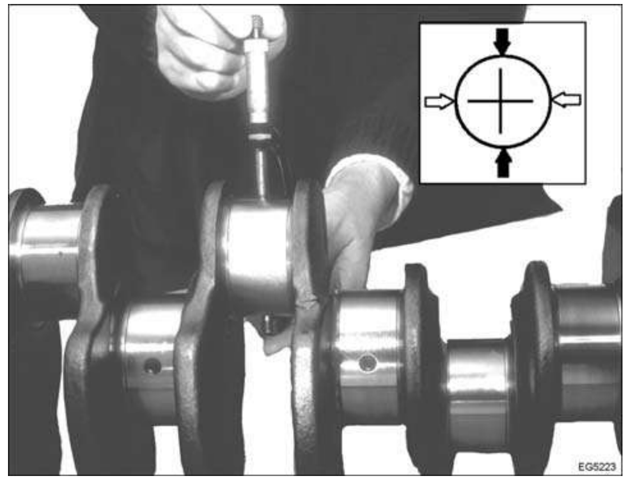


Figure 375 Inspecting the crankshaft journals

6. Measure the diameter of each journal using a micrometer. Measure each journal at two points, right angles to each other. Move the micrometer over the entire width of the journal.

NOTE: If journals exceed maximum out-of-round specification, crankshaft must be reground or replaced. The crankshaft can be ground to the following undersizes:

- 0.25 mm (0.010 in)
- 0.51 mm (0.020 in)
- 0.76 mm (0.030 in)

Checking Camshaft Assembly

1. Use a soft bristle brush and a suitable solvent to clean the camshaft and cam gear.
2. Inspect the cam gear for worn and damaged teeth. Replace the gear assembly, if necessary.
3. Inspect the camshaft for scuffed, scored and cracked lobes. Replace the camshaft if necessary.
4. Inspect the camshaft thrust plate for wear, cracks, and distortion. Use an outside micrometer to measure the thickness of the thrust plate. If the thrust plate is too worn or damaged, replace the thrust plate.

Checking Camshaft Lobes and Journals

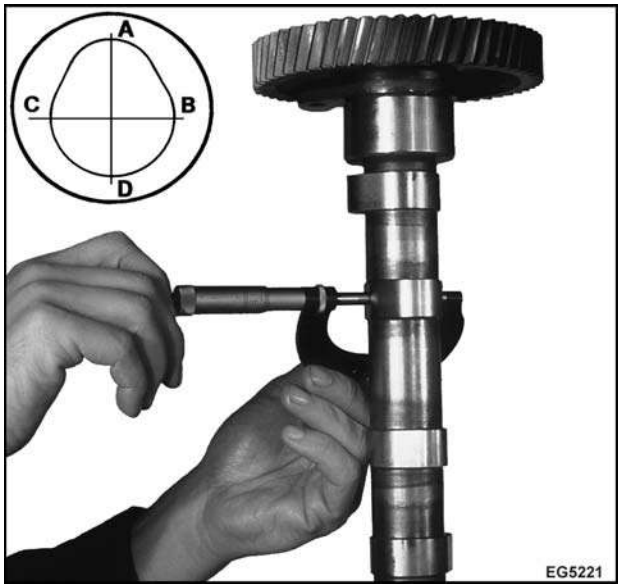


Figure 376 Checking camshaft lobes and journals for wear

1. Use an outside micrometer to measure across each camshaft lobe from A-D and B-C. Subtract measurement B-C from measurement A-D. This is the cam lobe lift.

   If any measurement exceeds the specification, replace the camshaft.

2. Use an outside micrometer to measure the diameter of each camshaft journal.

   If any measurement exceeds the specification (Table 38), replace the camshaft.

Installation

Coolant Heater (if equipped)

1. If servicing a leaky coolant heater, replace O-ring on heater assembly.
2. Place nonpetroleum base lubricant around O-ring area and install into crankcase. Orient electrical connector so that it is facing downward (6 o'clock position).
3. Tighten the 5/32 in hex socket head cap screw to the special torque value (Table 39).
4. Replenish coolant level if only servicing coolant heater.

Camshaft Bushings

1. Identify each camshaft bushing according to its outside diameter.

Table 36

Bushing Location	Outside Diameter (nominal)	Width (nominal)
Front	65.5 mm (2.50 in)	25.4 mm (1.00 in)
Rear	65.5 mm (2.50 in)	17.8 mm (0.70 in)
Intermediate	63.0 mm (2.48 in)	17.8 mm (0.70 in)

2. Lubricate each new camshaft bushing and crankcase bushing bore with clean engine oil.

Figure 377 Camshaft bushing installation tool

3. Install new camshaft bearing onto the expanding collet. Tighten collet by turning adjusting nut until the bushing is held securely in place.

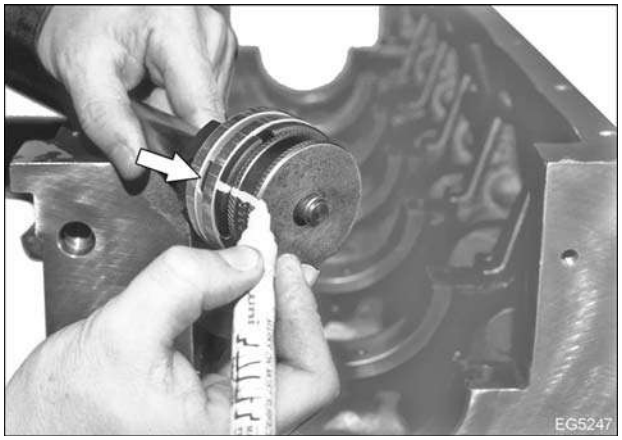


Figure 378 Marking oil hole location on bushing

4. Mark the bearing oil hole location on the backup nut of the installation tool to help align the oil hole in the bushing with the oil hole in the crankcase. Repeat this step for each bushing.

CAUTION: To prevent engine damage, camshaft bushings must be installed in the proper order due to differing outside diameters. Both intermediate cam bushings have an outer diameter that is slightly smaller than bushings used in the front and rear positions.

Cam bearings oil holes must align with oil holes in cylinder block.

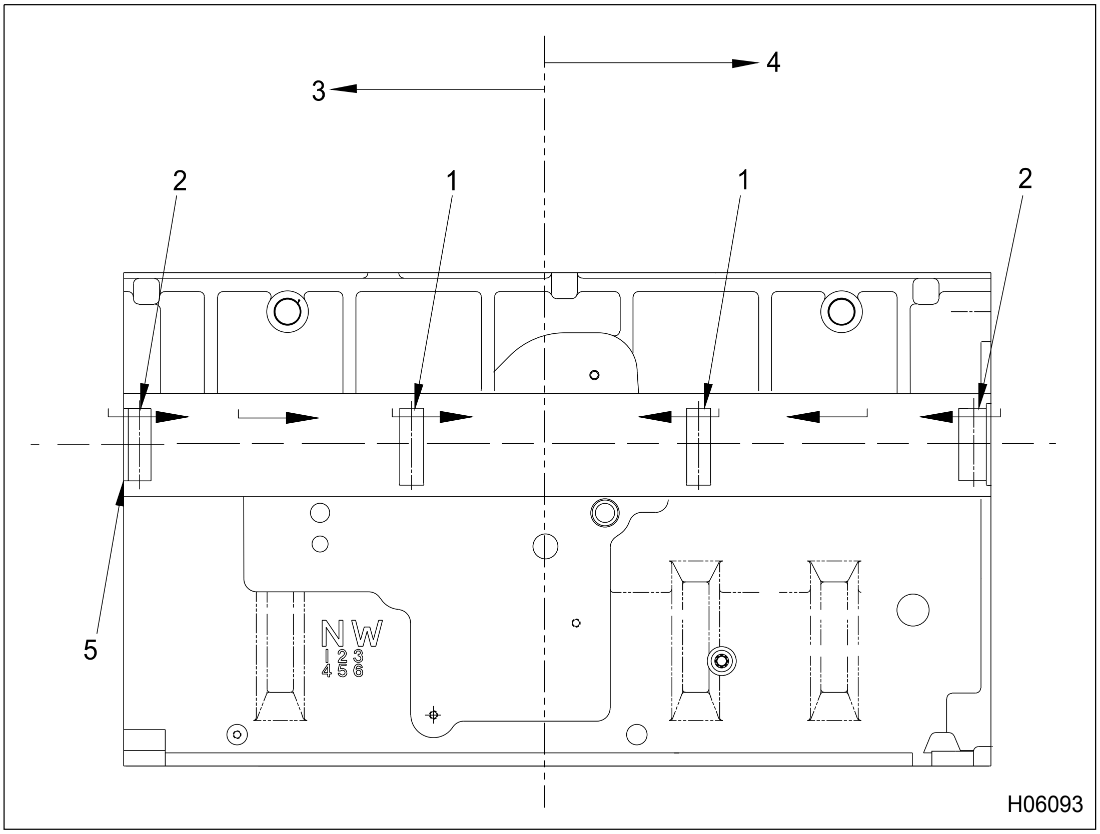


Figure 379 Pulling direction for camshaft bushing installation

1. Intermediate bushings
2. Front and rear bushings
3. Rear half of engine
4. Front half of engine
5. Camshaft seal ring

5. Install the rear intermediate bushings through the rear of the crankcase. Pull the bushing into place from the front of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
6. Install the front intermediate bushing through the front of the crankcase. Pull the bushing into place from the rear of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect oil hole alignment.

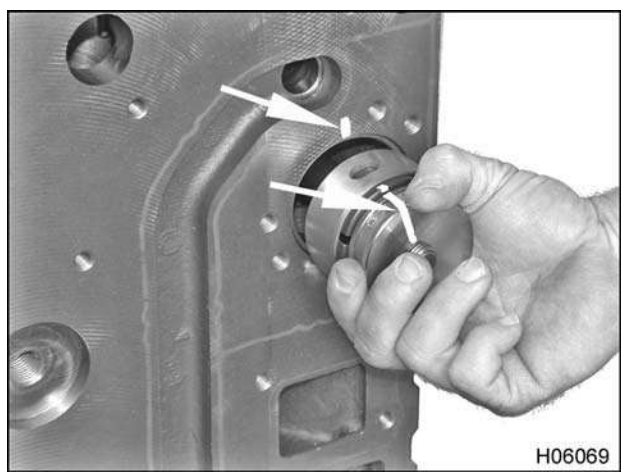


Figure 380 Paint marks indicating oil hole alignment

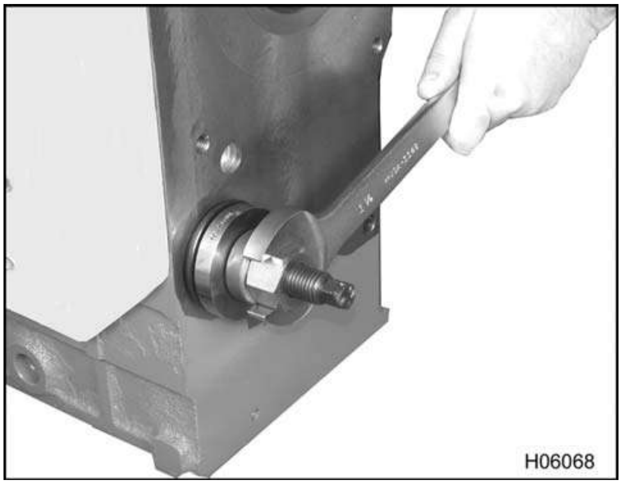


Figure 381 Pulling in the front bushing

7. Install the front bushing through the front of the crankcase. Pull the bushing into place from the rear of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
8. Install the rear bushing through the rear of the crankcase. Pull the bushing into place from the front of the crankcase by turning the pulling nut on the puller screw. Remove the installation tool and inspect the oil hole alignment.
9. Install camshaft seal ring in rear of crankcase.

Camshaft Assembly

NOTE: Use this procedure to install the cam gear and camshaft as a unit.

Figure 382 Installing camshaft assembly

1. Rotate crankcase to a vertical position.
2. Lubricate all camshaft journals and bushings with clean engine oil.
3. Install the camshaft assembly in the crankcase.

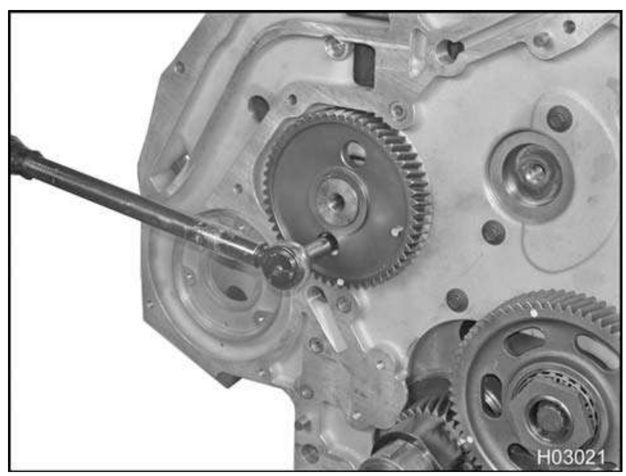


Figure 383 Torquing camshaft thrust plate bolts

4. Install the two camshaft thrust plate bolts (M8 x 20). Tighten the bolts to the special torque value (Table 39).

Cam Gear on Camshaft

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

Figure 384 Heating the camshaft gear

CAUTION: To prevent engine damage, do not heat the cam gear above 177 °C (350 °F). This will turn the gear blue and reduce wear resistance. Do not use any gear turned blue.

1. If the camshaft gear was removed from the camshaft, heat the cam gear on a hot plate (Table 40) or other controlled heat source to 149-177 °C (300-350 °F).
2. Pull camshaft assembly forward prior to sliding heated gear onto camshaft.

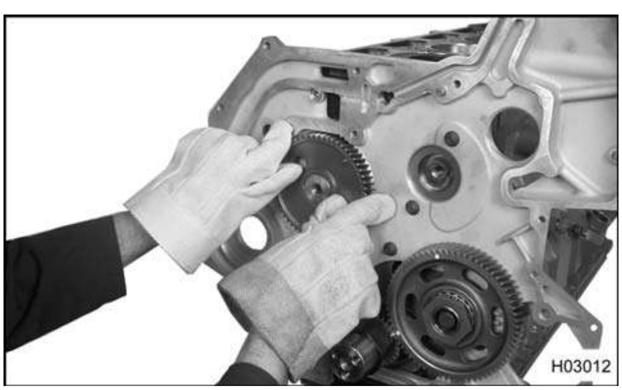


Figure 385 Installing cam gear on camshaft

3. Use heat resistant gloves to install the heated cam gear onto the camshaft. The cam gear should slide onto the camshaft with only slight hand pressure. Hold the cam gear (while thoroughly seated) until it cools onto the camshaft (approximately 30 seconds).

NOTE: Heated gear should easily slide onto camshaft. Do not tap into place to avoid camshaft end play issues. If gear does not slide easily, reheat gear and try again.

Checking Camshaft End Play

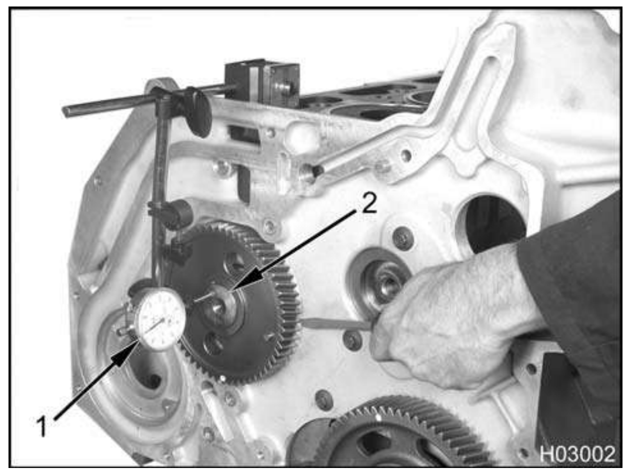


Figure 386 Checking camshaft end play

1. Dial indicator set
2. Camshaft

1. Mount magnetic base of a dial indicator set (Table 40) on a flat engine surface.
2. Place the tip of the dial indicator on the end of the camshaft and zero the dial indicator.
3. Use a screwdriver to pry the camshaft gear back and forth. Record the reading on the dial indicator.

   If the end play exceeds the specification, remove the cam gear and pull the camshaft forward. Repeat the procedure.

Crankshaft Assembly

1. Rotate the engine so the main bearing saddles are facing up. Clean the bearing saddles with a lint-free cloth. The supports must be free of oil. Do not lubricate the back side of the bearing inserts.

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

2. With gears removed, heat the crankshaft gear and oil pump drive spline, using a hot plate (Table 40), to 188-202 °C (370-395 °F).
3. Position the slotted locating pin (5/32 x 5/16) onto the crankshaft.

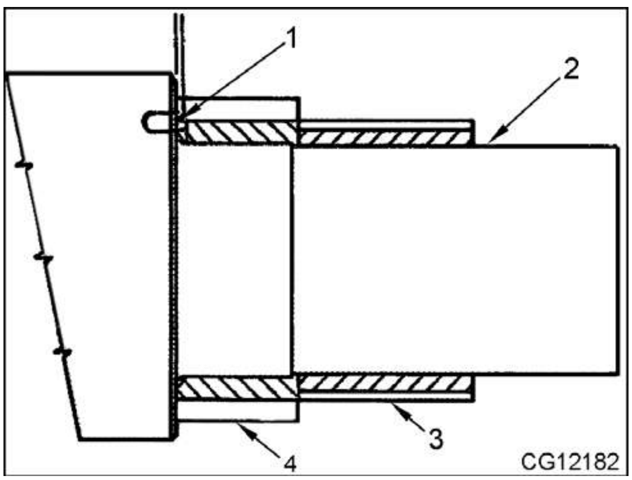


Figure 387 Installing crankshaft gear

1. Slotted pin, 5/32 x 5/16
2. Crankshaft
3. Oil pump drive spline
4. Crankshaft gear

4. Using gloves specifically designed for extremely hot objects, install heated crankshaft gear first, aligning the slotted pin with hole in crankshaft gear. Press the gear into place holding against crankshaft shoulder.
5. Slide the hot oil pump drive (splined) up against the crankshaft gear (no orientation required).
6. Hold oil pump drive and crankshaft gear in place until cool enough to sufficiently hold onto crankshaft.

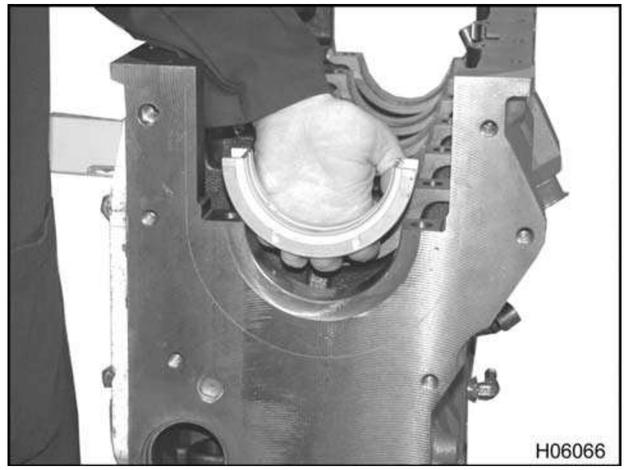


Figure 388 Installing the number seven thrust bearing

7. Install the thrust bearing into the number seven upper bearing saddle. Make sure the locking tangs on the bearings are snapped into the crankcase.
8. Install the remaining six upper bearing inserts into the saddles. Make sure the locking tangs on the bearings are snapped into the crankcase.
9. Apply Prussian Blue® to the crankshaft main bearing journals.

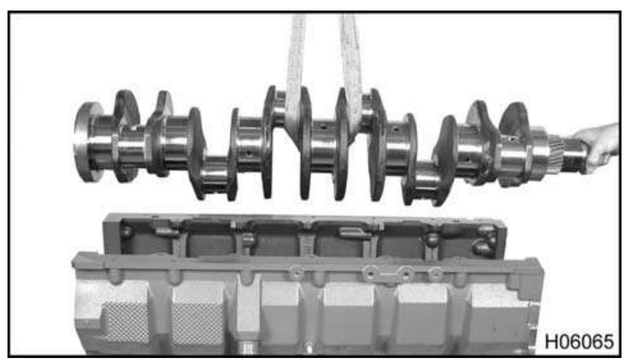


Figure 389 Installing the crankshaft assembly

10. Using an appropriate lifting sling, carefully lower the crankshaft onto the main bearing inserts in the crankcase.

NOTE: Do not install the main bearing caps and lower bearing inserts at this time.

11. Rotate the crankshaft 180 degrees (1/2 turn).

12. Carefully remove the crankshaft and inspect the upper bearing inserts for an even transfer of bluing agent from the journals to the bearings.

NOTE: If voids appear in the bluing transfer, crankcase integrity is considered questionable.

13. If the crankcase is not damaged and is free of distortion and burrs around upper bearing insert seats, then clean all Prussian Blue® from the bearings and crankshaft journals.

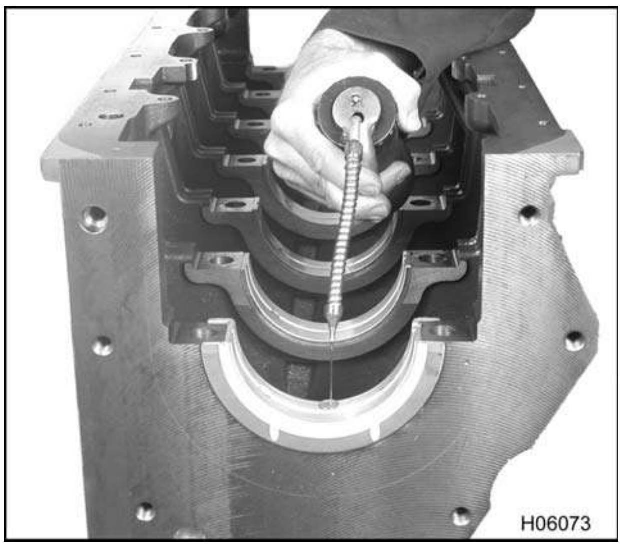


Figure 390 Lubricating the upper main bearing inserts

14. Lubricate the upper main bearing inserts with clean engine oil.

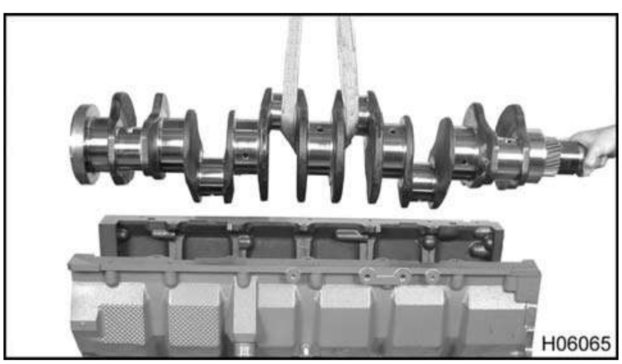


Figure 391 Installing the crankshaft assembly

15. Using an appropriate lifting sling, carefully lower the crankshaft onto the main bearings.

Bearing Fitting Procedure

1. Install a new bearing insert into the bearing cap, as required. The bearing surface of the bearing caps must be free of oil. Do not lubricate the backside of the bearing inserts. Make sure the locking tangs on the bearing inserts are snapped into the bearing cap notch.

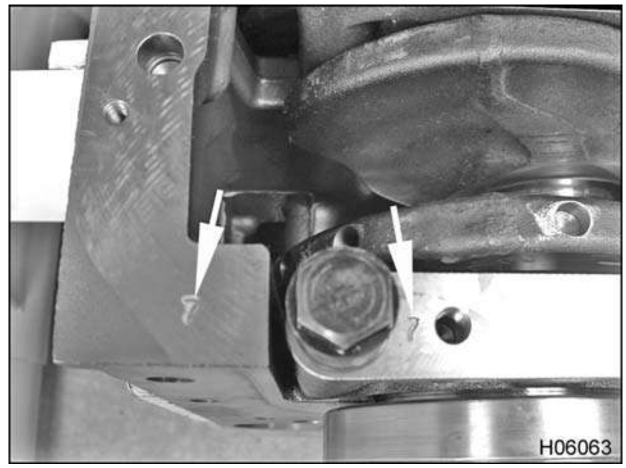


Figure 392 Main bearing cap identification stamps

2. Align each main bearing cap with its identification stamp.
3. Check bearing clearance as follows:
   a. Clean the bearing surface and the exposed half of the crankshaft journal. Make sure these surfaces are free of oil.
   b. Install the lower inserts and bearing caps. Oil the threads of new main bearing bolts with clean engine oil.
   c. Torque bolts in the following steps in a circular pattern.

   NOTE: This two step torque procedure to 177 N·m (130 lbf·ft), simply checks bearing fit and will not permanently stretch the new main bearing bolts. Do not follow the torque-to-yield procedure until final assembly.

   1. Tighten each main bearing bolt to 136 N·m (100 lbf·ft) using the recommended torque sequence (Figure 395).

2. Tighten each main bearing bolt to 177 N·m (130 lbf·ft) using the recommended torque sequence (Figure 395).

d. Remove one bearing cap and insert at a time. Leave the remaining caps tight while checking the fit of the bearing with the cap removed.

e. Wipe oil from all contact surfaces of the exposed journal, bearing insert and cap that is removed.

f. Place a piece of Plastigage® across the full width of the bearing surface on the crankshaft journal (or bearing insert) approximately 6 mm (¼ in) off center. Install the bearing cap and tighten the cap bolt to 177 N·m (130 lbf·ft).

NOTE: Do not turn the crankshaft.

NOTE: In chassis service only: When bearing oil clearance is checked, the crankshaft will have to be supported and held against the upper main bearing halves to get a correct Plastigage® reading. Use a jack at the crankshaft counterweight nearest to each main bearing being checked to apply local support. Failure to support the crankshaft will result in inaccurate readings.

g. Remove the bearing cap and insert.

h. Do not disturb the Plastigage®. Use the scale on the Plastigage® envelope to measure the widest point of the flattened Plastigage®. This reading indicates the bearing clearance in thousandths of an inch or millimeters.

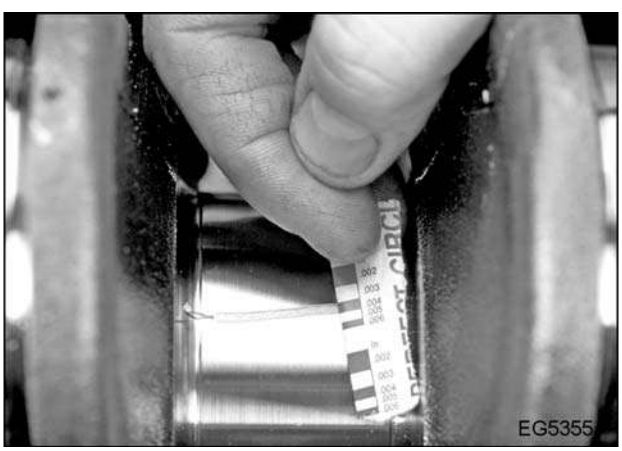


Figure 393 Measuring widest point of flattened Plastigage®

i. If the bearing clearance is not within specifications, the crankshaft must be replaced or reground and undersize bearings installed.

Main Bearings and Caps

CAUTION: To prevent engine damage, use new main bearing cap bolts whenever the bearing caps are serviced.

NOTE: The thrust bearing located at number 7 is found only in the upper half. All seven lower bearings share the same part number.

1. Clean the Plastigage® from main bearing and or crankshaft journal surfaces.
2. Coat all bearing surface journals with clean engine oil.
3. Apply clean engine oil to main bearing bolts (threads and under head).
4. Place the No. 1 through No. 7 main bearing caps with the lower bearing inserts installed.

NOTE: Make sure the main bearings are installed with the arrow pointing to the cam side and numbered from the front of the engine to the rear.

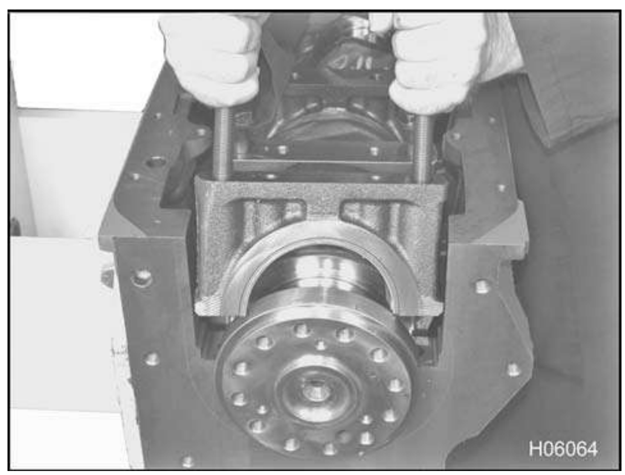


Figure 394 Installing the main bearing caps

5. Align and seat each of the main bearing caps.

Torque Procedure for Torque-to-Yield Main Bearing Bolts

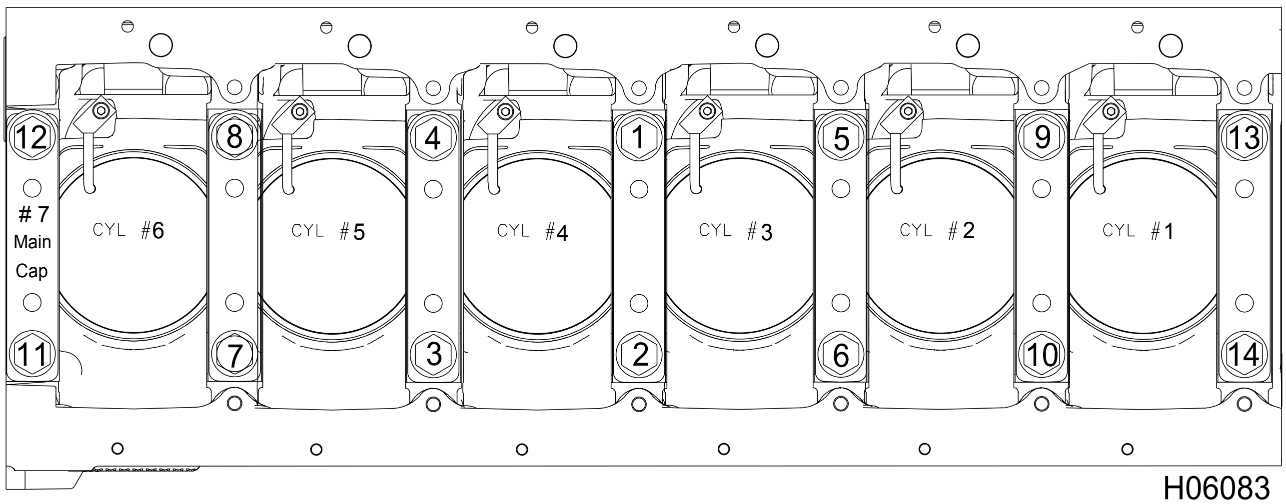


Figure 395 Recommended main bearing bolt torque sequence

1. Torque new bolts for main bearing caps 1 through 7.
   a. Tighten each main bearing bolt to 136 N·m (100 lbf·ft) using the recommended torque sequence.

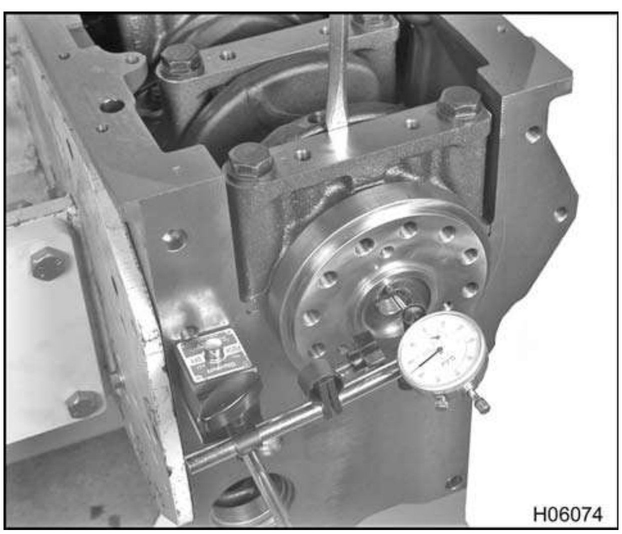


Figure 396 Checking crankshaft end play

Check crankshaft end play using a dial indicator as follows:

1. Mount the dial indicator onto crankcase with indicator tip on crankcase flange face.
2. Lightly pry the crankshaft forward and zero indicator.
3. Pry crankshaft rearward and record dial indicator reading. Repeat to ensure an accurate reading.
4. If end play exceeds specifications, replace thrust bearing and recheck crankshaft end play. If end play is less than specified, loosen the thrust bearing cap, reposition, torque and check end play again.

b. Tighten each main bearing bolt to 177 N·m (130 lbf·ft) using the recommended torque sequence.

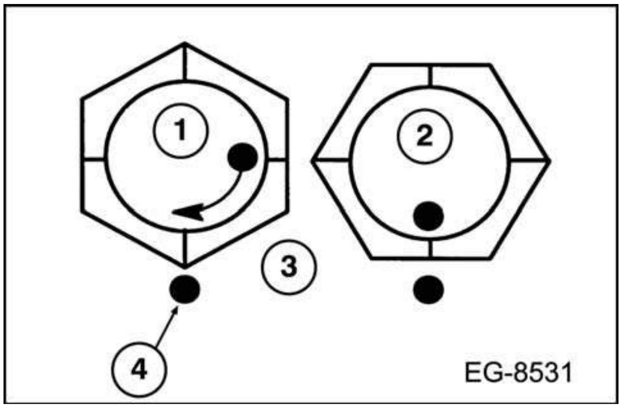


Figure 397 Crankshaft main bearing bolt

1. Head of bolt with mark, position 1
2. Head of bolt with mark, position 2 (bolt stretches)
3. Main cap surface
4. Mark (permanent marker)

c. Use a permanent marker to add a mark on each bolt head and another mark 90° clockwise on the main cap. Also mark the socket to match the bolt marking.

d. Rotate each crankshaft main bearing bolt (Figure 397) 90 degrees (1/4 turn).

Crankcase Ladder (DT 466 series – 225 hp and 245 hp @ 2600 rpm) and all 570 ratings

NOTE: The crankcase ladder is symmetrical; therefore, it does not matter which way it is installed.

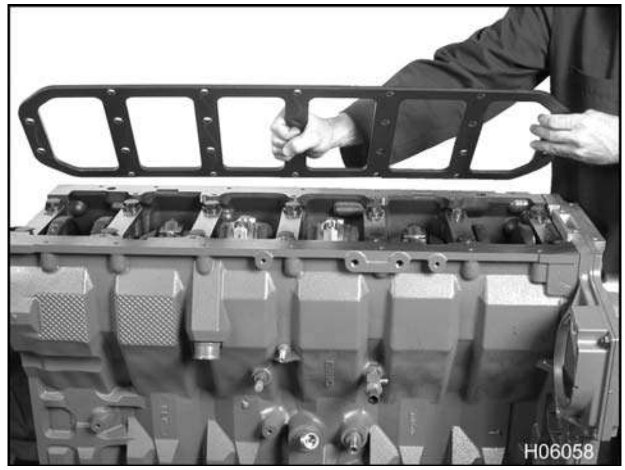


Figure 398 Installing the crankcase ladder

1. Install crankcase ladder onto crankcase.

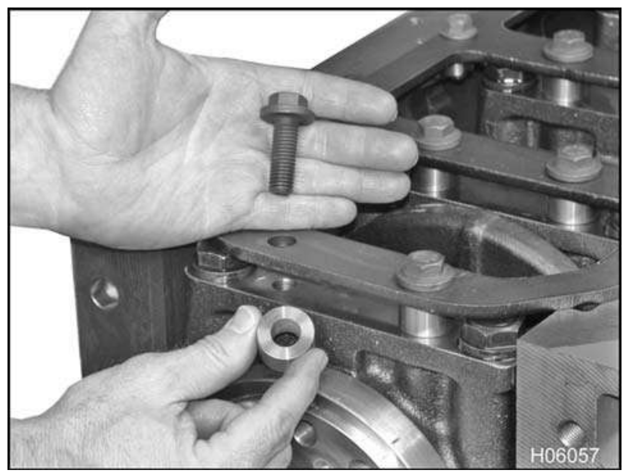


Figure 399 Crankcase ladder hardware

2. Install 14 crankcase ladder spacers and bolts (M12 x 35) to the 14 inboard bolt holes finger tight.
3. Install 10 crankcase ladder bolts (M10 x 25) to the 10 outboard bolt holes finger tight.

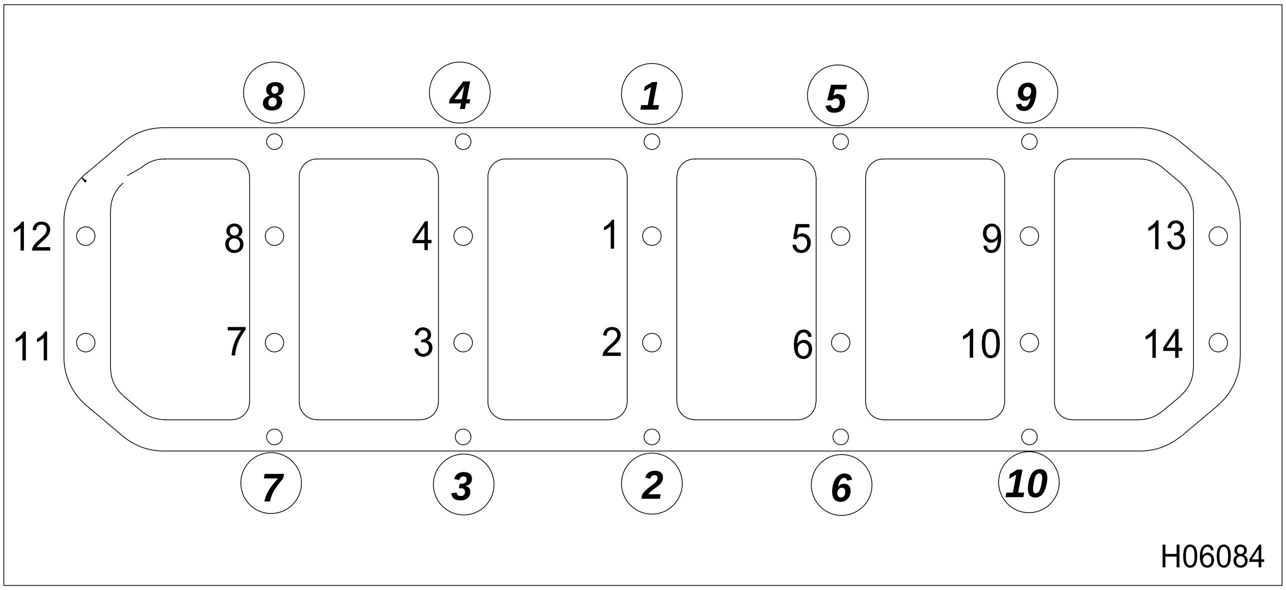


Figure 400 Recommended crankcase ladder torque sequence

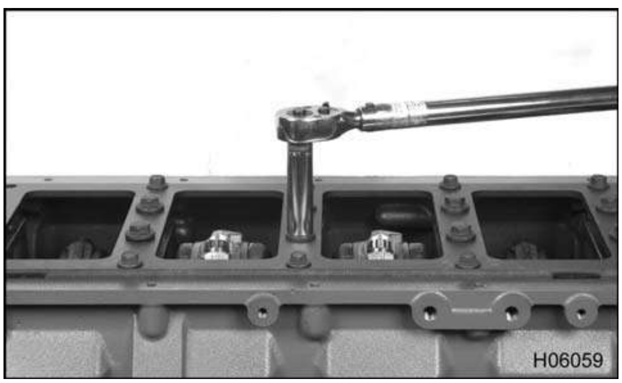


Figure 401 Torquing the crankcase ladder bolts

4. Using the recommended crankcase ladder torque sequence, tighten the inboard bolts (M12 x 35) to the special torque value (Table 39).
5. Using the recommended crankcase ladder torque sequence, tighten the outboard bolts (M10 x 25) to the special torque value (Table 39). These bolts are indicated by the circled numbers in the above illustration.

Oil Level Gauge

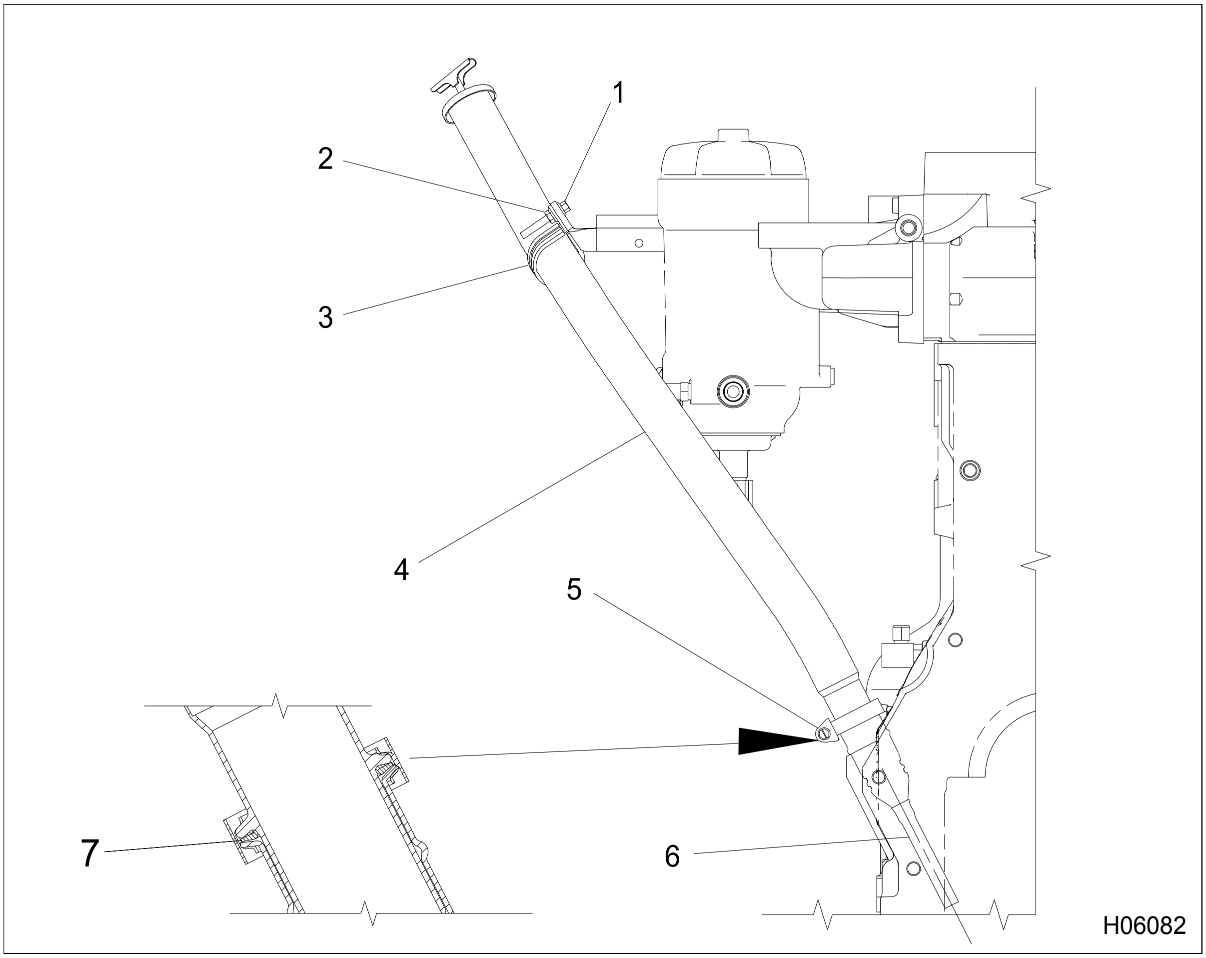


Figure 402 Oil level gauge assembly

1. Bolt, M6 x 40
2. Nut, M6
3. Cushioned clamp
4. Oil filler tube
5. Tube clamp
6. Oil level gauge tube
7. Oil dipstick tube seal

1. If removed earlier, install the oil level gauge tube by first applying Loctite® #277 around entire circumference of tube and casting. Drive tube into crankcase until bead of tube is seated in chamfer of crankcase boss.
2. Install a new oil dipstick tube seal between oil filler tube and crankcase oil tube flange.
3. Install the tube clamp at the crankcase.
4. Install the oil filler tube bolt (M6 x 40) and nut (M6) at the fuel filter bracket.

Crankcase Ventilation System

1. If fitting assembly (M12) was leaking at the crankcase, replace O-ring. Tighten fitting to the standard torque value (General Torque Guidelines, page445) .

   CAUTION: To prevent engine damage, do not use any type of impact tools to seat the (M8 x 35) bolts. Using impact tools will cause thread damage.

2. Install a new O-ring onto breather assembly and push into valve cover grommet.

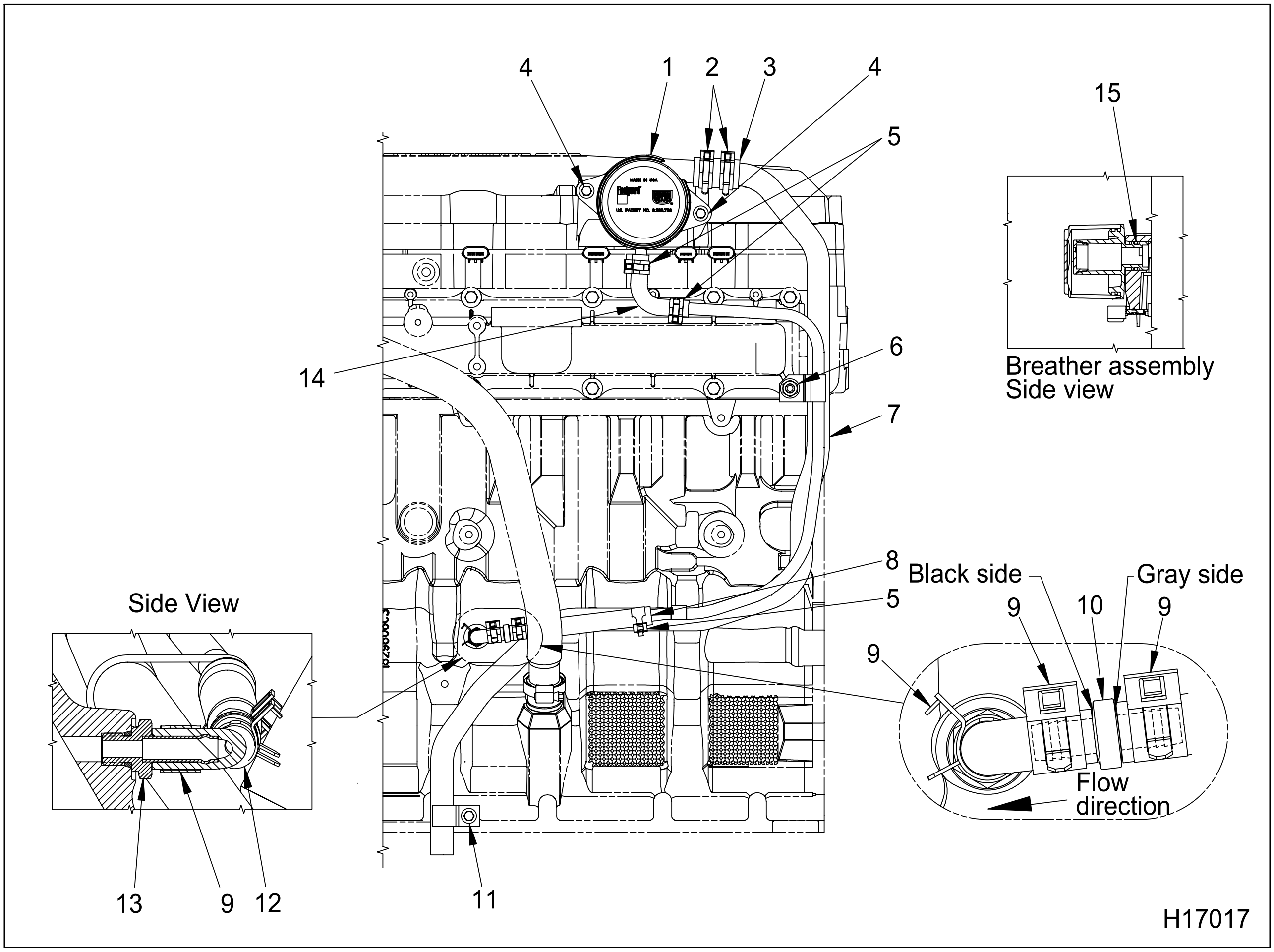


Figure 403 Crankcase ventilation

1. Breather assembly
2. Clamp, (1 in) diameter (2)
3. Hose, (1 in) I.D.
4. Bolt, M8 x 35 (2)
5. Clamp, 1/2 in diameter (3)
6. Nut, M10
7. Vent and drain tube assembly
8. Reducer hose
9. Clamp (3)
10. Check valve
11. Bolt, M8 x 16
12. Rubber elbow
13. Fitting assembly, M12
14. Drain hose elbow
15. O-ring, #214

3. Position drain hose elbow and one inch hose onto breather assembly. Secure with clamps, see illustration.
4. Place appropriate hose clamps onto vent and drain tube assembly. Position vent and drain tube assembly into breather assembly hoses.
5. Align vent and drain tubing assembly bracket with intake manifold stud. Thread nut (M10) onto stud finger tight.
6. Attach bottom of vent tubing to crankcase and secure with bolt (M8 x 16).
7. Combine rubber elbow, clamps, check valve, and reducer hose, making sure check valve is oriented correctly. Connect to drain side of tubing and clamp.
8. Tighten all hardware to the standard torque value (General Torque Guidelines, page445) and move clamps into their sealing positions.

Specifications

Table 37 Crankshaft Specifications

Type	Steel forged, induction hardened, grindable
Main Bearing journal diameter	
Standard size	107.95 ± 0.015 mm (4.250 ± 0.0006 in)
0.254 mm (0.010 in) undersized	107.70 ± 0.015 mm (4.240 ± 0.0006 in)
0.508 mm (0.020 in) undersized	107.44 ± 0.0152 mm (4.230 ± 0.0006 in)
0.762 mm (0.030 in) undersized	107.19 ± 0.0152 mm (4.220 ± 0.0006 in)
Damper mounting area runout (maximum)	0.03 mm (0.001 in)
Flywheel mounting surface runout (maximum)	0.05 mm (0.002 in)
Main bearing journal maximum out-of-round	0.05 mm (0.002 in)
Main bearing journal taper (maximum per inch)	0.071 mm (0.0028 in)
Main bearing thrust face runout (TIR maximum)	0.03 mm (0.001 in)
Main bearing width (except rear thrust)	34.19 ± 0.13 mm (1.346 ± 0.005 in)
Number of main bearings	7
Rear oil seal journal runout (maximum)	0.08 mm (0.003 in)
Thrust taken by	No. 7 rear upper main bearing
Thrust bearing journal length	34.404 ± 0.038 mm (1.3545 ± 0.0015 in)
Connecting rod journal diameter	
Standard Size	80.0 ± 0.0152 mm (3.1500 ± 0.0006 in)
0.0254 mm (0.010 in) undersized	79.7 ± 0.0152 mm (3.1400 ± 0.0006 in)
0.508 mm (0.020 in) undersized	79.5 ± 0.0152 mm (3.1300 ± 0.0006 in)
0.762 mm (0.030 in) undersized	79.2 ± 0.0152 mm (3.1200 ± 0.0006 in)
Center line of main bearing bore to head deck	368.3 ± 0.05 mm (14.50 ± 0.002 in)
Connecting rod bearing to crankshaft running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod bearing width	40.01 mm (1.575 in)
Connecting rod journal maximum out-of-round	0.0064 mm (0.00025 in)
Connecting rod journal taper (maximum per inch)	0.0069 mm (0.00027 in)
Crankshaft end play	0.15-0.31 mm (0.006 - 0.012 in)
Crankshaft end play maximum wear limit	0.51 mm (0.020 in)
Crankshaft flange outside diameter	155.58 mm (6.125 in)
Crankshaft gear backlash	0.08-0.41 mm (0.003 - 0.016 in)
Main bearing to crankshaft running clearance	0.046 - 0.127 mm (0.0018 - 0.0050 in)
Connecting rod to crankshaft side clearance	0.30 ± 0.11 mm (0.012 ± 0.005 in)
Standard size to 0.51 mm (0.020 in) undersized	34.404 ± 0.03 mm (1.3545 ± 0.010 in)

Table 38 Crankcase Specifications

Cap attachment	2 bolts per cap
Coolant heater rating	1250 W, 120 V
Counterbore depth in crankcase	8.865 ± 0.025 at 132 mm (0.349 ± 0.001 at 5.189 in)
Crankcase deck flatness	0.08 mm (0.003 in)
Crankcase main bearing bore diameter	116.421 ± 0.0127 mm (4.4583 ± 0.0005 in)
Cylinder sleeve counterbore maximum allowable depth	9.25 mm (0.364 in)
Main bearing type	Precision replaceable
Material	Steel-backed copper, lead, tin
Maximum allowable variation of counterbore depth (between four points)	0.025 mm (0.001 in)
Piston cooling tube dia. (spray hole) DT 466	1.91 - 2.06 mm (0.075 - 0.081 in)
Piston cooling tube dia. (spray hole) DT 570, HT 570	2.26 - 2.41 mm (0.089 - 0.095 in)
Roller tappet outside diameter	28.435 - 28.448 mm (1.1195 -1.1200 in)
Sleeve protrusion above crankcase	0.05 - 0.13 mm (0.002 - 0.005 in)
Tappet bore diameter	28.51 - 28.55 mm (1.123 - 1.124 in)
Thrust taken by	No. 7 rear upper main bearing
Camshaft	
Bushing I.D. (installed)	58.03 - 58.12 mm (2.285-2.288 in)
Cam lobe lift, exhaust	6.91 mm (0.272 in)
Cam lobe lift, intake	6.68 mm (0.263 in)
Camshaft end play	0.18 - 0.33 mm (0.007 - 0.013 in)
Camshaft journal diameter	57.95 - 58.98 mm (2.282 - 2.283 in)
Camshaft radial clearance	0.05 - 0.17 mm (0.002 - 0.007 in)
Maximum permissible cam lobe wear	0.25 mm (0.010 in)
Service bushings furnished to size	Yes
Thrust plate thickness (new)	6.96 - 7.01 mm (0.274 - 0.276 in)
Camshaft bushing bore diameter in crankcase	
Front	65.51 - 63.55 mm (2.501 - 2.502 in)
Intermediate front	63.01 - 63.04 mm (2.481 - 2.482 in)
Intermediate rear	63.01 - 63.04 mm (2.481 - 2.482 in)
Rear	65.51 - 63.55 mm (2.501 - 2.502 in)

Special Torque

Table 39 Crankcase, Crankshaft and Camshaft Special Torques

Camshaft thrust plate bolts	26 N·m (19 lbf·ft)
Crankcase ladder, M12 x 35	122 N·m (90 lbf·ft)
Coolant heater bolt	4.5 - 5.1 N·m (40 - 45 lbf·in)
Crankcase ladder, M10 x 25	63 N·m (46 lbf·ft)
Crankshaft main bearing cap bolt torque and sequence	(Torque Procedure for Torque-to-Yield Main Bearing Bolts, page271)

Special Service Tools

Table 40 Crankcase, Crankshaft and Camshaft Special Service Tools

Cam gear puller	ZTSE4411
Camshaft bushing puller	ZTSE2893B
Dial indicator set	Obtain locally
Hot plate	Obtain locally
Nylon brush	ZTSE4389
Plastigage®.	Obtain locally
Prussian Blue®	Obtain locally
Tap, cylinder head bolt holes	ZTSE4671
Tap set	ZTSE4386
Stiff nylon brush	ZTSE4392

Table of Contents

Component Exploded View

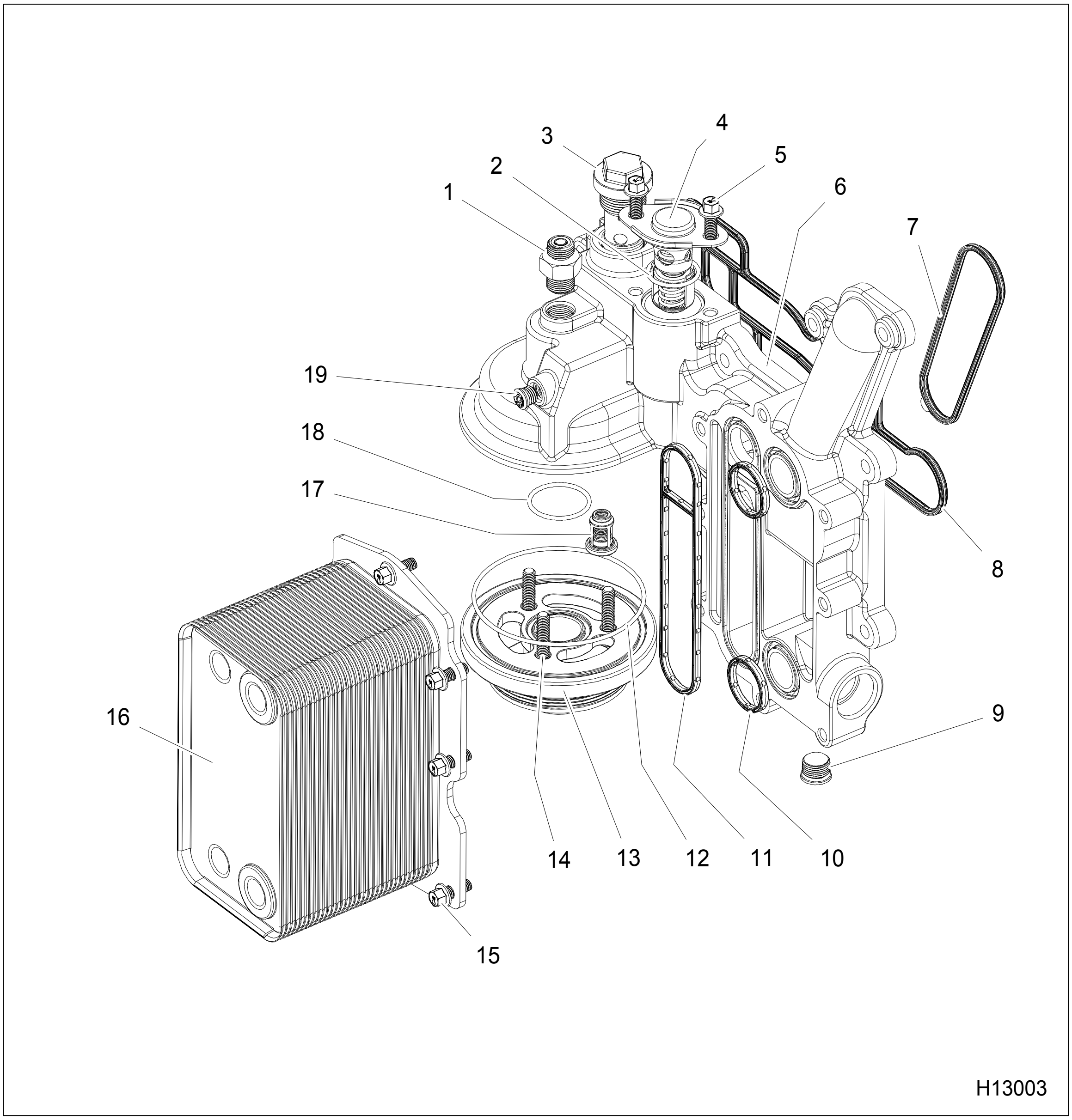


Figure 404 Oil system module assembly

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

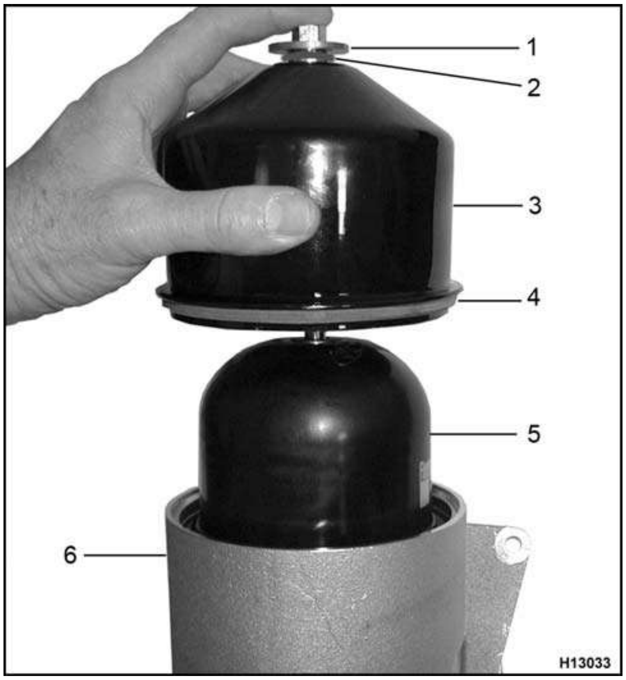


Figure 405 Secondary filter components

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

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.

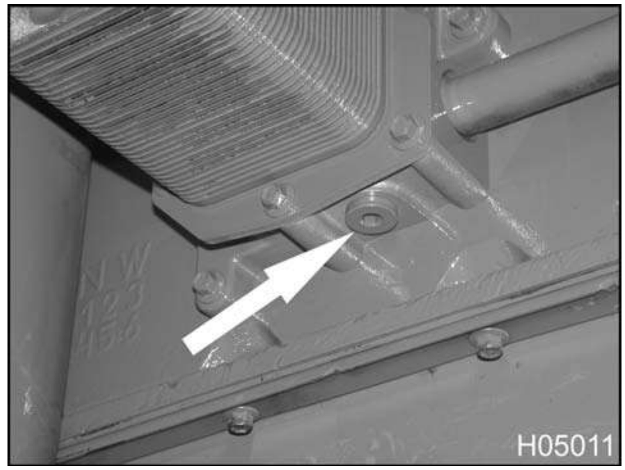


Figure 406 Coolant drain plug

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.

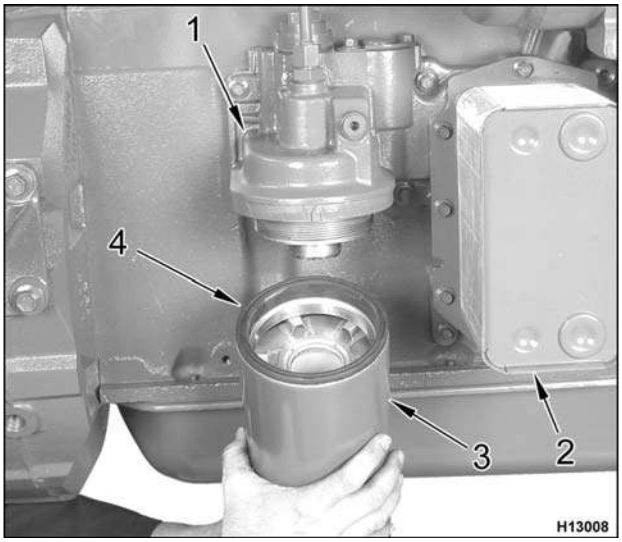


Figure 407 Removing the oil filter

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.

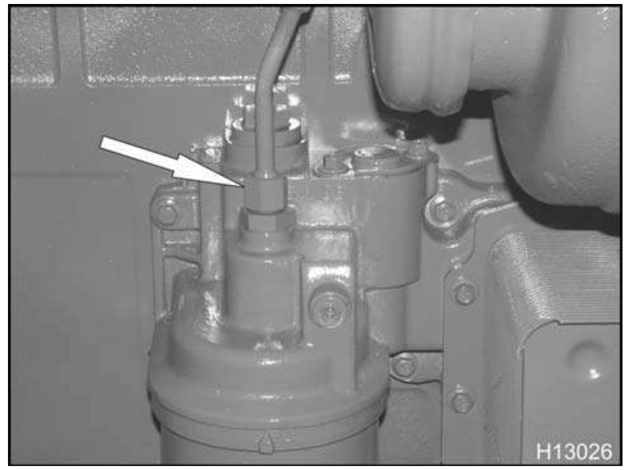


Figure 408 VGT oil supply tubing

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

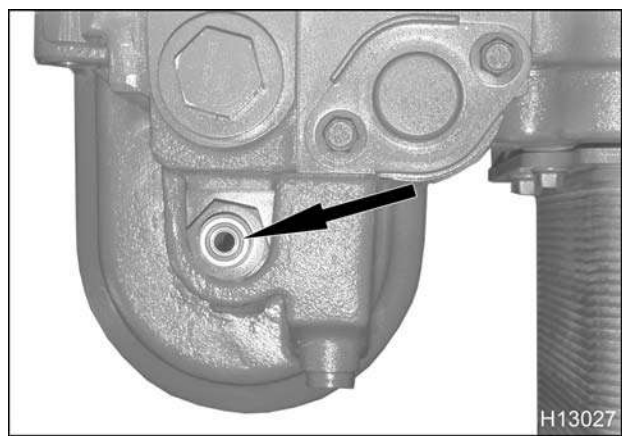


Figure 409 VGT oil supply tubing O-ring

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

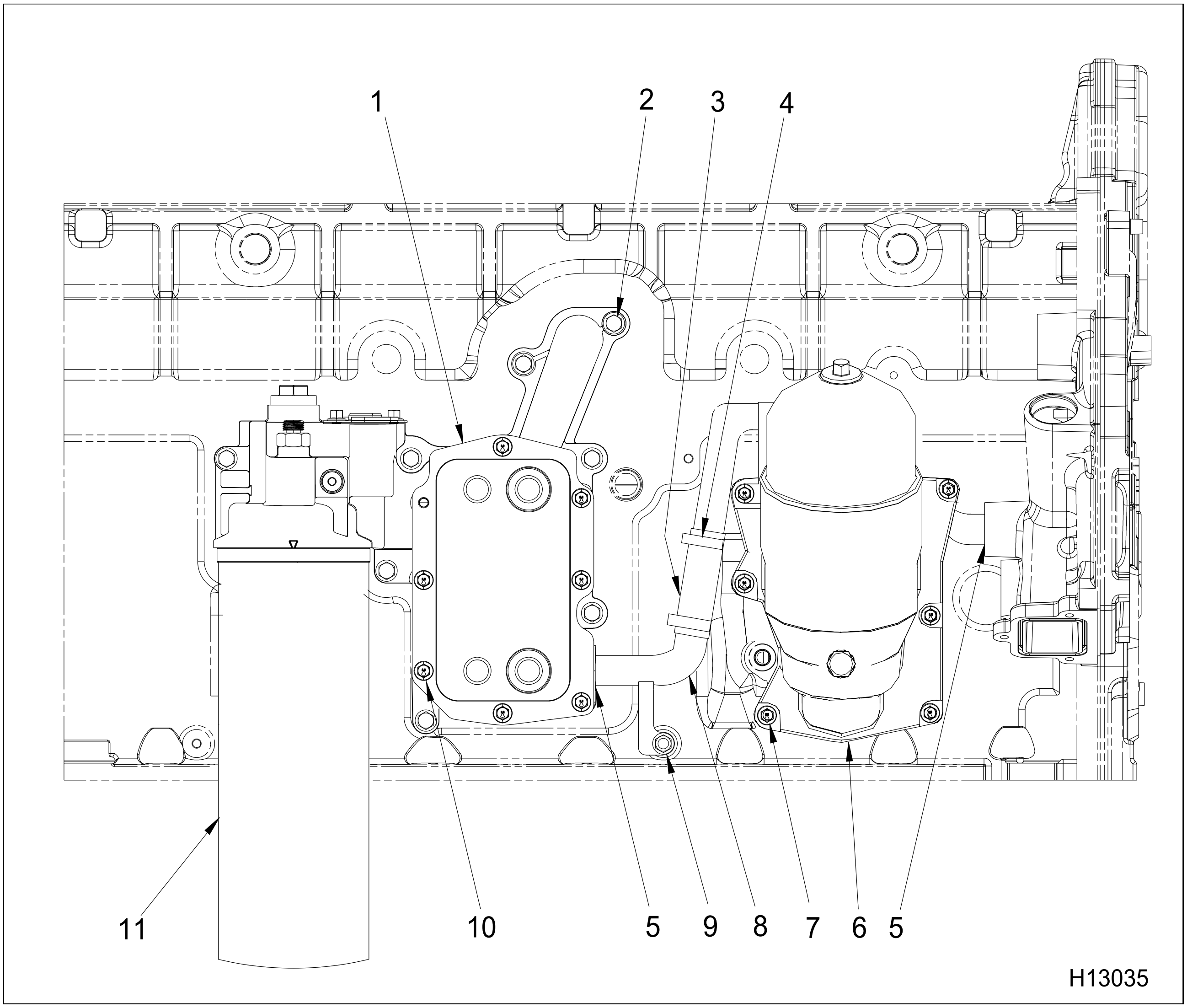


Figure 410 Oil system module and secondary filter assembly

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.

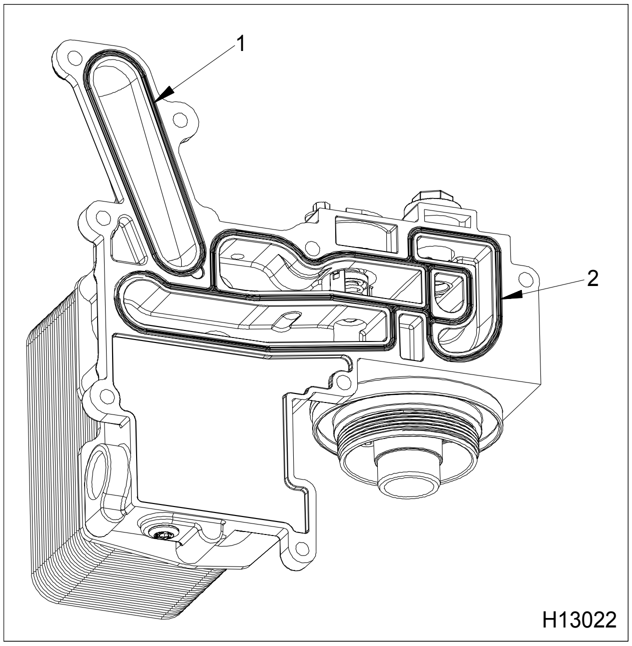


Figure 411 Oil and coolant seal locations

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.

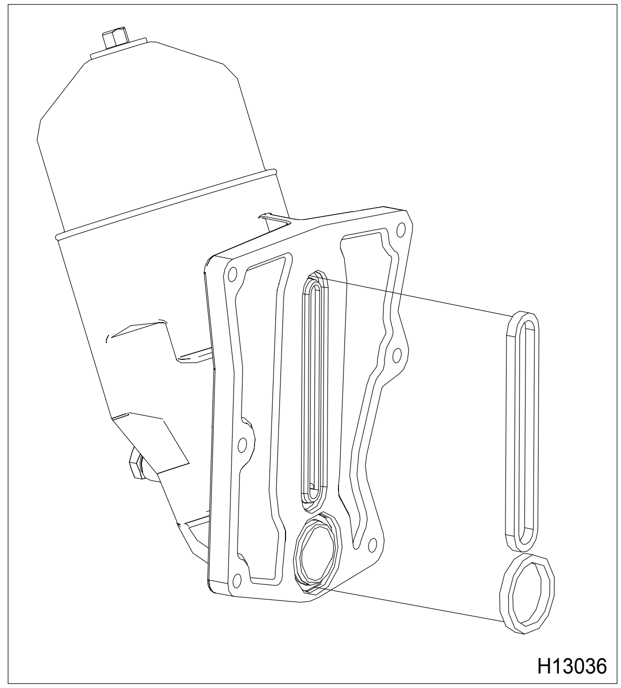


Figure 412 Secondary filtration gasket seals

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.

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.

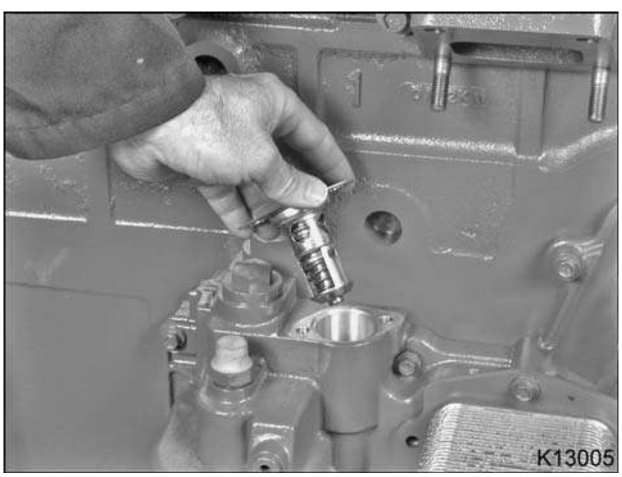


Figure 414 Removing the oil thermal valve

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

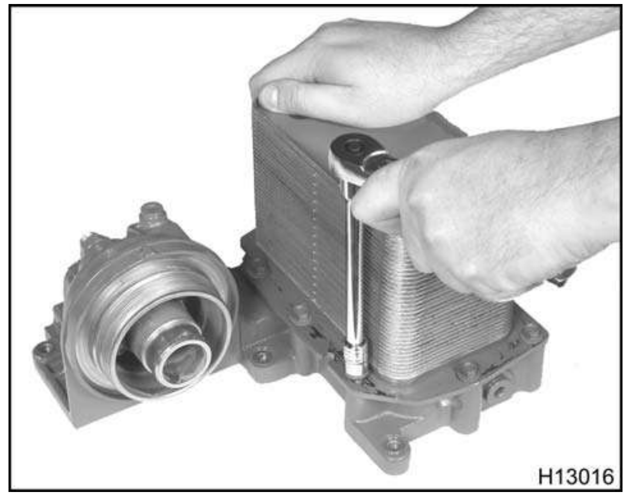


Figure 415 Separating cooler heat exchanger from oil cooler housing

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.

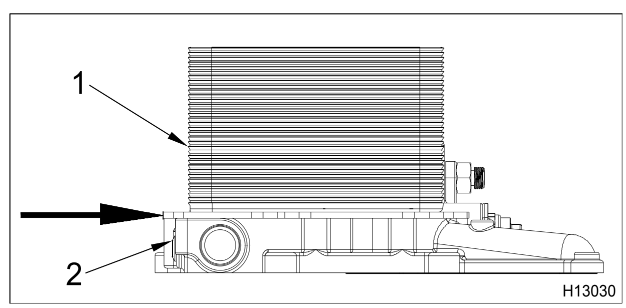


Figure 416 Separation of cooler heat exchanger from oil cooler housing base

1. Cooler heat exchanger
2. Oil cooler housing base

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.

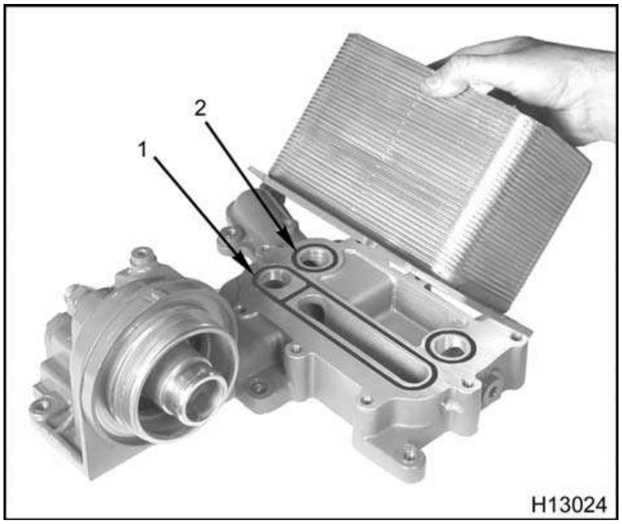


Figure 417 Oil and coolant seals

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.

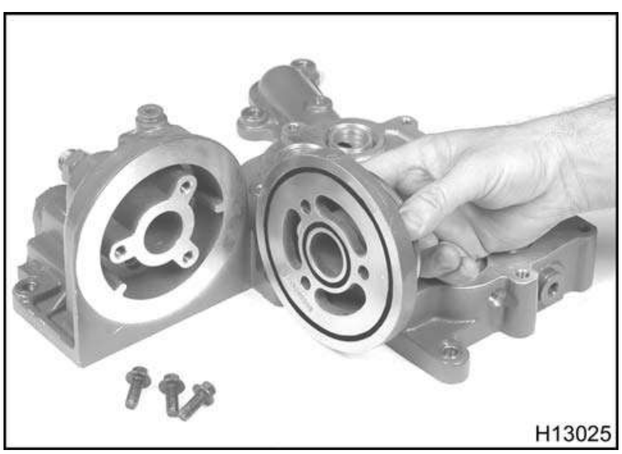


Figure 418 Lube adapter assembly and gaskets

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.

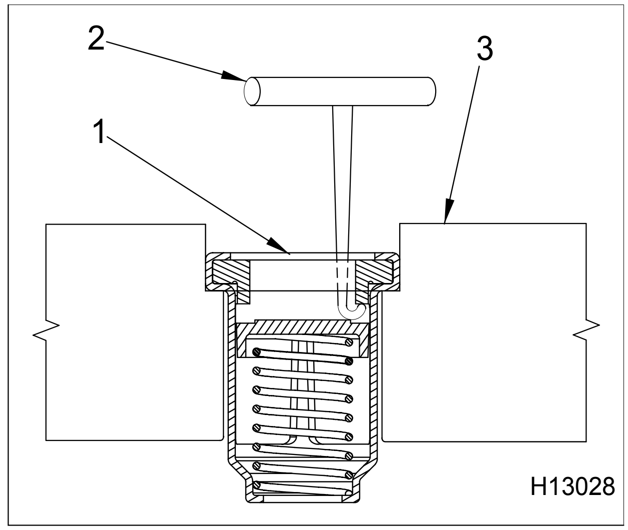


Figure 419 Removing the oil bypass valve

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.

Disassembling the Secondary Filtration Filter

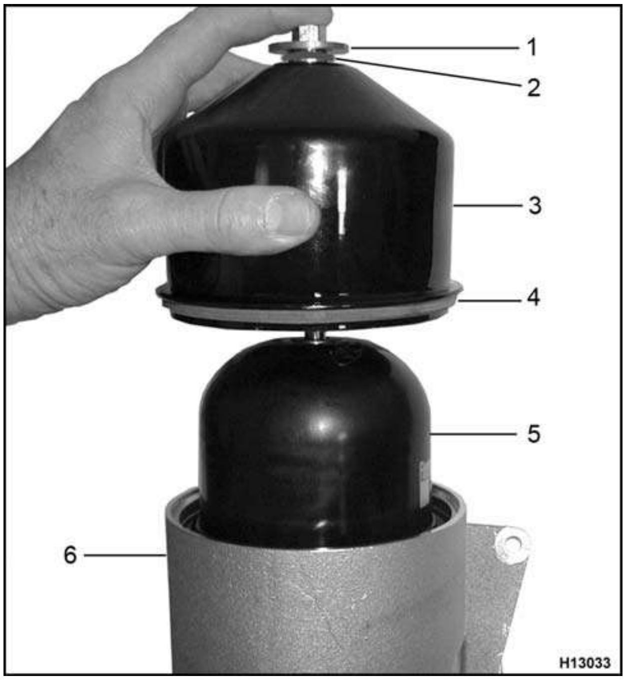


Figure 420 Secondary filter components

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.

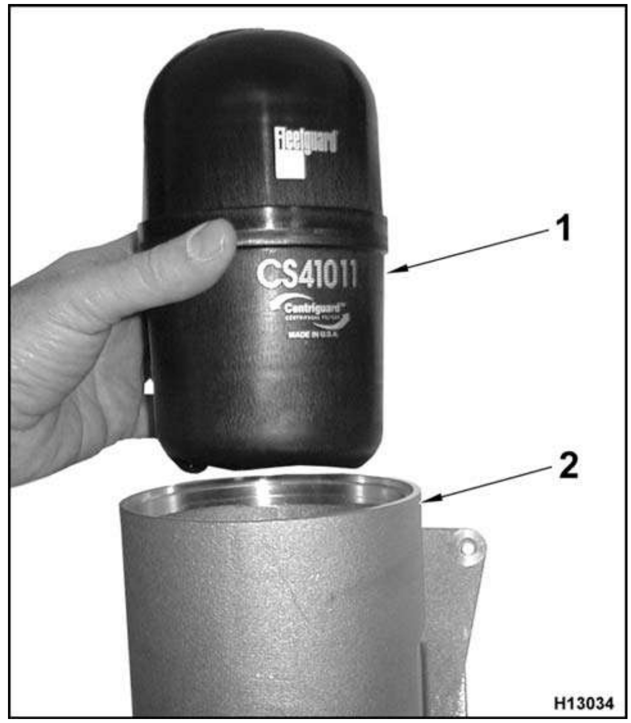


Figure 421 Secondary filter removed

1. Filter removed
2. Filter header

3. Lift out filter and dispose of properly.

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.

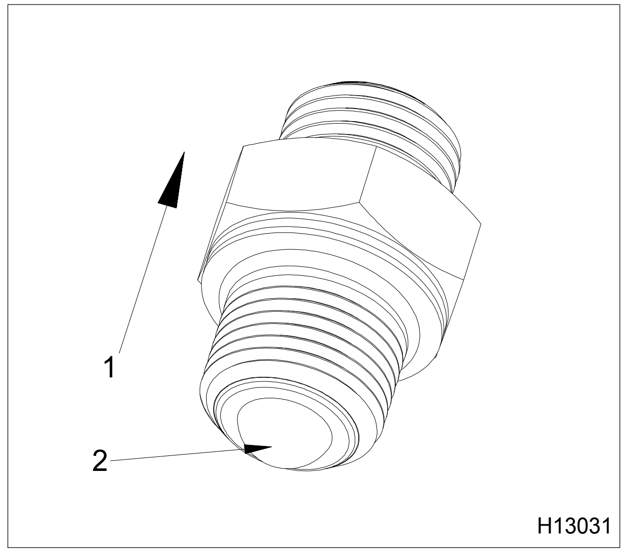


Figure 422 Oil supply tube fitting

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.

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.

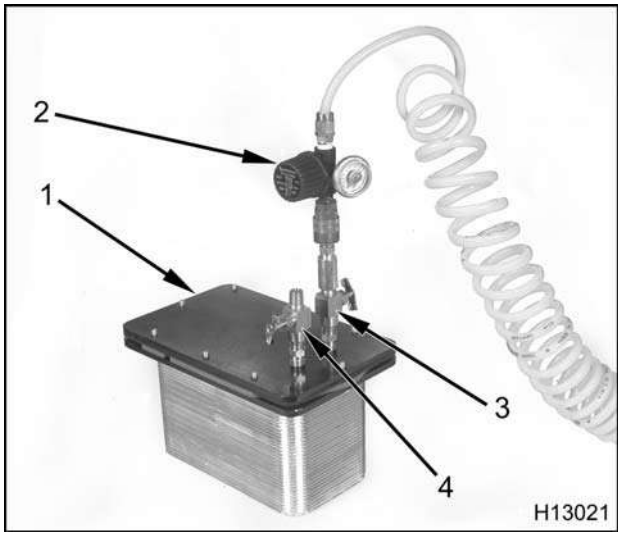


Figure 423 Checking cooler heat exchanger for external leakage

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.

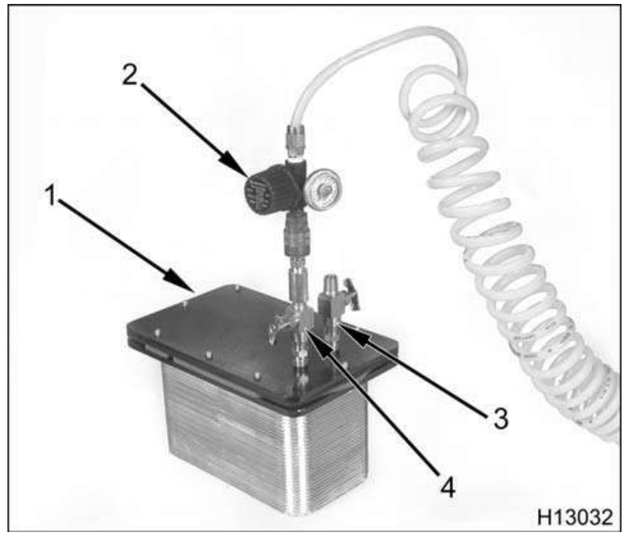


Figure 424 Checking cooler heat exchanger for external leakage

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.

Internal

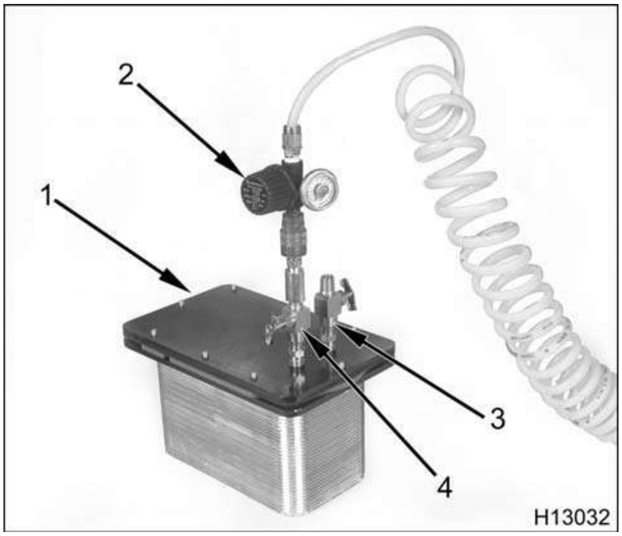


Figure 425 Checking cooler heat exchanger for internal leakage

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.

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.

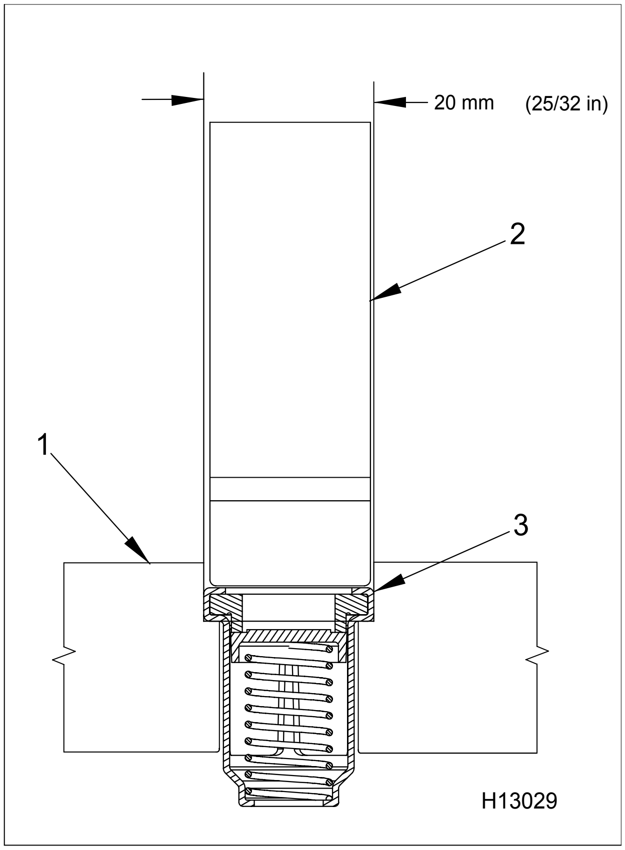


Figure 426 Installing the oil bypass valve

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.

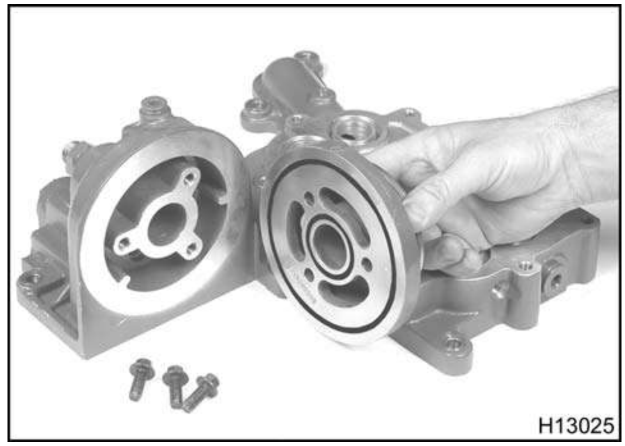


Figure 427 Lube adapter assembly and gaskets

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).

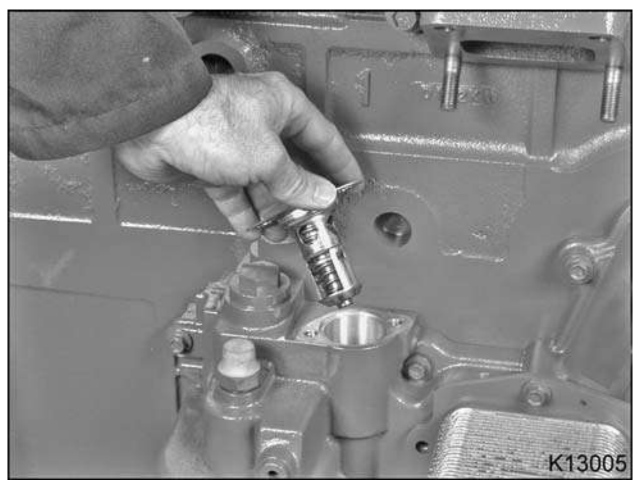


Figure 428 Installing the oil thermal valve

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.

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).

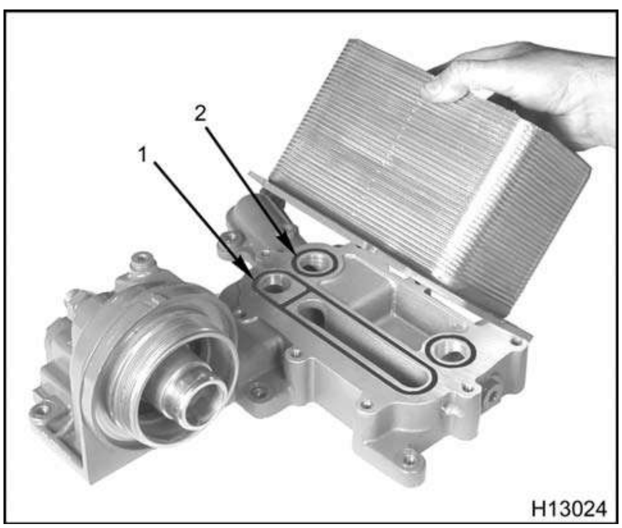


Figure 430 Oil and coolant seals

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.

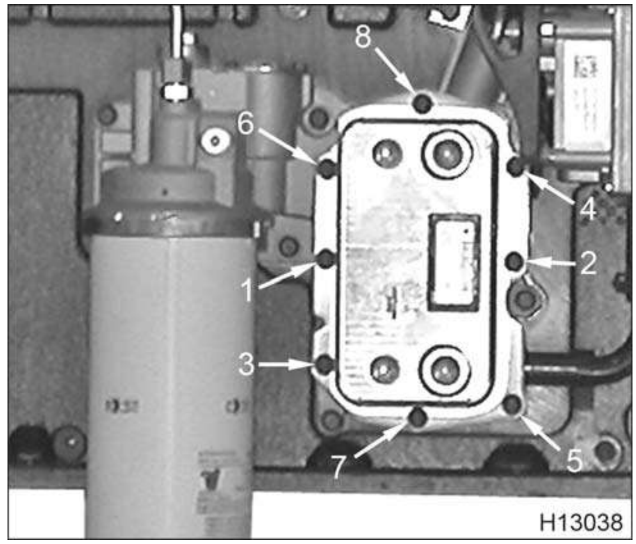


Figure 431 Bolt torque sequence for cooler heat exchanger

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.

Assembling the Secondary Filtration Filter

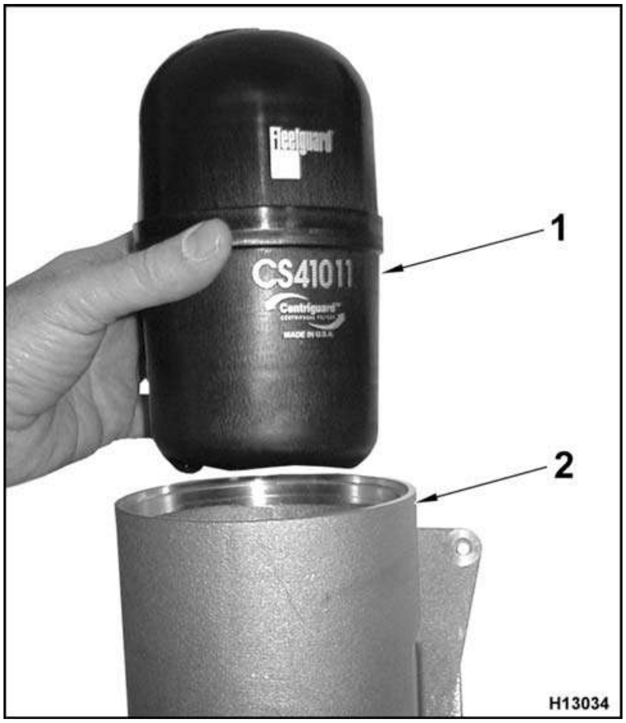


Figure 432 Secondary filter installation

1. Filter element
2. Filter header

1. Install a new secondary oil filter.

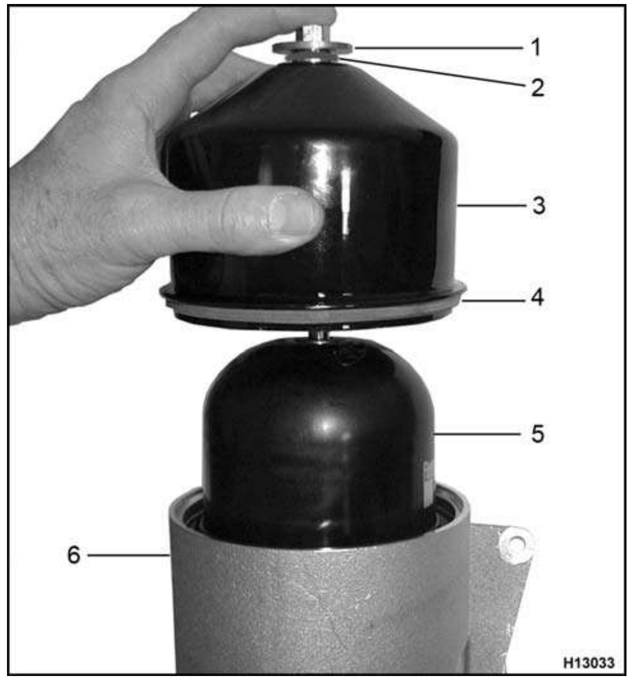


Figure 433 Secondary filter components

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).

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.

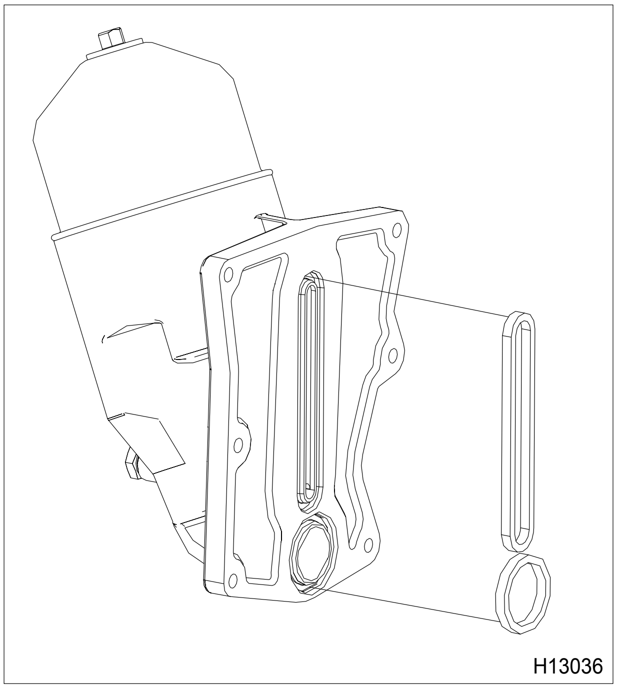


Figure 434 Secondary filtration gasket seals

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

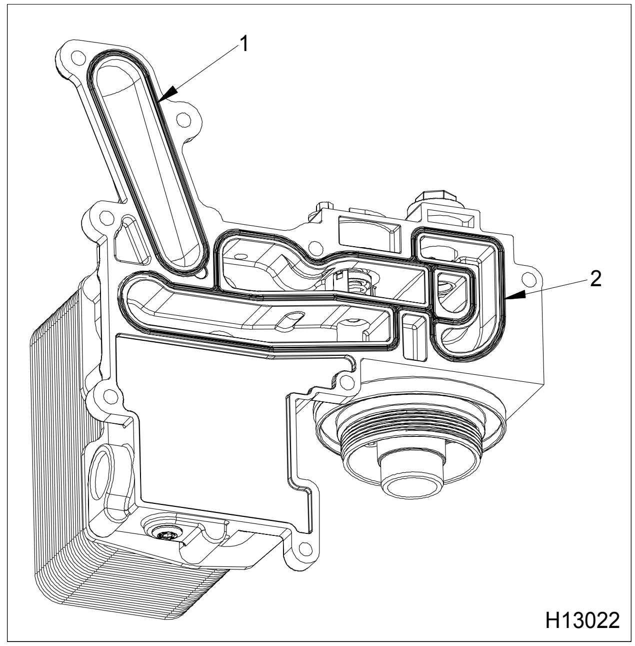


Figure 435 Oil and coolant seal locations

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).

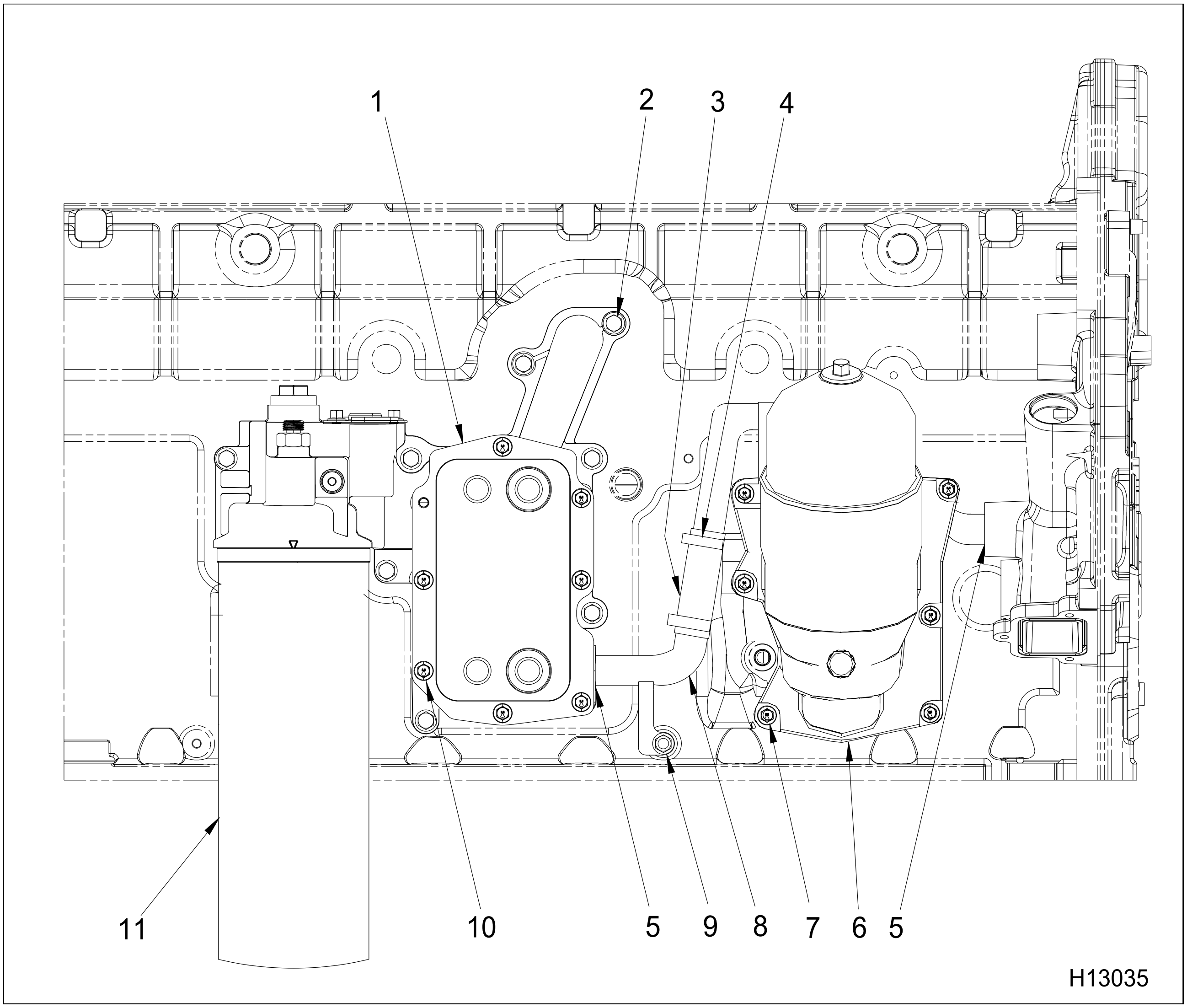


Figure 436 Oil system module and secondary filter assembly

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).

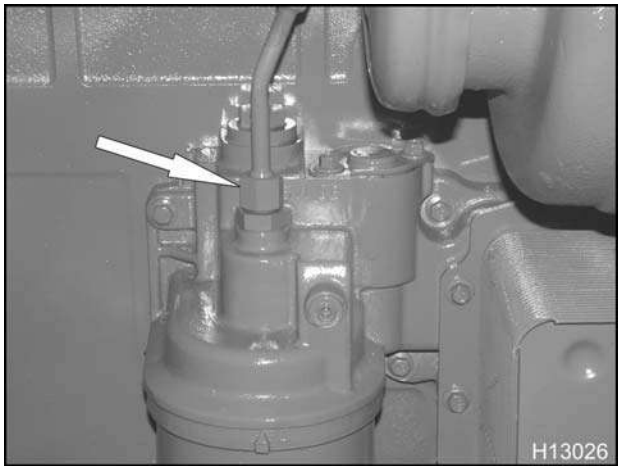


Figure 437 Installing oil supply tube

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.

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

Table of Contents

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.

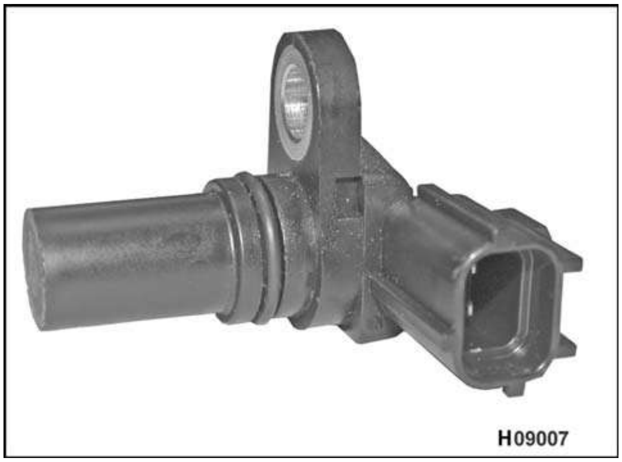


Figure 438 Camshaft Position (CMP) sensor

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.

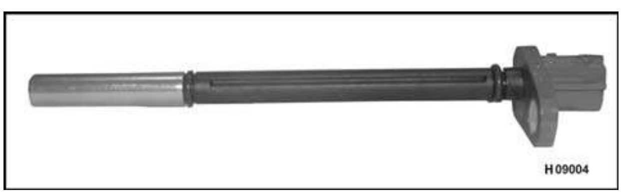


Figure 439 Crankshaft Position (CKP) sensor

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.

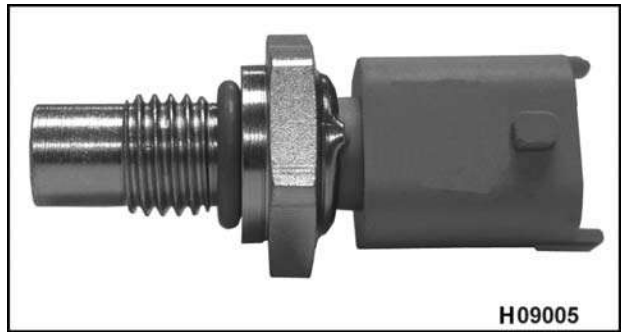


Figure 440 Engine Oil Temperature (EOT) sensor and Engine Coolant Temperature (ECT) sensor

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.

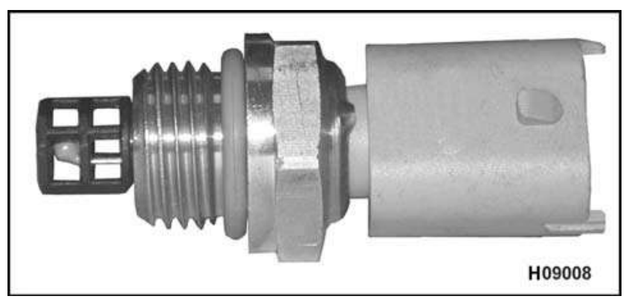


Figure 441 Manifold Absolute Temperature (MAT) sensor

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

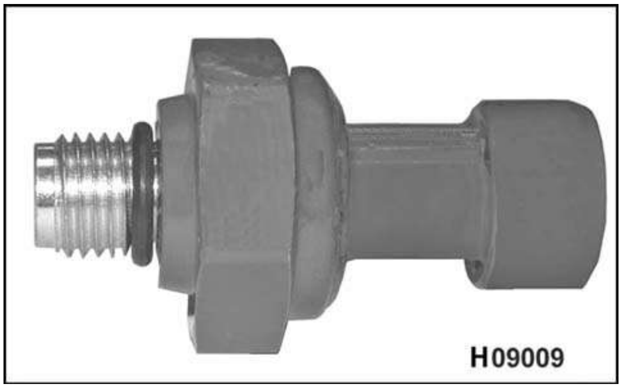


Figure 442 Engine Oil Pressure (EOP) sensor

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.

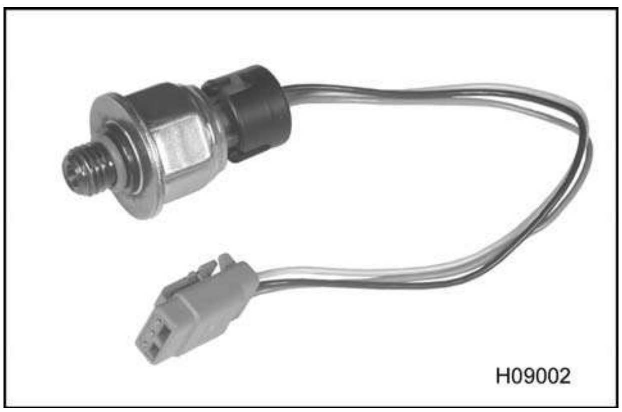


Figure 443 Injection Control Pressure (ICP) sensor

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.

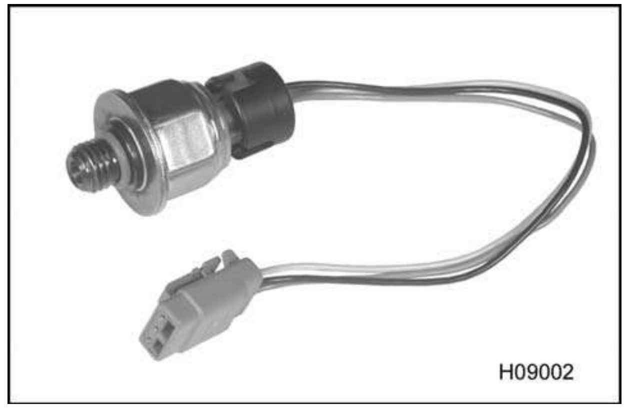


Figure 444 Brake Control Pressure (BCP) sensor

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.

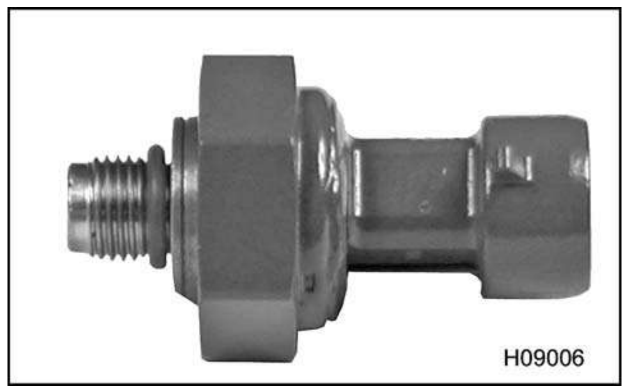


Figure 445 Engine Fuel Pressure (EFP) sensor

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

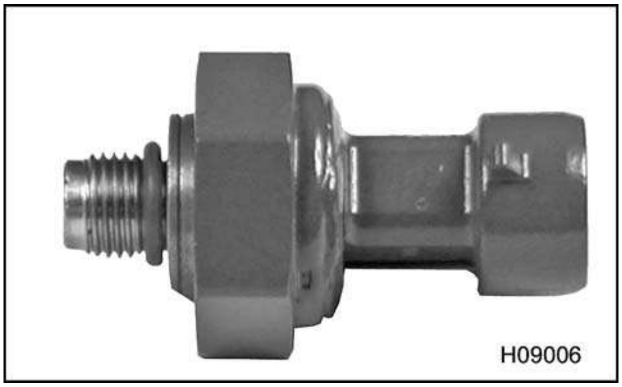


Figure 446 Manifold Absolute Pressure (MAP) sensor

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

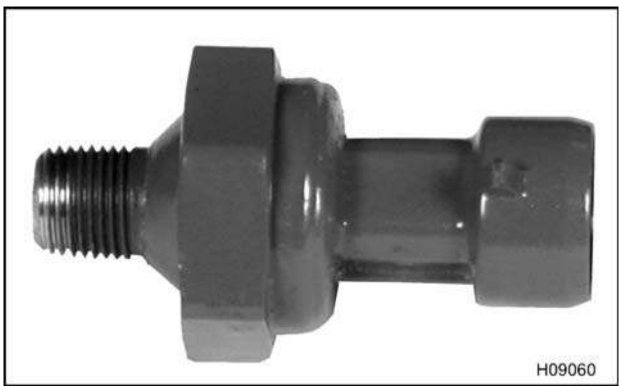


Figure 447 Exhaust Back Pressure (EBP) sensor

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).

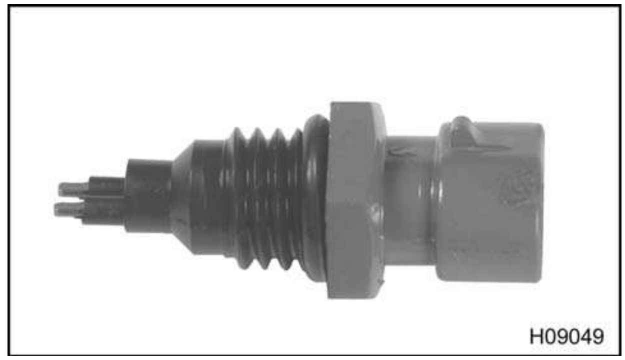


Figure 448 Water In Fuel (WIF) sensor

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

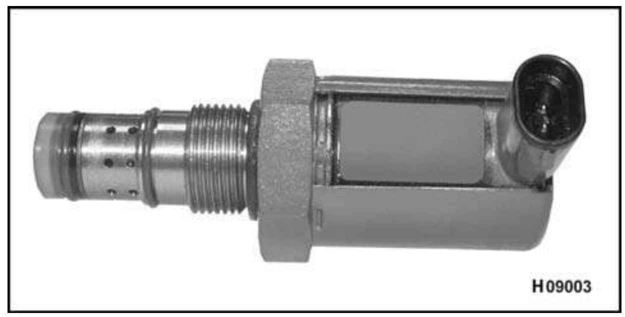


Figure 449 Injection Pressure Regulator (IPR) valve

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.

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

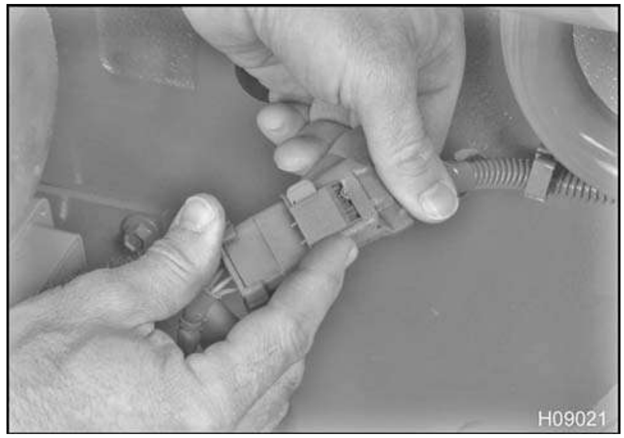


Figure 450 Disconnecting the VGT connector

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

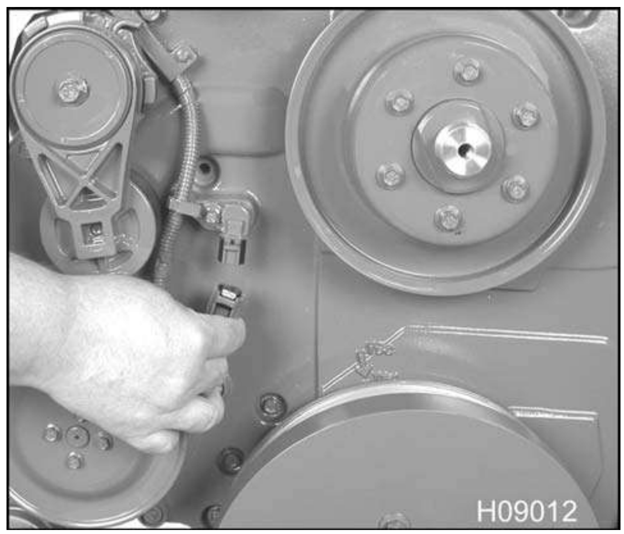


Figure 451 Disconnecting the CMP sensor

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

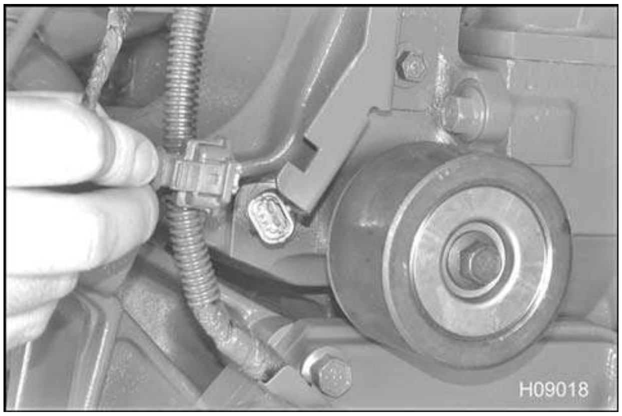


Figure 452 Disconnecting the ECT sensor

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

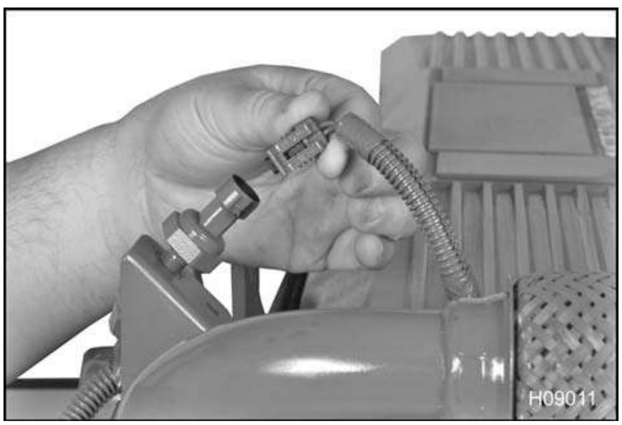


Figure 453 Disconnecting the EBP sensor

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

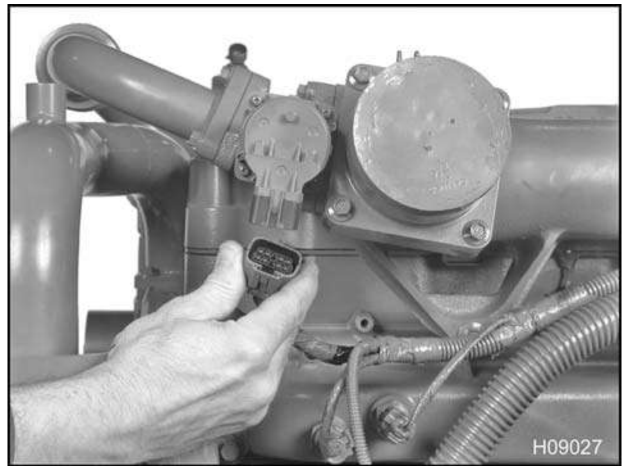


Figure 454 Disconnecting the EGR control valve connector

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

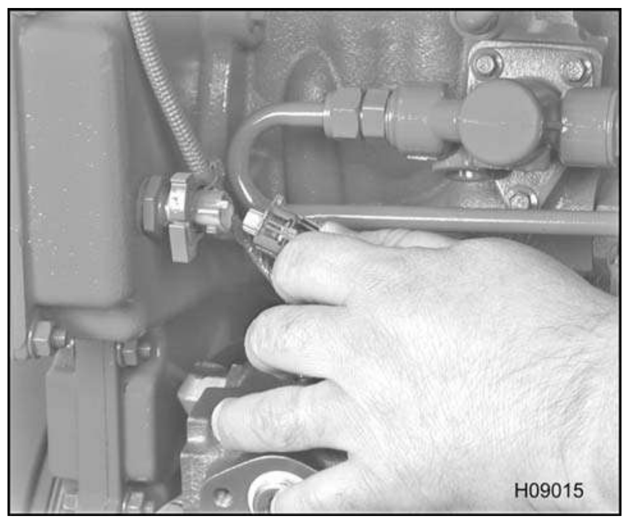


Figure 455 Disconnecting the EOT sensor

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

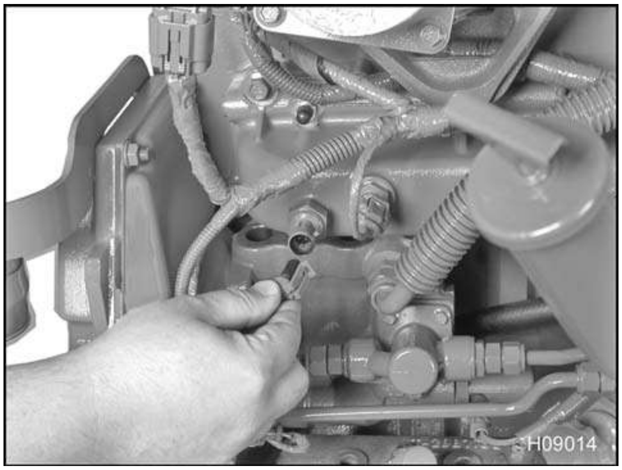


Figure 456 Disconnecting the MAP sensor

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.

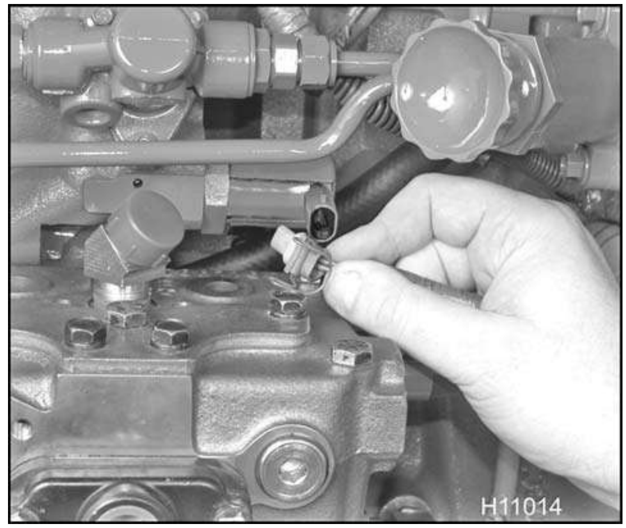


Figure 458 Disconnecting the IPR valve connector

9. Disconnect wiring harness connector from the IPR valve.

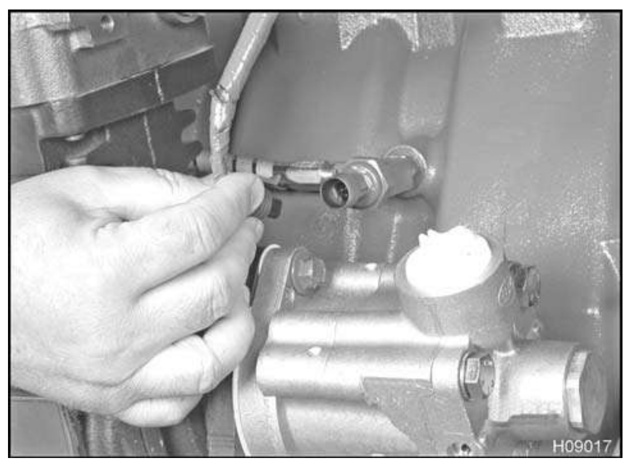


Figure 459 Disconnecting the EOP sensor

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

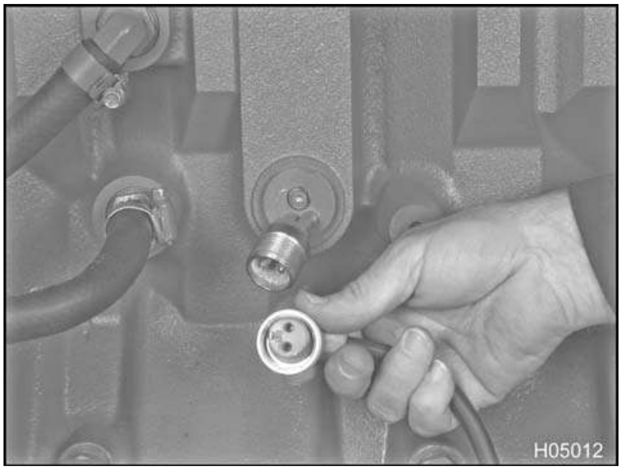


Figure 460 Disconnecting the block heater

11. Disconnect the block heater cable (optional).

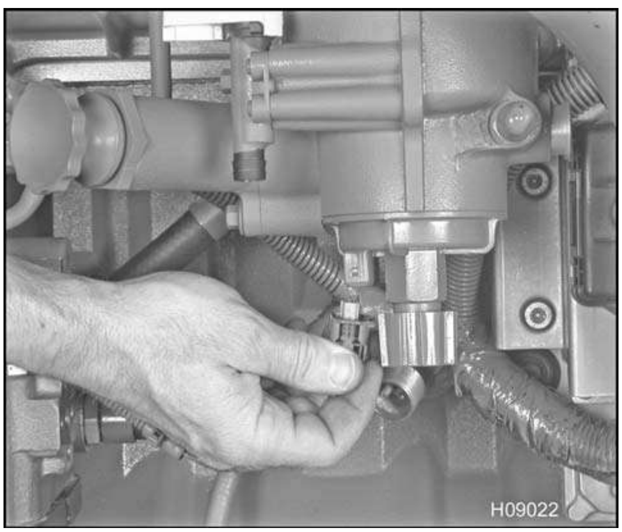


Figure 461 Disconnecting the fuel heater connector

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

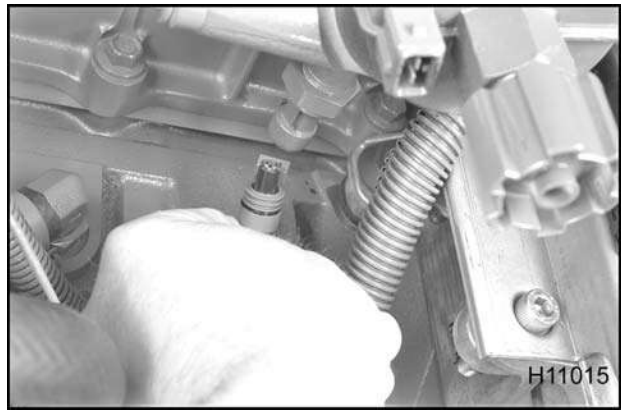


Figure 462 Disconnecting the fuel pressure sensor

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.

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).

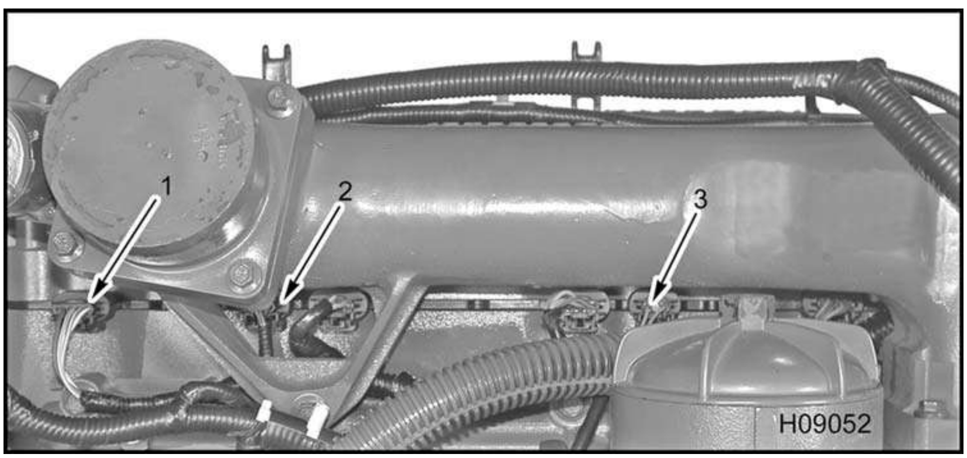


Figure 465 BCP, Brake shutoff valve, and injector locations

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.

Figure 466 12 wire engine connector

21. Disconnect one, 12 wire engine connector.

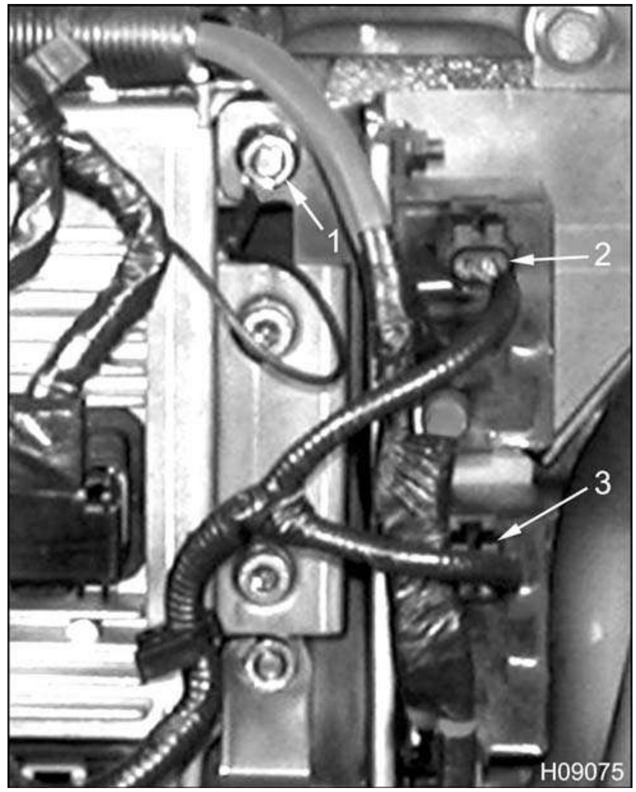


Figure 467 Intake air heater relay connectors (2)

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.

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.

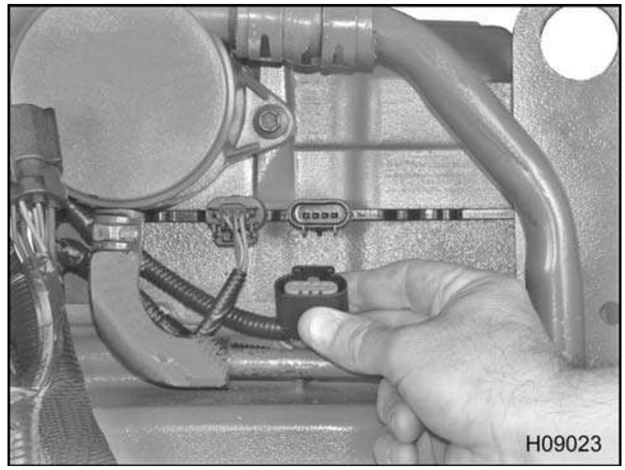


Figure 468 Disconnecting the No. 6 fuel injector connector

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.

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.

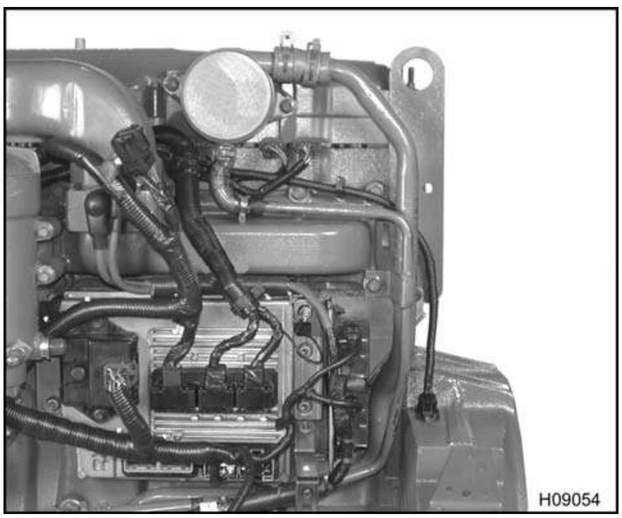


Figure 469 ECM, IDM, EGR drive module, and tube assembly overview

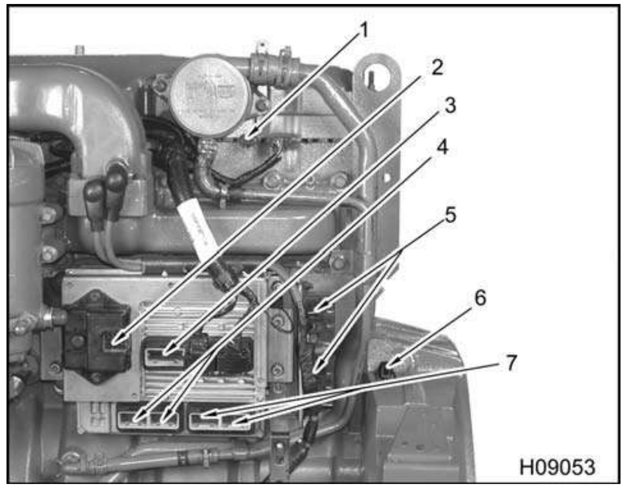


Figure 470 ECM and sensor harness locations

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.

Injector wiring harness at ECM and IDM drive modules

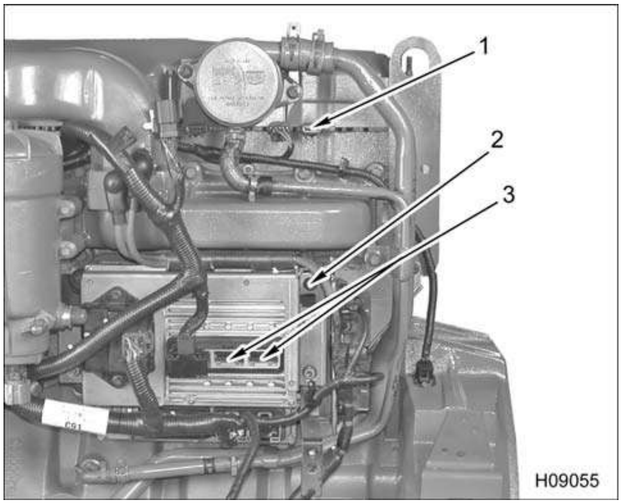


Figure 471 Injector harness locations

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.

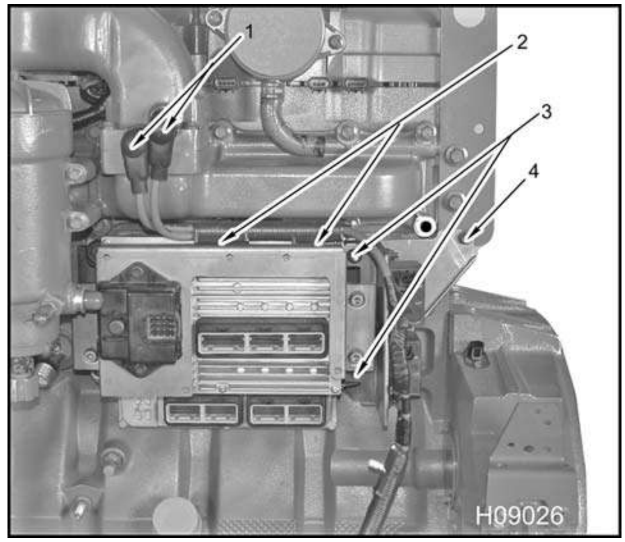


Figure 472 Intake air heater and relay wiring harness

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

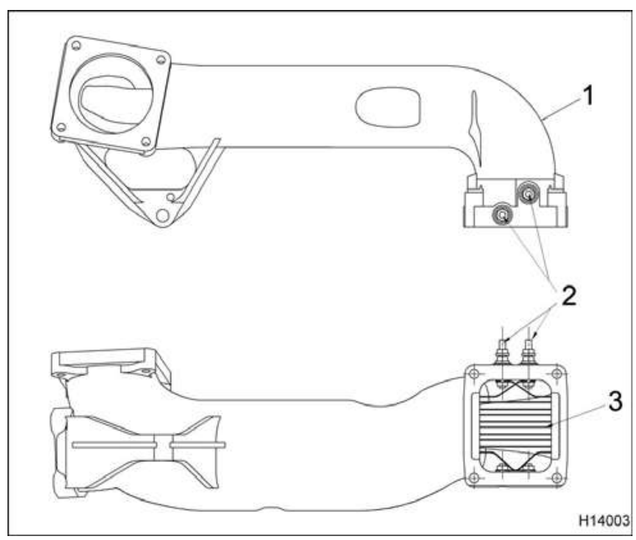


Figure 473 Intake air heater – dual element

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, page466).

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.

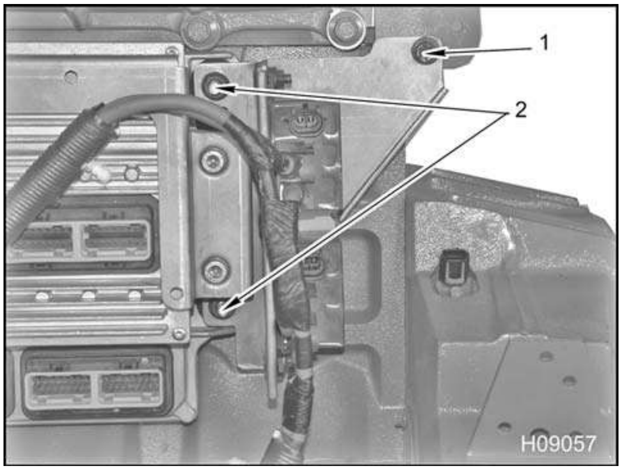


Figure 474 Intake air heater relay bracket

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.

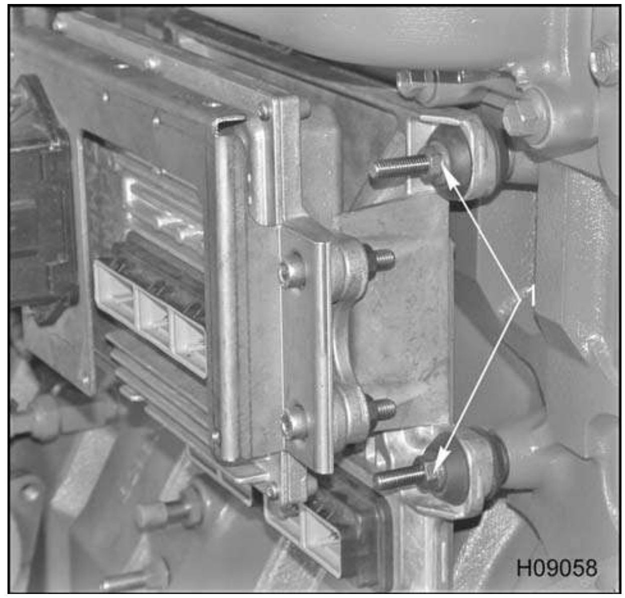


Figure 475 ECM, IDM, and EGR drive module assembly (side view)

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).

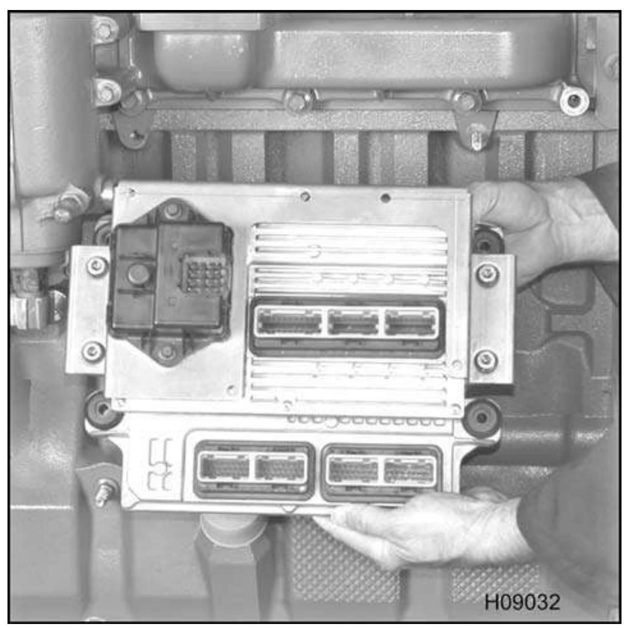


Figure 476 ECM, IDM, and EGR drive module assembly

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

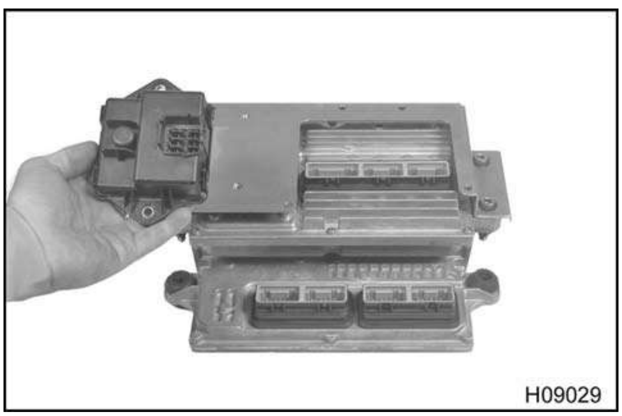


Figure 478 EGR drive module

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

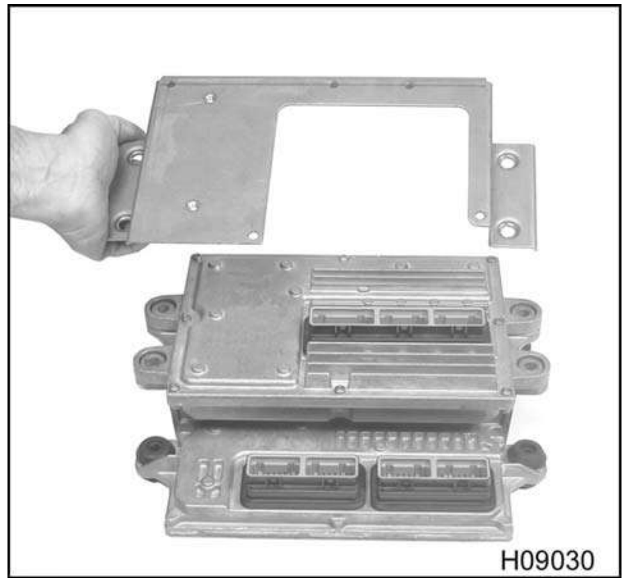


Figure 479 ECM / IDM bracket

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.

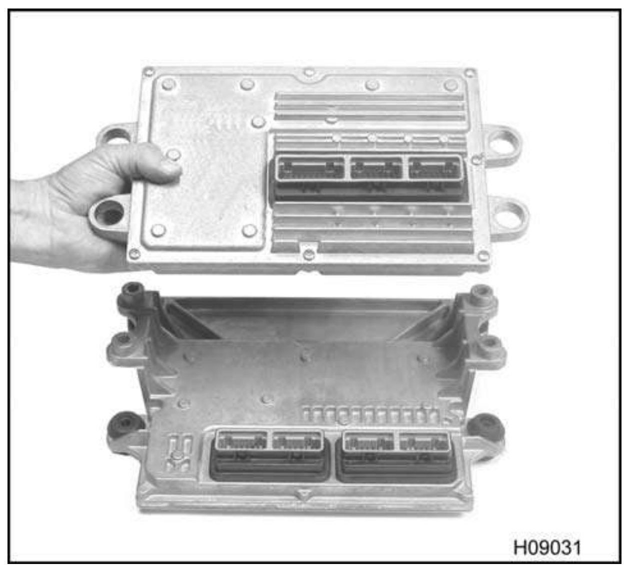


Figure 480 Removing IDM from ECM

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

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.

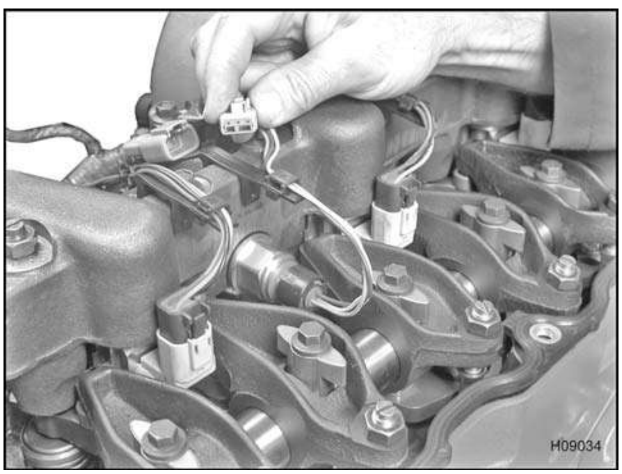


Figure 481 Disconnecting the ICP sensor

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

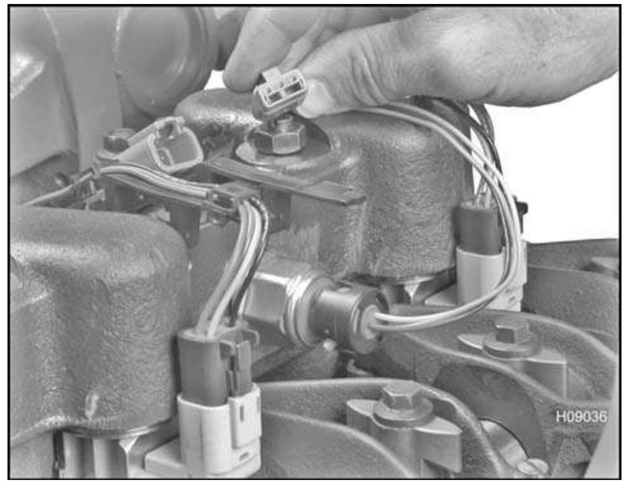


Figure 482 Disconnecting the BCP sensor

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

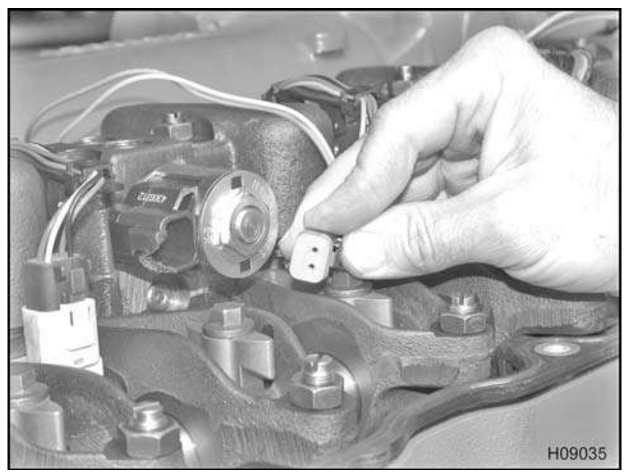


Figure 483 Brake shutoff valve connector

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

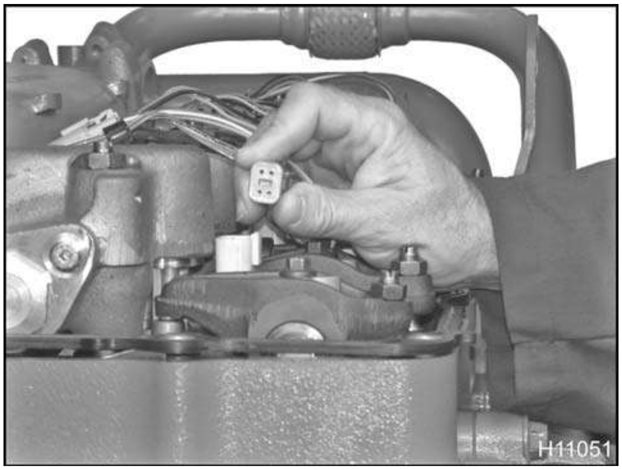


Figure 484 Injector connector

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.

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.

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.

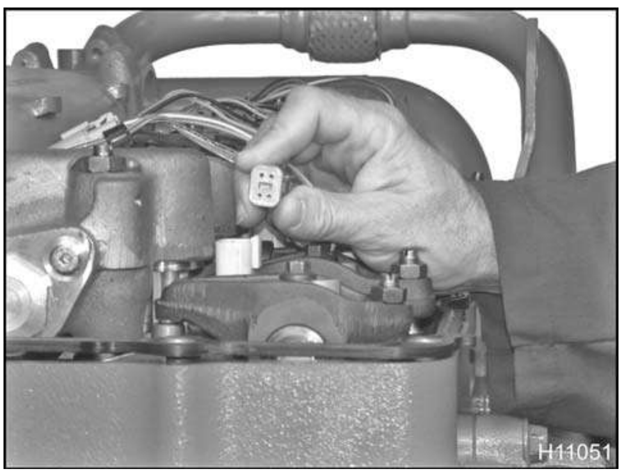


Figure 485 Injector connector

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.

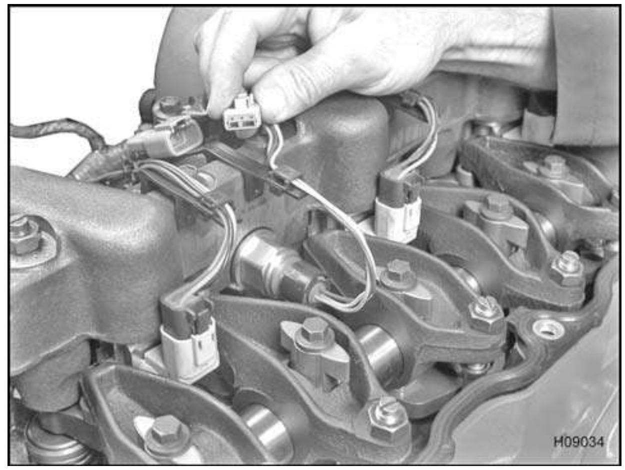


Figure 486 Connecting the ICP sensor

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

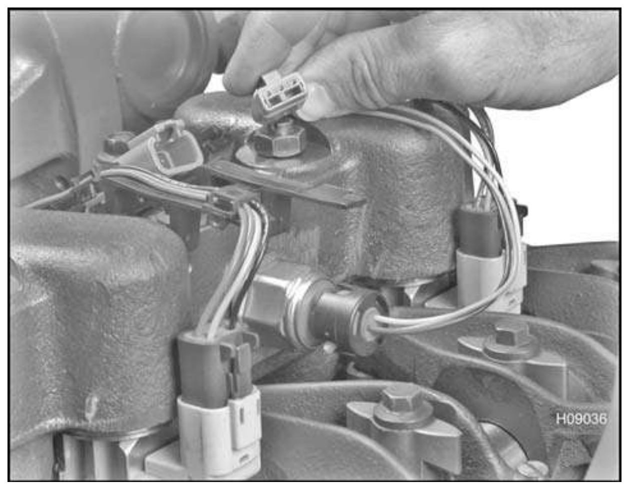


Figure 487 Connecting the BCP sensor

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

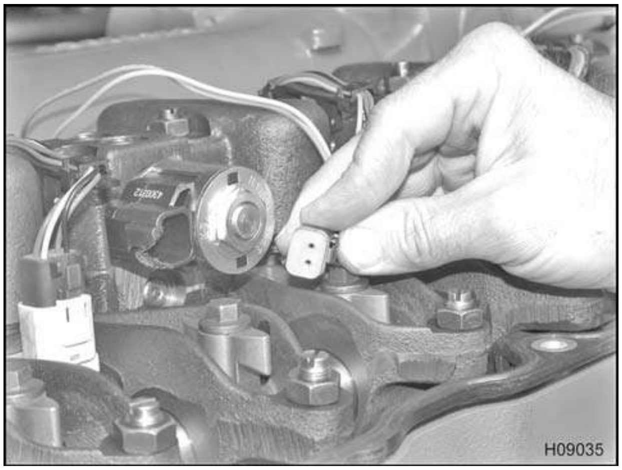


Figure 488 Connecting brake shutoff valve

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.

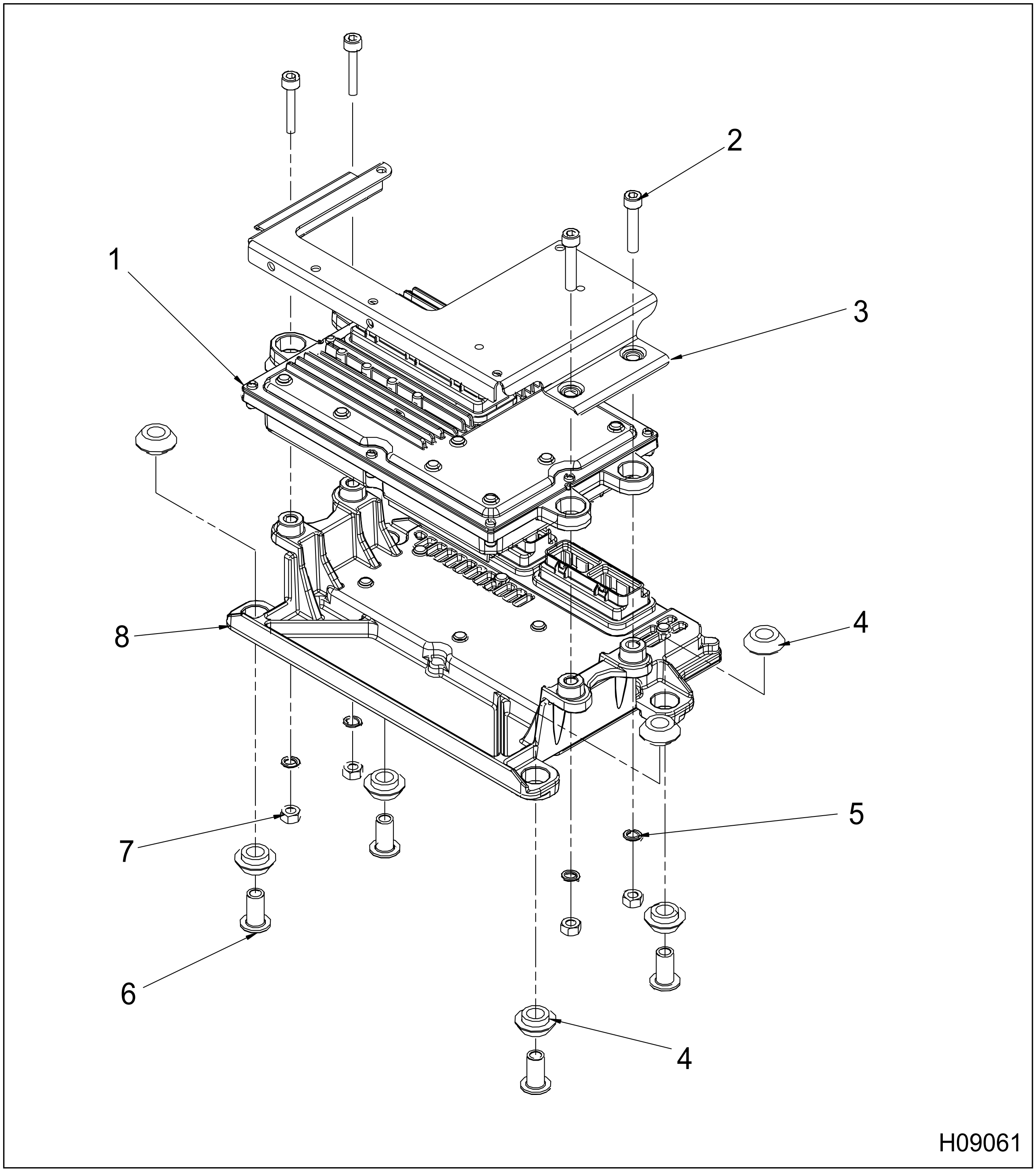


Figure 489 ECM / IDM module assembly

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)

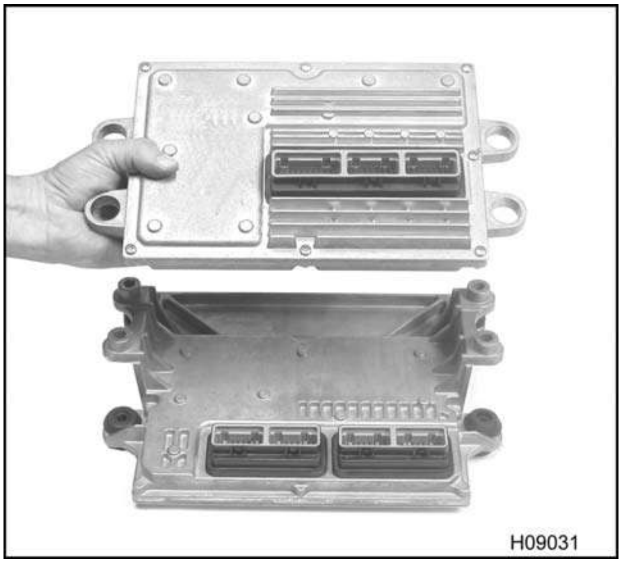


Figure 490 Installing the IDM onto the ECM

1. Lay the IDM over the ECM as shown.

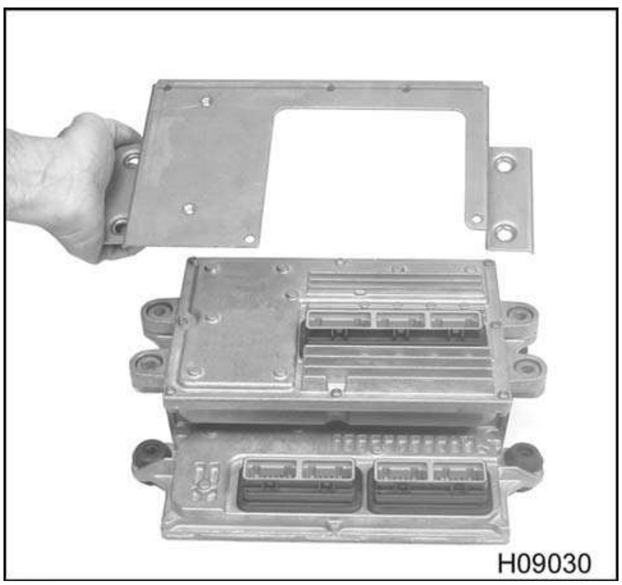


Figure 491 IDM / ECM bracket assembly

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.

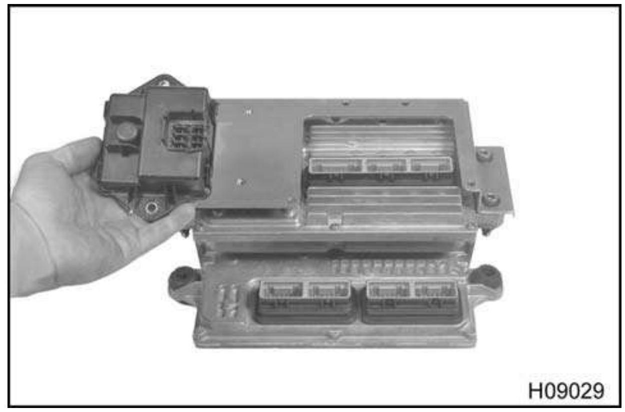


Figure 492 EGR drive module

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

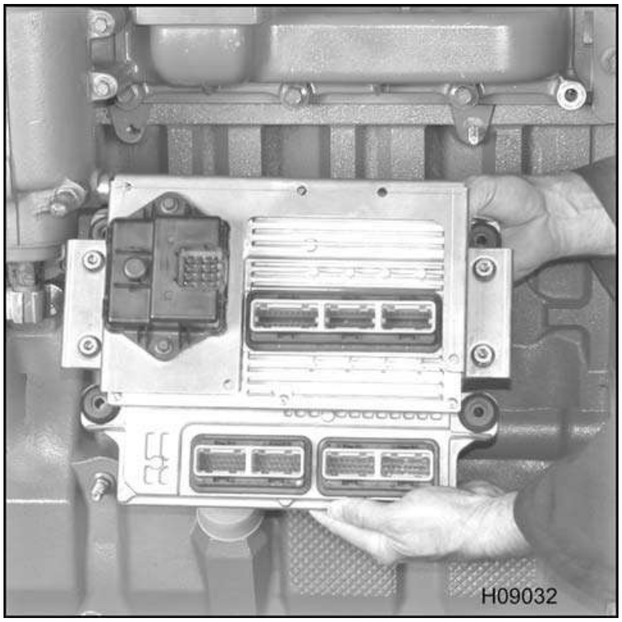


Figure 494 Installing the ECM, IDM, and EGR drive module assembly to crankcase

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

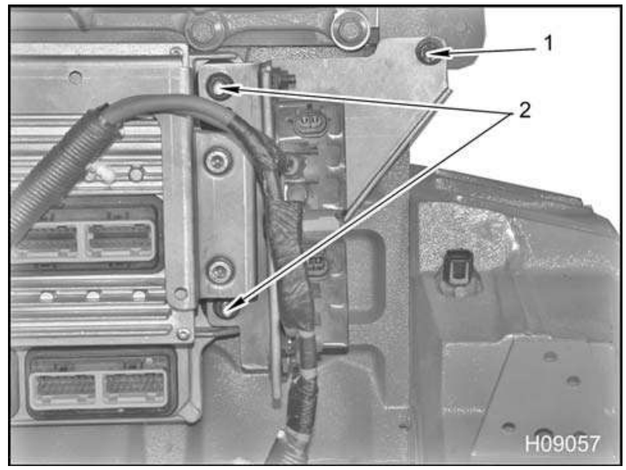


Figure 495 Intake air heater relay bracket

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).

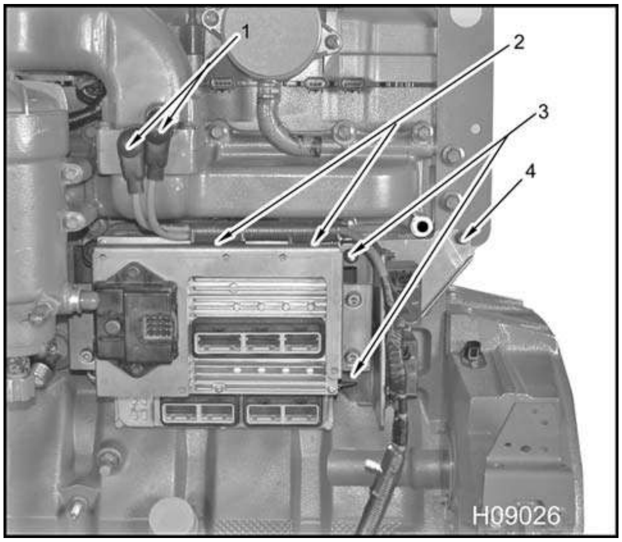


Figure 496 Intake air heater and relay wiring harness

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.

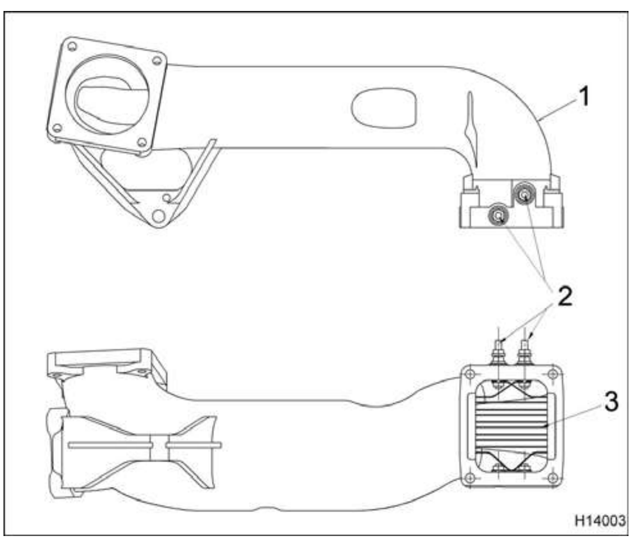


Figure 497 Intake air heater – dual element

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, page466).

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

Injector harness at ECM, IDM, and EGR drive module

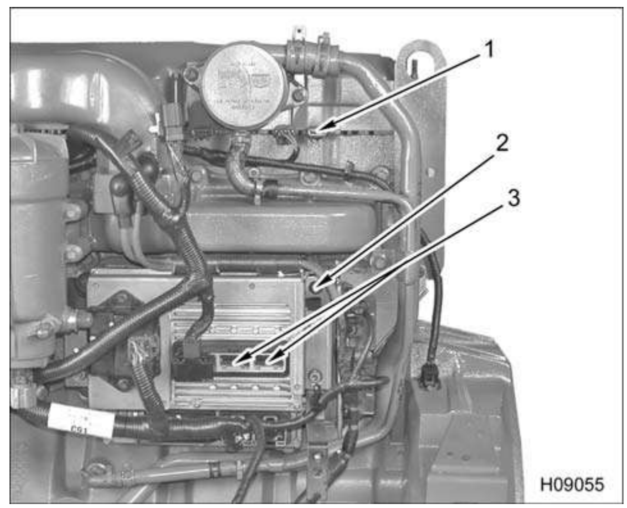


Figure 498 Injector harness locations

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.

Sensor harness at ECM, IDM, and EGR drive module

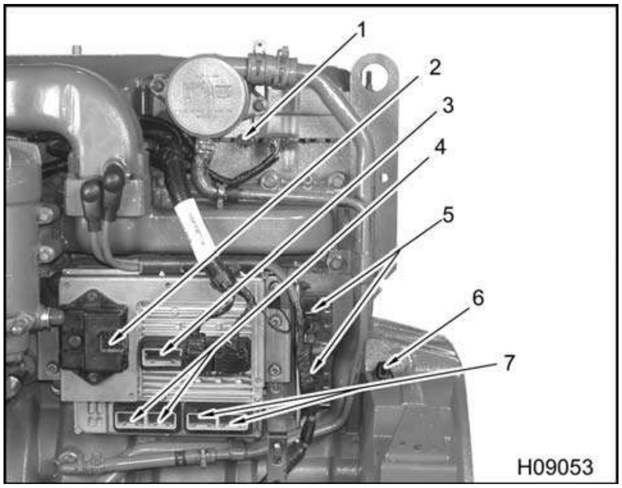


Figure 499 Sensor harness locations

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.

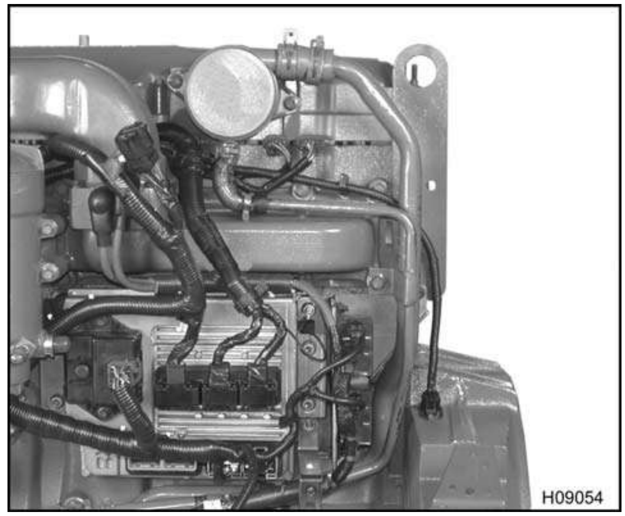


Figure 500 ECM, IDM, EGR drive module, and tube assembly overview

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.

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.

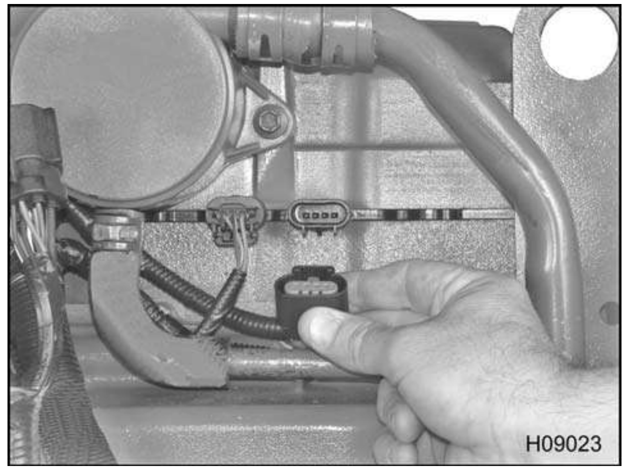


Figure 501 Connecting the No. 6 fuel injector connector

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.

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.

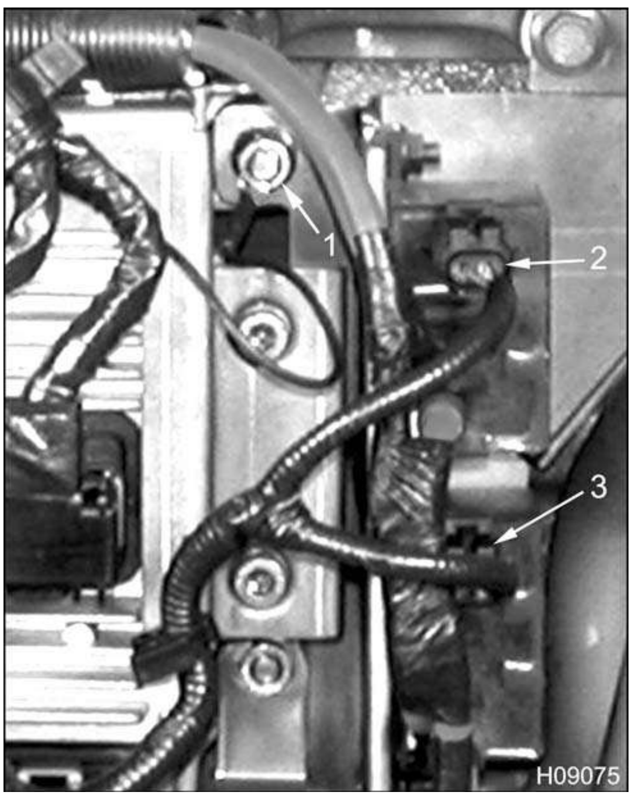


Figure 502 Intake air heater relay connectors (2)

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.

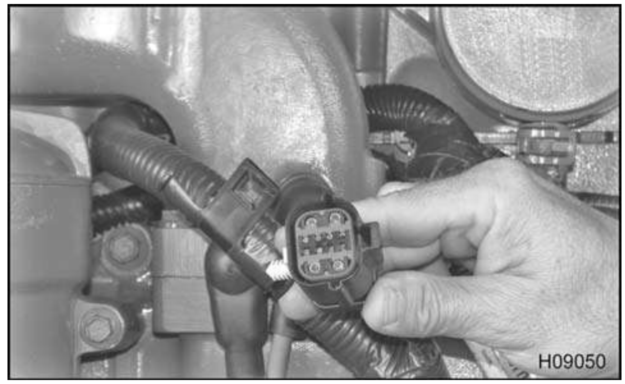


Figure 503 12 wire engine connector

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

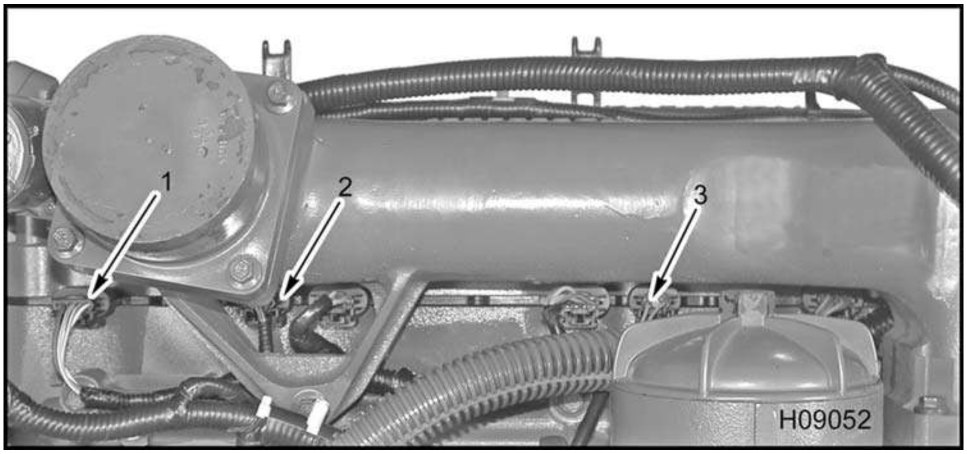


Figure 504 BCP, brake shutoff valve, and injector locations

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.

Figure 506 Connecting to the WIF sensor

15. Connect the wiring harness at the WIF sensor.

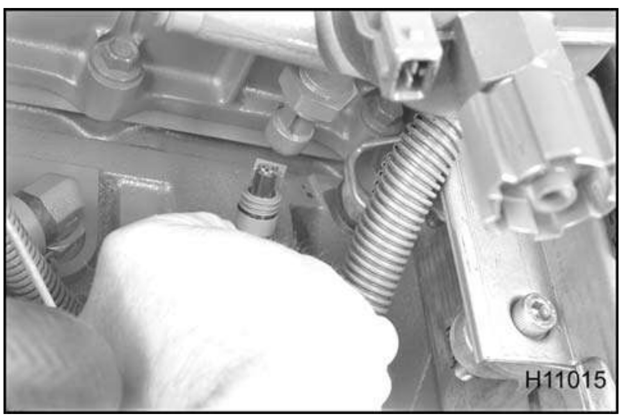


Figure 507 Connecting to the fuel pressure sensor

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

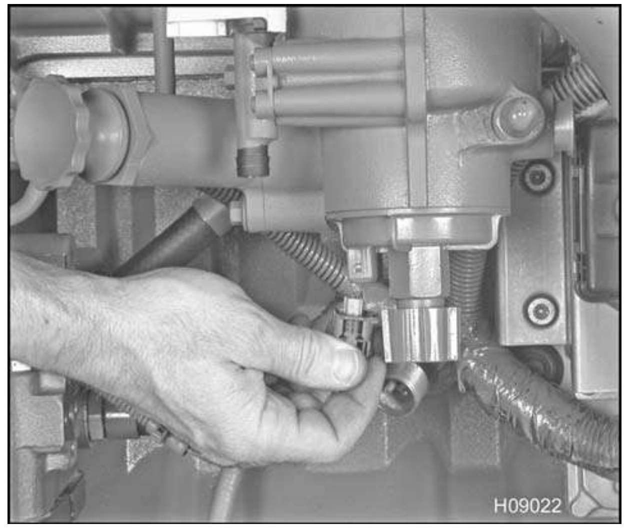


Figure 508 Connecting to the fuel heater

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

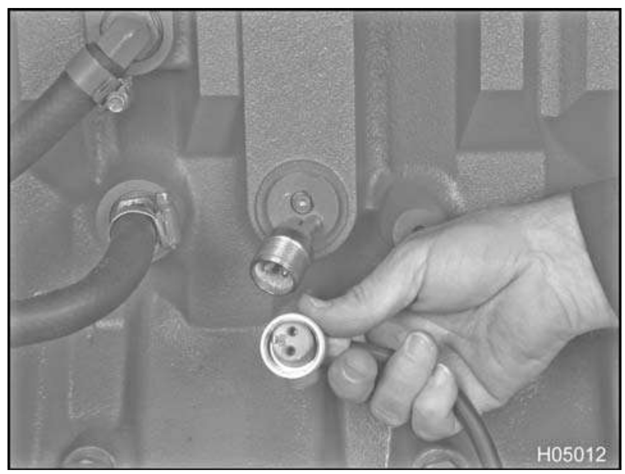


Figure 509 Connecting to the block heater

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

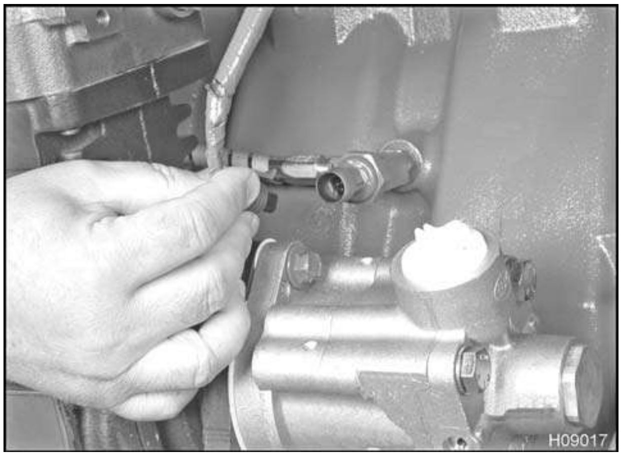


Figure 510 Connecting to the EOP sensor

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

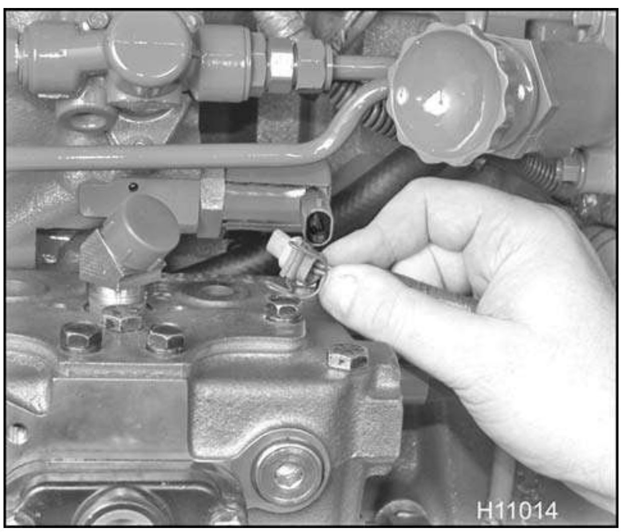


Figure 511 Connecting to the IPR valve

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.

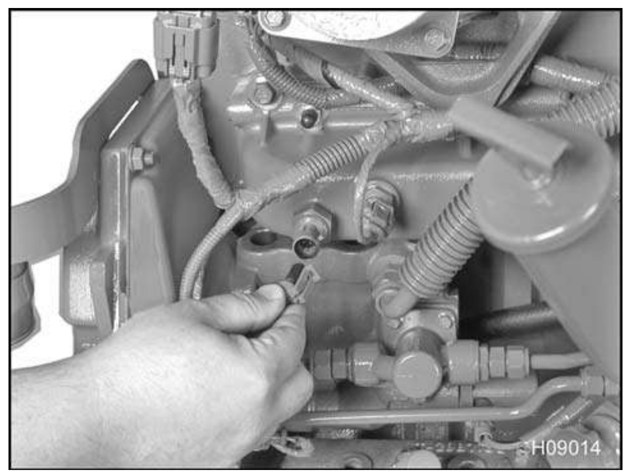


Figure 513 Connecting the MAP sensor

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

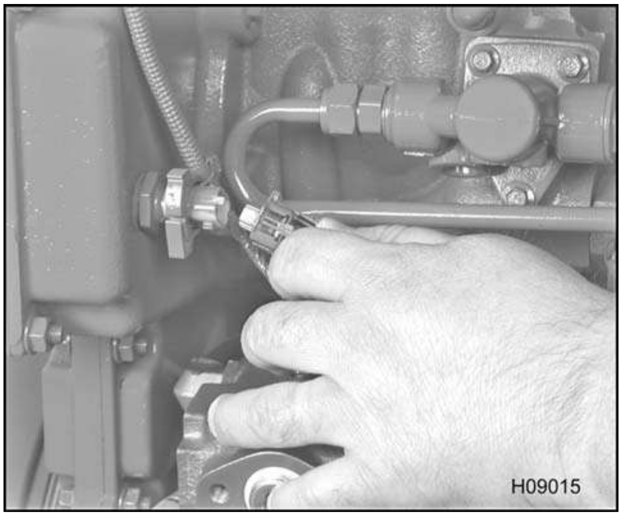


Figure 514 Connecting to the EOT sensor

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

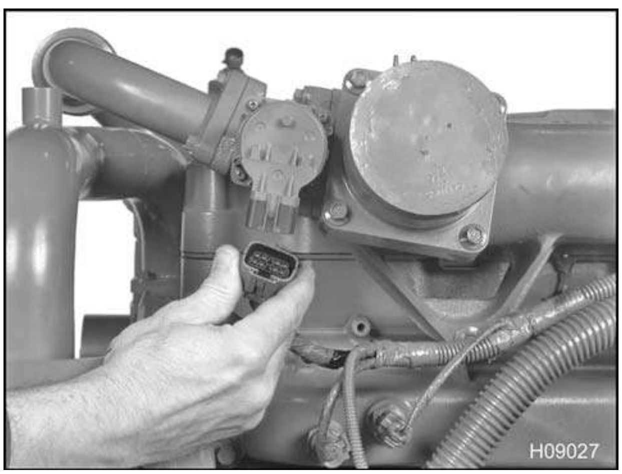


Figure 515 Connecting to the EGR control valve

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

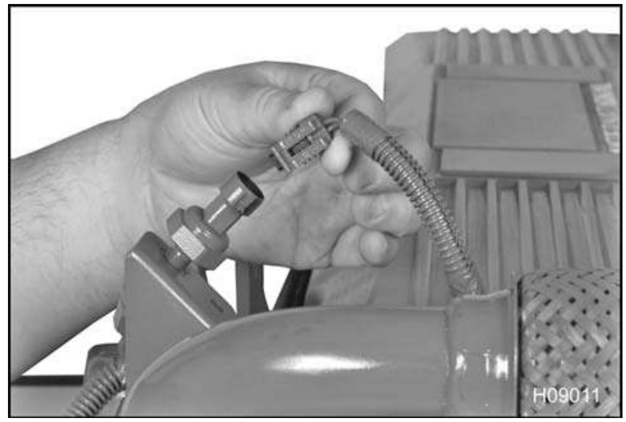


Figure 516 Connecting to the EBP sensor

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

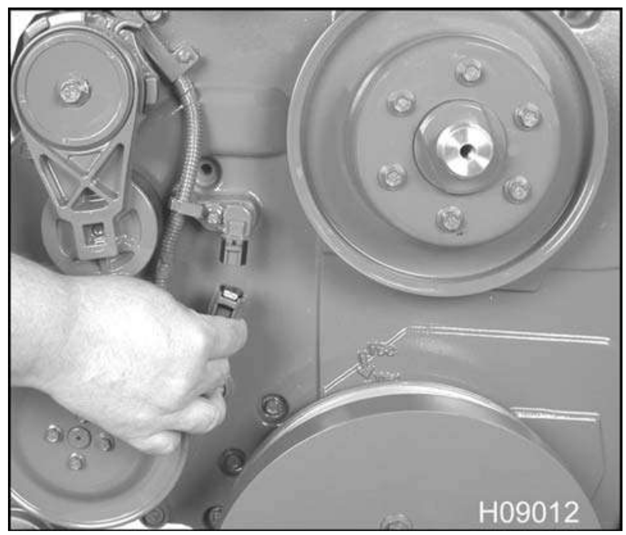


Figure 517 Connecting to the CMP sensor

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

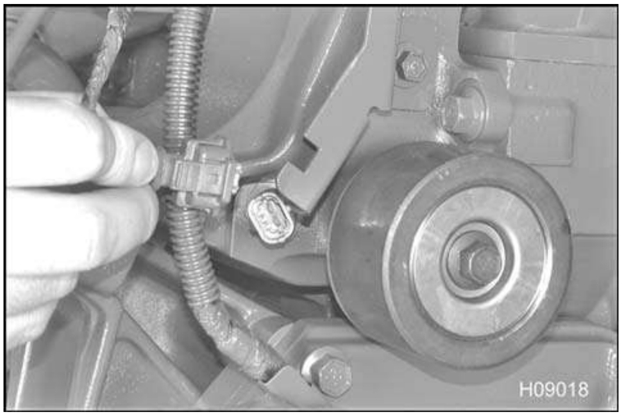


Figure 518 Connecting to the ECT sensor

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

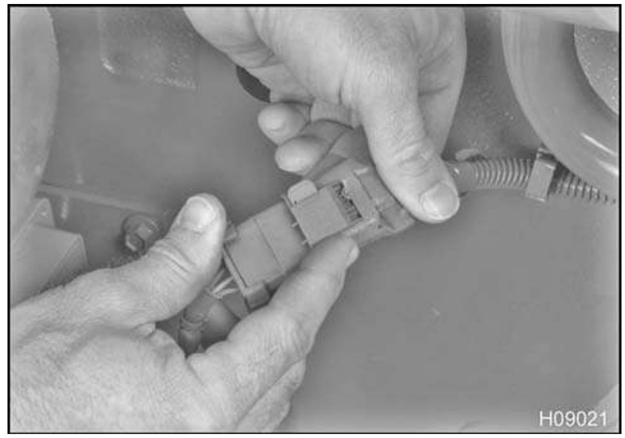


Figure 519 Connecting to the VGT harness

28. Connect the VGT harness at the VGT.

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)

Table of Contents

Description

Low-pressure Fuel System

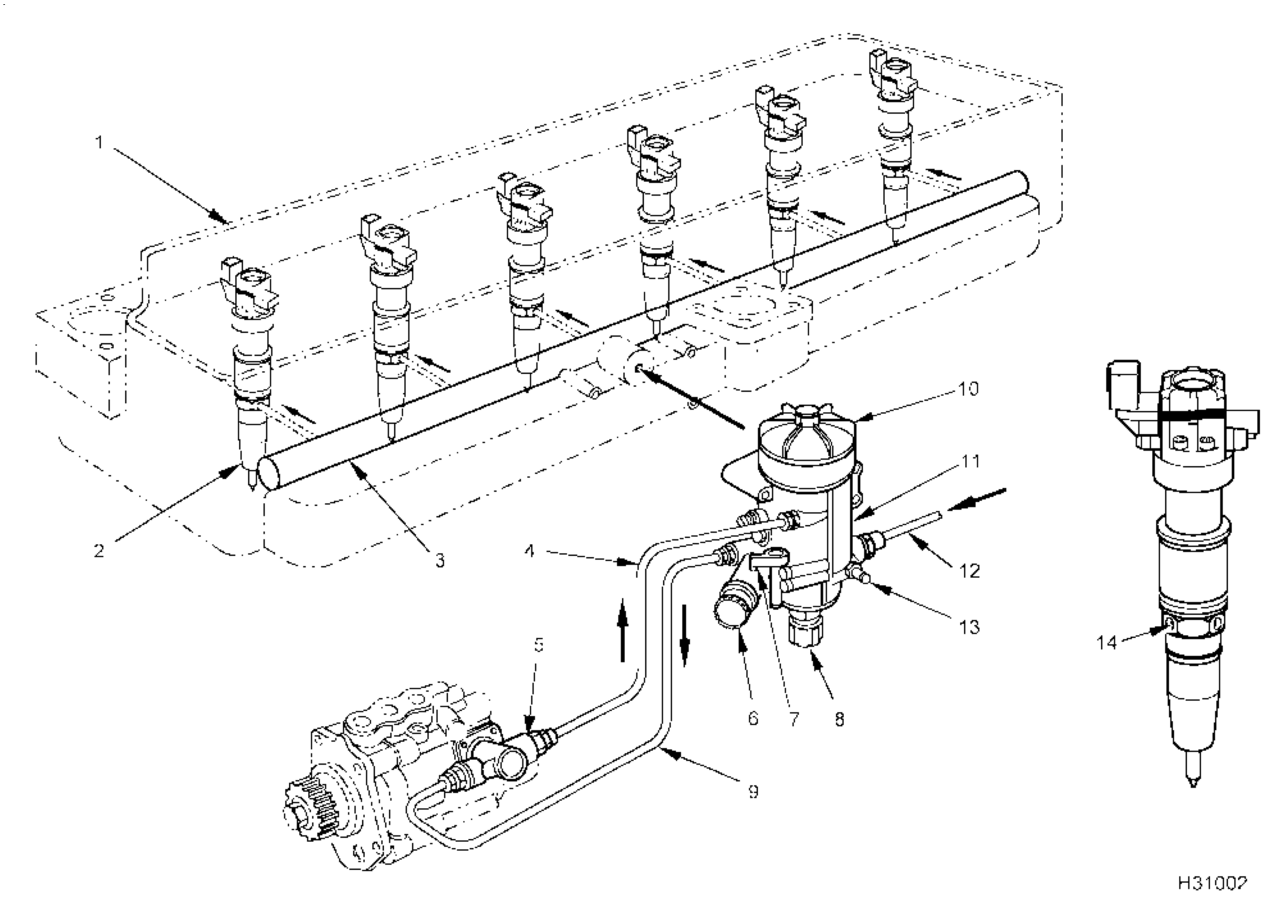


Figure 520 Low-pressure fuel system

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.

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

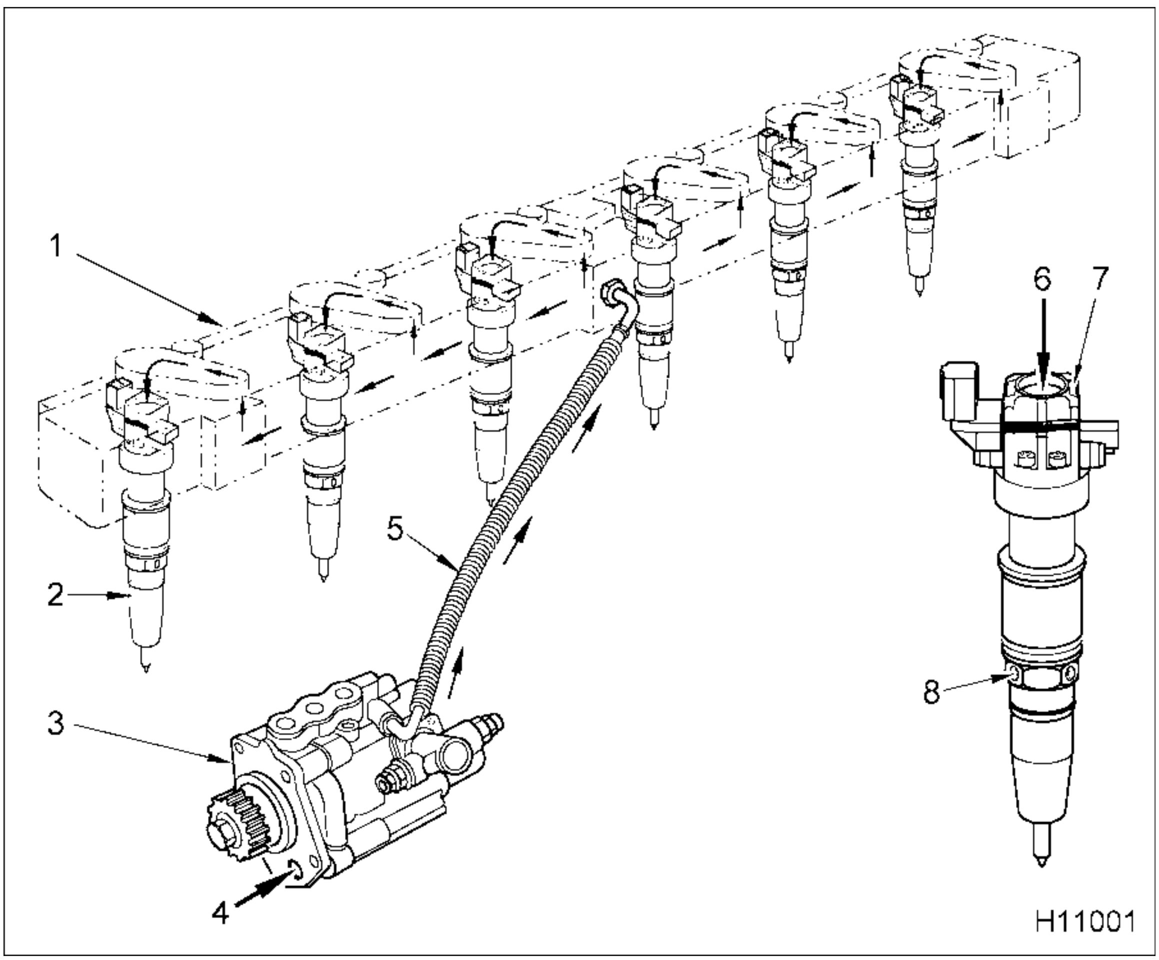


Figure 521 High-pressure oil system

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)

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.

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.

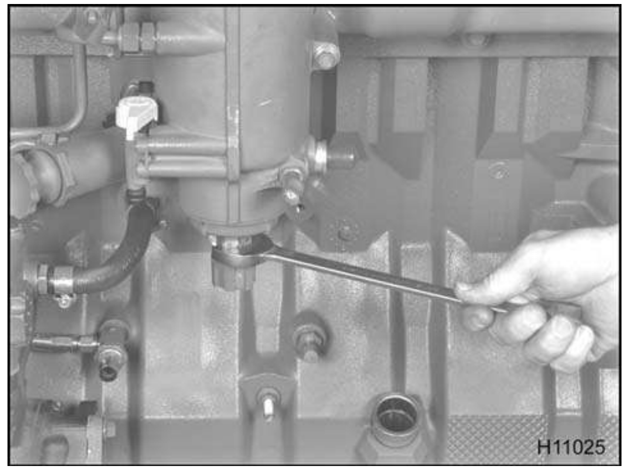


Figure 522 Removing the fuel strainer

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

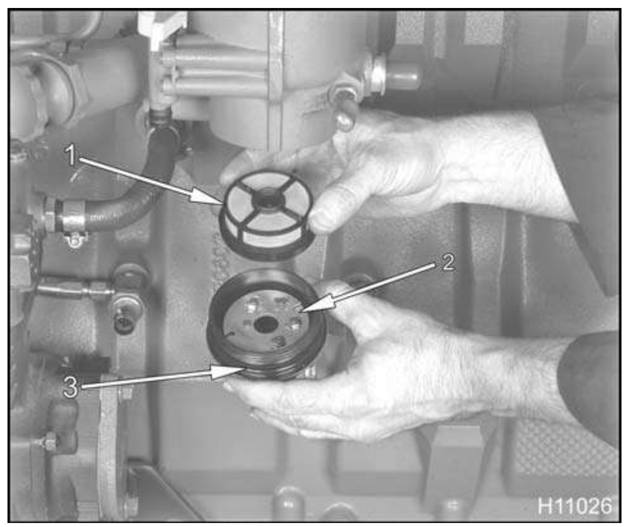


Figure 523 Strainer and heater assembly

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

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

Fuel Filter

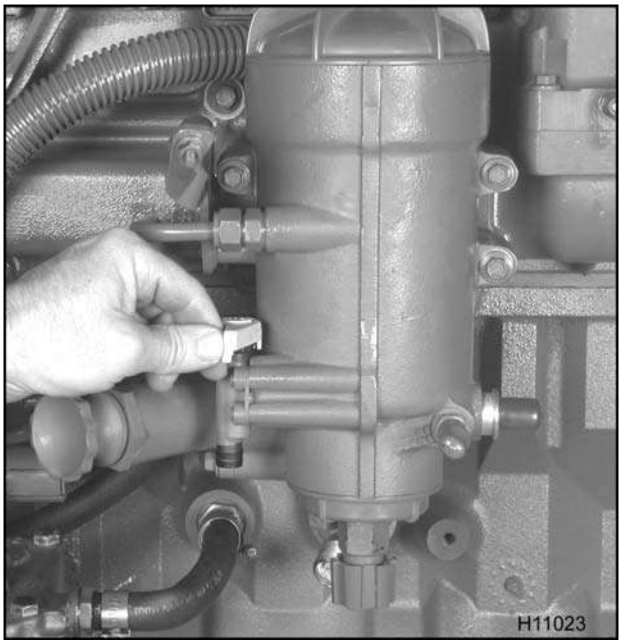


Figure 524 Water drain valve

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

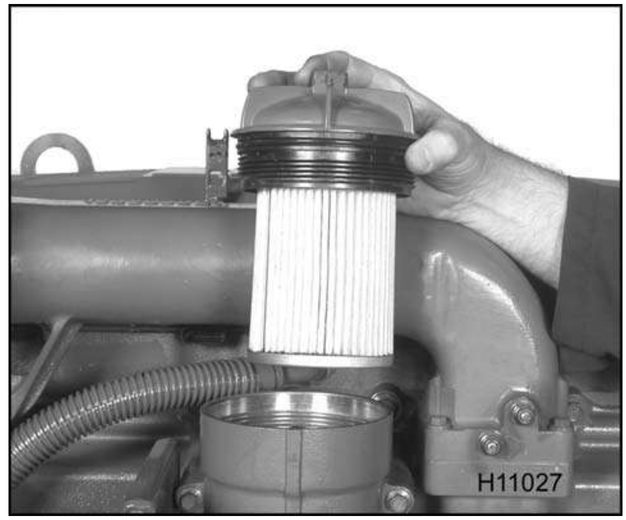


Figure 525 Fuel filter element

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).

Removal

Low-pressure Fuel Supply Pump and Tubing

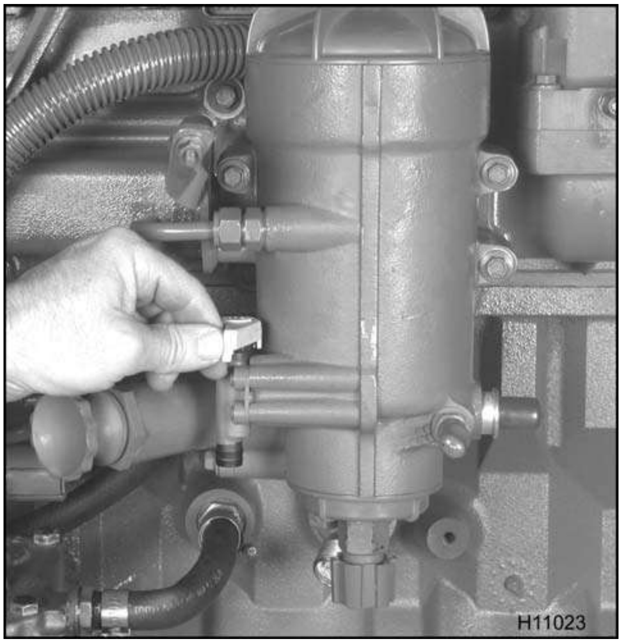


Figure 526 Water drain valve

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

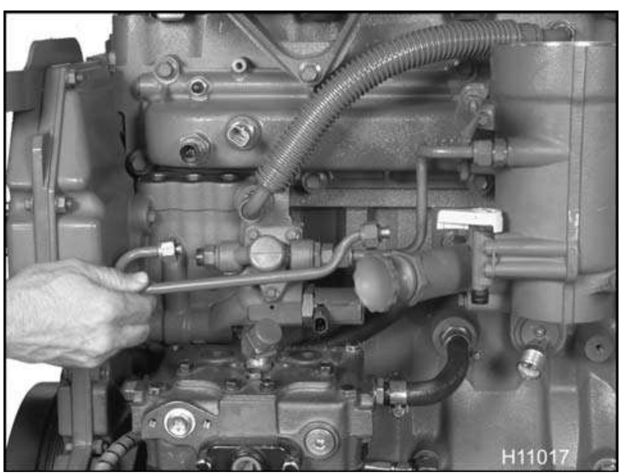


Figure 527 Removing the transfer pump inlet tube assembly

2. Remove the transfer pump inlet tube assembly.

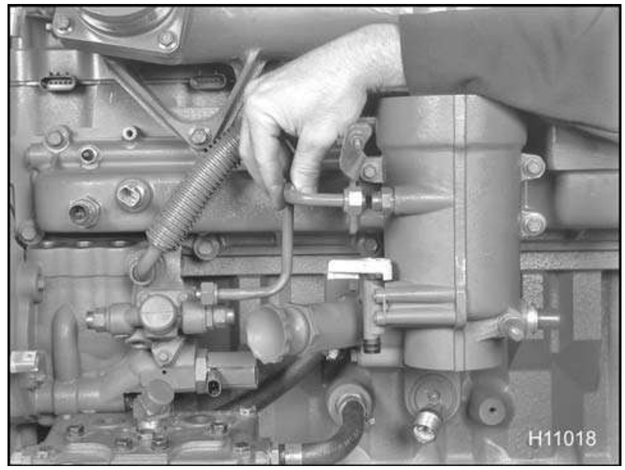


Figure 528 Removing the transfer pump outlet tube assembly

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

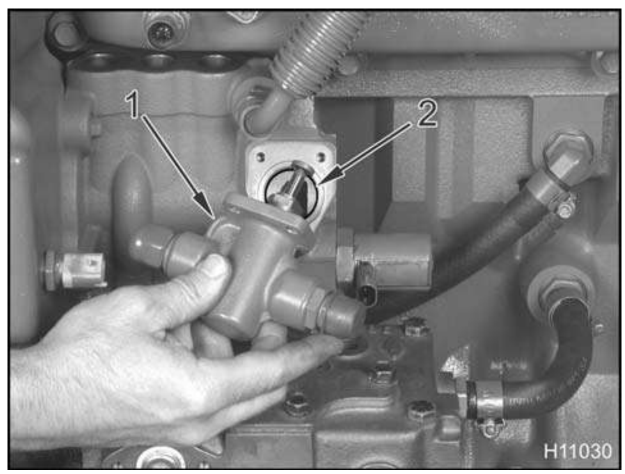


Figure 529 Removing the low-pressure fuel pump

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.

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.

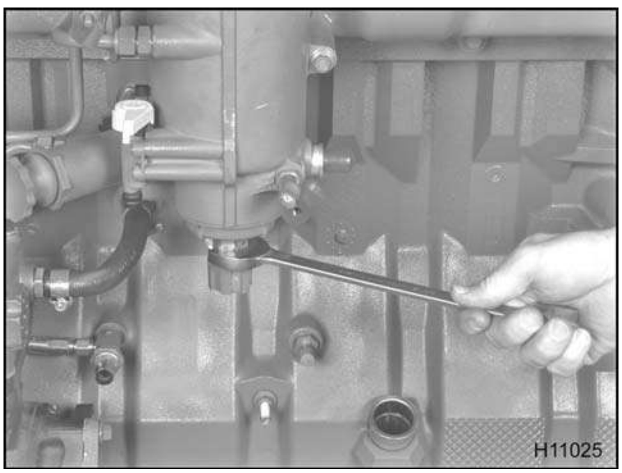


Figure 530 Removing fuel bowl and strainer

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

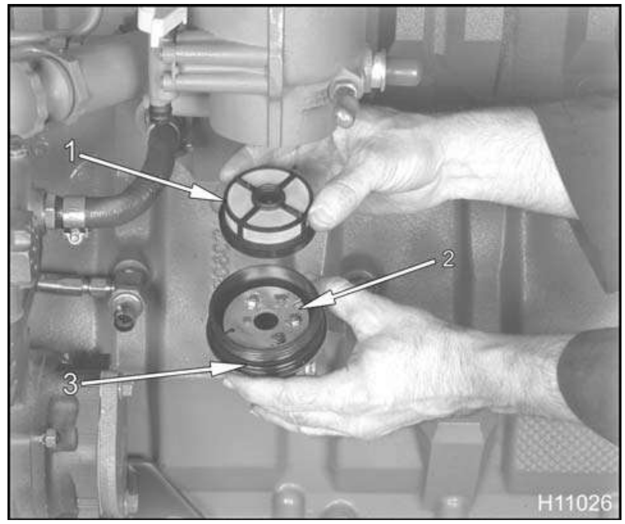


Figure 531 Strainer and heater assembly

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.

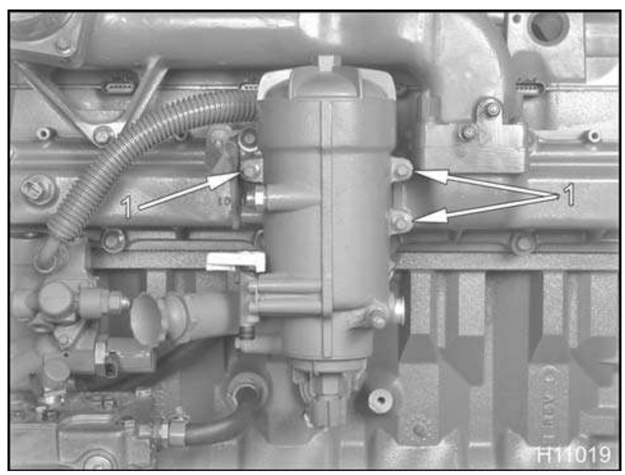


Figure 532 Fuel filter assembly mounting bolts

1. Bolts, M8 x 100

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

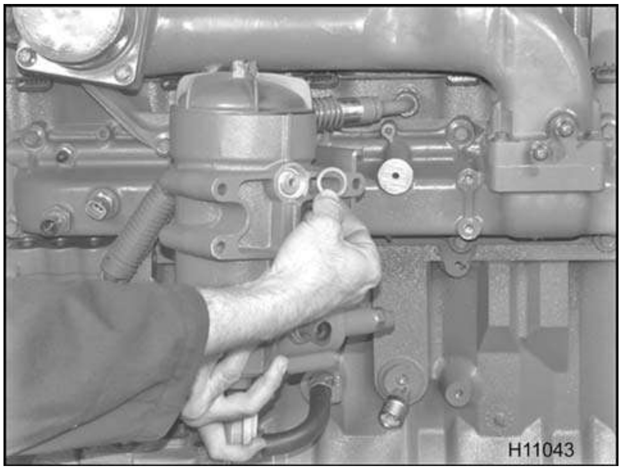


Figure 533 Removing the fuel filter outlet gasket

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

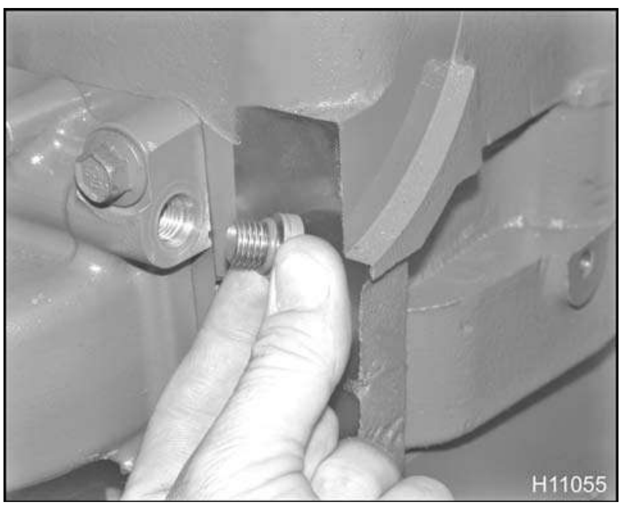


Figure 534 Removing the fuel rail plug assembly (2)

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.

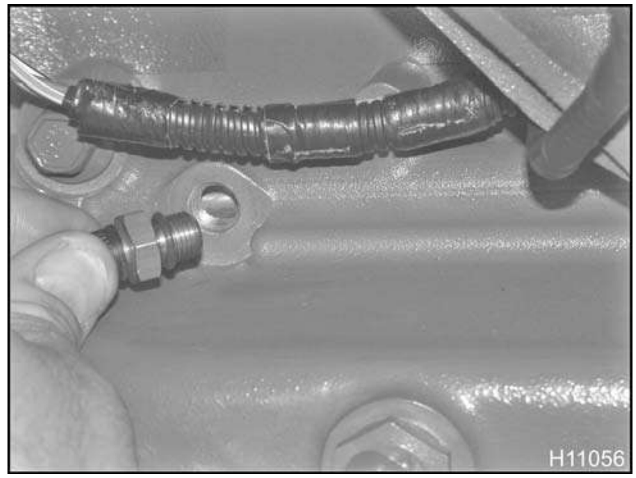


Figure 535 Removing the fuel valve assembly (air bleed and pressure test port)

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.

High-pressure Hose Assembly – Generation 1

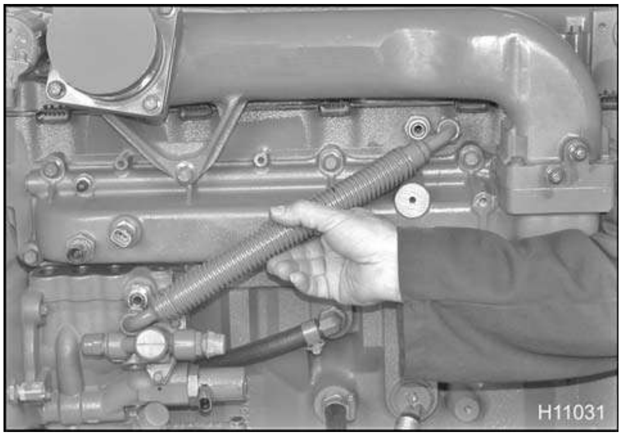


Figure 536 Removal of high-pressure oil hose assembly

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.

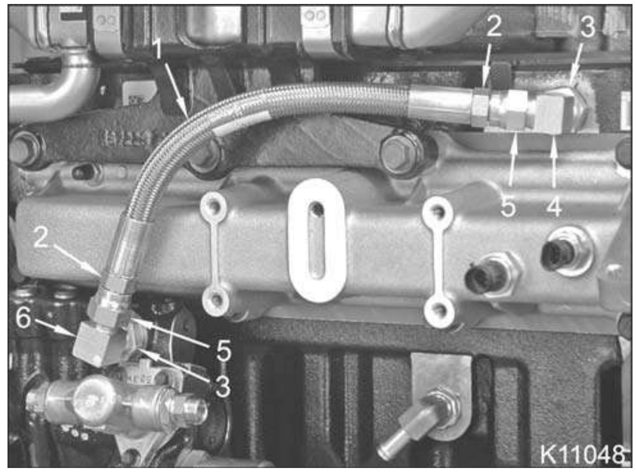


Figure 537 High-pressure hose assembly connections (typical)

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.

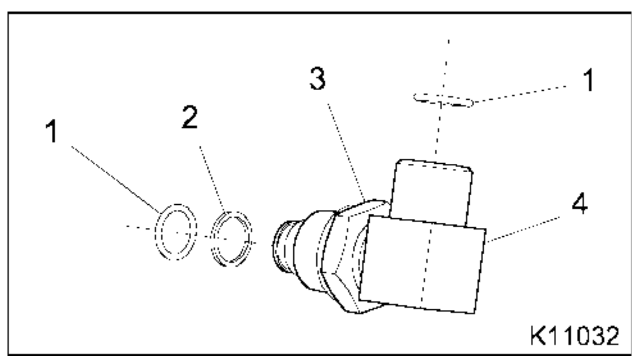


Figure 538 High-pressure oil elbow (typical)

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

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

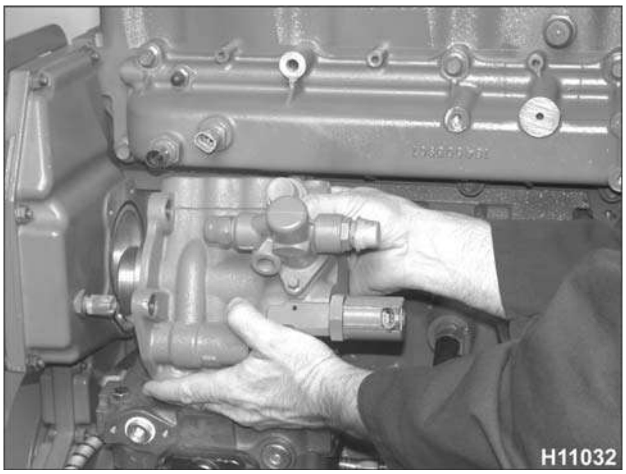


Figure 539 Removing the high-pressure pump assembly

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.

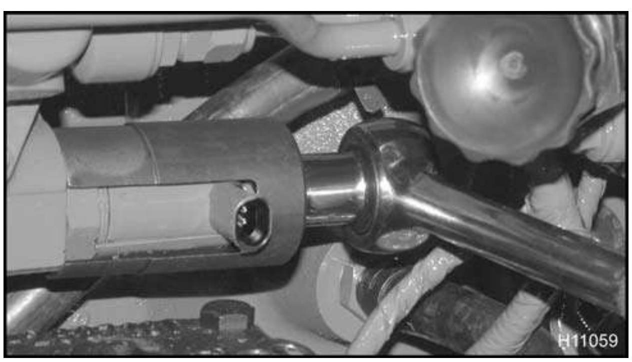


Figure 540 Removing the IPR valve

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.

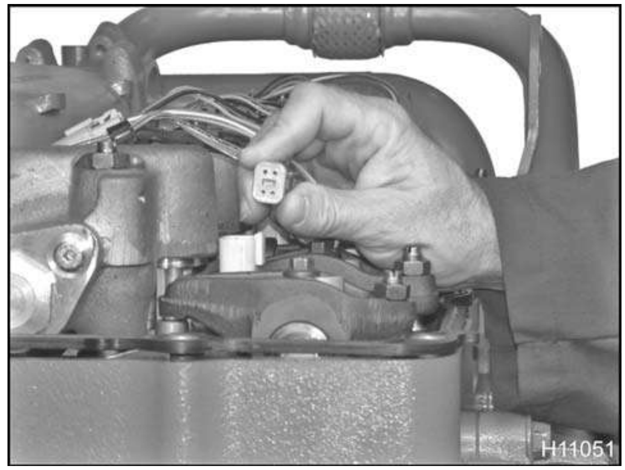


Figure 541 Removing the injector harness connector

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.

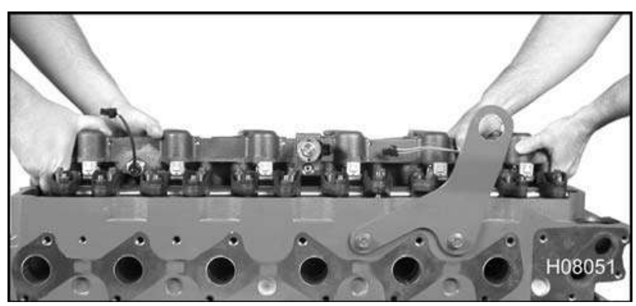


Figure 542 Removing the high-pressure oil rail

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.

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

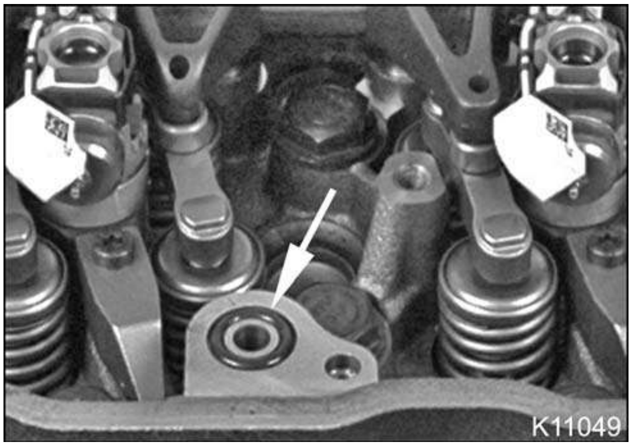


Figure 543 High-pressure oil rail

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

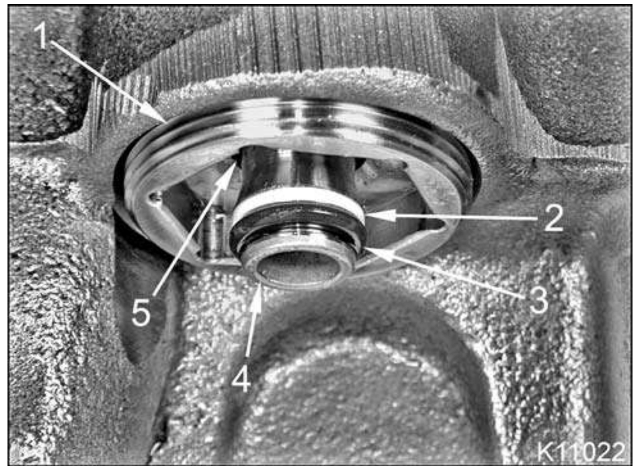


Figure 544 Injector oil inlet adapter installed in high-pressure oil rail

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.

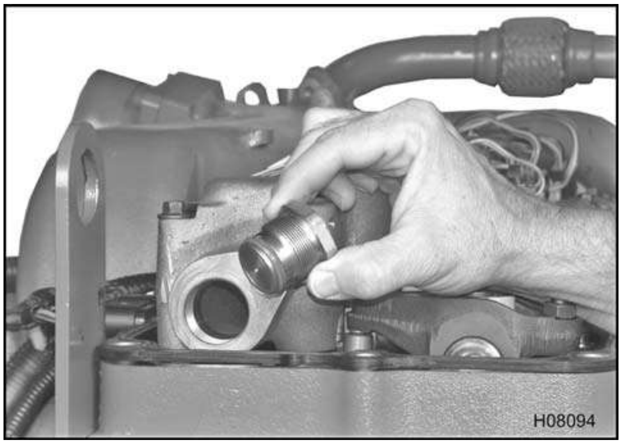


Figure 545 Rail end plug assembly

8. If necessary, remove rail end plug or attenuator. See (TSI-05-12-28 New High-pressure Oil Rails, page 465).

Figure 546 ICP sensor assembly

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

Fuel Injector Assemblies

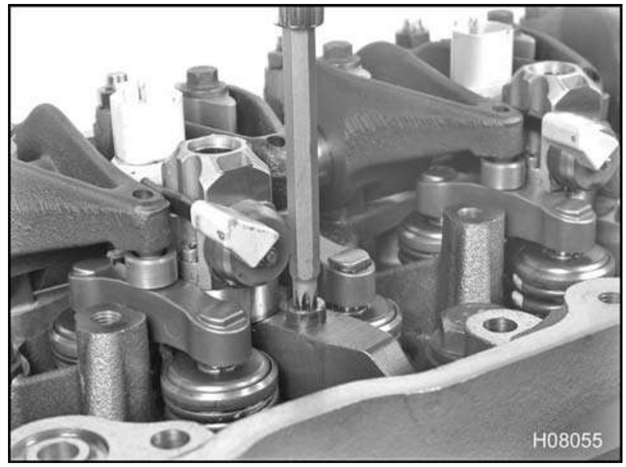


Figure 547 Removing the injector clamp and injector

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

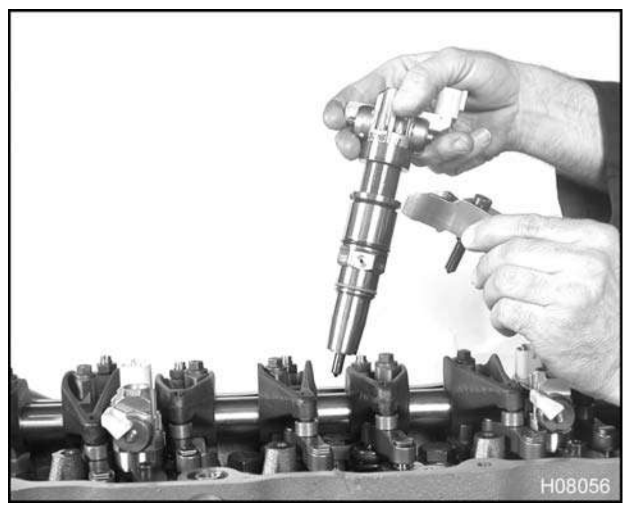


Figure 548 Removing the fuel injector assembly

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.

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.

Disassembly

Fuel Filter Header Assembly

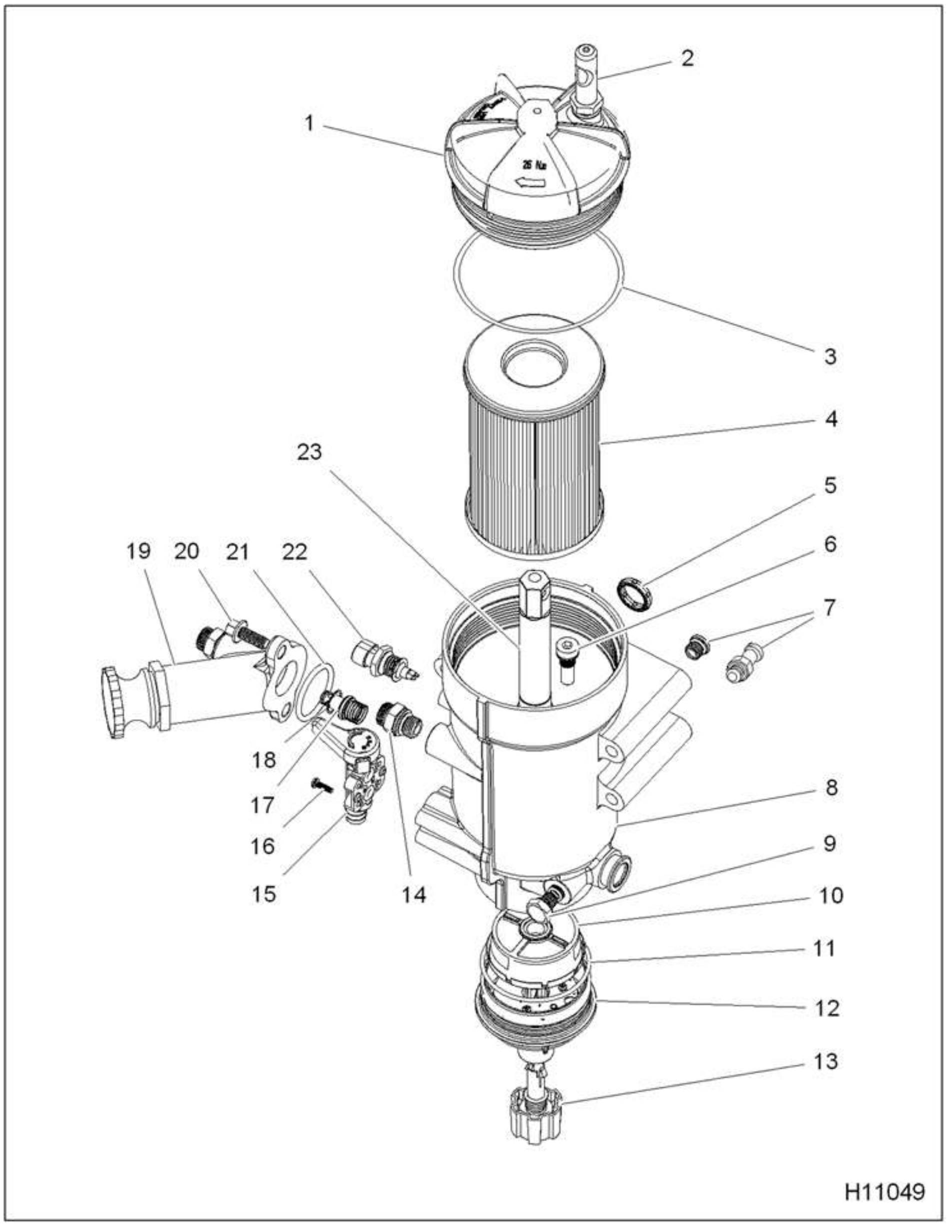


Figure 549 Fuel filter header assembly

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

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).

Installation

Fuel Injectors

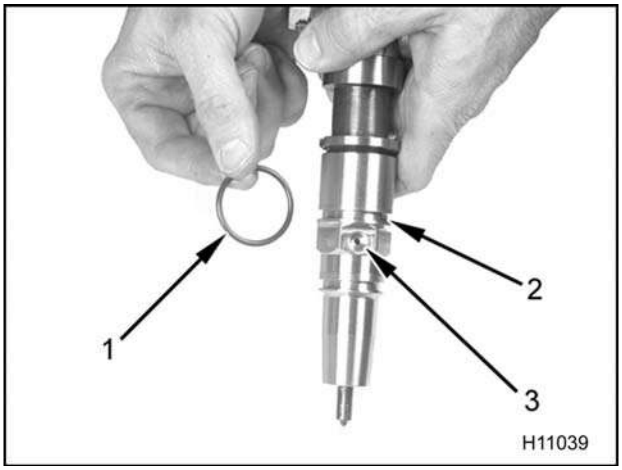


Figure 550 Injector upper O-ring

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.

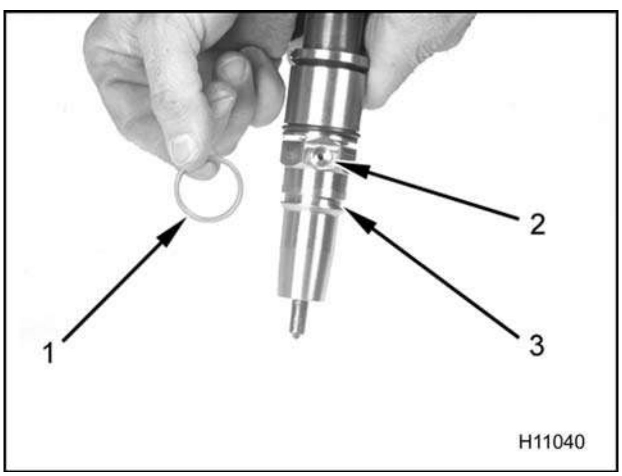


Figure 551 Injector lower O-ring

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.

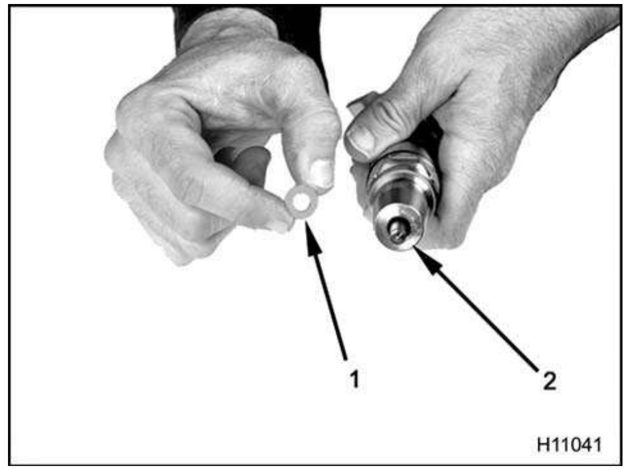


Figure 552 Installing injector nozzle gasket

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.

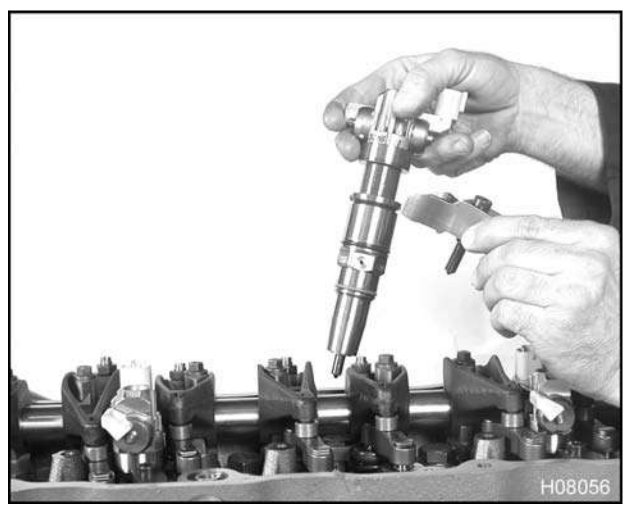


Figure 553 Install injector assembly

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

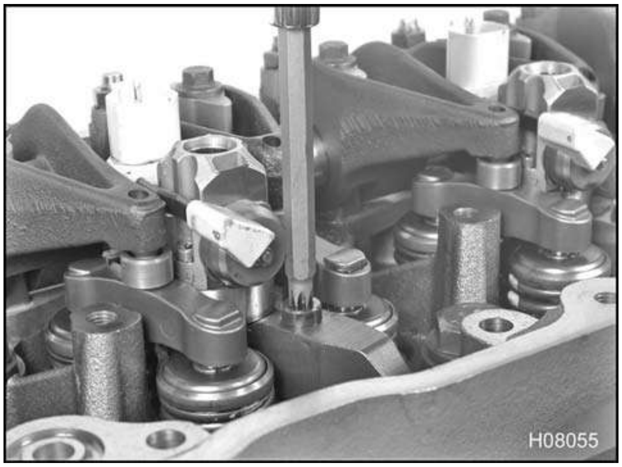


Figure 554 Installing the injector clamp

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).

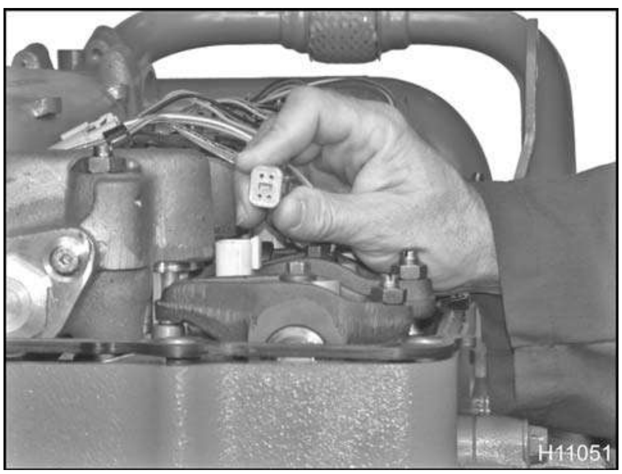


Figure 555 Injector connector

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.

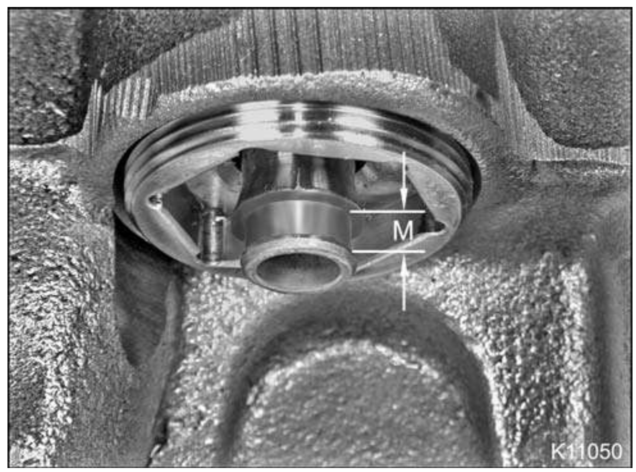


Figure 556 Groove Measurement (M) in injector oil inlet tube

2. Measure groove in the injector oil inlet tube.

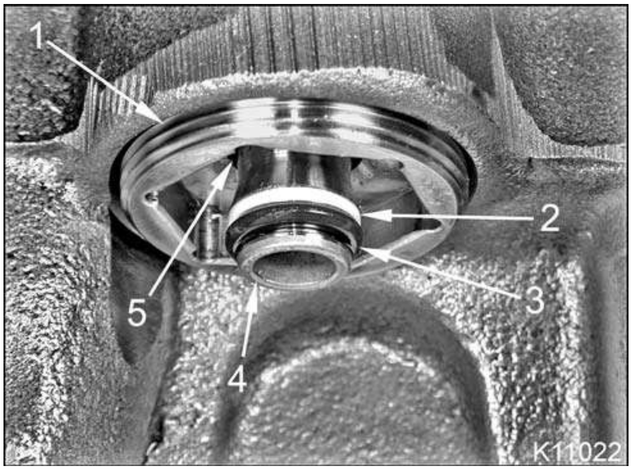


Figure 557 Injector oil inlet adapter installed in high-pressure oil rail

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.

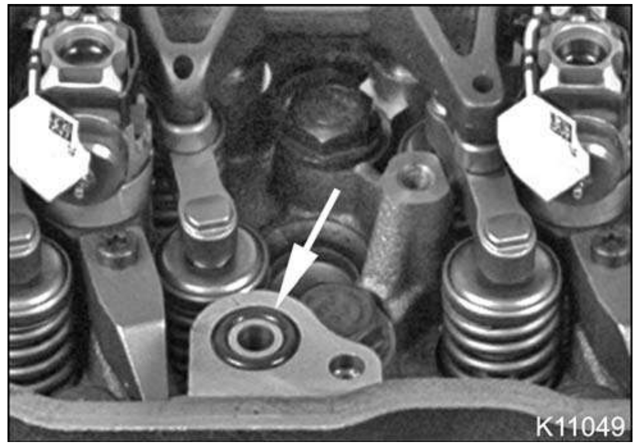


Figure 558 Oil inlet O-ring

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

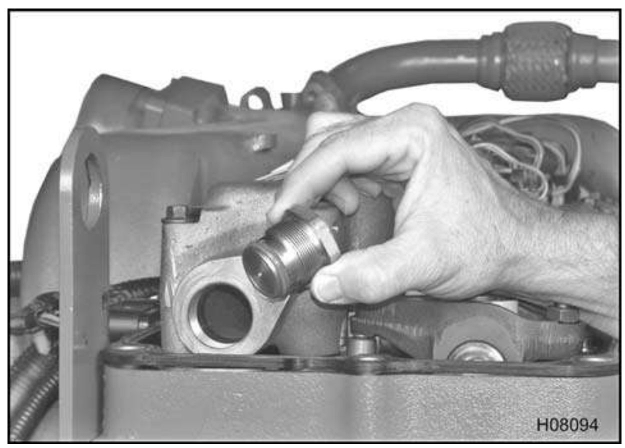


Figure 559 Rail end plug assembly

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.

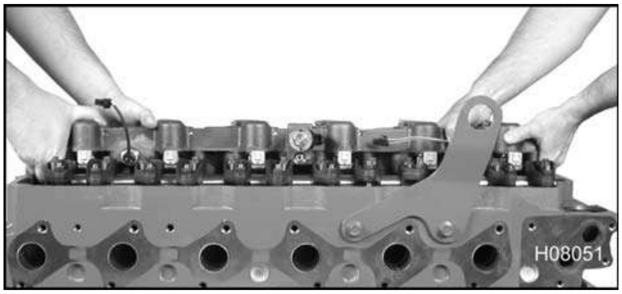


Figure 560 Installing the high-pressure oil rail assembly

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

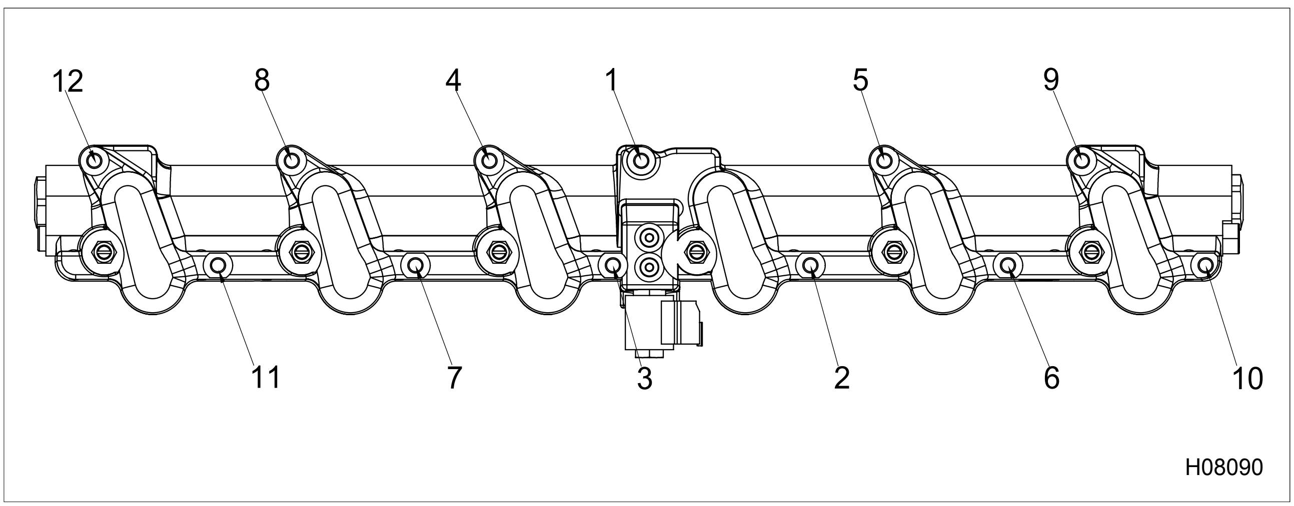


Figure 561 High-pressure oil rail bolt torque sequence (typical)

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.

High-pressure Oil Pump and IPR Valve Assembly

IPR Valve Assembly

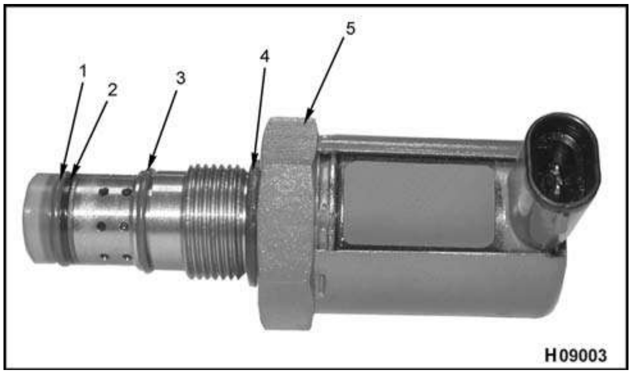


Figure 562 IPR valve assembly

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.

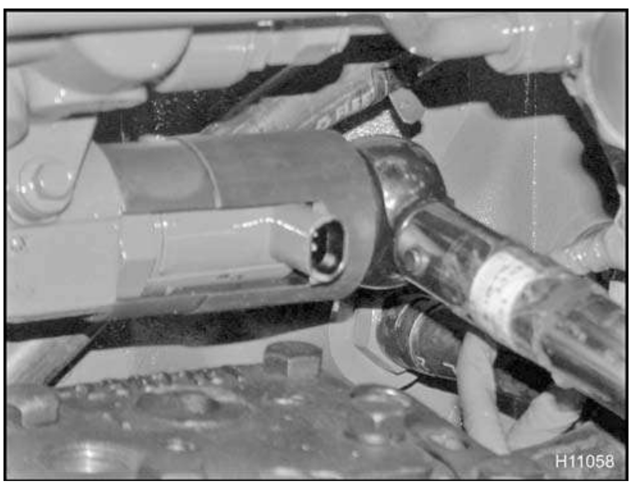


Figure 563 Installing the IPR valve

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.

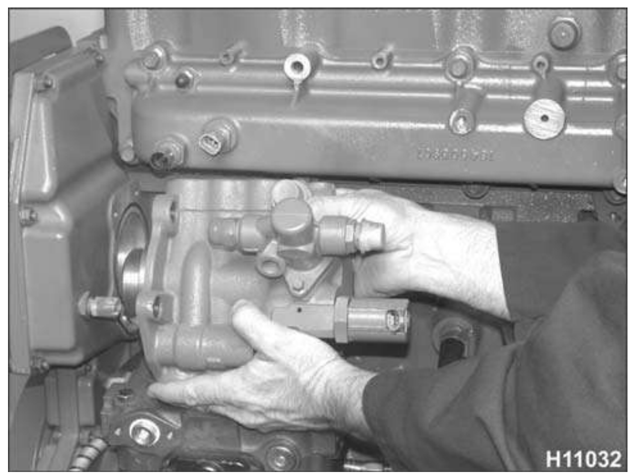


Figure 564 Installing the high-pressure pump assembly

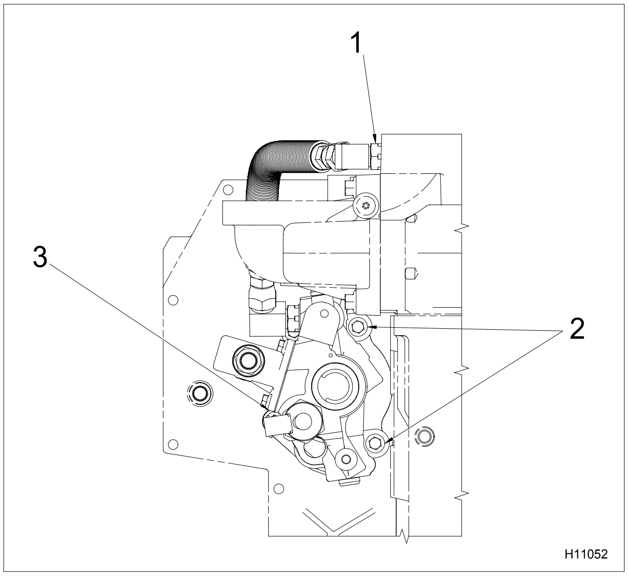


Figure 565 IPR orientation

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

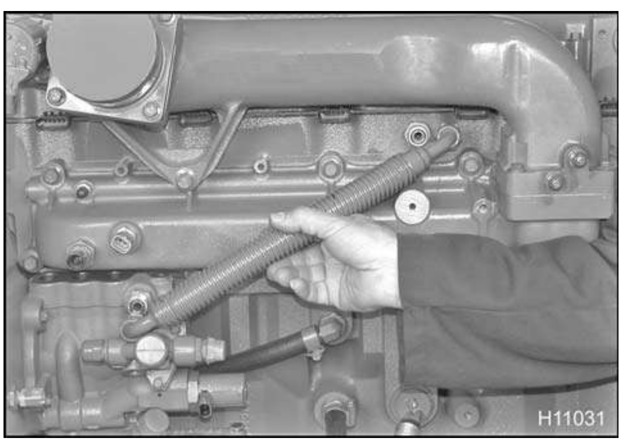


Figure 566 Installation of high-pressure hose assembly

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

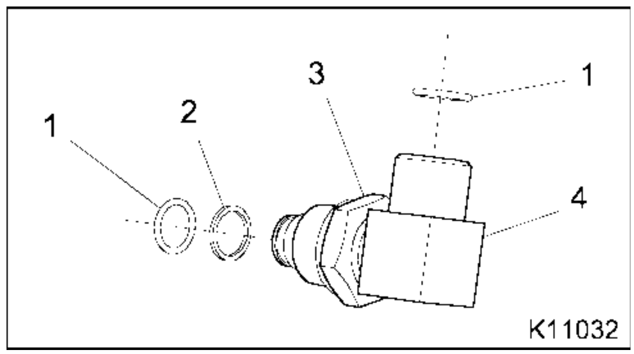


Figure 567 High-pressure oil elbow (typical)

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.

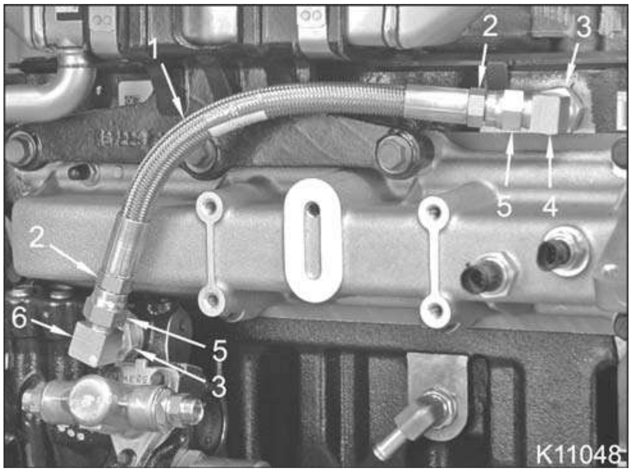


Figure 568 Good position and alignment of new high-pressure oil hose (typical)

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.

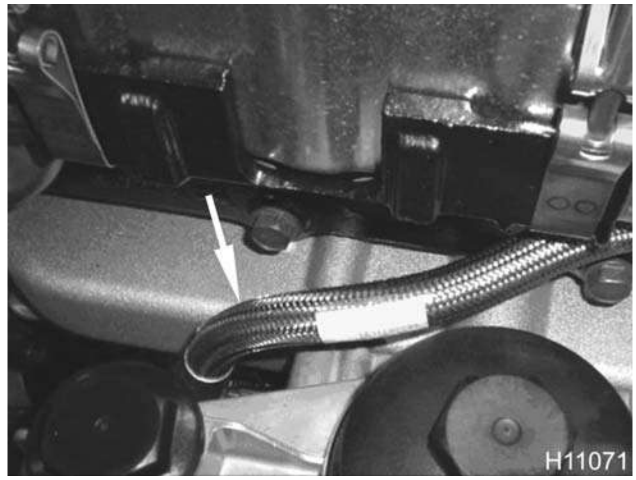


Figure 569 Bad alignment of high-pressure oil hose (hose twisted)

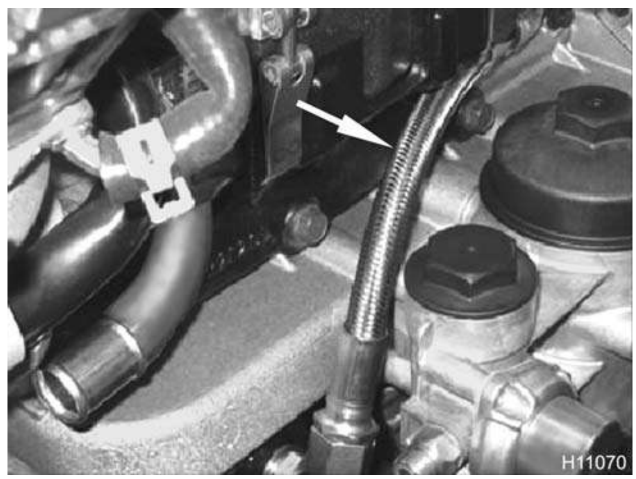


Figure 570 Good alignment of high-pressure oil hose (hose not twisted)

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

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

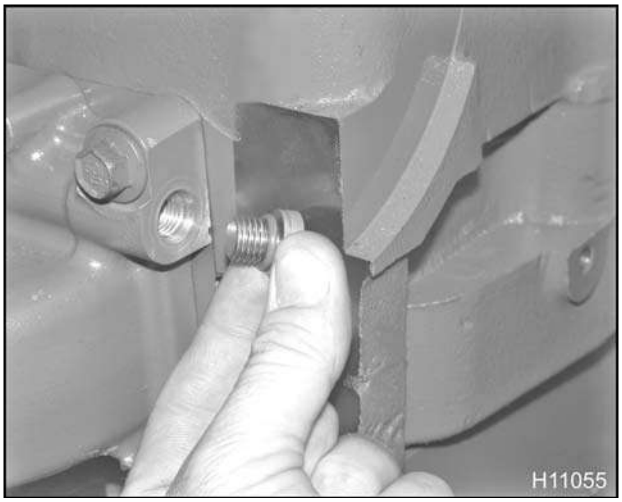


Figure 571 Installing the fuel rail plug assembly (2)

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).

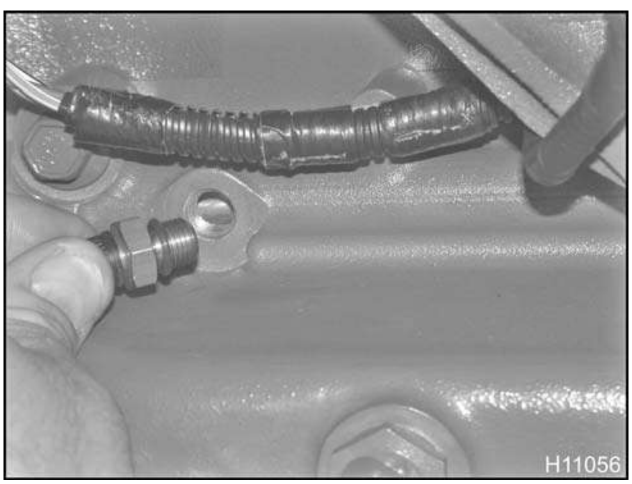


Figure 572 Installing the fuel valve assembly (air bleed and pressure test port)

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).

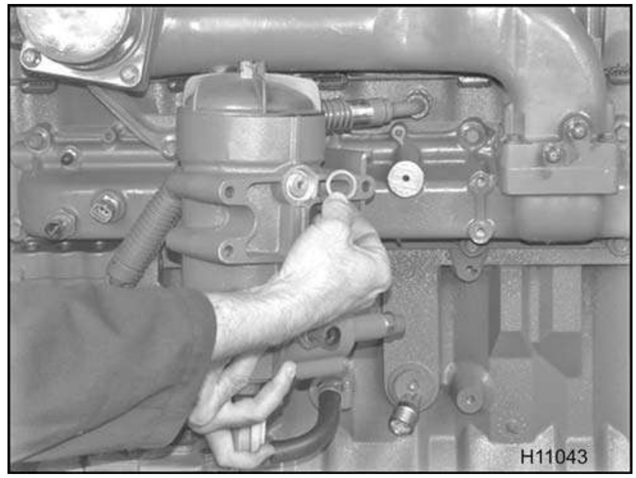


Figure 573 Installing the fuel filter outlet gasket

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.

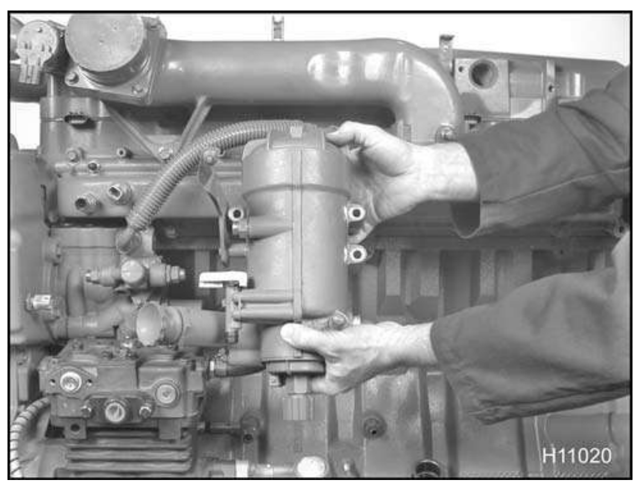


Figure 574 Installing fuel filter header

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

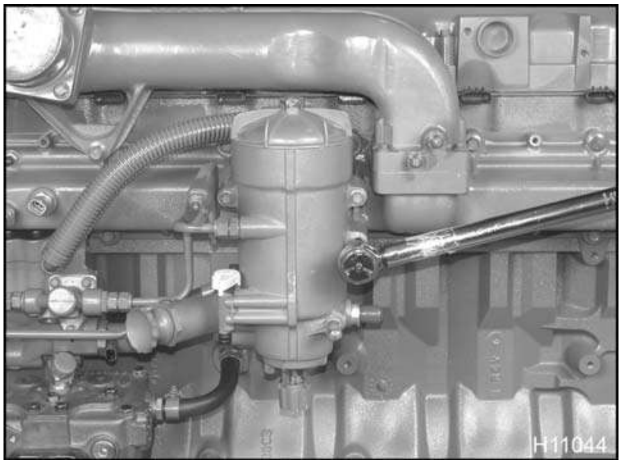


Figure 575 Fuel filter mounting bolts

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

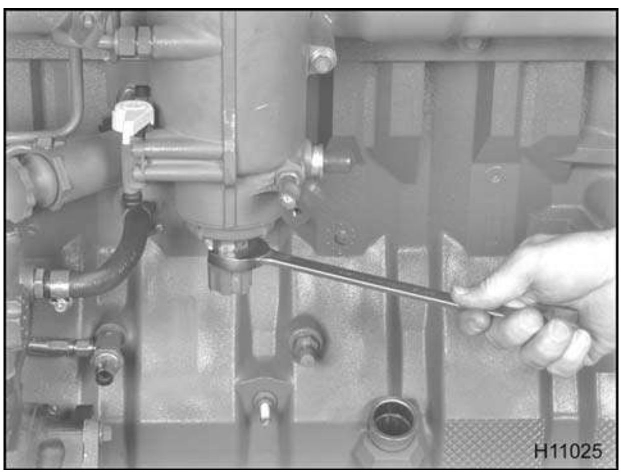


Figure 576 Installing the fuel strainer

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).

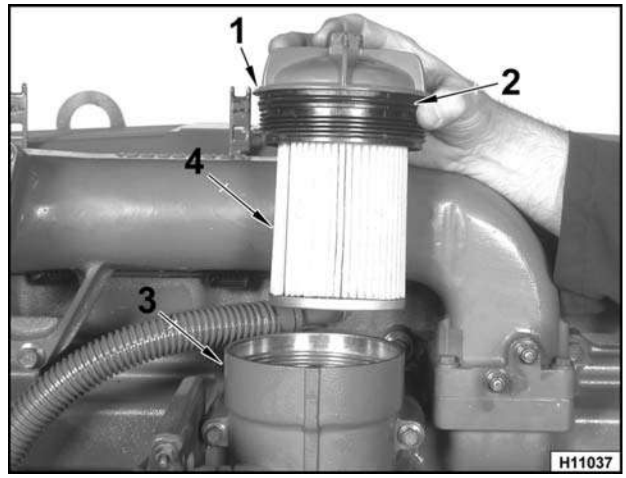


Figure 577 Installing the fuel filter

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.

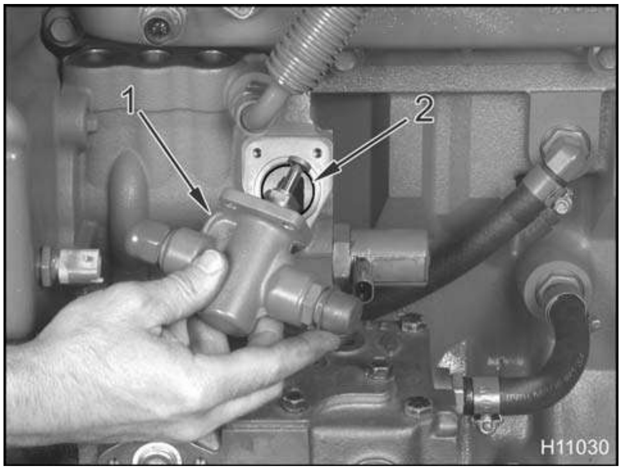


Figure 578 Installing the low-pressure fuel supply pump

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).

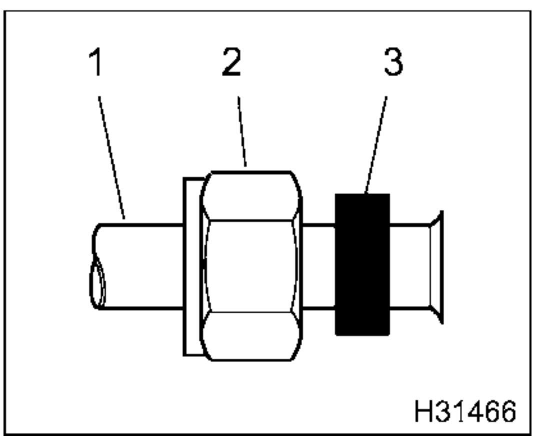


Figure 579 Position of tube sleeve on fuel line ends

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).

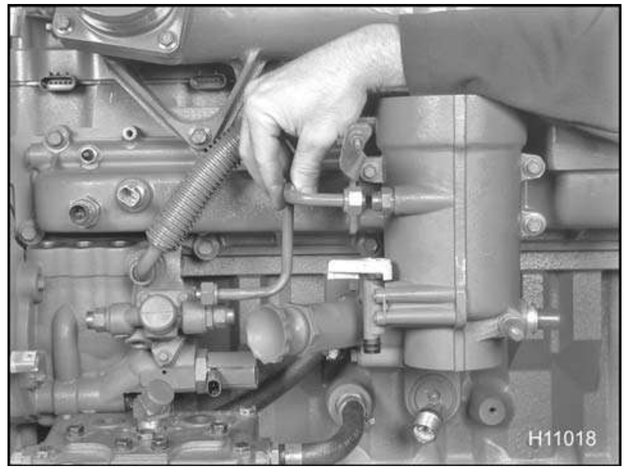


Figure 580 Connecting the transfer pump outlet tube assembly

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

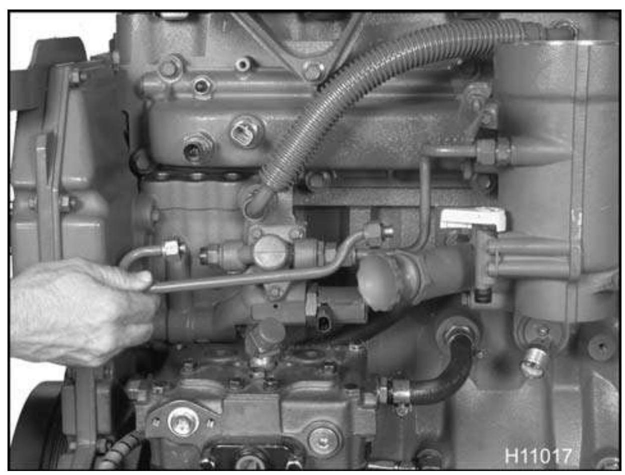


Figure 581 Connecting fuel lines

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

Priming Fuel System after Out of Fuel

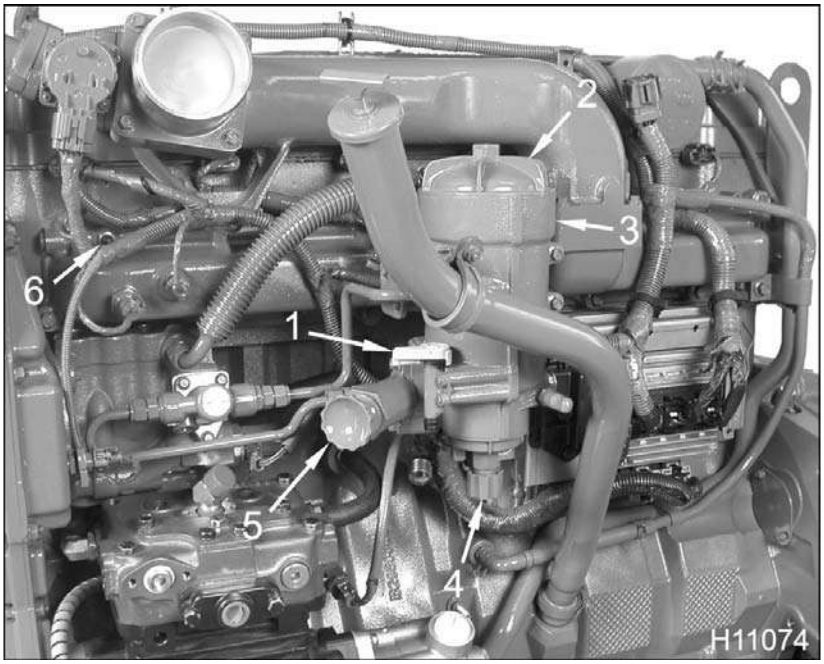


Figure 582 Fuel filter components and fuel valve assembly

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*.

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)

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

Table of Contents

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.

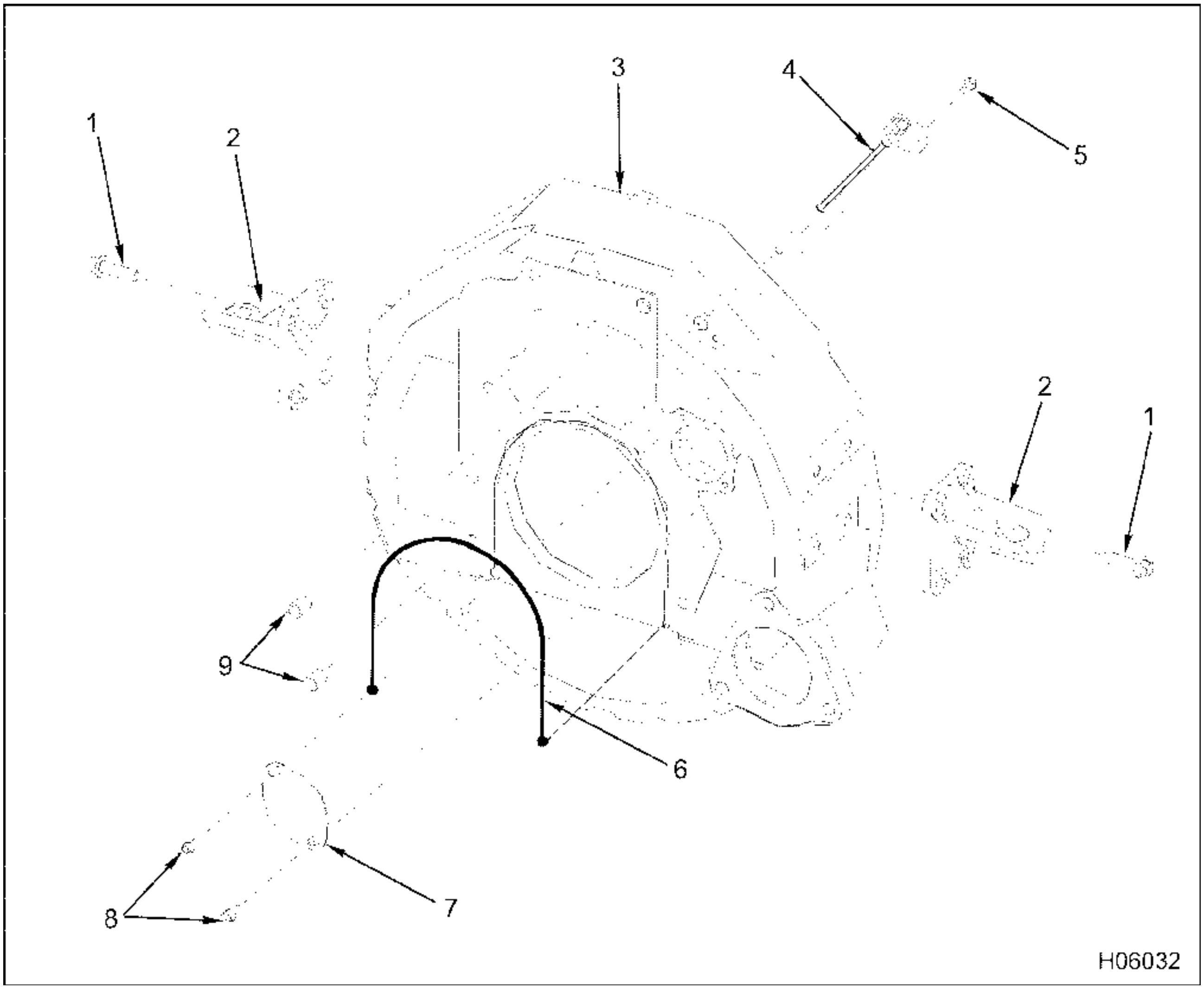


Figure 583 Flywheel housing and related parts

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)

Flywheel and Flexplate Applications

Manual Transmissions

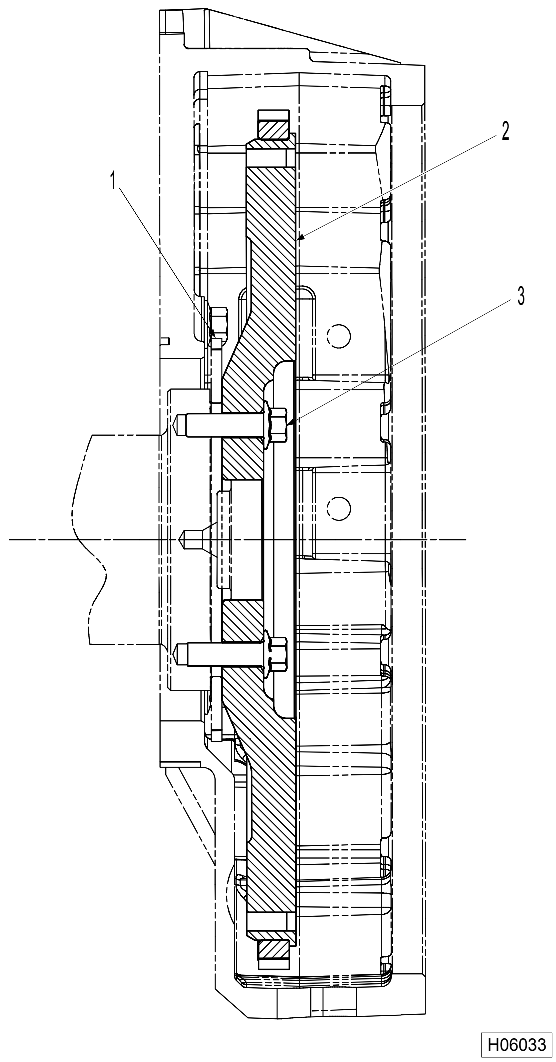


Figure 584 14 inch flywheel - for multiple plate clutch applications, 800 lbf·ft and below

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

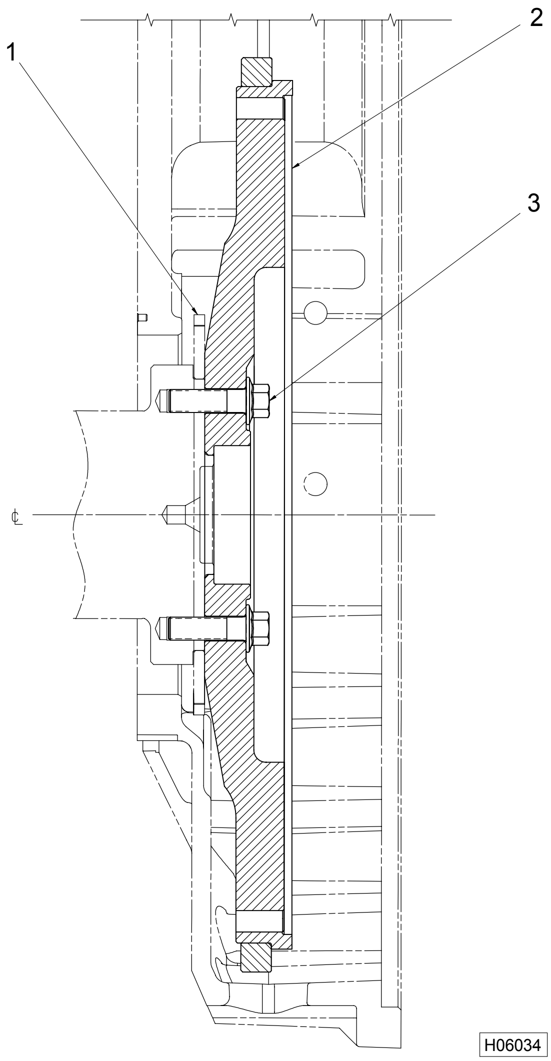


Figure 585 15.5 inch flywheel - for multiple plate clutch applications, 800 lbf·ft and above

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

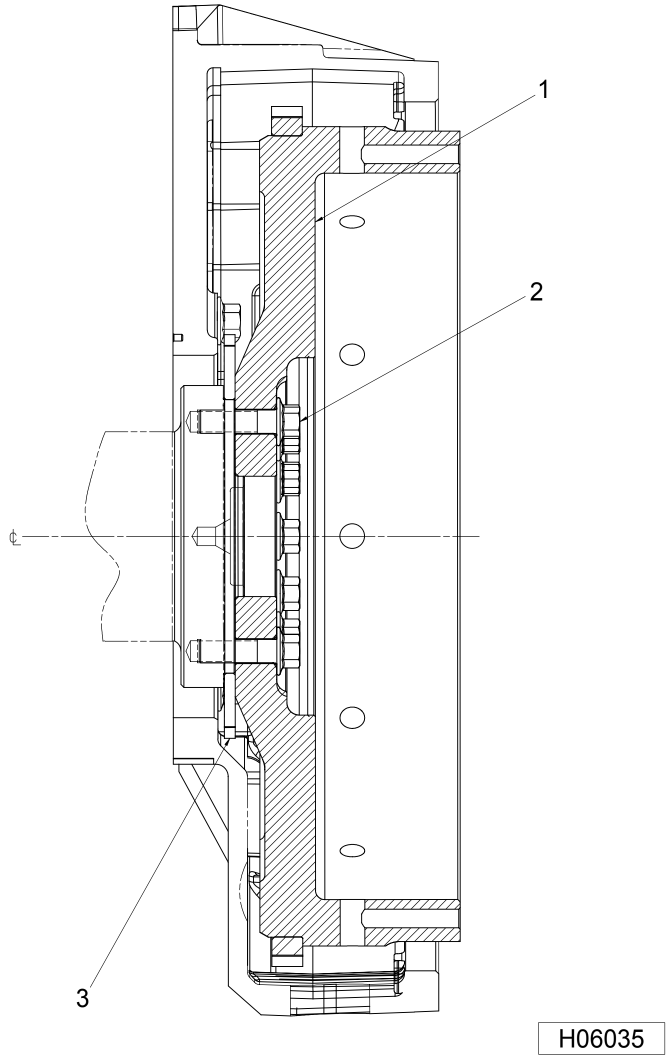


Figure 586 Pot type flywheel – for multiple plate clutch applications, 800 lbf·ft and above

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

Automatic Transmissions

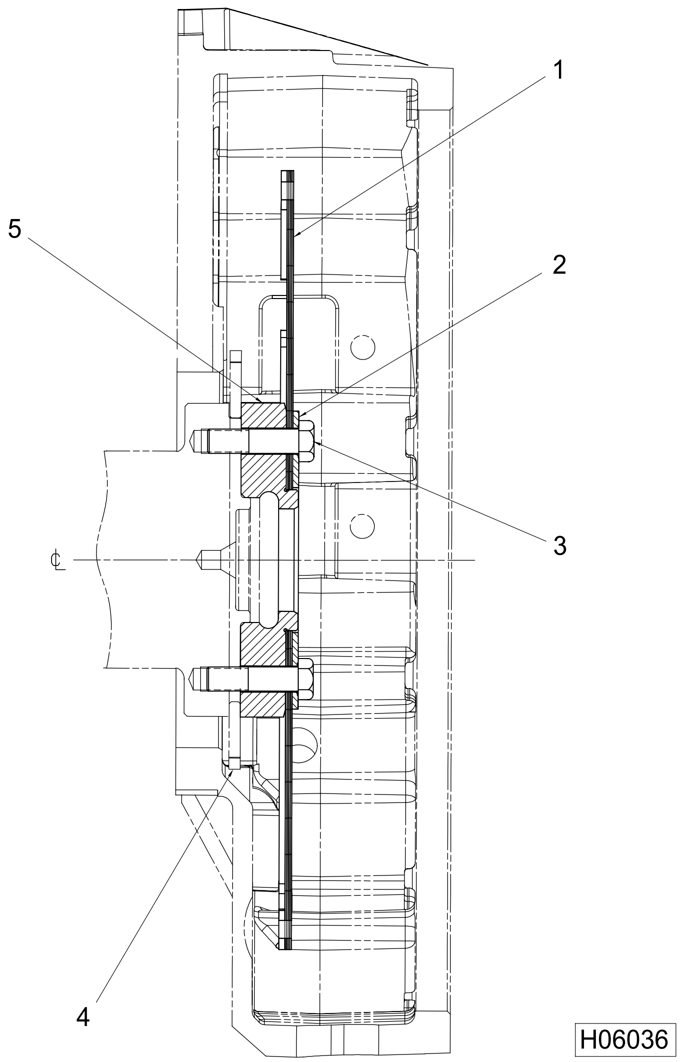


Figure 587 Application for Allison World Transmissions - MD-3060, MD-3560

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

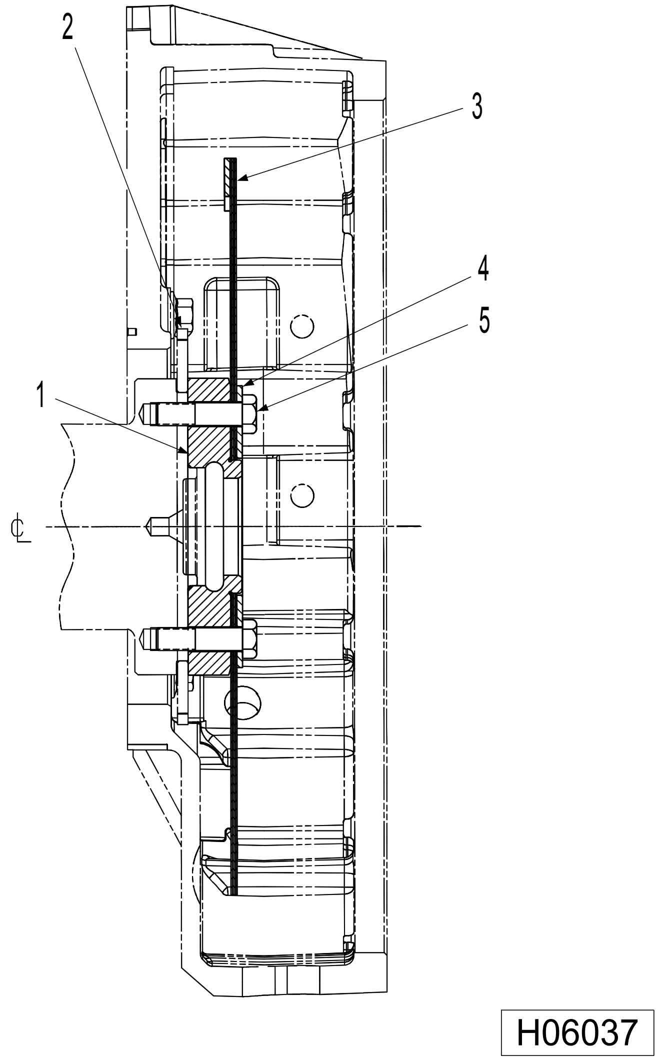


Figure 588 Application for Allison World Transmission - HD-4000

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

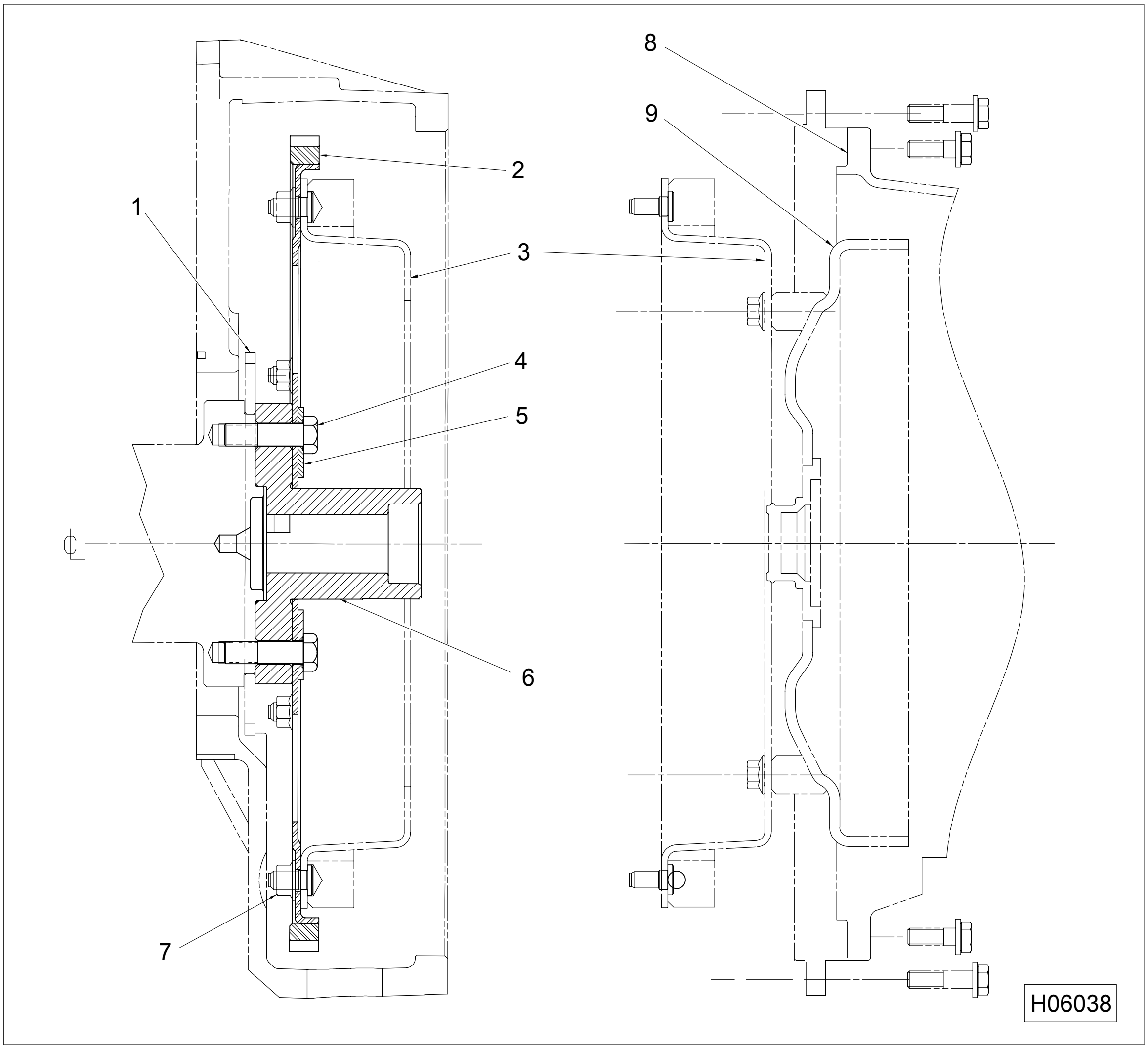


Figure 589 Application for Allison transmissions - 2000 through 2400 Series

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

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).

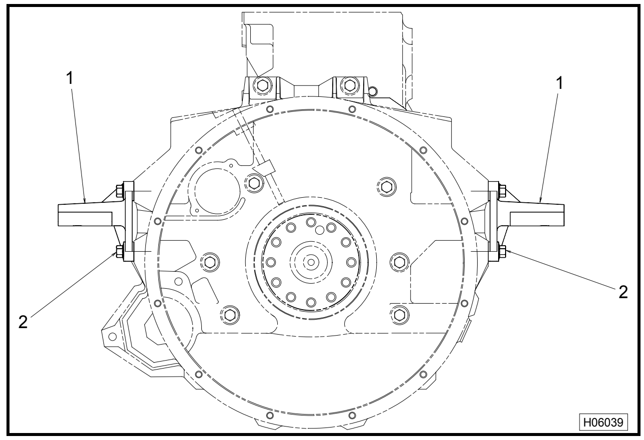


Figure 590 Loosening engine mounting bolts (148–tooth ring gear only)

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.

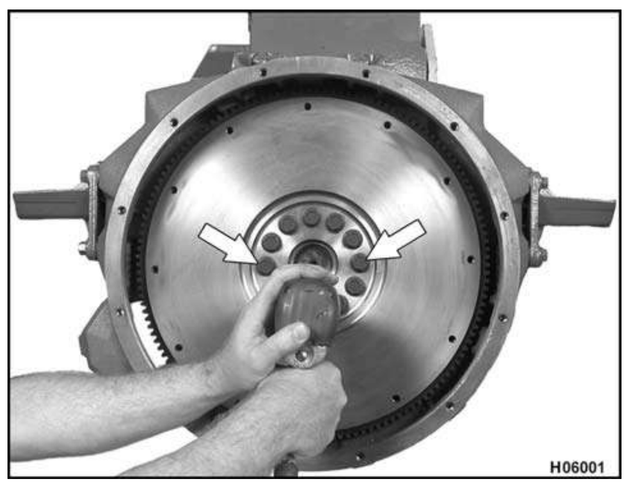


Figure 591 Removing flywheel mounting bolts

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.

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

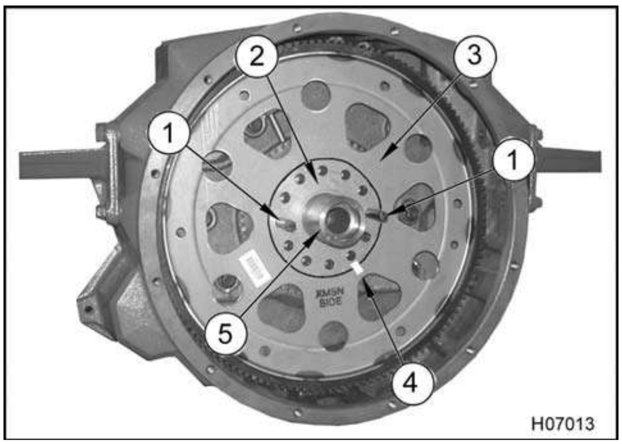


Figure 592 Removing flexplate (Allison 2000 Series Transmission)

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

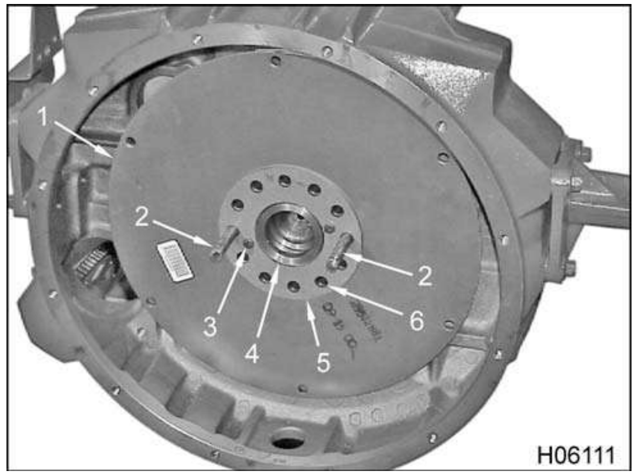


Figure 593 Removing flexplate (MD-3000 and HD-4000 Series Transmissions)

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.

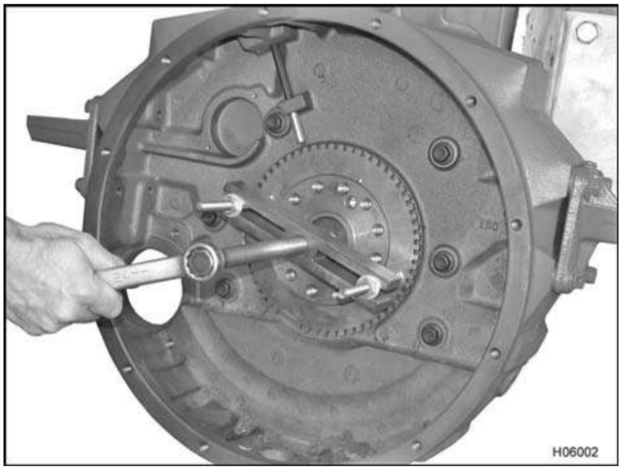


Figure 594 Removing the crankshaft timing disk

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

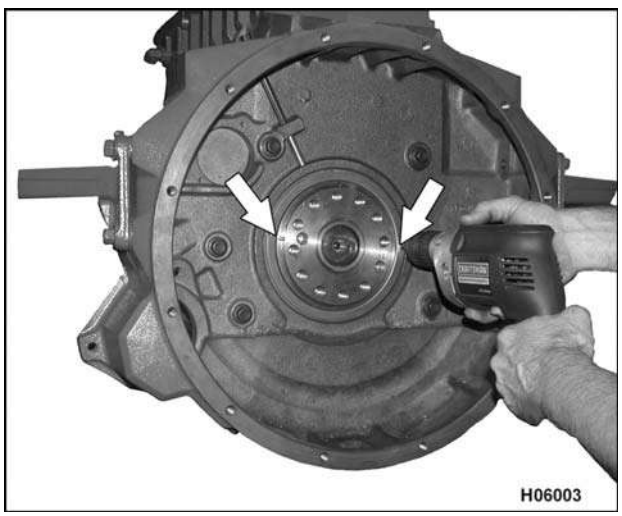


Figure 595 Drilling holes in the rear oil seal

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.

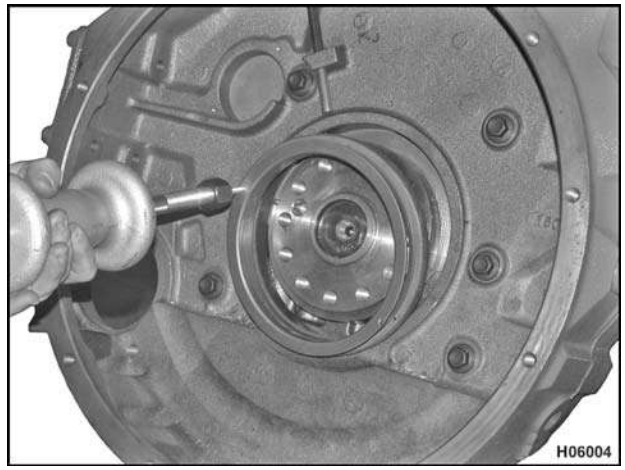


Figure 596 Removing the rear oil seal

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.

Inspection

Flywheel Housing Face Runout

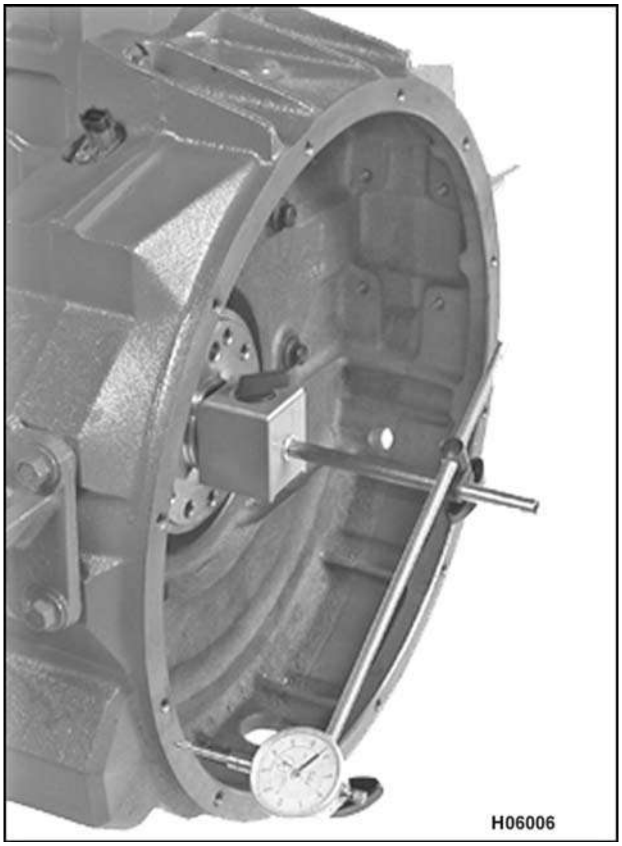


Figure 597 Flywheel housing face runout

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

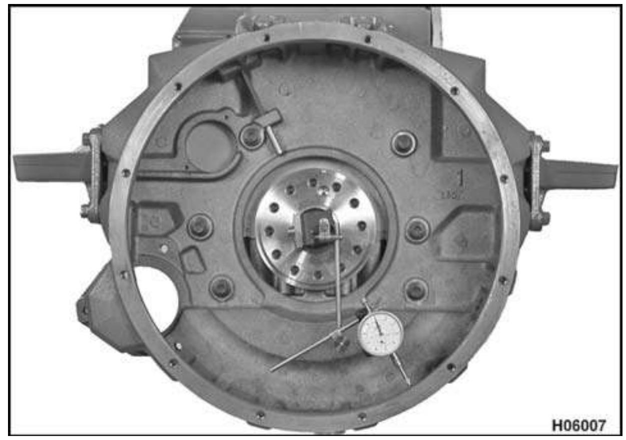


Figure 598 Flywheel housing bore concentricity

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

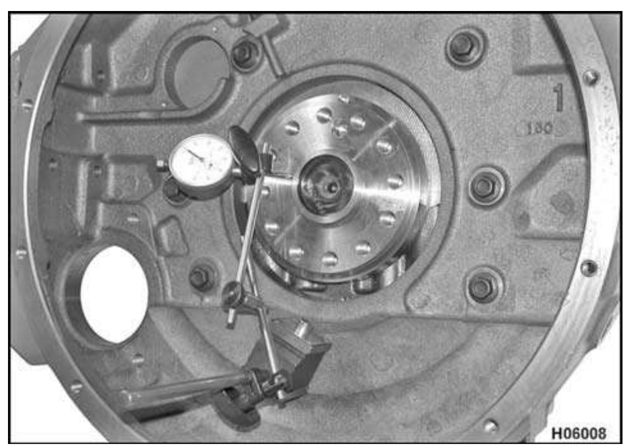


Figure 599 Crankshaft pilot concentricity

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.

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.

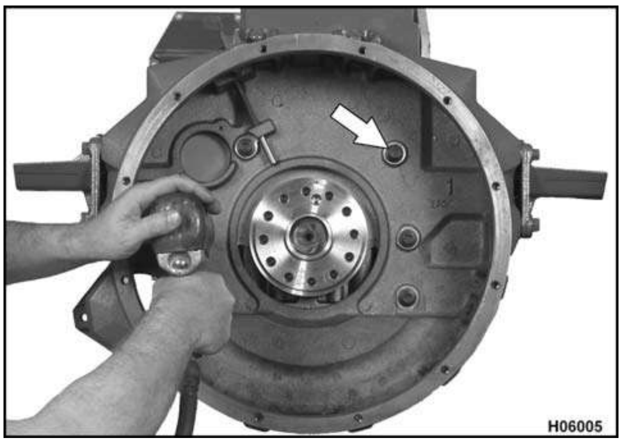


Figure 600 Removing flywheel housing mounting bolts

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.

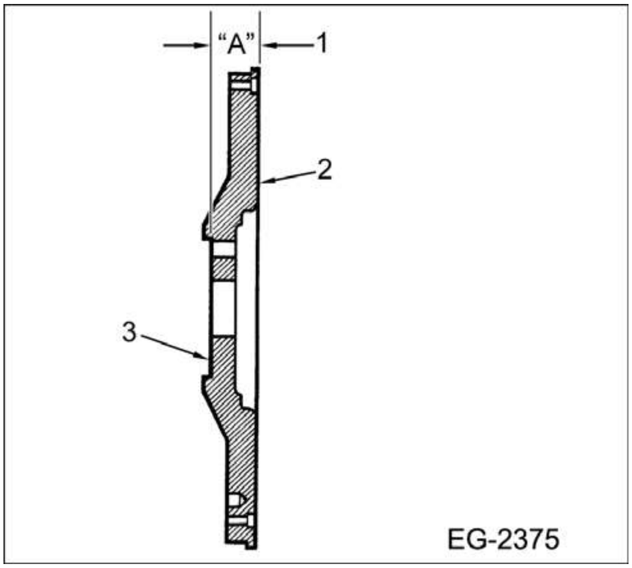


Figure 601 Flywheel reconditioning

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).

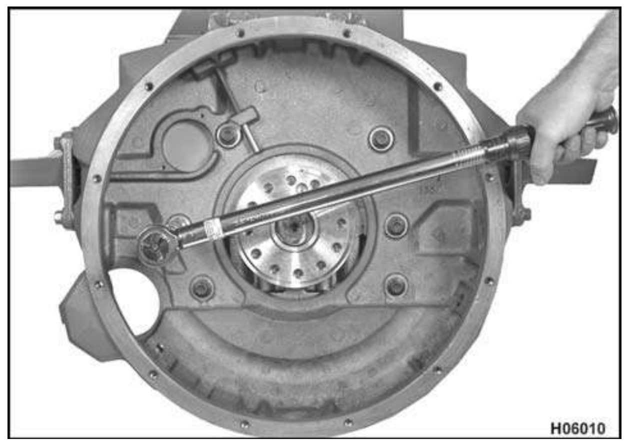


Figure 602 Torquing flywheel housing mounting bolts

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.

Rear Oil Seal

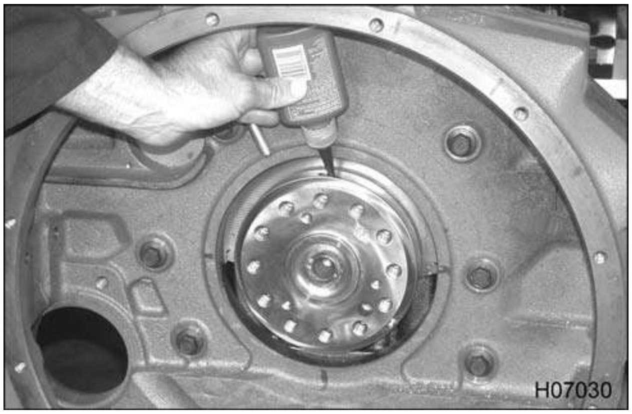


Figure 603 Applying sealant to the crankshaft and seal assembly

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

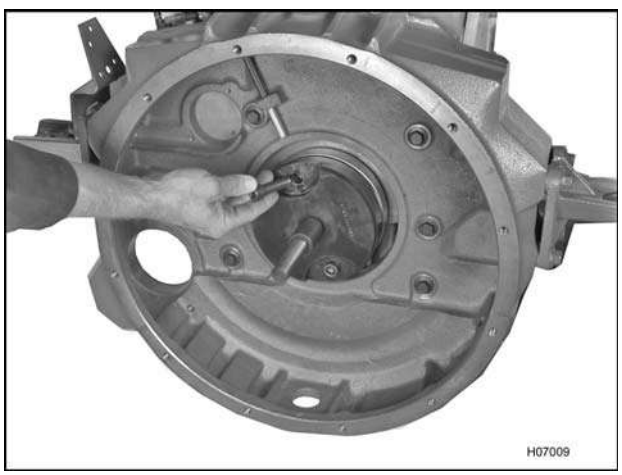


Figure 604 Installing the rear oil seal installer base

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

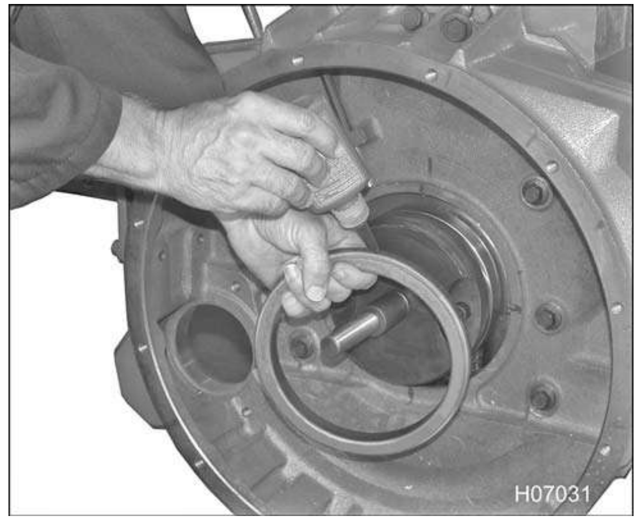


Figure 605 Applying sealant to the seal assembly

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

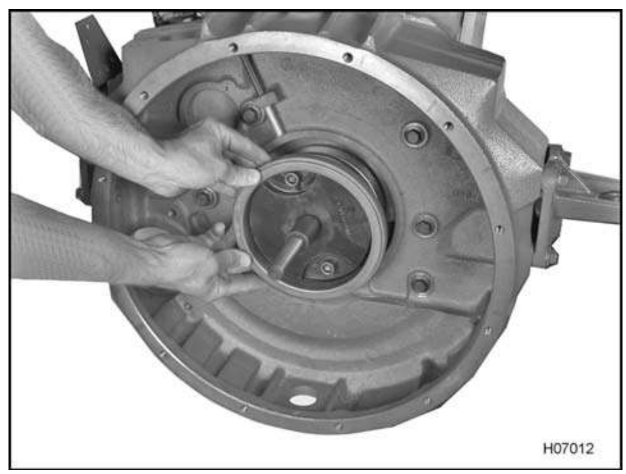


Figure 606 Placing oil seal onto rear oil seal installer base

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

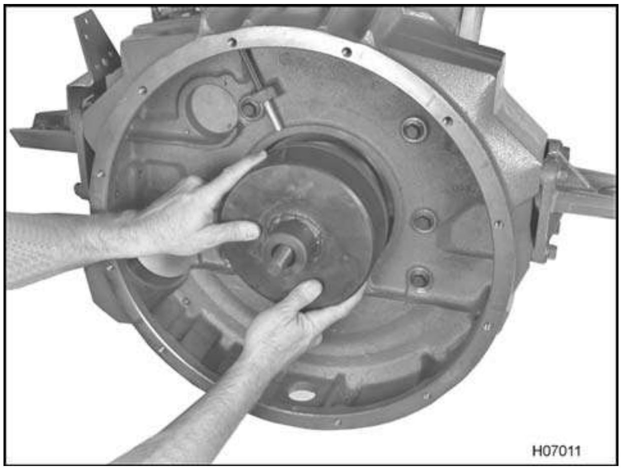


Figure 607 Installing rear oil seal installer onto base

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

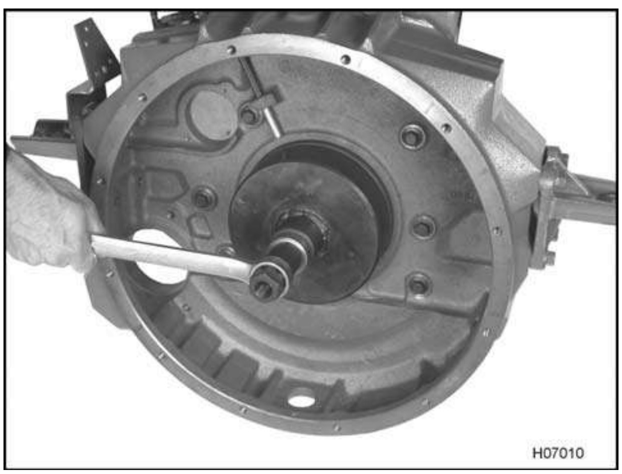


Figure 608 Installing the rear oil seal

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).

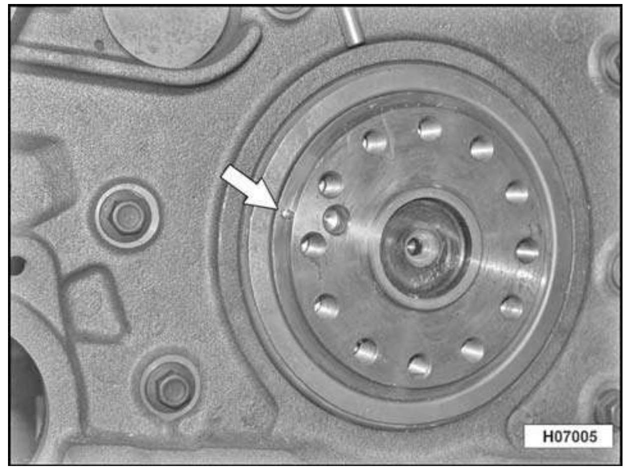


Figure 609 Crankshaft timing disk alignment dowel

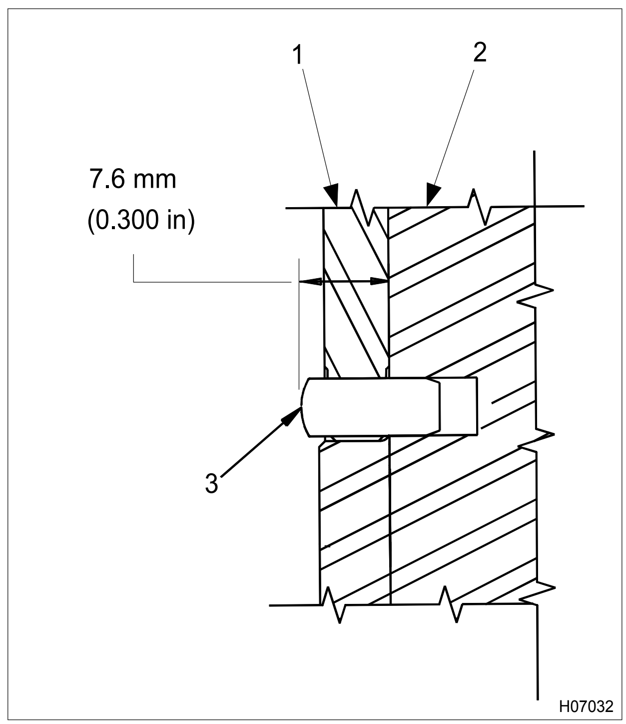


Figure 610 Crankshaft timing disk alignment dowel details

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

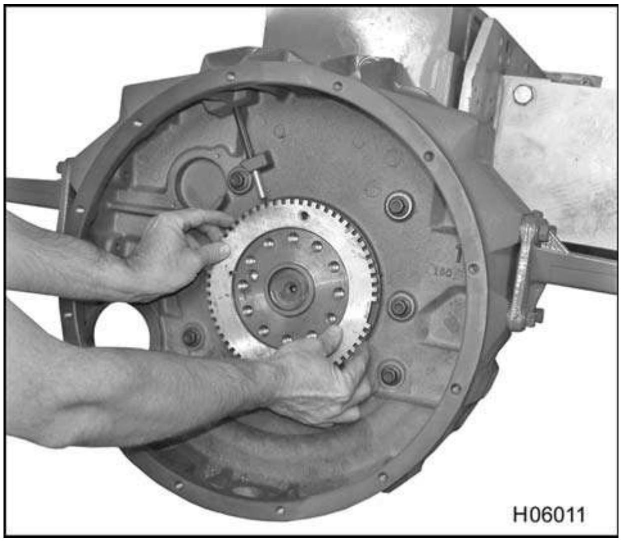


Figure 611 Installing the crankshaft timing disk

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

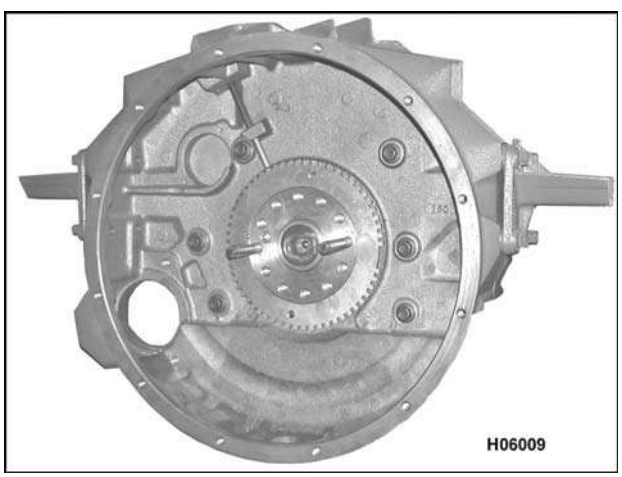


Figure 612 Installing guide pins

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.

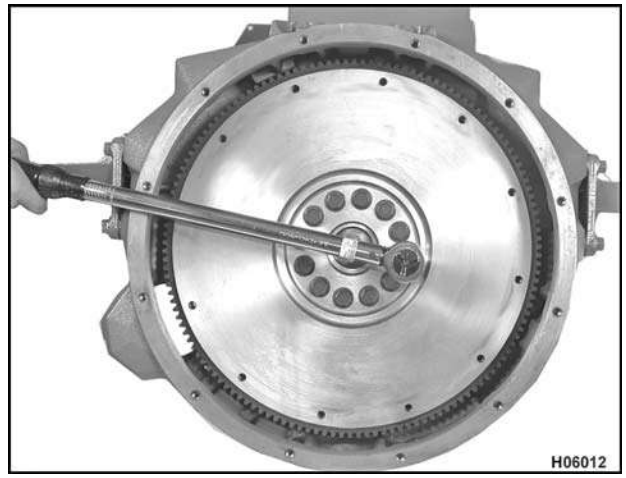


Figure 613 Torquing the flywheel mounting bolts

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).

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.

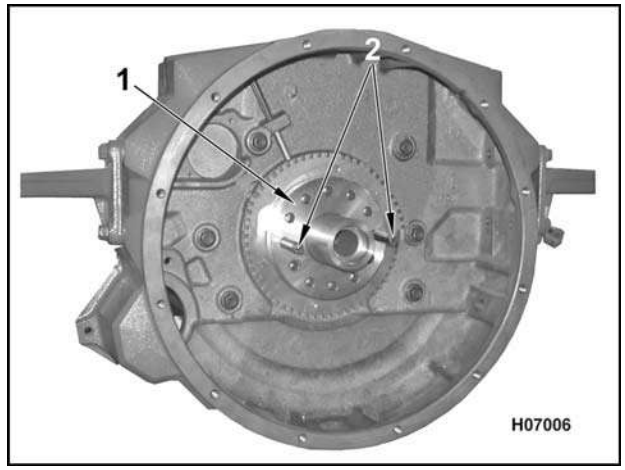


Figure 615 Installing guide pins and adapter hub

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.

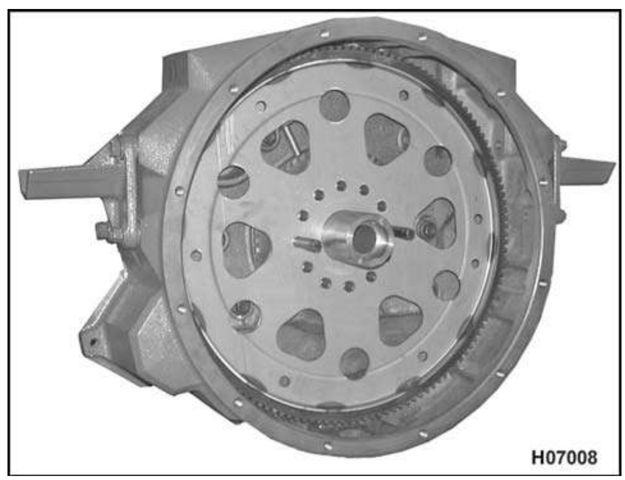


Figure 616 Installing the flexplate

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.

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.

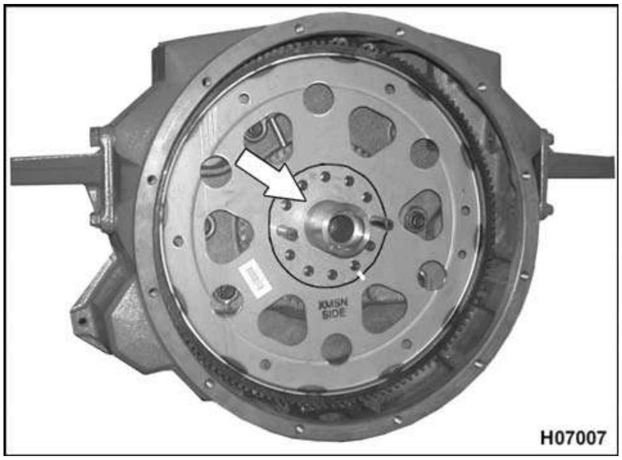


Figure 617 Installing reinforcement ring with paint mark

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

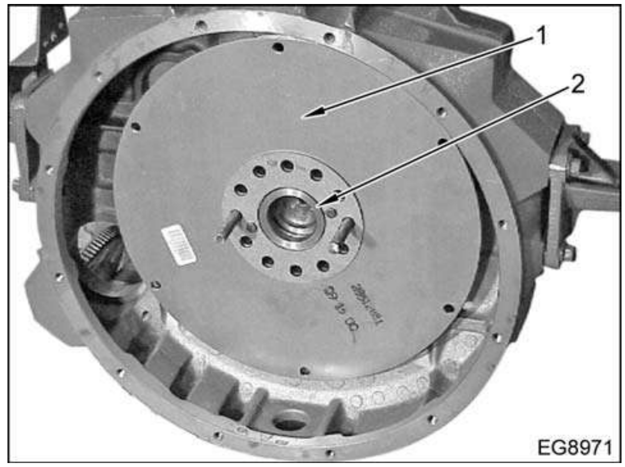


Figure 618 Installing the flexplate assembly

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).

Specifications

Table 49 Flywheel and Flywheel Housing Specifications

Flywheel housing:	
Flywheel housing bore concentricity	SAE # 1 = 0.30 mm (0.012 in)
	SAE # 2 = 0.28 mm (0.011 in)
Flywheel housing face runout	SAE # 1 = 0.30 mm (0.012 in)
	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.	

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

Table of Contents

Brake Specific High-pressure Oil Rail Assembly

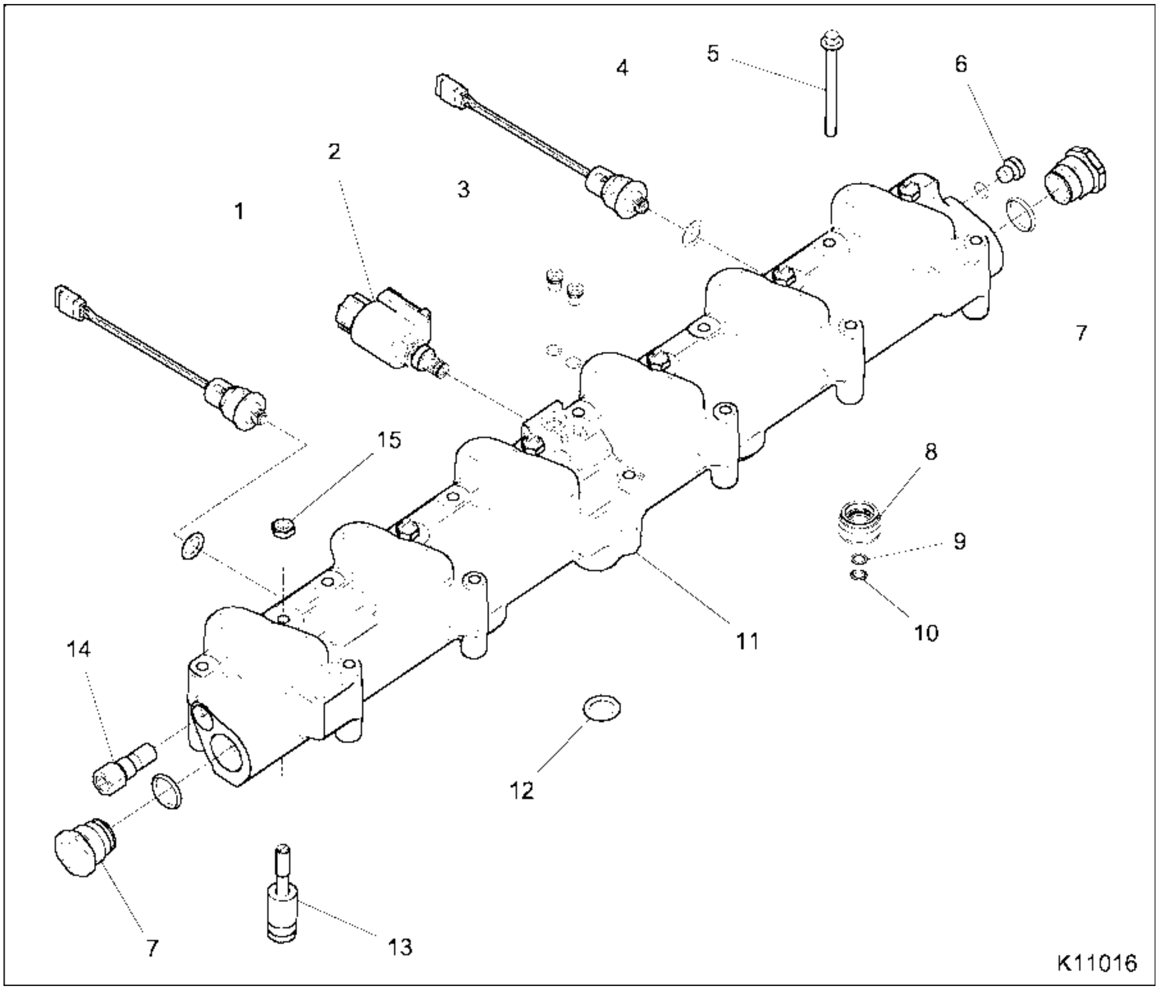


Figure 619 Brake specific high-pressure oil rail assembly

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)

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.

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

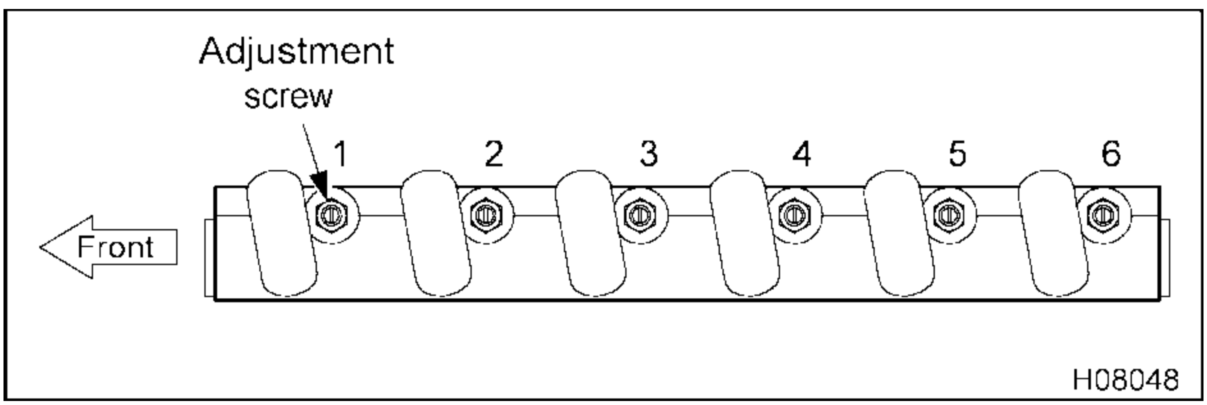


Figure 620 Brake lash adjustment

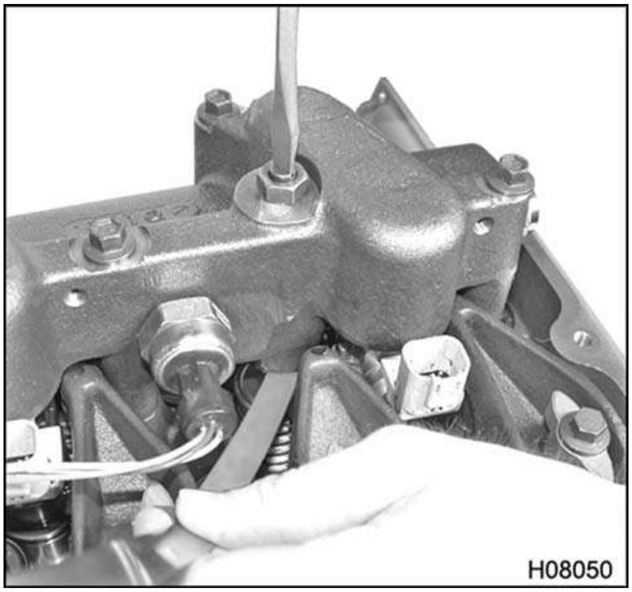


Figure 621 Measure between valve bridge and brake actuator

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.

Brake Shutoff Valve

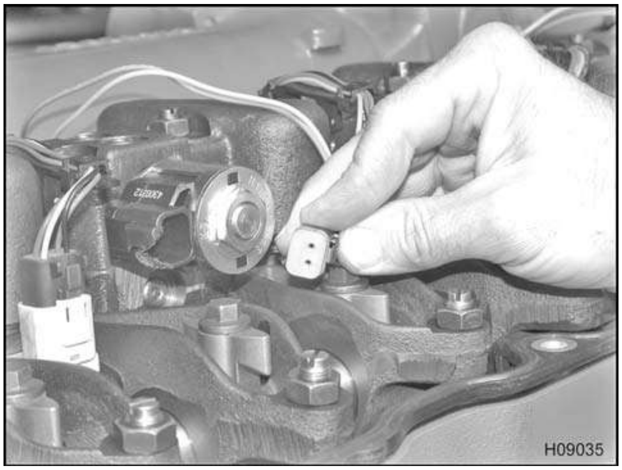


Figure 622 Disconnecting brake shutoff valve

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

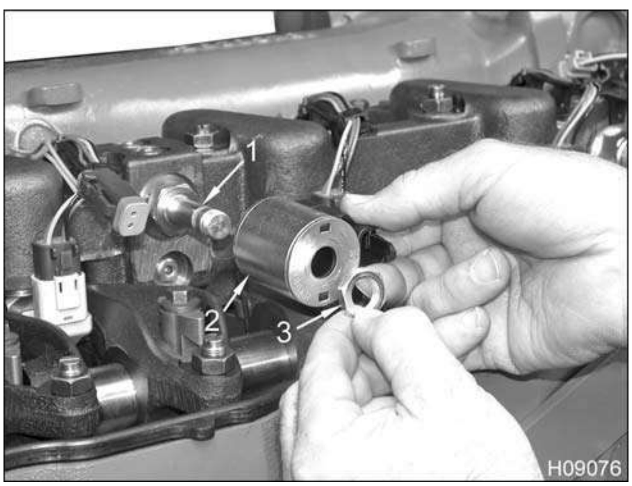


Figure 623 Brake shutoff valve assembly

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

2. Remove Tinnerman nut and solenoid.

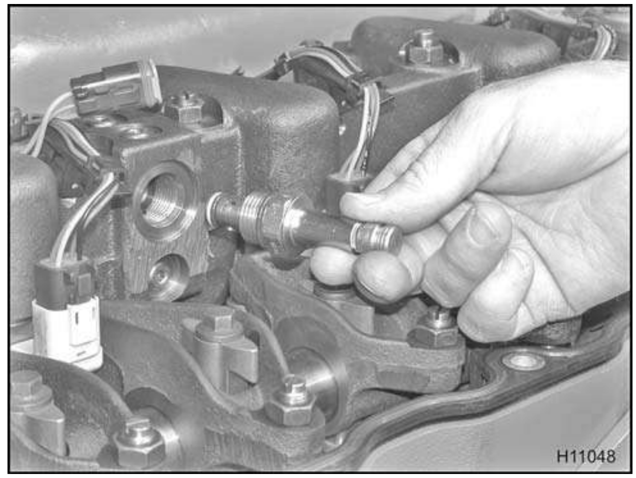


Figure 624 Brake shutoff valve

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).

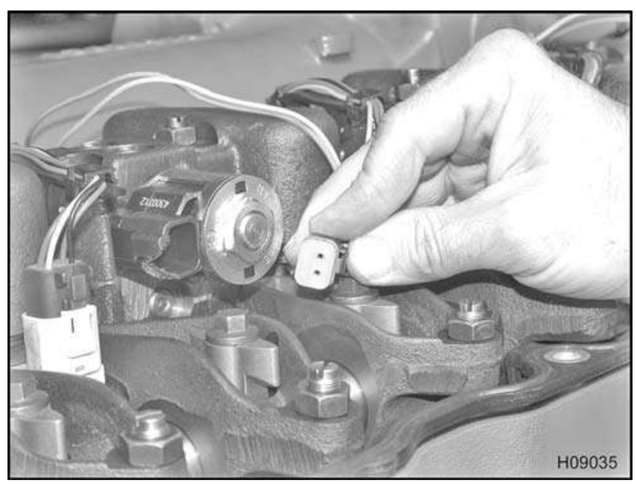


Figure 625 Connect brake shutoff valve

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

BCP Sensor

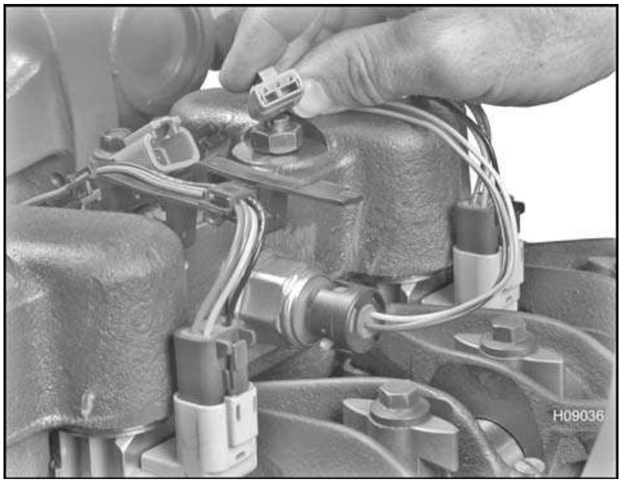


Figure 626 Disconnecting BCP sensor

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

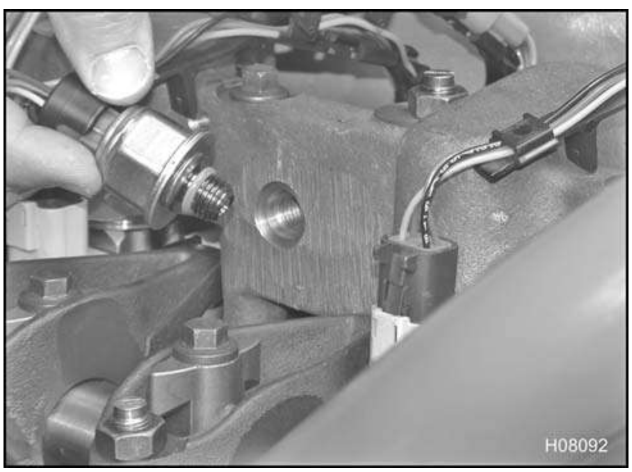


Figure 627 BCP sensor

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

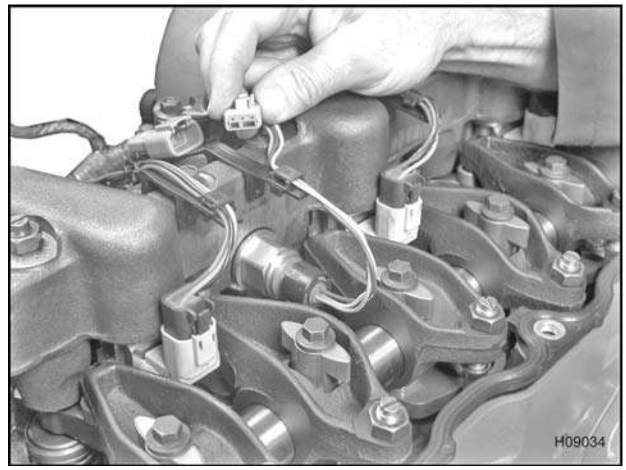


Figure 628 Disconnecting ICP sensor

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

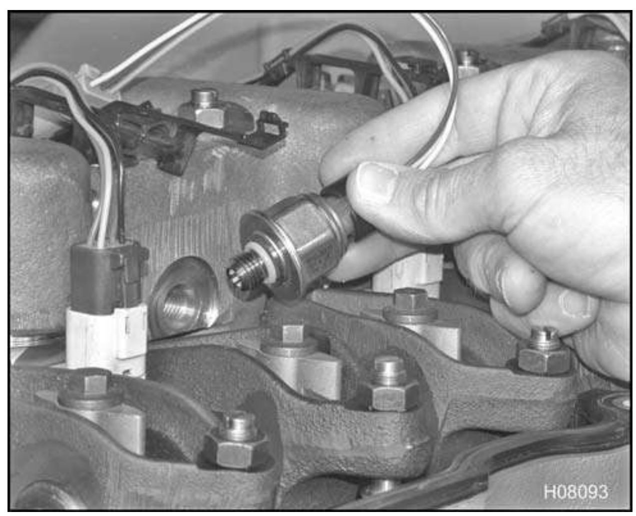


Figure 629 ICP sensor

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

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

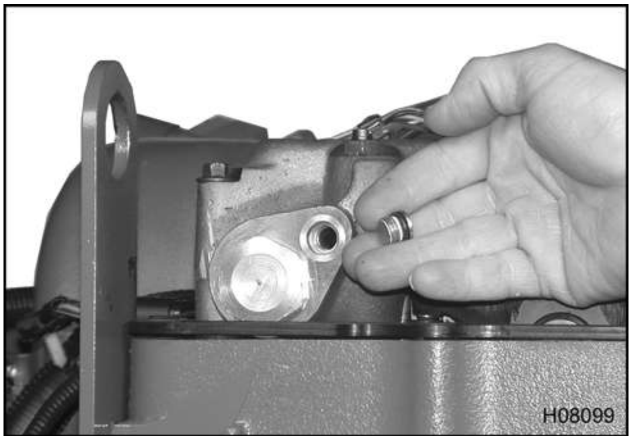


Figure 630 M12 Plug assembly,

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

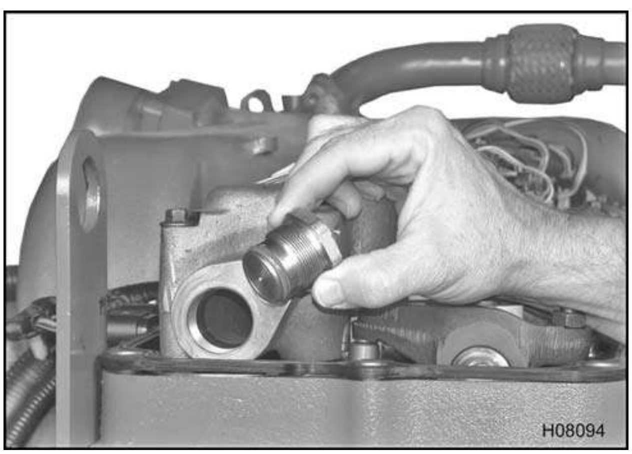


Figure 631 Rail end plug assembly

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

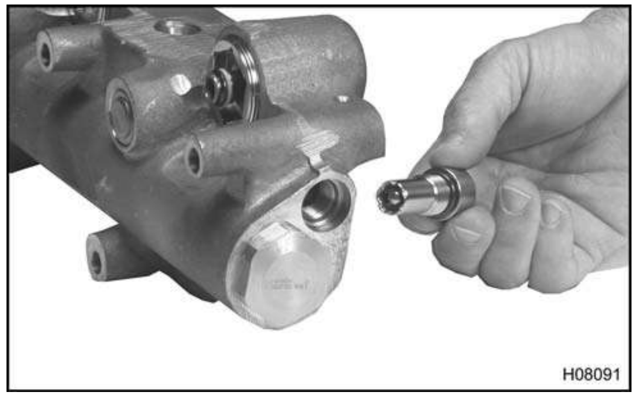


Figure 632 Oil pressure relief valve

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.

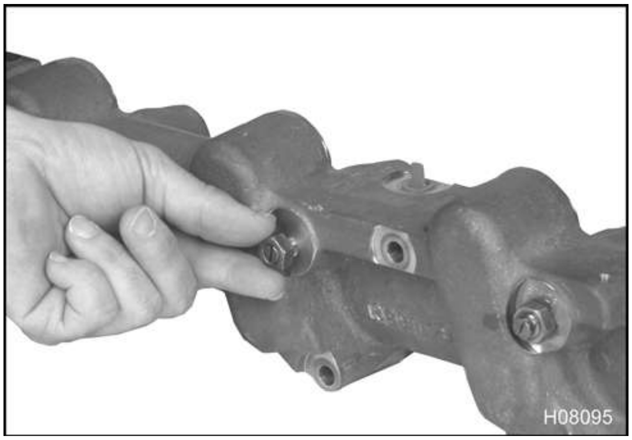


Figure 633 Brake actuator lash locknut

2. Remove brake actuator lash locknut.

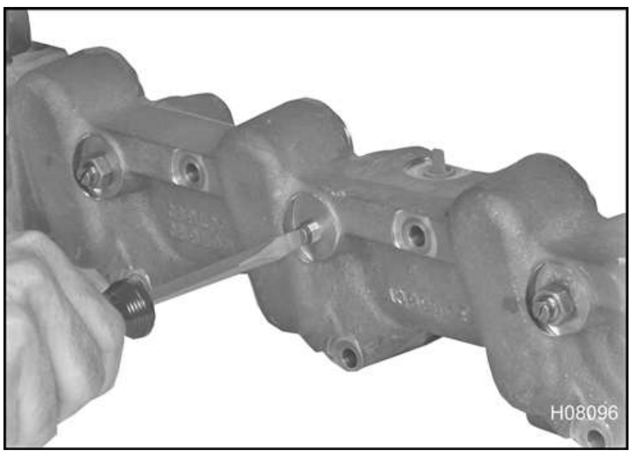


Figure 634 Removing brake actuator piston

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

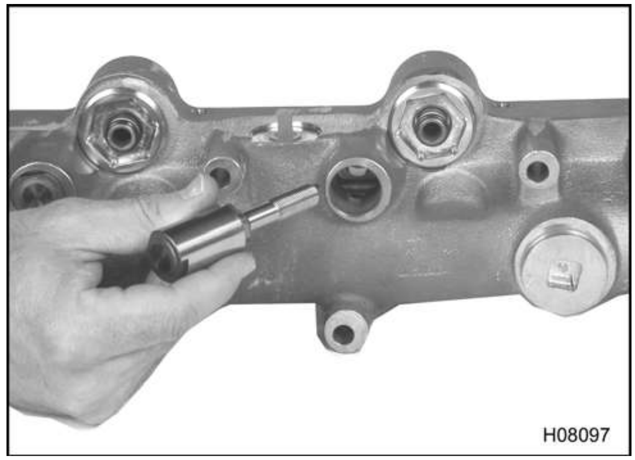


Figure 635 Brake actuator piston assembly

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.

Removal

Valve Cover

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

Electrical Connectors

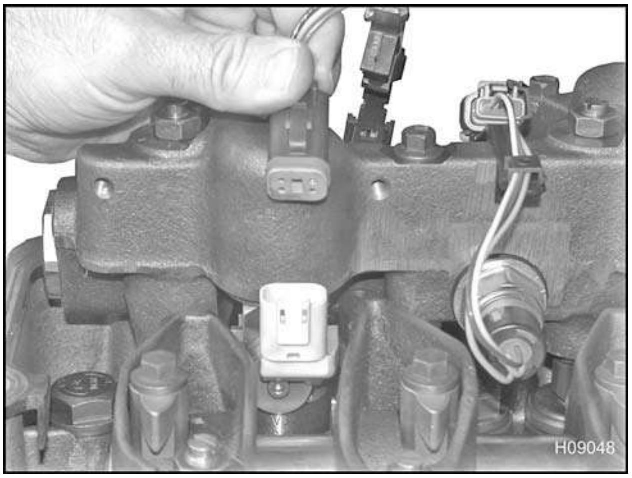


Figure 636 Injector electrical connector

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

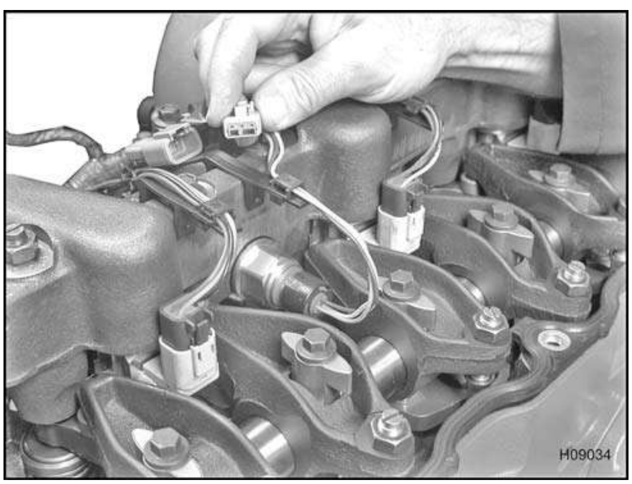


Figure 637 ICP sensor electrical connector

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

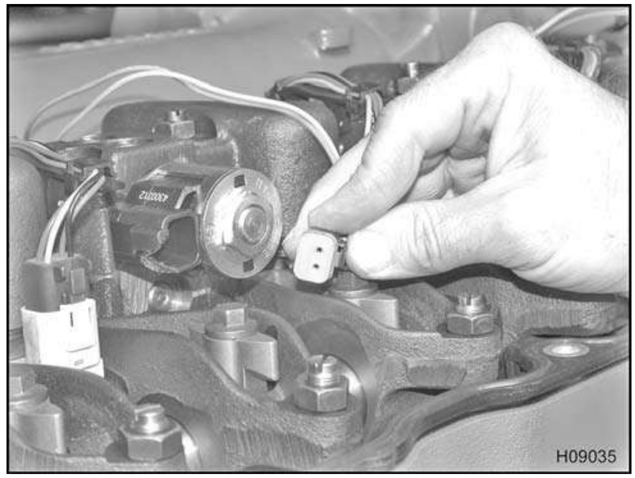


Figure 638 Brake shutoff valve assembly electrical connector

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

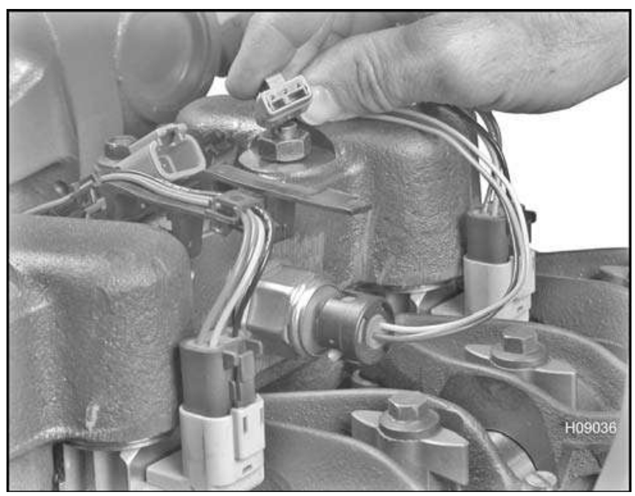


Figure 639 BCP sensor electrical connector

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.

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.

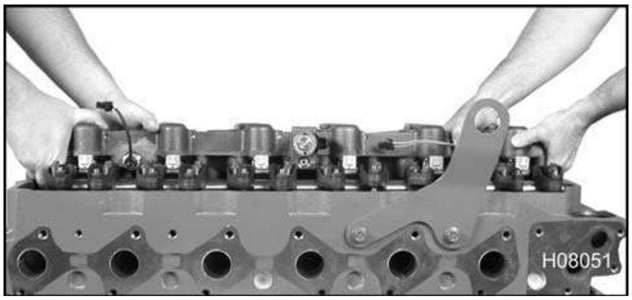


Figure 640 Removing the high-pressure oil rail

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.

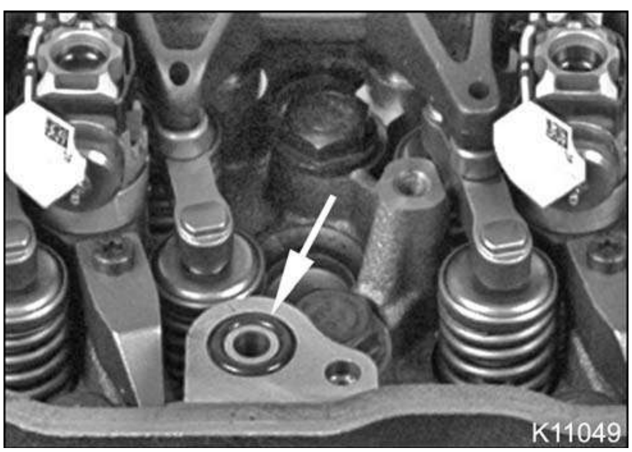


Figure 641 Oil inlet O-ring

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

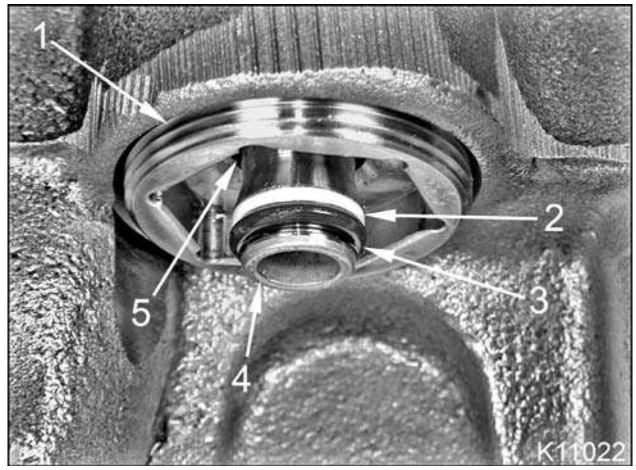


Figure 642 Injector oil inlet adapter installed in high-pressure oil rail

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.

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.

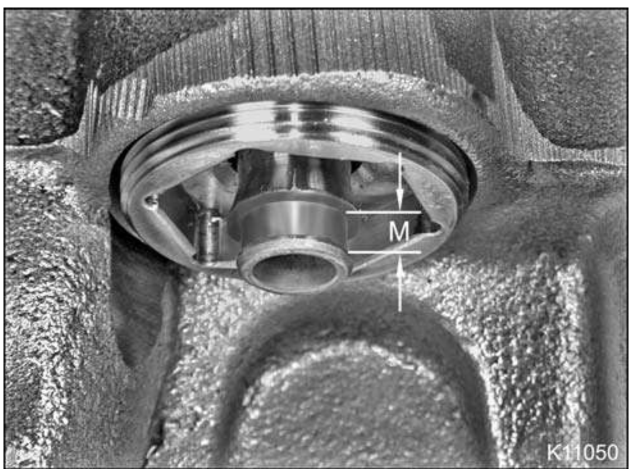


Figure 643 Groove Measurement (M) in injector oil inlet tube

3. Measure groove in the injector oil inlet tube.

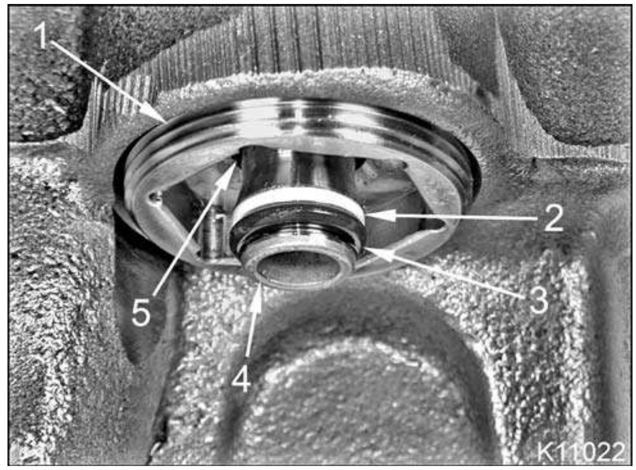


Figure 644 Injector oil inlet adapter installed in high-pressure oil rail

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.

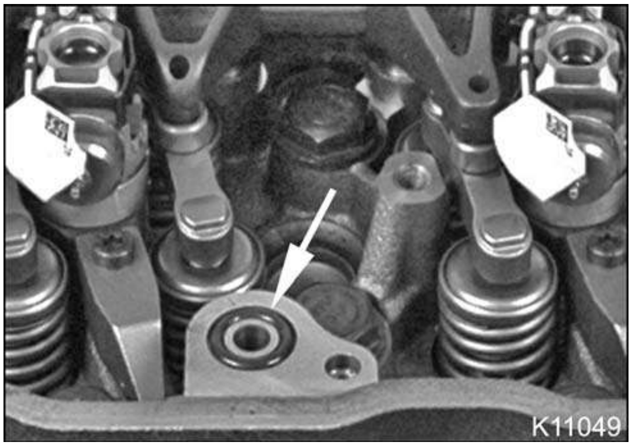


Figure 645 Oil inlet O-ring

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.

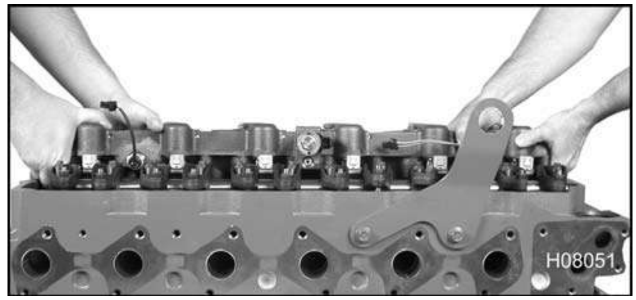


Figure 646 High-pressure oil rail

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

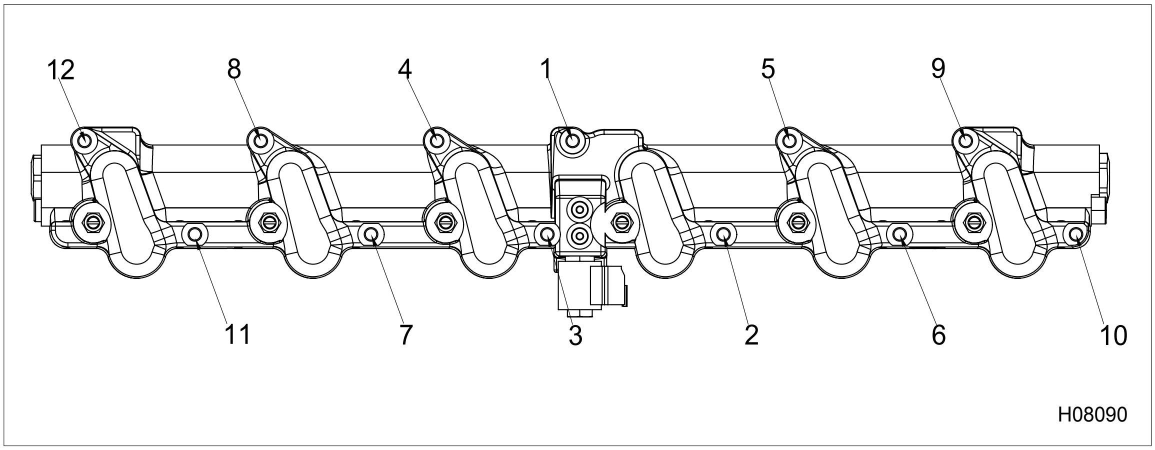


Figure 647 Torque sequence for high-pressure oil rail bolts

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

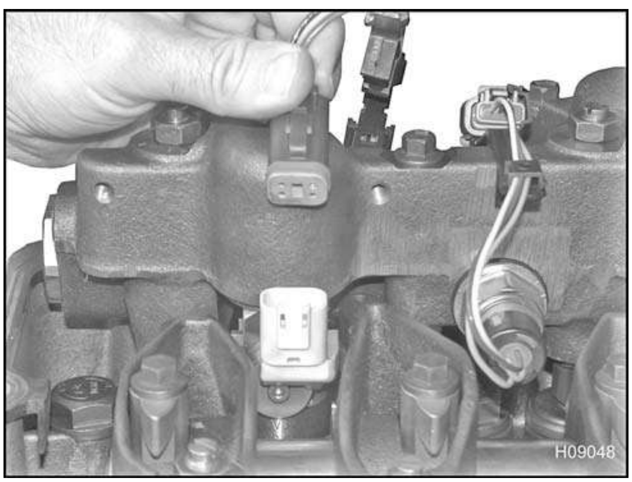


Figure 648 Injector electrical connector

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

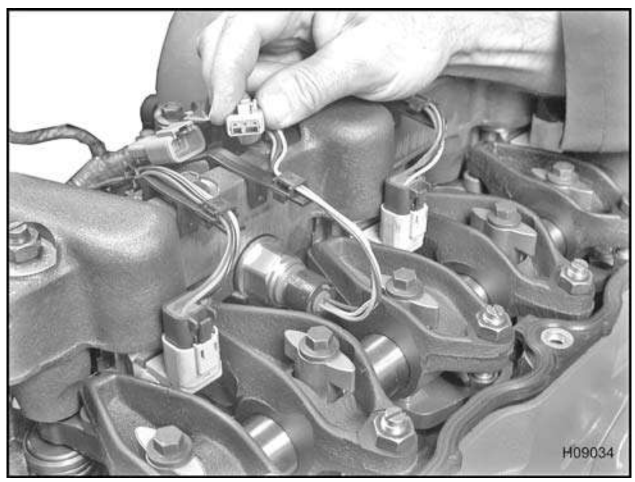


Figure 649 ICP sensor electrical connector

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

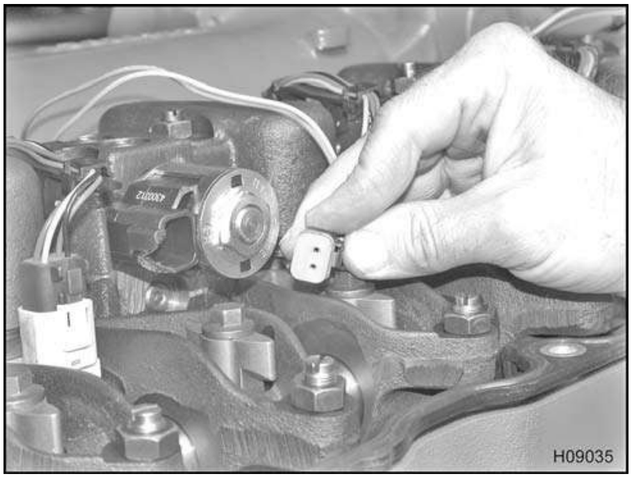


Figure 650 Brake shutoff valve assembly electrical connector

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

Figure 651 BCP sensor electrical connector

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.

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

Table of Contents

Description

The air compressor and power steering pump assemblies are optional on International® DT 466, DT 570 and HT 570 Diesel Engines. They can be configured individually or together depending on vehicle application requirements. A front cover mounted Power Take-off (PTO) devise can be used in conjunction with the air compressor.

AIR COMPRESSOR

Air for braking is supplied by an air compressor mounted on the lower left side of the engine. It is gear driven from the lower idler gear located within the front engine cover.

- Lubrication of the compressor is provided by a hose connected at the engine oil pressure sensor port with oil draining back to the crankcase through an elbow at the bottom of the compressor.
- Filtered air is furnished through an air hose connected to the air cleaner assembly, and compressed into a supply tank. When the air supply tank is full, compressed air is simply vented to the atmosphere.
- Coolant to the compressor is supplied and returned through two hoses to ports located on the left side of the engine crankcase.

POWER STEERING PUMP

The power steering pump assembly is mounted in one of two following configurations:

A. **Without** an air compressor, the power steering pump is mounted onto rear half of the front cover and is driven by the lower idler gear that would normally drive the air compressor.

B. **With** an air compressor, the power steering pump is mounted to the air compressor. The compressor is driven by the lower idler gear and power is transferred through the compressor crankshaft to drive the power steering pump.

NOTE: For component service procedures other than removal and installation refer to the **International Service Information Solutions - ISIS®** and then select manufacturer from suppliers tab.

POWER TAKE-OFF

A front cover mounted Power Take-off (PTO) devise can only be used in conjunction with an air compressor. See (1171813R1 Front Cover PTO Adaptation Kit, page487) .

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, 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.

NOTE: Air compressor and power steering pump may be removed as an assembly depending on servicing circumstances.

Air Compressor

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, do the following before removing the air compressor because of its heavy weight and possibly high temperature. Wait until the air compressor cools down. Also, it is advised to have two people remove the air compressor and power steering pump combination from the engine, especially in chassis.

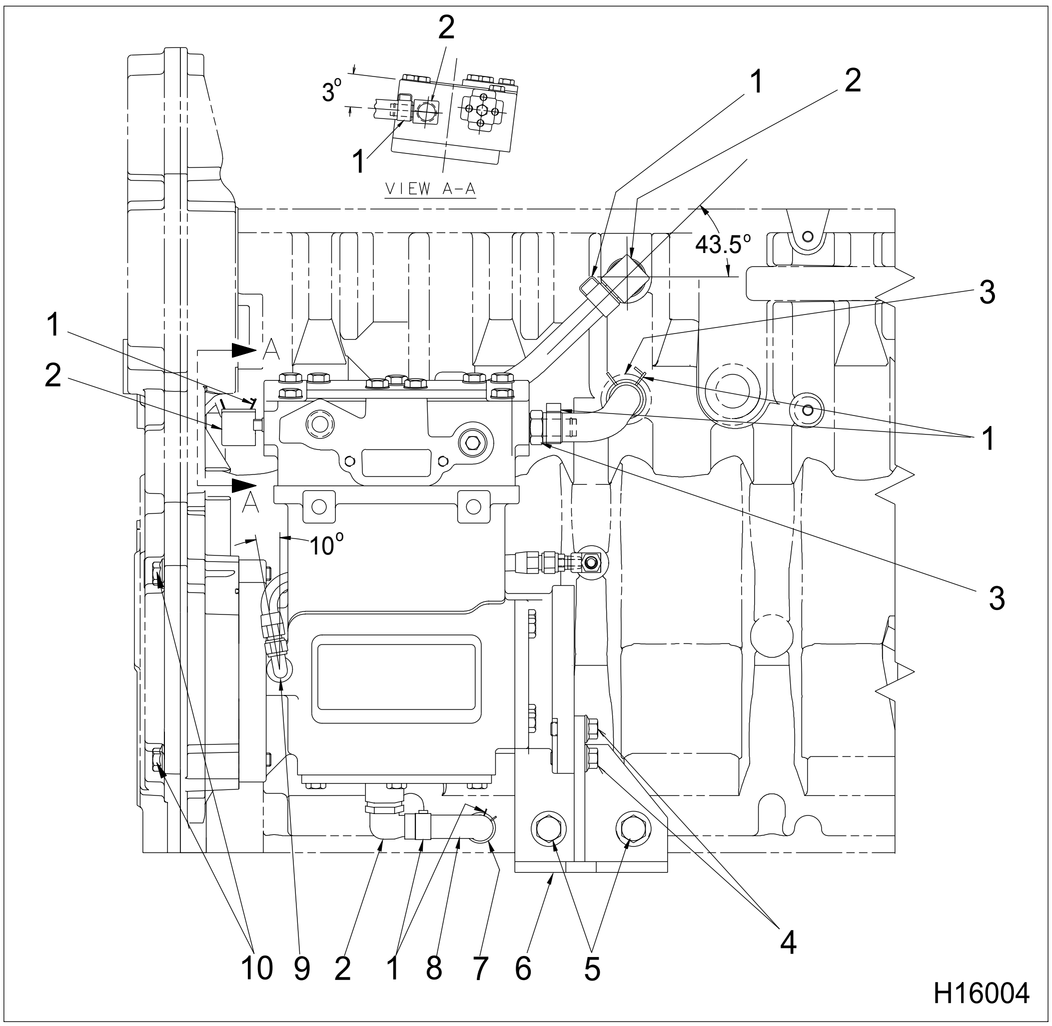


Figure 652 Air compressor mounting and connections

1. Hose clamps (6)
2. Elbow assembly, M18 (3)
3. Connector assembly, M18 (2)
4. Support bracket bolts (to compressor), M10 x 25 (2)
5. Support bracket bolts (to crankcase), M12 x 25 (2)
6. Air compressor support bracket assembly
7. Fitting (NPTF), 3/8 x 1/2
8. Drain hose elbow
9. Elbow assembly, M10 (oil supply)
10. Air compressor mounting bolts, M12 x 80 (2)

1. Place a coolant drain pan beneath air compressor bracket.
2. Loosen the coolant outlet hose clamp (from crankcase).
3. Loosen the coolant inlet hose clamp (to crankcase).
4. Remove hose ends from both crankcase fittings. Cap and plug open fittings and hose ends to keep clean.
5. Disconnect oil supply line at air compressor. Cap line and fitting.
6. Disconnect oil drain hose elbow and clamps.
7. Remove two bolts (M12 x 80) and nuts (M12) securing compressor to front cover.
8. Support weight of air compressor and remove two air compressor support bracket bolts (M12 x 25). Lift air compressor and bracket assembly from engine.
9. Place air compressor and bracket onto work bench.
10. Remove and discard air compressor gasket.
11. Remove remaining two bracket bolts attached to air compressor (M10 x 25) (Figure 652).

Power Steering Pump

1. Disconnect the high-pressure hose at power steering pump.
2. Disconnect the low-pressure hose at power steering pump.
3. Cap oil lines to eliminate contamination.
4. Depending on application, do one of the following:
   - For applications with power steering pump attached to the rear of air compressor, remove two bolts (M10 x 35).
   - For applications with power steering pump attached to rear of the front cover, remove two bolts (M12 x 90 and nuts).
5. Remove gasket and discard.

Installation

Air Compressor

WARNING: To prevent serious personal injury, possible death, or damage to the engine or vehicle, do not attempt to install the air compressor alone. It is advised to have two people install the air compressor onto the engine.

1. On work bench, loosely install air compressor support bracket assembly (Figure 652) to the air compressor with two bolts (M10 x 25). Thread finger tight but do not tighten.
2. Apply a small amount of assembly grease to the O-ring and install into groove on front cover.
3. Install the air compressor and support bracket assembly onto front cover with two bolts (M12 x 80) and nuts. Tighten, but do not torque.
4. Loosely install two bolts (M12 x 25) through air compressor bracket into crankcase.
5. Torque all air compressor bolts in the following order:

   CAUTION: To prevent engine damage, do not over torque the air compressor mounting bolts. Over torquing bolts will result in a fractured front cover.

   a. Torque two compressor to front cover bolts (M12 x 80) to the special torque value (Table 57).

   b. Torque two compressor to bracket assembly bolts (M12 x 25) to the special torque value (Table 57).

   c. Torque two bracket assembly to crankcase bolts (M12 x 10) to the special torque value (Table 57).
6. Uncap coolant hoses and install onto elbow assembly (M18) and connector assembly (M18) fittings with hose clamps.

NOTE: If these fittings were removed from the crankcase or air compressor for any reason, they will require standard torque values (General Torque Guidelines, page 445) and need to be oriented to the correct angle (Figure 652) upon installation.

7. Remove caps and install oil supply hose to elbow assembly (M10) (Figure 652). Tighten oil supply line fitting.
8. Install oil drain hose elbow and clamps.

Power Steering Pump with Air Compressor

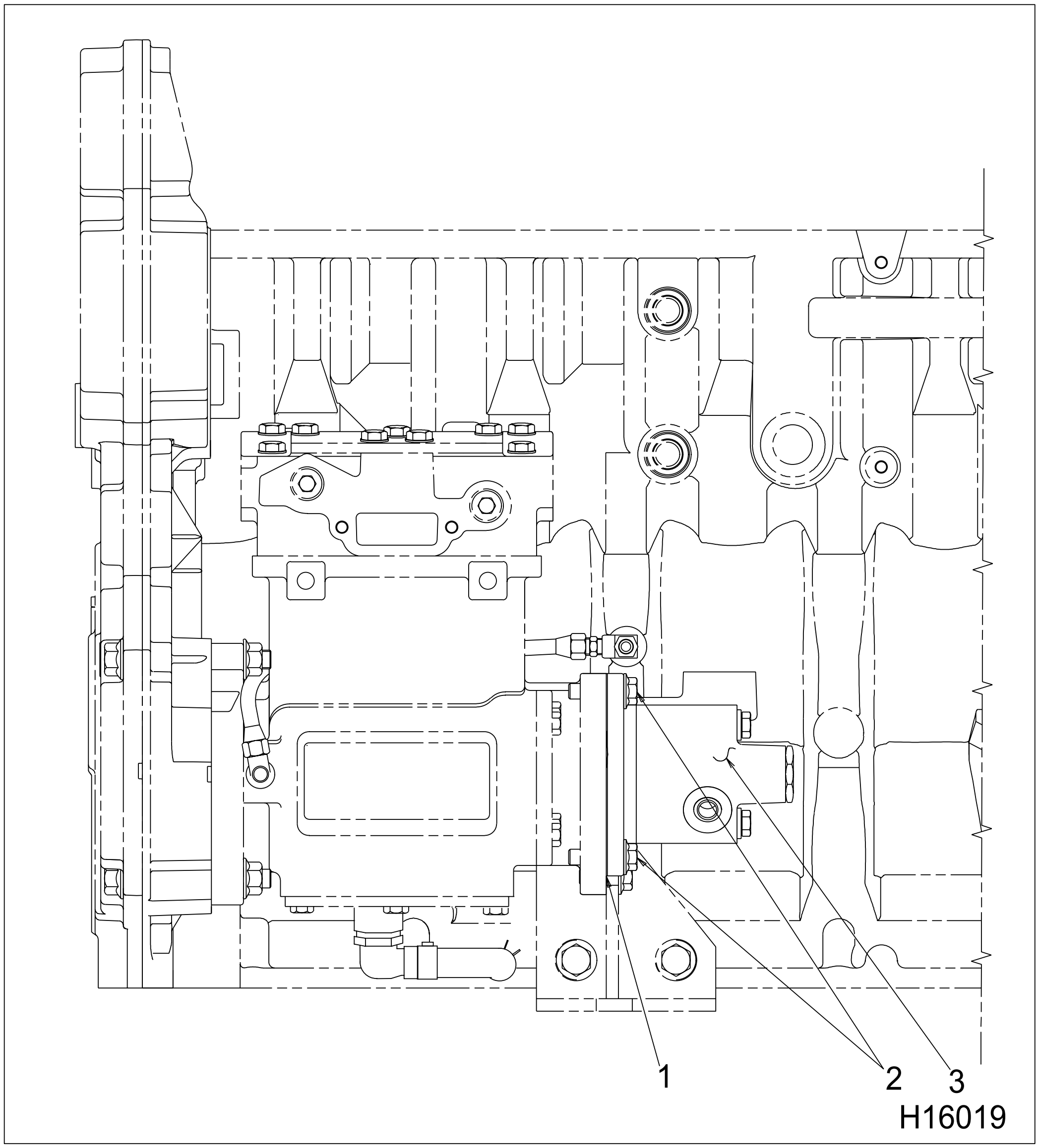


Figure 653 Power steering pump with air compressor

1. Power steering pump gasket
2. Hex flange bolt, M10 x 35
3. Power steering pump assembly

1. Apply a small amount of assembly grease to the O-ring and install into groove on backside of compressor.
2. Install two power steering pump mounting bolts (M10 x 35) and tighten to the special torque value (Table 57).
3. Install low-pressure hose.
4. Install high-pressure hose.

Power Steering Pump without Air Compressor

NOTE: The following steps are only for applications that are not equipped with an air compressor.

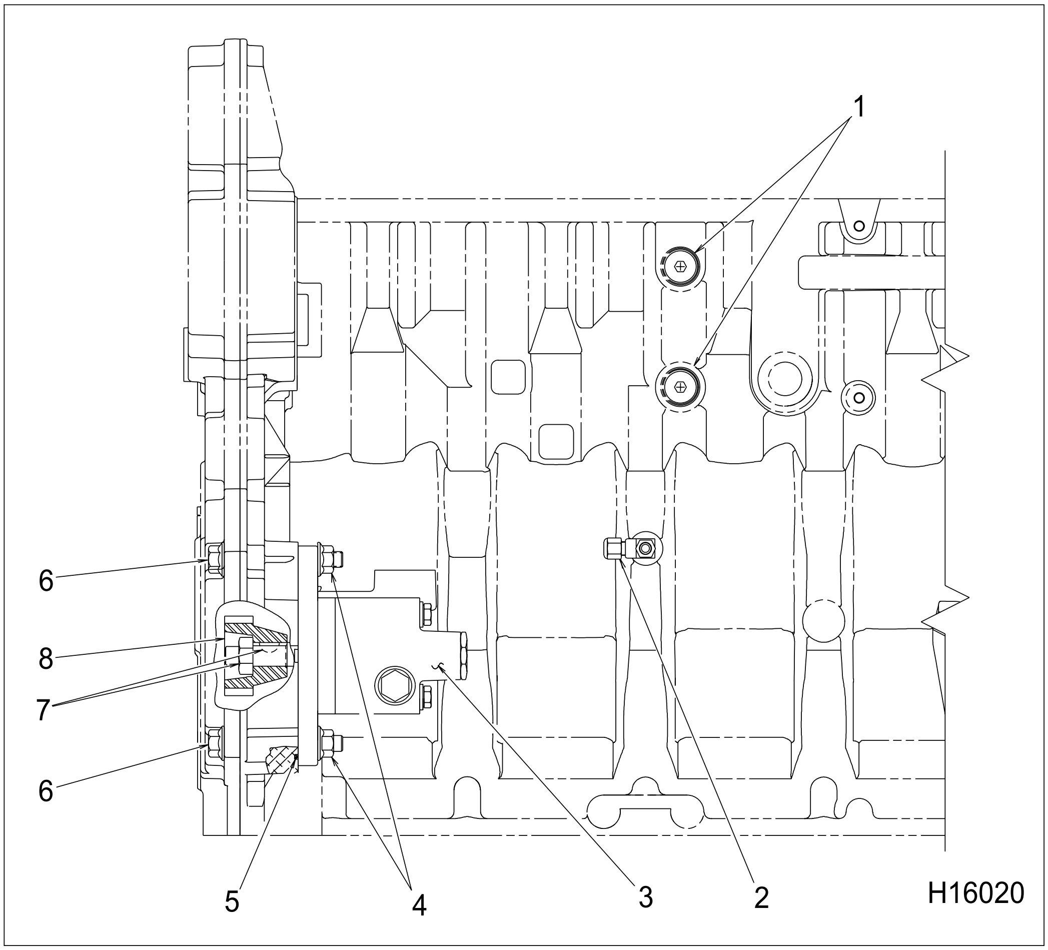


Figure 654 Power steering pump without air compressor

1. Plug assembly, M18 (standard torque) (General Torque Guidelines, page445)
2. Cap
3. Power steering pump assembly
4. Nut, M12 (2)
5. O-ring gasket
6. Bolt, M12 x 90 (2)
7. Power steering pump gear nut and shaft key (supplied with pump)
8. Drive gear (supplied with pump)

1. Apply a small amount of assembly grease to the O-ring and install into groove on front cover.
2. Install two power steering pump mounting bolts (M10 x 90) and nuts (M10) and tighten to the standard torque value (General Torque Guidelines, page445).
3. Install power steering low-pressure hose.
4. Install power steering high-pressure hose.

Special Torques

Table 57 TF 550 and TF 750 Air Compressor and Power Steering Pump Special Torques

Air compressor gear nut	150 N·m (110 lbf·ft)
Air compressor mounting bolts (through front cover), M12 x 80	83 N·m (61 lbf·ft)
Bracket bolt to air compressor, M10 x 25	67 N·m (49 lbf·ft)
Bracket bolt to crankcase, M12 x 25	115 N·m (85 lbf·ft)
Elbow assembly, M10	15-16 N·m (132-141lbf·in)
Elbow fitting assembly, M18	48 N·m (35 lbf·ft)
Hose connector assembly, M18	48 N·m (35 lbf·ft)
Power steering mounting bolts, M10 x 35	57 N·m (42 lbf·ft)
Power steering pump drive nut	90 N·m (66 lbf·ft)

Table of Contents

Abbreviations and Acronyms

ABS – Antilock Brake System
AC – Alternating Current
ACCEL – Accelerate
amp – Ampere
AMS – Air Management System
API – American Petroleum Institute
APS – Accelerator Position Sensor
ATA – American Trucking Association
AWA – Acoustic Wave Attenuator

BAP – Barometric Absolute Pressure
BCP – Brake Control Pressure
BDC – Bottom Dead Center
bhp – Brake horsepower

C – Celsius
CAC – Charge Air Cooler
CAN – Controller Area Network
CAN 1 – Controller Area Network (public)
CAN 2 – Controller Area Network (private)
CAP – Cold Ambient Protection
cc – Cubic centimeter
CDPF – Catalyzed Diesel Particulate Filter
cfs – Cubic feet per second
CKP – Crankshaft Position
CKPO – Crankshaft Position Output
cm – Centimeter
CMP – Camshaft Position
CMPO – Camshaft Position Output
CPU – Central Processing Unit
CTC – Coolant Temperature Compensation

DC – Direct Current
DDS – Driveline Disengagement Switch
DLC – Data Link Control
DMM – Digital Multimeter
DT – Diesel Turbocharged
DTC – Diagnostic Trouble Code

ECL – Engine Coolant Level
EBP – Exhaust Back Pressure
ECI – Engine Crank Inhibit
ECM – Electronic Control Module
ECT – Engine Coolant Temperature
EFAN – Engine Fan
EFRC – Engine Family Rating Code
EGR – Exhaust Gas Recirculating
EGRP – Exhaust Gas Recirculating Position
EOP – Engine Oil Pressure
EOT – Engine Oil Temperature
EPA – Environmental Protection Agency
EPR – Engine Pressure Regulator
ESC – Electronic System Controller
ESN – Engine Serial Number
EST – Electronic Service Tool
EURO – Eurpoean
EVRT™ – Electronic Variable Response Turbocharger
EWPS – Engine Warning Protection System

F – Fahrenheit
ft – Feet
FMI – Failure Mode Indicator

gal – Gallon
gph – Gallons Per Hour
GVW – Gross Vehicle Weight

H_2O – Water
Hg – Mercury
hp – Horsepower
HT – High Torque

IAT – Intake Air Temperature
ICP – Injector Control Pressure
IDM – Injector Drive Module
IGN – Ignition
in – Inch
in Hg – Inches of mercury
in H_2O – Inches of water
INJ – Injector drive
IPR – Injection Pressure Regulator
ISIS® – International® Service Information Solutions
IST – Idle Shutdown Timer
IVS – Idle Validation Switch

kg – Kilogram
km – Kilometer
KOEO – Key-On Engine-Off
KOER – Key-On Engine-Running
kPa – Kilopascal

L – Liter
lb – Pound
lbf – Pounds of force
lbf•ft – Pounds of force per foot
lbf•in – Pounds of force per inch

m – Meter
m/s – Meters per second
MAP – Manifold Absolute Pressure
MAT – Manifold Air Temperature
mm – Millimeter
mph – Miles per hour
MY – Model Year

N – Newton

NEG – Negative
NETS – Navistar Electronics Technical Support
N•m – Newton meter
NO – Nitrogen Oxide
NO_x – Nitrogen Oxides
NSBU – Netural Start Backup Switch

OCC – Output Circuit Check
OL – Over Limit

PID – Parameter Identifier
P/N – Part Number
POS – Positive
POSE – Positive On Shaft Excluder
PROM – Programmable Read Only Memory
psi – Pounds per square inch
pt – Pint
PTO – Power Take Off

RAM – Random Access Memory
rev – Revolution
rpm – Revolutions per minute
ROM – Read Only Memory
RSE – Radiator Shutter Enable

SAE – Society of Automotive Engineers
SCCS – Speed Control Command Switches
SID – Subsystem Identifier
SO_2 – Sulfur Dioxide
SYNC – Synchronization

TACH – Tachometer output signal
TCAPE – Truck Computer Analysis of Performance and Economy
TDC – Top Dead Center

UVC – Under Valve Cover

V – Volt
V_{BAT} – Battery Voltage
V_{IGN} – Ignition Voltage
V_{REF} – Reference Voltage
V_{REF} A – Reference Voltage (engine)
V_{REF} B – Reference Voltage (chassis)
VGT – Variable Geometry Turbocharger
VIN – Vehicle Identification Number
VOP – Valve Opening Pressure
VSS – Vehicle Speed Sensor

WIF – Water In Fuel
WTEC – World Transmission Electronically Controlled automatic transmissions (Allison)

Table of Contents

Terminology

Accelerator Position Sensor (APS) – A potentiometer sensor that indicates the position of the accelerator pedal.

Accessory work – The work per cycle required to drive engine accessories (normally, only those essential to engine operation).

Actuator – A device that performs work in response to an input signal.

Aeration – The entrainment of gas (air or combustion gas) in the coolant, lubricant, or fuel.

After cooler (Charge Air Cooler) – A heat exchanger mounted in the charge air path between the turbocharger and engine intake manifold. The after cooler reduces the charge air temperature by transferring heat from the charge air to a cooling medium (usually air).

Air Management System (AMS) – The AMS controls and directs air through the intake and exhaust which affects engine performance and controls emissions.

Alternating Current (AC) – An electric current that reverses its direction at regularly recurring intervals.

Ambient temperature – The environmental air temperature in which a unit is operating. In general, the temperature is measured in the shade (no solar radiation) and represents the air temperature for other engine cooling performance measurement purposes. Air entering the radiator may or may not be the same ambient due to possible heating from other sources or recirculation. (SAE J1004 SEP81)

Ampere (amp) – The standard unit for measuring the strength of an electrical current. The flow rate of a charge in a conductor or conducting medium of one coulomb per second. (SAE J1213 NOV82)

Analog – A continuously variable voltage.

Analog to digital converter (A/D) – A circuit in the ECM processing section that converts an analog signal (DC or AC) to a usable digital signal for the microprocessor.

American Trucking Association (ATA) Data link – A serial data link specified by the American Trucking Association and the SAE.

Acoustic Wave Attenuator – A component of the high-pressure oil rail designed to reduce hydraulic fluctuations resulting in a decrease of acoustic energy.

Barometric Absolute Pressure (BAP) sensor – A variable capacitance sensor which, when supplied with a 5 volt reference signal from the ECM, produces a linear analog voltage signal indicating atmospheric pressure.

Boost pressure – 1. The pressure of the charge air leaving the turbocharger.

2. Inlet manifold pressure that is greater than atmospheric pressure. Obtained by turbocharging.

Bottom Dead Center (BDC) – The lowest position of the piston during the stroke.

Brake Control Pressure (BCP) sensor – The BCP sensor is a variable capacitance sensor that senses the oil pressure in the brake gallery of the high-pressure oil rail.

Brake Horsepower (bhp) – The power output from an engine, not the indicated horsepower. The power output of an engine, sometimes called flywheel horsepower is less than the indicated horsepower by the amount of friction horsepower consumed in the engine.

Brake Horsepower (bhp) net – Net brake horsepower is measured with all engine components. The power of an engine when configured as a fully equipped engine. (SAE J1349 JUN90)

Calibration – The data values used by the strategy to solve equations and make decisions. Calibration values are stored in ROM and put into the processor during programming to allow the engine to operate within certain parameters.

Camshaft Position (CMP) sensor – The CMP sensor is a magnetic pickup sensor which indicates engine position. Speed is indicated by the number of vanes counted per revolution of the camshaft. Camshaft position is indicated by a single position peg that indicates Cylinder Number 1.

Catalyst – A substance that produces a chemical reaction without undergoing a chemical change itself.

Catalytic converter – An antipollution device in the exhaust system that contains a catalyst for chemically converting some pollutants in the exhaust gases (carbon monoxide, unburned hydrocarbons, and oxides of nitrogen) into harmless compounds.

Cavitation – A dynamic condition in a fluid system that forms gas-filled bubbles (cavities) in the fluid.

Cetane number – 1. The auto ignition quality of diesel fuel.

2. A rating applied to diesel fuel similar to octane rating for gasoline.

3. A measure of how readily diesel fuel starts to burn (autoignites) at high compression temperature.

Diesel fuel with a high cetane number autoignites shortly after injection into the combustion chamber. Therefore, it has a short ignition delay time. Diesel fuel with a low cetane number resists autoignition. Therefore, it has a longer ignition delay time.

Charge air – Dense, pressurized, heated air discharged from the turbocharger.

Charge Air Cooler (CAC) – See **After cooler**.

Closed crankcase – Crankcase ventilation system that recycles crankcase gases through a breather, then back to the clean air intake.

Closed loop operation – A system that uses a sensor to provide feedback to the ECM. The ECM uses the sensor to continuously monitor variables and it make adjustments to match engine requirements.

Cloud point – The point when wax crystals occur in fuel, making fuel cloudy or hazy. Usually below –12°C (10°F).

Cold cranking ampere rating (battery rating) – The sustained constant current (in amperes) needed to produce a minimum terminal voltage under a load of 7.2 volts per battery after 30 seconds.

Continuous Monitor Test – An ECM function that continuously monitors the inputs and outputs to ensure that readings are within set limits.

Controller Area Network (CAN) – This is a J1939 high speed communication link. **CAN 1** is a public drive train data link between the vehicle modules and ECM. **CAN 2** is a private link between the ECM and IDM.

Coolant – A fluid used to transport heat from one point to another.

Coolant level switch – A switch used to indicate coolant level.

Cooling system capacity (volume) – The amount of coolant that completely fills a cooling system to its designated cold level mark. (SAE J1004 SEP81)

Crankcase – The housing that encloses the crankshaft, connecting rods, and allied parts.

Crankcase breather – A vent for the crankcase to release excess interior air pressure.

Crankcase pressure – The force of air inside the crankcase against the crankcase housing.

Crankshaft (CKP) sensor – The CKP sensor is a magnetic pickup sensor that indicates crankshaft speed and position.

Current – The flow of electrons passing through a conductor. Measured in amperes.

Damper – A device that reduces the amplitude of torsional vibration. (SAE J1479 JAN85)

Deaeration – The removal or purging of gases (air or combustion gas) entrapped in coolant or lubricating oil.

Deaeration tank – A separate tank in the cooling system used for one or more of the following functions:

- Deaeration
- Coolant reservoir (fluid expansion and after boil)
- Coolant retention
- Filling
- Fluid level indication (visible)

Diagnostic Trouble Code (DTC) – Formerly called a Fault Code or Flash Code. A DTC is a three digit numeric code used for troubleshooting.

Diamond Logic™ Engine Brake – The Diamond logic™ Engine Brake is a compression release braking system that uses a high-pressure oil rail components together with the VGT for additional braking. The operator controls the engine brake for different operating conditions.

Diamond Logic™ Exhaust Brake – The Diamond Logic™ Exhaust Brake is an exhaust brake system that uses only the VGT to restrict exhaust flow for additional braking. The operator controls the exhaust brake for different operating conditions.

Digital Multimeter (DMM) – An electronic meter that uses a digital display to indicate a measured value. Preferred for use on microprocessor systems because it has a very high internal impedance and will not load down the circuit being measured.

Direct Current (DC) – An electric current flowing in one direction only and substantially constant in value.

Disable – A computer decision that deactivates a system and prevents operation of the system.

Displacement – The stroke of the piston multiplied by the area of the cylinder bore multiplied by the number of cylinders in the engine.

Driveline Disengagement Switch (DDS) – A switch that indicates when the driveline is disengaged from the engine.

Driver (high side) – A transistor in an electronic module that controls the power to an actuator circuit.

Driver (low side) – A transistor in an electronic module that controls the ground to an actuator circuit.

Drivetrain data link (CAN 1) J1939 – The primary communication link for the ECM, ESC, and instrument cluster.

Duty cycle – A control signal that has a controlled on/off time measurement from 0 to 100%. Normally used to control solenoids.

Elastomer – An elastic, rubber like substance such as natural or synthetic rubber material. (SAE J111 MAR85)

Electronic Control Module (ECM) – The Electronic Control Module is an electronic microprocessor that monitors and controls engine performance, exhaust emissions, and vehicle system performance (cruise control, transmission control, starter engagement, etc.). The ECM provides diagnostic information for engine and vehicle systems and can be programmed at different levels for engine protection, warning, and shutdown.

Electronic Service Tool (EST) – A computer diagnostic and programming tool for the ECM and ESC. The hardware is typically a laptop computer or notebook computer. The diagnostic and programming software includes International Master Diagnostics, ISIS on-line documentation, and NETS for factory programming.

Electronic System Controller (ESC) – An electronic module that provides multiple analog and switched input interfaces to monitor vehicle functions through solid state switches, relay driver outputs, and serial data communication.

Engine Control Module (ECM) power relay – An ECM controlled relay that supplies power to the ECM.

Engine Coolant Temperature (ECT) sensor – A thermistor sensor that senses engine coolant temperature.

Engine Fuel Pressure (EFP) sensor – A variable capacitance sensor that senses fuel pressure.

Engine Family Rating Code (EFRC) – A readable code in the calibration list of the EST that identifies engine horsepower and emission calibrations.

Engine lamp – An instrument panel lamp that comes on when DTCs are set. DTCs can be read as flash codes (red and amber instrument panel lamps).

Engine OFF tests – Tests that are done with the ignition key ON and the engine OFF.

Engine RUNNING tests – Tests done with the engine running.

Engine Oil Pressure (EOP) sensor – A variable capacitance sensor that senses engine oil pressure.

Engine Oil Temperature (EOT) sensor – A thermistor sensor that senses engine oil temperature.

Exhaust brake – A brake device using engine exhaust back pressure as a retarding medium.

Exhaust Gas Recirculation (EGR) – The Exhaust Gas Recirculation is a system that recycles a controlled portion of exhaust gas back into the combustion chamber to reduce Nitrogen Oxide exhaust emissions.

Exhaust Gas Recirculation (EGR) drive module – The EGR drive module controls the position of the EGR valve.

Exhaust Gas Recirculation (EGR) cooler – The exhaust gas is cooled in the EGR cooler and flows through the EGR control valve to the EGR mixer duct.

Exhaust Gas Recirculation (EGR) valve – The EGR valve, when open, will mix exhaust gas with filtered intake air which flows into the intake manifold. The EGR valve, when closed, only allows filtered air to flow into the intake manifold.

Exhaust manifold – Exhaust gases flow through the exhaust manifold to the turbocharger exhaust inlet and are directed to the EGR cooler or out the exhaust system.

EVRT® electronic controlled turbocharger – International's version of a Variable Geometry Turbocharger (VGT).

EZ-Tech® inerface cable – The EZ-Tech® inerface cable connects to the EST to communicate with the Electronic Controlled Module (ECM).

Fault detection and management – An alternate control strategy that reduces adverse effects that can be caused by a system failure. If a sensor fails, the ECM substitutes a good sensor signal or assumed sensor value in its place. A lit amber or red instrument panel lamp signals that the vehicle needs service.

Filter restriction – A blockage, usually from contaminants, that prevents the flow of fluid through a filter.

Flash code – See **Diagnostic Trouble Code (DTC)**.

Fuel inlet restriction – A blockage, usually from contaminants, that prevents the flow of fluid through the fuel inlet line.

Fuel pressure – The force that the fuel exerts on the fuel system as it is pumped through the fuel system.

Fuel strainer – A prefilter in the fuel system that keeps larger contaminants from entering the fuel system.

Fully equipped engine – A fully equipped engine is an engine equipped with only those accessories necessary to perform its intended service. A fully equipped engine does not include components that are used to power auxiliary systems. If these components are integral with the engine or for any reason are included on the test engine, the power absorbed may be determined and add to the net brake power. (SAE J1995 JUN90)

Fusible link (fuse link) – A fusible link is a special section of low tension cable designed to open the circuit when subjected to an extreme current overload. (SAE J1156 APR86)

Gradeability – The maximum percent grade which the vehicle can transverse for a specified time at a specified speed. The gradeability limit is the grade upon which the vehicle can just move forward. (SAE J227a)

Gross brake horsepower – The power of a complete basic engine, with air cleaner, without fan, and alternator and air compressor not charging.

Hall effect – The development of a transverse electric potential gradient in a current-carrying conductor or semiconductor when a magnetic field is applied.

Hall effect sensor – Generates a digital on or off signal that indicates speed or position.

High speed digital inputs – Inputs to the ECM from a sensor that generates varying frequencies (engine speed and vehicle speed sensors).

Horsepower (hp) – Horsepower is the unit of work done in a given period of time, equal to 33,000 pounds multiplied by one foot per minute. **1 hp = 33,000 lb x 1 ft /1 min**.

Hydrocarbons – Unburned or partially burned fuel molecules.

Idle speed – Low idle is the minimum engine speed. High idle is the maximum governed engine speed with no load.

Idle Validation Switch (IVS) – An On/Off switch that senses when the accelerator pedal is in the idle position. There is also a cold idle advance that increases low idle speed for a short period to aid in engine warm-up in cold temperatures.

Injector Drive Module (IDM) power relay – An IDM controlled relay that supplies power to the IDM.

Indicated horsepower – The theoretical power transmitted to the pistons by gas in the cylinders.

Injection Control Pressure (ICP) – High lube oil pressure generated by a high-pressure pump/pressure regulator used to hydraulically actuate the fuel injectors and the optional Diamond Logic™ engine brake.

Injection Pressure Regulator (IPR) – A Pulse Width Modulated (PWM) regulator valve, controlled by the ECM, that regulates injection control pressure.

Injection Control Pressure (ICP) sensor – A variable capacitance sensor that senses injection control pressure.

Intake Air Temperature (IAT) sensor – A thermistor sensor that senses intake air temperature.

Intake manifold – A plenum through which the air mixture flows from the charged air cooler piping to the intake passages of the cylinder head.

International NGV Tool Utilized for Next Generation Electronics (INTUNE) – The diagnostics software for chassis related components and systems.

Low speed digital inputs – Switched sensor inputs that generate an on/off (high/low) signal to the ECM. The input to the ECM from the sensor could be from a high input source switch (usually 5 or 12 volts) or from a grounding switch that grounds the signal from a current limiting resistor in the ECM that creates a low signal (0 volts).

Lubricity – Lubricity is the ability of a substance to reduce friction between solid surfaces in relative motion under loaded conditions.

Lug (engine) – A condition when the engine is operating at or below maximum torque speed.

Manifold Absolute Pressure (MAP) – Intake manifold pressure (boost pressure).

Manifold Absolute Pressure (MAP) sensor – A variable capacitance sensor that senses intake manifold pressure.

Manometer – A double-leg liquid-column gauge, or a single inclined gauge, used to measure the difference between two fluid pressures. Typically, a manometer records in inches of water.

Master Diagnostics (MD) – The diagnostics software for engine related components and systems to use on the electronic service tool or personal computer.

Manifold Air Temperature (MAT) – Intake manifold air temperature

Manifold Air Temperature (MAT) sensor – A thermistor style sensor housed in the intake manifold used to indicate air temperature after passing through the charge air cooler.

Microprocessor – An integrated circuit in a microcomputer that controls information flow.

Nitrogen Oxides (NO_x) – Nitrogen oxides form by a reaction between nitrogen and oxygen at high temperatures and pressures in the combustion chamber.

Normally closed – Refers to a switch that remains closed when no control force is acting on it.

Normally open – Refers to a switch that remains open when no control force is acting on it.

Ohm (Ω) – The unit of resistance. One ohm is the value of resistance through which a potential of one volt will maintain a current of one ampere. (SAE J1213 NOV82)

On demand test – A self test that the technician initiates using the EST. It is run from a program in the processor.

Output Circuit Check (OCC) – An On demand test done during an Engine OFF self test to check the continuity of selected actuators.

Output State Check (OSC) – An On demand test that forces the processor to activate actuators (High or Low) for additional diagnostics.

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.

Positive On Shaft Excluder (POSE) – It is a separate piece from the rest of the front or rear seal used to keep out dust / debris.

Potentiometer – A potentiometer is a variable voltage divider that senses the position of a mechanical component. A reference voltage is applied to one end of the potentiometer. Mechanical rotary or linear motion moves the wiper along the resistance material, changing voltage at each point along the resistive material. Voltage is proportional to the amount of mechanical movement.

Power – Power is a measure of the rate at which work is done. Compare with **Torque**.

Power Take Off (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) – The time that an actuator, such as an injector, remains energized.

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.

Read Only Memory (ROM) – Computer memory that stores permanent information for calibration tables and operating strategies. Permanently stored information in ROM cannot be changed or lost by turning the engine off or when ECM power is interrupted.

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

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

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

Speed Control Command Switches (SCCS) – A set of switches used for cruise control, Power Take Off (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 – Stroke is 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.

Sulfur dioxide (SO_2) – Sulfur dioxide is caused by oxidation of sulfur contained in fuel.

Switch sensors – Switch sensors indicate position. They operate open or closed, allowing or preventing the flow of current. A switch sensor can be a voltage input switch or a grounding switch. A voltage input switch supplies the ECM with a voltage when it is closed. A grounding switch grounds the circuit closed, causing a zero voltage signal. Grounding switches are usually installed in series with a current limiting resistor.

System restriction (air) – The static pressure differential that occurs at a given air flow from air entrance through air exit in a system. Usually measured in inches (millimeters) of water. (SAE J1004 SEP81)

Tachometer output signal – Engine speed signal for remote tachometers.

Thermistor – A thermistor sensor changes its electrical resistance to temperature. Resistance in the thermistor decreases as temperature increases, and increases as temperature decreases. Thermistors works with a resistor that limits current in the ECM to form a voltage signal matched with a temperature value.

Thrust load – A thrust load pushes or reacts through a bearing in a direction parallel to the shaft.

Top Dead Center (TDC) – The highest position of the piston during the stroke.

Top Dead Center (compression) – Top Dead Center (compression) is when the piston is at the highest position and both intake and exhaust valves are closed.

Torque – Torque is a measure of force producing torsion and rotation around an axis. Torque is the product of the force, usually measured in pounds, and radius perpendicular to the axis of the force extending to the point where the force is applied or where it originates, usually measured in feet.

Truck Computer Analysis of Performance and Economy (TCAPE) – Truck Computer Analysis of Performance and Economy is a computer program that simulates the performance and fuel economy of trucks.

Turbocharger – A turbine driven compressor mounted to the exhaust manifold. The turbocharger increases the pressure, temperature and density of intake air to charge air.

Valve cover gasket – A valve cover gasket that contains the pass through electronic wiring harness connectors for the ICP and BCP sensors, the brake shutoff valve, and six fuel injectors.

Variable capacitance sensor – A variable capacitance sensor is a sensor that measures pressure. The pressure measured is applied to a ceramic material. The pressure forces the ceramic material closer to a thin metal disk. This action changes the capacitance of the sensor.

Variable Geometry Turbocharger (VGT) – The VGT is a turbocharger with actuated vanes inside the turbine housing. The vanes modify flow characteristics of exhaust gases through the turbine housing for boast pressure control at various engine speeds and load conditions.

(VGT) control module – The VGT control module is an electronic microprocessor that converts a pulse width modulated signal from the ECM to control a DC motor that controls the VGT vane position.

Vehicle Electronic System Programming System – The computer system used to program electronically controlled vehicles.

Vehicle Retarder Enable/Engage – Output from the ECM to a vehicle retarder.

Vehicle Speed Sensor (VSS) – A magnetic pickup sensor mounted in the tail shaft housing of the transmission, used to calculate ground speed.

Viscosity – The internal resistance to the flow of any fluid.

Viscous fan – A fan drive that is activated when a thermostat, sensing high air temperature, forces fluid through a special coupling. The fluid activates the fan.

Volt (v) – A unit of electromotive force that will move a current of one ampere through a resistance of one Ohm.

Voltage – Electrical potential expressed in volts.

Voltage drop – Reduction in applied voltage from the current flowing through a circuit or portion of the circuit current multiplied by resistance.

Voltage ignition – Voltage supplied by the ignition switch when the key is ON.

Water In Fuel (WIF) switch – The WIF switch detects water in the fuel.

Water supply housing (Freon bracket) – The water supply housing (Freon Bracket) is a coolant supply housing with a deaeration port and a connection for cab heat.

Table of Contents

Specifications

NOTE: The following sections of the manual do not require any specifications for service work:

- *Mounting Engine on Stand*
- *Engine Electrical*
- *Air Compressor and Power Steering Pump*

Table 58 VGT Specifications

Turbine shaft axial end play	0.05 - 0.13 mm (0.002-0.005 in)
Turbine shaft radial movement	0.52 - 0.74 mm (0.020-0.029 in)
VGT axial linkage shaft	Must strike open and closed stops in actuator, 90° rotation

Table 59 Exhaust Manifold Specifications

Allowable warpage (max.)	0.10 mm (0.004 in) overall
Flange thickness (min.)	21.59 mm (0.850 in)

Table 60 Valve Specifications

Camshaft lobe lift	**Intake:** 6.68 mm (0.263 in)
	Exhaust: 6.91 mm (0.272 in)
Valve face angle	**Intake:** 59.75- 60.00°
	Exhaust: 44.75-45.00°
Valve face margin (min.)	**Intake:** 1.32 mm (0.052 in)
	Exhaust: 1.16 mm (0.046 in)
Valve face-to-valve stem runout (max.)	0.038 mm (0.0015 in)
Valve lash (cold), intake and exhaust	0.48 mm (0.019 in)
Valve stem diameter (new condition)	**Intake:** 7.928 ± 0.0089 mm (0.3121 ± 0.00035 in)
	Exhaust: 7.908 ± 0.0089 mm (0.3113 ± 0.00035 in)
Valve stem-to-valve guide clearance (max.)	**Intake:** 0.10 mm (0.004 in)
	Exhaust: 0.11 mm (0.005 in)

Table 61 Valve Spring Specifications

Intake and Exhaust Valve Springs	
Free length	52.35 mm (2.061 in)
Solid height (max.)	27.43 mm (1.080 in)
Valve closed test length @ 410.1 ± 24.5 N (92.2 ± 5.5 lbf) test load	40 mm (1.575 in)
Valve closed test length @ 764.2 ± 48.9 N (171.8 ± 11.0 lbf) test load	29.3 mm (1.155 in)

Table 62 Cylinder Head Specifications

Cylinder head gasket surface flatness	0.10 mm (0.004 in.) per 229 mm (9.0 in)
Cylinder head thickness	**New:** 160.48 mm (6.318 in)
	Minimum: 159.97 mm (6.298 in)
Exhaust valve seat insert counterbore diameter	**Standard:** 37.503 ± 0.003 mm (1.477 ± 0.001 in)
	Oversize: 0.05 mm (0.002 in) 37.55 ± 0.03 mm (1.478 ± 0.001 in)
Exhaust valve seat outside diameter	**Standard:** 37.56 mm (1.479 in)
	Oversize: 0.05 mm (0.002 in) 37.61 mm (1.481 in)
Intake valve seat insert counterbore diameter	**Standard:** 33.50 ± 0.03 mm (1.319 ± 0.001 in)
	Oversize: 0.05 mm (0.002 in) 35.55± 0.03 mm (1.321 ± 0.001 in)
Intake valve seat outside diameter	**Standard:** 40.20 mm (1.583 in)
	Oversize: 0.05 mm (0.002 in) 40.25 mm (1.585 in)
Push rod runout (maximum)	0.508 mm (0.020 in)
Valve guide bore diameter	14.308 ± 0.017 mm (0.5633 ± 0.0007 in)
Valve guide bore out-of-round (max.)	0.005 mm (0.0002 in)
Valve guide bore taper (max.)	0.013 mm (0.0005 in)
Valve guide height from cylinder head spring pocket (intake)	16.53 ± 0.13 mm (0.651 ± 0.005 in)
Valve guide insert inside diameter (installed)	7.98 - 8.00 mm (0.314 - 0.315 in)
Valve guide insert interference fit dimension	0.043 mm (0.0017 in)
Valve guide insert outside diameter	14.351 ± 0.010 mm (0.5650 ± 0.0004 in)
Valve guide length (overall)	65.71 mm (2.587 in)
Valve recession	**Intake:** 1.02 mm (0.040 in)
	Exhaust: 1.40 mm (0.055 in)
Valve seat angles	**Intake:** 59.75 - 60°
	Exhaust: 44.75 - 45°

Table 62 Cylinder Head Specifications (cont.)

Valve seat runout (max.)	0.05 mm (0.002 in)
Valve seat width	1.91 - 2.16 mm (0.075 - 0.085 in)

Table 63 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications

Camshaft gear end play	0.33 mm (0.013 in)
Camshaft gear-to-upper idler gear backlash	0.46 mm (0.018 in)
High-pressure pump end play	0.45 - 1.22 mm (0.018-0.48 in)
Lower idler gear-to-air compressor gear backlash	0.508 mm (0.020 in)
Lower idler gear-to-crankshaft gear backlash	0.36 mm (0.014 in)
Oil pump end clearance	0.05 - 0.13 mm (0.002-0.005 in)
Oil pump side clearance	0.36 - 0.48 mm (0.014-0.019 in)
Upper idler gear-to-high-pressure oil pump gear backlash	0.48 mm (0.019 in)
Upper idler gear-to-lower idler gear backlash	0.48 mm (0.019 in)
Vibration damper face runout (max.)	1.52 mm (0.060 in)

Fan Drive Configurations Diameters and Ratios

Engine fan drive configuration	Fan CL to Crankshaft CL, mm (in)	Pulley Diameter OBD, mm (in)	Drive Ratio
466 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	0.894 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	242.8 (9.56)	1.08 : 1
570 high-mount, (Horton DriveMaster)	508 (20)	219.4 (8.636)	1.2 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
570 high-mount, (Horton DriveMaster)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	1.2 : 1
466 high-mount, (Horton DriveMaster)	465 (18.3)	219.4 (8.636)	0.99 : 1
466 mid-mount, (Horton DriveMaster)	411 (16.2)	201.2 (7.92)	1.08 : 1
466 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.08 : 1

Table 63 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Specifications (cont.)

570 high-mount, (spin-on)	465 (18.3)	201.2 (7.92)	1.3 : 1
466 mid-mount, (spin-on)	411 (16.2)	201.2 (7.92)	1.08 : 1
466 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
466 low-mount, Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (spin-on)	310 (12.2)	201.2 (7.92)	1.3 : 1
570 low-mount, (Horton DriveMaster)	310 (12.2)	201.2 (7.92)	1.3 : 1
466 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.08 : 1
570 low-mount, (bolt-on)	310 (12.2)	201.2 (7.92)	1.3 : 1
NOTE: The high-mount and mid-mount fan drives share the same part number, however the fan drive is inverted depending upon application.			

Table 64 Oil Fill Specifications

Dry engine (after rebuild and new filter)	34 L (36 quarts US)
Wet engine (after oil drain and filter change)	28 L (30 quarts US)

Table 65 Connecting Rod Specifications

Bend (max.)	0.06 mm (0.003 in)
Center-to-center distance between connecting rod bearing bore and piston pin bushing bore	219.4 - 219.5 mm (8.638 - 8.642 in)
Connecting rod bearing bore inside diameter	85.130 - 85.156 mm (3.3516 - 3.3526 in)
Connecting rod bearing inside diameter (installed)	80.05 - 80.10 mm (3.1518 - 3.1536 in)
Connecting rod bearing bore out-of-round (max.)	0.02 mm (0.00078 in)
Connecting rod bearing bore taper (max.)	0.02 mm (0.00078 in)
Connecting rod bearing running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod side clearance on crankshaft	0.13 - 0.48 mm (0.005 - 0.019 in)
Piston pin bushing inside diameter	46.393 - 46.401 mm (1.8265 - 1.8268 in)
Twist (max.)	0.05 mm (0.002 in)

Table 66 Piston Specifications

466 piston configuration	
Piston material	Aluminum alloy

Table 66 Piston Specifications (cont.)

Piston rings	
225 bhp and below	Top ring - keystone cross section Intermediate - rectangular cross section
230 bhp and above	Top ring - keystone cross section Intermediate - keystone cross section
570 piston configuration	
Piston crown	Steel crown, two-piece articulated
Piston skirt	Aluminum alloy
Piston rings	
All 570 series engines	Top ring – keystone cross section Intermediate – rectangular cross section
466 and 570 piston specifications	
Running clearance between piston and cylinder sleeve	**466 piston:** 0.076 - 0.128 mm (0.0030 - 0.0050 in) **570 piston:** 0.063 - 0.115 mm (0.0025 - 0.0045 in)
Skirt diameter	**466 piston:** 116.44 - 116.49 mm (4.584 - 4.586 in) **570 piston:** 116.48 - 116.51 mm (4.586 - 4.587 in)
Top compression ring groove width, 466 measure over 0.122 gauge pins	115.90 - 115.68 mm (4.563 - 4.554 in)
Top compression ring groove width, 570 measure over 0.126 gauge pins	116.74 - 116.50 mm (4.596 - 4.587 in)
Intermediate compression ring groove width (keystone shaped ring) measure over 0.110 gauge pins	115.92 - 115.73 mm (4.564 - 4.556 in)
Intermediate compression ring groove width (rectangular shaped ring), 466	3.05 - 3.03 mm (0.120 - 0.119 in)
Intermediate compression ring groove width (rectangular shaped ring), 570	3.05 - 3.03 mm (0.120 - 0.119 in)
Oil control ring, side clearance, 466	0.076 - 0.026 mm (0.0030 - 0.0010 in)
Oil control ring, side clearance, 570	0.080 - 0.030 mm (0.0031 - 0.0012 in)

Table 67 Piston Ring Specifications

Intermediate compression ring end gap	1.65 - 1.90 mm (0.065 - 0.075 in)
Oil control ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)
Top compression ring end gap	0.35 - 0.66 mm (0.014 - 0.026 in)

Table 68 Piston Pin Specifications

Clearance in piston	**466 piston:** 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	0.035 - 0.048 mm (0.0014 - 0.0019 in)
	570 skirt (vertical plane): 0.0165 - 0.0292 mm (0.00065 - 0.00115 in)
	570 skirt (horizontal plane): 0.0280 - 0.0574 mm (0.00114 - 0.00226 in)
	570 crown: 0.038 - 0.053 mm (0.0015 - 0.0021 in)
Diameter	46.352 - 46.357 mm (1.8249 - 1.8251 in)
Length	96.57 - 96.82 mm (3.802 - 3.812 in)

Table 69 Cylinder Sleeve Specifications

Allowable variation of counterbore depth between four points (max.)	0.03 mm (0.001 in)
Counterbore depth before adding shims (max.)	10.49 mm (0.413 in)
Counterbore depth (including shims- if any)	8.84 - 8.89 mm (0.348 - 0.350 in)
Cylinder sleeve protrusion	0.05 - 0.13 mm (0.002 - 0.005 in)
Cylinder sleeve taper, at top of ring travel (max.)	0.10 mm (0.004 in)
Flange thickness	8.94 - 8.96 mm (0.352 - 0.353 in)
Inside diameter	114.50 - 116.60 mm (4.590 - 4.591 in)

Table 70 Crankshaft Specifications

Type	Steel forged, induction hardened, grindable
Main Bearing journal diameter	
Standard size	107.95 ± 0.015 mm (4.250 ± 0.0006 in)
0.254 mm (0.010 in) undersized	107.70 ± 0.015 mm (4.240 ± 0.0006 in)
0.508 mm (0.020 in) undersized	107.44 ± 0.0152 mm (4.230 ± 0.0006 in)
0.762 mm (0.030 in) undersized	107.19 ± 0.0152 mm (4.220 ± 0.0006 in)
Damper mounting area runout (maximum)	0.03 mm (0.001 in)

Table 70 Crankshaft Specifications (cont.)

Flywheel mounting surface runout (maximum)	0.05 mm (0.002 in)
Main bearing journal maximum out-of-round	0.05 mm (0.002 in)
Main bearing journal taper (maximum per inch)	0.071 mm (0.0028 in)
Main bearing thrust face runout (TIR maximum)	0.03 mm (0.001 in)
Main bearing width (except rear thrust)	34.19 ± 0.13 mm (1.346 ± 0.005 in)
Number of main bearings	7
Rear oil seal journal runout (maximum)	0.08 mm (0.003 in)
Thrust taken by	No. 7 rear upper main bearing
Thrust bearing journal length	34.404 ± 0.038 mm (1.3545 ± 0.0015 in)
Connecting rod journal diameter	
Standard Size	80.0 ± 0.0152 mm (3.1500 ± 0.0006 in)
0.0254 mm (0.010 in) undersized	79.7 ± 0.0152 mm (3.1400 ± 0.0006 in)
0.508 mm (0.020 in) undersized	79.5 ± 0.0152 mm (3.1300 ± 0.0006 in)
0.762 mm (0.030 in) undersized	79.2 ± 0.0152 mm (3.1200 ± 0.0006 in)
Center line of main bearing bore to head deck	368.3 ± 0.05 mm (14.50 ± 0.002 in)
Connecting rod bearing to crankshaft running clearance	0.030 - 0.107 mm (0.0012 - 0.0042 in)
Connecting rod bearing width	40.01 mm (1.575 in)
Connecting rod journal maximum out-of-round	0.0064 mm (0.00025 in)
Connecting rod journal taper (maximum per inch)	0.0069 mm (0.00027 in)
Crankshaft end play	0.15-0.31 mm (0.006 - 0.012 in)
Crankshaft end play maximum wear limit	0.51 mm (0.020 in)
Crankshaft flange outside diameter	155.58 mm (6.125 in)
Crankshaft gear backlash	0.08-0.41 mm (0.003 - 0.016 in)
Main bearing to crankshaft running clearance	0.046 - 0.127 mm (0.0018 - 0.0050 in)
Connecting rod to crankshaft side clearance	0.30 ± 0.11 mm (0.012 ± 0.005 in)
Standard size to 0.51 mm (0.020 in) undersized	34.404 ± 0.03 mm (1.3545 ± 0.010 in)

Table 71 Crankcase Specifications

Cap attachment	2 bolts per cap
Coolant heater rating	1250 W, 120 V
Counterbore dimension in crankcase	8.865 ± 0.025 at 132 mm (0.349 ± 0.001 at 5.189 in)
Crankcase deck flatness	0.08 mm (0.003 in)
Cylinder sleeve counterbore maximum allowable depth	9.25 mm (0.364 in)
Main bearing type	Precision replaceable
Material	Steel-backed copper, lead, tin
Maximum allowable variation of counterbore depth (between four points)	0.025 mm (0.001 in)
Piston cooling tube dia. (spray hole) DT 466	1.91 - 2.06 mm (0.075 - 0.081 in)
Piston cooling tube dia. (spray hole) DT 570, HT 570	2.26 - 2.41 mm (0.089 - 0.095 in)
Roller tappet outside diameter	28.435 - 28.448 mm (1.1195 -1.1200 in)
Sleeve protrusion above crankcase	0.05 - 0.13 mm (0.002 - 0.005 in)
Tappet bore diameter	28.51 - 28.55 mm (1.123 - 1.124 in)
Thrust taken by	No. 7 rear upper main bearing
Camshaft	
Bushing I.D. (installed)	58.03 - 58.12 mm (2.285 - 2.288 in)
Cam lobe lift, exhaust	6.91 mm (0.272 in)
Cam lobe lift, intake	6.68 mm (0.263 in)
Camshaft end play	0.18 - 0.33 mm (0.007 - 0.013 in)
Camshaft journal diameter	57.95 - 58.98 mm (2.282 - 2.283 in)
Camshaft radial clearance	0.05- 0.17 mm (0.002 - 0.007 in)
Maximum permissible cam lobe wear	0.25 mm (0.010 in)
Service bushings furnished to size	Yes
Thrust plate thickness (new)	6.96 - 7.01 mm (0.274 - 0.276 in)
Camshaft Bushing Bore Diameter in Crankcase	
Front	65.51 - 63.55 mm (2.501 - 2.502 in)
Intermediate front	63.01 - 63.04 mm (2.481 - 2.482 in)
Intermediate rear	63.01 - 63.04 mm (2.481 - 2.482 in)
Rear	65.51 - 63.55 mm (2.501 - 2.502 in)

Table 72 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)

Table 73 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)

Table 74 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.	

Table 75 Engine Brake Specifications

Brake actuator lash (cold)	0.48 mm (0.019 in)
Engine exhaust valve lash (cold)	Refer to (Adjusting Valve Lash, page 150)

Table of Contents

General Torque Guidelines

CAUTION: To prevent engine damage, do not substitute fasteners. Original equipment standard hardware is defined as Class 10.9 metric or Grade 8 standard coarse thread bolts (Rockwell "C" 33-39), all phosphate coated.

CAUTION: To prevent engine damage, do not use this standard torque chart with other International brand engines or engines made by other manufacturers.

The standard torque chart provides the tightening values for general purpose applications using original equipment standard hardware as listed in the Parts Catalog for the application involved.

Table 76 Standard Torque Values – Class 10.9 Metric Flange Head Bolts and Studs

Thread Diameter (mm)	Thread Pitch (mm)	Torque[1]
6	1	13 N·m (115 lbf·in)
8	1.25	31 N·m (23 lbf·ft)
10	1.5	62 N·m (45 lbf·ft)
12	1.75	107 N·m (79 lbf·ft)
14	2	172 N·m (127 lbf·ft)
15	2	216 N·m (159 lbf·ft)
16	2	266 N·m (196 lbf·ft)
18	2.5	368 N·m (272 lbf·ft)
20	2.5	520 N·m (384 lbf·ft)

[1] Values listed are 80% of proof load.

DESIGNATION				HEAD MARKING	
INTERNATIONAL CLASS	ISO R 898 I	MATERIAL TYPE	THERMAL TREATMENT	PREFFERED	OPTIONAL
10.9	10.9	MEDIUM CARBON OR MEDIUM CARBON ALLOY STEEL OR LOW CARBON BORON STEEL	QUENCH AND TEMPERED		
10.9R	10.9R	MEDIUM CARBON , MEDIUM CARBON ALLOY STEEL	QUENCH AND TEMPERED, ROLL THREADED AFTER HEAT TREATMENT		

H31259

Figure 655 Classification and Identification – Metric and Special Use Fasteners

Many conditions affect torque and the results of torque applications. The major purpose in tightening a fastener to a specified torque is to obtain tension in the fastener (i.e., bolt, nut, etc.), which in turn develops a clamping load which exceeds any possible loading imposed on parts due to engine rpm or vibration.

Phosphate coated fasteners do not require oil lubrication during assembly and torque application. Reused fasteners, even if originally phosphate coated, do require a light film of engine oil lubrication to threads and under head area for proper torque application.

Threads that are dry, excessively rough, battered or filled with dirt require considerable effort just to rotate. Then when the clamping load is developed or the bolt tension is applied, the torque reading mounts rapidly (due to thread friction) to the specified torque value. However, the desired bolt tension and maximum clamping effect is not achieved. This condition can lead to failure of the fastener to maintain component integrity. The proper bolt tension and clamping effect can never be attained if the fastener is dry. The fastener threads must have a film of clean lubricant (engine oil) to be considered lubricated.

Using a Torque Wrench Extension

Occasionally the need will arise to use an extension, crowfoot, or other type of adapter with your torque wrench to torque a bolt or line fitting. Sometimes an extension or adapter is necessary to reach a bolt in a hard to reach location. Adding adapters or extensions will alter the actual clamping force at the fastener. By using the following formula you can determine what the torque wrench setting should be to achieve the known standard or special torque value.

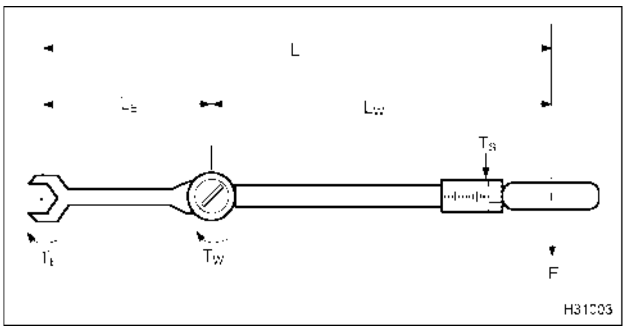


Figure 656 Torque wrench extension

- F – Force applied by service technician
- L – Length through which force is applied to fastener
- L_E – Length of extension
- L_W – Length of torque wrench
- T_E – Torque applied at fastener
- T_W – Torque applied at end of torque wrench
- T_S – Torque wrench setting

$T_S = T_E$ (L_W / (L_W + L_E)

Example:

A component has a known torque value of 88 N·m (65 lbf·ft) and an extension is required to reach it. What will the torque wrench setting have to be in order to compensate for the additional extension?

- Torque wrench = 12 inches
- Extension = 6 inches

T_S = 65 lbf·ft (12 in / (12 in + 6 in)

T_S = 65 lbf·ft (12 in / 18 in)

T_S = 65 lbf·ft (0.666)

T_S = **43.3 lbf·ft or 58.9 N·m**

Special Torque

Table 77 Engine Mounting Special Torques

Oil pan drain plug (M25)	68 N·m (50 lbf·ft)

Table 78 VGT Special Torques

VGT Spiralock® nuts (M10)	71 N·m (52 lbf·ft)

Table 79 Intake Manifold, Inlet and EGR Mixer, and Exhaust Manifold Special Torques

Exhaust manifold mounting torque and sequence.	See “Exhaust manifold torque sequence” (page 85).
Fuel assembly valve	15 N·m (132 lbf·in)
Intake manifold mounting bolts	40 N·m (30 lbf·ft)
Intake plug assembly	25 N·m (18 lbf·ft)

Table 80 EGR Cooler Special Torques

Constant tension EGR hose clamps (if equipped)	3.4 N·m (30 lbf·in)
EGR cooler mounting bracket lower bolt, M12 x 120	116 N·m (85 lbf·ft)
EGR cooler mounting bracket	116 N·m (85 lbf·ft)
EGR cooler supply tube retaining bolt	15-22 N·m (11.3-6.2 lbf·ft)

Table 81 Cylinder Head and Valve Train Special Torques

BCP sensor	20-30 N·m (15-22 lbf·ft)
Cylinder head mounting bolts torque and sequence	
Fuel injector mounting bolt	41 N·m (30 lbf·ft)
High-pressure oil hose fitting	46 N·m (34 lbf·ft)
ICP sensor	20-30 N·m (15-22 lbf·ft)
Rocker arm bolts torque and sequence	(Installing Rocker Arms, page148)
Valve adjustment locknut	27 N·m (20 lbf·ft)

Table 82 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mount, and Gear Train Special Torques

Automatic belt tensioner assembly	50 N·m (37 lbf·ft)
Damper retaining plate bolts	163 N·m (120 lbf·ft) Retorque all bolts until no movement
End cover adapter (PTO equipped engines only)	52 N·m (38 lbf·ft)
Fan drive, high-mount, Horton DriveMaster (20, 18.3 in.)	26 N·m (19 lbf·ft)
Fan drive, mid-mount, Horton DriveMaster (16.2 in.)	26 N·m (19 lbf·ft)
Fan drive, low-mount, Horton DriveMaster (12.2 in.)	26 N·m (19 lbf·ft)
Fan spacer retaining bolt, M10 x 20 (bolt-on drive only)	52 N·m (38 lbf·ft)
Front cover mounting bolts (rear half)	26 N·m (19 lbf·ft)
Front engine mounting bracket bolts (4)	386 N·m (284 lbf·ft)
Horton DriveMaster bearing retainer nut	177 N·m (130 lbf·ft)
Lower idler gear mounting bolt	639 N·m (470 lbf·ft)
Oil pump and rotor housing M8 bolts	25 N·m (18 lbf·ft)
Upper idler gear mounting bolt	326 N·m (240 lbf·ft)
Viscous or rubber vibration damper mounting bolts	54 N·m (40 lbf·ft)
Water outlet tube assembly at cylinder head	33 N·m (24 lbf·ft)
Water outlet tube assembly at front cover	33 N·m (24 lbf·ft)
Wear plate (water pump)	7 N·m (60 lbf·in)

Table 83 Oil Pan and Oil Suction Tube Special Torques

Oil pan drain plug	68 N·m (50 lbf·ft)
Oil heating element assembly (optional)	68 N·m (50 lbf·ft)
Oil pan heater plug	68 N·m (50 lbf·ft)
Oil pan mounting bolts	32 N·m (24 lbf·ft)
Oil suction tube bracket, M10 x 25	63 N·m (46 lbf·ft)
Oil suction tube, M8 x 35	27 N·m (20 lbf·ft)

Table 84 Power Cylinder Special Torque

Connecting rod bolts (verify connecting rod type)	See Torque Procedures for Connecting Rod with M12 Bolts (page241) or M11 Bolts (page241).
Piston cooling tube bolts, M6 x 12	13 N·m (115 lbf·in)
Piston cooling tube bolts, M6 x 16	13 N·m (115 lbf·in)

Table 85 Crankcase, Crankshaft and Camshaft Special Torques

Camshaft thrust plate bolts	26 N·m (19 lbf·ft)
Crankcase ladder, M12 x 35	122 N·m (90 lbf·ft)
Coolant heater bolt	4.5-5.1 N·m (40-45 lbf·in)
Crankcase ladder, M10 x 25	63 N·m (46 lbf·ft)
Crankshaft main bearing cap bolt torque and sequence	(Torque Procedure for Torque-to-Yield Main Bearing Bolts, page271)

Table 86 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)

Table 87 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)

Table 88 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·ft)
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 supply 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)

Table 89 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)

Table 90 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)

Table 91 TF 550 and TF 750 Air Compressor and Power Steering Pump Special Torques

Air compressor gear nut	150 N·m (110 lbf·ft)
Air compressor mounting bolts (through front cover), M12 x 80	83 N·m (61 lbf·ft)
Bracket bolt to air compressor, M10 x 25	67 N·m (49 lbf·ft)
Bracket bolt to crankcase, M12 x 25	115 N·m (85 lbf·ft)
Elbow assembly, M10	15-16 N·m (132-141 lbf·in)
Elbow fitting assembly, M18	48 N·m (35 lbf·ft)
Hose connector assembly, M18	48 N·m (35 lbf·ft)
Power steering mounting bolts, M10 x 35	57 N·m (42 lbf·ft)
Power steering pump drive nut	90 N·m (66 lbf·ft)

Table of Contents

Description

Special service tools for the DT 466, DT 570 and HT 570 series engines can be ordered from the **SPX Corporation, 1-800-520-2584**.

NOTE: The following sections of the manual do not require any special tools for service work:

- *Intake, Inlet, and Exhaust Manifolds*
- *Oil Pan and Oil Suction Tube*
- *Engine Electrical*
- *Air Compressor and Power Steering Pump*

Table 92 Special Tools

Engine mounting plate	ZTSE4649
Engine stand	OTC1750A

Table 93 EGR System Special Service Tools

EGR cooler pressure test plates	ZTSE4636

Table 94 Cylinder Head Special Service Tools

Cylinder head test plate	ZTSE4289A
Dye penetrant kit	Obtain locally
Feeler gauge	Obtain locally
Head bolt thread gauge	ZTSE4667
Injector sleeve brush set (set of 2)	ZTSE4304
Injector sleeve installer	ZTSE4642
Injector sleeve remover	ZTSE4643
Pressure regulator	Obtain locally
Slide hammer puller set	ZTSE1879
Small hole gauge set	Obtain locally
Straightedge	Obtain locally
Thermostat opening pressure adapter	ZTSE4647
Valve guide deburring tool	ZTSE4393
Valve guide installer	ZTSE1943
Valve guide remover	ZTSE4377
Valve seat extractor kit (universal)	ZTSE1951C
Valve seat grinder	ZTSE1631A
Valve seat grinding stones 45° (exhaust)	Obtain locally
Valve seat grinding stones 60° (intake)	Obtain locally
Valve seat installer	ZTSE4641
Valve seat remover (collet)	ZTSE4640
Valve spring compressor	ZTSE1846
Valve spring compressor jaws	ZTSE4652
Water supply housing pressure adapter	ZTSE4648

Table 95 Front Cover, Vibration Damper, Gerotor Oil Pump, Front Engine Mounts, and Gear Train Special Service Tools

Dial indicator set	Obtain locally
Feeler gauge	Obtain locally
Front seal and wear sleeve installer	ZTSE3004B
H-bar	Obtain locally
Hot plate	Obtain locally
Loctite® 569 Hydraulic Sealant	Obtain locally
Lower Idler Gear Socket	ZTSE4383
Slide hammer puller set	ZTSE1879
Straightedge	Obtain locally
Thermo-melt crayon, 100 °C (212 °F)	Obtain locally
16 mm 12 point impact socket	Obtain locally

Table 96 Oil Pan and Oil Suction Tube

Wacker T – 442 RTV sealant	Obtain locally

Table 97 Piston, Piston Ring, and Connecting Rod Special Service Tools

Counterbore cutting head	ZTSE25144A
Cylinder bore gauge	Obtain locally
Cylinder sleeve counterbore tool kit	ZTSE2514
Cylinder sleeve holding adapters (set of 3)	ZTSE4672
Cylinder sleeve puller	ZTSE2536
Dial indicator set	Obtain locally
EGR water coolant supply plate	ZTSE4648
Piston ring compressor tool	ZTSE4396
Piston ring expander	Obtain locally
Piston ring gauge pins (set of 3)	ZTSE4653
Telescoping gauge set	Obtain locally

Table 98 Crankcase, Crankshaft and Camshaft Special Service Tools

Cam gear puller	ZTSE4411
Camshaft bushing puller	ZTSE2893B
Hot plate	Obtain locally
Nylon brush	ZTSE4389
Tap, cylinder head bolt holes	ZTSE4671
Tap set	ZTSE4386
Stiff nylon brush	ZTSE4392

Table 99 Oil System Module and Secondary Filter Special Tools

Air Pressure Regulator	Obtain locally
Oil CoolerTest Plate	ZTSE4654
Oil Filter Wrench	ZTSE1879
Slide Hammer Puller Set	Obtain locally

Table 100 Fuel System Special Service Tools

Cap kit, injectors	ZTSE4660
Fuel injector rack cups	ZTSE4645
Fuel injector remover tool (#40 Torx®)	ZTSE4524
IPR removal / installation tool	ZTSE4666
Loctite® 246 Threadlocker	Obtain locally

Table 101 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

Table 102 Engine Brake Special Service Tools

Feeler gauge (long)	Obtain locally

Photos of Essential Tools

Figure 657 EGR cooler pressure test plates, ZTSE4636

Figure 658 Rear seal installer, ZTSE4637

Figure 659 Valve seat remover (collet), ZTSE4640

Figure 660 Valve seat installer, ZTSE4641

Figure 661 Injector sleeve installer, ZTSE4642

Figure 662 Injector sleeve remover, ZTSE4643

Figure 663 Injector rack – ZTSE4299B, Injector rack cups – ZTSE4645

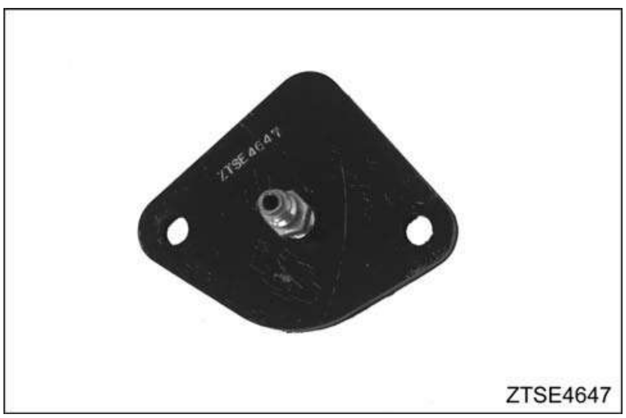


Figure 664 Thermostat opening pressure adapter– cylinder head, ZTSE4647

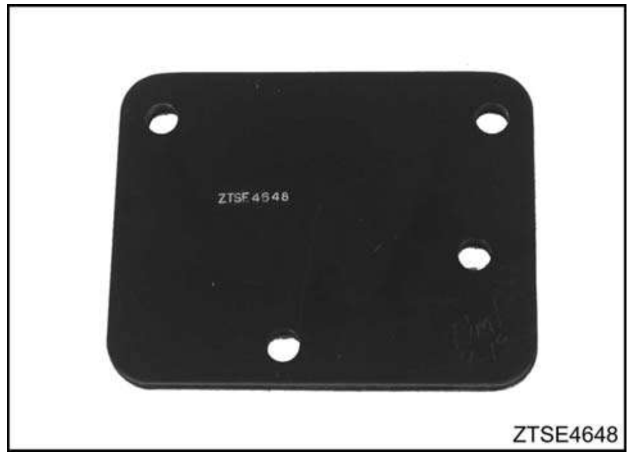


Figure 665 Water supply housing pressure adapter-cylinder head, ZTSE4648

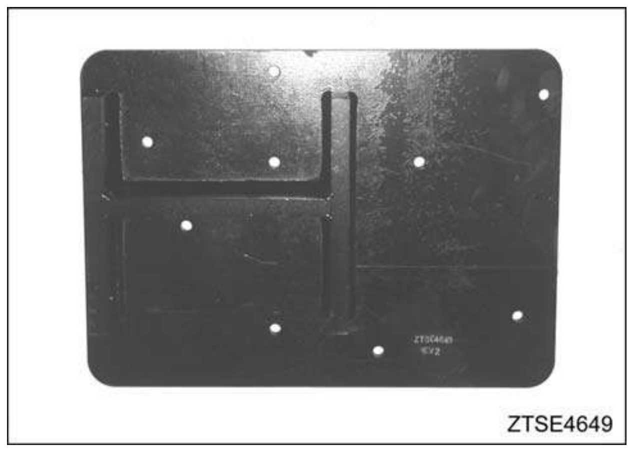


Figure 666 Engine mounting plate, ZTSE4649

Figure 667 Valve spring compressor jaws, ZTSE4652

Figure 668 Piston gauge pins (set of three), ZTSE4653

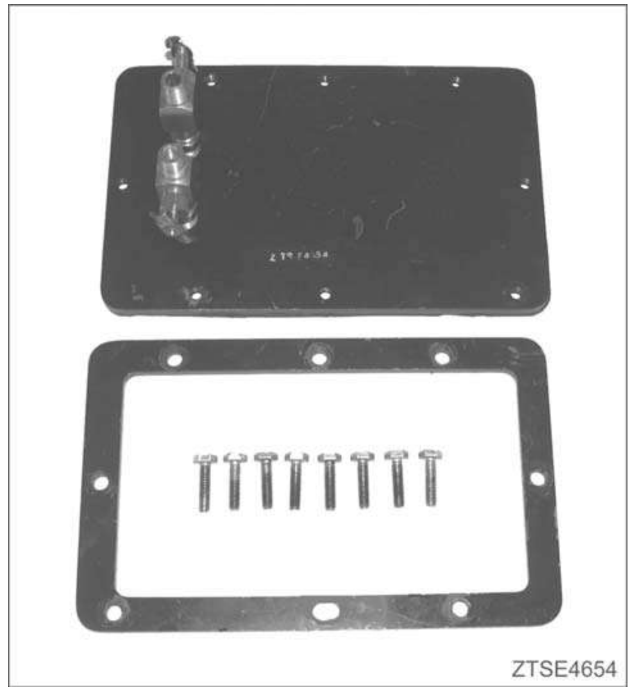


Figure 669 Oil cooler test plate, ZTSE4654

Figure 670 Head bolt and main bolt thread gauge, ZTSE4667

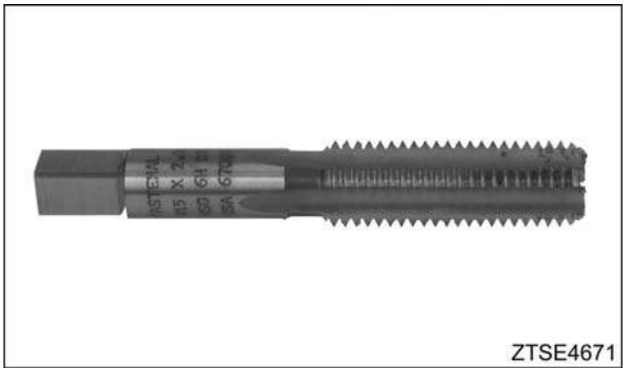


Figure 671 Head bolt bottoming tap, ZTSE4671

Figure 672 Sleeve protrusion hold down clamps, ZTSE4672

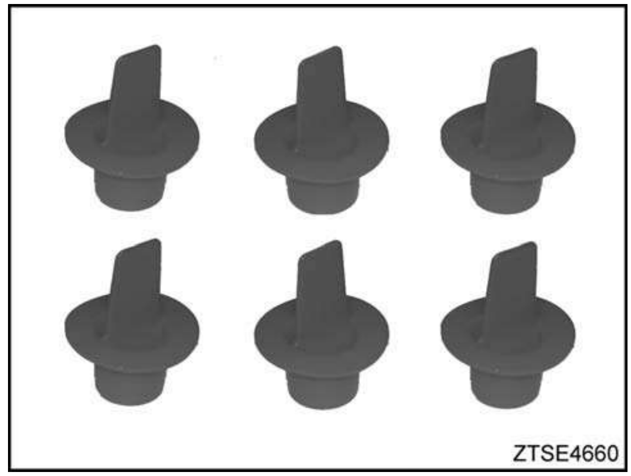


Figure 673 Cap kit– Injector, ZTSE4660

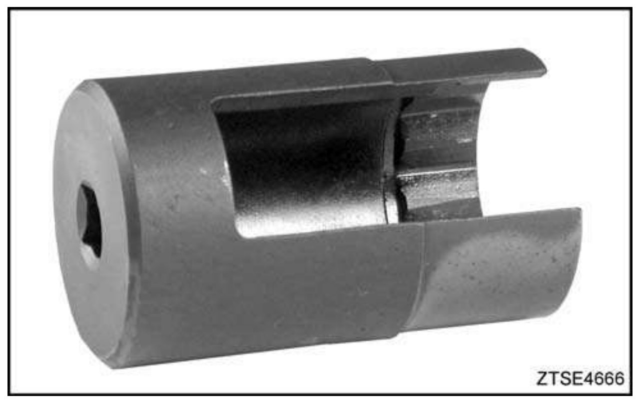


Figure 674 IPR valve removal and installation tool, ZTSE4666

Table of Contents

TSI-05-12-28 New High-pressure Oil Rails

Technical Service Information

TSI–05–12–28

Date: July 2005

Subject File: Engine

Subject: New High-pressure Oil Rails

Engine Family: International® DT 466, DT 570, and HT 570 Diesel Engines – all applications
SN Range: 2,000,001 and up

Description

New high-pressure oil rails are a direct replacement for the old and have casting and machining changes which remove internal clearance depths for attenuator assemblies. New high-pressure oil rails can only use oil rail plug assemblies (1, Figure 1). Identify new high-pressure oil rails by the part number cast into the rail (Table 1).

Old high-pressure oil rails can use either oil rail plug assemblies or attenuator assemblies (Figure 1).

Table 1 New High-pressure Oil Rails

Description	Part Number
High pressure oil rail	1847778C1
High pressure oil rail (w/o brake)	1848234C1
High pressure oil rail assembly (w/o brake)	1847785C91 or 1848235C91
Brake specific high pressure oil rail assembly	1847786C91

CAUTION: Installing an attenuator assembly in a new high-pressure oil rail may result in a high-pressure oil leak and a loss of oil pressure.

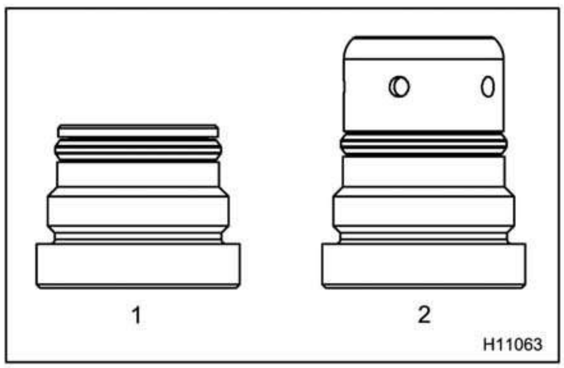


Figure 1 Oil rail plug and attenuator assemblies

1. Oil rail plug assembly 1854685C91
2. Attenuator assembly 1846058C91 (for use with old high-pressure oil rail only)

 Page 1 of 1 TSI051228-p1

TSI-05-12-35 New 1500 Watt Single Grid Intake Air Heater Production Option

Technical Service Information

TSI–05–12–35

Date: November 2005

Subject File: Engine

Subject: New 1500 Watt single grid intake air heater production option

Engine Family: International® DT 466, DT 570, and HT 570 Diesel Engines (2005 Model Year and up).

Description

A new 1500 Watt single grid intake air heater is being released for production.

This new intake air heater uses an inlet and EGR mixer duct which has machining to accept a single heater grid (1, Figure 1). No other intake duct features have changed.

The new single grid intake air heater harness assembly (2, Figure 1) uses a single circuit for one heater grid and one high current relay (3, Figure 1).

Table 1 1500 Watt single grid intake air heater components

Description	Part number
Inlet and EGR mixer with heater duct assembly	1858634C1
Inlet and EGR mixer duct	1832264C1
Intake air heater assembly	1858537C1
Intake air heater harness assembly	1850214C91
High current relay	1845347C1

The new 1500 Watt single grid intake air heater is now the standard intake air heater option. The 3000 Watt dual grid intake air heater is still available as a production option and parts will be available for service.

Refer to figures 1 and 2 for views of single and dual grid intake air heater production options installed.

NOTE: If an intake air heater is needed on a vehicle that is not equipped with one, 3000 Watt add-on inlet air heater kit (1858201C91) may be installed on certain vehicles. This add-on inlet air heater fits between the Charge Air Cooler (CAC) and the original inlet and EGR mixer duct. It may not fit on some vehicles due to clearance problems .

WARNING: To avoid personal injury, death, including damage to the engine or vehicle, do not install an add-on intake air heater kit on a vehicle that already has an intake air heater.

NOTE: Reprogramming of the Electronic Control Module (ECM) will be required if installing an intake air heater on a vehicle that was not originally equipped with one.

Description (cont.)

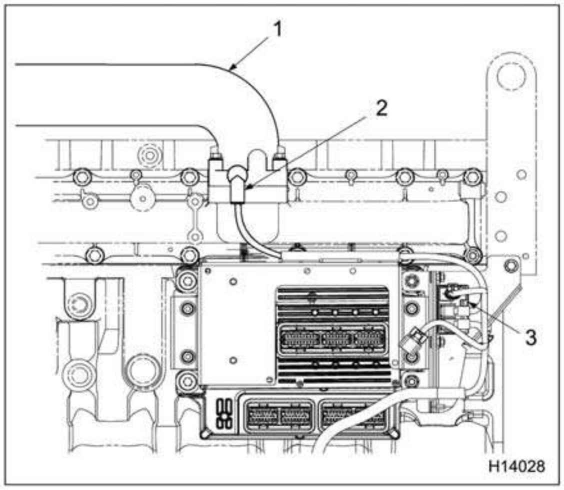


Figure 1 1500 Watt single grid intake air heater production option

1. Inlet and EGR mixer with heater duct assembly (1858634C1)
2. Intake air heater harness assembly (1850214C91)
3. High current relay (1)

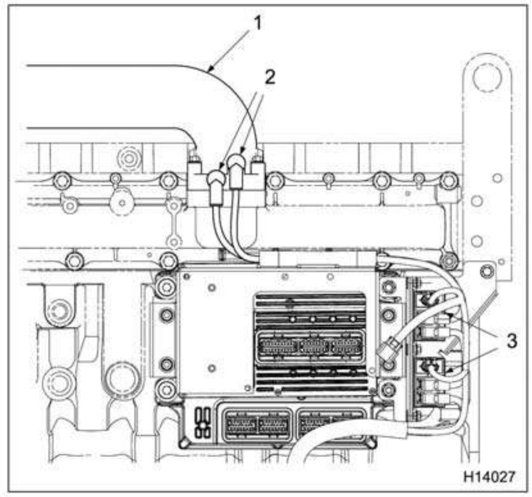


Figure 2 3000 Watt dual grid intake air heater production option

1. Inlet and EGR mixer with heater duct assembly (1845068C3)
2. Intake air heater harness assembly (1846241C95)
3. High current relay (2)

TSI-06-12-15 Sensor O-ring Kit for CMP or CKP Applications

Technical Service Information

TSI–06-12-15

Date: August 2006

Subject File: Engine

Subject: Sensor O-ring Kit for CMP or CKP Applications

Engine Family: INTERNATIONAL® VT 365 Diesel Engines

Engine Family: INTERNATIONAL® VT 275 Diesel Engines

Engine Family: INTERNATIONAL® DT 466, DT 570, and HT 570 Diesel Engines

Description

A sensor O-ring Kit 1871132C1 has been released. Sensor O-rings 1836505C1 and 1837889C1, in this kit, are no longer available separately.

O-ring Installation for CMP or CKP Applications

WARNING: To prevent personal injury or death, put transmission in neutral or park, set parking brake, and block wheels before doing diagnostic or service procedures on the engine or vehicle. Read all safety instructions in the "Safety Information" section of the *Engine Service* manual or the *Engine Diagnostic* manual.

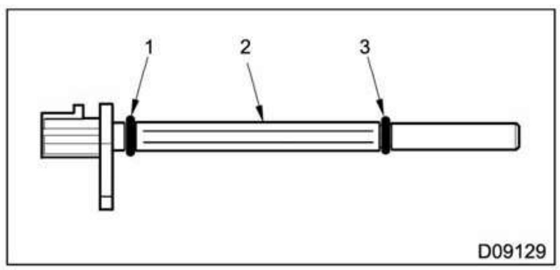


Figure 1 O-rings for CMP or CKP sensor applications

1. Sensor O-ring 1836505C1 (Blue)
2. Sensor
3. Sensor O-ring 1837889C1 (Red)

NOTE: The sensor shown measures camshaft position for INTERNATIONAL® VT 365 and VT 275 diesel engines; However, for INTERNATIONAL® DT 466, DT 570, and HT 570 diesel engines, this sensor measures crankshaft position, not camshaft position.

1. Remove both O-rings from sensor.
2. Install new O-rings.

TSI-06-12-14 Update Valve Train Components – Push Rod and Tappet Compatibility

Technical Service Information

TSI–06-12-14

This TSI replaces TSI-05-12-38

Date: May 2006

Subject File: Engine

Subject: Update Valve Train Components

Engine Family: International® DT 408, DT 466, and 530

Engine Family: International® DT 466E and 530E

Engine Family: International® DT 466, DT 530, and HT 530

Engine Family: International® 530E with Green Diesel Technology

Engine Family: International® DT 466 with Green Diesel Technology

Engine Family: International® DT 466, DT 570, and HT 570

Description

Engine valve train load carrying requirements have resulted in the release of several different push rod and tappet configurations. The main differences are noted by improved geometry designs and materials.

The tables included in this TSI provide service technicians with information on push rod and tappet compatibility for different engine model year configurations.

CAUTION: To prevent engine damage, follow push rod and tappet compatibility tables in this TSI when servicing components.

The following tables show the different types of push rod and tappet configurations service technicians may encounter.

Inline Six Cylinder Diesel Engines without Electronics and ECM (1994 to 1999) - See Table 1

ESN	Push Rod PN	Description	Tappet PN	Description
85000 to 120000	1809589C2	10.4658 in. long with small ball	1809570C3[1]	Small cup

1 Production used 1809570C1. Use 1809570C3 for service.

Inline Six Cylinder Diesel Engines with Electronics and Truck and Engine Mounted ECM (1995 to Current) - See Table 2 (except where noted)

ESN	Push Rod PN	Description	Tappet PN	Description
931164 to 1460269	1821962C2	10.6510 in. long with small ball	1809570C3[1]	Small cup
1460270 to 1493052[2]	1850010C1	10.6510 in. long with small ball	1809570C3	Small cup
1493053 and up[3]	1872746C1	10.5370 in. long with large ball	1850160C1	Large cup

1 Production used 1809570C1. Use 1809570C3 for service.

2 Excluding ESN 1492338 to 1492390, 1492392, 1492394 to 1492412, and 1492414 to 1492420 large geometry valve train components, see Table 4.

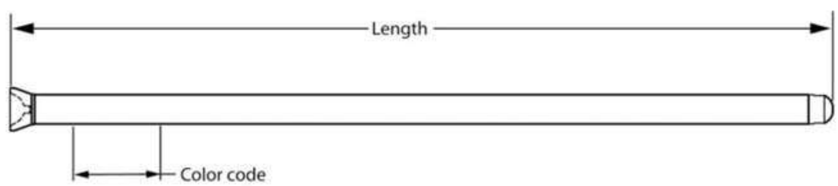
3 See Table 4

Inline Six Cylinder Diesel Engines with EGR System (2004 to Current) - See Table 3

ESN	Push Rod PN	Description	Tappet PN	Description
2000001 to 2072379	1833122C3	10.9420 in. long with small ball	1809570C3	Small cup
2072380 and up	1854756C1	10.9110 in. long with large ball	1850160C1	Large cup

Table 1 - ESN 85000 to 120000 (Model Year 1994-1999)

International® DT 408, DT 466, and 530 Applications

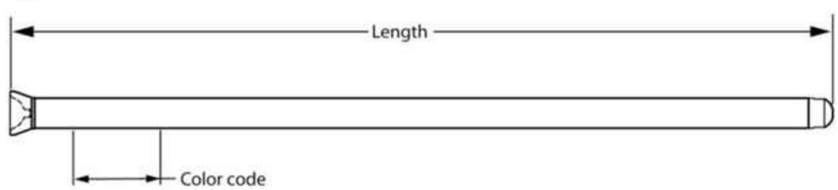


Engine Serial Number	Push Rod	Tappet	Color Code	Length
85000 to 120000	1809589C2	1809570C3[1]	Yellow	(10.4658 in.)

1 Production used 1809570C1. Use 1809570C3 for service.

Table 2 - ESN 931164 and 1493052 (see footnote)

International® DT 466E, DT 530E, 530E, DT 466, DT 530, HT 530, and 530E with Green Diesel Technology Applications



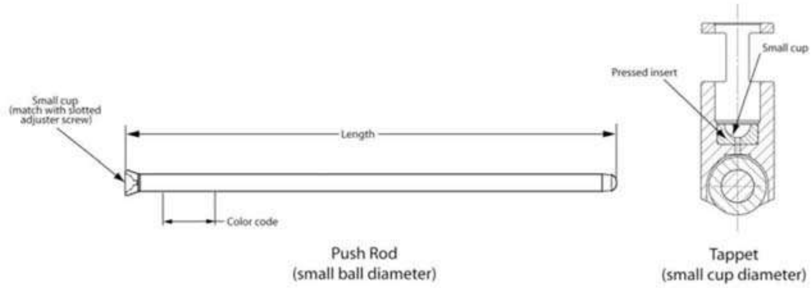
Engine Serial Number	Push Rod	Tappet	Color Code	Length
931164 to 1460269	1821962C2	1809570C3[1]	None	(10.6510 in.)
1460270 to 1493052[2]	1850010C1	1809570C3	Pink	(10.6510 in.)

1 Production used 1809570C1. Use 1809570C3 for service.

2 Excluding ESN 1492338 to 1492390, 1492392, 1492394 to 1492412, and 1492414 to 1492420 large geometry valve train components, see Table 4.

Table 3 - ESN 2000001 and Up

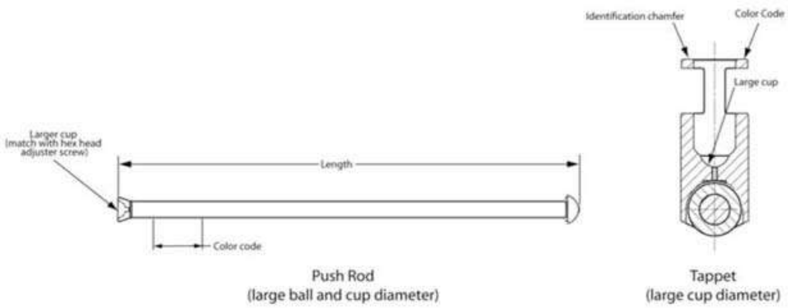
International® DT 466, DT 570, HT 570, and DT 466 with Green Diesel Technology Applications



NOTE: The following components are not compatible with applications below ESN 2000001.

Engine Serial Number	Push Rod	Tappet	Color Code	Length
2000001[1] to 2072379	1833122C3	1809570C3	Orange	(10.9420 in.)

CAUTION: To avoid engine damage, do not interchange the push rod and tappet configurations. The push rod and tappet configurations are a matched set and are only interchangeable as a matched set.



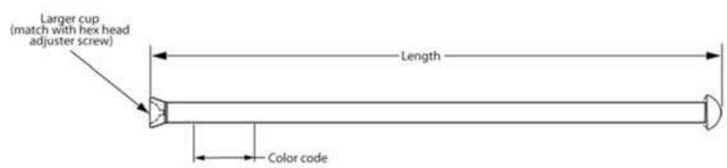
Engine Serial Number	Push Rod	Tappet	Color Code	Length
2072380 and up	1854756C1	1850160C1	Fluorescent- yellow (Rod and tappet)	(10.9110 in.)

NOTE: In addition to the fluorescent-yellow paint identifier, the adjuster screw is unique and can aid as a supplemental identifier. The new adjuster screw has a hex head instead of the typical slot found on all other inline six adjuster screws.

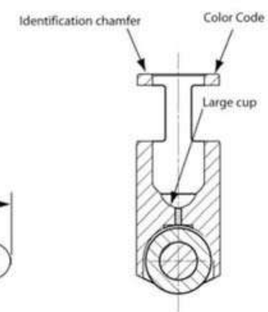
1 A small number of 2004 MY International® DT 466 were built with ESN below 2000001. These can be identified by checking the Engine Family designation on the emission label. Use the ESN 2000001 to 2072379 table for these engines.

Table 4 - ESN 1493053 and Up (see footnote)

International® DT 466, DT 530, HT 530 Applications



Push Rod
(large ball and cup diameter)



Tappet
(large cup diameter)

CAUTION: To prevent possible engine damage, do not install large geometry valve train components in engines produced with small geometry valve train components.

Engine Serial Number	Push Rod	Tappet	Color Code	Length
1493053 and up[1]	1872746C1	1850160C1	Blue	(10.5370 in.)

1 Refers to engines below ESN 2000001.

TSI-06-12-21 Update Valve Train Components – Adjuster Screws

Technical Service Information

TSI–06-12-21

Date: September 2006

Subject File: Engine

Subject: Update Valve Train Components

Engine Family: International® DT 466, DT 570, and HT 570 Diesel Engines
SN Range: 2000001 to 2072379

Description

International® DT 466, DT 570, and HT 570 Diesel Engines with serial numbers between 2000001 and 2072379 were produced with small geometry valve train components.

NOTE: A small number of 2004 MY International® DT 466 diesel engines were built with an ESN below 2000001. These can be identified by checking the Engine Family designation on the emission label.

The small geometry support and rocker shaft assembly will be discontinued from service.

A Small Geometry Adjuster Kit (1876798C91) provides a replacement large geometry rocker shaft assembly with small geometry adjuster screws that can be used with existing small geometry push rods and tappets.

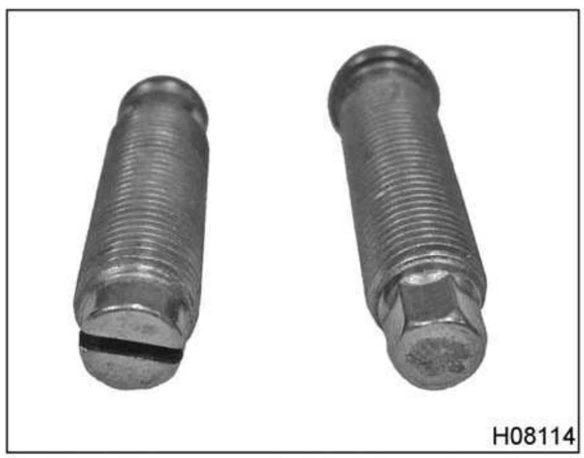


Figure 1 Adjuster screws (small geometry on the left)

NOTE: The large geometry adjuster screws have a hex head, larger diameter ball, and are longer. The small geometry adjuster screws have a slotted head, smaller diameter ball, and are shorter.

TSI-06-12-27 New Piston and Piston Ring Assemblies

Technical Service Information

TSI–06-12-27

Date: December, 2006

Subject File: Engine

Subject: New piston and piston ring assemblies

Engine Family: International® DT 466 diesel engines (210 to 245 horsepower applications)
SN Range: 2148234 and up

Description

Description	New Style Service Part	Old Style Service Part
Engine Overhaul Kit	1871003C95	1871003C94
Piston Ring Kit	1876098C91	1830724C92
Piston Sleeve and Ring Kit	1876100C91	1850401C92

NOTE: Engine Overhaul Kit contains six Piston Sleeve and Ring kits.

CAUTION: To prevent damage to the engine, old and new style pistons and rings must not be mixed. Old style pistons must be used with old style piston rings. New style pistons must be used with new style piston rings.

CAUTION: To prevent damage to the engine, all six piston assemblies must match. If one piston assembly needs to be replaced, it must be replaced with a matching piston assembly. If a matching piston assembly is not available, all six piston assemblies must be replaced.

New style piston and piston rings are being used in 210 to 245 horsepower applications starting with engine serial number 2148234 and up. Old style piston and piston rings will continue as service parts until stock is exhausted.

When replacing piston and ring assemblies, engines with serial number 2148234 and up, replace with new style piston sleeve and ring kit (1876100C91).

When replacing an old style piston assembly, on engines with serial number between 2000001 and 2148234, replace with an old style piston sleeve and ring kit (1850401C92). If an old style piston sleeve and ring kit is not available, all six old style piston assemblies must be replaced using new style engine overhaul kit (1871003C95).

Description (cont.)


H04027

Figure 1 New style piston - 1847682C2

H04028

Figure 2 Old style piston - 1858120C1

 Page 2 of 2 TSI061227 p2

TSI-07-12-12 EGR Coolant Return Kit

Technical Service Information

TSI–07-12-12

Date: July 2007

Subject File: Engine

Subject: EGR Coolant Return Kits

Engine Family: International® DT 466 Diesel Engine
SN Range: 2000001-2030022

Engine Family: International® DT 570 Diesel Engine
SN Range: 2000001-2030022

Engine Family: International® HT 570 Diesel Engine
SN Range: 2000001-2030022

Description

New Exhaust Gas Recirculation (EGR) Coolant Return Kits are available for truck and bus applications. Installation of an EGR Coolant Return Kit prevents coolant leaks from the return circuit of the EGR cooler. The selection and application of a kit is based on the length of the EGR cooler and the installation of the EGR cooler return elbow in the EGR coolant return port.

Description (cont.)

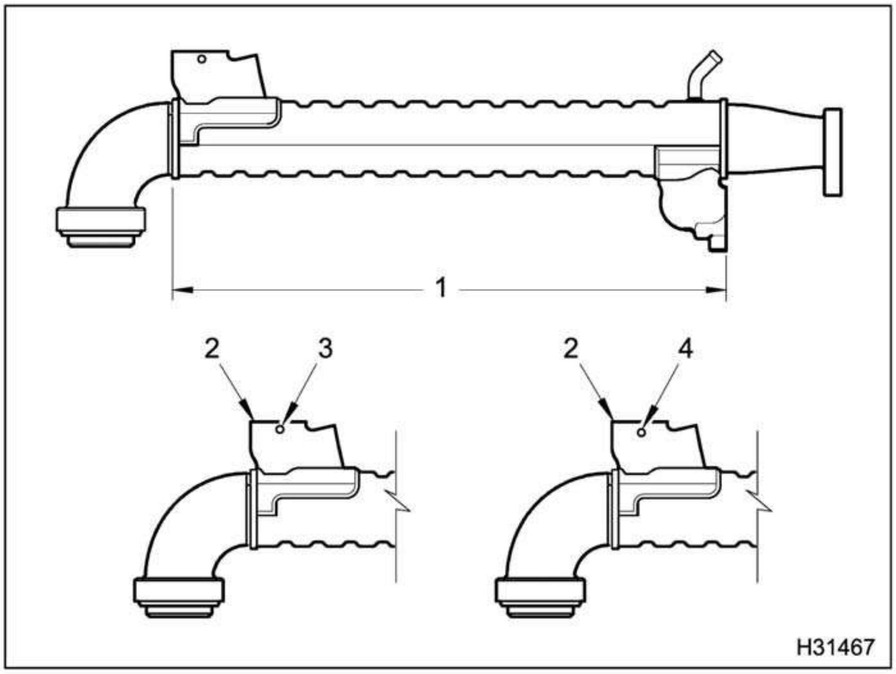


Figure 1 EGR cooler assembly

1. Reference length: 11.5, 17, or 21 inches
2. EGR coolant return port
3. Untapped hole (2) for spring clip
4. Tapped hole (2) for set screws

Selection of EGR Coolant Return Kit

NOTE: If the return elbow in the coolant return port is secured with a spring clip, order the correct length kit from Chart 1. If the return elbow is secured with two set screws, order the correct length kit from Chart 2.

Chart 1 Untapped Spring Clip Holes in Coolant Return Port of EGR Cooler

Length	Part Number	Table Number
EGR cooler	EGR Coolant Return Kit	Kit contents
11.5 inches	1880270C91	1
17 inches	1880271C91	2
21 inches	1880271C91	2

Chart 2 Tapped Set Screw Holes in Coolant Return Port of EGR Cooler

Length	Part Number	Table Number
EGR cooler	EGR Coolant Return Kit	Kit contents
11.5 inches	1880272C91	3
17 inches	1880273C91	4
21 inches	1880273C91	4

Selection of EGR Coolant Return Kit (cont.)

Table 1 EGR Coolant Return Kit 1880270C91

Description	Qty.	Part Number
EGR coolant return adapter tube	1	1855632C1
EGR coolant return hose	1	1855571C1
EGR coolant return elbow	1	1880020C1
EGR elbow retaining clip	1	1850250C1
EGR tube bracket	1	1858107C3
Hose clamp	2	1850645C1
O-ring seal	2	1844447C1
Bolt, M10 x 1.5 x 25 mm	1	1817965C1
Flat Washer, 3/8 in	1	25724R1
Instruction sheet	1	1171924R1

Table 2 EGR Coolant Return Kit 1880271C91

Description	Qty.	Part Number
EGR coolant return adapter tube	1	1855632C1
EGR coolant return hose	1	1855592C1
EGR coolant return elbow	1	1880020C1
EGR elbow retaining clip	1	1850250C1
EGR tube bracket	1	1858107C3
Hose clamp	2	1850645C1
O-ring seal	2	1844447C1
Bolt, M10 x 1.5 x 25 mm	1	1817965C1
Flat Washer, 3/8 in	1	25724R1
Instruction sheet	1	1171924R1

Table 3 EGR Coolant Return Kit 1880272C91

Description	Qty.	Part Number
EGR coolant return adapter tube	1	1855632C1
EGR coolant return hose	1	1855571C1
EGR coolant return elbow	1	1880319C1
EGR elbow retaining clip	1	1850250C1
EGR tube bracket	1	1858107C3
Hose clamp	2	1850645C1
O-ring seal	2	1844447C1
Bolt, M10 x 1.5 x 25 mm	1	1817965C1
Flat Washer, 3/8 in	1	25724R1
Instruction sheet	1	1171924R1

Table 4 EGR Coolant Return Kit 1880273C91

Description	Qty.	Part Number
EGR coolant return adapter tube	1	1855632C1
EGR coolant return hose	1	1855592C1
EGR coolant return elbow	1	1880319C1
EGR elbow retaining clip	1	1850250C1
EGR tube bracket	1	1858107C3
Hose clamp	2	1850645C1
O-ring seal	2	1844447C1
Bolt, M10 x 1.5 x 25 mm	1	1817965C1
Flat Washer, 3/8 in	1	25724R1
Instruction sheet	1	1171924R1

TSI-08-12-20 Rubber Vibration Damper Replacement Kits

Technical Service Information

A NAVISTAR COMPANY

TSI–08–12–20

This TSI replaces TSI-06-12-26 and TSI-07-12-02 and clarifies the use of the new smaller rubber vibration damper in the Vibration Damper Replacement kits.

Date: November 2008

Subject File: Engine

Subject: Rubber Vibration Damper Replacement Kits

Engine Family: International® DT 570 and HT 570 diesel engines
SN Range: 2000001 through 2999999

Description

Three Rubber Vibration Damper Replacement Kits were released to eliminate premature belt wear. Starting 11/03/2006, DT 570 and HT 570 diesel engines were produced with a smaller, rubber vibration damper. The same smaller, rubber vibration damper in the replacement kits is usable on all DT 570 and HT 570 diesel engines, including those manufactured with the larger viscous vibration damper.

Description (cont.)

Table 1 Rubber Vibration Damper Replacement Kits and Drive Belts

Rubber Vibration Damper Replacement Kit	Vehicle DT570 and HT 570 only	A/C	Special Alternator Ratio (Fire and Rescue Only)	Belt Part Number
1875872C91 Horton 1.2	7000 Series	No	No	1842460C1
		Yes	No	1874774C1
		Yes	Yes	1874773C1
1875871C91 Horton 1.3	7000 Series	No	No	1841755C1
		Yes	No	1874773C1
		Yes	Yes	1876008C1
	4000/8000 Series	No	No	1842456C1
		Yes	No	1842596C1
		Yes	Yes	1876006C1
1875873C91 Borg-Warner 1.3	4000/8000 Series	No	No	1842456C1
		Yes	No	1842596C1
		Yes	Yes	1876006C1

CAUTION: To prevent engine damage, use the correct Rubber Vibration Damper Replacement Kit and drive belt specified for the vehicle/engine application.

Horton Drivemaster Kits

To determine which Horton kit to order, remove the drive belt and put a tape measure around the center ribs of the pulley, not around the outer most flanges of the pulley, and record the measurement. Select a kit as specified below:

- Use the Horton 1.2:1 ratio kit 1875872C91, if the measurement is approximately 686 mm (27 inches).
- Use the Horton 1.3:1 ratio kit 1875871C91, if the measurement is approximately 610 mm (24 inches).

NOTE: If the vehicle being refitted with a rubber damper has a Front End PTO, discard the original FEPTO adapter and order FEPTO adapter 3588711C4.

Description (cont.)

NOTE: The components in each kit are identical with the exception of the fan pulley.

Table 2 Rubber Vibration Damper Replacement Kit Components

Description	Quantity	Part Number
Rubber vibration damper assembly	1	1836434C2
Water pump pulley	1	1817629C1
Fan pulley assembly	1	Horton 1.2:1 1874597C91
		Horton 1.3:1 1874596C91
		Borg Warner 1.3:1 1820309C1
M10 x 16 hex bolt	6	1823283C1
Service Kit Blank Label	2	1876229C1
Instruction Sheet	1	1171894R1

Two identical blank labels are in the Rubber Vibration Damper Replacement Kit. Write the part number of the drive belt, vibration damper, water pump, and fan pulley on both blank labels.

Put one label on the air cleaner lid and other label on the driver's side door jam.

TSI-09-12-02 High-pressure Pump Assembly Inlet Filter Service Kit

Technical Service Information

A NAVISTAR COMPANY

TSI–09-12-02

Date: March 2009

Subject File: Engine

Subject: High-pressure Pump Assembly Inlet Filter Service Kit

Engine Family: International® DT 466, DT 570, and HT 570 Diesel Engines
SN Range: 2,000,000 and up

Engine Family: International® MaxxForce® DT, 9, and 10 Diesel Engines
SN Range: 3,000,000 and up

Description

A high-pressure pump inlet filter service kit 1886397C91 (Table 1) has been released for use with high-pressure pump kits listed in Tables 2, 3, and 4. The high-pressure pump in these kits has a stepped inlet throttle spring retainer.

NOTE: High-pressure pumps (serial numbers P07J02154 and up) have the stepped inlet throttle spring retainer.

The inlet filter can only be used with pumps having the stepped inlet throttle spring retainer.

NOTE: There is no service interval for the inlet filter. The inlet filter should be replaced only if damaged.

Description (cont.)

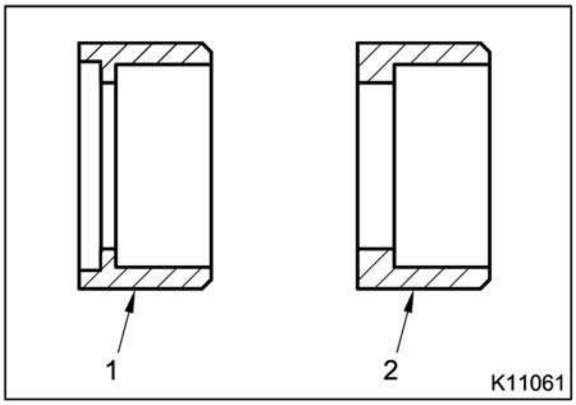


Figure 1 Cross-section of inlet throttle spring retainers (stepped and nonstepped)

1. Inlet throttle spring retainer (stepped)
2. Inlet throttle spring retainer (nonstepped)

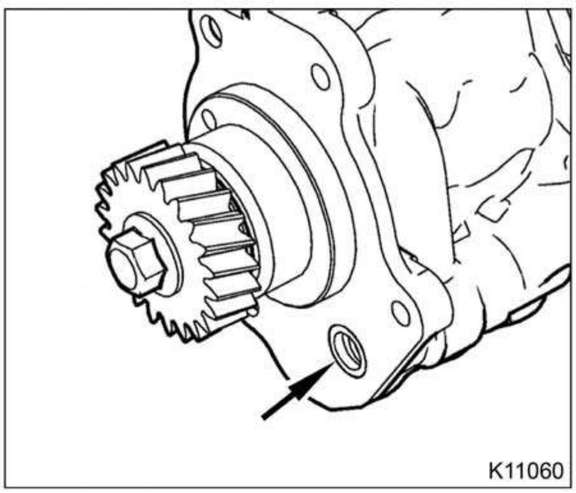


Figure 2 Stepped inlet throttle spring retainer in high-pressure pump

Table 1 High-pressure Pump Assembly Inlet Filter Service Kit (1886397C91)

Description	Qty.	Part Number
Inlet filter	1	1879441C1
3/8 Tube sleeve	4	1812348C1
O-ring seal (No. 12)	1	1839026C1
High-pressure pump gasket	1	1836005C1
O-ring seal (No. 112)	1	1879755C1
O-ring seal (No. 14)	2	1842105C1

High-pressure Pump Kits with Stepped Inlet Throttle Spring Retainer

Table 2 International® DT 466, DT 570, and HT 570 Diesel Engines (Engine serial numbers 2000001 and up)

Description	Part Number
High-pressure pump kit (12cc)	1883888C91
High-pressure pump kit (16cc)	1885000C91

Table 3 International® MaxxForce® DT, 9, and 10 Diesel Engines (Engine serial numbers 3000001 through 3040000)

Description	Part Number
High-pressure pump kit (12cc)	1876105C93
High-pressure pump kit (16cc)	1876106C93

Table 4 International® MaxxForce® DT, 9, and 10 Diesel Engines (Engine serial numbers 3040001 and up)

Description	Part Number
High-pressure pump kit (12cc)	1882258C91
High-pressure pump kit (16cc)	1882259C91

Table of Contents

1171813R1 Front Cover PTO Adaptation Kit

Instruction Sheet
Front Cover PTO Adaptation Kit

Instruction 1171813R1

APPLICATION: International® DT 466, DT 570, and HT 570 Diesel Engines

S/N: 2,000,001 and Above, 2004 Model Year,

PURPOSE: This instruction sheet contains the procedure for the vehicle owner to attach a front cover mounted Power Take-off (PTO) device to the engine. The PTO device is mounted opposite the air compressor on the front cover, getting power from the air compressor gear.

KIT CONTENTS:

Front Cover PTO Adaptation Kit

- PTO spline adapter assembly (Consisting of:)
    - PTO spline adapter
    - Retaining ring (installed in spline adapter)
- O-ring seal (#235)
- Instruction sheet

> ⚠ **WARNING**: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle. Read all safety instructions in the “Safety Information” section of the service manual for this engine.

NOTE: This feature may be used alone or with any other PTO options available through your International Truck and Engine Corporation service center.

PROCEDURE:

Your engine is equipped with an air compressor having an internal spline drive gear. The front cover mounted PTO device can only be used in conjunction with the air compressor.

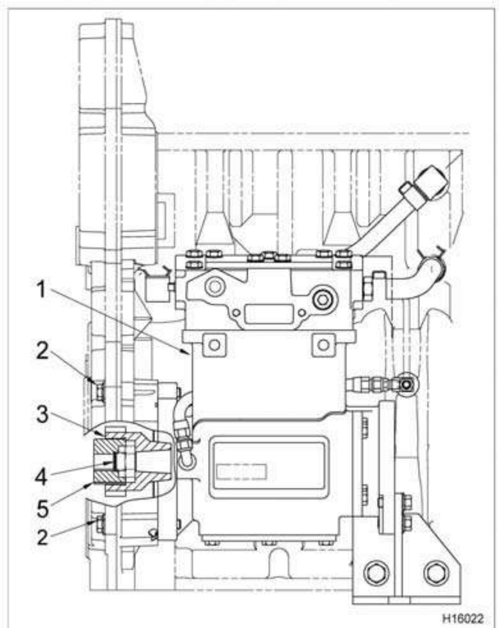


Figure 1. PTO spline adapter installed onto air compressor drive gear.

1. Air compressor
2. PTO flange cover mounting bolts
3. Air compressor drive gear
4. Spline adapter retaining ring
5. PTO spline adapter

1. Remove the two mounting bolts securing the PTO flange cover from the front cover.

CAUTION: To insure proper installation of the spline adapter assembly, be sure the internal spline is pointing outward from the engine (Figures 1 and 2).

2. Install the PTO spline adapter assembly into the air compressor drive gear. The PTO spline adapter has both internal and external teeth. The external teeth slide into the air compressor drive gear.

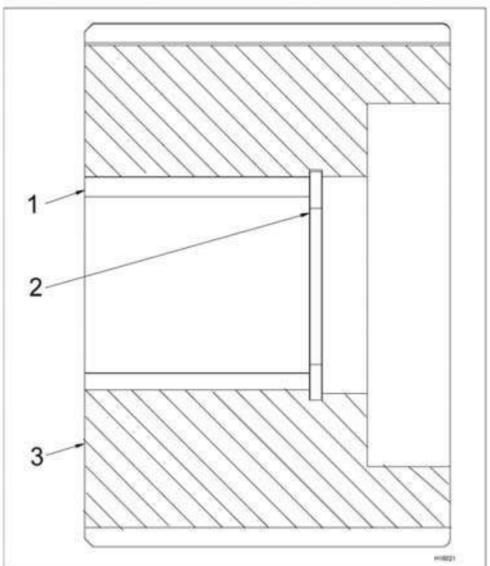


Figure 2. Correct position of PTO spline adapter assembly

1. Internal spline facing outward from engine
2. Retaining ring
3. PTO spline adapter

The PTO spline adapter assembly floats on the drive shaft between the air compressor drive gear and the auxiliary PTO device. The retaining ring properly locates the PTO spline adapter to the auxiliary PTO device.

3. Install the O-ring (#235) onto the PTO pilot hub.

CAUTION: To avoid engine damage, be sure the PTO shaft protrusion (dimension 'A', Figure 4) does not exceed 34mm (1.345 in.).

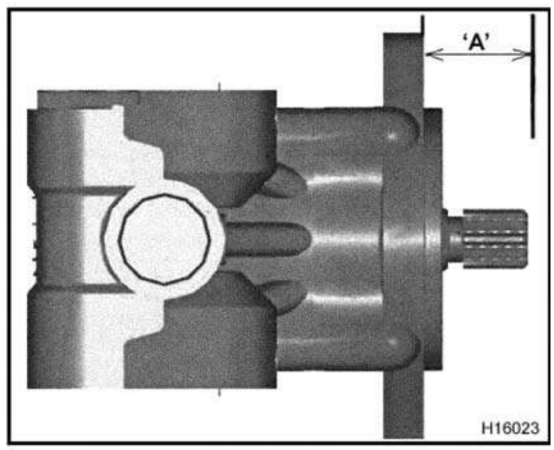


Figure 4. Maximum PTO shaft protrusion

4. Install the desired auxiliary PTO device. Be sure to engage the spline of the PTO device into the PTO spline adapter assembly.

5. Install and finger-tighten the PTO mounting bolts to the front cover. Tighten to the standard torque value of 50 N·m (37 lbf-ft).

 Page 2 of 2 IS1171831R1-p2

1171836R1 Air Compressor Bracket Kit

Instruction Sheet
Air Compressor Bracket Kit

1171836R1

Application

International® DT 466E, DT 530E, DT 466, DT 530, DT 570, and HT 570 Diesel Engines

Purpose

A new, air compressor bracket kit is used for the following applications:

- Replacement and service for the steel air compressor bracket
- Service parts for an aluminum air compressor bracket

Kit Contents

Table 1 Air Compressor Bracket Kit

Description	Quantity.
Air compressor bracket	1
Bolt, M12 x 50	2
Bolt, M10 x 30	2
Instruction sheet	1

NOTE: The following torque sequence is critical during installation of the new air compressor bracket:

1. Initially, torque M10 X 30 bolts to 6 N·m (50 in·ft).
2. Single torque M12 X 50 bolts to 115 N·m (85 lbf·ft).
3. Finally, torque M10 X 30 bolts to 66 N·m (49 lbf·ft).

> **WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle. Read all safety instructions in the "Safety Information" section of the service manual for this engine.**

Procedure

Removal and installation

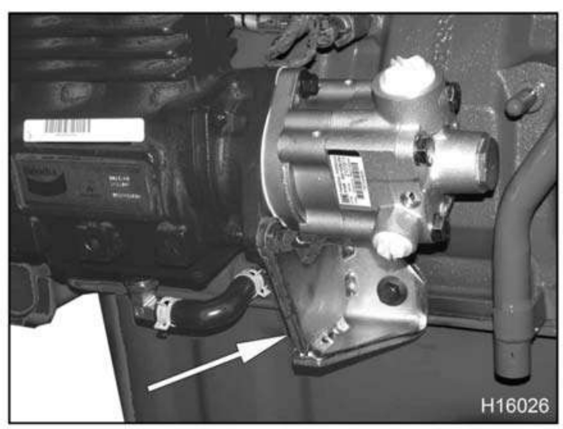


Figure 1 Old air compressor bracket

 Page 1 of 3 IS1171836R1-p1

Removal and installation (cont.)

Figure 2 Old air compressor bracket

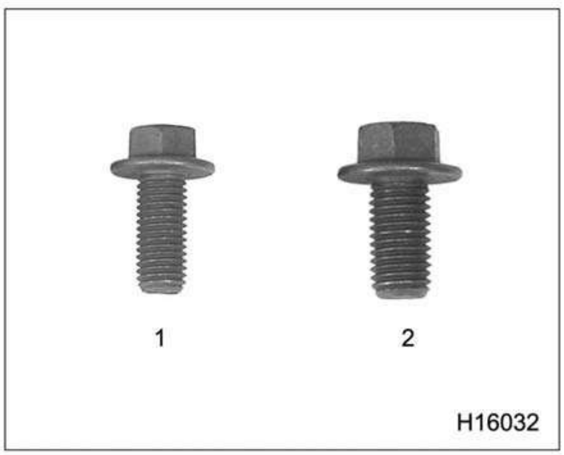


Figure 3 Old mounting bolts

1. Bolt, M10 X 25 (2)
2. Bolt, M12 X 25 (2)

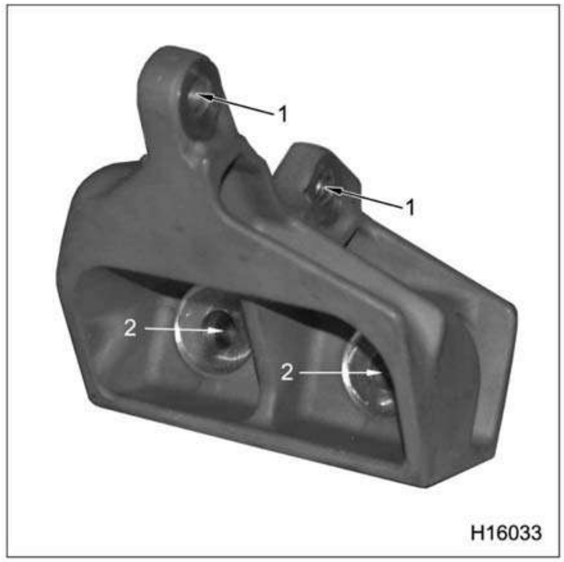


Figure 4 New air compressor bracket

1. Bolt holes for M10 X 30 Bolt
2. Bolt holes for M12 X 50 Bolt

Figure 5 Bolts for new air compressor bracket

1. Bolt, M10 X 30 (2)
2. Bolt, M12 X 50 (2)

Removal and installation (cont.)

NOTE: The following procedure and torque sequence are critical:

1. Remove old air compressor bracket.
2. Position new air compressor bracket, and install M10 X 30 bolts to attach bracket to air compressor.
3. Initially, torque M10 X 30 bolts to 6 N·m (50 in·ft).
4. Install M12 X 50 bolts to attach bracket to engine block.
5. Single torque M12 X 50 bolts to115 N·m (85 lbf·ft).
6. Finally, torque M10 X 30 bolts to 66 N·m (49 lbf·ft).

1171846R1 Aluminum Air Inlet Adapter

Instruction Sheet
Aluminum Air Inlet Adapter

1171846R1

Application

International® DT 466, DT 570, and HT 570

Purpose

A new, aluminum inlet adapter kit is used for the following applications:

- Replacement of the old, plastic inlet adapter and seal
- Service parts for an aluminum inlet adapter
- Service parts for an aluminum inlet adapter used with the inlet air heater

Kit Contents

Aluminum Inlet Adapter Kit

Description	Quantity
Inlet adapter	1
Inlet adapter gasket	2
Instruction sheet	1

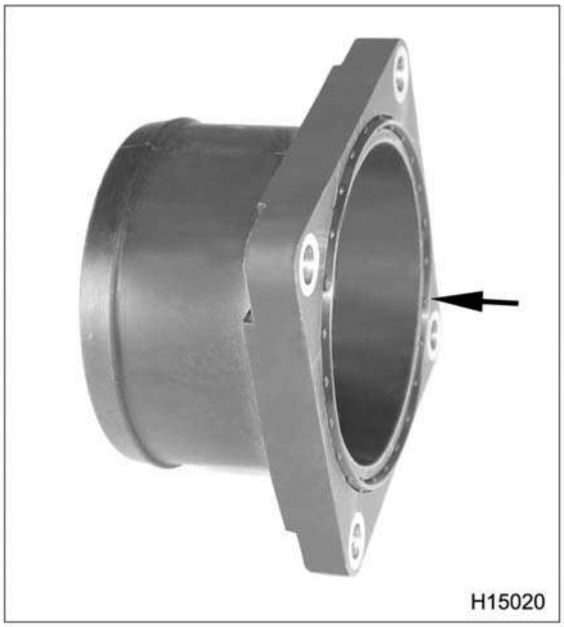


Figure 1 Plastic inlet adapter with seal

Procedure

WARNING: To avoid serious personal injury, possible death or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic procedures. Read all safety instructions in the "Safety Information" section of the service manual for this engine.

Procedure (cont.)

Figure 2 Aluminum inlet adapter

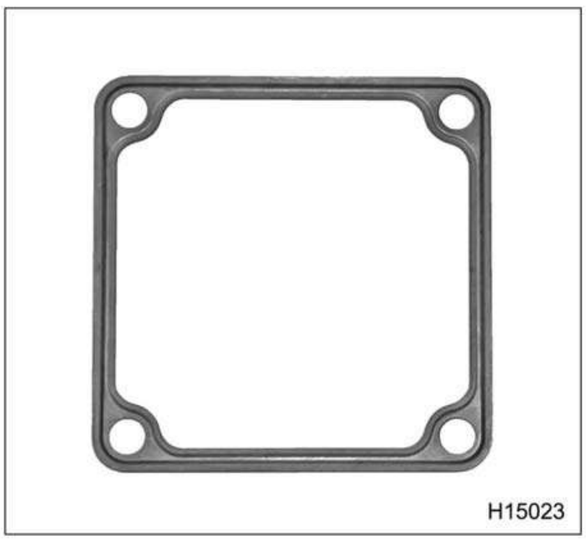


Figure 3 Inlet adapter gasket

Replacement of plastic inlet adapter or service for aluminum inlet adapter

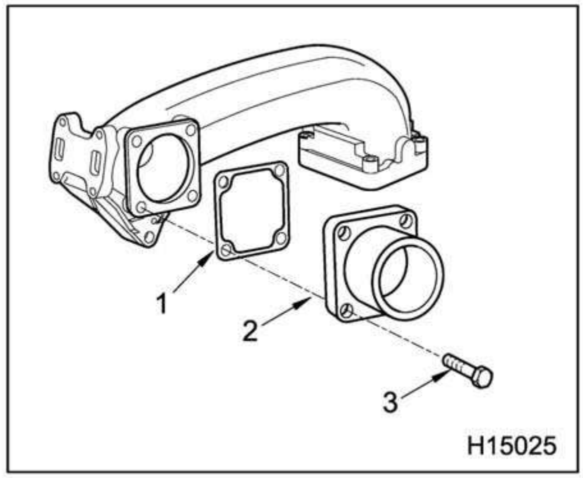


Figure 4 Installation of aluminum inlet adapter without air inlet heater

1. Inlet adapter gasket
2. Aluminum inlet adapter
3. Bolt, M8 X 35 (4)

1. Remove plastic inlet adapter and seal or aluminum inlet adapter and gasket.
2. Save the four M8 X 35 bolts.
3. Install one new gasket, inlet adapter, and four M8 X 35 bolts.
4. Torque bolts, in a criss-cross pattern, to 31 N·m (23 lbf·ft).

 Page 2 of 3 IS1171846R1-p2

Installation of service parts for aluminum inlet adapter used with air inlet heater

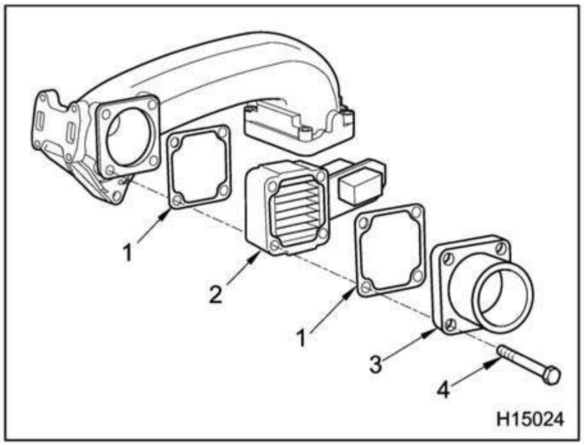


Figure 5 Installation of aluminum inlet adapter with air inlet heater

1. Inlet adapter gasket
2. Air heater module
3. Aluminum inlet adapter
4. Bolt, M8 X 80 (4)

1. Remove aluminum inlet adapter, gasket, air heater module, and gasket.
2. Save air heater module and four M8 X 80 bolts.
3. Install new gasket, air heater module, new gasket, new inlet adapter, and four M8 X 80 bolts.
4. Torque bolts, in a criss-cross pattern, to 31 N·m (23 lbf·ft).

1171848R1 300 Watt Oil Pan Heater Kit

Instruction Sheet
300 Watt Oil Pan Heater Kit

1171848R1

Application

International® DT 466, DT 570, and HT 570 diesel engines.

Purpose

Provide procedure to install 300 watt oil pan heater to improve cold startability.

Kit Contents

NOTE: Installation of this kit requires two plug style oil pan. The bottom plug is for draining oil. The corner plug is for installation of the oil pan heater element. If the two plug style pan is not currently on the engine, it must be changed before installing the heater.

300 Watt Oil Pan Heater Kit

Description	Quantity
Oil heating element assembly	1
Y-cord cable assembly	1
Instruction sheet	1

Procedure

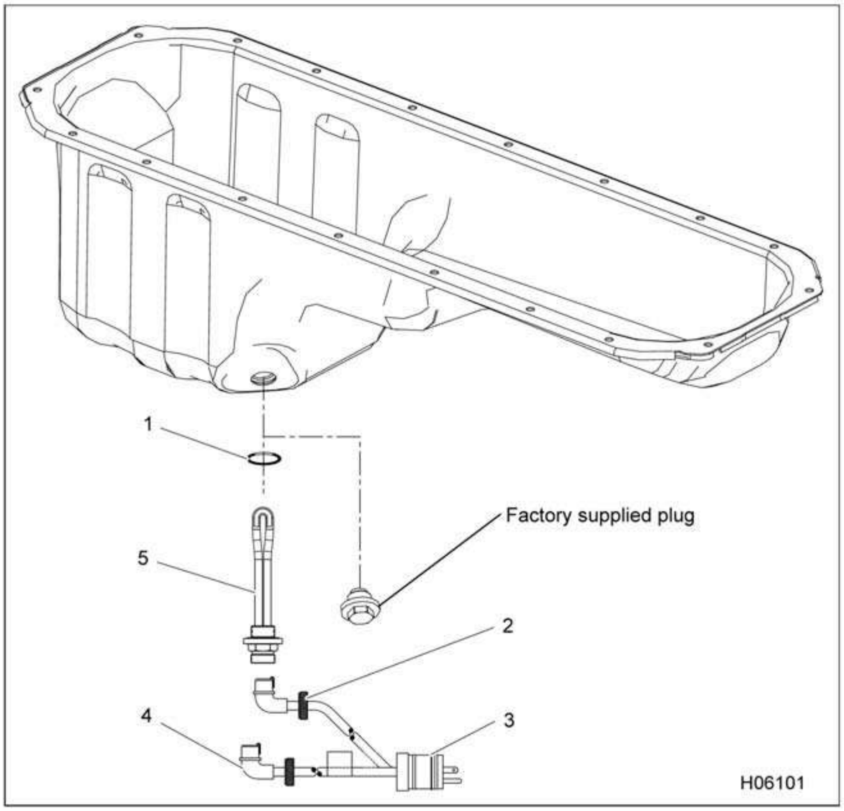


Figure 1 300 Watt oil pan heater

1. O-ring (included on oil heating element assembly)
2. Cordnut
3. Y-cord cable assembly
4. To block heater assembly (shorter cable section)
5. Oil heating element assembly

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure the transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle. Read all safety instructions in the "Safety Information" section of the service manual for this engine.

1. Remove factory supplied plug from oil pan.
2. Install oil heating element assembly, with O-ring, into oil pan and torque to 68 N·m (50 lbf·ft).
3. Plug Y-cord cable assembly (longer cable section) into oil heating element assembly and hand tighten cordnut.
4. If equipped with block heater assembly, plug Y-cord cable assembly (shorter cable section) into block heater assembly and hand tighten cordnut. If not equipped with block heater assembly, securely tie off Y-cord cable assembly (shorter cable section).
5. Route and secure Y-cord cable assembly to vehicle. Avoid routing close to rotating parts or belt drives.

1171855R1 Turbo Actuator Service Kit (SRA)

Instruction Sheet
Turbo Actuator Service Kit (SRA)

1171855R1

Application

International® DT 466, DT 570, and HT 570 Diesel Engines.

Purpose

Removal and installation of turbocharger actuator.

Kit Contents

Turbo Actuator kit

Description	Quantity
Actuator, 12V I-6	1
Serrated lock nut, M6 x 1.0	4
Nord-lock washer assembly	2
Fork lever bolt	2
Instruction sheet	1

NOTE: Kit comes with one extra fork lever bolt and nord-lock washer assembly.

Procedure

WARNING: To avoid serious personal injury, possible death, or damage to the engine or vehicle, make sure transmission is in neutral, parking brake is set, and wheels are blocked before doing diagnostic or service procedures on engine or vehicle. Read all safety instructions in the "Safety Information" section of the *Engine Service Manual* for this engine.

WARNING: To avoid serious personal injury or possible death, disconnect the main battery negative terminal before disconnecting or connecting electrical components. See "Safety Information" in *Engine Service Manual.*

WARNING: To avoid serious personal injury or possible death, make sure engine has cooled down before removing components. See "Safety Information" in *Engine Service Manual.*

Procedure (cont.)

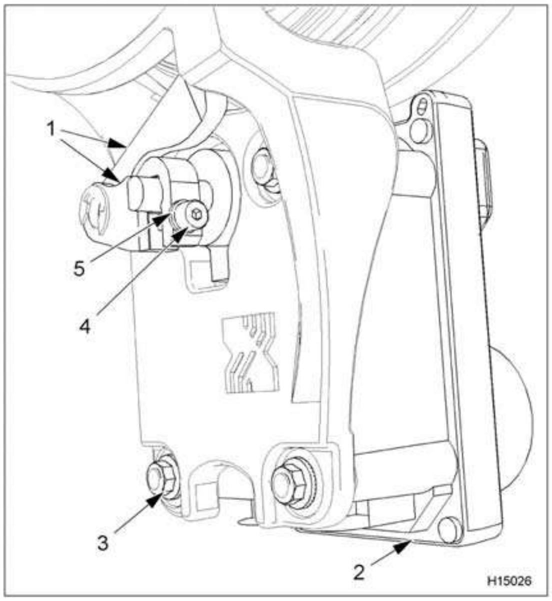


Figure 1 Turbocharger Actuator

1. Actuator linkage
2. Actuator
3. Serrated lock nut (4)
4. Fork lever bolt
5. Nord-lock washer assembly

NOTE: Removal of turbocharger assembly from engine is not required to perform this repair.

Removal

1. Unplug turbocharger wiring harness from engine wiring harness.
2. Remove fork lever bolt and nord-lock washer assembly from actuator linkage, using a long 4 mm (5/32 in) allen wrench. Do not remove other end of linkage from turbocharger.
3. Pivot actuator linkage out of the way, against spring pressure, to access blocked serrated lock nut. Linkage can be held in place using a tie strap against spring tension.
4. Remove four serrated lock nuts.
5. Pull actuator away from its mounting bracket. Actuator shaft is notched and may require rotation or rocking motion to remove.
6. Move turbocharger linkage through its normal operating motion. If turbocharger linkage or vanes are sticking, do not proceed with actuator installation steps below, turbocharger assembly should be replaced.

Installation

1. Hold turbocharger linkage above actuator shaft before installing actuator on mounting bracket.
2. Slide actuator studs into mounting bracket holes. Install four serrated lock nuts on studs. Torque nuts to 13.6 N·m (120 lbf·in). (Cut tie strap holding actuator linkage, if used.)
3. Push turbocharger linkage onto actuator shaft; rotation of shaft or linkage may be required.
4. Install nord-lock washer assembly on fork lever bolt and screw into lever arm. Torque bolt to 6.8 N·m (60 lbf·in).
5. Perform bounce test to check actuator linkage for binding. Hold actuator linkage toward frame rail and then release. If linkage is not binding it will fall back towards the engine, bounce once, and then stay toward engine.

   If actuator linkage is binding, use a long 4 mm (5/32 in) allen wrench to carefully twist the fork lever bolt counter-clockwise to free linkage binding, while not untorquing fork lever bolt.
6. Reconnect turbocharger wiring harness connector to engine wiring harness.

1171908R1 Turbocharger VGT Linkage Kit

Instruction Sheet
Turbocharger VGT Linkage Kit

1171908R1

Application

International® DT 466, DT 570, and HT 570 Diesel Engines

SN Range: 2000001 and up

Purpose

Removal and installation of turbocharger actuator linkage.

Kit Contents

Description	Quantity
Linkage, Turbo Assembly	1
Instruction Sheet	1

Procedure

Remove

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of EGES 265-1 *Service 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, remove ground cable from negative terminal of main battery before disconnecting or connecting electrical components. Always connect ground cable last.

CAUTION: To prevent damage to the engine or turbocharger, the area of the turbocharger adjacent to the housing on both the turbocharger and the control module shafts must be clean and function freely.

Remove (cont.)

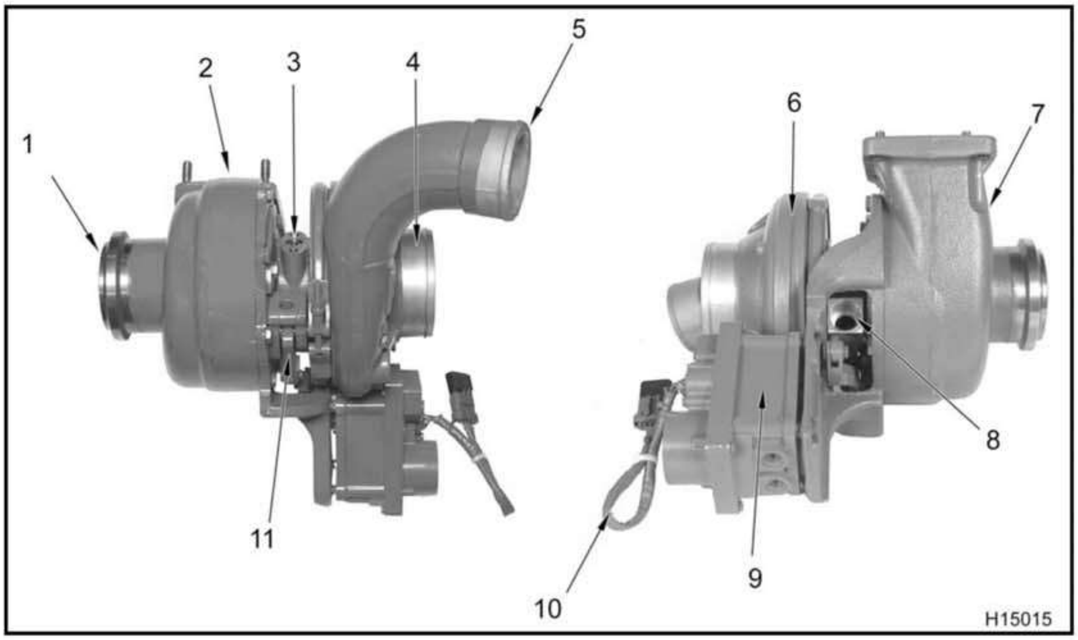


Figure 1 VGT Turbocharger component locations

1. Turbine outlet
2. Turbine inlet
3. Oil supply port
4. Compressor inlet
5. Compressor outlet
6. Compressor housing
7. Turbine housing
8. Oil drain port
9. Turbocharger control module (SRA - Smart Remote Actuator)
10. Electrical connector
11. VGT linkage

1. Remove inner fender from the vehicle.
2. Turn the ignition switch to OFF and disconnect the engine harness electrical connector from the SRA.

Remove (cont.)

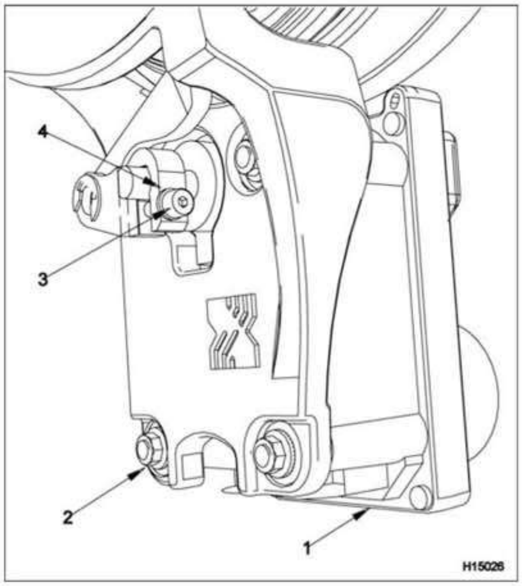


Figure 2 Turbocharger control module

1. Turbocharger control module (SRA - Smart Remote Actuator)
2. Serrated lock nut (4)
3. Fork lever bolt and Nord-Lock® washer assembly
4. Actuator linkage

CAUTION: To prevent engine damage, carefully remove the fork lever bolts. The Nord-Lock® washer assembly may fall off when the top fork lever bolt (turbocharger side) is removed.

NOTE: The fork lever bolts and Nord-Lock® washers are stainless steel. Magnets cannot be used to retrieve dropped parts.

3. Remove both fork lever bolts and Nord-Lock® washer assemblies on each end of the linkage.
4. Remove the linkage from the turbocharger and then from the SRA. If needed, remove the SRA to allow removal of a sticking or stuck linkage.

Clean

NOTE: Corrosion on the turbocharger or SRA shafts may impede the motion of the turbocharger vane mechanism.

1. Clean the area adjacent to the housing on both the turbocharger and the SRA shafts and ensure both shafts turn freely. Use suitable corrosion removal product to clean the shafts of corrosion.
2. If the turbocharger shaft cannot move freely, or cannot be positioned against its internal stop, replace the turbocharger.
3. If the SRA shaft cannot move freely, or cannot be positioned against its internal stop, replace the SRA.

Install

Figure 3 Actuator linkage

1. Turbocharger side of linkage
2. Nord-Lock® washer assemblies (2 sets of 2)
3. Fork lever bolts (2)
4. SRA side of linkage

1. Install the linkage with the SRA side, item 4 (Figure 3), tucked under the intermediate (center) linkage.

CAUTION: To prevent engine damage, carefully install the fork lever bolts. The Nord-Lock® washer assembly may fall off when the top fork lever bolt (turbocharger side) is installed.

NOTE: The fork lever bolts and Nord-Lock® washers are stainless steel. Magnets cannot be used to retrieve dropped parts.

Install (cont.)

2. Install the Nord-Lock® washer assemblies, item 2 (Figure 3), on each of the fork lever bolts, item 3 (Figure 3), and screw into the lever arms. Tighten each fork lever bolt on the linkage to 6.8 N·m (60 lbf·in).

CAUTION: To prevent engine damage, do not loosen the fork lever bolt when ensuring the fork lever and fork lever bolt are free to move.

3. Carefully twist the fork lever and fork lever bolt counter-clockwise to free the linkage.
4. Test to make sure the new linkage is properly installed. Move the linkage up and away from the engine, in the direction of the frame rail, several inches until movement stops. Release the linkage, it should fall back towards the engine, bounce once, and then stay in towards the engine.
5. If the linkage fails the test, repeat steps 3 and 4.
6. Connect the engine harness electrical connector to the SRA.
7. Install inner fender on the vehicle.

1171913R1 Turbine Vane Assembly Cleaning Kit

Instruction Sheet
Turbine Vane Assembly Cleaning Kit

1171913R1

Kit Contents

Table 1 Turbine Vane Assembly Cleaning Kit

Description	Quantity
Oil drain plug	1
Turbine wheel / compressor outlet cap	2
Oil inlet cap	1
Turbo oil inlet gasket	1
Oil drain O-ring seal	2
M8x30 HFH (None locking) bolt	3
M6x20mm bolt	1
O-ring #206 (0.484x0.623)	1
Yellow compressor inlet cap	1
Instruction sheet	1

Procedure

REMOVAL

NOTE: Use this cleaning procedure when the turbocharger vanes are stuck due to excessive oil deposits. If corrosion is found, the turbocharger cannot be cleaned.

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of the service 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 and turbocharger have cooled before removing the turbocharger.

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

See appropriate *Service Manual* for removal of the turbocharger.

INSPECTION AND CLEANING

NOTE: If the turbine blades are found not to be damaged during inspection, but the turbine V-clamp and nut are worn, bent, or damaged, it is necessary to obtain a Turbine V-Clamp and Nut Kit to complete the installation procedure.

1. Place the turbocharger on a work bench and inspect the compressor and turbine blades for damage.

- If the blades are damaged, the turbocharger should be replaced.
- If the blades are not damaged, continue with the inspection.

Procedure (cont.)

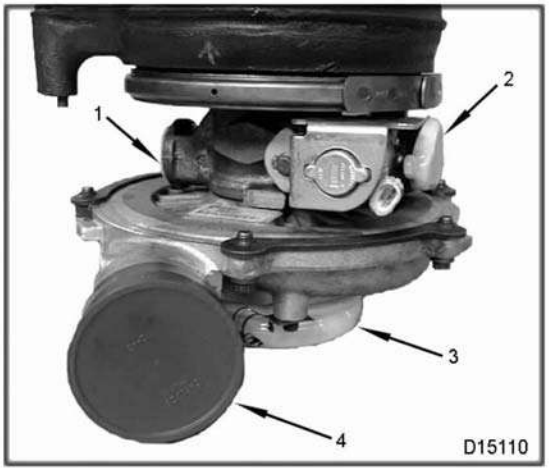


Figure 1 Turbocharger covers

1. Turbocharger oil drain outlet
2. Turbocharger oil supply inlet
3. Turbocharger outlet to Charge Air Cooler (CAC)
4. Turbocharger compressor inlet

2. Cover the compressor and turbine outlets with the red caps provided in the kit.

3. Cover the compressor inlet with the yellow cap provided in the kit.

4. Clean the oil supply line mounting surface and cover with the oil inlet cap.

5. Clean the oil drain passage and insert the oil drain plug.

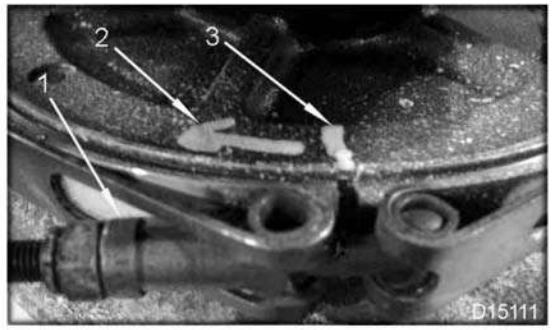


Figure 2 V-clamp location and direction

1. V-clamp
2. Direction of V-clamp locknut
3. Paint mark

6. Using a paint pen, mark the location of the V-clamp and direction of the V-clamp locknut (Figure 2).

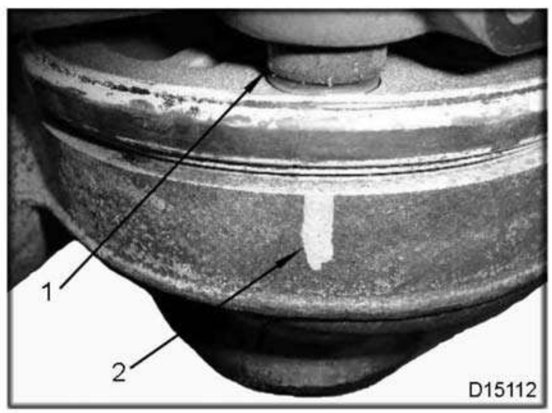


Figure 3 Unison ring cam

1. Unison ring cam
2. Paint mark

7. Using a paint pen, mark the location of the unison ring cam (Figure 3).

8. Remove the locknut nut completely from the V-clamp assembly, then remove the V-clamp from the turbocharger.

9. Carefully separate the turbine housing from the center section by using a hammer and brass drift.

Procedure (cont.)

Figure 4 Unison ring cam

10. Inspect the unison ring cam for wear (Figure 4). If excessive wear is found on the unison ring cam, the turbocharger cannot be cleaned.

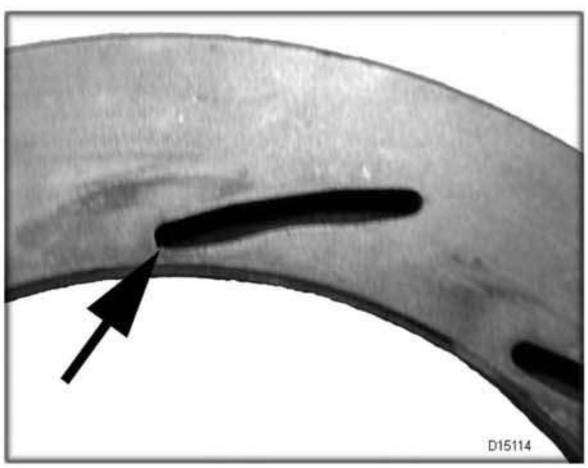


Figure 5 Damaged unison ring

11. Inspect the unison ring for cracks, excessive wear, and signs of corrosion. If any of these conditions are found the turbocharger cannot be cleaned (Figure 5).

CAUTION: To prevent engine damage and damage to the turbocharger, use an oil solvent or carburetor cleaner with a non-abrasive scrubbing pad. Clean surfaces until all carbon has been removed. Do not damage or gouge the machined surfaces of the turbine housing or unison ring cam.

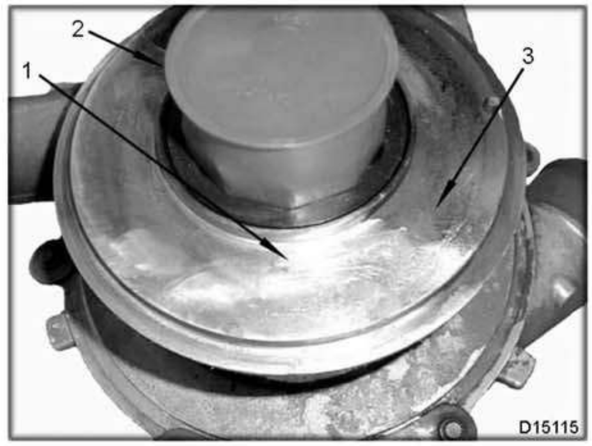


Figure 6 Oil deposit surface of center housing

1. Cleaned area
2. Protective cap
3. Oil deposit area

12. Use the protective cap from the compressor outlet and place this cap over the backplate hub. Clean the center section with an oil solvent or carburetor cleaner and a non-abrasive scrubbing pad (Figure 6). Do not damage or gouge the machined surfaces of the turbine housing or unison ring cam.

Procedure (cont.)

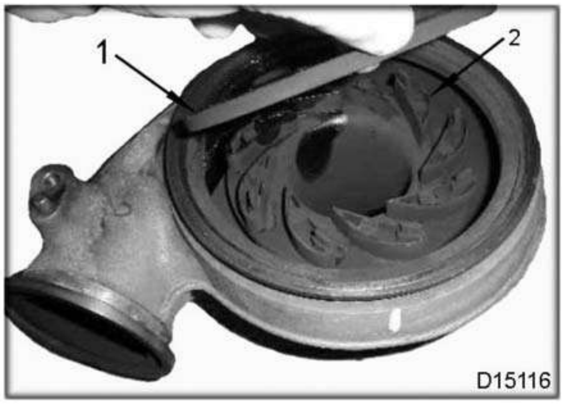


Figure 7 Unison ring and vanes

1. Unison ring
2. Vanes

13. Clean the pilot area of the center section that contacts the unison ring. Remove debris from the housing with an oil solvent or carburetor cleaner and compressed air (Figure 7).

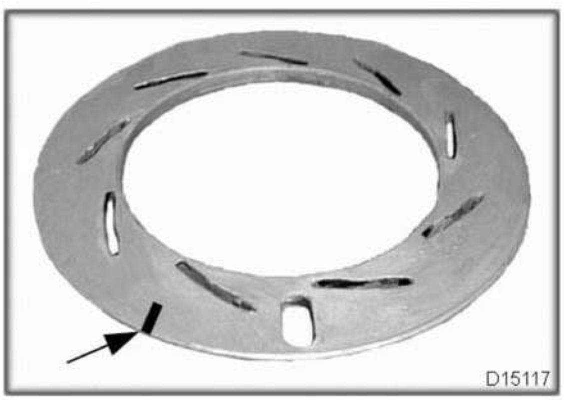


Figure 8 Unison ring

CAUTION: To prevent engine damage, mark the top of the unison ring with a paint pen. This will insure the correct position for installation of the unison ring.

14. Place a mark on the top side of the unison ring with a paint pen. Remove the unison ring and vanes from the turbine housing (Figure 8).

NOTE: If excessive corrosion is found on the unison ring, the turbocharger cannot be cleaned.

15. Clean the unison ring with an oil solvent or carburetor cleaner and a non-abrasive scrubbing pad.

Figure 9 Clean areas

1. Clean surface of disc
2. Turbine vane posts

NOTE: Do not damage machined surfaces and vane posts when cleaning.

16. Clean the surface of the disc and turbine vane posts using an oil solvent or carburetor cleaner with a non-abrasive scrubbing pad (Figure 9).

17. Clean debris from the turbine housing with an oil solvent or carburetor cleaner and compressed air.

Procedure (cont.)

INSTALLATION

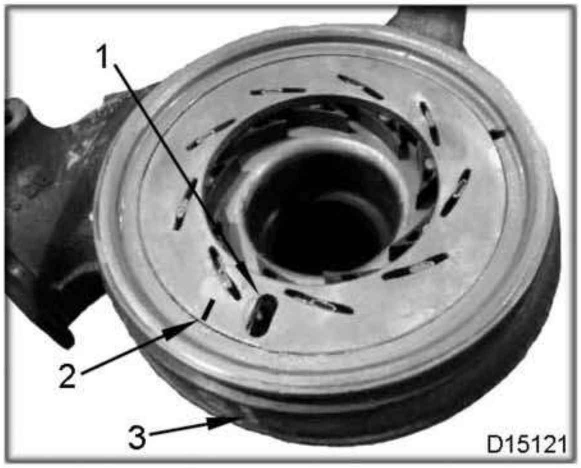


Figure 10 Vanes into turbine housing

1. Unison ring cam slot
2. Paint mark indicating top side of unison ring
3. Alignment mark

CAUTION: To prevent engine damage, place the unison ring into the turbine housing with the paint mark facing up.

1. Install vanes into the turbine housing as follows (Figure 10):

    1. With the paint mark on the unison ring facing up, index the unison ring onto the vanes.
    2. Turn the unison ring and vanes to ensure free movement.
    3. Align the painted mark on the turbine housing and the unison ring cam slot.

NOTE: Replace the V-clamp if it is worn, bent, or damaged. Use Turbine V-clamp and Nut Kit which consists of a V-clamp and locknut.

2. Check the condition of the V-clamp bolt. Place the V-clamp in the correct direction and position the V-clamp onto the turbine housing.

Figure 11 Center section onto the turbine housing

3. Lower the center section onto the turbine housing, aligning the unison ring cam first, then the housing dowel (Figure 11).

4. Align the V-clamp with the paint marks. Coat the threads with Anti-Sieze lubricant. Install the lock nut onto the V-clamp bolt. Tighten the lock nut to 141 to 176 lbf-in (16 to 20 Nm).

5. Loosen the locknut to 44 to 53 lbf-in (5 to 6 Nm), then retighten to 132 to 141 lbf-in (15 to 16 Nm).

6. Install the turbocharger. Use the appropriate *Service Manual*.

1171915R2 Turbocharger Actuator Flange and Pivot Shaft Kit

Instruction Sheet
Turbocharger Actuator Flange and Pivot Shaft Kit

1171915R2

Application

International® DT 466, DT 570, and HT 570 Diesel Engines

Kit Contents

Turbocharger Actuator Flange and Pivot Shaft Kit

Description	Quantity
Flange assembly, actuator pivot shaft and bolts	1
Turbocharger mounting kit	1
Instruction sheet	1

WARNING: To prevent personal injury or death, read all safety instructions in the "Safety Information" section of EGES 265-1 *Service 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, remove ground cable from negative terminal of main battery before disconnecting or connecting electrical components. Always connect ground cable last.

CAUTION: To prevent engine damage, an anti-seize compound should only be used on linkage assembly.

Procedure

Removal

1. See the "EVRT Electronically Controlled Turbocharger" section in *Engine Service Manual*
2. Remove turbocharger assembly.
3. Set turbocharger assembly on a clean workbench.

Disassembly

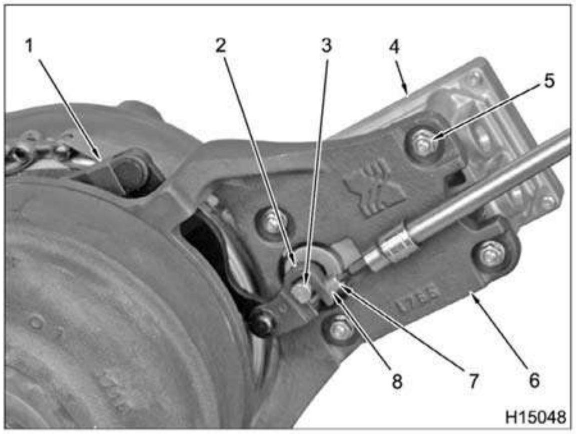


Figure 1 Removal of actuator linkage and actuator

1. Actuator linkage
2. Actuator shaft fork
3. Actuator shaft
4. Actuator
5. Serrated locknut (4)
6. Actuator flange
7. Fork lever bolt (2)
8. Nord-Lock® washer assembly (2)

1. Remove bolt and Nord-Lock® washer assembly from fork on linkage to pivot shaft and actuator shaft.
2. Remove linkage from pivot shaft and actuator shaft.
3. Remove locknuts from turbocharger actuator studs.
4. Remove turbocharger actuator from actuator flange.

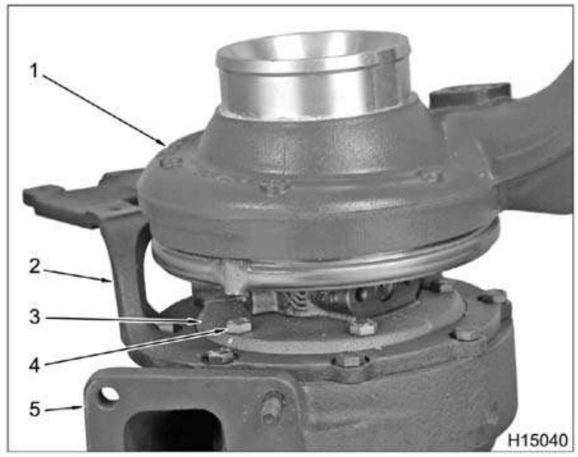


Figure 2 Removal of center section bolts

1. Compressor housing
2. Actuator flange
3. Center section
4. Bolt - center section (4)
5. Turbine housing

5. Remove four bolts from center section of the turbocharger. Discard bolts.

CAUTION: To prevent engine damage, do not damage turbine wheel. If the turbine wheel is damaged, new turbocharger must be installed.

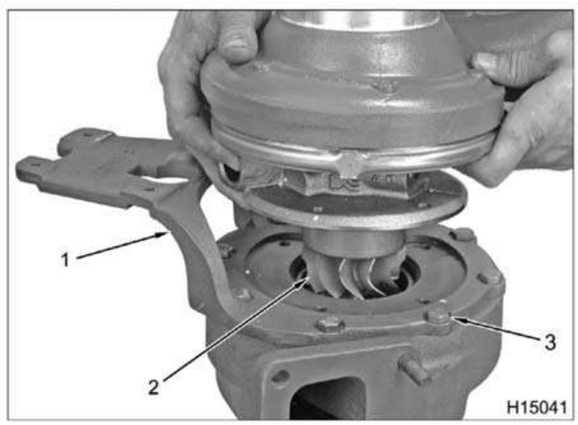


Figure 3 Separation of center section

1. Actuator flange
2. Turbine wheel
3. Bolts – actuator flange (8)

6. Separate the center section from actuator flange.

Disassembly (cont.)

7. Set compressor housing on work bench with center section and turbine wheel up.

Figure 4 Plastic cap plug

CAUTION: To prevent engine damage, protect turbine wheel.

NOTE: A plastic cap plug RC-40 should be put over turbine wheel.

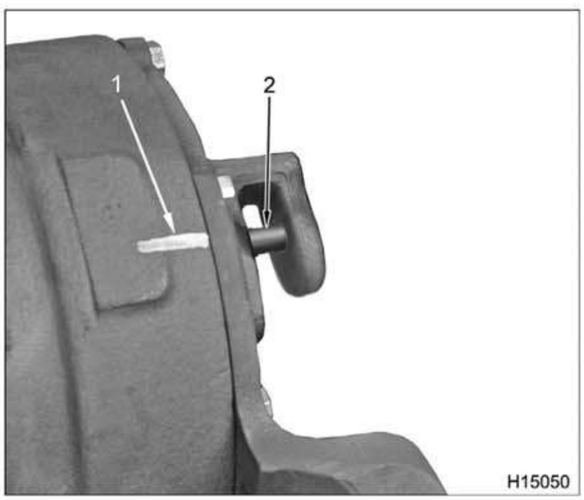


Figure 5 Paint mark on turbine housing

1. Paint mark
2. Pivot shaft

8. Paint a mark on turbine housing for the position of the pivot shaft.
9. Apply penetrating oil to actuator flange bolts and wait 5 minutes.

CAUTION: To prevent engine damage, do not use an impact wrench to remove bolts from actuator flange. If a bolt is broken, a new turbocharger may need to be installed.

10. Remove eight bolts from actuator flange. Discard bolts.

Figure 6 Removal of actuator flange

11. Tap the actuator flange with a hammer to remove from turbine housing.

NOTE: If the pivot shaft was not seized in the actuator flange, remove pivot shaft from unison ring.

Cleaning and Inspection

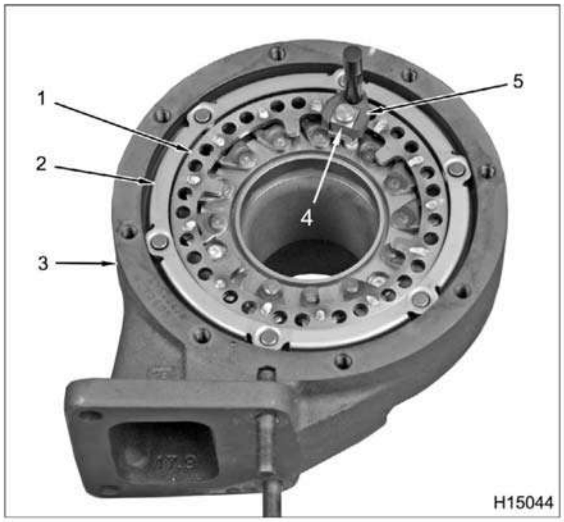


Figure 7 Removal of pivot shaft, outer ring, and unison ring

1. Unison ring
2. Outer ring and six rollers
3. Turbine housing
4. Main pivot block
5. Pivot shaft

1. Remove the outer ring and six rollers.
2. Remove the unison ring.
3. Use a 2 inch cleaning pad (3M® or equivalent) to remove rust from roller surfaces.

CAUTION: To prevent engine damage, do not use an anti-seize compound on inside surfaces of the turbocharger.

4. Turn the turbine housing over and remove loose debris with a brush.

Assembly

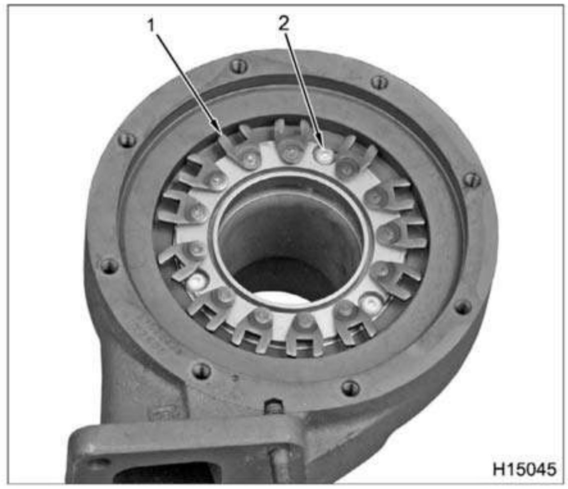


Figure 8 Vane levers

1. Vane lever
2. Torx® screw (3)

1. Center vane levers in the turbine housing.

NOTE: The unison ring only fits one way. The main pivot block on top of the unison ring must line up with the Torx® screw (Item 2, Figure 8) opposite the exhaust flange of turbine housing.

2. Position the main pivot block on top of the unison ring with the Torx® screw opposite the exhaust flange of the turbine housing.
3. Use a small screwdriver or pick to line up vanes with the small pivot blocks under the unison ring. The unison ring will drop in place when the small pivot blocks line up with the vanes.
4. Install six rollers and outer ring.

CAUTION: To prevent engine damage, do not rotate the unison ring too far clockwise. The unison ring will detach from the vanes.

5. Test movement of vane levers and make sure they move freely.

Assembly (cont.)

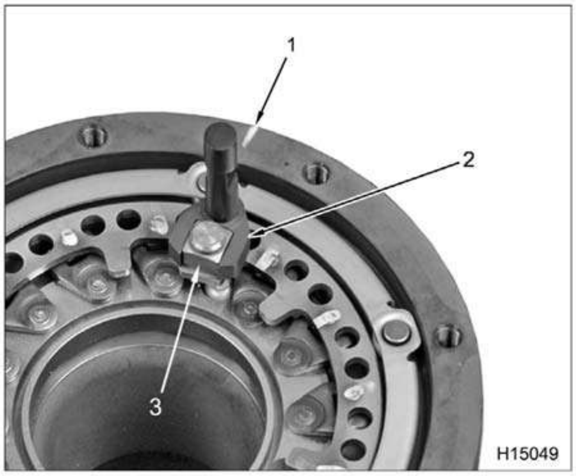


Figure 9 Paint mark, pivot shaft, and main pivot block

1. Paint mark
2. Pivot shaft
3. Main pivot block

6. Install new pivot shaft on main pivot block.
7. Align main pivot block with the line painted on the turbine housing.

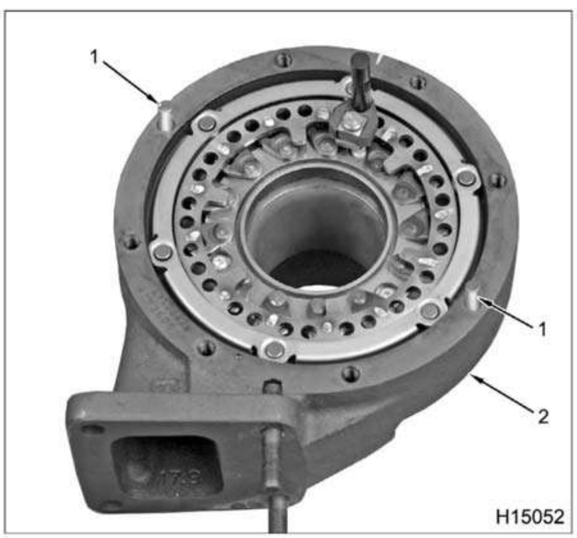


Figure 10 Guide pins

1. Guide pins
2. Turbine housing

8. Install two M8 x 1.25 guide studs in turbine housing.

NOTE: Guide studs are available locally or can be made from the removed bolts.

9. Hold the new actuator flange an inch or two over the turbine housing, making sure the pivot shaft is positioned correctly with the main pivot block on the unison ring.
10. Position the actuator flange on the turbine housing and install six new bolts, finger tight.
11. Remove guide studs and install two new bolts, finger tight.
12. Tighten all bolts to 29 N·m (21 lbf·ft).

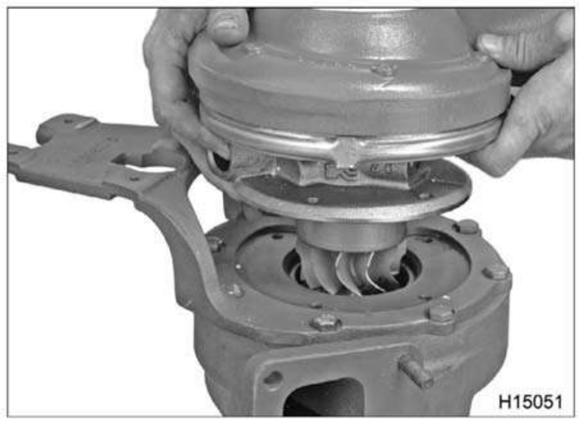


Figure 11 Alignment of center section

CAUTION: To prevent engine damage, do not damage turbine wheel. If the turbine wheel is damaged, new turbocharger must be installed.

13. Align center section with turbine housing and install four new center section bolts.
14. Use a torque adapter to tighten center section bolts. See "Using a Torque Wrench Extension" in "Appendix B" of *Service Manual* EGES-265-1.

- Tighten to 11 N·m (97 lbf·in). Make sure the turbine shaft spins freely.
- Tighten to 25 N·m (18 lbf·ft). Make sure the turbine shaft spins freely.

NOTE: If the actuator is stamped A, B, C, or D, install a new actuator.

Assembly (cont.)

15. Install actuator and four locknuts.
16. Torque locknuts to 14 N·m (124 lbf·in).
17. Position fork lever on pivot shaft.
18. Position fork lever on actuator shaft.
19. Put Nord-Lock® washer assemblies on each fork lever bolt and screw into fork levers.
20. Tighten fork lever bolts to 7 N·m (62 lbf·in).

CAUTION: To prevent engine damage, do not loosen fork lever bolts when testing free movement of fork lever and bolt.

21. Move the pivot shaft linkage to make sure the vanes move freely.

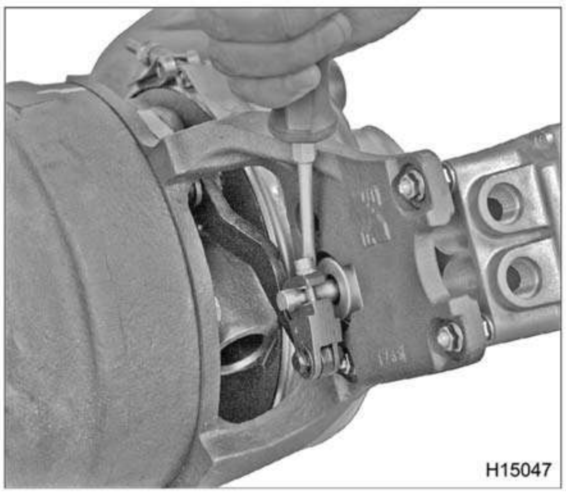


Figure 12 Actuator shaft adjustment

22. Use a screw driver to square linkage fork on actuator shaft.

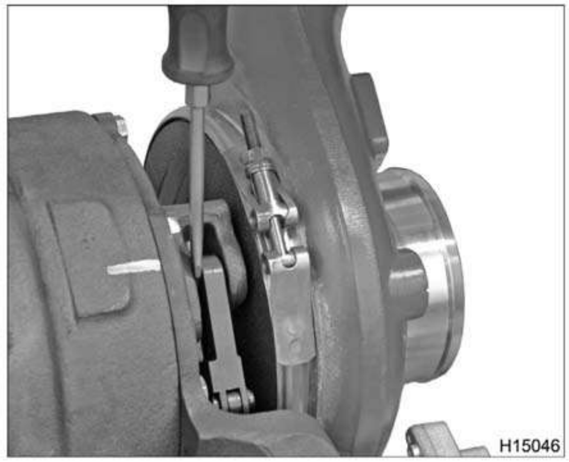


Figure 13 Pivot shaft adjustment

23. Use a screw driver to square linkage fork on pivot shaft.
24. Position turbocharger on workbench with actuator facing down (as mounted on the engine).
25. Move fork lever on actuator shaft until it stops. Release the fork lever; the actuator linkage should fall, bounce once, and stop. Repeats steps 22, 23, and 25 if necessary.

Installation

1. See "EVRT Electronically Controlled Turbocharger" section in Engine *Service Manual* EGES-265-1.
2. Install turbocharger assembly.

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