Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions properly.

Improper operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.

⚠ WARNING

When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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Disassembly and Assembly Section

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Disassembly and Assembly Section

i01845932

Fuel Filter Base - Remove and Install

Removal Procedure

Note: Put identification marks on all the hose assemblies and on all the tube assemblies for installation purposes. Plug all the hose assemblies and the tube assemblies. This helps prevent fluid loss, and this helps to keep contaminants from entering the system.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

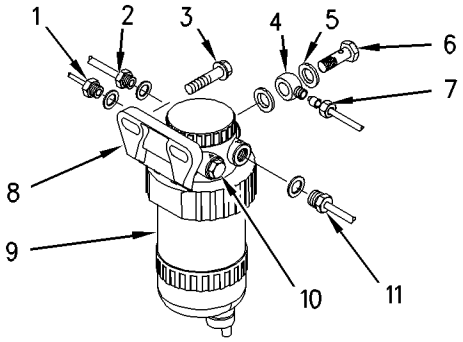


Illustration 1 g00938347

1. Disconnect the tube assembly (11).
2. Disconnect the tube (7).
3. Disconnect both tube assemblies (1) and (2).
4. Remove the fuel filter (9). Refer to Operations and Maintenance Manual, “Fuel System Primary Filter/Water Separator Element - Replace”.
5. Remove the plug (10).
6. Remove the banjo bolt (6). Remove the washers (5) and the connector (4) from the fuel filter base.
7. Remove the setscrews (3).
8. Remove the fuel filter base (8).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

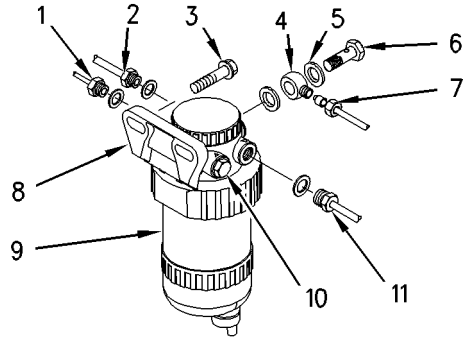


Illustration 2 g00938347

1. Position the fuel filter base (8) and install the setscrews (3). Tighten the setscrews (3) to a torque of 44 N·m (32 lb ft).
2. Install the fuel filter (9). Refer to Operations and Maintenance Manual, “Fuel System Primary Filter/Water Separator Element - Replace”.
3. Connect both tube assemblies (1) and (2). Tighten both tube assemblies (1) and (2) to a torque of 23 N·m (17 lb ft).
4. Connect the tube assembly (11). Tighten the tube assembly (11) to a torque of 23 N·m (17 lb ft).
5. Install the plug (10). Tighten the plug (10) to a torque of 23 N·m (17 lb ft).
6. Position the new washers (5) and the connector (4) on the fuel filter base. Install the banjo bolt (6). Tighten the banjo bolt (6) to a torque of 12 N·m (106 lb in).

7. Connect the tube assembly (7).

8. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, “Fuel System - Prime”.

i01846124

Fuel Priming Pump - Remove and Install

Removal Procedure

Note: Put identification marks on all hose assemblies, and all tube assemblies for installation purposes. Plug all hose assemblies and all tube assemblies. This helps prevent fluid loss, and this helps to keep contaminants from entering the system.

Note: The reflective heat shield must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the heat shield may not protect the component and the component may be damaged.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

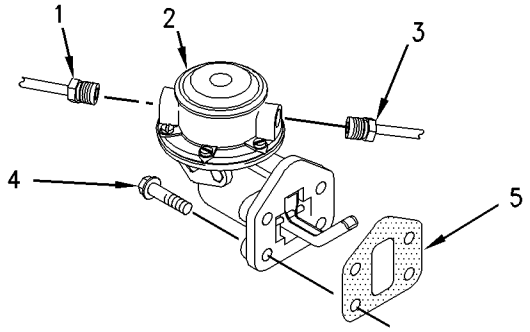


Illustration 3 g00938617

1. Remove the heat shield if a heat shield is installed.

2. Disconnect the fuel lines (1) and (3) from the fuel priming pump (2).

3. Remove the setscrews (4).

Note: Ensure that the rocker arm for the fuel priming pump (2) is not under pressure in order to remove the fuel priming pump.

4. Remove the fuel priming pump (2) and the gasket (5).

Installation Procedure

Note: The camshaft must be on the heel of the cam in order to fit the fuel priming pump.

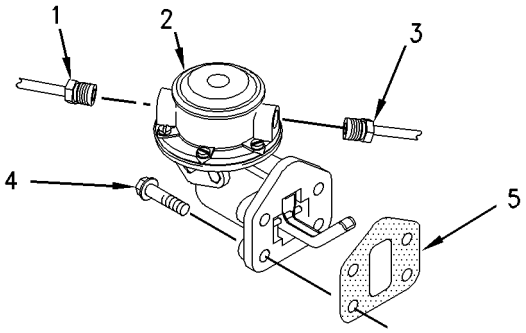


Illustration 4 g00938617

1. Install a new gasket (5) and the fuel priming pump (2).

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews (4), clean the old sealant from the setscrews and apply 1861108 POWERPART silicone rubber sealant to the setscrews (4). Clean the old sealant from the threads in the cylinder block.

2. Install the setscrews (4) that mount the fuel priming pump (2) to the cylinder block. Tighten the setscrews to a torque of 22 N·m (16 lb ft).

3. Connect the fuel lines (1) and (3).

4. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, “Fuel System - Prime”.

5. Start the engine and check the fuel system for fuel leaks and for air leaks.

i01845935

Fuel Injection Lines - Remove

Removal Procedure

Start By:

a. Remove the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Remove and Install”.

Note: Put identification marks on all hose assemblies and on all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. This helps prevent fluid loss, and this helps to keep contaminants from entering the system.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

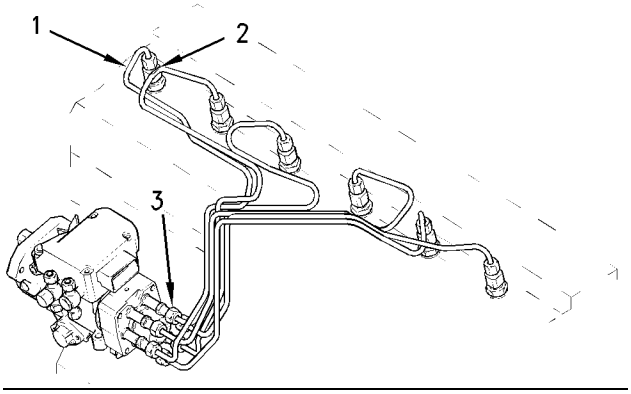


Illustration 5 g00943387

1. Remove the low pressure fuel injection lines.

2. Disconnect the fuel injection lines (1) at the fuel injectors (2).

3. Disconnect the fuel injection lines (1) at the fuel injection pump (3).

4. Remove the fuel injection lines (1) at the fuel injectors.

5. Remove the fuel injection lines (1).

i01845933

Fuel Injection Lines - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

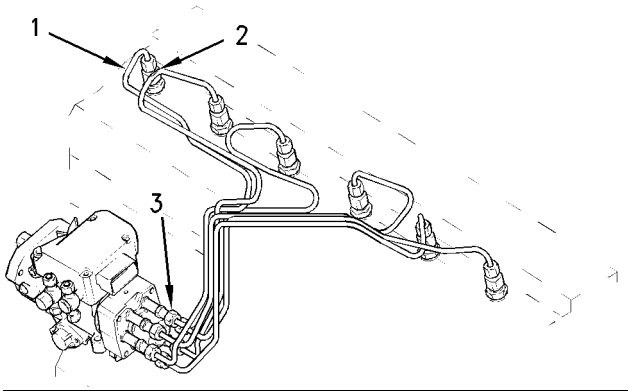


Illustration 6 g00943387

1. Install the fuel injection lines (1).

2. Connect the fuel injection lines at fuel injectors (2). Tighten the nut to 28 N·m (21 lb ft).

3. Connect the fuel injection lines at fuel injection pump (3). Tighten the nut to 28 N·m (21 lb ft).

4. Install the low pressure fuel injection lines.

5. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, “Fuel System - Prime”.

End By:

a. Install the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Remove and Install”.

i01845959

Fuel Injector - Remove

Removal Procedure

Start By:

a. Remove the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

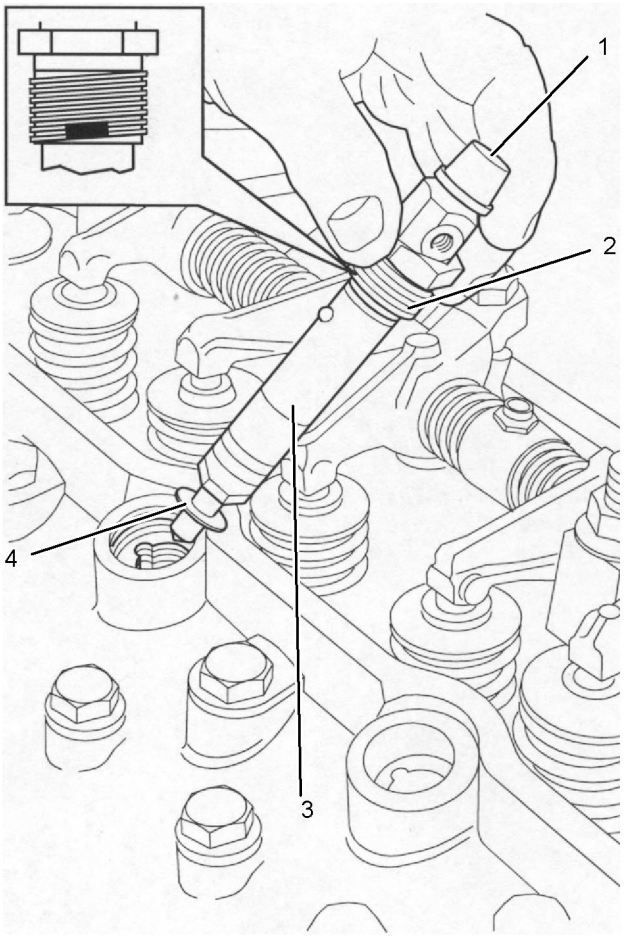


Illustration 7 g01020885

1. Loosen the threaded nut (2) on the fuel injector (3).

2. Install a plastic cap (1) in order to cover the fuel inlet connection on the fuel injector (3).

3. Remove the fuel injector (2) from the cylinder head.

4. Remove the seat washer (4).

Note: If the original seat washer is not removed, the projection of the fuel injector will be incorrect when a new seat washer is installed.

i01845939

Fuel Injector - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

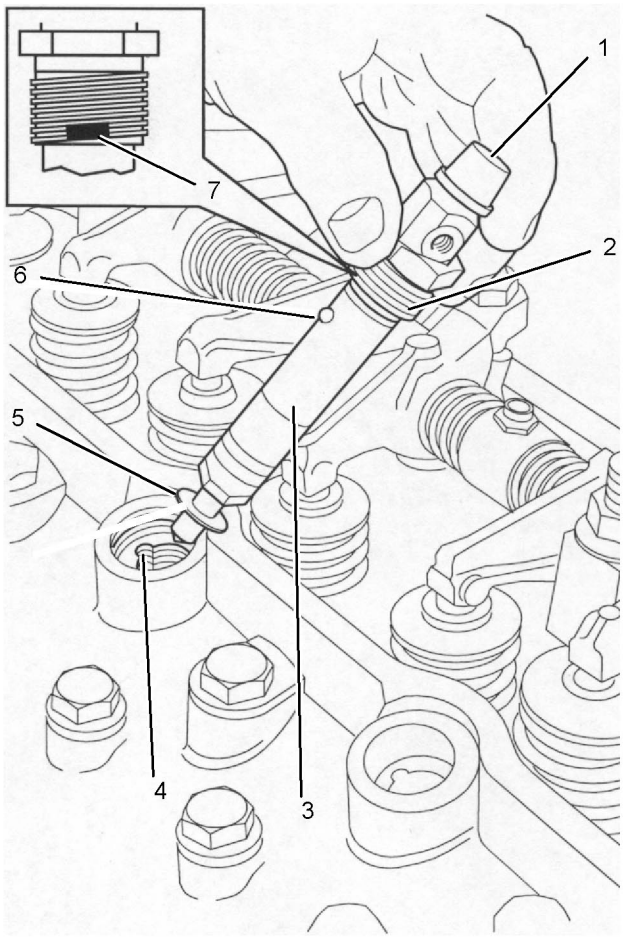


Illustration 8 g01020907

1. Thoroughly clean the threads on the threaded nut (2) on the fuel injector (3) and in the cylinder head.

2. Install a new seat washer (5) into the recess in the cylinder head.

3. Put a 2.0 mm (0.08 inch) bead of 1861117 POWERPART universal jointing compound on the first two threads (7) of the threaded nut (2) on the fuel injector (3).

4. Put the fuel injector (3) into position in the cylinder head. Make sure that the detent ball (6) in the fuel injector is aligned correctly with the ball detent (4) in the cylinder head.

5. Carefully tighten the threaded nut (2) on the fuel injector to a torque of 40 N·m (30 lb ft). Remove any excess 1861117 POWERPART universal jointing compound from the fuel injector.

Note: Do not rotate the fuel injector after installation. The seal which is made by the 1861117 POWERPART universal jointing compound may break. A broken seal may allow water leakage and corrosion of the fuel injector and the cylinder head.

End By:

a. Install the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove and Install”.

i01921083

Fuel Injection Pump - Remove

Removal Procedure

Table 1

Required Tools		
Part Number	**Part Description**	**Qty**
27610032	Timing pin	1
21825964	Spanner for Bosch fuel injection pumps	1

Start By:

a. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove and Install”.

b. Remove the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

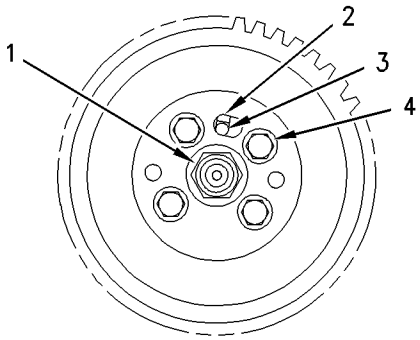


Illustration 9 g00999852

Note: Do not remove hub nut (1) from the shaft of the fuel injection pump. The hub of the fuel injection pump is installed in the correct position from the factory in order to ensure proper timing. If hub nut (1) is removed and the hub is removed, the hub will need to be accurately installed on the shaft of the fuel injection pump by the use of special equipment. Refer to your Perkins dealer or your Perkins distributor for more information.

Note: Ensure that the engine is set to 4 degrees after Top Center. Refer to Testing and Adjusting, “Fuel Injection Timing - Check”.

1. Insert the timing pin through the hole (3) in the fuel injection pump gear and the slot (2) in the hub. Push the timing pin fully into the hole (3) in the body of the fuel injection pump. If the timing pin can be fully inserted then the fuel injection pump timing is correct. There should be no resistance when the timing pin is inserted.

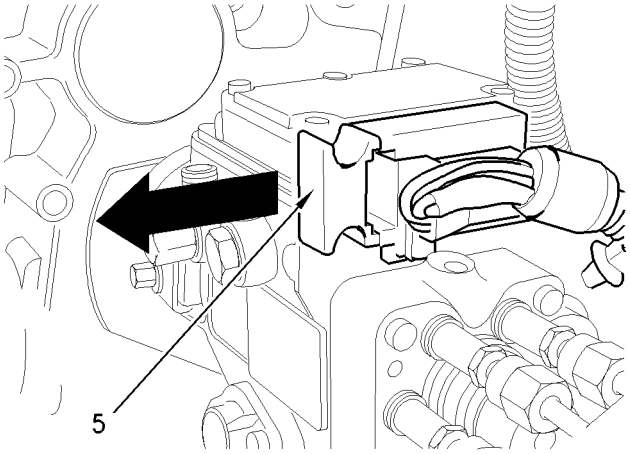


Illustration 10 g00999838

2. Disconnect the electrical connection (5). Pull the electrical connector from the connection in order to disconnect the locking mechanism for the connector. Carefully remove the connector from the fuel injection pump. Do not damage the pins of the connector.

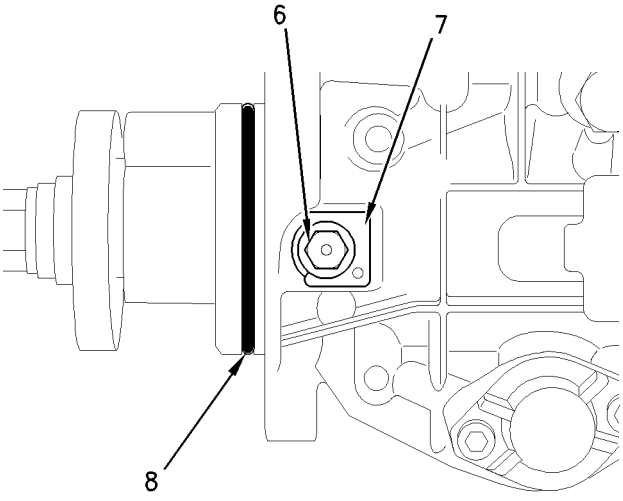


Illustration 11 g00999837

Note: Do not rotate the crankshaft when the fuel injection pump is not installed on the engine.

3. Remove the four setscrews (4) and the hardened washers. Remove the fuel injection pump gear from the hub of the fuel injection pump.

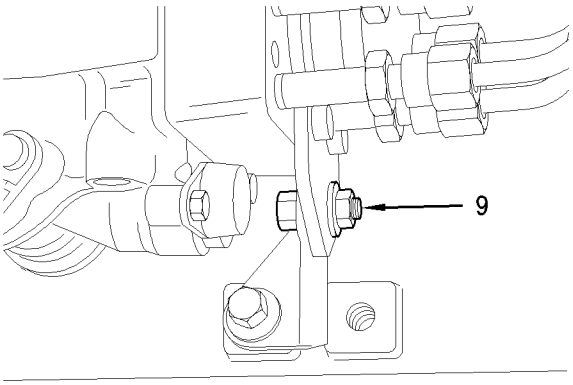


Illustration 12 g00999839

4. Remove the nut and bolt (9) from the support bracket of the fuel injection pump.

5. Remove the three nuts from the mounting flange studs and remove the fuel injection pump. If access to the nuts is restricted, use the spanner for the Bosch fuel injection pump.

6. Discard the O ring (8) of the fuel injection pump.

i01899919

Fuel Injection Pump - Install

Installation Procedure

Table 2

Required Tools		
Part Number	**Part Description**	**Qty**
27610032	Timing pin	1
21825964	Spanner for Bosch fuel injection pumps	1

Note: Ensure that the engine is set to 4 degrees after Top Center. Refer to Testing and Adjusting, “Fuel Injection Timing - Check”.

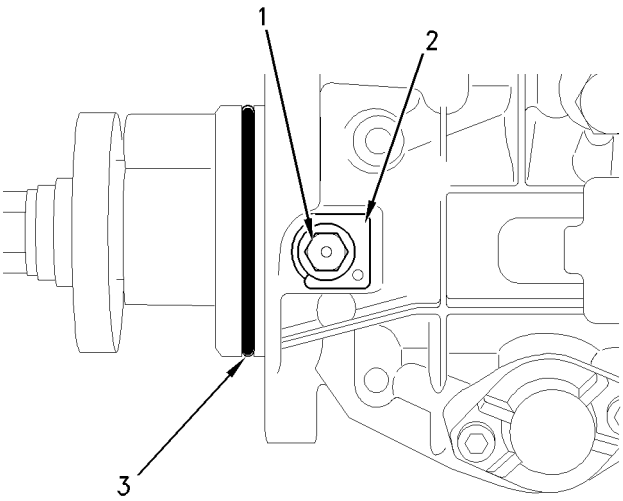


Illustration 13 g01000388

Note: A new fuel injection pump may be supplied with the pump shaft in the locked position. The drive shaft of fuel injection pump must not be rotated without the spacer (2) in position under the locking screw (1). Before the crankshaft is turned or the fuel injection pump is installed, put the spacer (2) into position under the locking screw (1) in order to ensure that the drive shaft of the fuel injection pump is not locked.

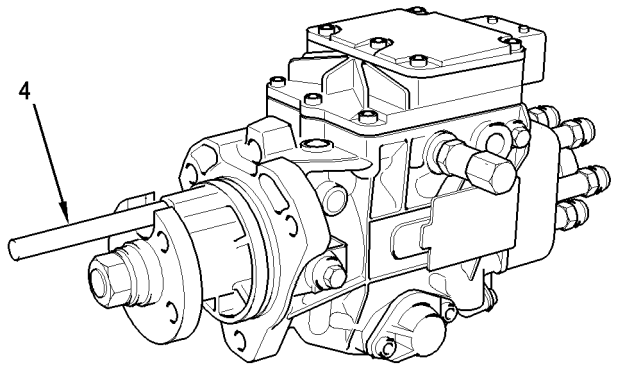


Illustration 14 g01000390

1. Install a new O ring (3) to the fuel injection pump flange.

2. Lightly lubricate the O ring (3) with clean engine oil. Install the timing pin (4) into the fuel injection pump. Install the fuel injection pump onto the three studs. Install the three nuts onto the studs and tighten to a torque of 22 N·m (16 lb ft).

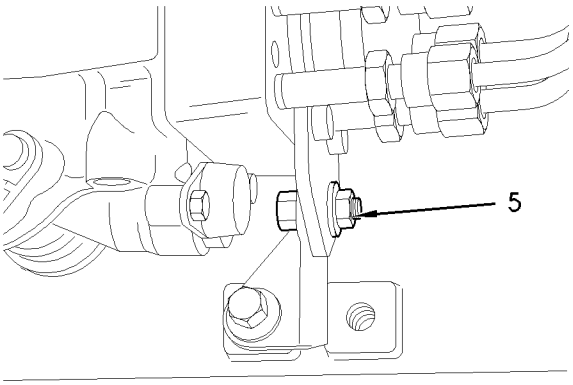


Illustration 15 g01000391

Note: Ensure that force is not applied to the fuel injection pump when the support bracket is installed.

3. Install the nut and bolt (5) for the support bracket of the fuel injection pump.

4. Tighten the nut and bolt (5) of the support bracket of the fuel injection pump to a torque of 22 N·m (16 lb ft).

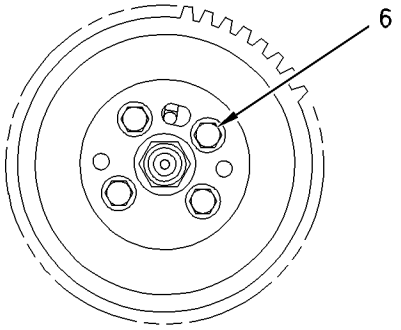


Illustration 16 g01000392

5. Install fuel injection pump gear onto the hub of the fuel injection pump. In order to remove the backlash, ensure that the four setscrews (6) are in the center of the slots for the fuel injection pump gear. Lightly install the four setscrews (6) of the fuel injection pump.

Note: The fuel injection pump gear must be installed to the fuel injection pump before the crankshaft is rotated.

6. Check for backlash between the idler gear and the fuel injection pump gear. In order to remove the backlash, rotate the fuel injection pump gear counterclockwise. Do not rotate the crankshaft or the fuel injection pump shaft. Tighten the four setscrews (6) of the fuel injection pump gear and tighten to a torque of 28 N·m (20 lb ft).

7. Remove the timing pin (4).

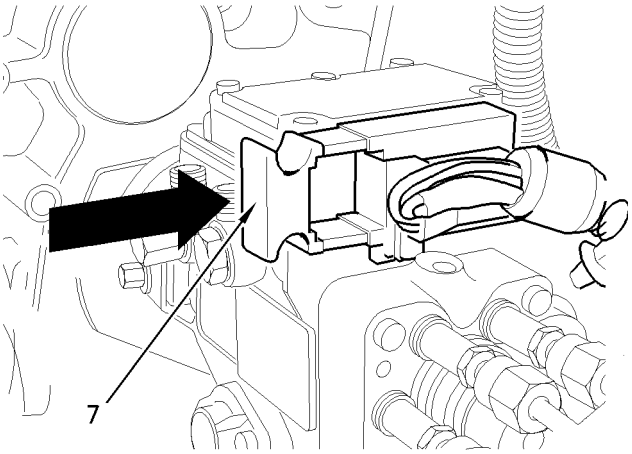


Illustration 17 g01000402

8. Install the electrical connector (7). In order to install the electrical connector, push the locking mechanism fully into the electrical connection.

End By:

a. Install the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove and Install”.

b. Install the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove and Install”.

i01855084

Turbocharger - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Loosen the hose clamps and remove the air inlet hose at the turbocharger compressor housing.

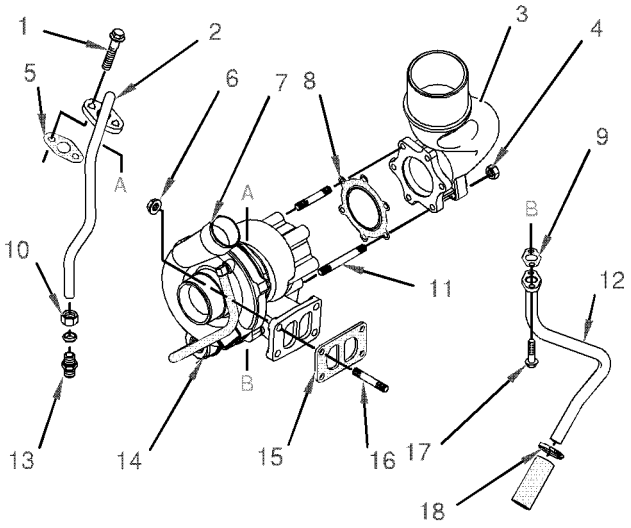


Illustration 18 g01026244

2. Loosen the clamps and remove the exhaust pipe from elbow (3).

3. Loosen the nut (10). Remove the setscrews (1). Remove the oil supply tube assembly (2) from the turbocharger. Remove the gasket (5) and discard the gasket. If necessary, remove the adapter (13) from the cylinder block.

4. Loosen the hose clamp (18). Remove the setscrews (17). Remove the oil drain tube assembly (12) from the turbocharger. Remove the gasket (9) and discard the gasket.

5. Remove the nuts (4) and remove the elbow (3) from the turbocharger. Remove the gasket (8) and discard the gasket. If necessary, remove the studs (11) from the turbocharger housing.

Note: Ensure that the actuator rod of the wastegate is not used to lift or move the turbocharger (14).

6. Remove the nuts (6) and remove the turbocharger (7). Remove the gasket (15) and discard the gasket. If necessary, remove the studs (16) from the exhaust manifold.

7. Plug the oil supply and the oil drain ports of the turbocharger.

i01855020

Turbocharger - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The reflective heat shield must be kept clean and free from dust, oil or paint. If the surface of the heat shield is not shiny, the heat shield may not protect the component and the component may be damaged.

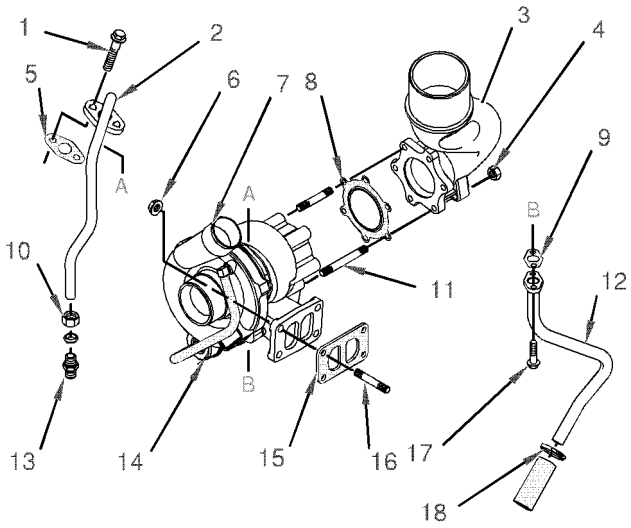


Illustration 19 g01026244

Note: New phosphated nuts can be used in order to prevent seizure.

1. Clean the mating surfaces of the exhaust manifold and the turbocharger. Clean the mating surfaces of the turbocharger and the oil supply tube assembly and the oil drain tube assembly.

2. If necessary, install the studs (16) in the exhaust manifold. Install a new gasket (15) over the studs (16).

Note: Do Not use any sealant on the gasket.

3. Position the turbocharger (7) on the exhaust manifold.

Note: Ensure that the actuator rod of the wastegate (14) is not used to lift or move the turbocharger.

4. Install the nuts (6). Tighten the nuts to a torque of 44 N·m (32 lb ft).

5. If necessary, install the studs (11) in the turbocharger housing. Install a new gasket (8) over the studs (11).

Note: Do Not use any sealant on the gasket.

6. Position the elbow (3) on the studs. Install the nuts (4). Tighten the nuts to a torque of 22 N·m (16 lb ft). Install the exhaust pipe onto the elbow (3). Tighten the clamps.

7. Install the oil drain tube assembly (12) in the hose. Install a new gasket (9) and install the setscrews (17). Tighten the setscrews to a torque of 20 N·m (15 lb ft). Tighten the clamp (18) to a torque of 3 N·m (27 lb in).

8. If necessary, install the adapter (13) in the cylinder block. Tighten the adapter to a torque of 25 N·m (18 lb ft). Install the oil drain tube assembly (2) in the adapter (13).

9. Install a new gasket (5) and install the setscrews (1). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

10. Tighten the nut (10). Tighten the nut to a torque of 23 N·m (17 lb ft).

i01893155

Exhaust Manifold - Remove and Install

Removal Procedure for the Two-Piece Exhaust Manifold

Start By:

a. Remove the turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Remove”.

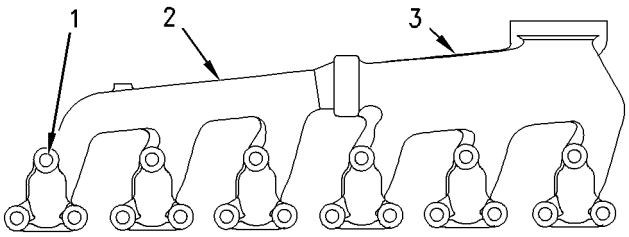


Illustration 20 g00935363

1. Remove the setscrews (1) in order to remove the exhaust manifold.

2. Remove the exhaust manifold gaskets from the cylinder head.

3. If necessary, remove the exhaust manifold (2) from the exhaust manifold (3). Clean the ends of the exhaust manifolds for reassembly.

Removal Procedure for the Three-Piece Exhaust Manifold

Start By:

a. Remove the turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Remove”.

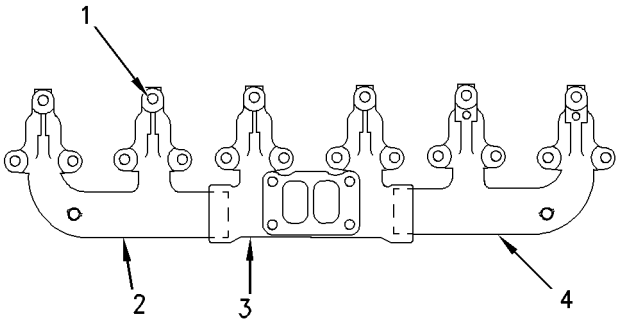


Illustration 21 g00935235

1. Remove the setscrews (1) in order to remove the exhaust manifold.

2. Remove the exhaust manifold gaskets from the cylinder head.

3. If necessary, remove the exhaust manifold (4) and the exhaust manifold (2) from the exhaust manifold (3). Clean the ends of the exhaust manifolds for reassembly.

Installation Procedure for the Two-Piece Exhaust Manifold

Table 3

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 X 1.5 by 100 mm)	4

Note: Incorrect installation of the exhaust manifold can result in a cracked exhaust manifold. The exhaust manifold must be carefully centered on the guide studs while the setscrews are tightened.

Note: If a setscrew for the exhaust manifold has become loose, or a setscrew for the exhaust manifold must be loosened, all of the setscrews for the exhaust manifold must be loosened. The setscrews for the exhaust manifold must be tightened in the correct sequence and to the correct torque.

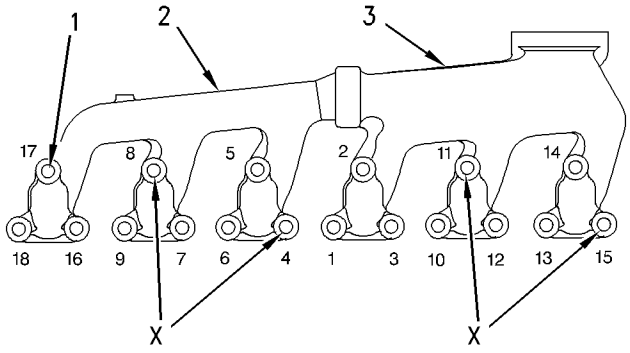


Illustration 22 g00935350

1. Install the guide studs (A) in the cylinder head in the Holes (X).

Note: Do Not use any sealant on the exhaust manifold gaskets.

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820638 POWERPART retainer high strength to the setscrews.

2. Position the exhaust manifold gaskets on the guide studs in the cylinder head. Assemble exhaust manifold (2) to exhaust manifold (3). Position the assembled exhaust manifold on the guide studs. Install setscrews (1) in order to secure the exhaust manifolds to the cylinder head.

3. Tighten the setscrews (1) to a torque of 12 N·m (9 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 22.

4. Remove the guide studs (A). Install the remaining setscrews (1) and tighten the setscrews to a torque of 12 N·m (9 lb ft).

5. Tighten the setscrews (1) to a torque of 33 N·m (24 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 22.

6. Tighten the setscrews (1) again to a torque of 33 N·m (24 lb ft).

End By:

a. Install the turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Install”.

Installation Procedure for the Three-Piece Exhaust Manifold

Table 4

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 X 1.5 by 100 mm)	4

Note: incorrect installation of the exhaust manifold can result in a cracked exhaust manifold. The exhaust manifold must be carefully centered on the guide studs while the setscrews are tightened.

Note: If a setscrew for the exhaust manifold has become loose, or a setscrew for the exhaust manifold must be loosened, all of the setscrews for the exhaust manifold must be loosened. The setscrews for the exhaust manifold must be tightened in the correct sequence and to the correct torque.

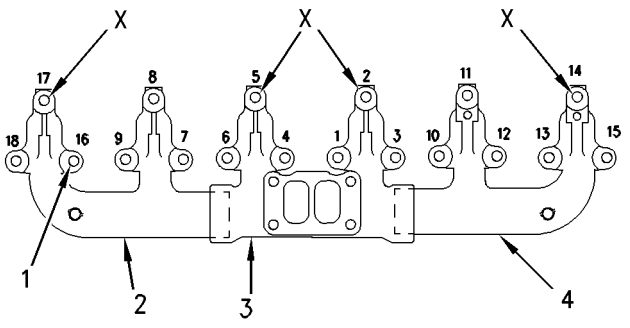


Illustration 23 g00935215

1. Install the guide studs (A) in the cylinder head in the Holes (X).

Note: Do Not use any sealant on the exhaust manifold gaskets.

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820638 POWERPART retainer high strength to the setscrews.

2. Position the exhaust manifold gaskets on the guide studs in the cylinder head. Assemble the exhaust manifold (4) and the exhaust manifold (2) to the exhaust manifold (3). Position the assembled exhaust manifold on the guide studs. Install the setscrews (1) in order to secure the exhaust manifolds to the cylinder head.

3. Tighten the setscrews (1) to a torque of 12 N·m (9 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 23.

4. Remove the guide studs (A). Install the remaining setscrews (1) and tighten the setscrews to a torque of 12 N·m (9 lb ft).

5. Tighten the setscrews (1) to a torque of 33 N·m (24 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 23.

6. Tighten the setscrews (1) again to a torque of 33 N·m (24 lb ft).

End By:

a. Install the turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Install”.

i01987710

Starting Aid (Air Inlet Heater) - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

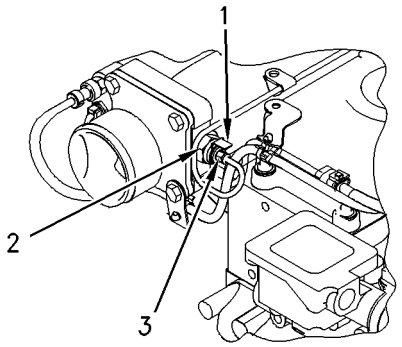


Illustration 24 g00945750

1. Disconnect the harness assembly from the electrical connector (1).

2. Disconnect the fuel line (3) from the air inlet heater.

3. Remove the air inlet heater (2) from the inlet manifold.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the threads of the air inlet heater. Clean the threads of the inlet manifold.

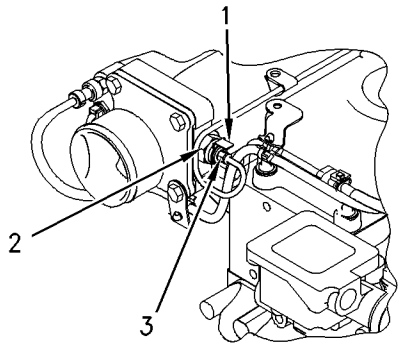


Illustration 25 g00945750

2. Apply a suitable compound to the threads of the air inlet heater. Install the air inlet heater (2) into the inlet manifold.

Note: The electrical connector (1) must be facing toward the front of the engine.

3. Connect the fuel line (3) onto the air inlet heater (2). Tighten the fuel line nut to a torque of 6 N·m (53 lb in).

4. Remove the air from the fuel system. Refer to the Systems Operation, Testing and Adjusting Module, “Fuel System - Prime” topic for additional information on removing the air from the fuel system.

5. Connect the harness assembly to the electrical connector (1).

i01854186

Inlet Manifold - Remove

Removal Procedure

1. Remove the air inlet hose from the turbocharger and the air inlet adapter.

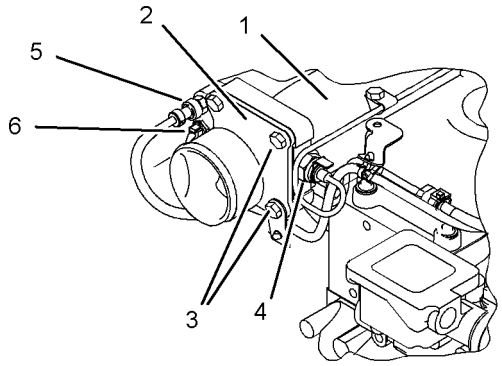


Illustration 26 g01033839

2. Remove the air inlet heater (4). Refer to Disassembly and Assembly Manual, “Starting Aid (Air Inlet Heater - Remove and Install)”.

3. Disconnect the harness assembly (6) at the inlet air temperature sensor.

4. Remove the inlet manifold pressure sensor (5) from the intake manifold (1).

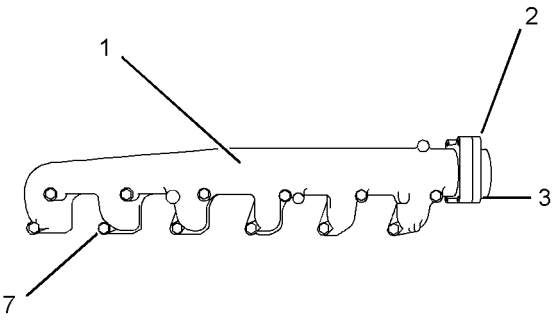


Illustration 27 g01033846

5. Remove the setscrews (7). Remove the intake manifold from the cylinder head. Remove the gasket for the intake manifold from the cylinder head and the intake manifold.

6. If necessary, remove the setscrews (3) in order to remove the air inlet adapter (2) from the intake manifold (1). Remove the gasket for the air inlet adapter and discard the gasket.

i01854185

Inlet Manifold - Install

Installation Procedure

Table 5

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M8 X 1.25 by 130 mm)	4

1. Clean all surfaces thoroughly.

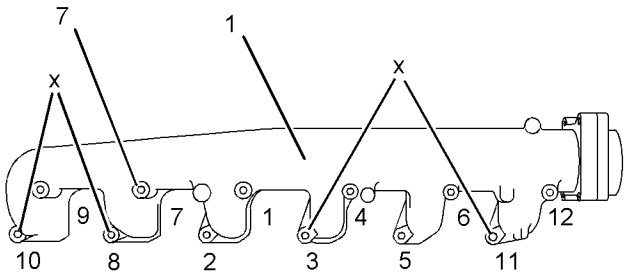


Illustration 28 g01034035

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820117 POWERPART Threadlock and nutlock to the setscrews.

Note: Do Not use any sealant on the inlet manifold gaskets.

2. Install the tooling (A) in the cylinder head in Holes (X). Position new gaskets onto the studs. Install the manifold onto the cylinder head. Install the setscrews (7) in order to secure the inlet manifold to the cylinder head. Tighten the setscrews finger tight.

3. Remove the tooling (A) and install the remaining setscrews. Tighten the setscrews (7) to a torque of 22 N·m (16 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 28.

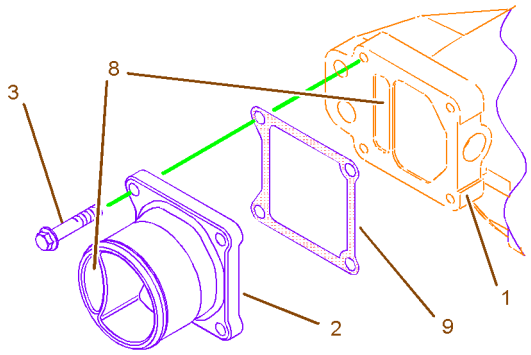


Illustration 29 g01035440

Note: Do Not use any sealant on the gasket for the air inlet adapter (2).

Note: Align the Internal Passages (8) of the air inlet adapter and the inlet manifold (1).

4. Position a new gasket (9) and the air inlet adapter (2) on the inlet manifold (1). Install the setscrews (3) and tighten to a torque of 22 N·m (16 lb ft).

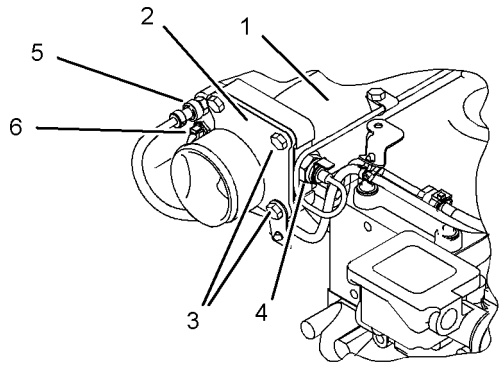


Illustration 30 g01033839

5. Install the air inlet heater (4). Refer to Disassembly and Assembly Manual, “Starting Aid (Air Inlet Heater) - Remove and Install”.

6. Connect the harness assembly (6) at the inlet air temperature sensor.

7. Install the inlet manifold pressure sensor (5).

8. Install the air inlet hose from the turbocharger to the air inlet adapter.

i01854968

Inlet and Exhaust Valve Springs - Remove and Install (Installed cylinder head)

Removal Procedure

Table 6

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825666	Valve Spring Compressor	1
B	21825931	Stud Adapter	1
C	21825932	Setscrew Adapter	1

Start By:

a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the piston is at the top center position.

Note: Use the following procedure in order to find the top center position.

NOTICE
Do not turn the crankshaft while the valve springs are removed.

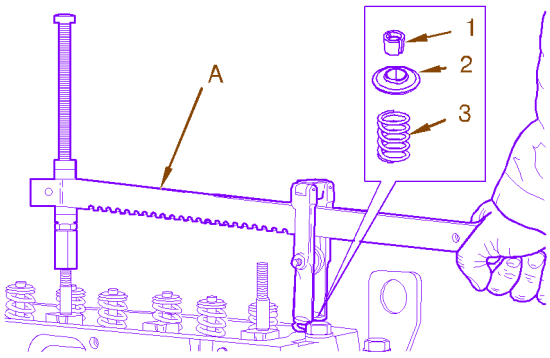


Illustration 31 g01025973

WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

a. Install the Tooling (A) with the adapter (B) or adapter (C) to the cylinder head.

b. Compress the valve spring in order to open the valve.

c. Turn the crankshaft until the piston touches the valve.

d. Continue to turn the crankshaft and release the pressure of the Tooling (A) until the piston is at the Top Center position.

2. Use the Tooling (A) in order to compress the valve spring (3). Remove the valve keepers (1).

NOTICE
Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

3. Carefully release the pressure on Tooling (A). Remove the valve spring retainer (2) and the valve spring (3).

Note: If you are replacing all of the valve springs, the procedure can be done on two cylinders at the same time. The procedure can be done on cylinder 1 and cylinder 6, on cylinder 2 and cylinder 5, and on cylinder 3 and cylinder 4.

NOTICE
Do not turn the crankshaft while the valve springs are removed.

Installation Procedure

Table 7

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825666	Valve Spring Compressor	1
B	21825931	Stud Adapter	1
C	21825932	Setscrew Adapter	1

WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Install new valve seals to the valve stems, if necessary.

1. Place the new valve spring into position.

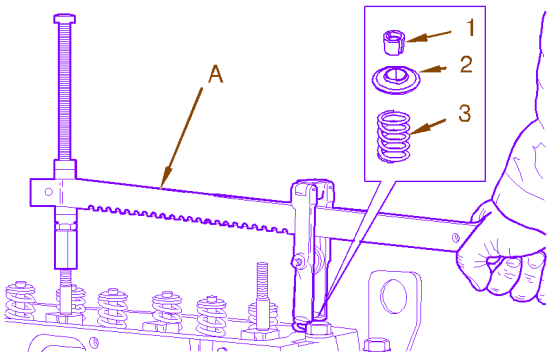


Illustration 32 g01025973

2. Install the valve spring retainer (2).

3. Install the Tooling (A) and compress the valve spring (3).

NOTICE
Ensure that the valve spring is compressed squarely or damage to the valve stem may occur.

4. Install the valve keepers (1).

WARNING

The valve keepers can be thrown from the valve when the valve spring compressor is released. Ensure that the valve keepers are properly installed on the valve stem. To help prevent personal injury, keep away from the front of the valve keepers and valve springs during the installation of the valves.

5. Carefully release the pressure on Tooling (A). Remove the Tooling (A).

Note: If you are replacing all of the valve springs the procedure can be done on two cylinders at the same time. The procedure can be done on cylinder 1 and cylinder 6, on cylinder 2 and cylinder 5, and on cylinder 3 and cylinder 4.

End By:

a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install”.

i01854850

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 8

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825666	Valve Spring Compressor	1
B	21825931	Stud Adapter	1
C	21825932	Setscrew Adapter	1

Start By:

a. Remove the cylinder head assembly. Refer to Disassembly and Assembly, “Cylinder Head - Remove”.

⚠ WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bottom face of the cylinder head. Use a dial indicator to check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, “Cylinder Head Valves” for the correct dimensions.

2. Place an index mark on the heads of the inlet valves and the exhaust valves for installation purposes.

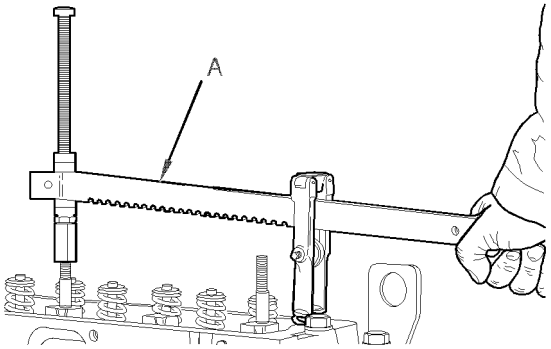


Illustration 33 g01025972

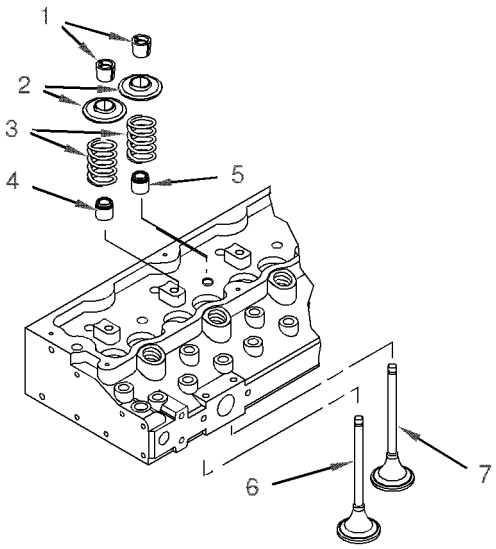


Illustration 34 g01026335

3. Use the Tooling (A) to compress the spring (3).

4. Remove the valve keepers (1).

5. Carefully release the pressure on Tooling (A) and remove Tooling (A).

6. Remove the valve spring retainer (2).

7. Remove the spring (3).

8. Remove the valve stem seal (4 or 5).

9. Remove the valve (6 or 7).

Installation Procedure

Table 9

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825666	Valve Spring Compressor	1
B	21825931	Stud Adapter	1
C	21825932	Setscrew Adapter	1

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

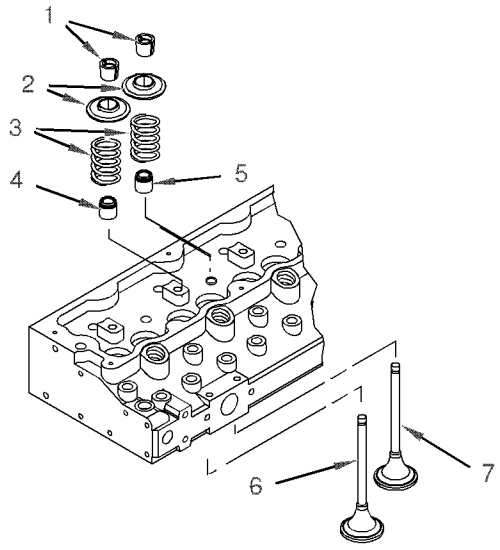


Illustration 35 g01026335

1. Lubricate the stems of the valves (6) and (7) with clean engine oil.

2. Install the valves (6) and (7) in the correct positions.

Note: The valve seals are color coded for identification.

3. Install a new valve seal (4). Ensure that the brown seal is installed to the exhaust valve. Ensure that the green seal is installed to the inlet valve.

4. Install the spring (3).

5. Install the valve spring retainer (2).

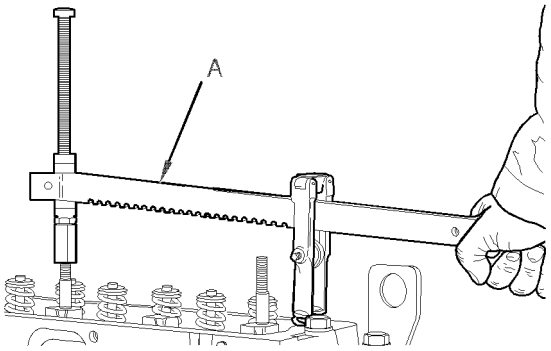


Illustration 36 g01025972

⚠ WARNING

The valve keepers can be thrown from the valve when the valve spring compressor is released. Ensure that the valve keepers are properly installed on the valve stem. To help prevent personal injury, keep away from the front of the valve keepers and valve springs during the installation of the valves.

6. Use the Tooling (A) to compress the spring (3).

7. Install the valve keepers (1).

8. Carefully release the pressure on Tooling (A) and remove Tooling (A). Ensure that the valve keepers are correctly installed.

Note: Refer to Specifications, “Cylinder Head Valves” for more information on inlet valves and exhaust valves.

9. Use a dial indicator to check the depth of the new valves below the cylinder head. If the depth of the new valves is below the correct depth, the valve seat inserts must be replaced. Refer to Disassembly and Assembly, “Inlet and Exhaust Valve Seat Inserts - Remove and Install”.

End By:

a. Install the cylinder head assembly. Refer to Disassembly and Assembly, “Cylinder Head - Install”.

i01854879

Inlet and Exhaust Valve Guides - Remove and Install

Removal Procedure

Table 10

Required Tools		
Part Number	**Part Description**	**Qty**
21825478	Valve guide tool	1
27610019	Adapter	1

Start By:

a. Remove the inlet valves and the exhaust valves. Refer to Disassembly and Assembly, “Inlet and Exhaust Valves - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

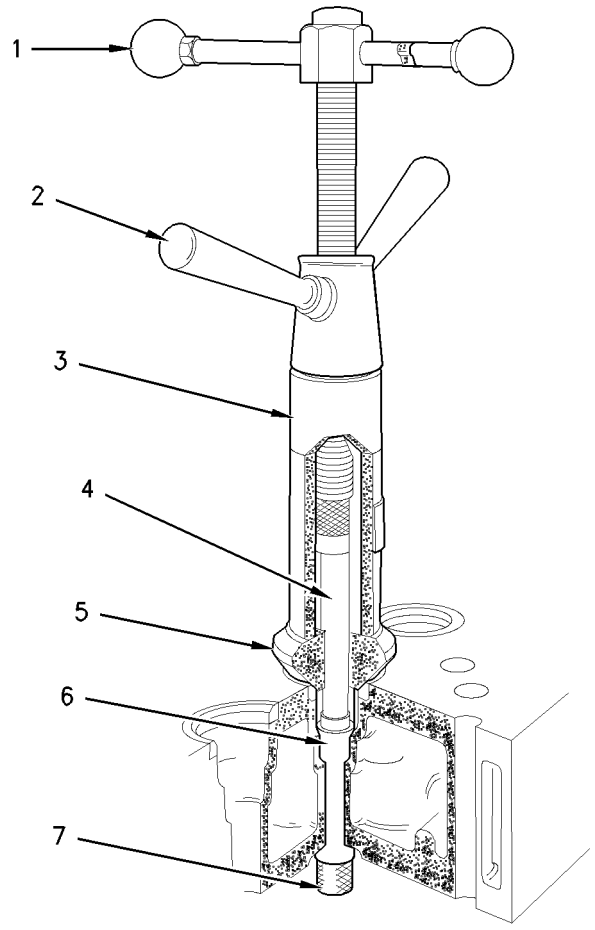


Illustration 37 g00998500

1. Install the adapter (4) into the valve guide tool (3) and fit the spacer (5).

2. Put the adapter (4) through the valve guide (6) and put the spacer (5) and the valve guide tool (3) in position on the valve seat.

3. Fit the attachment (7) in order to secure the adapter to the valve guide.

4. Hold the top handle (1) of the valve guide tool and turn the bottom handle (2) of the valve guide tool clockwise in order to pull the valve guide (6) out of the cylinder head.

5. Repeat the procedure for the remaining valve guides.

Installation Procedure

Table 11

Part Number	Part Description	Qty
21825478	Valve guide tool	1
27610019	Adapter	1
21825482	Distance piece (inlet valve guide)	1
27610029	Distance piece (exhaust valve guide)	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

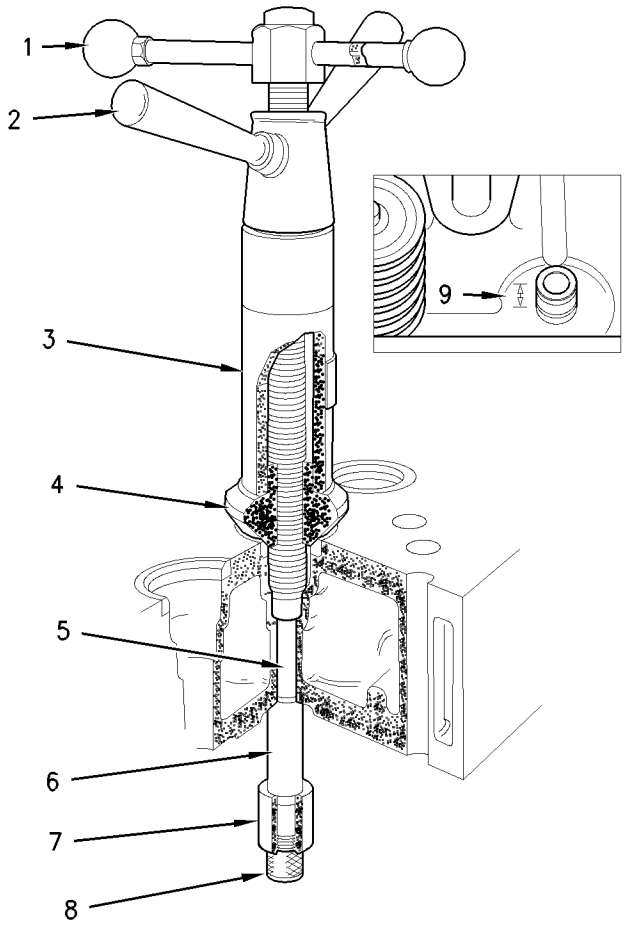


Illustration 38 g00998495

NOTICE
If the valve seats are to be cut, the valve seat and the valve guide must be machined at the same time.

1. Put the valve guide in position. Lubricate the outer surface of the new valve guide (6) with clean engine oil. Put the adapter (5) into the valve guide tool (3).

With the adapter (5) on the valve guide tool, put the spacer (4) in position on the valve guide tool (3).

Pass the adapter (5) through the cylinder head and place the spacer (4) and the valve guide tool in position on the valve seat.

Put the valve guide in position and use either the distance piece (inlet valve guide) or the distance piece (exhaust valve guide) (7). Install the attachment (8) in order to secure the valve guide to the adapter (5).

Note: The internal recess in the valve guide must be facing the tool.

Hold the top handle (1) and turn the bottom handle (2) clockwise in order to pull the valve guide until the distance piece contacts the cylinder head.

Check the protrusion of the valve guide. When the valve guide is assembled correctly, the top of the valve guide will have a protrusion (9) of 14.85 to 15.15 mm (0.5846 to 0.5965 inch) above the cylinder head.

Note: After installing the unfinished valve guides and the valve seat inserts, ream the valve guides and the valve seat inserts to the finished diameter. The valve guides and valve seat inserts are cut and reamed in one operation. Refer to Specifications, “Cylinder Head Valves” for the finished diameter of the valve guides and valve seat inserts.

2. Repeat the procedure for the remaining valve guides.

End By:

a. Install the inlet valves and the exhaust valves. Refer to Disassembly and Assembly, “Inlet and Exhaust Valves - Remove and Install”.

i01854960

Inlet and Exhaust Valve Seat Inserts - Remove and Install

Removal Procedure

Table 12

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610030	Valve Seat Cutters and reamer	1

Start By:

a. Remove the inlet valves and the exhaust valves. Refer to Disassembly and Assembly, “Inlet and Exhaust Valves - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: When the new valve seat inserts are installed, new valves and new valve guides must be installed.

1. Remove the valve guides. Refer to Disassembly and Assembly, “Inlet and Exhaust Valve Guides - Remove and Install”.

2. Install the new partially finished valve guides. Refer to Disassembly and Assembly, “Inlet and Exhaust Valve Guides - Remove and Install”.

3. In order to machine the valve seat insert for removal, the bore of the new partially finished valve guide must be used as a pilot. In order to machine a new recess in the cylinder head for the valve seat insert, the bore of the new partially finished valve guide must be used as a pilot. Refer to Specifications, “Cylinder Head Valves” for the correct dimensions.

4. Repeat the procedure for the remaining valve seat inserts.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Do not use a hammer to install the valve seat insert and do not use lubrication to install the valve seat insert. Use a hydraulic press or a hand press to install the valve seat inserts in one continuous movement.

1. Use a suitable tool in order to install the valve seat insert into the cylinder head assembly.

Note: Ensure that the bottom of the valve seat insert is in contact with the bottom of the recess in the cylinder head.

2. Repeat the procedure for the remaining valve seat inserts.

Note: Refer to the Specifications for more information on the valve seat inserts.

3. After installing the valve guides and valve seat inserts, the valve guides must be reamed and the valve seat inserts must be cut to the finished diameter. The valve guides and valve seat inserts are cut and reamed in one operation. This procedure ensures the concentricity of the valve seat to the valve guide in order to create a good seal. Refer to Specifications, “Cylinder Head Valves” for the finished diameter of the valve guides and valve seat inserts.

Note: Ensure that the correct valve seat cutter is installed. 31 degrees for the exhaust valve seat or 46 degrees for the inlet valve seat.

4. Position Tooling (A) into the valve guide. Carefully turn the handle in a clockwise direction and gradually move the reamer into the valve guide until the valve guide is reamed to the finished size.

5. Continue to turn the handle in a clockwise direction in order to cut the valve seat insert. Remove the minimum amount of material in order to ensure a good valve seat. Keep the valve seat as narrow as possible.

6. Remove Tooling (A). Clean the debris from the valve guide and the valve seat.

End By:

a. Install the inlet valves and the exhaust valves. Refer to Disassembly and Assembly, “Inlet and Exhaust Valves - Remove and Install”.

i01852846

Engine Oil Filter Base - Remove and Install

Removal Procedure for the Oil filter Base

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

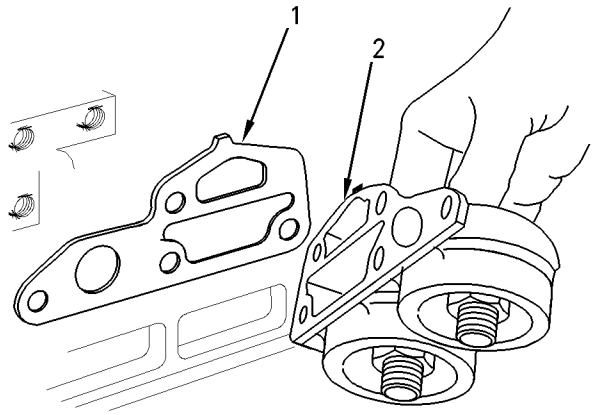


Illustration 39 g01003101

Note: According to the application, the oil filter base (2) can be installed on the left hand side of the engine or the oil filter base (2) can be installed on the right hand side of the engine.

1. Remove the oil filters from the oil filter base (2).

2. If equipped, remove the turbocharger oil line from the right hand side of the oil filter base (2).

3. Remove the setscrews from the oil filter base.

4. Remove the oil filter base (2) and the gasket (1).

Removal Procedure for the High Mounted Oil filter Base and Adapter Plate

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Remove the oil filter from the oil filter base.

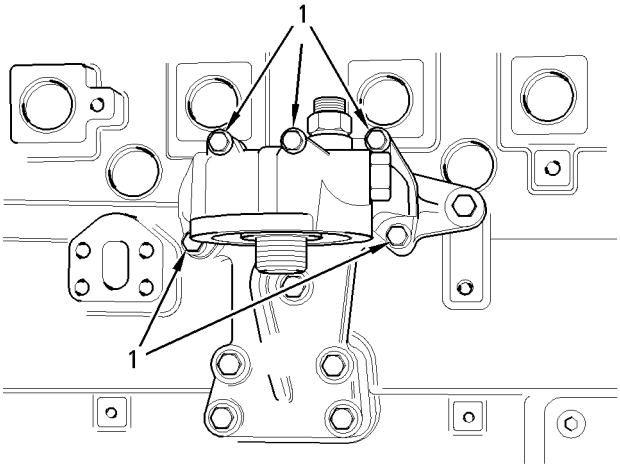


Illustration 40 g01003374

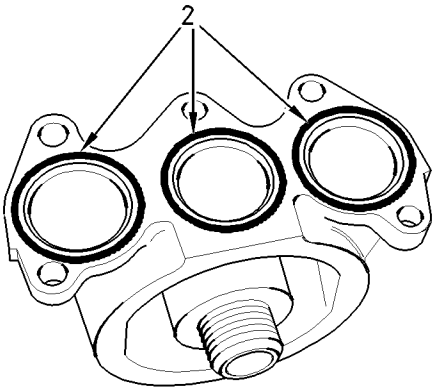


Illustration 41 g01003376

2. Remove the five setscrews (1) and remove the oil filter base from the adapter plate. Discard the three O rings (2) from the rear face of the oil filter base.

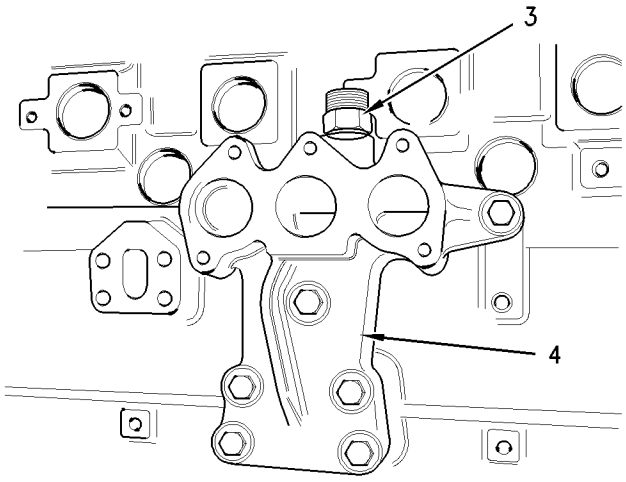


Illustration 42 g01003375

3. Disconnect the turbocharger oil line from the union (3) in the adapter plate (4). Use a spanner to ensure that the union for the oil line does not rotate.

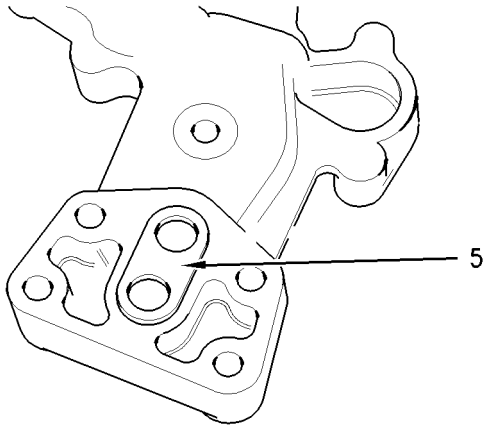


Illustration 43 g01003377

4. Remove the six setscrews and remove the adapter plate (4) from the cylinder block. Discard the seal (5) from the rear of the adapter plate.

Installation Procedure for the Oil filter Base

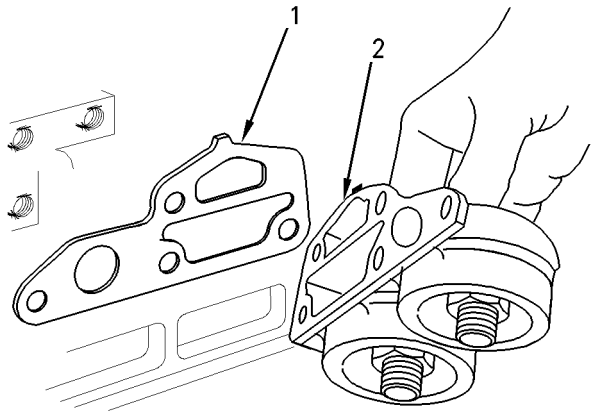


Illustration 44 g01003101

1. Clean the mating surfaces of the cylinder block and the engine oil filter base.

2. Position the gasket (1) and the engine oil filter base (2) on the cylinder block.

Note: Do not use sealants on the gasket (1).

3. Install the setscrews. Tighten the setscrews to a torque of 44 N·m (33 lb ft).

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820117 POWERPART threadlock and nutlock. Clean the old sealant from the threads in the cylinder block.

4. If equipped, connect the turbocharger oil line to the right hand side of the oil filter base (2), or connect the flexible oil cooler lines to the left hand side of the oil filter base (2).

5. Install new filters.

6. Check the level of the lubrication oil, and adjust the level of the lubricating oil. Refer to Operation and Maintenance Manual, “Refill Capacities” for the lubrication system capacity of the engine.

Installation Procedure for the High Mounted Oil filter Base and Adapter Plate

1. Clean the mating surfaces of the cylinder block, the engine oil filter base, and the adapter plate.

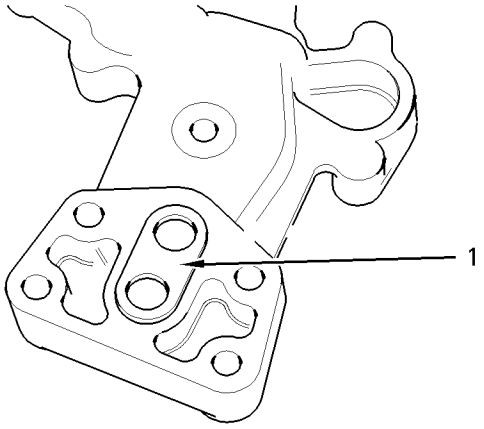


Illustration 45 g01003621

2. Install a new rubber seal (1) to the recess in the rear of the adapter plate. A small amount of a suitable sealant can be used to ensure that the seal (1) does not move during the installation of the adapter plate.

3. Install the adapter plate to the cylinder block with the six setscrews. Tighten the six setscrews to a torque of 40 N·m (29 lb ft).

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820117 POWERPART threadlock and nutlock. Clean the old sealant from the threads in the cylinder block.

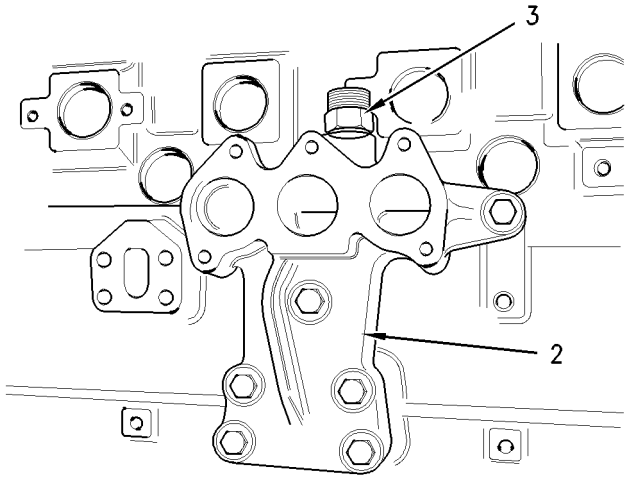


Illustration 46 g01003622

4. Install the turbocharger oil line to union (3) on the adapter plate (2) and tighten to 15 N·m (11 lb ft). Use a spanner to ensure that the union (3) for the oil line does not rotate.

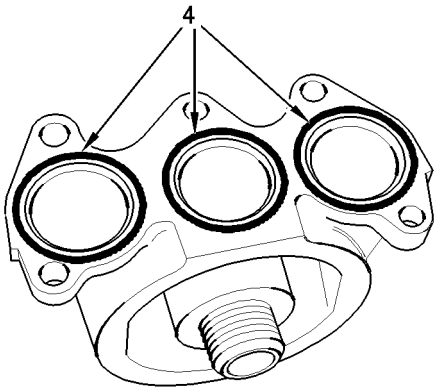


Illustration 47 g01003625

5. Install new O rings (4) into the recess in the rear face of filter base.

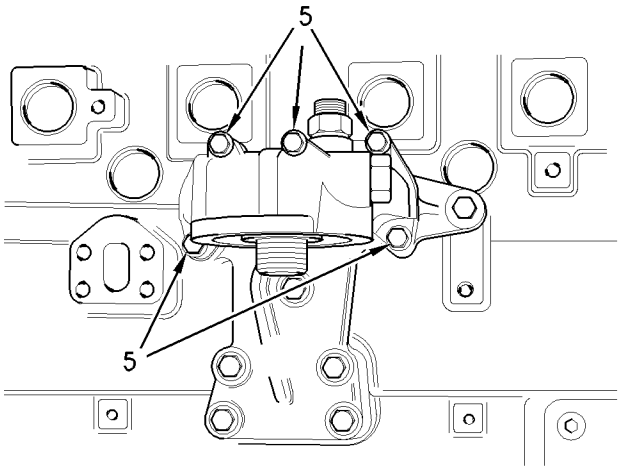


Illustration 48 g01003624

6. Install the filter base to the adapter plate (2) with the five setscrews (5). Tighten the five setscrews to 22 N·m (16 lb ft).

7. Install a new filter.

8. Check the level of the lubrication oil, and adjust the level of the lubricating oil. Refer to Operation and Maintenance Manual, “Refill Capacities” for the lubrication system capacity of the engine.

i01852350

Engine Oil Cooler - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the engine oil cooler into a suitable container. Drain the engine oil from the engine oil cooler into a suitable container. Refer to Operation and Maintenance Manual for the procedure on draining the engine coolant and the engine lubricating oil.

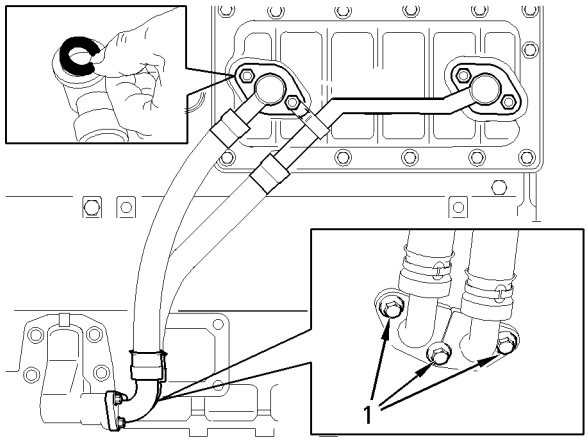


Illustration 49 g01003650

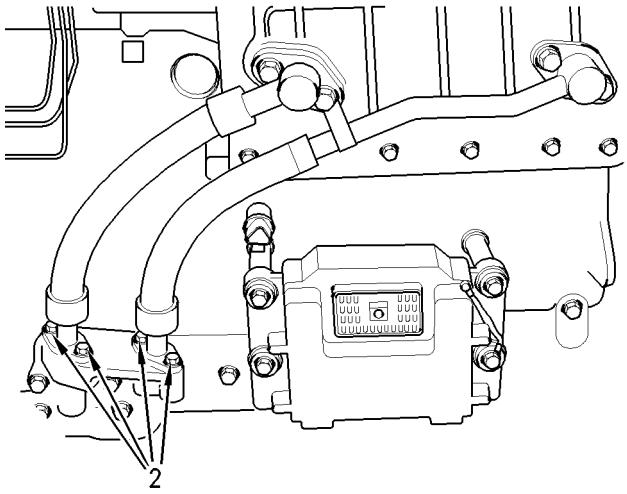


Illustration 50 g01003649

2. Remove the setscrews from the oil filter base (1) or from the adapter (2).

3. Disconnect the oil lines (3) and (4) from the oil filter base (1) or from the adapter (2) and discard the joints.

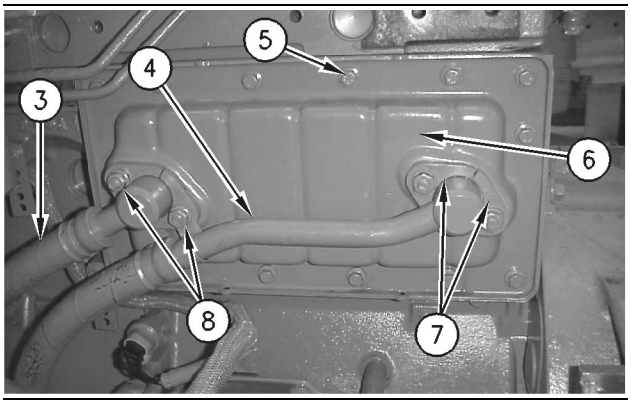


Illustration 51 g01003930

4. Remove the setscrews (5) from the housing for the oil cooler (6).

5. Remove the housing for the engine oil cooler (6) and the gasket (12).

6. Remove the nuts (8) and the flanges (7) from the housing for the oil cooler (6).

7. Remove the oil lines (3) and (4) from the housing for the oil cooler (6).

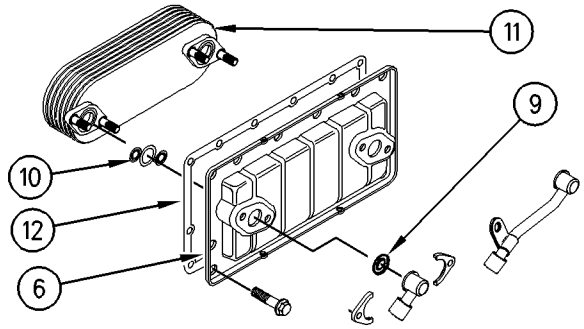


Illustration 52 g00985727

8. Remove the seals (9).

9. Remove the engine oil cooler (11) and the seals (10) from the housing (6).

i01851851

Engine Oil Cooler - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the mating surfaces of the housing for the oil cooler and the cylinder block.

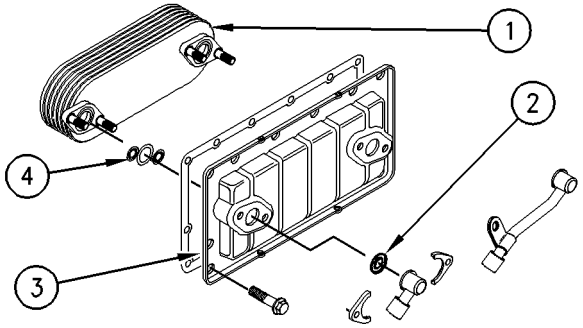


Illustration 53 g01004279

2. Position the engine oil cooler (1) and the new seals (4) on the housing for the oil cooler (3).

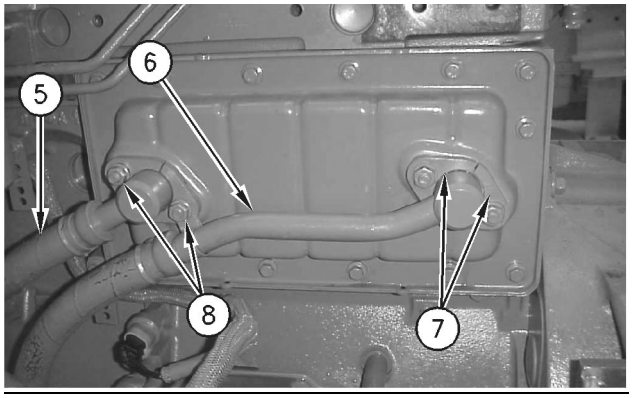


Illustration 54 g01004278

3. Install the seals (2) on the hose assemblies (5) and (6). Position the hose assemblies (5) and (6) on the housing (3) for the oil cooler. Install the flanges (7) and the nuts (8). Tighten the nuts to a torque of 22 N·m (16 lb ft).

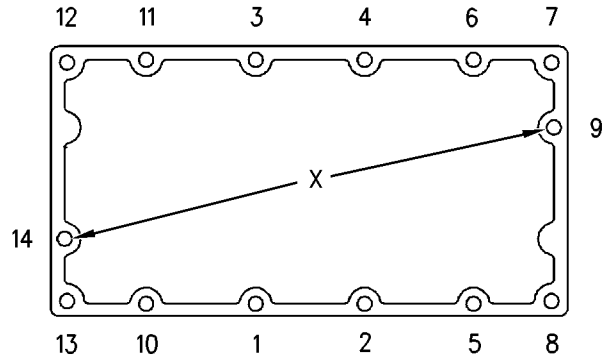


Illustration 55 g00941155

4. Install two suitable guide studs into the holes (X) on the cylinder block.

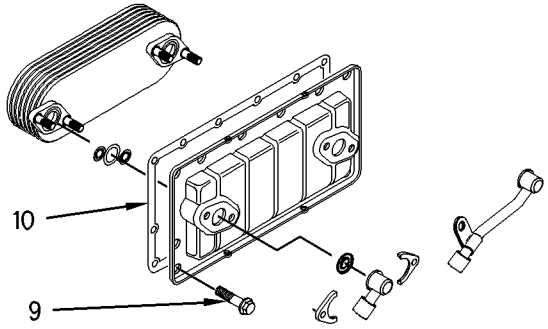


Illustration 56 g01004285

5. Install a new gasket (10) onto the guide studs.

Note: Do not use sealants on gasket (10).

6. Position the housing for the oil cooler (3) on the guide studs. Install the setscrews (9) in order to secure the housing for the oil cooler to the cylinder block. Tighten the setscrews (9) finger tight.

7. Remove the two guide studs. Install the remaining setscrews (9) and tighten all setscrews (9) to a torque of 22 N·m (16 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 55.

8. Clean the mating surfaces of oil filter base or the adapter and the flanges of the hose assemblies (5) and (6).

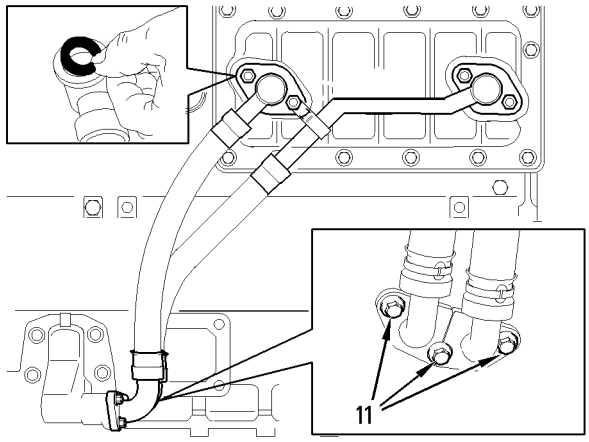


Illustration 57 g01004286

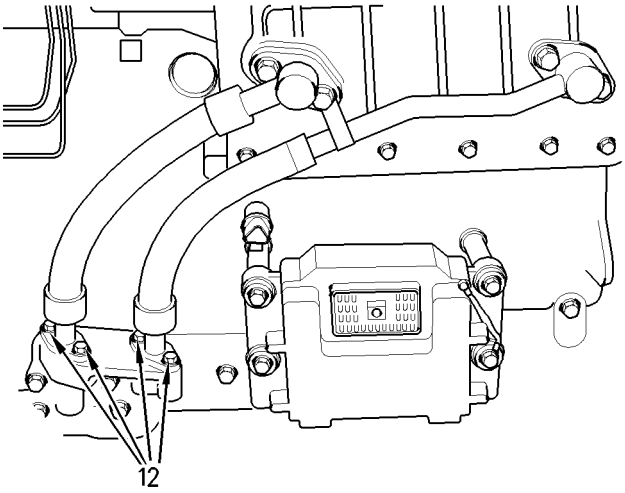


Illustration 58 g01004287

9. Install new gaskets on the flanges of the hose assemblies. Position the hose assemblies onto the oil filter base, or onto the adapter. Install the setscrews (11) or (12) and tighten to a torque of 22 N·m (16 lb ft).

10. Fill the cooling system with coolant. Fill the lubrication system with engine oil. Refer to Operation and Maintenance Manual, “Refill Capacities” for the cooling system capacity and the lubrication system capacity of the engine.

i01851816

Engine Oil Bypass Valve - Remove

Removal Procedure

Start By:

a. Remove the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

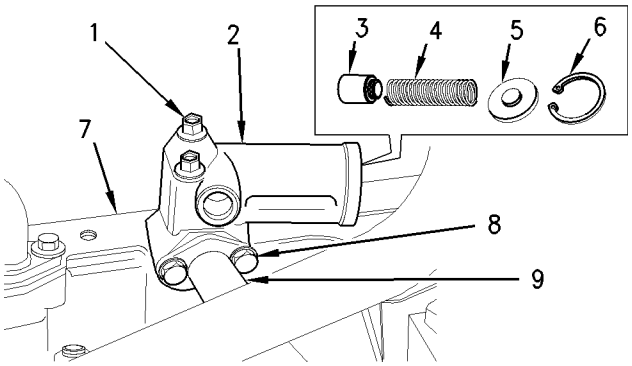


Illustration 59 g00941609

1. Remove the setscrews (8) that hold the tube assembly (9) for the engine oil relief valve (2).

Note: Tube assembly (9) is used only when the engine oil filter is installed on the right side of the engine.

2. Remove the setscrews (1). Remove the engine oil bypass valve (2) from cylinder block (7).

⚠ WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

3. Use pliers for circlips in order to remove the retaining ring (6), seat (5), spring (4), and the plunger (3) from the housing.

4. Check the seat, the spring, the plunger, and the housing for wear or for other damage. The plunger (3) must slide easily in the housing.

i01851797

Engine Oil Bypass Valve - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

1. Clean the mating surfaces of the engine oil relief valve and the cylinder block.

2. Clean the internal components of the engine oil relief valve. Lubricate the internal components of the engine oil relief valve with clean engine oil.

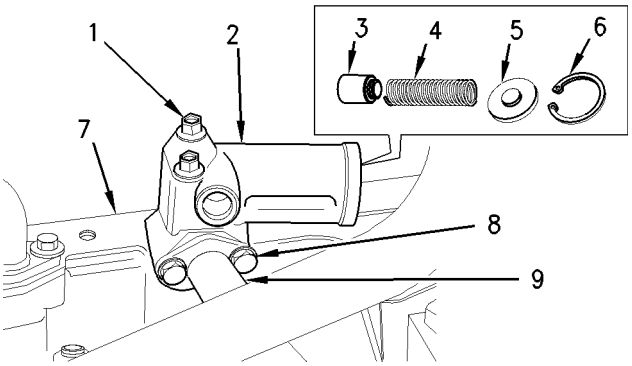


Illustration 60 g00941609

3. Install the plunger (3), the spring (4), and the seat (5) in the housing. Apply pressure to the seat (5) and install the retaining ring (6) with pliers for circlips.

4. Install the engine oil bypass valve (2). Install the setscrews (1). Tighten the setscrews (1) to a torque of 22 N·m (16 lb ft).

5. Install the tube assembly (9) (if equipped) to the engine oil bypass valve (2). Install the setscrews (8).

Note: Tube assembly (9) is used when the engine oil filter is installed on the right side of the engine.

End By:

a. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

i01989676

High Mounted Oil Filter Bypass Valve - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

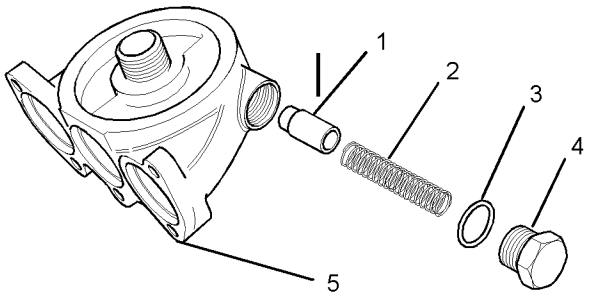


Illustration 61 g01030425

1. Remove the plug (4) that holds the assembly of the oil filter bypass valve into the filter head (5).

2. Remove the spring (2) from the filter head. Remove the oil bypass valve (1) from the filter head.

3. Clean all of the components of the assembly of the oil bypass valve. Check all of the components for wear or for damage.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

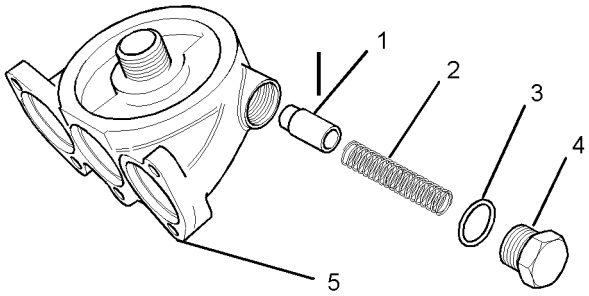


Illustration 62 g01030425

1. Lubricate the bypass valve (1) with clean engine oil. Install the bypass valve into the recess in the filter head (5).

2. Install the spring (2) into the recess in the bypass valve.

Note: The O ring (3) must be installed dry.

3. Check the condition of the O ring that is installed on the rear of the plug (4). If necessary, replace the O ring.

4. Install the plug into the filter and tighten the plug to a torque of 60 N·m (44 lb ft).

i01853425

Engine Oil Pump - Remove

Removal Procedure

Start By:

a. Remove the oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

b. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove”.

Note: The engine oil pump is mounted on the No. 1 crankshaft main bearing cap. The engine oil pump can be removed without removing the timing case if the No. 1 crankshaft main bearing cap is removed. In order to remove the crankshaft main bearing cap bolt for the No. 1 crankshaft journal, use the torque wrench extension. The engine oil pump is then removed from the No. 1 crankshaft main bearing cap.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

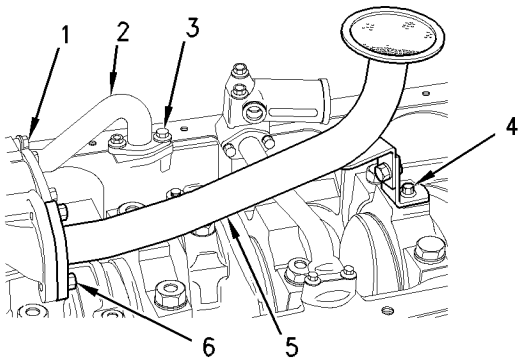


Illustration 63 g01004316

1. Remove the setscrew (4) from the bracket.

2. Remove the setscrews (6), the suction pipe (5) and the gasket. Discard the gasket.

3. Remove the setscrews (1) and (3) from the oil supply tube assembly (2). Remove the oil supply tube assembly (2) from the cylinder block and the engine oil pump.

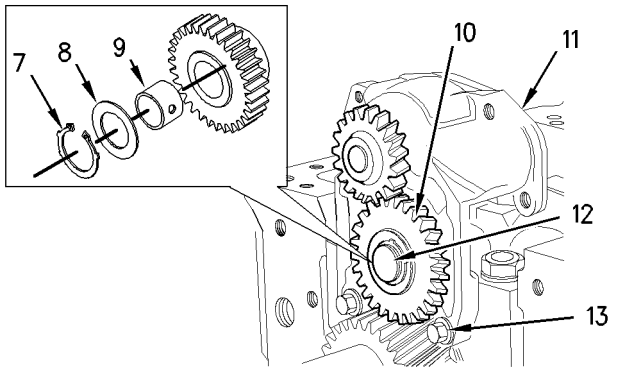


Illustration 64 g00941777

WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

4. Use pliers for circlips to remove the retaining ring (7). Remove the washer (8) and the idler gear (10) from the shaft (12).

5. Remove the setscrews (13) that fasten the engine oil pump to the main bearing cap. Remove the engine oil pump (11).

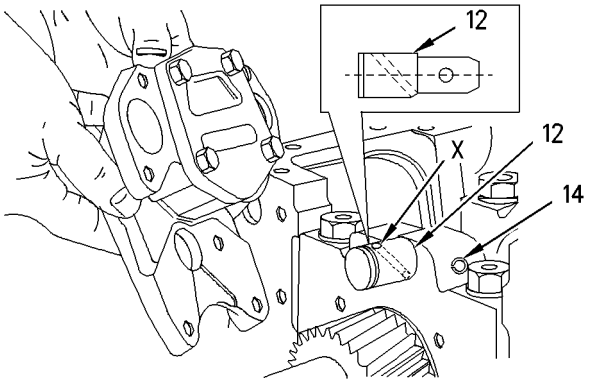


Illustration 65 g00941944

6. Inspect the shaft (12) for wear or damage. If necessary, remove the bolts for the main bearing cap. Remove the oil pump idler gear shaft (14) from the main bearing cap. Refer to Disassembly and Assembly, “Engine Oil Pump Idler Gear Shaft - Remove and Install”.

i01853472

Engine Oil Pump - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
If any of the parts on the engine oil pump are worn or damaged, the entire pump must be replaced.

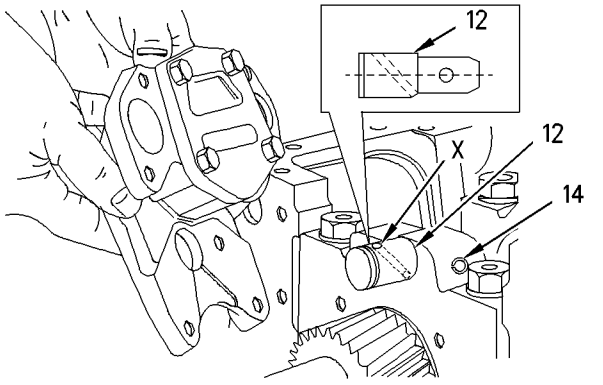


Illustration 66 g00942040

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

1. If the oil pump idler gear shaft was removed, refer to Disassembly and Assembly, “Engine Oil Pump Idler Gear Shaft - Remove and Install”.

Note: If the No. 1 crankshaft main bearing cap was removed, install the main bearing cap with the engine oil pump. Use the torque wrench extension to tighten the setscrews for the main bearing cap to a torque of 265 N·m (195 lb ft).

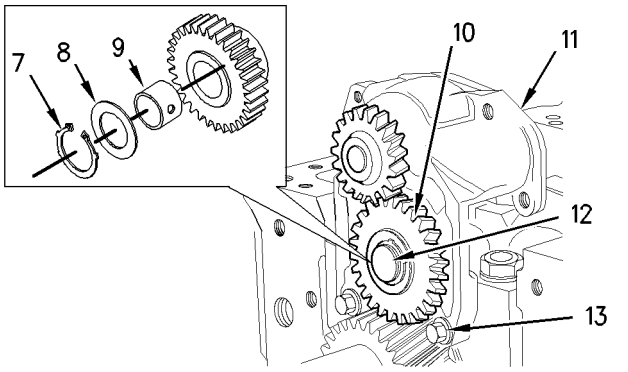


Illustration 67 g00942205

2. Fill the engine oil pump (11) with clean engine oil. Install the engine oil pump on the main bearing cap. Install the setscrews (13). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

3. Install the idler gear (10) and the washer (8) on the shaft (12). Use pliers for circlips to install the retaining ring (7).

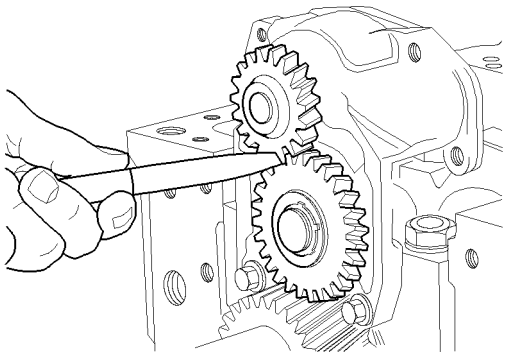


Illustration 68 g00942080

4. Check the backlash between the gear for the engine oil pump and the idler gear. The backlash for the gears is 0.062 to 0.122 mm (0.0024 to 0.0048 inch).

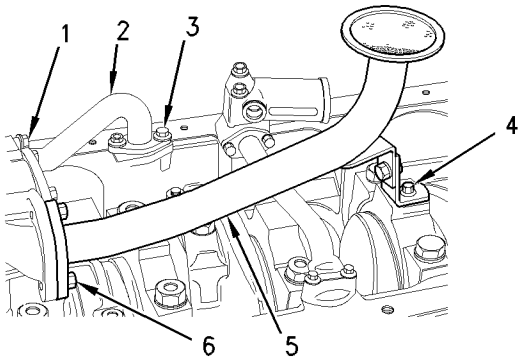


Illustration 69 g01004316

Note: After you install the engine oil pump and the idler gear, ensure that there is a minimum of 0.08 mm (0.003 inch) backlash between the gear on the engine oil pump and the idler gear.

5. Install the oil supply tube assembly (2) to the engine oil pump and the cylinder block. Install the setscrews (1) and setscrews (3). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

6. Install a new gasket to the suction pipe. Install the suction pipe (6) and the setscrews (5) to the engine oil pump. Tighten the setscrews to a torque of 22 N·m (16 lb ft).

End By:

a. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install”.

b. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

i01989624

Water Pump - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container for storage or disposal.

Note: Refer to Operation and Maintenance Manual, “Refill Capacities” for the coolant capacity of the engine.

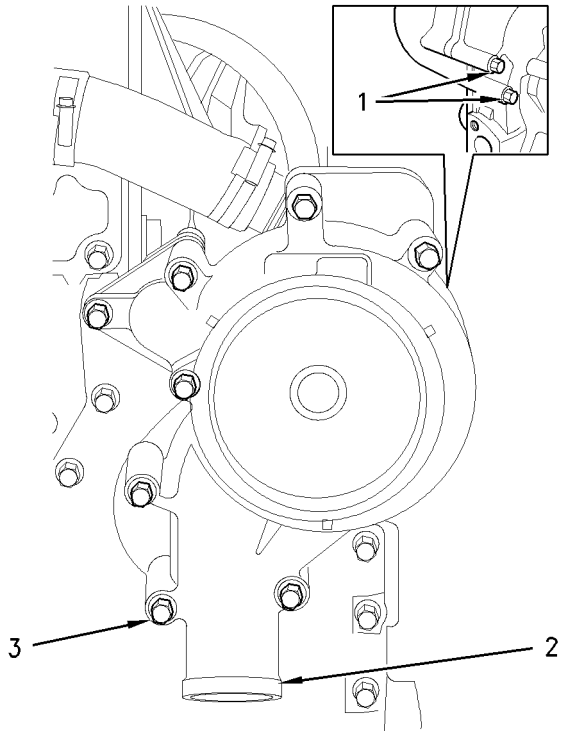


Illustration 70 g01004638

2. Loosen the clamps and remove the hose from the water pump inlet (2).

3. Remove the two setscrews (1) from the back side of the front housing. Remove the eight setscrews (3) that fasten the water pump to the front housing.

4. Tap the water pump with a soft hammer in order to loosen the water pump.

5. Remove the water pump and discard the joint.

i01992175

Water Pump - Disassemble

Disassembly Procedure

Table 13

Required Tools		
Part Number	**Part Description**	**Qty**
21825565	Puller	1

Start By:

a. Remove the water pump. Refer to this Disassembly and Assembly, “Water Pump - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

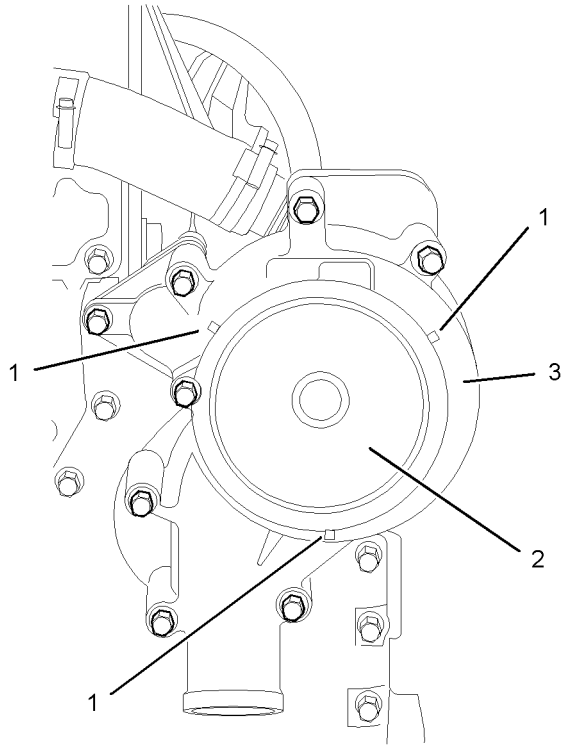


Illustration 71 g01031747

1. Insert a suitable lever into one of the slots (1) in order to force the cover (2) from the body of the water pump (3). It will probably be necessary to gradually force the cover (2) from the water pump by using each of the slots (1) in sequence. Discard the removed cover (2).

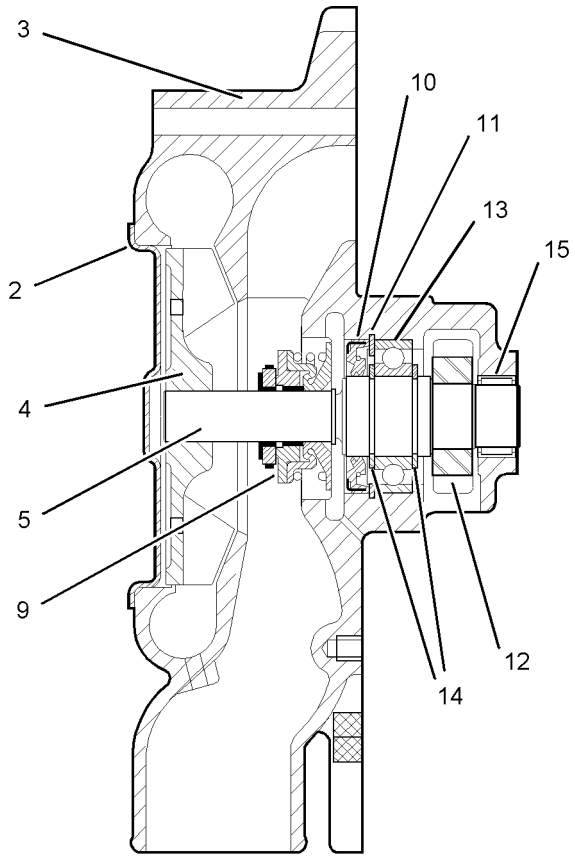


Illustration 72 g01031746

2. Drill four equally spaced 6.35 mm (0.25 inch) holes into the central hub of the impeller (4) close to the water pump shaft (5). The drilled holes will loosen the fit of the central hub on the shaft (5).

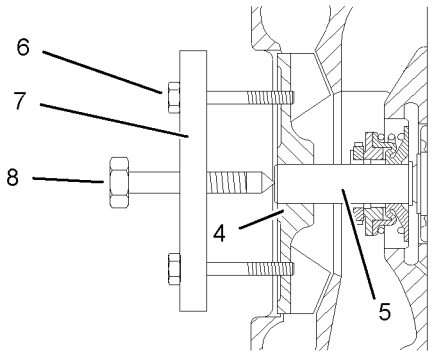


Illustration 73 g01031829

Note: The impeller has two 8 mm threaded holes that are suitable for the 21825565 Puller.

3. Slacken the central setscrew (8) of the 21825565 Puller (7). Install the two setscrews (6) through the puller (7) and into the two threaded holes in the impeller (4). Tighten the central setscrew (8) finger tight against the shaft (5). Tighten the two setscrews (6) so that the puller (7) is parallel to the face of the impeller (4). Gradually tighten the central setscrew (8) in order to pull the impeller (4) from the shaft (5). Discard the removed impeller (4).

Note: Take great care to ensure that the sealing face in the housing of the water pump seal is not damaged during the removal of the water pump seal.

4. Carefully break the carbon seal on the water pump seal (9) and remove all of the debris. Use a suitable extractor tool in order to carefully remove the central sleeve of the carbon seal from the pump shaft (5). Drill three equally spaced 3.175 mm (0.125 inch) holes through the top of the remainder of the water pump seal (9). Install three 25.4 mm (1.00 inch) self-tapping screws into the holes. Insert a suitable lever through the water inlet of the water pump and under the head of each screw in sequence in order to evenly force the water pump seal (9) from the shaft (5). Discard the water pump seal (9).

Note: Take great care to ensure that the sealing face in the housing of the oil seal is not damaged during the removal of the oil seal.

5. Drill a 3.175 mm (0.125 inch) hole through the top of the oil seal (10). Install a 25.4 mm (1.00 inch) self-tapping screw into the hole. Insert a suitable lever through the water inlet of the water pump and under the head of the screw in order to force the oil seal (10) from the shaft (5) and from the recess for the oil seal. Discard the oil seal (10).

6. Remove the circlip (11) and discard the circlip.

7. Place the impeller side of the water pump onto a suitable support. Use a suitable press in order to press the assembly of the shaft (5) and the ball bearing (13) out of the drive gear (12) and out of the water pump housing (3). Discard the assembly of the shaft (5), the ball bearing (13), and the two circlips (14).

8. Remove the drive gear (12) from the opening in the side of the water pump housing (3). Inspect the drive gear (12) for wear and for damage. If necessary, discard the drive gear (15).

9. Place the impeller side of the water pump onto a suitable support. Use a suitable press in order to press the needle bearing (15) from the water pump housing (3). Discard the needle bearing (15).

i01994180

Water Pump - Assemble

Assembly Procedure

Table 14

Required Tools		
Part Number	**Part Description**	**Qty**
27610031	Oil seal installer	1

Note: Ensure that all of the parts in the kit for the water pump are used. The kit includes all of the latest parts which may be to a slightly different design to the original parts.

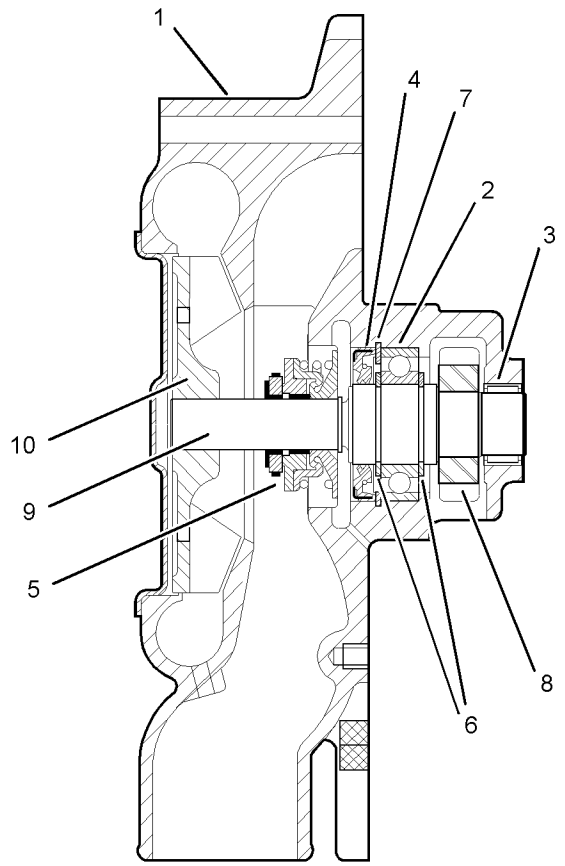


Illustration 74 g01032047

1. Thoroughly clean the inside of the water pump (1). Ensure that the recesses for the ball bearing (2), the needle bearing (3), the oil seal (4), and the water pump seal (5) are clean and free from damage. Ensure that the recesses for the oil seal (4) and the water pump seal (5) are free from corrosion. Ensure that the grooves for the circlips (6) and the circlip (7) are clean and free from damage.

2. Install a new circlip (6) onto the drive gear end of a new shaft (9). Ensure that the circlip (6) is located correctly within the groove.

Note: If the drive gear (8) is the gear that was previously removed from the pump, apply 21820638 POWERPART Retainer (high strength) to the bore of the gear. POWERPART Retainer (high strength) is not required if the drive gear (8) is new.

3. Place the drive gear end of the water pump (1) onto a suitable press. Insert the drive gear (8) into the water pump (1) through the opening. Insert the shaft (9) into the water pump (1) and ensure that the shaft and the drive gear (8) align.

4. Press the shaft (9) into the drive gear (8) until the shoulder on the shaft is against the gear.

Note: Ensure that no POWERPART Retainer (high strength) is applied close to the ends of the needle bearing (3).

5. Place the impeller end of the water pump (1) onto a suitable press. Apply a little 21820638 POWERPART Retainer (high strength) to the center of the outer surface of the new needle bearing (3). Press the needle bearing (3) into the bearing housing until the end of the bearing is in-line with the top face of the water pump (1) or the bearing is no more than 0.5 mm (0.020 inch) below the top face.

6. Place the drive gear end of the water pump (1) onto a suitable press. Use a suitable spacer to support the drive gear (8). Apply a little 21820638 POWERPART Retainer (high strength) to the center of the outer surface of the new ball bearing (2). Use a suitable adapter in order to press the ball bearing (2) into the water pump (1) until the ball bearing is in contact with the circlip (6). Remove the spacer from below the drive gear (8). Continue to press the ball bearing (2) into the water pump (1) until the new circlip (7) can be inserted into the appropriate groove. Ensure that the beveled side of the circlip (7) is toward the oil seal (4) and insert the circlip into the appropriate groove.

7. Insert a new circlip (6) into the groove in the shaft (9). Ensure that all of the circlips are correctly seated. Lubricate the ball bearing (2) and the needle bearing (3) with clean engine lubricating oil.

8. Insert the 27610031 Oil seal installer onto the shaft (9) and ensure that the tapered section is toward the ball bearing (2).

Note: A suitable tool can be manufactured in order to press the oil seal (4) into the water pump (1). Refer to the table 15 and the illustration 75 for further information.

Table 15

Required Dimensions	
A	40.0 mm (1.57 inch)
B	80.0 mm (3.15 inch)
C	60.0 mm (2.36 inch)
D	42.0 mm (1.65 inch)
E	29.0 mm (1.14 inch)
F	14.5 mm (0.57 inch)
G	12.0 mm (0.47 inch)

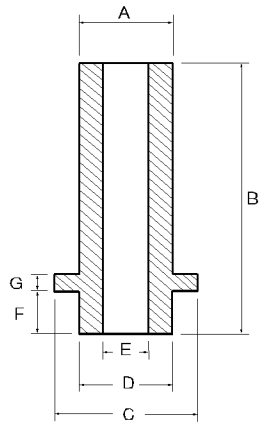


Illustration 75 g01032256

9. Lightly lubricate the new oil seal (4) with clean engine lubricating oil. With the lip of the oil seal (4) toward the ball bearing (2), push the oil seal over the oil seal installer. Use the special tool that was previously manufactured to the illustration 75 in order to press the oil seal (4) into the appropriate recess. Press the oil seal (4) into the recess until the oil seal is 14.5 mm (0.57 inch) from the top of the recess for the water pump seal (5). Continue to apply force to the seal for approximately 10 seconds in order to ensure that the oil seal (4) will remain in position. Remove the oil seal installer and remove any surplus oil.

Note: Do not lubricate the water pump seal (5). It is important to ensure that the water pump seal (5) is not contaminated by oil or by grease. Also, ensure that you do not touch the water pump seal (5) by hand. If it is necessary to touch the water pump seal (5), ensure that only the outside edge of the flange is touched. Do not damage the ring of green sealant that was previously applied to the body of the water pump seal (5) by the manufacturer of the seal.

10. Install the new water pump seal (5) onto the shaft (9) with the widest part of the seal toward the oil seal (4).

Note: A suitable tool can be manufactured in order to press the water pump seal (5) into the water pump (1). Refer to the table 16 and the illustration 76 for further information.

Table 16

Required Dimensions	
A	44.0 mm (1.73 inch)
B	40.0 mm (1.57 inch)
C	12.2 mm (0.48 inch)
D	35.8 mm (1.41 inch)
E	16.1 mm (0.63 inch)
F	1.0 mm (0.04 inch) at 45 degrees
G	2.0 mm (0.08 inch) at 45 degrees

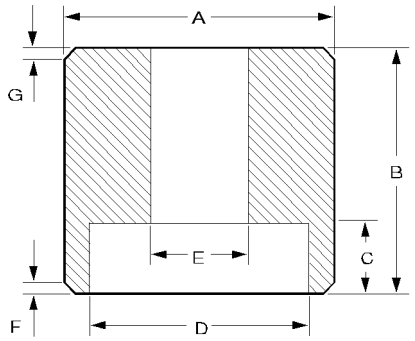


Illustration 76 g01032254

11. Push the water pump seal (5) down the shaft (9) until the seal is in contact with the recess for the seal in the water pump body. Ensure that the water pump seal (5) is square to the top face of the recess. Use the special tool that was previously manufactured to the illustration 76 in order to press the water pump seal (5) into the recess until the outer flange of the seal is in contact with the recess. Continue to apply force to the seal for approximately 10 seconds in order to ensure that the water pump seal (5) will remain in position.

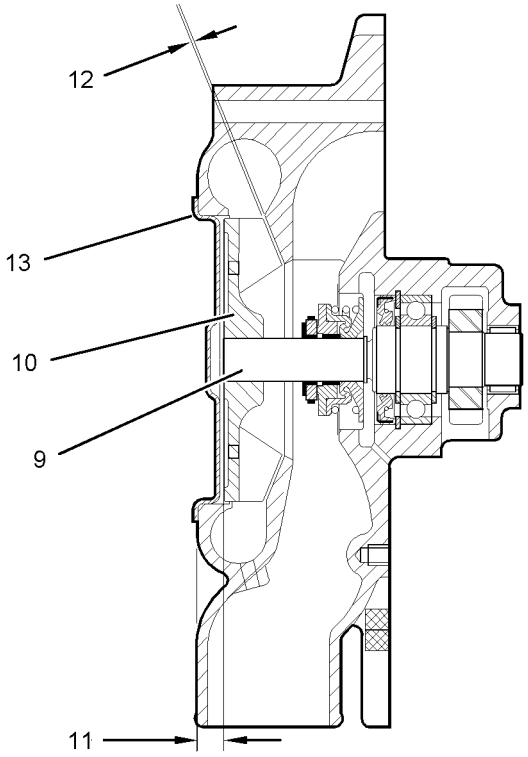


Illustration 77 g01032592

12. Ensure that the drive end of the shaft (9) is supported and use a suitable spacer, flat bar, and a press in order to press the new impeller (10) onto the shaft (9). Continue to press the impeller (10) onto the shaft (9) until the gap between the top face of the impeller and the flange face of the water pump is from 10.35 mm (0.410 inch) to 10.48 mm (0.413 inch) (11). This gap (11) should result in a clearance (12) between the impeller blades and the pump body of 0.44 mm (0.017 inch) to 1.06 mm (0.042 inch).

13. Apply a ring of 21820518 POWERPART Gasket and flange sealant onto the contact surface of the new pressed steel cover (13). Ensure that the cover (13) is square to the pump body and use a suitable adapter in order to press the cover until the flange of the cover is fully engaged onto the flange of the water pump body.

End By:

a. Install the water pump. Refer to this Disassembly and Assembly Manual, “Water Pump - Install”.

i01989620

Water Pump - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the drive gear for the water pump for wear or other damage. If necessary, replace the drive gear.

Note: Do not use sealant on the joint for the water pump.

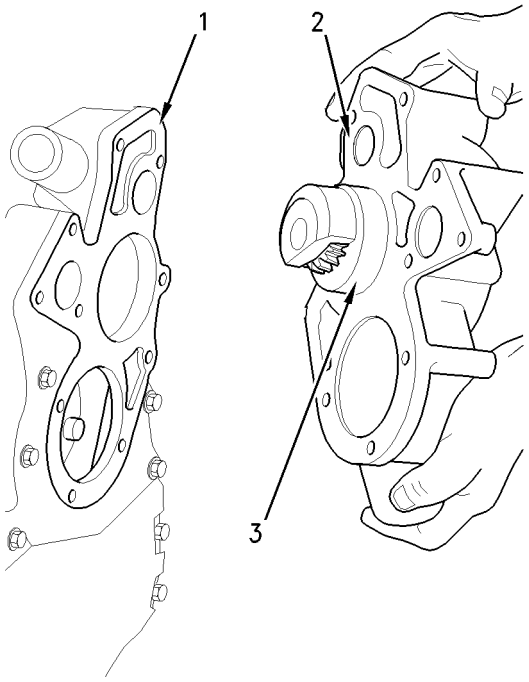


Illustration 78 g01004639

2. Clean the joint faces of the water pump (2) and the front housing (1). Clean the spigot (3) on the water pump. Install a new joint on the water pump.

3. Install the water pump and the joint onto the front housing (1). Ensure that the gear of the water pump and the gear of the fuel injection pump mesh.

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820117 POWERPART threadlock and nutlock.

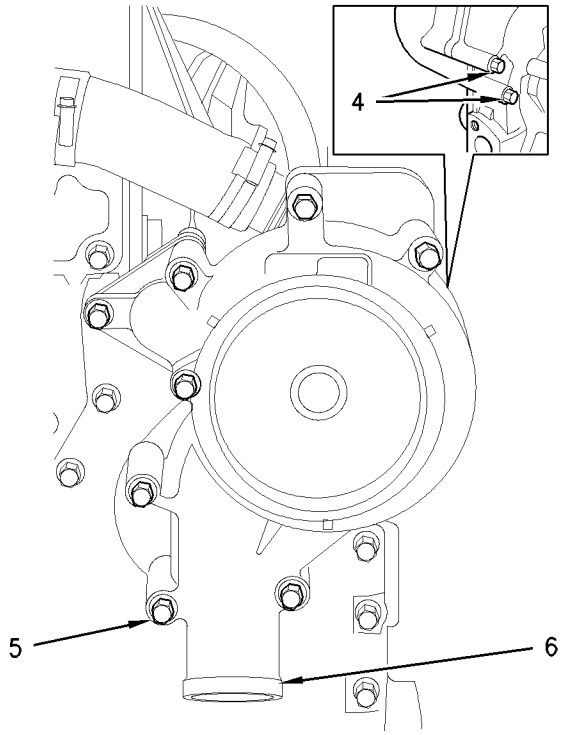


Illustration 79 g01004640

4. Install the eight setscrews (5) that fasten the water pump to the front housing. Install the two setscrews (4) on the back side of the front housing. Tighten all setscrews to a torque of 22 N·m (16 lb ft).

5. Install the hose to the water pump inlet (6). Tighten the hose clamps.

6. Fill the cooling system with coolant. Refer to Operation and Maintenance, “Refill Capabilities” for the coolant capacity of the engine.

i01874896

Water Temperature Regulator - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Identification of the water temperature regulator (9) is by the nominal temperature that is stamped on the bypass valve of the water temperature regulator.

1. Drain the coolant from the cooling system to a level below the water temperature regulator into a suitable container for storage or disposal.

2. Loosen the hose clamp from the upper radiator hose and remove the upper radiator hose from the water temperature regulator housing.

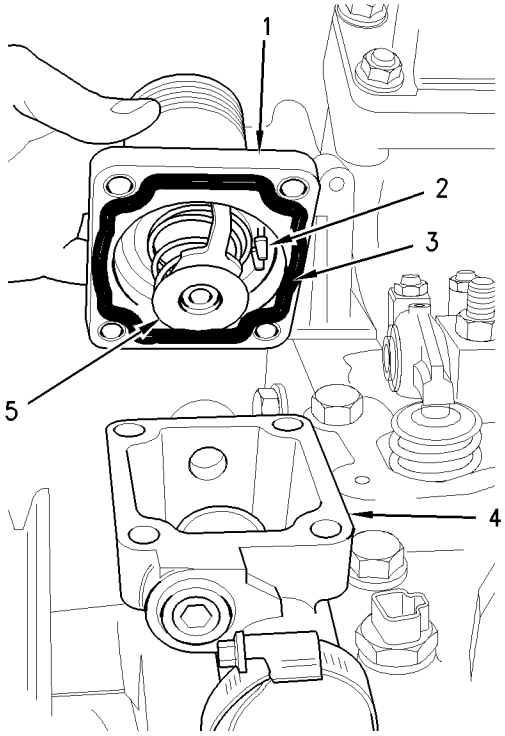


Illustration 80 g01004651

3. Remove the four setscrews that hold the water temperature regulator housing (1) in position on the water outlet manifold (4). Remove the water temperature regulator housing. Remove the seal and discard the seal (3).

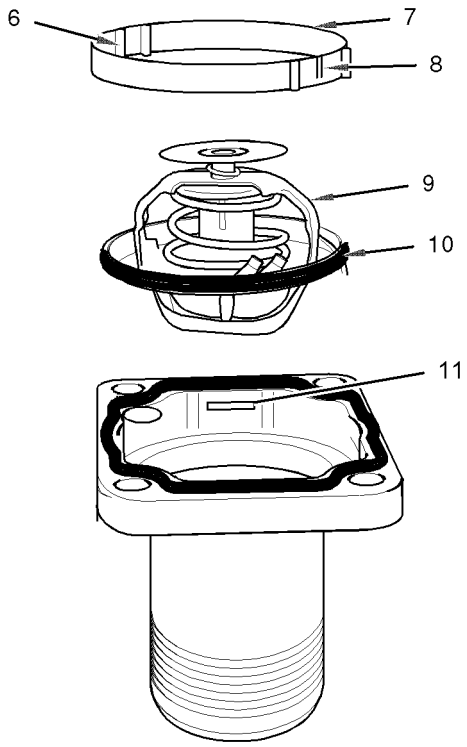


Illustration 81 g01021666

4. Press the retaining clips (6) and (8) of collar (7) away from the groove (11) in the water temperature regulator housing. Remove the collar (7) from the water temperature regulator housing (1). Remove the water temperature regulator (9) from the water temperature regulator housing. Remove the O-ring seal (10) from the water temperature regulator and discard the O-ring. Note the position of the water temperature regulator in the water temperature regulator housing for installation.

Note: Refer to Systems Operation, Testing and Adjusting, “Water Temperature Regulator - Test” for the correct procedure on testing the water temperature regulator.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

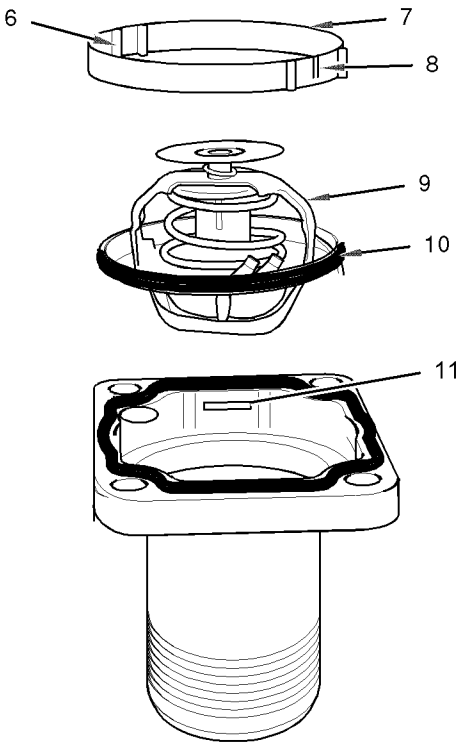


Illustration 82 g01021666

1. Install the water temperature regulator (9) and the new O-ring seal (10) into the water temperature regulator housing (1). Make sure that water temperature regulator (9) is installed in the original position.

Note: Push the collar (7) onto the water temperature regulator housing (1) until the retaining clips (6) and (8) engage in the grooves (11) in order to secure the water temperature regulator during engine operation.

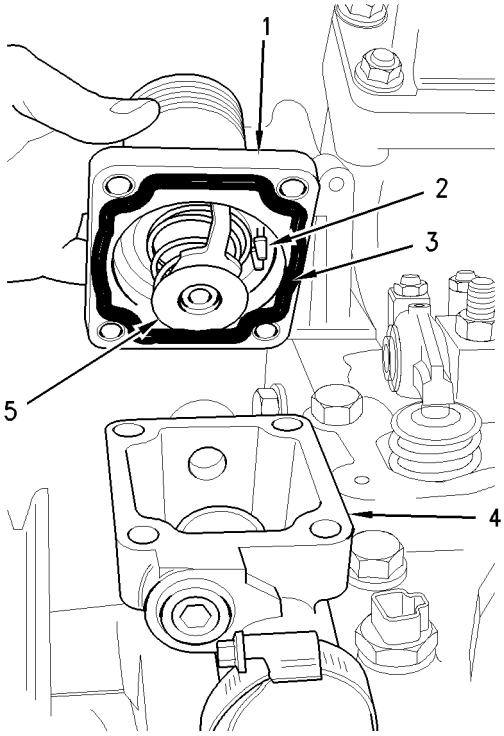


Illustration 83 g01004651

2. Install the seal (3) in the water temperature regulator housing (1). Position the water temperature regulator housing on the water outlet manifold (4).

3. Install the four setscrews that fasten water temperature regulator housing (1) to the water outlet manifold (4). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

4. Install the upper radiator hose and fill the radiator to the correct level with coolant. Refer to the Operation and Maintenance Manual for the correct procedure.

i01872261

Water Outlet Manifold - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system to a level below the water outlet manifold into a suitable container for storage or disposal.

2. If the engine is equipped with a vent hose and a radiator hose then disconnect the vent hose and the radiator hose.

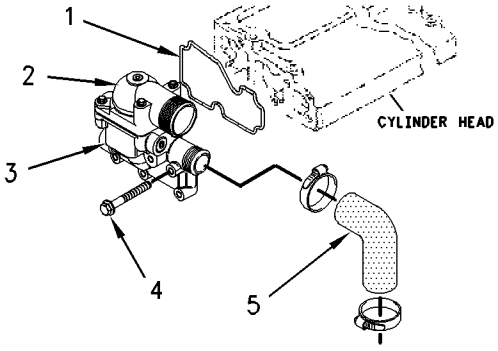


Illustration 84 g00940671

3. Loosen the clamps and disconnect the hose (5). If your engine is equipped with a heater core, then loosen the clamps and remove the hoses that are connected to the water outlet manifold for the heater core.

Note: It is not necessary to remove the water temperature regulator housing (2) and the water temperature regulator in order to remove the water outlet manifold.

4. Remove the setscrews (4) that hold the water outlet manifold to the cylinder head.

5. Remove the water outlet manifold (3) and the seal (1).

Installation Procedure

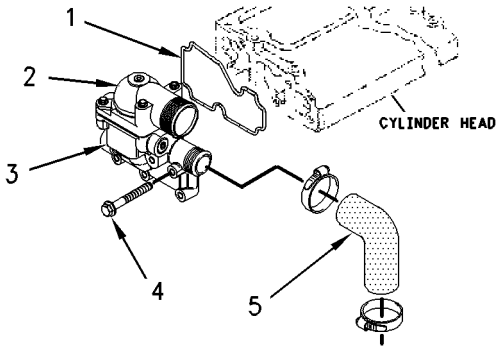


Illustration 85 g00940671

1. Install the seal (1) onto the water outlet manifold (3). Position the water outlet manifold onto the cylinder head, and install the setscrews (4). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

2. Connect the hose (5) and tighten the clamps. If your engine is equipped with a heater core, then tighten the clamps and install the hoses that are connected to the water outlet manifold for the heater core.

3. If the engine is equipped with a radiator hose and a vent hose then connect the radiator hose and the vent hose.

4. Fill the cooling system with coolant. Refer to the Operation and Maintenance Manual, “Refill Capacities”.

i01853902

Flywheel - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The flywheel is heavy. Use equipment or get help to assist with the operation before removal of the setscrews for the flywheel.

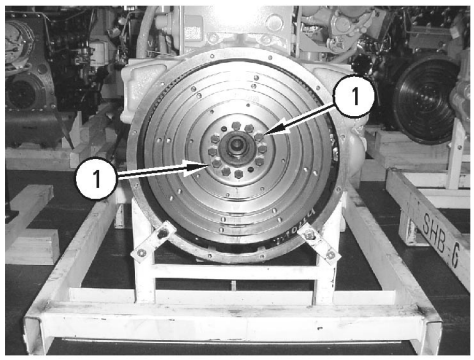


Illustration 86 g01005260

1. Remove the two setscrews (1) from the flywheel that are at 90 degrees to the two unthreaded holes in the crankshaft flange.

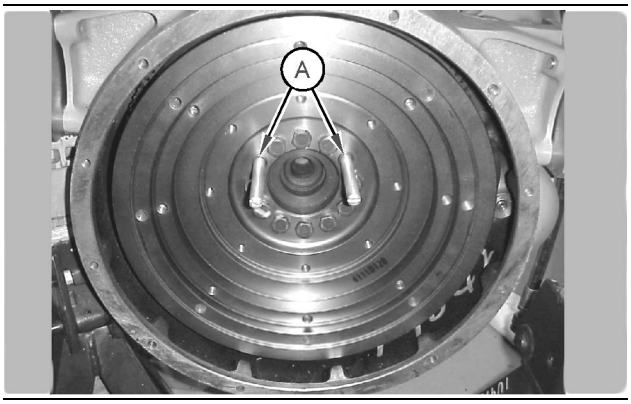


Illustration 87 g01024672

2. Install two suitable guide studs (A) in order to ensure that the flywheel can be removed and installed safely.

3. Remove the remaining setscrews that secure the flywheel (2) to the crankshaft.

4. Use a suitable lifting device in order to remove the flywheel (2) from the housing.

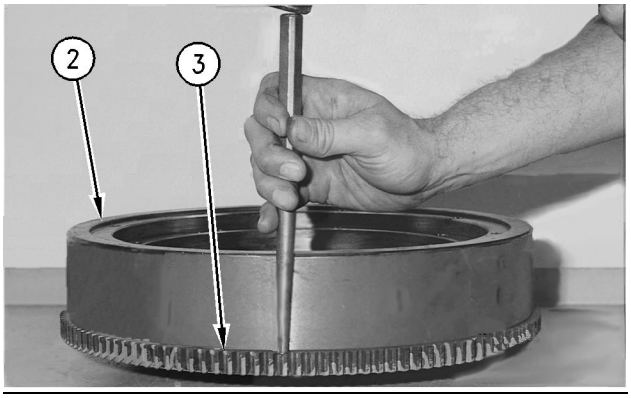


Illustration 88 g00906037

5. Check the condition of the ring gear (3). Replace the ring gear with a new part if the ring gear is worn or damaged.

Note: Identify the orientation of the ring gear on the flywheel for the correct positioning when the new ring gear is installed.

6. Place the flywheel (2) and the ring gear (3) on a suitable support.

7. Use a hammer and a punch in order to remove the ring gear (3) from the flywheel.

i01853872

Flywheel - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

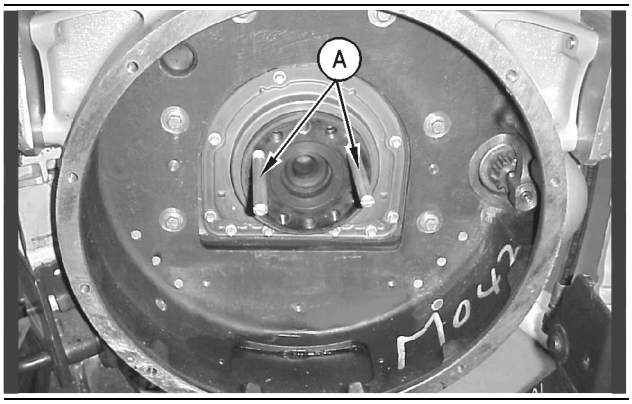


Illustration 89 g00909351

1. Install two suitable guide studs (A) on the crankshaft.

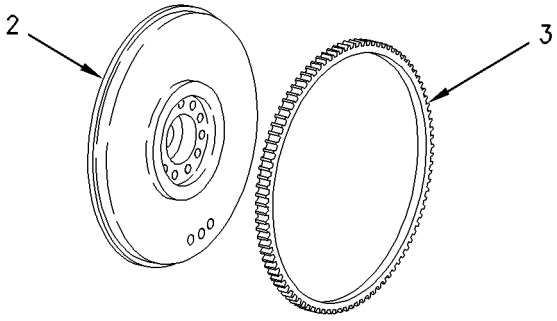


Illustration 90 g00909349

⚠ WARNING

Always wear protective gloves when handling parts that have been heated.

2. Heat the ring gear (3) to 250 °C (482 °F) in order to install the ring gear (3) on the flywheel (2).

Note: Do not use a torch to heat the flywheel.

3. Install a suitable lifting device on the flywheel (2) and position the flywheel in the flywheel housing.

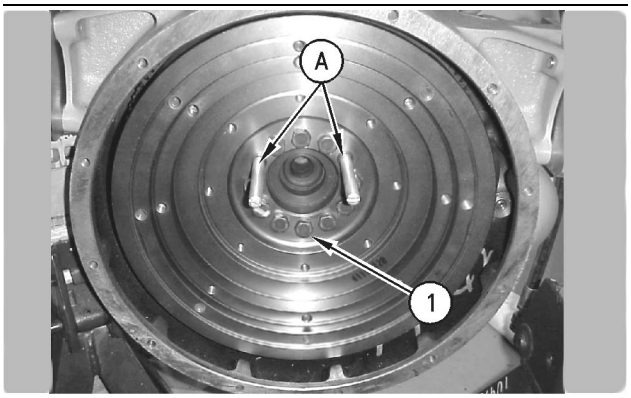


Illustration 91 g00909346

4. Install the hardened steel washers to the setscrews (1). Install the setscrews.

5. Remove the two guide studs (A) and install the remaining two setscrews (1). Tighten all the setscrews to a torque of 107 N·m (80 lb ft).

6. Check the alignment of the flywheel with the crankshaft. Refer to Testing and Adjusting, “Flywheel - Inspect”.

i01851295

Crankshaft Rear Seal - Remove

Removal Procedure

Start By:

a. Remove any drive components from the rear of the engine.

b. Remove the flywheel. Refer to Disassembly and Assembly Manual, “Flywheel - Remove”.

c. Remove the flywheel housing. Refer to Disassembly and Assembly Manual, “Flywheel Housing - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The housing assembly and the rear oil seal are manufactured as a one-piece assembly. The housing assembly uses ten setscrews in order to fasten the housing assembly to the cylinder block.

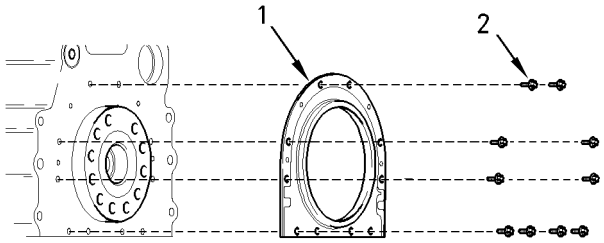


Illustration 92 g01004712

1. Remove the ten setscrews (2).

2. Remove the one-piece oil seal (1) from the cylinder block.

i01851254

Crankshaft Rear Seal - Install

Installation Procedure

Note: The rear oil seal and the housing for the oil seal are manufactured as a one-piece assembly. The assembly of the rear oil seal uses ten setscrews in order to fasten the assembly to the cylinder block.

Note: The assembly of the rear oil seal is lubricated during manufacture. Do not lubricate the seal or the crankshaft flange before installation.

Inspect the rear oil seal and replace the assembly if there is the slightest sign of damage to the seal.

Note: The following procedure assumes that the assembly of the rear oil seal is a replacement assembly.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

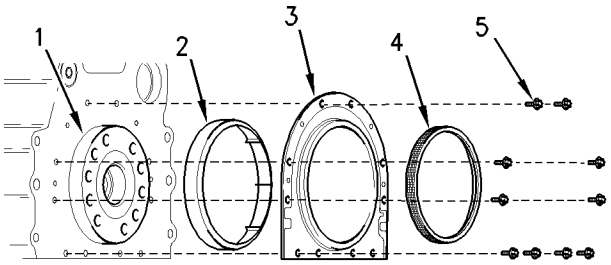


Illustration 93 g01004915

Note: Do not lubricate the crankshaft flange (1).

1. Ensure that the crankshaft flange (1) is clean, dry and free from rough metal edges. Ensure that the face of the cylinder block and the bridge are clean and dry.

2. Remove the packaging from the new assembly of the rear oil seal. Ensure that the plastic sleeve (2) is squarely installed within the oil seal. The plastic sleeve (2) is included in order to protect the lip of the oil seal as the lip is pushed over the crankshaft flange (1).

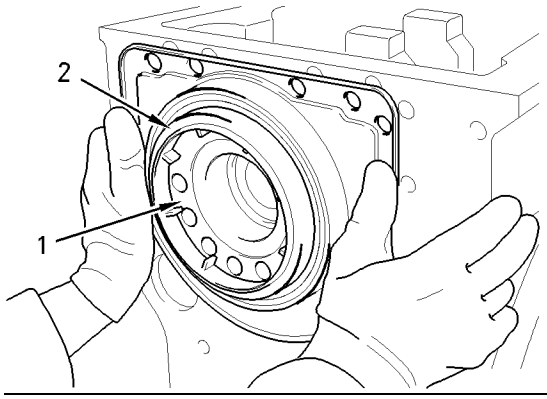


Illustration 94 g01004951

3. Place the assembly of the rear oil seal over the crankshaft flange (1) and engage the plastic sleeve (2) onto the crankshaft flange (1).

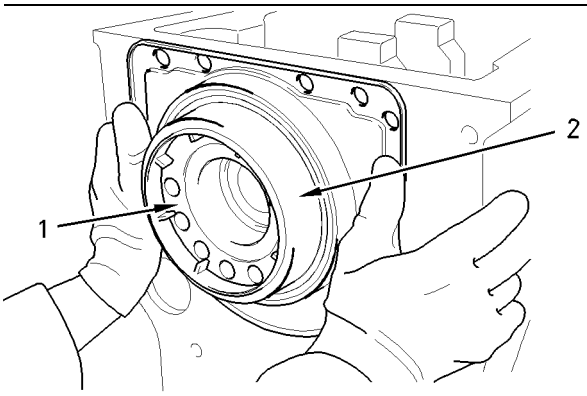


Illustration 95 g01004958

4. Ensure that the plastic sleeve (2) is engaged on the crankshaft flange (1). Push the assembly of the rear oil seal evenly and push the assembly smoothly onto the crankshaft flange (1) until the assembly is against the cylinder block. During this process, the plastic sleeve (2) will be forced out of the oil seal. Discard the plastic sleeve (2).

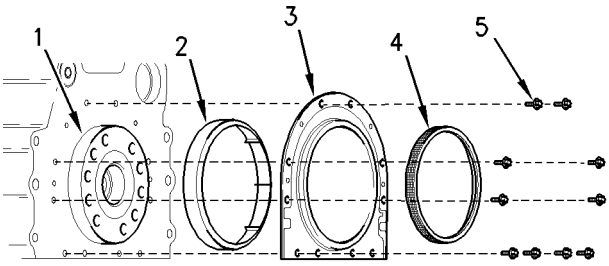


Illustration 96 g01004915

5. Rotate the assembly of the rear oil seal (3) in order to align the setscrew holes in the assembly with the setscrew holes in the rear face of the cylinder block.

6. By using the ten setscrews (5), loosely secure the assembly of the rear oil seal (3) to the cylinder block.

7. Install the alignment tool (4) onto the crankshaft flange (1) and over the assembly of the rear oil seal (3) in order to align the assembly with the crankshaft flange.

Note: The alignment tool (4) is not currently available from Perkins. Refer to the Specifications Manual, “Crankshaft Seals” for information regarding the required dimensions in order for the alignment tool to be manufactured locally.

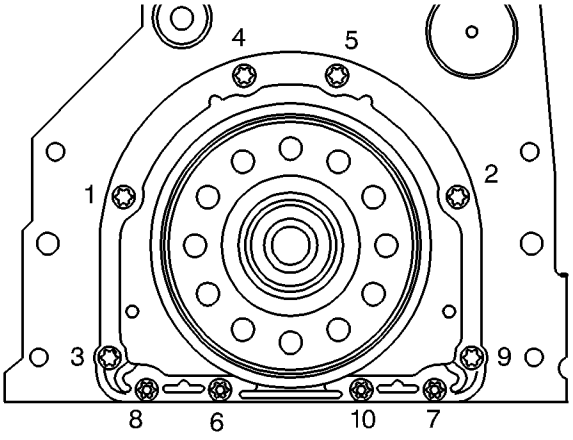


Illustration 97 g01004982

8. Tighten the setscrews (1 and 2) to a torque of 22 N·m (16 lb ft). Refer to illustration 97.

9. Remove the alignment tool (4). Tighten the remaining setscrews in sequence to a torque of 22 N·m (16 lb ft).

End By:

a. Install the flywheel housing. Refer to Disassembly and Assembly Manual, “Flywheel Housing - Remove and Install”.

b. Install the flywheel. Refer to Disassembly and Assembly Manual, “Flywheel - Install”.

c. Install any drive components that were previously removed from the rear of the engine.

i01935222

Crankshaft Wear Sleeve (Rear) - Remove

Removal Procedure

Start By:

a. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Wear sleeves are not installed at the factory.

1. Use a suitable sharp tool to mark a deep line along the length of the crankshaft wear sleeve.

2. Insert a suitable thin blade between the crankshaft flange and the crankshaft wear sleeve next to the marked line. The crankshaft wear sleeve will separate along the marked line.

3. Remove the crankshaft wear sleeve from the end of the crankshaft.

4. Remove any sealant from the crankshaft flange.

i01935330

Crankshaft Wear Sleeve (Rear) - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the rear of the crankshaft is thoroughly clean and dry prior to the installation of the crankshaft wear sleeve.

2. Ensure that the crankshaft is fully forward in the engine.

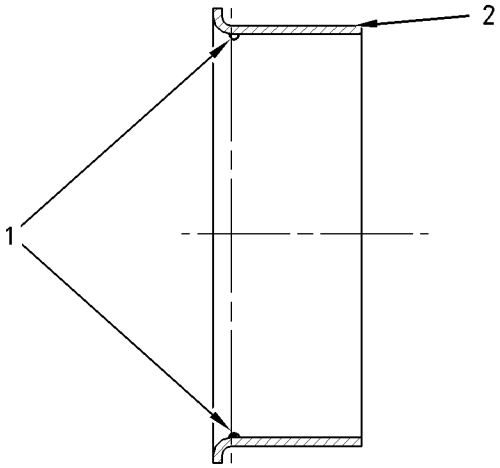


Illustration 98 g01007266

3. Apply a small continuous bead of 21820518 POWERPART liquid gasket (1) to the inner surface 5.00 mm (0.197 inch) from the flange end of crankshaft wear sleeve (2).

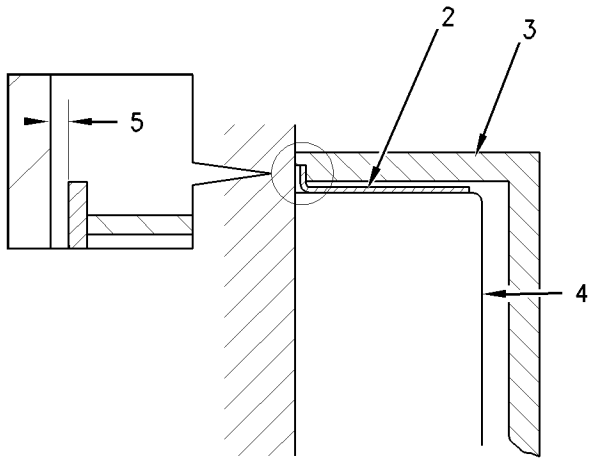


Illustration 99 g01007248

4. Position the crankshaft wear sleeve (2) on the crankshaft (4). Position the installation tool (3) that is provided with the new crankshaft wear sleeve over the crankshaft. Use a hammer to drive the crankshaft wear sleeve onto the crankshaft. The flange of the crankshaft wear sleeve must be within 0.40 to 0.60 mm (0.017 to 0.024 inch) of the cylinder block.

5. Remove the installation tool (3). Measure the distance between the flange of the crankshaft wear sleeve and the cylinder block in two places that are 180 degrees from each other. The correct distance (5) is 0.40 to 0.60 mm (0.017 to 0.024 inch).

6. After the crankshaft wear sleeve has been installed, remove any rough edges from the crankshaft wear sleeve.

End By:

a. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install”.

i01845926

Flywheel Housing - Remove and Install

Removal Procedure

Start By:

a. Remove the starter motor. Refer to Disassembly and Assembly Manual, “Starter Motor - Remove and Install”.

b. Remove the flywheel. Refer to Disassembly and Assembly Manual, “Flywheel - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: The flywheel housing is heavy. To avoid injury, take care when the flywheel housing is lifted. Also take care not to damage the finished surfaces of the flywheel housing during lifting and lowering the flywheel housing.

1. Support the flywheel housing with a suitable lifting device.

2. Remove all of the setscrews from the flywheel housing. By using a soft faced hammer, carefully hit the horizontal back face of the flywheel housing in order to remove the flywheel housing from the dowels in the rear face of the cylinder block.

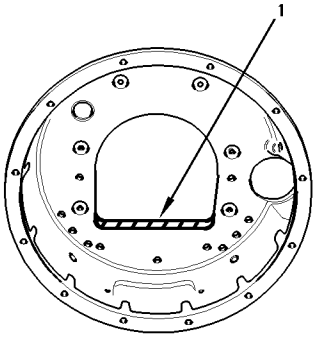


Illustration 100 g01005184

3. If the engine is equipped with an aluminum oil pan, remove the dust seal (1).

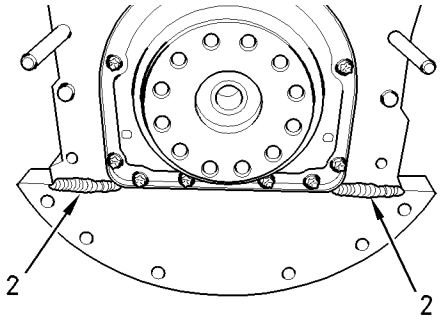


Illustration 101 g01005215
Typical example

4. If the engine is equipped with a cast iron oil pan, remove any old sealant (2) from the joint between the oil pan and the cylinder block.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the rear face of the cylinder block and the mating surface of the flywheel housing. Ensure that the dowels are installed in the cylinder block face. Inspect the condition of the dowels and the dowel holes in the flywheel housing. If it is necessary replace the dowels.

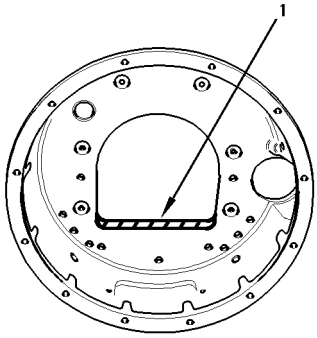


Illustration 102 g01005184
Typical example

2. If the engine is equipped with an aluminum oil pan, install a new dust seal (1).

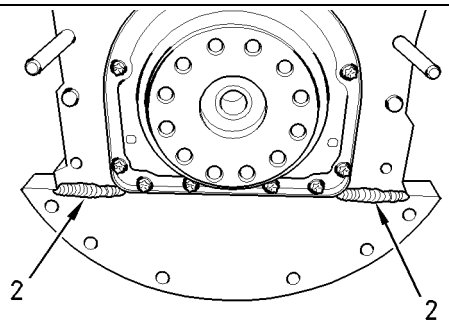


Illustration 103 g01005215
Typical example

3. If the engine is equipped with a cast iron oil pan, apply a bead of 1861117 POWERPART Universal Jointing Compound along the joint (2) between the oil pan and the cylinder block.

Note: The flywheel housing is heavy. To avoid injury, take care when the flywheel housing is lifted. Also take care not to damage the finished surfaces of the flywheel housing during lifting and lowering the flywheel housing.

4. By using suitable lifting equipment, install the flywheel housing onto the dowels in the end face of the cylinder block. Install all of the setscrews for the flywheel housing finger tight.

5. Check the concentricity of the flywheel housing. Refer to the Systems Operation, Testing and Adjusting, “Flywheel Housing - Inspect” for further details.

Note: These engines are equipped with aluminum flywheel housings or with cast iron flywheel housings. The correct torques for the setscrews vary for each type of oil pan.

6. Tighten the setscrews to the correct torque. Refer to the Specifications Manual, “Flywheel Housing” for the correct torques.

7. Check the alignment of the flywheel housing. Refer to the Systems Operation, Testing and Adjusting Manual, “Flywheel Housing - Inspect” for further details.

End By:

a. Install the flywheel. Refer to this Disassembly and Assembly Manual, “Flywheel - Install”.

b. Install the starter motor. Refer to this Disassembly and Assembly Manual, “Starter Motor - Remove and Install”.

i01893703

Vibration Damper and Pulley - Remove

Removal Procedure

Start By:

a. Remove the V-Belts. Refer to Disassembly and Assembly, “V-Belts - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The assembly of the crankshaft pulley and the vibration damper is heavy. If the engine is equipped with a vibration damper that is installed onto the front of the crankshaft pulley, remove this type of damper from the pulley before the pulley is removed from the engine.

Remove the Front Mounted Vibration Damper

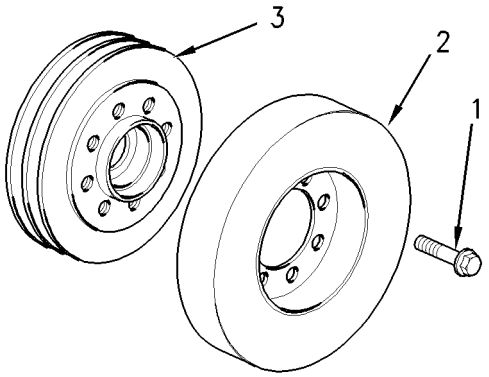


Illustration 104 g01002874

Front vibration damper

1. Remove the eight setscrews (1) from the vibration damper (2).

2. Remove the vibration damper (2) from the crankshaft pulley (3).

Remove the Crankshaft Pulley

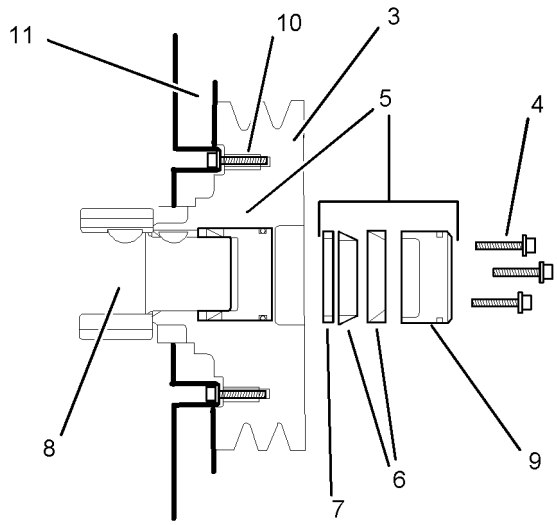


Illustration 105 g01034084

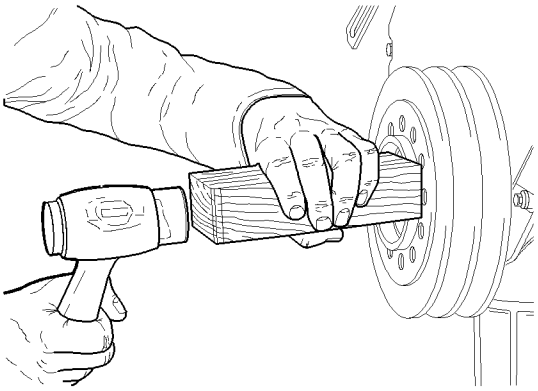


Illustration 106 g01002931

Typical example

1. Remove the three setscrews (4) from the inner hub assembly (5) of the crankshaft pulley (3). Hold a wood block against the crankshaft pulley. Strike the wood block with a hammer in order to loosen the split lock rings (6) and the spacer (7).

2. Carefully remove the crankshaft pulley from the crankshaft (8). Remove the thrust block (9) and the O-ring seal from the pulley. Also remove the split lock rings and the spacer.

Remove the Rear Mounted Vibration Damper

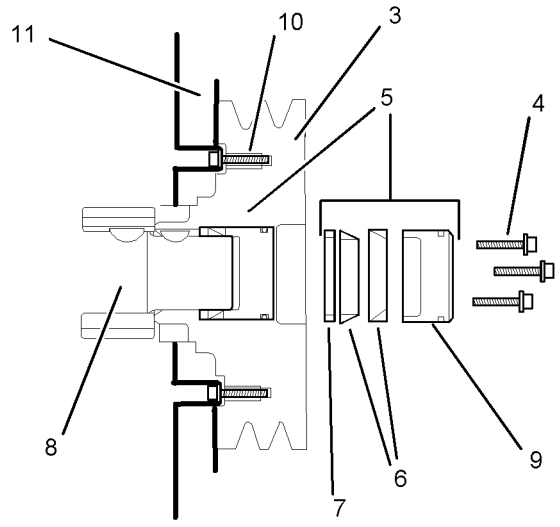


Illustration 107 g01034084

Rear mounted damper

1. Place the front face of the crankshaft pulley onto a flat surface.

2. Remove the setscrews (10) and remove the retaining ring.

3. Remove the rear vibration damper (11) from the crankshaft pulley.

i01871262

Vibration Damper and Pulley - Install

Installation Procedure

Note: Thoroughly clean all the components.

Note: If the crankshaft pulley is equipped with a rear mounted vibration damper, then the damper must be installed onto the pulley before the pulley is installed onto the engine. If the crankshaft pulley is equipped with a front mounted vibration damper then the pulley should be installed onto the engine before the damper is installed onto the pulley.

Install the Rear Mounted Vibration Damper

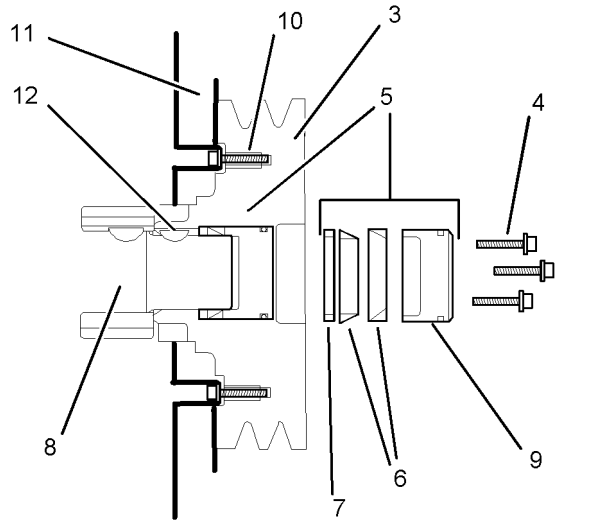


Illustration 108 g01034128

1. If the crankshaft pulley (3) is equipped with a rear mounted vibration damper (11), align the holes in the damper with the holes in the crankshaft pulley. Install the retaining ring onto the damper.

Note: New setscrews have sealant to the first 13 mm (0.5 inch) of the threads. In order to reuse the old setscrews, clean the old sealant from the setscrews and apply 21820603 POWERPART retainer (oil tolerant) to the setscrews.

2. Install the fasteners (10). Tighten M10 fasteners to a torque of 65 N·m (48 lb ft) or tighten the M8 fasteners to a torque of 35 N·m (26 lb ft).

Install the Crankshaft Pulley

Note: If equipped, the rear mounted vibration damper must be installed first.

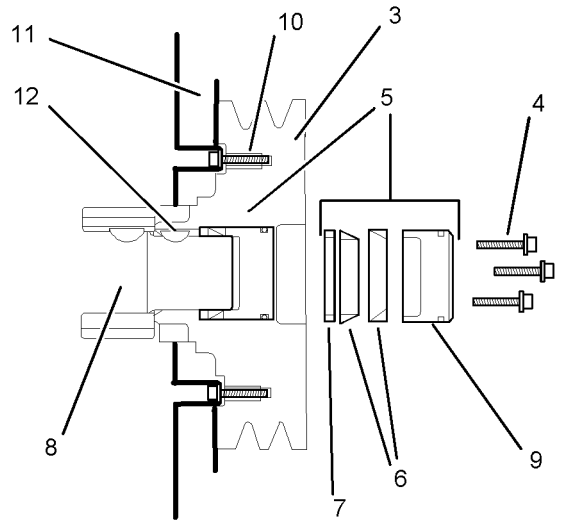


Illustration 109 g01034128

1. Ensure that the woodruff key (12) is installed into the crankshaft (8) correctly.

2. Align the keyway in the crankshaft pulley (3) to the woodruff key in the crankshaft.

3. Install the pulley onto the crankshaft. Install the spacer (7) into the pulley, and install both of the split lock rings (6) onto the crankshaft.

Note: There is an internal split lock ring and an external split lock ring. Position the gap in the split lock rings at 180 degrees away from each other.

4. Lubricate the thrust block (9) with clean engine oil and install the thrust block with the O ring into the pulley. Install the three setscrews (4). Tighten the setscrews to a torque of 115 N·m (85 lb ft). Check the torque of the setscrews again in order to ensure that the pulley is correctly installed onto the crankshaft and that the hub assembly (5) is correctly installed in the pulley.

Install the Front Mounted Vibration Damper

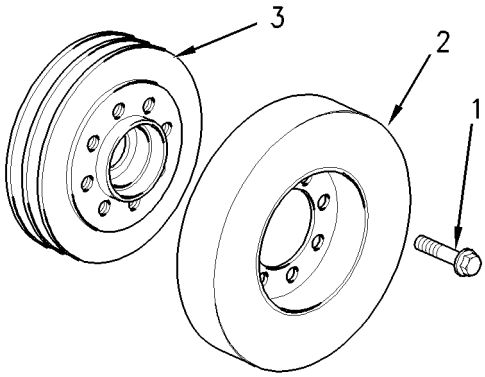


Illustration 110 g01002874

1. Align the setscrew holes in the damper (2) to the setscrew holes of the crankshaft pulley (3).

2. Locate the eight setscrews (1) through the damper and into the crankshaft pulley. Tighten the setscrews by hand. Tighten the setscrews (8) to a torque of 78 N·m (58 lb ft).

End By:

a. Install the V-Belts. Refer to Disassembly and Assembly Manual, “V-Belts - Remove and Install”.

i01928891

Crankshaft Front Seal - Remove

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Remove the Front Oil Seal that is installed in the Engine

1. If the front cover is still attached to the engine, use a suitable lever in order to remove the oil seal from the front cover.

Remove the Front Oil Seal from a Disassembled Front Cover

1. If the front cover has been removed from the engine, use a suitable hydraulic press in order to remove the oil seal from the front cover. Ensure that the front cover is supported correctly in order to prevent damage to the cover while the oil seal is being removed.

i01851201

Crankshaft Front Seal - Install

Installation Procedure

Table 17

Required Tools		
Tool	**Part Description**	**Qty**
21825577	Threaded bar	1
21825578	Pressure plate	1
21825580	Anchor plate	1
21825579	Sleeve	1
21825581	Adapter	1

Seal Installation Procedure for the Installed Front Cover

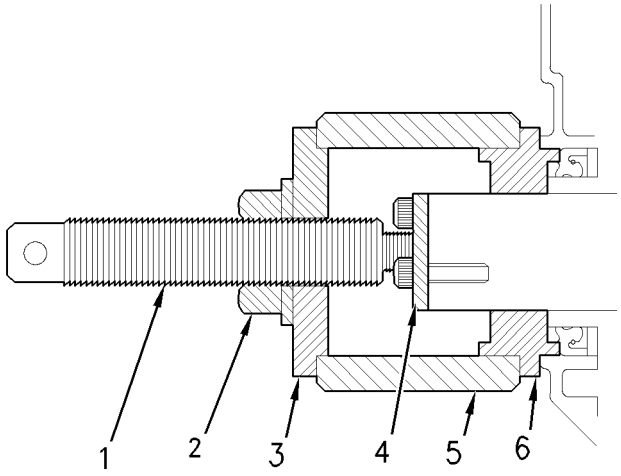


Illustration 111 g01006303
Front seal installation tool

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Check that the front cover is clean and that the front cover is not damaged.

2. Lubricate the bore for the oil seal in the front cover. Align the new oil seal to the bore.

NOTICE
Ensure that the lip of the crankshaft front seal that is spring loaded is facing toward the inside of the front housing and that it is square with the bore of the housing for the crankshaft front seal.

3. Assemble the installation tool. Install the anchor plate (4) onto the crankshaft. Align the adapter (6) to the new oil seal. Ensure that the side stamped 10.5 mm (0.4134 inch) on the adapter is toward the new oil seal.

4. Assemble the pressure plate (3) together with the sleeve (5) onto the threaded bar (1). Install the assembly onto the adapter (6). Tighten the threaded bar (1) onto the anchor plate (4).

5. Lock a rod through the threaded bar (1) in order to stop the threaded bar from rotating. Tighten the nut (2) on the threaded bar in order to push the new oil seal into the front cover.

Seal Installation Procedure for the Disassembled Front Cover

1. Check that the front cover is clean and that the front cover is not damaged.

2. Lubricate the bore for the oil seal in the front cover. Align the new oil seal to the bore.

3. Place the correct adapter onto the oil seal and use a suitable hydraulic press to press the oil seal into the bore.

Note: Ensure that the front cover is supported correctly. Do not use excessive force to install the seal, as this will damage the front cover.

4. Press the oil seal into a depth of 10.20 to 10.70 mm (0.4016 to 0.4213 inch).

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install”. **Or** Install the front cover. Refer to the Disassembly and Assembly, “Front Cover - Remove and Install”.

i01845928

Front Cover - Remove and Install

Removal Procedure

Table 18

Required Tools		
Part Number	**Part Description**	**Qty**
21825574	Centering tool (Front cover)	1

Start By:

a. Remove the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

b. Completely remove the V-belts during the removal of the alternator. Remove the alternator. Refer to Disassembly and Assembly Manual, “Alternator - Remove”.

c. Remove the crankshaft pulley. Refer to Disassembly and Assembly Manual, “Vibration Damper and Pulley - Remove and Install”.

d. Remove the water pump. Refer to Disassembly and Assembly Manual, “Water Pump - Remove and Install”.

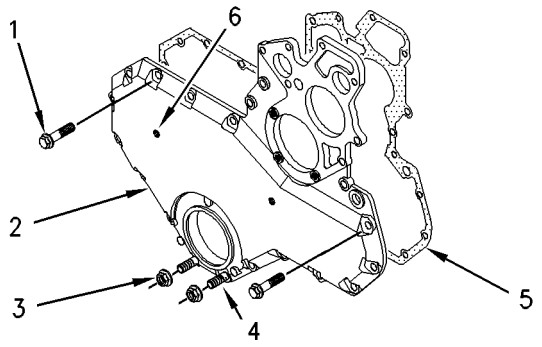


Illustration 112 g01003627

1. Remove the setscrews (1) and remove the nuts (3) in order to remove the front cover (2).

2. Remove the joint (5) and discard the joint.

3. If necessary, remove the two setscrews (6) that secure the sound suppression panel to the front cover. Remove the sound suppression panel from the front cover.

4. Remove the crankshaft front oil seal. Refer to Disassembly and Assembly Manual, “Crankshaft Front Seal - Remove”.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all surfaces of the timing case and clean the front cover thoroughly.

2. Install the crankshaft front seal. Refer to this Disassembly and Assembly Manual, “Crankshaft Front Seal - Install”.

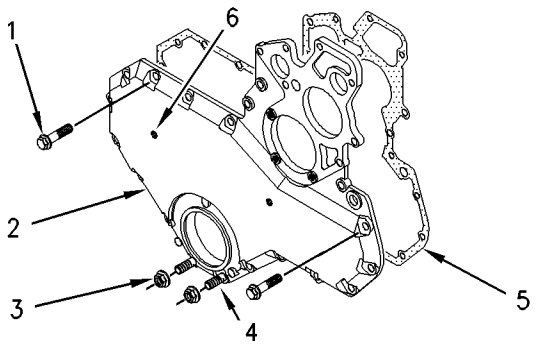


Illustration 113 g01003627

3. Install a new joint (5) onto the two studs (4).

NOTICE
The location of the front cover is critical. If the front cover is not centered, the backlash between the fuel injection pump gear and the water pump gear could be affected. This could result in damage to the fuel injection pump.

4. Install the front cover (2) onto the two studs (4). Loosely install two of the setscrews (1) at opposite locations in order to secure the front cover (2) and the joint (5).

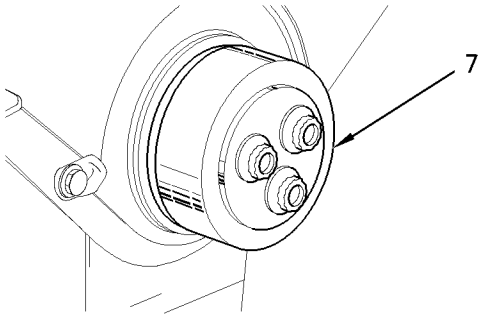


Illustration 114 g01003629

5. Install the centering tool (7) into the front oil seal housing and use the special washer and the setscrews for the crankshaft pulley to install the centering tool. Do not overtighten the setscrews.

6. Install the remainder of the setscrews (1) and the nuts (3) to the front cover. Gradually tighten and evenly tighten all of the setscrews (1) and the nuts (3) to a torque of 22 N·m (16 lb ft).

7. Remove the centering tool (7).

8. Replace the sound suppression panel and install the two setscrews (6) if the sound suppression panel was previously removed. Tighten the two setscrews (6) to a torque of 9 N·m (7 lb ft).

End By:

a. Install the water pump. Refer to Disassembly and Assembly Manual, “Water Pump - Remove and Install”.

b. Install the crankshaft pulley. Refer to Disassembly and Assembly Manual, “Vibration Damper and Pulley - Remove and Install”.

c. Install the alternator. Refer to Disassembly and Assembly Manual, “Alternator - Install”.

d. Install the V-belts. Refer to Disassembly and Assembly Manual, “V-Belts - Remove and Install”.

e. Install the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

i01935422

Engine Oil Pump Idler Gear Shaft - Remove and Install

Preferred Removal Procedure

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Remove”.

b. Remove the front main bearing cap.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The idler gear shaft for the engine oil pump is installed in the front main bearing cap for the crankshaft. The idler gear shaft is secured to the bearing cap by a hardened pin and by 21820603 POWERPART Retainer (oil tolerant). There are two methods for removing the hardened pin because the pin is very hard.

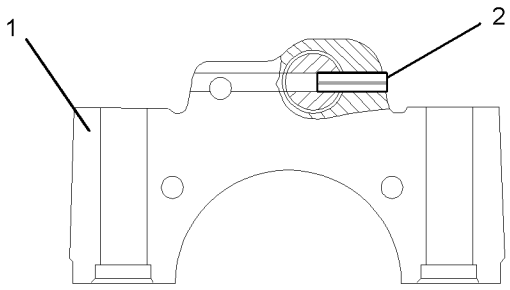


Illustration 115 g01007766

1. By using a No.1 thread tap, carefully cut a M5 by 0.8 mm thread into the pin (2). Remove the thread tap.

2. By using a No. 3 thread tap, cut no less than three full M5 by 0.8 mm threads into the pin (2). Remove the thread tap.

3. Obtain the following parts: a 2314E007 M5 by 0.8 mm setscrew, a 2318A601 M5 by 0.8 mm nut, and a 0920481 spacer or a 0330819 spacer.

Note: Alternatively use an M5 by 0.8 mm setscrew with at least 15 mm (0.6 inch) of thread. If neither of the spacers are available then use a spacer with a suitable outside diameter, a minimum inside diameter of 8.73 mm (0.344 inch), and a minimum length of 9.53 mm (0.375 inch).

4. Install the nut fully onto the setscrew and install the spacer onto the setscrew beneath the nut.

5. Hold the spacer in position and install the setscrew into the pin (2).

6. Centrally place the spacer over the pin (2) and tighten the nut against the spacer. Continue to tighten the nut against the spacer in order to pull the pin (2) through the spacer. Withdraw the pin (2) sufficiently in order to pull the pin out of the main bearing cap (1) with a pair of pliers. Discard the pin (2).

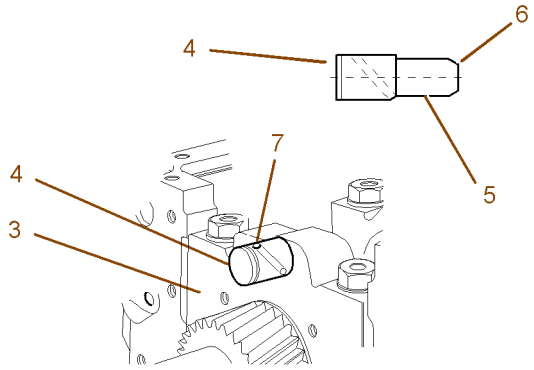


Illustration 116 g01007768

7. Support the front face (3) of the main bearing cap (1) so that the idler shaft (4) is toward the bottom. Ensure that there are no obstructions that will prevent the idler shaft (4) from being pressed out of the main bearing cap (1) in a downward direction. Install a suitable adapter onto the small diameter (5) of the idler shaft (4) and press the idler shaft out of the main bearing cap. Discard the idler shaft.

Alternative Removal Procedure

Note: This alternative removal procedure must only be used if the pin (2) could not be removed by the previous removal procedure.

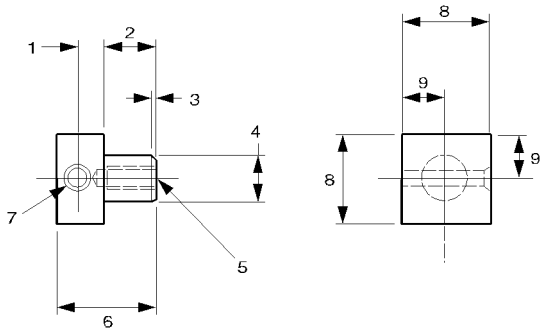


Illustration 117 g01007767

Table 19

Callout	Dimension
1	8.3 mm (0.327 inch)
2	20.0 mm (0.7874 inch)
3	1.0 mm (0.0394 inch)
4	16.1 ± 16.4 mm (0.634 ± 0.646 inch)
5	Refer to the Notes below.
6	36.0 mm (1.42 inch)
7	Refer to the Notes below.
8	31.75 mm (1.25 inch)
9	15.9 mm (0.626 inch)

Note: Refer to illustration 117 and refer to table 19. The hole 5 has a diameter of 6.9 mm (0.272 inch). The depth of the hole 5 should be 22 mm (0.866 inch). The hole 5 should be threaded to a depth of 18 mm (0.709 inch) with a 5/16 by 24 UNF thread.

Note: The hole 7 has a diameter of 6.5 mm (0.256 inch) to 6.6 mm (0.260 inch). One end of the hole 7 should have a 9 mm (0.354 inch) countersink with a 90 degree included angle.

1. Manufacture a drill guide. Refer to the illustration 117 and refer to the table of dimensions 19.

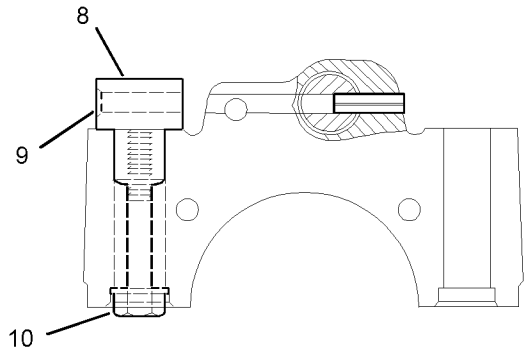


Illustration 118 g01007509

2. Install the drill guide (8) into the setscrew hole in the main bearing cap (1) on the opposite side to the pin (2) for the idler shaft (4).

Note: Ensure that the countersink (9) in the drill guide (8) is facing away from the pin (2) in the main bearing cap. Also ensure that drill guide (8) is aligned with the front face of the main bearing cap.

By using a 5/16 UNF setscrew (10) and a plain washer, secure the drill guide (8) to the main bearing cap (1).

3. By using the drill guide (8), drill a hole 6.35 mm (0.25 inch) in diameter in the main bearing cap (1).

Note: The hole should be drilled to a depth of 47.0 mm (1.85 inch).

4. Remove the drill and remove the drill guide (8). Ensure that all debris is removed from the main bearing cap (1).

5. Insert a suitable drift into the drilled hole in the main bearing cap (1) and drive out the pin (2). Discard the pin.

6. Support the main bearing cap (1) so that the idler shaft (4) is toward the bottom. Install a suitable adapter onto the small diameter (5) of the idler shaft (4) and press the idler shaft out of the main bearing cap (1). Discard the idler shaft.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Check that the replacement idler shaft (4) is clean and free from oil or grease. Check that the hole in the main bearing cap (1) is clean and free from oil, grease, and any rough edges.

2. Support the rear face of the main bearing cap (1) and ensure that the main bearing cap cannot move when the idler shaft (4) is pressed into the main bearing cap. Apply sufficient 21820603 POWERPART Retainer (oil tolerant) around the chamfer (6) of the idler shaft (4) in order to ensure that the surface of the hole in the main bearing cap (1) will be fully covered when the idler shaft (4) is pressed into position.

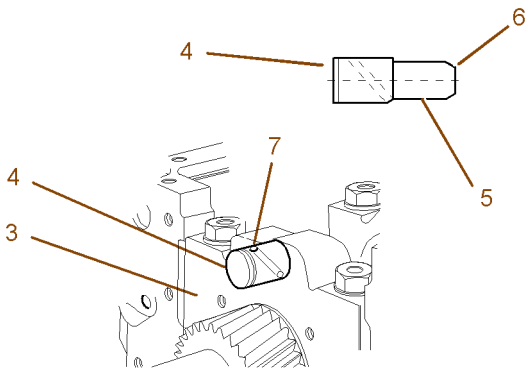


Illustration 119 g01007768

3. Enter the chamfer (6) of the idler shaft (4) into the hole in the main bearing cap (1) and ensure that the oil hole (7) is toward the top of the main bearing cap. Also ensure that the flat on the idler shaft (4) is toward the bottom of the main bearing cap (1).

4. Ensure that the idler shaft (4) is square to the main bearing cap (1) and press the idler shaft into the main bearing cap. Remove any surplus 21820603 POWERPART Retainer (oil tolerant) from the idler shaft (4), the oil hole, and the main bearing cap (1).

5. By using the original pin hole in the main bearing cap (1) as a guide, drill a hole into the idler shaft (4). The hole should have a diameter of 6.35 mm (0.25 inch). The hole should be 9.5 mm (0.374 inch) deep.

6. Install a new 2116087 pin (2) into the main bearing cap (1) in order to secure the idler shaft (4).

End By:

a. Ensure that the main bearing cap (1) is clean and install the main bearing cap. Refer to Disassembly and Assembly Manual, “Crankshaft - Install”.

b. Install the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Install”.

i02000959

Idler Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

b. Remove the front cover. Refer to Disassembly and Assembly Manual, “Front Cover - Remove”.

Note: Rotate the crankshaft until the timing marks on the crankshaft gear, the camshaft gear, the fuel injection pump gear, and the idler gear are aligned. Refer to the illustration 120.

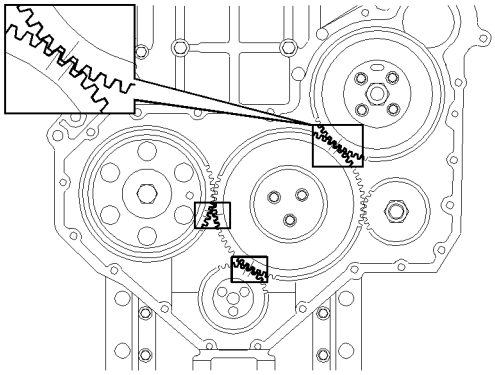


Illustration 120 g01035348

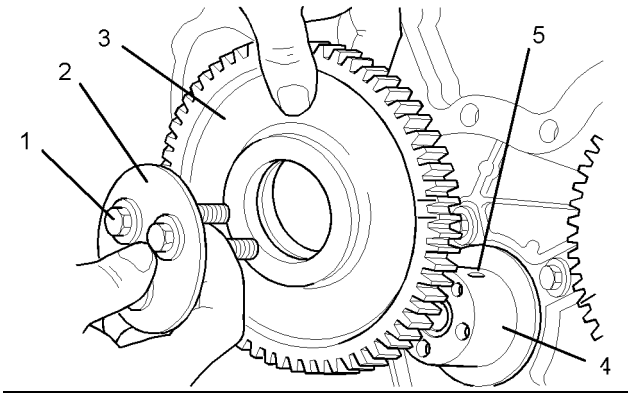


Illustration 121 g01035349

1. Remove the three setscrews (1) and remove the retaining plate (2) from the idler gear (3).

Note: Do not turn the crankshaft when the idler gear is removed. Turning the crankshaft will disrupt the timing for the valves and the fuel injection pump.

2. Remove the idler gear (3) from the idler gear hub (4). Note the position of the oil hole (5) in the idler gear hub (4) for installation purposes.

Installation Procedure

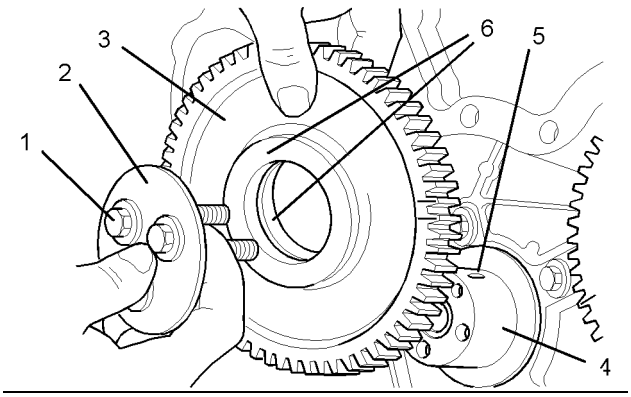


Illustration 122 g01035350

1. Clean all of the components and inspect all of the components. Replace the idler gear (3) and replace the split bearings (6) if the gear and the split bearings are worn or damaged. Refer to the Specifications Manual, “Gear Group (Front)” for information on allowed tolerances for wear and for clearance of the idler gear (3) and the split bearings (6).

Note: The gear and the split bearings are available as an assembly if both components need to be replaced.

2. Ensure that the oil hole (5) is toward the top of the idler gear hub (4). Use the three setscrews (1) in order to accurately position the idler gear hub (4) and install the hub. Remove the three setscrews (1).

3. Lubricate the split bearings (6) with clean engine lubricating oil.

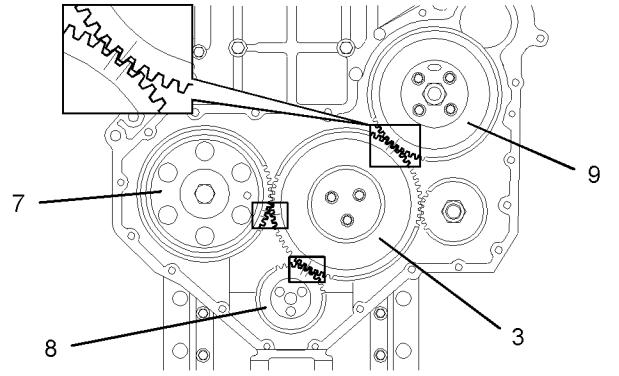


Illustration 123 g01035355

4. Ensure that the timing marks on the idler gear (3) align with the timing marks on the camshaft gear (7) and the crankshaft gear (8). Install the idler gear (3) onto the idler gear hub (4).

Note: If necessary, the fuel injection pump gear (9) can be turned in a clockwise direction only in order to align the timing marks of the fuel injection pump gear and the idler gear (3). Ensure that all of the timing marks are in alignment.

5. Install the retaining plate (2) and the setscrews (1). Tighten the setscrews (1) to a torque of 44 N·m (33 lb ft).

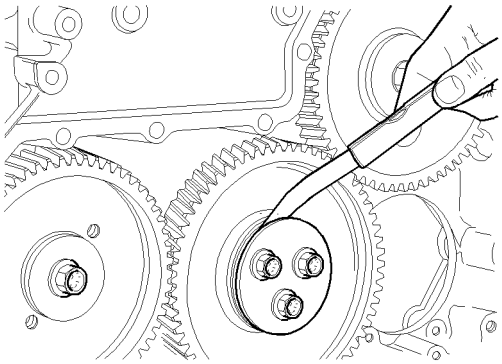


Illustration 124 g01035359

Typical example

6. Check the end play for the idler gear (3). Refer to the Specifications Manual, “Gear Group (Front)” for the tolerance for the end play for the idler gear (3).

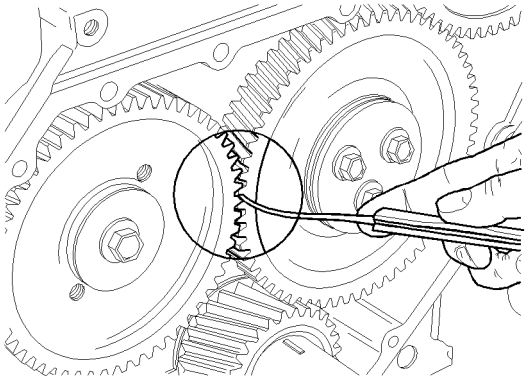


Illustration 125 g01035360

Typical example

7. Check the backlash for the idler gear (3). Refer to the Specifications Manual, “Gear Group (Front)” for the minimum backlash for the idler gear (3).

End By:

a. Install the front cover. Refer to Disassembly and Assembly Manual, “Front Cover - Install”.

b. Install the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

i01853980

Housing (Front) - Remove

Removal Procedure

Start By:

a. Remove the engine oil pan. Refer to Disassembly and Assembly Manual, “Engine Oil Pan - Remove and Install”.

b. Remove the idler gear. Refer to Disassembly and Assembly Manual, “Idler Gear - Remove”.

c. Remove the camshaft gear. Refer to Disassembly and Assembly Manual, “Camshaft Gear - Remove and Install”.

d. Remove the air compressor if an air compressor is installed on the engine. Refer to Disassembly and Assembly Manual, “Air Compressor - Remove and Install”.

e. Remove the air compressor idler gear if an air compressor is installed. Refer to Disassembly and Assembly Manual, “Air Compressor Idler Gear - Remove and Install”.

f. Remove the fuel pump. Refer to Disassembly and Assembly Manual, “Fuel Injection Pump - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

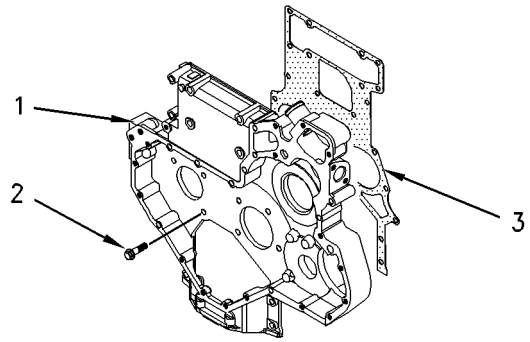


Illustration 126 g00944252

1. Remove all of the setscrews (2) that fasten the front housing (1) to the cylinder block.

2. Remove the front housing (1) and the joint. Discard the joint (3).

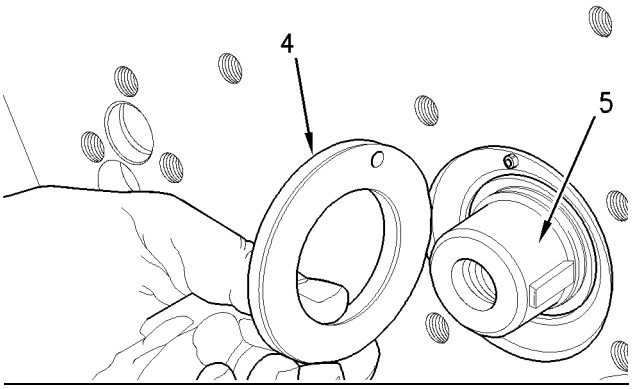


Illustration 127 g00949780

3. Remove the thrust washer (4) from the camshaft (5).

4. Remove the idler gear hub from the cylinder block.

i01853976

Housing (Front) - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

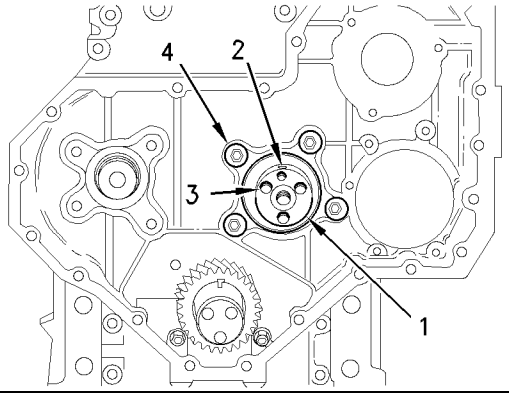


Illustration 128 g01006683

1. install the idler gear hub (1) to the cylinder block. Loosely install the three setscrews (3). Ensure that the oil hole (2) is toward the top.

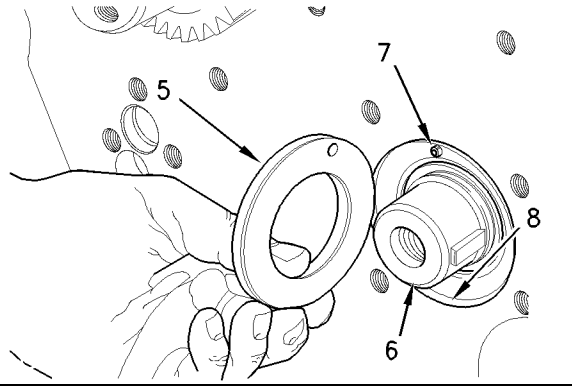


Illustration 129 g01006684

2. Install the thrust washer (5) for the camshaft (6) onto the dowel (7) and in the recess (8) in the cylinder block.

3. Ensure that the joint face on the cylinder block for the housing (10) is clean and dry. Ensure that the joint face on the housing (10) for the cylinder block is clean and dry.

4. Install a new joint for the housing (10) onto the cylinder block.

5. Install the housing (10).

6. Install the four setscrews (4). Tighten the four setscrews (4) finger tight.

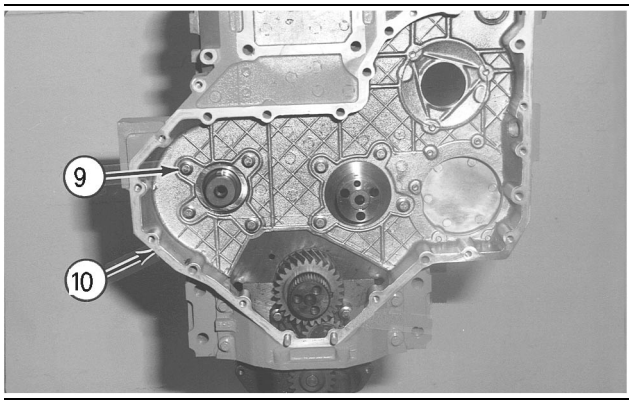


Illustration 130 g01007225

7. Install all of the remaining setscrews (9) that fasten the housing (10) to the cylinder block finger tight.

8. If necessary, cut the bottom ends of the joint to length in order for the joint to be installed correctly. Apply 1861117 POWERPART Joint Compound to the bottom portion of the new joint.

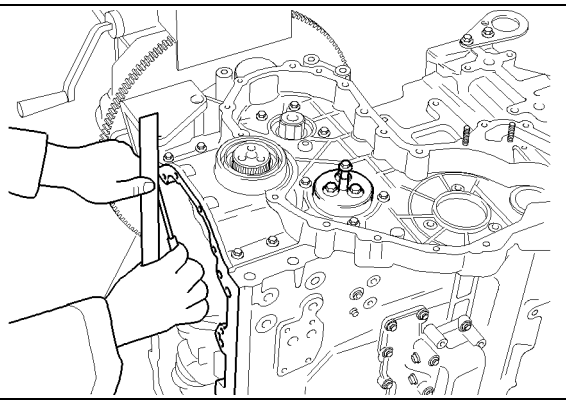


Illustration 131 g01007002

Typical example

9. Use a straight edge and use a feeler gauge in order to ensure that the bottom face of the housing (10) is aligned with the bottom face of the cylinder block. Refer to illustration 131.

Note: Any misalignment must be within a tolerance of 0.0 ± 0.1 mm (0.0000 ± 0.0039 inch).

Tighten all eight M8 setscrews (9) to a torque of 22 N·m (16 lb ft).

Tighten the four M10 setscrews (4) to a torque of 44 N·m (32 lb ft).

End By:

a. Install the engine oil pan. Refer to Disassembly and Assembly Manual, “Engine Oil Pan - Remove and Install”.

b. Install the fuel injection pump. Refer to Disassembly and Assembly Manual, “Fuel Injection Pump - Install”.

c. Install the camshaft gear. Refer to Disassembly and Assembly Manual, “Camshaft Gear - Remove and Install”.

d. Remove the three setscrews (3) and install the idler gear. Do not install the front cover at this time if there is an air compressor that must be installed onto the engine. Refer to Disassembly and Assembly Manual, “Idler Gear - Install”.

e. Install the idler gear for the air compressor if an air compressor was previously removed from the engine. Refer to Disassembly and Assembly Manual, “Air Compressor Idler Gear - Remove and Install”.

f. Install the air compressor if an air compressor was previously removed from the engine. Refer to Disassembly and Assembly Manual, “Air Compressor - Remove and Install”.

g. Install the front cover if the front cover was not installed earlier. Refer to Disassembly and Assembly Manual, “Front Cover - Remove and Install”.

i01930449

Accessory Drive - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

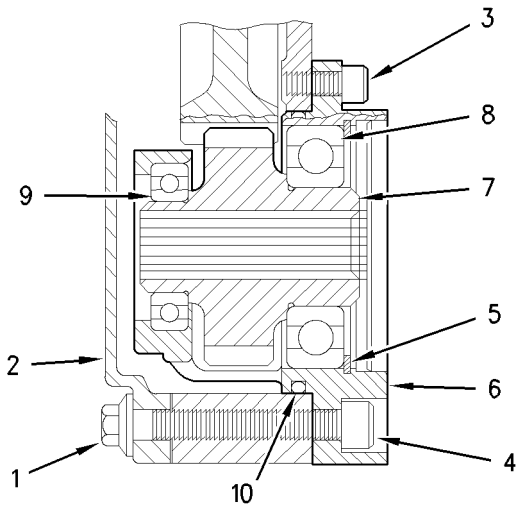


Illustration 132 g01004414

1. Remove the setscrews (1) and the front cover (2).

2. Remove the Allen head screws (3 and 4) and remove the accessory drive assembly from the rear face of the housing.

3. Remove the circlip (5).

4. Place the flange of the housing (6) onto a suitable support. Press the assembly of the gear (7) and the bearings (8 and 9) out of the housing. Use a suitable puller in order to remove the bearings (8 and 9) from the gear (7).

5. Remove the O-ring (10) from the housing (6) and discard the O-ring.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

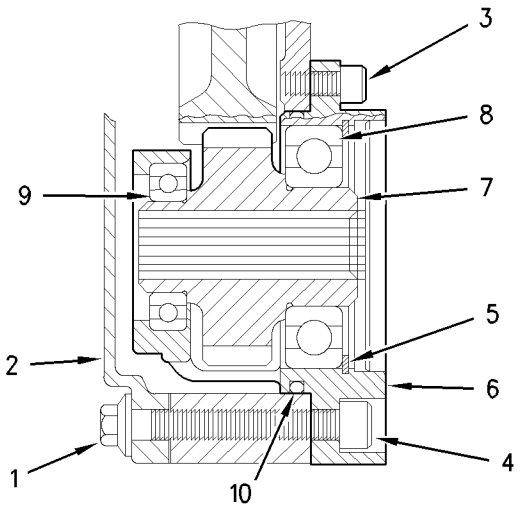


Illustration 133 g01004414

1. Inspect the condition of the teeth and of the splines of the gear (7), the bearings (8 and 9), the circlip (5), and the groove for the circlip in the housing (6) for wear and for damage. Replace any worn component or any damaged component.

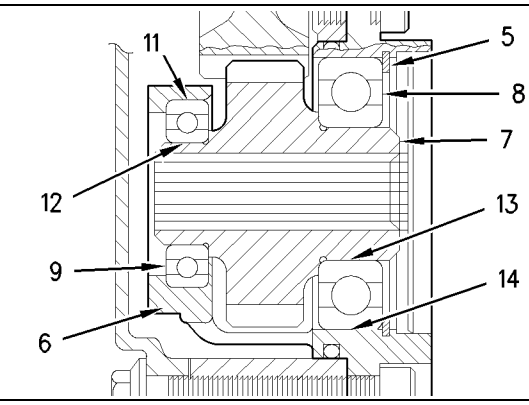


Illustration 134 g01004637

2. Apply a narrow sealant bead of 21820603 POWERPART Retainer (oil tolerant) around the outer race of the bearing (9) at position (11). Place the front flange of the housing (6) onto a suitable support. Press on the outer race of the bearing (9) until the bearing is against the front face of the recess for the bearing in the housing (6). Remove any excess sealant.

3. Apply a narrow sealant bead of 21820603 POWERPART Retainer (oil tolerant) around the inner race of the bearing (9) at position (12). Place the front face of the inner race of the bearing (9) onto a suitable support. Press the smaller shaft of the gear (7) into the bearing (9) until the shoulder of the gear is against the bearing. Remove any excess sealant.

4. Apply a narrow sealant bead of 21820603 POWERPART Retainer (oil tolerant) around the outer race of the bearing (8) at position (14). Apply a narrow sealant bead of 21820603 POWERPART Retainer (oil tolerant) around the inner race of the bearing (8) at position (13). Ensure that the front face of the inner race of the bearing (9) is still on a suitable support. Press the bearing (8) onto the larger shaft of the gear (7) until the bearing (9) is against the shoulder of the gear. Remove any excess sealant.

5. Install the circlip (5) into the groove in the housing (6). Ensure that the circlip (5) is correctly positioned in the groove.

6. Lightly lubricate a new O-ring (10) with clean engine lubricating oil and install the O-ring into the recess in the housing (6). Lightly lubricate the bearing (8), bearing (9), and the gear (7) with clean engine lubricating oil.

7. By using the Allen head screws (3 and 4), install the assembly of the accessory drive to the rear of the housing (front). Refer to the Torque Specifications Manual, “Standard Torques for Metric Fasteners” for the correct torques.

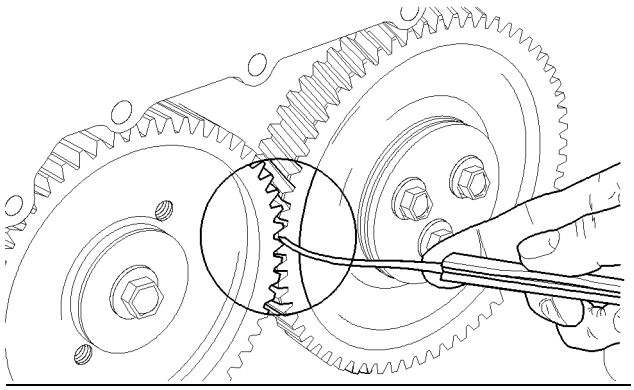


Illustration 135 g01004337

Typical example

8. Refer to illustration 135 and check the backlash between the accessory drive gear (7) and the idler gear. The backlash should be within 0.11 mm (0.004 inch) to 0.17 mm (0.007 inch).

End By:

a. Install the front cover. Refer to Disassembly and Assembly Manual, “Front Cover - Remove and Install”.

i01978005

Crankcase Breather - Remove and Install

Removal Procedure

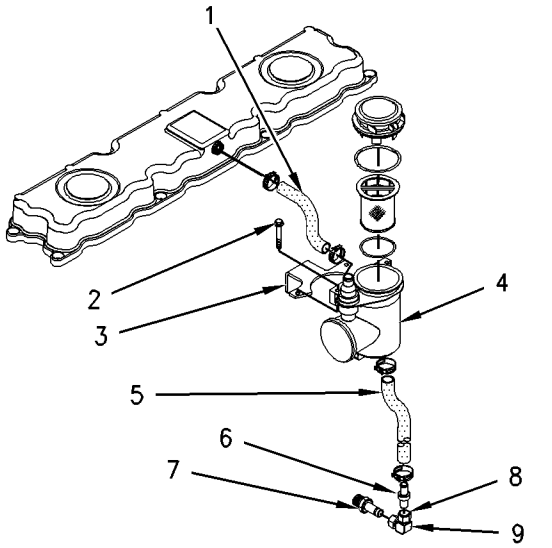


Illustration 136 g00942270

1. Loosen the clamps and remove the hose (1). Loosen the clamps and remove the hose (5).

2. Remove the setscrews (2) and remove crankcase breather (4) from the bracket (3).

3. If necessary, remove the setscrews that secure the bracket (3) to the cylinder block.

4. If necessary, loosen nut (8) and remove the valve (6) from the elbow (9). Remove the elbow (9) from the adapter (7). Remove the adapter (7) from the cylinder block.

Installation Procedure

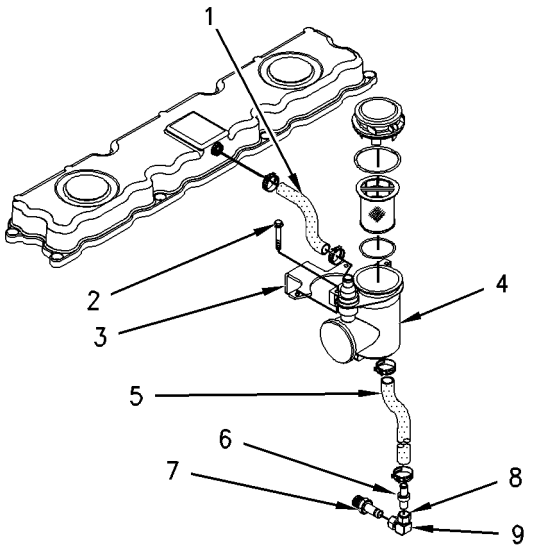


Illustration 137 g00942270

1. Install the adapter (7) in the cylinder block. Tighten the adapter to a torque of 30 N·m (22 lb ft).

2. Apply 21820117 POWERPART threadlock and nutlock to the threads of the valve (6). Install the valve (6) into elbow (9). Tighten the nut (8) finger tight. Tighten the nut for an additional 1 1/4 turn.

3. Position the bracket (3) on the cylinder block. Install the setscrews and tighten to a torque of 44 N·m (32 lb ft).

4. Position the crankcase breather (4) onto the bracket (3) and install the setscrews (2). Tighten the setscrews to a torque of 9 N·m (80 lb in).

5. Install the hose (1) and tighten the clamps. Install the hose (5) and tighten the clamps.

i01871184

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

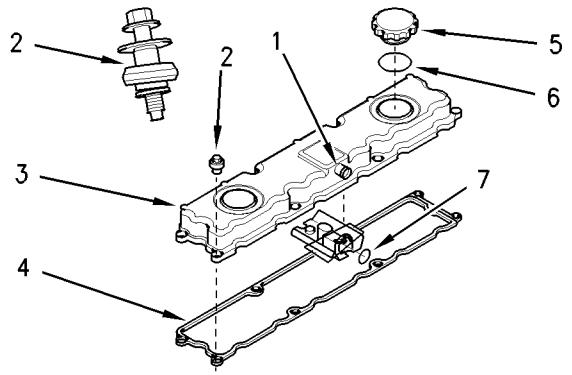


Illustration 138 g01005852

1. Loosen the hose clamp from the breather hose and remove the hose from the breather pipe (1).

2. Remove each fastener (2) and remove the valve mechanism cover (3).

3. Remove the joint (4).

Installation Procedure

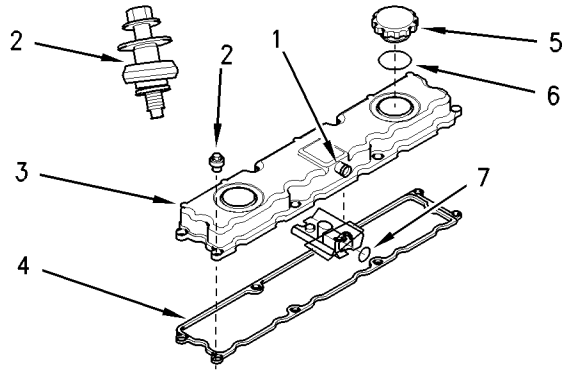


Illustration 139 g01005852

1. Check the condition of the seal (6) if the valve mechanism cover has an oil filler (5). Replace the seal (6) if it is necessary.

2. Check the condition of the O-ring (7) and replace the O-ring if it is necessary.

Note: Some valve mechanism covers are equipped with reflective heat shields. These reflective heat shields must not be painted. Also, these reflective heat shields must be kept clean, free from dust and free from oil. The component that is protected by the heat shield may be damaged if the surface of the heat shield is not kept shiny.

3. Inspect the condition of the heat shields if heat shields are installed on the valve mechanism cover. Clean the heat shields or replace the heat shields if it is necessary.

4. Inspect the condition of the joint (4) and replace the joint, if it is necessary.

5. Clean the machined face of the cylinder head for the joint (4).

Note: Ensure that the flat face of the joint (4) is toward the valve mechanism cover (3).

6. Install the joint (4) and the valve mechanism cover (3) onto the cylinder head.

7. Inspect the condition of the fasteners (2) and replace the fasteners if it is necessary. Install the fasteners (2) finger tight.

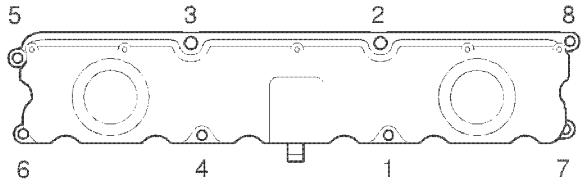


Illustration 140 g01024230

8. Tighten the fasteners (2) to a torque of 9 N·m (6.6380 lb ft) in the sequence that is shown illustration 140.

9. Connect the breather hose to the breather pipe (1) and tighten the hose clamp.

i01924099

Rocker Shaft and Pushrod - Remove

Removal Procedure

Start By:

a. Remove the valve mechanism cover. Refer to Disassembly and Assembly Manual, “Valve Mechanism Cover - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

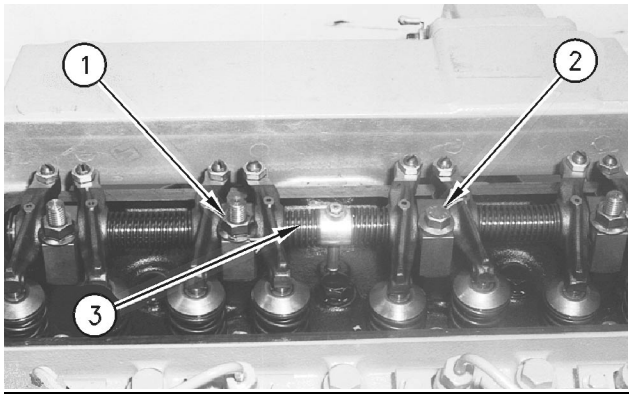


Illustration 141 g00635152

Typical example

Note: It is not necessary to remove the oil supply tube in order to remove the rocker shaft assembly and the pushrods.

1. Gradually remove the nuts (1) and the bolts (2) from the rocker shaft assembly. Begin with the end brackets and move toward the center of the rocker shaft assembly.

2. Remove the rocker shaft assembly (3).

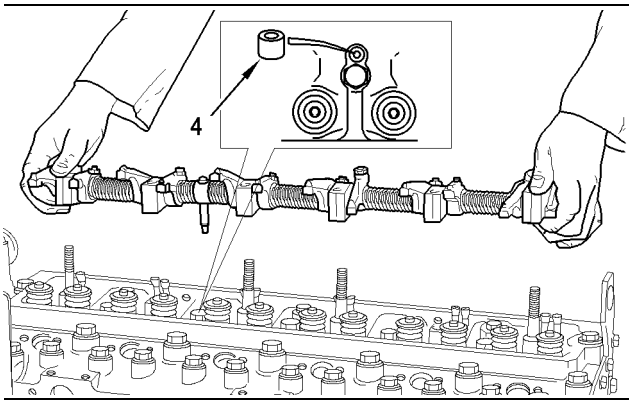


Illustration 142 g01001424

3. Remove the oil seal (4) from the oil supply passage in the cylinder head.

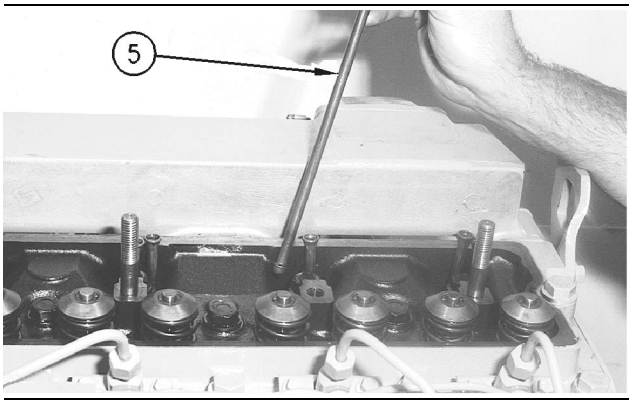


Illustration 143 g01001426

Typical example

4. Remove the pushrods (5). Place an identification mark on the pushrods for installation.

i01924102

Rocker Shaft - Disassemble

Disassembly Procedure

Start By:

a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly Manual, “Rocker Shaft and Pushrod - Remove”.

⚠ WARNING

Personal injury can result from being struck by parts propelled by a released spring force.

Make sure to wear all necessary protective equipment.

Follow the recommended procedure and use all recommended tooling to release the spring force.

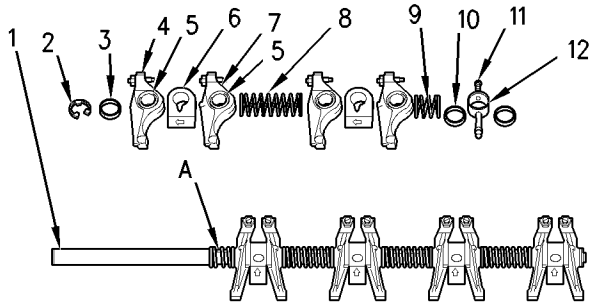


Illustration 144 g00939369

1. Remove the retaining ring (2) and remove the washer (3) from both ends of the rocker shaft assembly (1).

Note: Place an identification mark on each of the components for installation.

2. Remove the rocker arm assembly (4) for the inlet valve from the rocker shaft assembly (1). Remove the shaft bracket (6) and the rocker arm assembly (7) for the exhaust valve from the rocker shaft assembly (1).

3. Remove the spring (8) from the rocker shaft assembly (1).

4. Remove the rocker arm assembly for the inlet valve from the rocker shaft assembly (1). Remove the shaft bracket and the rocker arm assembly for the exhaust valve from the rocker shaft assembly (1).

5. Remove the spring (9) from the rocker shaft assembly (1).

6. Remove the shims (10) from the rocker shaft assembly (1). Remove the bolt (11). Remove the oil supply tube (13) from the rocker shaft assembly (1).

7. Repeat Step 2 through Step 6 in order to completely disassemble the rocker shaft assembly (1).

8. Check the clearance between the rocker arm assembly (4) and the rocker shaft assembly (1). If the clearance is larger than 0.13 mm (0.005 inch), replace the bushing (5). Check the clearance between the rocker arm assembly (7) and the rocker shaft assembly (1). If the clearance is larger than 0.13 mm (0.005 inch), replace the bushing (5).

i01924100

Rocker Shaft - Assemble

Assembly Procedure

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

Note: Ensure that all of the oil holes in the rocker shaft and in the rocker arms are not plugged before you begin the assembly procedure.

1. Lubricate all of the components with clean engine oil before assembly.

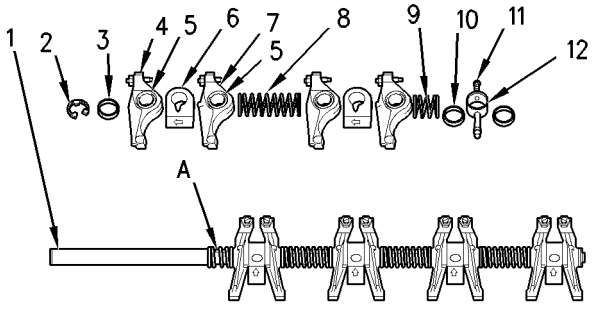


Illustration 145 g00937843

2. Position the oil supply tube (12) on the rocker shaft assembly (1). Install the bolt (11) in the top of the oil supply tube and into the oil passage (A) on the rocker shaft assembly (1). Install the shims (10) on the rocker shaft assembly (1). Install the springs (9) on the rocker shaft assembly.

Note: The clearance between the rocker arm bushing and the rocker shaft is 0.03 to 0.09 mm (0.001 to 0.004 inch).

3. If necessary, install a new bushing (5) in the rocker arm assembly (4) for the inlet valve. Install a new bushing (5) in the rocker arm assembly (7) for the exhaust valve.

Note: There is an arrow on the shaft bracket (6). This arrow must be positioned up when the shaft bracket is installed on the rocker shaft assembly.

4. Install the rocker arm assembly (4) for the inlet valve on rocker shaft assembly (1). Install the shaft bracket (6) and the rocker arm assembly (7) for the exhaust valve on rocker shaft assembly (1).

5. Install the spring (8) on the rocker shaft assembly (1).

6. Repeat Step 3 through Step 5 in order to completely assemble the rocker shaft assembly (1).

⚠ WARNING

Improper assembly of parts that are spring loaded can cause bodily injury.

To prevent possible injury, follow the established assembly procedure and wear protective equipment.

7. Install the washer (3) and the retaining ring (2) on the rocker shaft assembly (1).

End By:

a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install”.

i01924101

Rocker Shaft and Pushrod - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

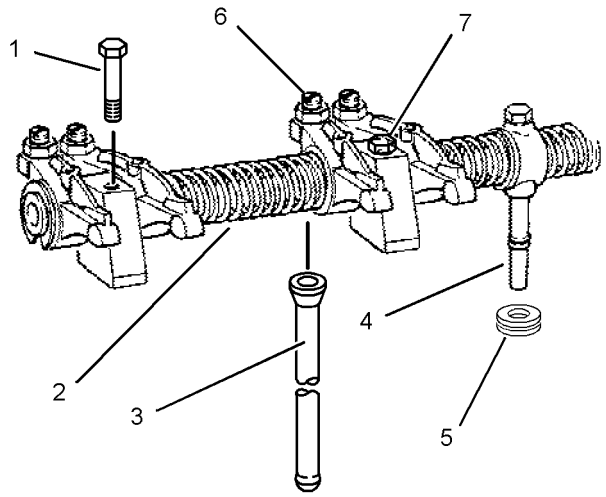


Illustration 146 g01034406
Typical example

1. Ensure that the pushrods (3) are clean and that the pushrods are not damaged. Install the pushrods.

Note: Ensure that the pushrods are installed in the original location and that the pushrods are correctly seated in the valve lifters.

2. Install a new oil seal (5) in the oil supply hole in the cylinder head.

3. Ensure that the rocker shaft assembly (2) is clean and that the rocker shaft assembly is not damaged. Ensure that the end plugs are installed in the ends of the rocker shaft. Put the rocker shaft assembly in position on the cylinder head. Make sure that the connection (4) for the oil supply is installed correctly into the oil seal.

Note: Ensure that the adjustment screws (6) for the valve lash are properly seated in the ends of pushrods.

Note: It may be necessary to loosen the adjustment screws on each rocker arm. This will help prevent a bent valve or a bent pushrod during the installation of the rocker shaft assembly.

4. Lubricate the nuts (7) and the setscrews (1) with clean engine oil.

5. Install the nuts and the setscrews.

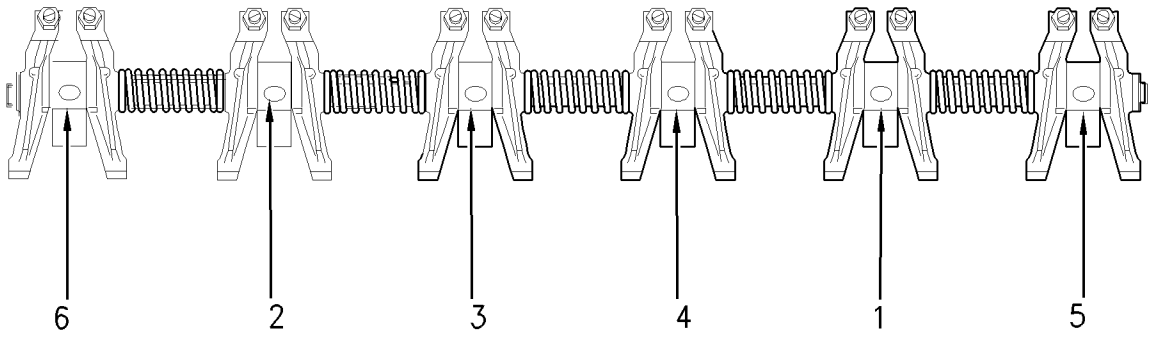


Illustration 147 g00954315

6. Gradually tighten and evenly tighten the nuts and the bolts to a torque of 75 N·m (55 lb ft) in the correct sequence. Refer to the illustration 147 for the correct sequence.

7. Adjust the intake valve lash to 0.20 mm (0.008 inch) and adjust the exhaust valve lash to 0.45 mm (0.018 inch). Refer to the Testing and Adjusting Manual, “Air Inlet and Exhaust System” for more information on adjusting the valve lash.

End By:

a. Install the valve mechanism cover. Refer to this Disassembly and Assembly Manual, “Valve Mechanism Cover - Remove and Install”.

i01851626

Cylinder Head - Remove

Removal Procedure

Start By:

a. Remove the crankcase breather system if a crankcase breather system is installed on this engine. Refer to Disassembly and Assembly Manual, “Crankcase breather - Remove and Install”.

b. Remove the MIC and the bracket for the MIC if the MIC is installed on the cylinder head.

c. Remove the pipe from the fuel priming pump to the fuel filter if the fuel filter is located on the cylinder head. Remove the fuel filter and the bracket for the fuel filter. Refer to Disassembly and Assembly Manual, “Fuel Filter Base - Remove and Install”.

d. Remove the fuel line for the air inlet heater starting aid. If it is necessary also remove the air inlet heater starting aid. Refer to Disassembly and Assembly Manual, “Starting Aid (Air Inlet Heater) - Remove and Install”.

e. If the fuel filter is installed on the right side of the engine disconnect the fuel lines from the fuel filter to the fuel injection pump at the connector housing that is installed on the rear face of the cylinder head. If it is necessary also remove the connector housing from the rear face of the cylinder head.

f. If the engine is equipped with a compressor remove the coolant hose between the cylinder head and the compressor and remove the coolant hose between the bypass for the coolant and the compressor. Refer to Disassembly and Assembly Manual, “Air Compressor - Remove and Install”.

g. Remove the fuel injectors. Refer to Disassembly and Assembly Manual, “Fuel Injector - Remove”.

h. Remove the air inlet manifold. Refer to Disassembly and Assembly Manual, “Intake Manifold - Remove”. If it is necessary also remove the engine coolant temperature sensor. Refer to Disassembly and Assembly Manual, “Coolant Temperature Sensor - Remove and Install”.

i. Remove the exhaust manifold. Refer to Disassembly and Assembly Manual, “Exhaust Manifold - Remove and Install”.

j. Remove the water outlet manifold. Refer to Disassembly and Assembly Manual, “Water Outlet Manifold - Remove”.

k. Remove the rocker shaft assembly and the pushrods. Refer to Disassembly and Assembly Manual, “Rocker Shaft and Pushrod - Remove”.

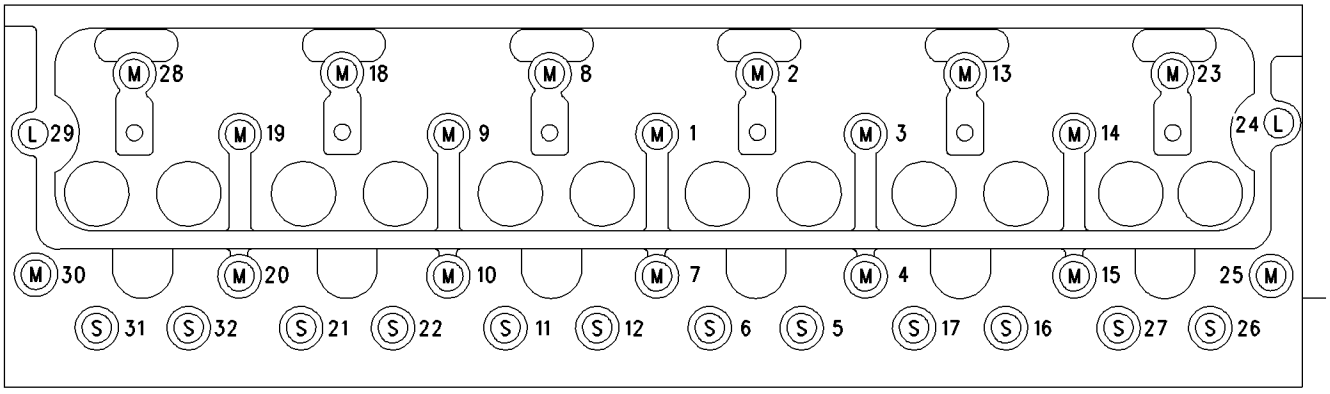


Illustration 148 g00893273

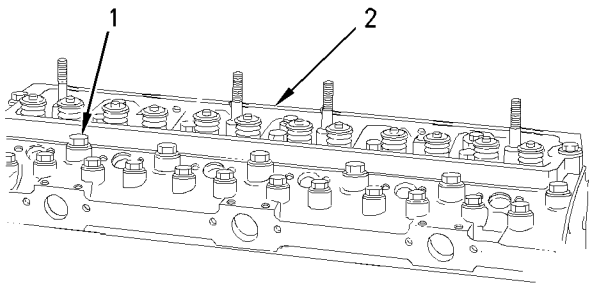


Illustration 149 g00942854

1. Gradually loosen the cylinder head bolts (1) in reverse numerical order. Refer to illustration 148. This will help prevent distortion of the cylinder head.

2. Remove the bolts (1) from the cylinder head (2).

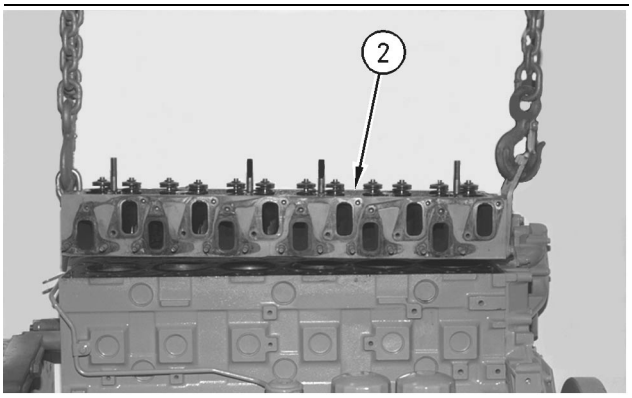


Illustration 150 g01001722

3. The cylinder head (2) is heavy. Take care when the cylinder head (2) is lifted or when the cylinder head is lowered. Use a suitable lifting device to carefully lift the cylinder head (2) off the engine block. Refer to illustration 150.

NOTICE
Place the cylinder head on a surface that will not scratch the face of the cylinder head.

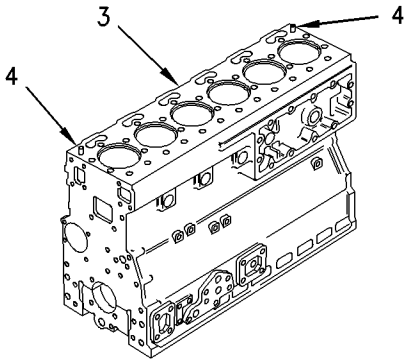


Illustration 151 g00942916

4. Remove the cylinder head gasket (3) and discard the cylinder head gasket.

Note: Note the location of the dowels (4) on each end of the cylinder block.

i01851625

Cylinder Head - Install

Installation Procedure

Table 20

Required Tools	
Description	**Part Number**
Angle gauge for cylinder head bolts	21825607

Note: Thoroughly clean the top surface of the cylinder block and the bottom surface of the cylinder head. Inspect the top surface of the cylinder block and the bottom surface of the cylinder head (2) for cracks and for score marks. Ensure that debris are not in the following: Cylinder bores, coolant passages, passages for the engine oil, and passages for the pushrods.

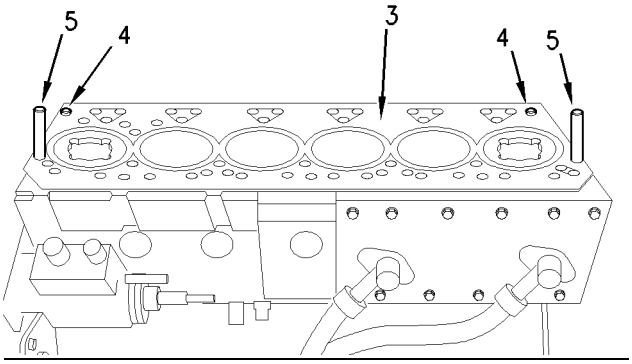


Illustration 152 g01001770

1. Install the cylinder head gasket (3) on the dowels (4) on top of the cylinder block. The cylinder head gasket (3) is stamped “FRONT TOP”. Do not use any sealant or compound on the cylinder head gasket. Install two 0.5 inch UNF studs (5) into the cylinder block in order to ensure the correct alignment of the cylinder head. The two studs should be installed into holes (25) and (30). Refer to illustration 156.

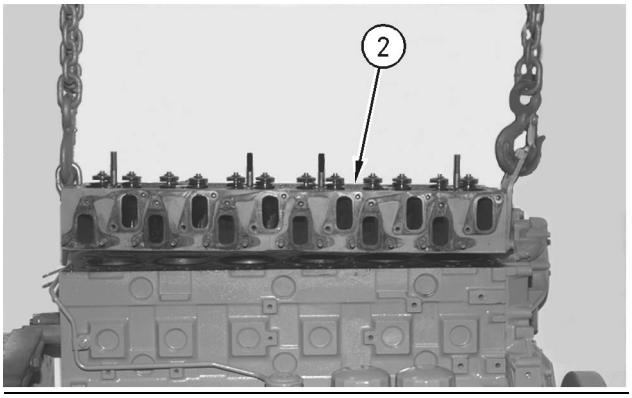


Illustration 153 g01001722

2. The cylinder head (2) is heavy. Take care when the cylinder head (2) is lifted or when the cylinder head is lowered. Use a suitable lifting device to carefully lift the cylinder head (2). By using the studs (5) as guides, carefully lower the cylinder head (2) onto the cylinder block.

Note: Ensure that the cylinder head is correctly located on the dowels (4).

3. Remove the lifting device.

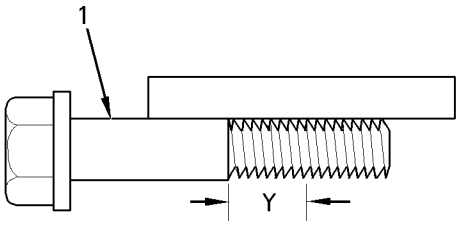


Illustration 154 g00942928

4. Clean the threads of the cylinder head bolts. Inspect the cylinder head bolts.

Note: Do Not use the bolts if there is any visual reduction in the diameter of the Threads (Y) that has not been engaged with the cylinder block. Use a straight edge to check the bolts.

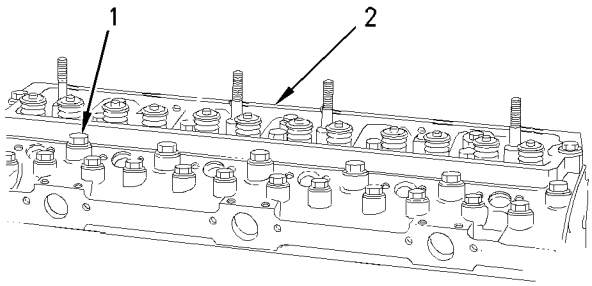


Illustration 155 g00942891

Note: There are three lengths of cylinder head bolt: long cylinder head bolt (L), medium cylinder head bolt (M), and short cylinder head bolt (S). Refer to illustration 156 in order to identify the correct location of each length of bolt.

5. Lubricate all of the cylinder head bolts (1) with clean engine oil before installation.

6. Do not install bolts (25 and 30). Install all of the other cylinder head bolts (1) into the cylinder head (2). Remove the studs and install cylinder head bolts (25 and 30).

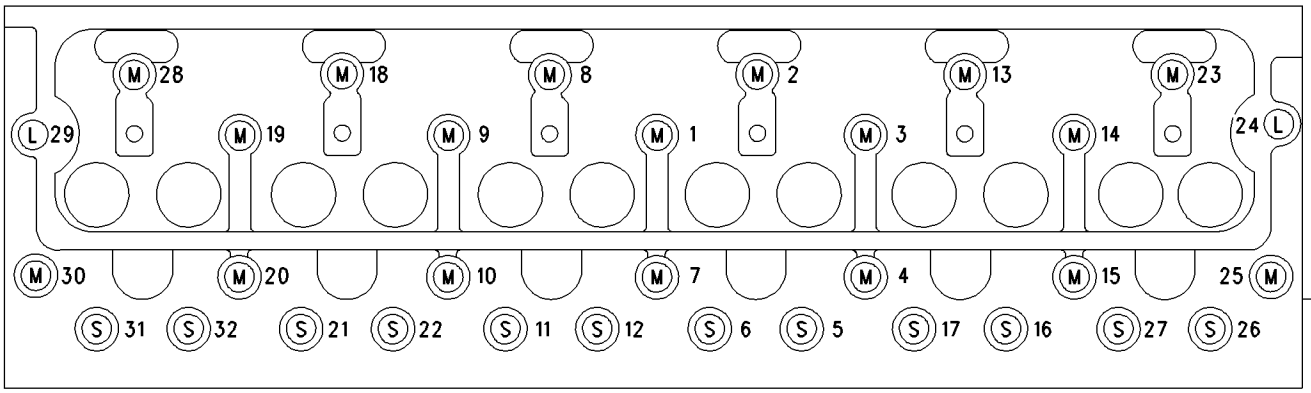


Illustration 156 g00893273

7. Refer to illustration 156 for the correct sequence in order to tighten the cylinder head bolts (1). Gradually tighten and evenly tighten all of the cylinder head bolts (1) to a torque of 110 N·m (80 lb ft) in the correct numerical sequence.

8. Repeat Step 7 in order to ensure that all of the bolts (1) have been tightened to the correct torque.

9. The cylinder head bolts need to be tightened further. Each different length of cylinder head bolt (1) requires a different amount of additional tightening.

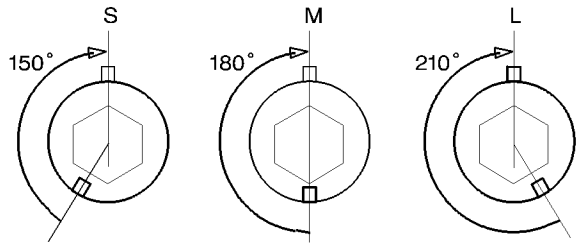


Illustration 157 g01002024

a. Turn the bolts that are marked with an “S” in illustration 156 an additional 150 degrees (2.5 flats).

b. Turn the bolts that are marked with an “M” in illustration 156 an additional 180 degrees (3.0 flats).

c. Turn the bolts that are marked with an “L” in illustration 156 an additional 210 degrees (3.5 flats).

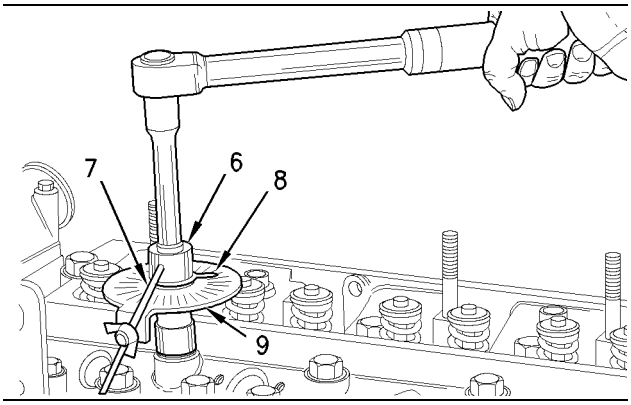


Illustration 158 g01002237

10. Further tighten the cylinder head bolts (1) with the 21825607 Angle Gauge. Install the angle gauge (6) between a suitable socket and a suitable ratchet wrench. Refer to illustration 156 for the first cylinder head bolt of the correct tightening sequence. Position the stop (7) against a suitable protrusion on the cylinder head (2) in order to prevent movement of the angle gauge (6) in a clockwise direction. Align the pointer (8) of the angle gauge (6) with the appropriate angle on the dial (9) of the angle gauge. Tighten the appropriate cylinder head bolt until the pointer aligns with the zero on the dial (9) of the angle gauge (6).

11. Repeat Step 10 for all of the cylinder head bolts in the correct tightening sequence. Refer to illustration 156.

End By:

a. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly Manual, “Rocker Shaft and Pushrod - Install”.

b. Install the water outlet manifold. Refer to Disassembly and Assembly Manual, “Water Outlet Manifold - Install”.

c. Install the exhaust manifold. Refer to Disassembly and Assembly Manual, “Exhaust Manifold - Remove and Install”.

d. Install the air intake manifold. Refer to Disassembly and Assembly Manual, “Inlet Manifold - Install”.

e. Install the fuel injectors. Refer to Disassembly and Assembly Manual, “Fuel Injectors - Install”.

f. If the engine is equipped with a compressor install the coolant hose between the bypass for the coolant and the compressor and also install the coolant hose between the cylinder head and the compressor.

g. If the fuel filter was previously removed from the right side of the engine install the fuel filter. Also install the connector housing on the rear face of the cylinder head if the connector housing was previously removed. Also connect the fuel lines from the fuel filter to the fuel injection pump at the connector housing. Refer to Disassembly and Assembly Manual, “Fuel Filter Base - Remove and Install”.

h. Install the air inlet heater starting aid if the air inlet heater starting aid was previously removed. Install the fuel line for the air inlet heater starting aid. Refer to Disassembly and Assembly Manual, “Starting Aid (Air Inlet Heater) - Remove and Install”.

i. Install the fuel filter and the bracket if the fuel filter was previously removed from the cylinder head. Also install the pipe from the fuel priming pump to the filter head.

j. Install the MIC and the bracket for the MIC if the MIC was previously removed from the cylinder head.

k. Install the crankcase breather system if the crankcase breather system was previously removed from the engine. Refer to this Disassembly and Assembly Manual, “Crankcase Breather - Install”.

i01851639

Lifter Group - Remove and Install

Removal Procedure

Start By:

a. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

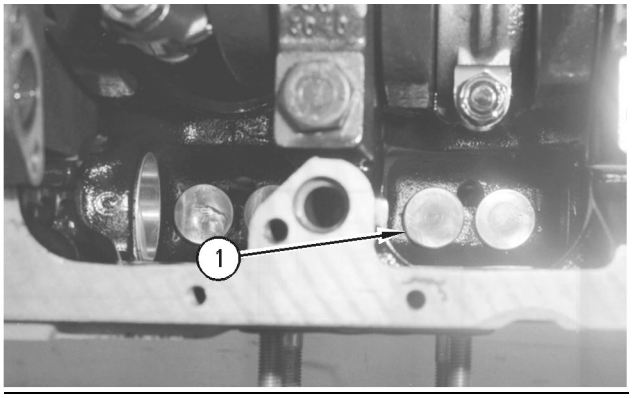


Illustration 159 g00540954

1. Use a suitable tool to remove the lifters (1).

Note: Ensure that the lifters are marked with the appropriate cylinder number and the appropriate valve for installation purposes.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Lubricate the lifters with clean engine oil.

2. Use a suitable tool to install the lifters (1).

Note: Ensure that the lifters are seated correctly and that the lifters are in the correct position.

End By:

a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install”.

i01846524

Camshaft - Remove and Install

Removal Procedure

Start By:

a. Remove the rocker shaft assembly and the pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove”.

b. Remove the fuel priming pump. Refer to Disassembly and Assembly, “Fuel Priming Pump - Remove”.

c. Remove the housing (front). Refer to Disassembly and Assembly, “Housing (Front) - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Turn the engine upside-down so the valve lifters are held in a position away from the camshaft (3).

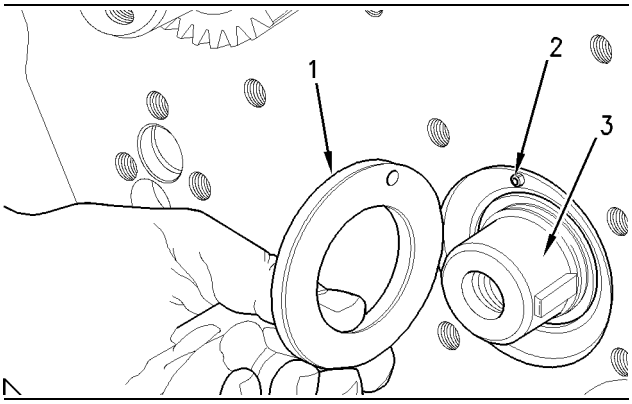


Illustration 160 g00938074

2. Remove the thrust washer (1). Make a note of the location of the hollow dowel (2) for installation purposes.

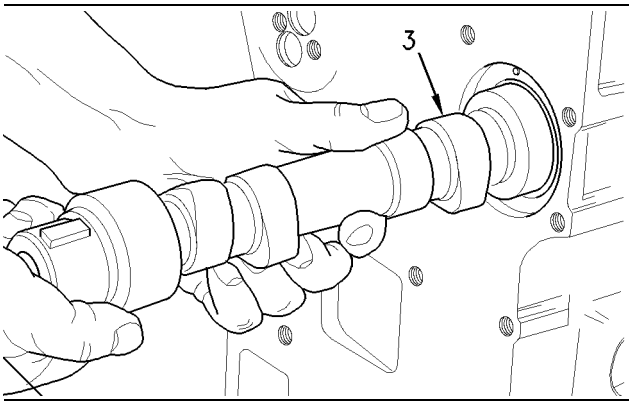


Illustration 161 g00938076

NOTICE
Do not damage the lobes or the bearings when the camshaft is removed or installed.

3. Carefully remove the camshaft from the engine.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Ensure that the camshaft is clean. Lubricate the camshaft with clean engine oil prior to installation.

1. Install the woodruff key into the keyway of the camshaft (3).

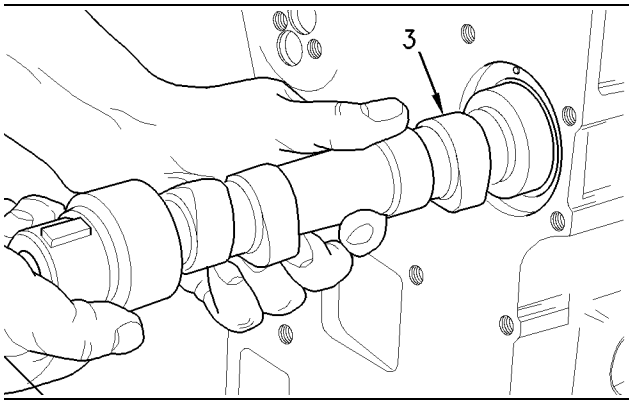


Illustration 162 g00938076

2. Carefully install the camshaft in the engine.

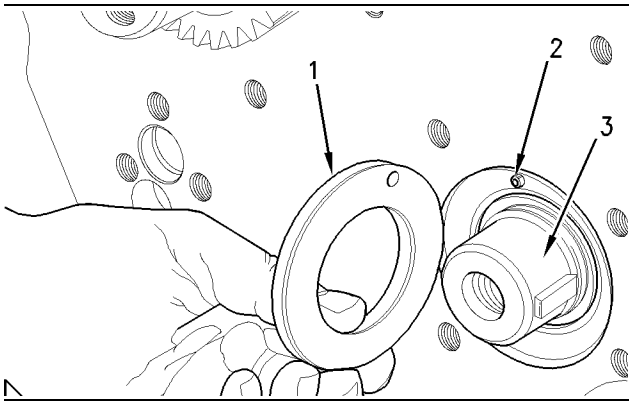


Illustration 163 g00938074

3. Put the thrust washer (1) in position. Make sure that the thrust washer is aligned with the hollow dowel (2).

End By:

a. Install the housing (front). Refer to Disassembly and Assembly, “Housing (Front) - Install”.

b. Install the fuel priming pump. Refer to Disassembly and Assembly, “Fuel Priming Pump - Install”.

c. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrods - Install”.

i01876574

Camshaft Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove”.

b. Remove the rocker shaft. Refer to Disassembly and Assembly, “Rocker Shaft and Push Rod - Remove”.

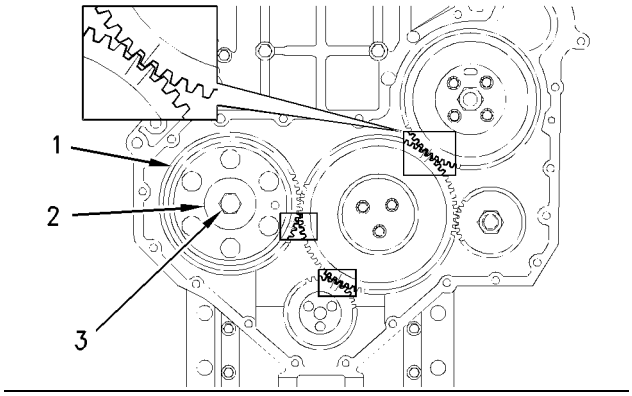


Illustration 164 g00943746

1. Rotate the crankshaft until the timing marks on the crankshaft gear, the camshaft gear, and the fuel injection pump gear are aligned, as shown.

2. Lock the crankshaft. Loosen the setscrew for the camshaft (3). Unlock the crankshaft.

3. Remove the idler gear. Refer to Disassembly and Assembly, “Idler Gear - Remove and Install”.

4. Remove the setscrew and the washer (2) from the camshaft gear (1).

5. Remove the camshaft gear.

6. Inspect the camshaft gear for wear and damage. Replace the gear, if necessary.

Installation Procedure

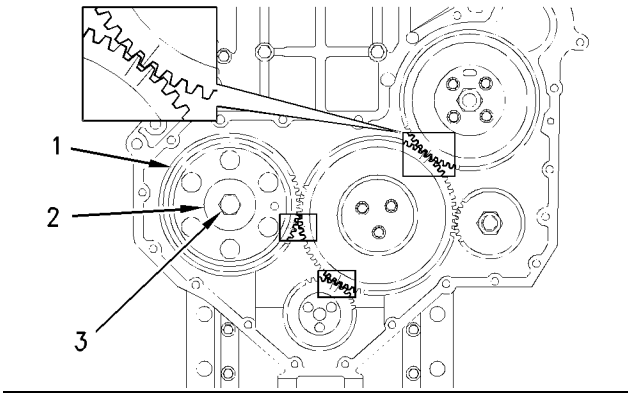


Illustration 165 g00943746

1. Check that the woodruff key in the camshaft is installed correctly.
2. Align the keyway in the camshaft gear (1) to the woodruff key in the camshaft and install the camshaft gear onto the camshaft.
3. Install the washer (2) and install the setscrew (3).
4. Install the idler gear. Refer to Disassembly and Assembly, “Idler Gear - Remove and Install”.
5. Lock the crankshaft. Tighten the setscrew for the camshaft to the following torque 95 N·m (70 lb ft). Unlock the crankshaft.
6. If a new camshaft gear is used, check the backlash of the camshaft gear. The minimum backlash for a new gear is 0.052 mm (0.0020 inch).

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Install”.

b. Install the rocker shaft. Refer to Disassembly and Assembly, “Rocker Shaft and Push Rod - Install”.

i01846532

Camshaft Bearings - Remove and Install

Removal Procedure

Start By:

a. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

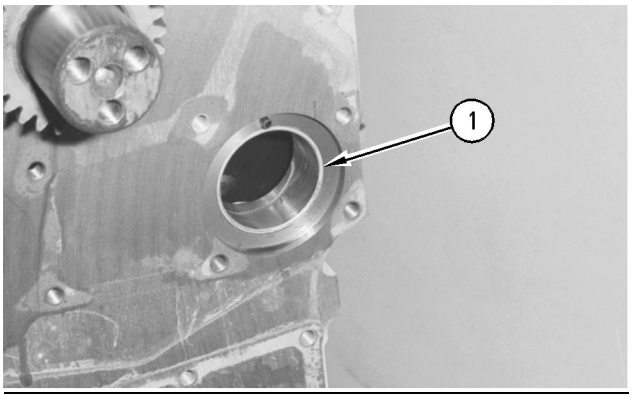


Illustration 166 g00546333
Camshaft bearing

1. Use a suitable tool to remove the camshaft bearing (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

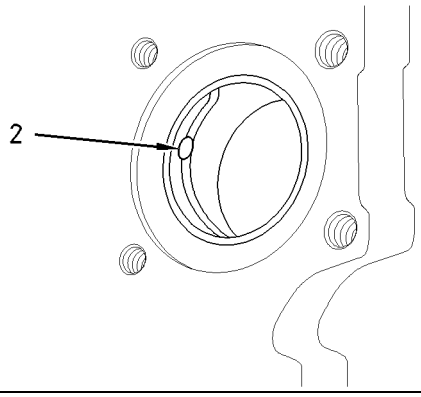


Illustration 167 g01001450
Bearing oil supply

1. Lightly lubricate the bearing. Align the oil supply hole (2) in the bearing to the oil feed in the cylinder block.
2. Use a suitable tool in order to press the bearing into the cylinder block.

Note: The bearing must be flush with the face of the recess in the cylinder block.

End By:

a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install”.

i01852918

Engine Oil Pan - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: Either aluminum oil pans or cast iron oil pans equip these engines. The cast iron oil pan is heavy. To avoid injury, take care when the cast iron oil pan is removed and/or installed.

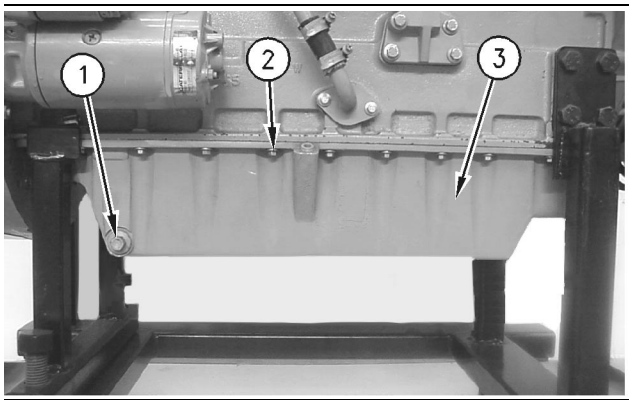


Illustration 168 g00902366

1. Operate the engine until the engine lubricating oil is warm.

2. In order to drain the engine oil, the engine may be equipped with a drain plug and a seal or the engine may be equipped with an oil drain valve. Either remove the oil drain plug (1) and the seal or open the oil drain valve. Drain the engine oil into a suitable container for storage or for disposal. If necessary, remove the dipstick and remove the dipstick tube.

3. Support the oil pan. Remove the setscrews (2) from the oil pan (3). If equipped, also remove the nuts from the oil pan.

4. Remove the engine oil pan (3) and the joint from the cylinder block. Some engines also have a felt dust seal that is installed at the rear end of the oil pan. If equipped, inspect this felt dust seal and replace this felt dust seal if it is necessary.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all surfaces thoroughly.

2. When the joint for the oil pan is removed, damage may occur to the existing seal in the groove of the bridge. If the seal is damaged, apply a sufficient amount of 1801108 POWERPART Silicone Sealant in order to fill the groove. The groove must be completely filled.

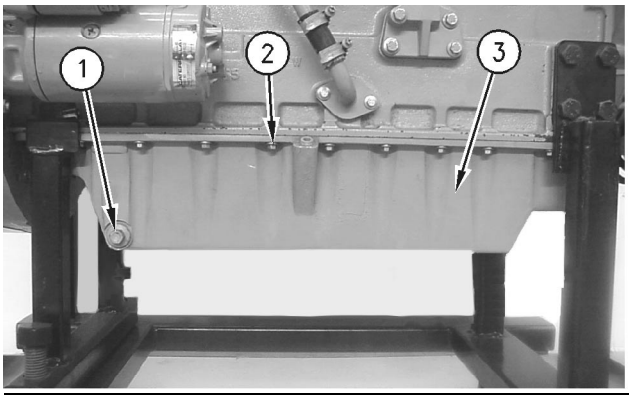


Illustration 169 g00902366

3. Install the joint and the engine oil pan (3) in the correct position on the cylinder block. Use four temporary studs in Holes (X) in order to ensure that the oil pan is correctly aligned.

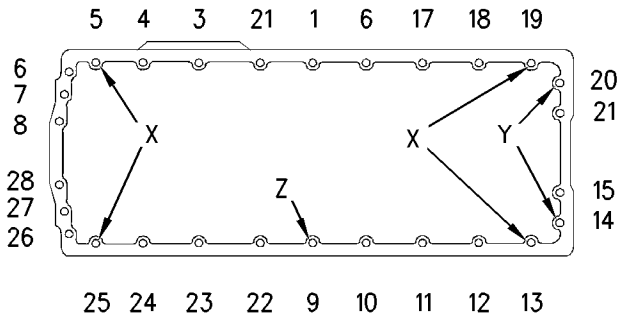


Illustration 170 g00935315

4. Apply 21820117 POWERPART Threadlock and Nutlock to the threads of the setscrew that is positioned in Hole (Z). Apply 21820117 POWERPART Threadlock and Nutlock to the threads of the setscrews that are positioned in Holes (Y).

5. Install most of the setscrews (2) and tighten these setscrews finger tight. Remove the four studs and install the remainder of the setscrews (2). Tighten setscrews (1) to a torque of 22 N·m (16 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 170.

6. Inspect the seal for the oil drain plug. Replace the seal for the oil drain plug, if necessary. Install the seal and the oil drain plug (1). Tighten the oil drain plug to a torque of 34 N·m (25 lb ft). Alternatively close the oil drain valve if an oil drain valve is installed.

7. If it was necessary to remove the dipstick and the dipstick tube, replace the dipstick tube. Ensure that the rubber seal is installed to the dipstick tube. Apply 21820117 POWERPART Threadlock and Nutlock to the thread of the gland nut for the dipstick tube. Tighten the gland nut for the dipstick tube to a torque of 18 N·m (13 lb ft). Install the dipstick.

Note: Replace the oil filter if new oil is being installed into the engine. Refer to the Operation and Maintenance Manual for further information on replacing the oil filter.

8. Fill the engine oil pan to the correct level that is indicated on the engine oil dipstick. Refer to the Operation and Maintenance Manual for further information.

i01851631

Cylinder Liner - Remove

Removal Procedure

Table 21

Required Tools		
Part Number	**Part Description**	**Qty**
21825543	Main tool for removing and for replacing cylinder liners	1
21825563	Adapters for use with the main tool	1

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly Manual, “Cylinder Head - Remove”.

b. Remove the pistons and connecting rods. Refer to Disassembly and Assembly Manual, “Pistons and Connecting Rods - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Before you proceed with the removal of the cylinder liner, check the cylinder liners for wear or for damage. Check the inner diameter of each cylinder liner at the top, the middle, and the bottom. Check the inner diameter at two places that are 90 degrees away from each other. Refer to the Specifications Manual, “Cylinder Liners” for the correct dimensions of the cylinder liner. The maximum wear for the cylinder liners is 0.25 mm (0.010 inch).

Note: An engine may have a high rate of oil consumption if the surface of the cylinder liners are glazed. Glaze can be removed from the cylinder liners by honing the bore of the cylinder liner.

1. Rotate the crankshaft in order to gain access to the cylinder liner. Place a protective cover on the crank pin in order to prevent damage to the crankshaft.

Note: If a partially finished cylinder liner will be installed in the cylinder block the crankshaft must be removed. Refer to Disassembly and Assembly Manual, “Cylinder Liner - Install” for further information on the types of cylinder line that are available for this engine. If necessary, refer to this Disassembly and Assembly Manual, “Crankshaft - Remove” for further information on removing the crankshaft.

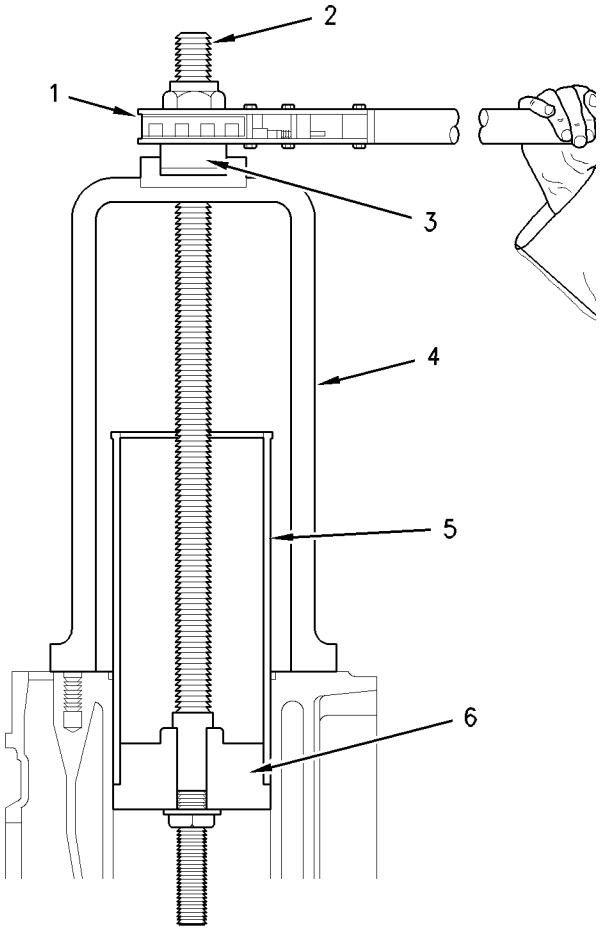


Illustration 171 g00999836

Note: The tool number 21825563 consists of two adapters. The smaller adapter is used in order to remove a cylinder liner. The larger adapter is used in order to install a cylinder liner.

2. Place the body (4) of the 21825543 main tool onto the top face of the cylinder block. Ensure that the tool will not restrict the removal of the cylinder liner (5) from the cylinder block. Install the top bearing (3), the ratchet wrench (1), and the threaded bar and top nut (2). Install the smaller adapter (6) and the lower nut. Ensure that the smaller adapter is within the cylinder liner. Ensure that the smaller adapter will not come into contact with the cylinder block during the removal of the cylinder liner.

3. Operate the ratchet wrench in order to remove the cylinder liner from the cylinder block.

Repeat Steps 1 through 3 for the remaining cylinder liners.

i01851629

Cylinder Liner - Install

Installation Procedure

Table 22

Required Tools		
Part Number	**Part Description**	**Qty**
21825543	Main tool for removing and for replacing cylinder liners	1
21825563	Adapters for use with the main tool	1
21825496	Gauge for cylinder liner flange	1
21825617	Dial gauge for use with 21825496	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: There are two types of cylinder liner for this engine. A service liner which is a transition fit in the cylinder bore and a partially finished liner which is an interference fit in the cylinder bore. The service liner will not need to be machined after the liner has been installed in the cylinder block. The partially finished liner will need to be machined after the liner has been installed in the cylinder bore.

Note: The service liner may not need the 21825543 main tool in order to install the liner into the cylinder block. It may be possible to push the service liner into the cylinder block. **Do not hit the cylinder liner with a hammer.** The partially finished cylinder liner may require a hydraulic press in order to install the liner into the cylinder block.

Note: The following procedure assumes that the service liner and the partially finished liner will require the 21825543 main tool in order to install the liner into the cylinder block.

1. Clean the cylinder block bore and clean the top recess for the cylinder liner flange with 21820128 POWERPART Special Cleaner.

2. Inspect the cylinder block bore for damage and for corrosion. Damaged cylinder blocks should be replaced.

3. Clean the outer face of the cylinder liner with 21820128 POWERPART Special Cleaner.

4. Lightly apply clean engine oil to the cylinder block bore. **Do not apply the clean engine oil to the top 50.0 mm (2.00 inch) of the cylinder block bore of an engine in order to install a service liner.**

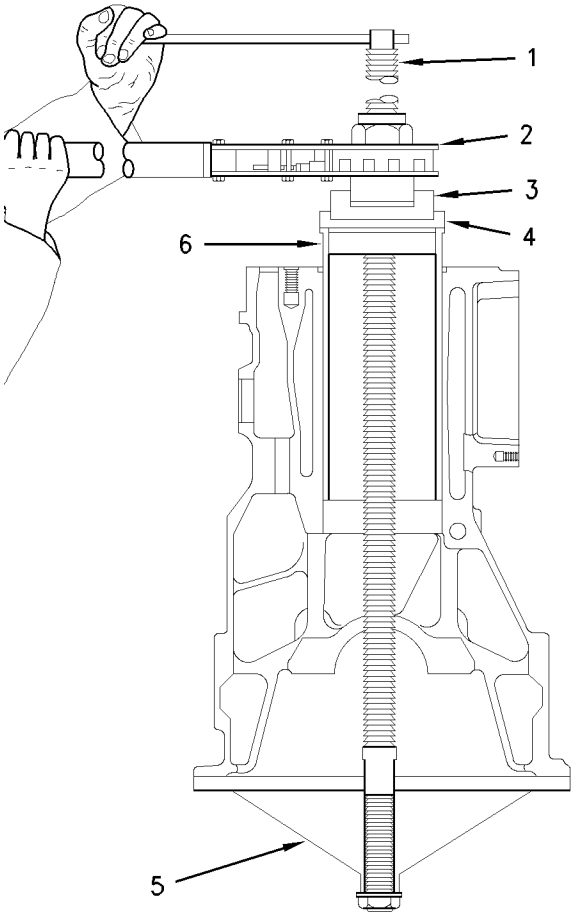


Illustration 172 g01000180

5. Install the lower end of the cylinder liner into the top of the cylinder bore. Ensure that the cylinder liner is vertical.

6. Install the adapter (4) onto the top of the cylinder liner with the shoulder of the adapter in the cylinder liner (6).

7. Install the bearing (3) with the flat face of the bearing in the recess in the adapter (4). Install the threaded bar (1) and the top nut through the ratchet wrench (2), bearing (3), adapter (4), and cylinder liner (6).

Note: The tool number 21825563 consists of two adapters. The smaller adapter is used in order to remove a cylinder liner. The larger adapter is used in order to install a cylinder liner.

8. Install the larger adapter (5) onto the threaded bar (1) and against the bottom face of the cylinder block. Secure the larger adapter with the lower nut of the threaded bar. Ensure that the threaded bar is in the center of the cylinder liner (6).

9. Lubricate the ratchet wrench (2), the bearing (3), and the threaded bar (1) with a suitable lubricant.

10. For a partially finished cylinder liner, operate the ratchet wrench (2) and operate the handle of the threaded bar (1) in order to press the cylinder liner (6) into the cylinder block. Remove the adapter (5) and the 21825543 main tool. Thoroughly clean the top face of the cylinder block and the cylinder liner. The partially finished cylinder liner must now be machined by a specialist. Refer to your nearest Perkins Distributor for further information. Remove all debris from the engine after the cylinder liners have been machined.

11. For a service liner, operate the ratchet wrench (2) and operate the handle of the threaded bar (1) in order to press the cylinder liner (6) into the cylinder block within 50 mm (2.0 inch) of the top face of the cylinder block. Clean the exposed outer face of the cylinder liner (6) with 21820128 POWERPART Special Cleaner.

12. Apply 21820603 POWERPART Retainer to the exposed area of the cylinder liner (6). Continue to press the cylinder liner (6) into the cylinder block until the liner is fully installed.

13. Wipe off any excess Retainer from the cylinder liner (6). Allow the Retainer to cure for 15 minutes.

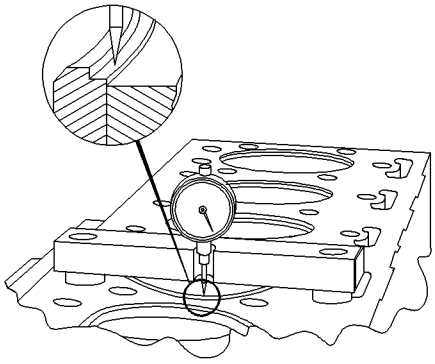


Illustration 173 g01000389

14. Use the gauge 21825496 and the dial gauge 21825617 in order to ensure that the cylinder liner is no more than 0.10 mm (0.004 inch) above the top face of the cylinder block or below the top face of the cylinder block. Ensure that the pointer of the dial gauge is positioned on the outer flange of the cylinder liner. Refer to illustration 173.

15. Immediately after you install a new cylinder liner, follow the recommendations:

a. Do not operate the engine at full load.

b. Do not operate the engine at high speed.

c. Do not allow the engine to run at low idle for an extended period of time.

Note: The duration of these recommendations are for the first 240 km (150 miles), or for the first 5 hours of operation.

End By:

a. If the crankshaft was removed, install the crankshaft. Refer to Disassembly and Assembly Manual, “Crankshaft - Install”.

b. Install the pistons and connecting rods. Refer to Disassembly and Assembly Manual, “Piston and Connecting Rods - Install”.

c. Install the cylinder head. Refer to Disassembly and Assembly Manual, “Cylinder Head - Install”.

i01850529

Piston Cooling Jets - Remove and Install

Removal Procedure

Start By:

a. Remove the engine oil pan. Refer to Disassembly and Assembly Manual, “Engine Oil Pan - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

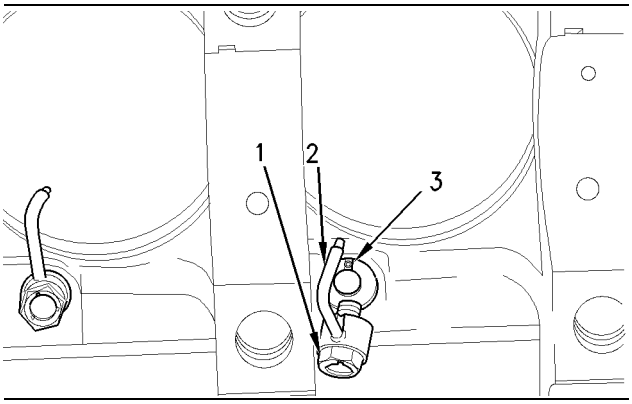


Illustration 174 g00938243

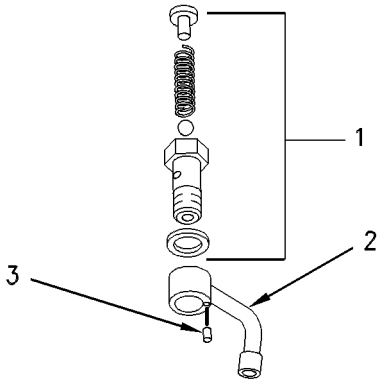


Illustration 175 g00606467

1. Remove the valve assembly (1) from the piston cooling jet (2).

2. Remove the piston cooling jet (2) from the cylinder block.

Note: The engine crankshaft may be rotated in order to access all of the piston cooling jets.

Note: Ensure that the ball moves freely within the valve assembly of the piston cooling jet. Check that the tube of the piston cooling jet is not damaged.

3. Remove the hollow dowel (3) from the cylinder block.

Note: The hollow dowel (3) is used to locate the piston cooling jet.

4. Repeat Steps 2 through 3 for the removal of the remaining piston cooling jets.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

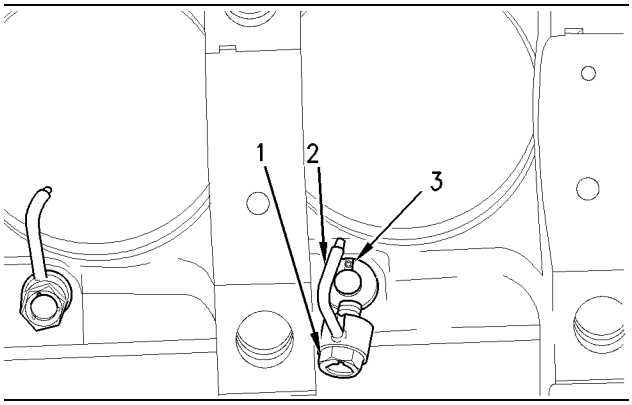


Illustration 176 g00938243

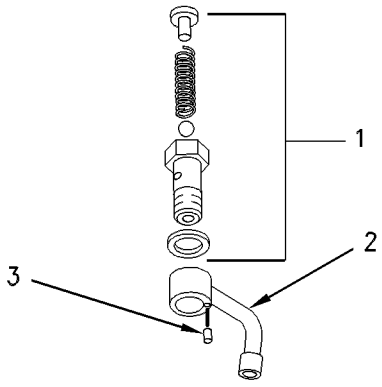


Illustration 177 g00606467

1. Install the hollow dowel (3) into the cylinder block.

2. Install the piston cooling jet (2) onto the hollow dowel in the cylinder block.

Note: Ensure that the piston cooling jet (2) is properly located on the hollow dowel (3). Refer to the Specifications Manual, “Piston Cooling Jet” for the correct procedure for the alignment of the piston cooling jet.

3. Install the valve assembly (1) into the piston cooling jet (2). Tighten the banjo bolt of the valve assembly (1) to a torque of 27 N·m (20 lb ft).

4. Repeat Steps 1 through 3 for the installation of the remaining piston cooling jets.

End By:

a. Install the engine oil pan. Refer to Disassembly and Assembly Manual, “Engine Oil Pan - Remove and Install”.

i01879257

Pistons and Connecting Rods - Remove

Removal Procedure for Serrated Connecting Rods

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove”.

b. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove”.

c. Remove the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Position the pistons that are being removed at the bottom center position.

2. Remove the carbon buildup from the inner surface of the top of the cylinder liner.

3. Ensure that the connecting rod and the cap are correctly marked to the cylinder.

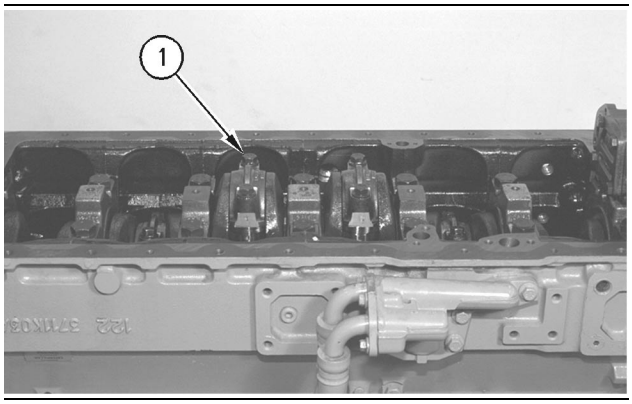


Illustration 178 g00893856

4. Remove the nuts (1) and the bolts from the connecting rod.

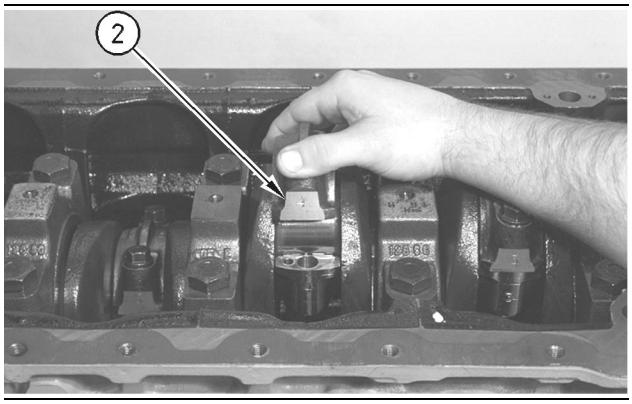


Illustration 179 g00633919

5. Remove the connecting rod cap (2) with the bearing shell.

6. Push the piston and the connecting rod through the top of the cylinder block.

Note: Make a mark under the piston on the pin boss in order to identify the cylinder. Always mark the front pin boss to aid installation.

7. The bearing shell for the connecting rod and the bearing shell for the connecting rod cap must be placed with the correct rod and the correct connecting rod cap.

Remove the Fractured Split Connecting Rods

1. Position the pistons that are being removed at the bottom center position.

2. Remove the carbon buildup from the inner surface of the top of the cylinder liner.

3. Ensure that the connecting rod and the cap are correctly marked to the cylinder.

Note: Do not punch the connecting rod or stamp the connecting rod assembly as this will cause damage.

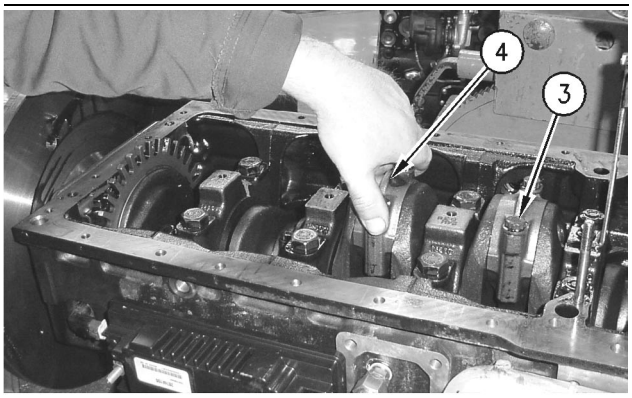


Illustration 180 g01000118

Removal procedure for fractured split rods

4. Remove the torx screws (3) from the connecting rod.

5. Remove the connecting rod cap (4) with the bearing shell.

6. Push the piston and the connecting rod through the top of the cylinder block.

Note: Make a mark under the piston on the pin boss in order to identify the cylinder. Always mark the front pin boss to aid installation.

7. The bearing shell for the connecting rod and the bearing shell for the connecting rod cap must be placed with the correct rod and the correct connecting rod cap.

8. Always tighten the connecting rod cap to the connecting rod, when the assembly is out of the engine. Tighten the assembly to the following torque 20 N·m (14 lb ft).

i01849543

Pistons and Connecting Rods - Disassemble

Disassembly for Serrated Connecting Rods

Start By:

a. Remove the pistons and the connecting rods. Refer to Disassembly and Assembly, “Piston and Connecting Rods - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

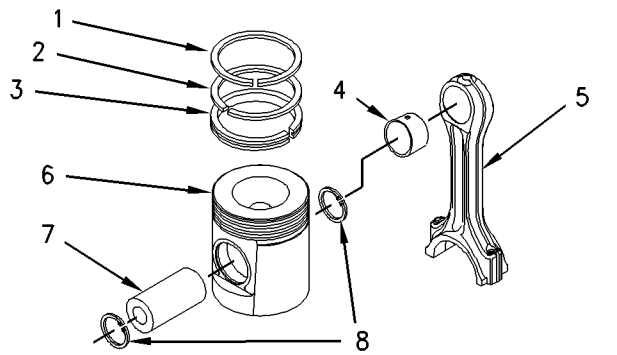


Illustration 181 g00964649
Typical example

1. Use a suitable ring expander in order to remove compression rings (1) and (2), and oil control ring (3) from piston (6).

2. Use suitable pliers in order to remove the circlip (8).

3. Remove the piston pin (7) from the piston.

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of 45 ± 5 °C (113 ± 9 °F). Do not use an oxyacetylene torch to heat the piston.

4. Remove the bearing shell from the connecting rod (5) and the connecting rod cap.

5. Use a suitable press and a suitable adapter in order to remove the piston pin bushing (4) from the connecting rod (5).

Disassembly for Fractured Split Connecting Rods

NOTICE
Removal of the piston pin bushing must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins dealer or your Perkins distributor.

1. Use a suitable ring expander in order to remove compression rings (1) and (2), and oil control ring (3) from piston (6).

2. Use suitable pliers in order to remove the circlips (8).

3. Remove the piston pin (7) from the piston.

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of 45 ± 5 °C (113 ± 9 °F). Do not use an oxyacetylene torch to heat the piston.

4. Remove the bearing shell from the connecting rod (5) and the connecting rod cap.

Note: Always tighten the connecting rod cap to the connecting rod, when the assembly is out of the engine. Tighten the connecting rod assembly to the following torque 20 N (14 ft).

5. Use a suitable press and a suitable adapter in order to remove the piston pin bushing (4) from the connecting rod (5).

i01850514

Pistons and Connecting Rods - Assemble

Assembly Procedure for Serrated Connecting Rods

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Installation of the piston pin bushing must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorizer Perkins dealer or your Perkins distributor.

1. Refer to Testing and Adjusting, “Connecting Rod - Inspect” for the correct height grade for the connecting rod.

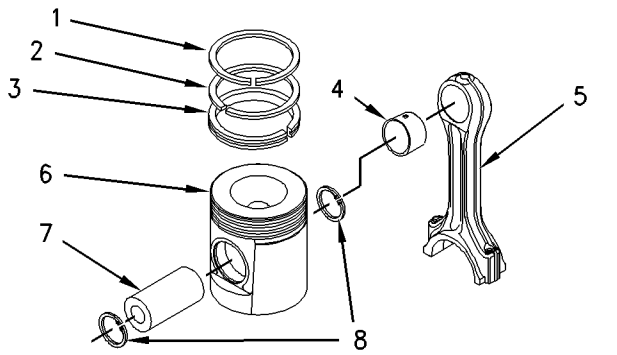


Illustration 182 g00964649

Typical example

2. Ream the piston pin bushing (4) in order to obtain a clearance of 0.023 to 0.044 mm (0.0009 to 0.0017 inch) between the piston pin and the piston pin bushing.

Note: Ensure that the oil hole in the piston pin bushing is aligned with the oil hole at the top of the connecting rod.

3. Use a suitable press and a suitable adapter to install the piston pin bushing (4) into the connecting rod (5).

4. Lubricate all components with clean engine oil.

5. Install the bearing shell in the connecting rod (5). The bearing shell is located by a locating tab.

6. Install the piston pin (7) into the piston and through the connecting rod (5).

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of 45° ± 5°C (113° ± 9°F).

7. Use suitable pliers in order to install the circlips (8) that hold the piston pin in position.

8. Use a suitable ring expander in order to install the compression rings (1) and (2), and oil control ring (3) to the piston (6).

a. Install the spring (12) for the oil control piston ring (11) in the groove (9) that is lowest on the piston. The latch pin (10) must be located inside the ends of the spring. Locate the oil control ring (11) over the internal spring (12).

Note: Ensure that the latch pin is 180 degrees from the oil control ring gap.

b. Install the intermediate piston ring (13) with the tapered face into the second groove on the piston. The stamp “TOP” must be toward the top of the piston.

Note: Intermediate piston rings that are new have a green mark which must be on the left of the piston ring gap when the piston ring is installed.

c. Install the top piston ring (14) with the barrel face and the molybdenum insert into the top groove on the piston. The top piston ring is a keystone ring. The stamp “TOP” must be toward the top of the piston.

Note: Top piston rings that are new have a red mark which must be on the left of the ring gap when the ring is installed.

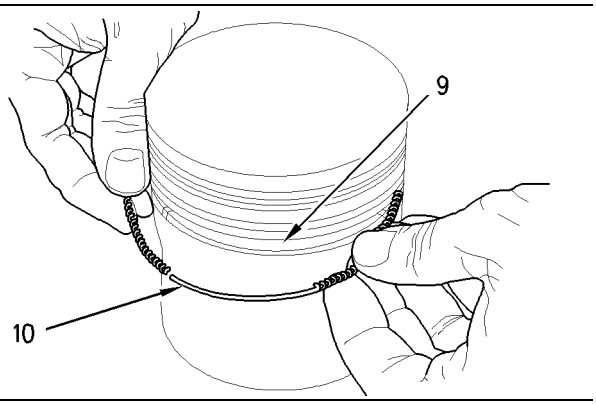


Illustration 183 g01000716

Installation of the spring

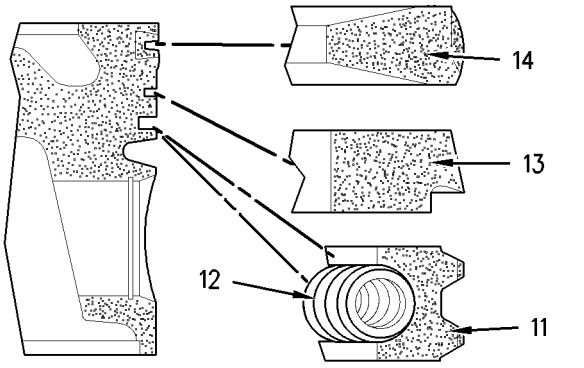


Illustration 184 g01000715

Piston rings

d. Position the piston ring gaps at 120 degrees away from each other.

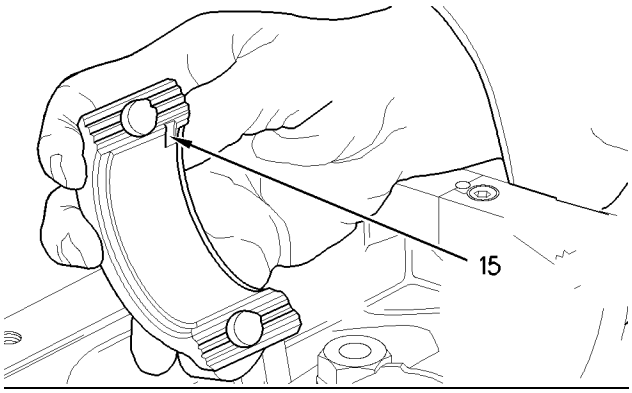


Illustration 185 g01000587

Location of the shell

9. Install the bearing shell into the connecting rod cap. Ensure that the locating tab (15) of the bearing shell is located into the connecting rod cap.

The Assembly Procedure for the Fracture Split Connecting Rods

NOTICE

Installation of the piston pin bushing must be carried out by personnel with the correct training. Also special machinery is required.

Note: A new piston pin bushing is in the shape of a wedge. For further information on installation of the piston pin bushing, refer to your authorized Perkins dealer or your Perkins distributor for assistance.

1. Refer to Testing and Adjusting, “Connecting Rod - Inspect” for the correct height grade for the fractured split connecting rod.

2. The bearing shells for the connecting rod must be aligned by a tool before the bearing shells are installed. Refer to illustration 186. Check the alignment of the bearing shells and remove the alignment tool from the assembly. The bearing shell must be an equal distance from each end. Refer to illustration 187.

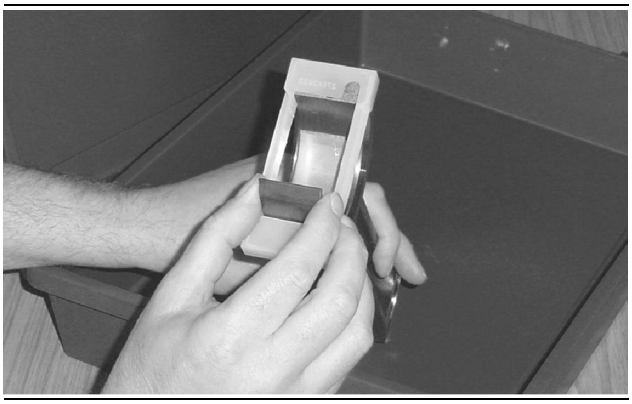


Illustration 186 g01000785

Alignment of the shell

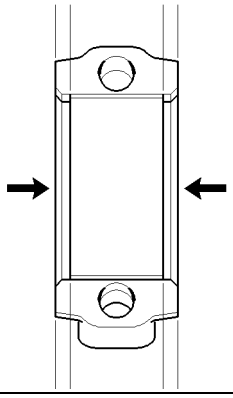


Illustration 187 g01001160

Aligned shell

Note: The alignment tool is supplied with the new bearing shells.

3. Align the mark (16) on the connecting rod to the boss cutout of the piston (17). Install the piston pin into the piston and through the connecting rod.

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of 45° ± 5°C (113° ± 9°F).

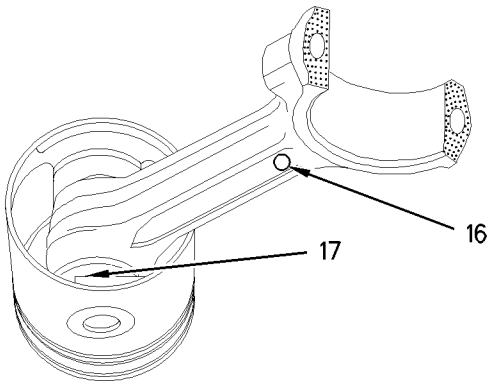


Illustration 188 g01000749

Typical example

4. Use suitable pliers in order to install the circlips (8) that hold the piston pin in position.

5. Use a suitable ring expander in order to install compression rings (1) and (2), and oil control ring (3) to the piston (6) with the following steps.

a. Install the spring (12) for the oil control piston ring (11) in the groove (9) that is lowest on the piston. The latch pin (10) must be located inside the ends of the spring. Locate the oil control ring (11) over the internal spring (12).

Note: Ensure that the latch pin is 180 degrees from the oil control ring gap.

b. Install the intermediate piston ring (13) with the tapered face into the second groove on the piston. The stamp “TOP” must be toward the top of the piston.

Note: Intermediate piston rings that are new have a green mark which must be on the left of the piston ring gap when the piston ring is installed.

c. Install the top piston ring (14) with the barrel face and the molybdenum insert into the top groove on the piston. The top piston ring is a keystone ring. The stamp “TOP” must be toward the top of the piston.

Note: Top piston rings that are new have a red mark which must be on the left of the ring gap when the ring is installed.

d. Position the piston ring gaps at 120 degrees away from each other.

End By:

a. Install the pistons and the connecting rods. Refer to Disassembly and Assembly, “Piston and Connecting Rods - Install”.

i01876575

Pistons and Connecting Rods - Install

Installation Procedure for Serrated Connecting Rods

Table 23

Required Tools		
Part Number	**Part Name**	**Quantity**
21825615	Piston sleeve (installation tool)	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean all of the components.

2. Lubricate the piston and the cylinder liner with clean engine oil.

3. Rotate the crankshaft until the connecting rod journal is at the bottom center. Lubricate the connecting rod journal with clean engine oil.

4. Lubricate the bearing shells for the connecting rod assembly with clean engine oil.

5. Ensure that the piston assembly is correctly marked to the cylinder.

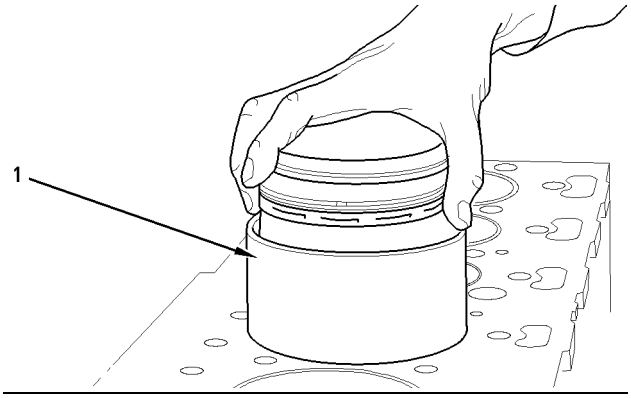


Illustration 189 g00999752

Piston installation

6. Lubricate the piston sleeve (1) with clean engine oil and install the piston sleeve .

Note: The arrow or the “FRONT” mark that is on the top of the piston must be toward the front of the engine.

Note: Ensure that the piston ring gaps are 120 degrees away from each other. Ensure that the piston sleeve is installed correctly and that the piston can easily slide from the tool and into the cylinder.

7. Push the piston and the connecting rod assembly into the cylinder liner and onto the connecting rod journal.

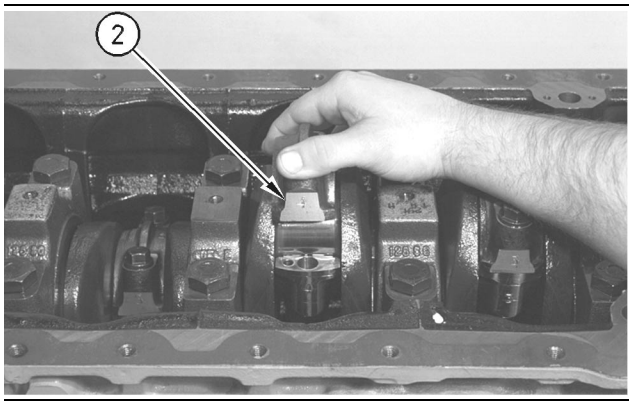


Illustration 190 g00633919

Installed cap for the connecting rod

8. Install the cap with the bearing shell onto the connecting rod journal (2).

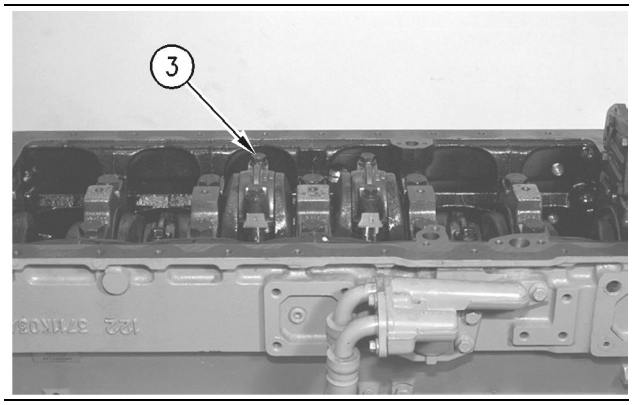


Illustration 191 g00999863

Fastener for the connecting rod

Note: Use new nuts (3) in order to install the connecting rod.

9. Install the bolts and the new nuts (3) on the connecting rod assembly. Tighten the nuts to a torque of 125 N·m (92 lb ft).

10. Rotate the crankshaft in order to ensure that the crankshaft rotates freely.

11. Refer to Testing and Adjusting, “Piston Height - Inspect” for the correct procedure on checking the height of the piston above the cylinder block.

Installation for Fractured Split Connecting Rods

1. Thoroughly clean all of the components.

2. Lubricate the piston and the cylinder liner with clean engine oil.

3. Rotate the crankshaft until the connecting rod journal is at the bottom center. Lubricate the connecting rod journal with clean engine oil.

4. Ensure that the piston assembly is correctly marked to the cylinder.

5. Lubricate the bearing shells for the connecting rod with clean engine oil.

6. Lubricate the piston sleeve (1) with clean engine oil and install the piston sleeve.

Note: The arrow or the “FRONT” mark that is on the top of the piston must be toward the front of the engine. Ensure that the piston ring gaps are 120 degrees away from each other.

Note: Ensure that the piston sleeve is installed correctly and that the piston can easily slide from the tool and into the cylinder.

7. Push the piston and the connecting rod assembly into the cylinder liner and onto the connecting rod journal.

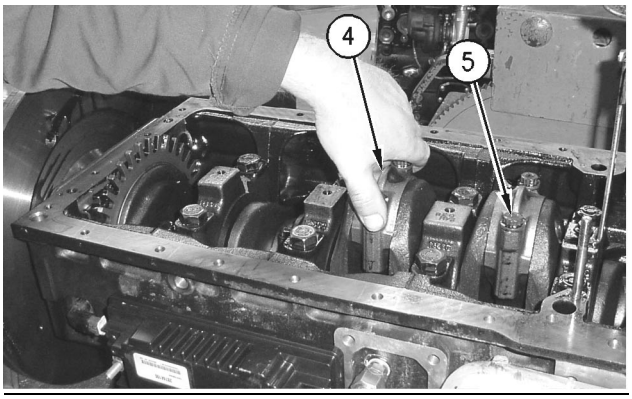


Illustration 192 g00999851

Installed fractured split connecting rod

Note: New torx screws must be installed.

8. Install the cap (4) with the bearing shell onto the connecting rod journal and the new torx screws for the cap.

9. Tighten the new torx screws to 20 N·m (14 lb ft).

Refer to Testing and Adjusting, “Piston Height - Inspect” for the correct procedure on checking the height of the piston above the cylinder block.

10. Tighten the torx screws (5) to 70 N·m (51 lb ft). Again tighten the torx screws by 120 degrees.

11. Rotate the crankshaft in order to ensure that the crankshaft rotates freely.

End By:

a. Install the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install”.

b. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install”.

c. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install”.

i01846904

Connecting Rod Bearings - Remove

The Removal of the Bearing Shells for Serrated Connecting Rods

Start By:

a. Remove the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

b. Remove the engine oil bypass valve. Refer to Disassembly and Assembly, “Engine Oil Bypass Valve - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. In order to remove the connecting rod caps, rotate the crankshaft in a clockwise direction until the piston is at the bottom center position.

Note: Check the location for each connecting rod cap on the crankshaft. Each connecting rod cap must have a number that is identical to the number that is on the connecting rod. Do not mix the bearings. If the connecting rod assembly requires marking do not punch the connecting rod assembly or stamp the connecting rod assembly as this may cause damage.

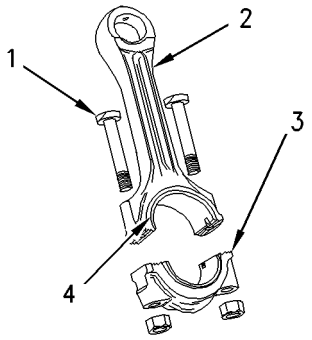


Illustration 193 g00893992

2. Remove the nuts and bolts (1) from the connecting rod (2).

3. Remove the connecting rod cap (3) with the bearing shell.

4. Carefully push the connecting rod and the piston into the cylinder liner. The connecting rod may need to be rotated in order to prevent contact with the piston cooling jet. Remove the bearing shell of the connecting rod (4).

5. Repeat Steps 1 through 4 for the remaining connecting rod bearings.

Removal of the Bearing Shells for Fractured Split Connecting Rods

Note: Remove one pair of connecting rod caps at a time and install one pair at a time. Damage can occur when the fractured split connecting rods are separated.

1. In order to remove the connecting rod caps, rotate the crankshaft in a clockwise direction until one pair of pistons is at the bottom center position.

Note: Check the location for each connecting rod cap on the crankshaft. Each connecting rod cap must have a number that is identical to the number that is on the connecting rod. Do not mix the bearings. If the connecting rod assembly requires marking do not punch the connecting rod assembly or stamp the connecting rod assembly as this may cause damage.

2. Remove the torx screws from the caps and remove both pair of caps with the bearing shells. Push both pair of connecting rods into the cylinder. Do not allow the connecting rods to contact the piston cooling jets.

3. Carefully rotate the crankshaft in order to give access to both pair of connecting rods.

4. Remove the bearing shells from the connecting rods and the caps.

5. Before continuing with the next pair of connecting rods, install all the bearing shell into the connecting rods and caps. Refer to Disassembly and Assembly Manual, “Connecting Rod Bearings - Install”.

i01924737

Connecting Rod Bearings - Install

Installation of the Bearing Shells for Serrated Connecting Rods

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Carefully rotate the crankshaft in order to give access to the connecting rod.

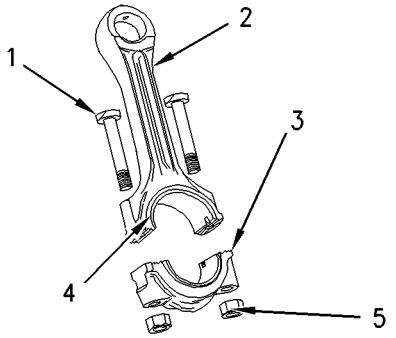


Illustration 194 g01001821
Typical example

Note: Do not allow the connecting rod to contact with the piston cooling jet.

2. Clean the connecting rod (4) and clean the connecting rod cap (3).

3. Align the tab (6) on the bearing shell with the recess in the connecting rod. Install the bearing shell. Align the tab (6) on the bearing shell for the cap to the recess in the cap. Install the bearing shell. Lubricate both the bearing shells and lubricate the crankshaft journal.

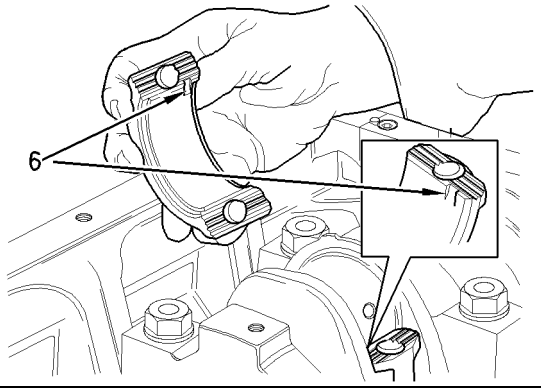


Illustration 195 g01001742
Tab for the connecting rod

4. Pull the connecting rod into position against the crankshaft journal.

5. Install the connecting rod cap (3) with the bearing shell onto the connecting rod (2).

6. Install the bolts (1) and the new nuts (5) onto the connecting rod (2). Tighten the nuts to a torque of 125 N·m (92 lb ft).

7. Repeat Steps 2 through 6 for the remaining connecting rod bearings.

Installation of the Bearing Shells for Fractured Split Connecting Rods

1. Carefully rotate the crankshaft in order to give access to the connecting rod.

2. Ensure that the components are clean before the components are assembled.

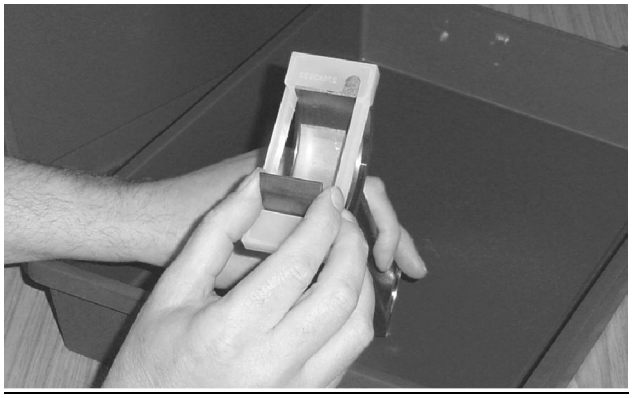


Illustration 196 g01000785
Alignment of the shell

Note: The alignment tool is supplied with the new bearing shells.

3. The bearing shell for the connecting rod must be aligned by a tool before the bearing shells are installed. Refer to illustration 196. Check the alignment of the shell and remove the tool from the assembly. The bearing shell must be an equal distance from each end. Refer to illustration 197. Lubricate both the bearing shells and lubricate the crankshaft journal.

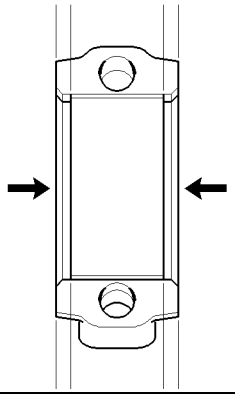


Illustration 197 g01001160
Aligned shell

4. Pull the connecting rod onto the crankshaft journal and install the correctly marked cap with the bearing shell onto the connecting rod.

Note: Do not allow the connecting rod to contact with the piston cooling jet.

Note: New torx screws must be installed.

5. Tighten the new torx screws to 20 N·m (14 lb ft).

   Refer to Testing and Adjusting, “Piston Height - Inspect” for the correct procedure on checking the height of the piston above the cylinder block.

6. Tighten the torx screws (5) to 70 N·m (51 lb ft). Again tighten the torx screws by 120 degrees.

7. Rotate the crankshaft in order to ensure that the crankshaft rotates freely.

End By:

a. Install the engine oil relief valve. Refer to Disassembly and Assembly, “Engine Oil Relief Valve - Remove and Install”.

b. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

i01851225

Crankshaft Main Bearings - Remove

Removal Procedure

Start By:

a. Remove the engine oil relief valve and the oil strainer. Refer to Disassembly and Assembly Manual, “Engine Oil Relief Valve - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: This procedure should only be used to remove the crankshaft main bearings with the crankshaft in position.

Note: Remove one pair of main bearing shells at a time. Replace the bearing shells or fit new bearing shells before removing the next pair of main bearing shells. Refer to Disassembly and Assembly Manual, “Crankshaft Main Bearings - Install” for further information on installing the main bearing shells.

Note: Remove the following components from the engine in order to remove the rear main bearing with the crankshaft in position: flywheel, flywheel housing, rear oil seal housing, and bridge assembly. Refer to Disassembly and Assembly Manual for further information on the removal of these components.

Note: Remove the front housing and the engine oil pump in order to remove the front main bearing cap. The engine oil pump is attached to the front main bearing cap. Removal of the setscrews is not possible with a socket. Refer to this Disassembly and Assembly Manual, “Engine Oil Pump - Remove” for further information on the removal of these components.

Note: There is a pair of thrust washers on both sides of the center main bearing cap in order to control side thrust. Ensure that these thrust washers are safely removed and replaced when the center main bearing shells are removed and installed. Refer to Disassembly and Assembly Manual, “Crankshaft - Remove and Crankshaft - Install” for information on the removal and installation of these thrust washers.

1. Remove all necessary components in order to gain access to the specific main bearing cap.

2. Make sure that the main bearing cap is marked for the location and direction for installation. The main bearings and the main bearing caps must be installed in the same location.

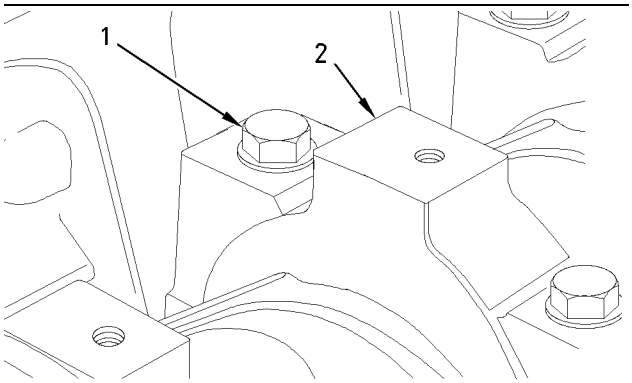


Illustration 198 g00947823

3. Remove the two setscrews (1) and the main bearing cap (2).

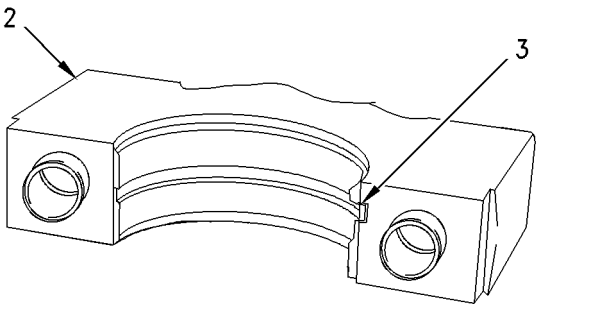


Illustration 199 g00934803

4. Remove the lower main bearing shell (3) from the lower main bearing cap (2). Keep the respective main bearing shell and the main bearing cap together for installation.

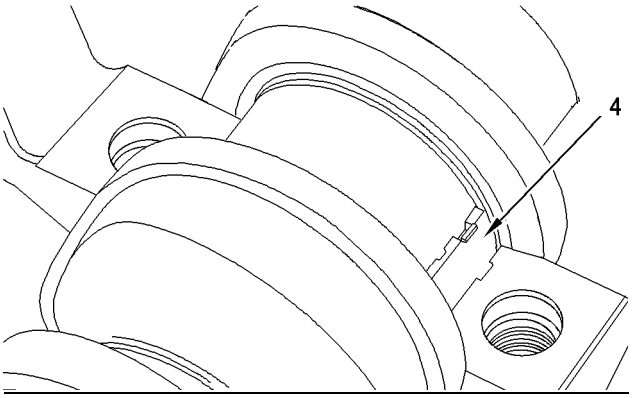


Illustration 200 g00934767

5. Push the upper main bearing shell (4) from the opposite side of the bearing tab with a suitable tool. Carefully rotate the crankshaft while you push on the bearing shell. Remove the upper main bearing shell (4) from the cylinder block. Keep the bearing halves together in order to ensure the correct installation.

6. Repeat Steps 1 through 5 for the remaining main bearings.

Note: The center main bearing is also equipped with thrust washers. Refer to Step 7 and Step 8.

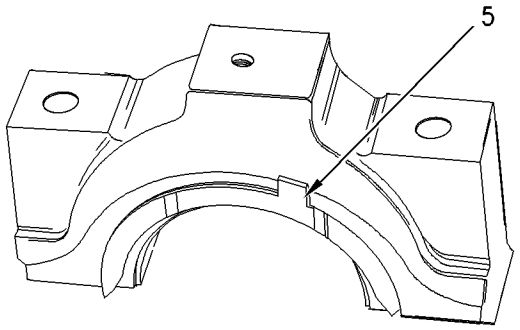


Illustration 201 g00934744

7. Remove the lower half of thrust washer (5) from the center main bearing cap.

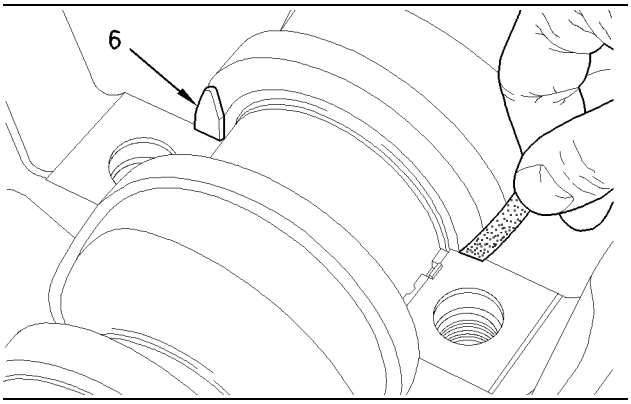


Illustration 202 g00947753

8. Remove the upper half of thrust washer (6) from the center main bearing in the cylinder block with a suitable tool. Carefully rotate the crankshaft while you push on the thrust washer (6). If necessary, move the crankshaft to the front or to the rear in order to loosen a tight thrust washer.

i01849505

Crankshaft Main Bearings - Install

Installation Procedure

Note: This procedure should only be used to replace the crankshaft main bearings with the crankshaft in position.

Note: Ensure that the correct main bearing cap is installed with the correct upper half. Also, ensure that the main bearing cap is installed correctly in relation to the upper main bearing. Refer to Step 7 for more information.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

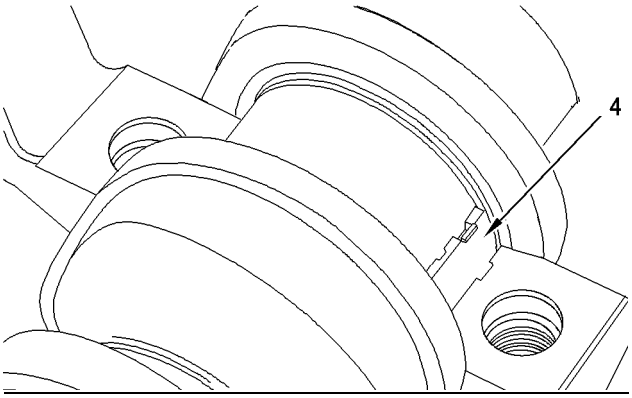


Illustration 203 g00934767

1. Clean the upper main bearing shell (4) and lubricate the surface of the bearing shell with clean engine oil.

Note: Ensure that the upper half of the main bearing shell is installed so that the tab on the bearing shell fits into the recess in the cylinder block.

NOTICE
Only the upper half of the main bearing has lubrication holes. Make sure the upper half of the main bearing is installed correctly in the cylinder block to ensure proper lubrication.

2. Slide the upper main bearing shell (4) into position between the crankshaft journal and the cylinder block.

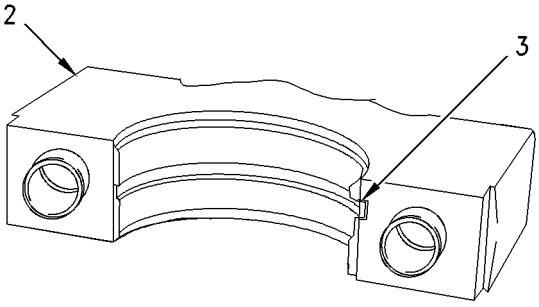


Illustration 204 g00934803

3. Clean the main bearing cap (2) and the lower main bearing shell (3). Lubricate the surface of the lower main bearing shell (3) with clean engine oil.

Note: Ensure that the lower half of the main bearing shell is installed so that the bearing tab fits into the recess in the main bearing cap.

4. Install the lower main bearing shell (3) in the main bearing cap (2).

Note: The center main bearing is also equipped with thrust washers. Only refer to Step 5 and only refer to Step 6 when you are installing the center main bearings.

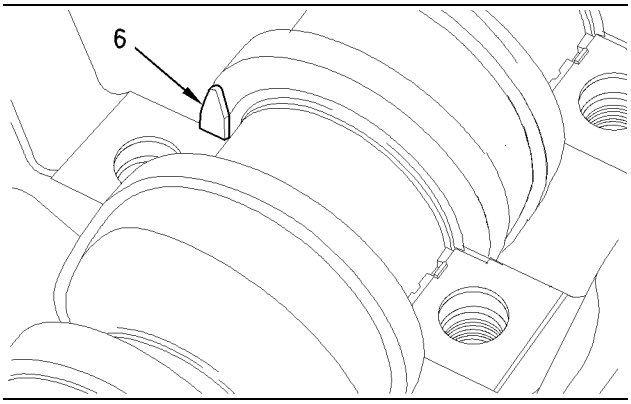


Illustration 205 g00947861

5. Install the lower half of thrust washer (6) on each side of the center main bearing cap. The grooves on the thrust washer must be located against the crankshaft.

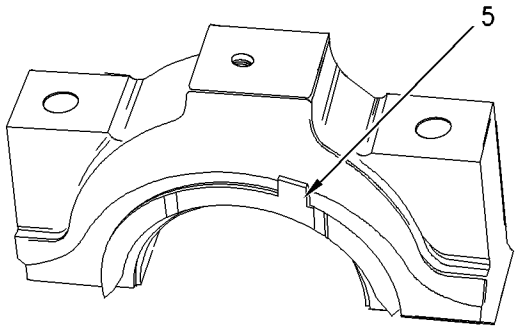


Illustration 206 g00934744

6. Install the upper half of the thrust washer (5) on each side of the center main bearing. The grooves on the thrust washer must be located against the crankshaft.

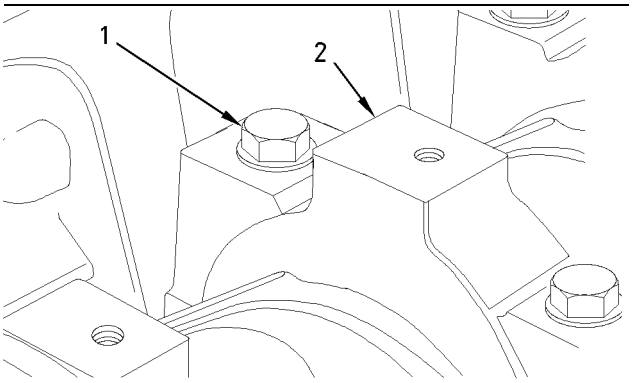


Illustration 207 g00947823

7. Make sure that the bearing tabs on both halves of the main bearing shell are located on the same side. Install the main bearing cap (2).

8. Lubricate the threads of the setscrews (1) with clean engine oil.

9. Install the setscrews (1). Lightly tighten the setscrews (1).

10. Repeat Steps 1 through 4 and Steps 7 through 9 for the remaining main bearing shells.

11. Rotate the crankshaft in order to ensure that the crankshaft turns freely.

12. Gradually tighten and evenly tighten all of the setscrews (1) to a torque of 265 N·m (195 lb ft).

13. Rotate the crankshaft again in order to ensure that the crankshaft turns freely.

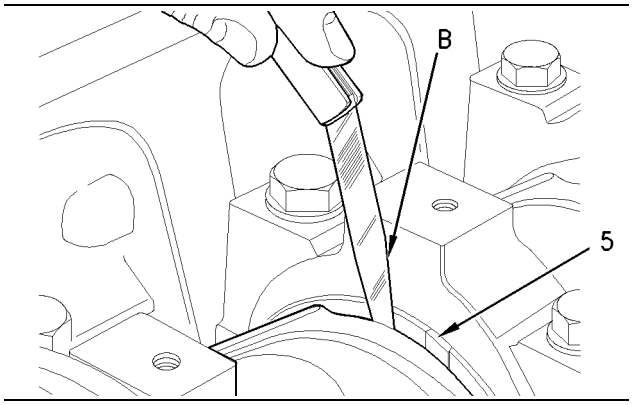


Illustration 208 g00947908

14. Check the crankshaft end play. Use a prybar to move the crankshaft toward the front of the engine. Use a suitable feeler gauge (B) to measure the end play between rear thrust washer (5) and the crankshaft. The maximum permissible crankshaft end play is 0.51 mm (0.020 inch).

Note: Install the following components if the rear main bearing was removed: bridge assembly, rear oil seal housing, flywheel housing, and flywheel. Refer to this Disassembly and Assembly Manual for more information on the installation of these components.

Note: Install the following components if the front main bearing was removed: engine oil pump and front housing. Refer to this Disassembly and Assembly Manual for further information on the installation of these components.

End By:

a. Install the engine oil relief valve and the oil strainer. Refer to this Disassembly and Assembly Manual, “Engine Oil Relief Valve - Remove and Install”.

i01846979

Crankshaft - Remove

Removal Procedure

Start By:

a. Remove the fuel injection pump. Refer to Disassembly and Assembly Manual, “Fuel Injection Pump - Remove”.

b. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Remove”.

c. Remove the timing case. Refer to Disassembly and Assembly Manual, “Housing (Front) - Remove”.

d. Remove the flywheel housing. Refer to Disassembly and Assembly Manual, “Flywheel Housing - Remove and Install”.

e. Remove the assembly of the oil seal at the rear of the crankshaft. Refer to Disassembly and Assembly Manual, “Crankshaft Rear Seal - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

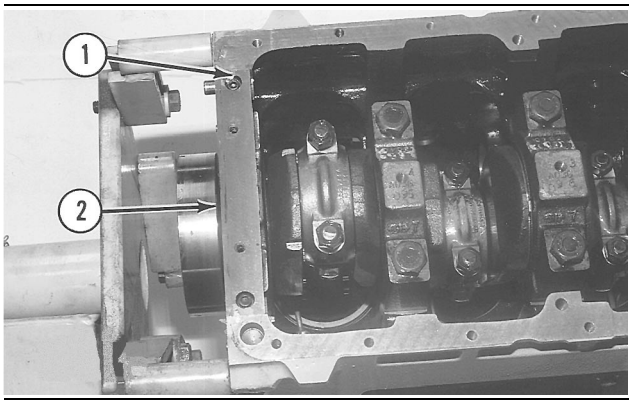


Illustration 209 g00541252
Typical example

1. Remove the allen head screws (1) from the bridge.

2. Remove the bridge (2) from the cylinder block.

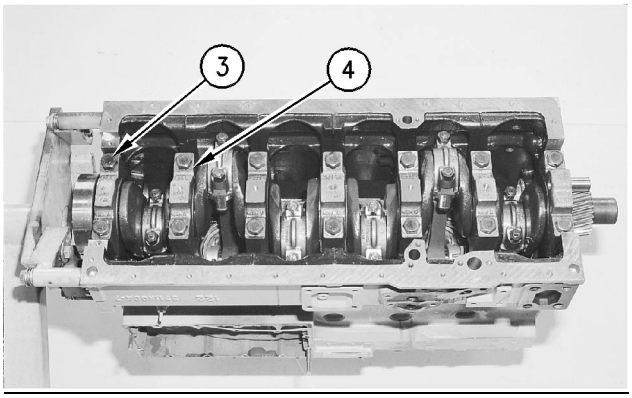


Illustration 210 g00572309
Typical example

Note: Inspect the main bearing caps and the connecting rod caps for the proper identification mark. The identification marks should give the location and the direction of the bearings in the engine.

3. Remove the setscrews for the main bearing cap (3).

4. Remove the main bearing caps (4) from the cylinder block.

5. Remove the lower main bearing shells and the lower thrust washers. Keep the lower main bearing shells with the respective main bearing cap.

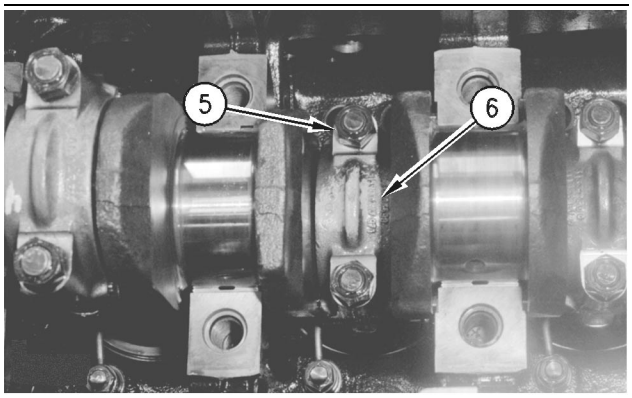


Illustration 211 g00541254

Note: Either serrated split connecting rods or fractured split connecting rods equip these engines.

Note: The cap of the serrated split connecting rod is fastened to the connecting rod by two bolts and two nuts.

Note: The cap of the fractured split connecting rod is fastened to the connecting rod by two setscrews that are threaded into the connecting rod.

6. Remove the fasteners (5) from the connecting rods.

7. Remove the connecting rod caps (6) from the connecting rods.

8. Do not remove the bearing shells from connecting rod caps (6). Ensure that the connecting rod caps are clearly identified.

NOTICE
Do not allow the connecting rods to strike the piston cooling jets. Damage or misalignment may occur.

9. Push the piston assemblies into the cylinder bores.

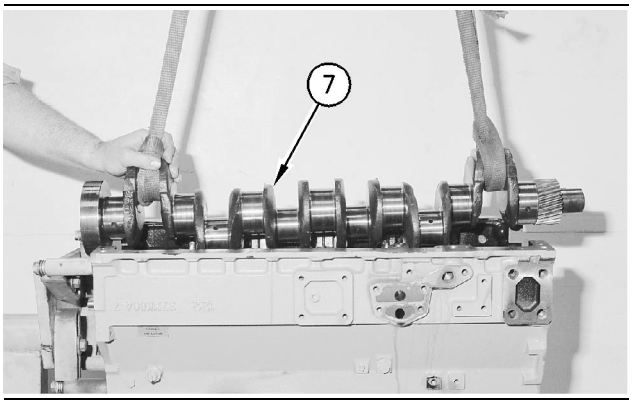


Illustration 212 g00572311
Typical example

10. Attach lifting straps and a suitable lifting device to the crankshaft (7).

Note: The crankshaft is heavy. To avoid injury, take care when the crankshaft is lifted. Also, be careful not to damage the finished surfaces of the crankshaft.

11. Lift the crankshaft (7) out of the cylinder block.

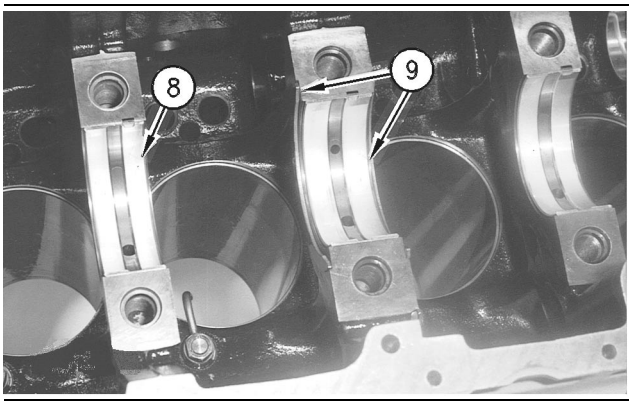


Illustration 213 g00541257

12. Remove the upper main bearing shells (8) and the upper thrust washers (9). Keep the upper bearing shells in the correct sequence so that the bearing shells can be installed correctly.

i01846933

Crankshaft - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all of the lubrication passages are clean and free of debris.

2. Clean the surface for the main bearings in the cylinder block and clean the upper main bearing shells (8).

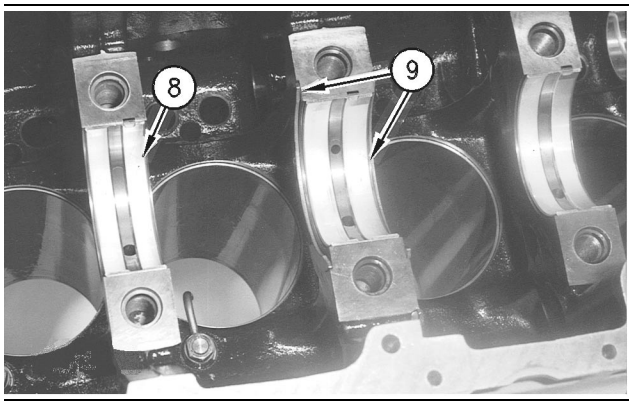


Illustration 214 g00541257

3. Install the upper main bearing shells (8). Ensure that the locating tabs for the upper main bearing shells are in the correct position in the cylinder block. Lubricate the upper main bearing shells (8) with clean engine oil.

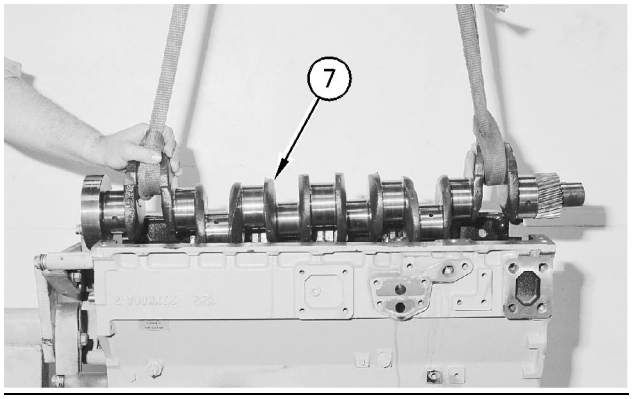


Illustration 215 g00572311
Typical example

4. Ensure that the main bearing journals of the crankshaft (7) are clean. Attach lifting straps and a suitable lifting device to the crankshaft.

Note: The crankshaft is heavy. To avoid injury, take care when the crankshaft is lifted or when the crankshaft is lowered into position. Also, be careful not to damage the finished surfaces of the crankshaft as the crankshaft is lowered into position.

5. Lift the crankshaft and lower the crankshaft into position in the cylinder block.

NOTICE
Ensure that the slotted sides of the thrust washers are toward the crankshaft.

6. Clean the upper thrust washers and lubricate the upper thrust washers (9). Place the upper thrust washers (9) in the cylinder block on both sides of the center main bearing. Refer to Illustration 214.

7. Clean the lower main bearing shells. Install the lower main bearing shells in the main bearing caps with the locating tabs in the correct position. Lubricate the lower main bearing shells with clean engine oil.

8. Clean the lower thrust washers and lubricate the lower thrust washers. Place the lower thrust washers in the center main bearing cap.

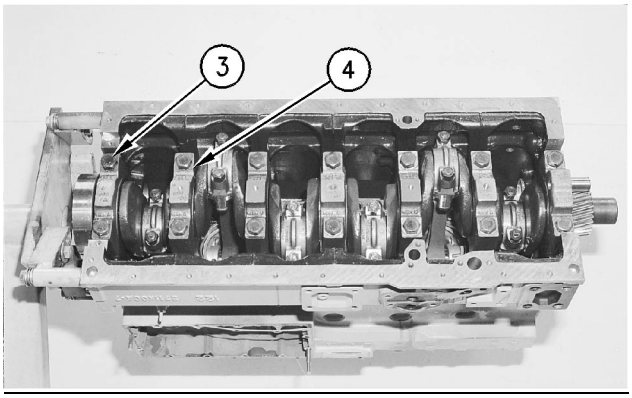


Illustration 216 g00572309
Typical example

9. Ensure that the dowels for the main bearing caps (4) are in the correct position in the main bearing caps or in the cylinder block. Install the main bearing caps (4) in the position that is marked during the removal process. All of the locating tabs on the main bearings should be on the same side. The serial number that is stamped on the main bearing cap should match the number that is stamped on the bottom face of the cylinder block.

10. Install the main bearing cap bolts and lightly tighten all of the main bearing cap bolts (3).

11. Rotate the engine in order to ensure that the crankshaft turns freely.

12. Gradually tighten and evenly tighten all of the main bearing cap bolts (3) to a torque of 265 N·m (195 lb ft).

13. Rotate the engine again in order to ensure that the crankshaft turns freely.

14. Check the crankshaft end play. Force the crankshaft toward the front of the engine and insert a feeler gauge between the rear thrust washer and the crankshaft. Alternatively, install a dial indicator to one end of the crankshaft. Force the crankshaft to the front of the engine and then force the crankshaft to the rear of the engine. Note the variation on the dial indicator. The maximum permissible crankshaft end play is 0.51 mm (0.020 inch).

Note: Either serrated split connecting rods or fractured split connecting rods equip these engines.

Note: The cap of the serrated split connecting rod is fastened to the connecting rod by two bolts and two nuts.

Note: The cap of the fractured split connecting rod is fastened to the connecting rod by two bolts that are threaded into the connecting rod.

15. Bring the connecting rods close to the crankshaft journals. Clean the bearing shells and inspect the bearing shells for the connecting rods. Clean the bearing shells and inspect the bearing shells for the connecting rod caps. If the bearing shells need to be replaced refer to this Disassembly and Assembly Manual, “Connecting Rod Bearing - Remove and Connecting Rod Bearings - Install” for further information.

16. If the bearing shells for the connecting rods do not need to be replaced, apply clean engine oil to the bearing shells of the connecting rod and the connecting rod cap.

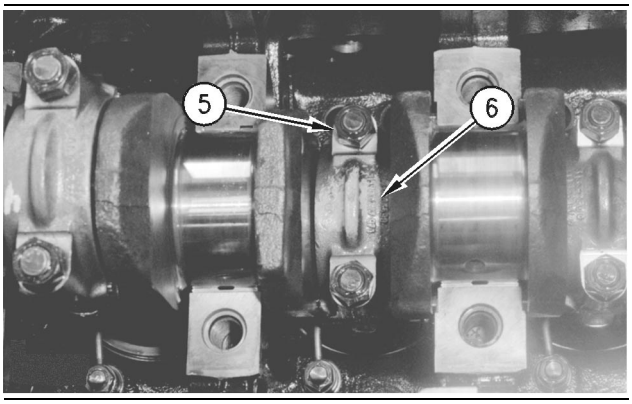


Illustration 217 g00541254

17. Install the connecting rods on the crankshaft journals. Ensure that the correct connecting rod cap is installed to the correct connecting rod. Ensure that the connecting rod cap is installed in the correct orientation. Install the connecting rod caps (6) and the fasteners for the connecting rod caps (5).

18. Tighten the fasteners for the connecting rod caps. For connecting rods with serrated caps, tighten the bolts to a torque of 125 N·m (92 lb ft). Fractured split connecting rods are tightened twice. First, tighten the bolts to a torque of 70 N·m (52 lb ft). Then tighten the bolts by 120 degrees of rotation. Refer to this Disassembly and Assembly Manual, “Pistons and Connecting Rods - Install” for further information.

19. Rotate the engine in order to ensure that the crankshaft rotates freely.

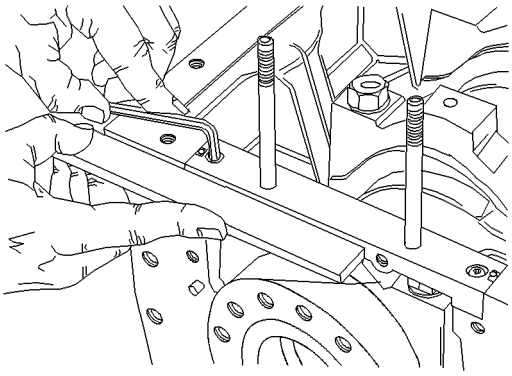


Illustration 218 g00541499

Typical example

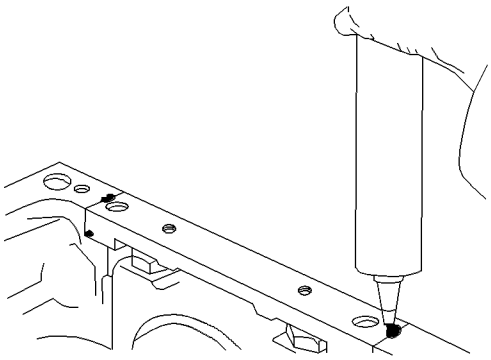


Illustration 219 g00541498

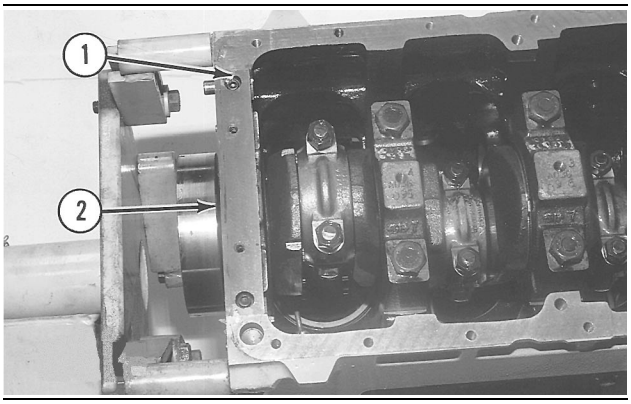


Illustration 220 g00541252

This is a typical example as the crankshaft timing ring is not shown.

20. Clean the bridge (2) and the bridge contact surfaces on the cylinder block. Use a straight edge to ensure that the bridge is in line with the rear face of the cylinder block. Install the allen head screws (1) for the bridge. Ensure that the protrusion of the bridge from the cylinder block is within these limits 0.0 ± 0.05 mm (0.0000 ± 0.002 inch). Tighten the allen head screws for the bridge to a torque of 16 N·m (12 lb ft). Apply a thin bead of 1861108 POWERPART Silicone Sealant into the groove on the bottom face of the bridge. Refer to illustration 219. Continue to inject the sealant into the groove until the sealant appears at all of the corners of the seat for the bridge.

End By:

a. Install the assembly of the oil seal at the rear end of the crankshaft. Refer to Disassembly and Assembly Manual, “Crankshaft Rear Seal - Install”.

b. Install the flywheel housing. Refer to Disassembly and Assembly Manual, “Flywheel Housng - Remove and Install”.

c. Install the housing (front). Refer to Disassembly and Assembly Manual, “Housing (Front) - Install”.

d. Install the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Install”.

e. Install the fuel injection pump. Refer to Disassembly and Assembly Manual, “Fuel Injection Pump - Install”.

i01933334

Crankshaft Timing Ring - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft. Refer to Disassembly and Assembly Manual, “Crankshaft - Remove”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Do Not apply heat to the crankshaft. Apply heat to the crankshaft timing ring only.

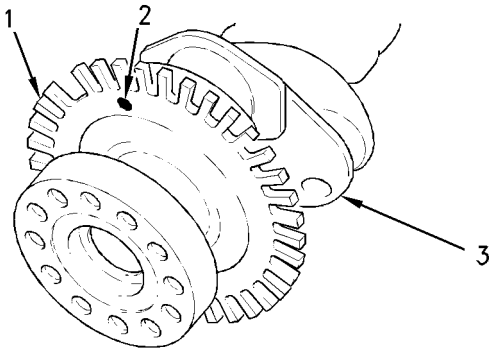


Illustration 221 g00946389

1. Support the crankshaft (3) in a vertical position with the crankshaft flange at the bottom.

Note: If a crankshaft wear sleeve (rear) is installed on the crankshaft, the shoulder of the crankshaft wear sleeve (rear) must be removed in order to provide clearance for removing the crankshaft timing ring.

2. Apply heat to the crankshaft timing ring (1) in order to remove the crankshaft timing ring from the crankshaft. The temperature must not exceed 270 °C (518 °F).

3. Allow the crankshaft timing ring to cool. Discard the crankshaft timing ring.

Note: Do not remove the dowel (2) from the crankshaft, unless the dowel has been damaged.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

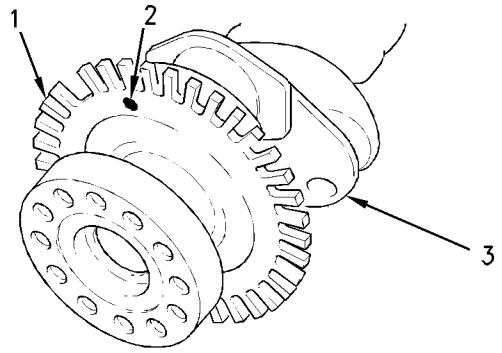


Illustration 222 g00946389

1. Ensure that the bore of the crankshaft timing ring and the location shoulder on the crankshaft are clean and free from rough edges.

2. If the dowel (2) was removed, install a new dowel in the web of the crankshaft (3).

3. Heat the crankshaft timing ring in an oven to 250 °C (482 °F).

4. Support the crankshaft in a vertical position with the crankshaft flange at the top.

5. Position the crankshaft timing ring with the chamfer and the groove toward the crankshaft web. Align the dowel (2) in the crankshaft with the hole in the crankshaft timing ring (1). Immediately install the crankshaft timing ring against the web of the crankshaft.

6. Allow the crankshaft timing ring to cool.

End By:

a. Install the crankshaft. Refer to Disassembly and Assembly Manual, “Crankshaft - Install”.

i01920056

Crankshaft Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

b. Remove the front cover. Refer to Disassembly and Assembly Manual, “Front Cover - Remove”.

Note: Rotate the crankshaft until the timing marks on the crankshaft gear, the camshaft gear, and the idler gear are aligned.

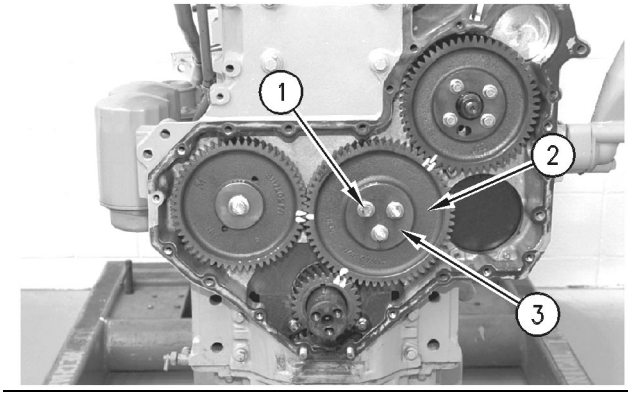


Illustration 223 g00556563
Typical example

1. Remove the setscrews (1) from the idler gear (2).

2. Remove the idler gear (2) and the retainer plate (3).

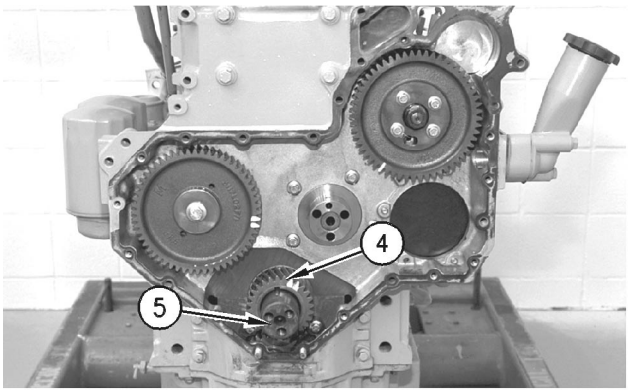
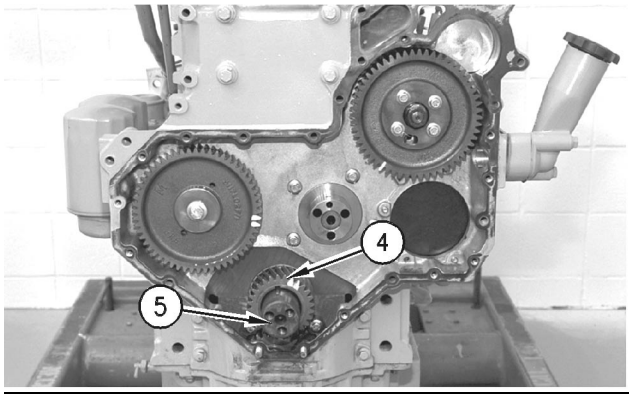


Illustration 224 g00556666
Typical example

3. Use a suitable puller to remove the crankshaft gear (4) from the crankshaft (5).

Note: Do not use a flame on the crankshaft gear for removal purposes.

Installation Procedure



g00556666

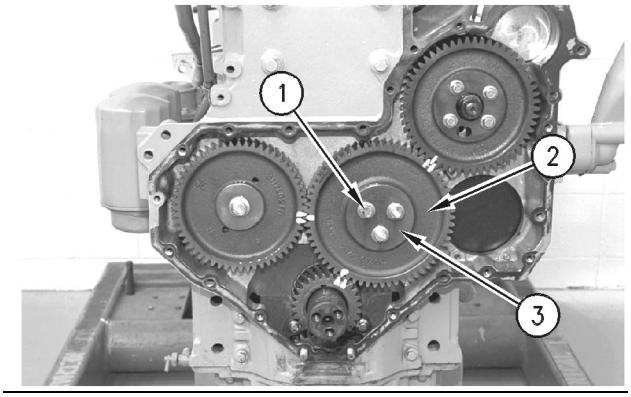
Illustration 225

Typical example

1. Inspect the woodruff key for the crankshaft gear. Replace the woodruff key if it is necessary.

2. The crankshaft gear may be a hand push fit on the crankshaft. If the crankshaft gear is not a hand push fit, heat the crankshaft gear (4) in an oven to no more than 200 °C (392 °F).

3. Align the crankshaft gear with the woodruff key in the crankshaft. Install the crankshaft gear (4) on the crankshaft (5) with the timing marks toward the front.



g00556563

Illustration 226

Typical example

4. Install the idler gear (2). Refer to Disassembly and Assembly Manual, “Idler Gear - Remove and Install” for further details.

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Install”.

b. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install”.

i01936102

Bearing Clearance - Check

Measurement Procedure

Table 24

Required Tools	
Description	**Qty**
Plastic Gauge (Green) 0.025 to 0.076 mm (0.001 to 0.003 inch)	1
Plastic Gauge (Red) 0.051 to 0.152 mm (0.002 to 0.006 inch)	1
Plastic Gauge (Blue) 0.102 to 0.229 mm (0.004 to 0.009 inch)	1
Plastic Gauge (Yellow) 0.230 to 0.510 mm (0.009 to 0.020 inch)	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Perkins does not recommend the checking of the actual clearances of the bearing shell particularly on small engines. This is because of the possibility of obtaining inaccurate results and the possibility of damaging the bearing shell or the journal surfaces. Each Perkins bearing shell is quality checked by Perkins for specific wall thickness.

Note: The measurements should be within specifications and the correct bearing shells should be used. No further checks are necessary if the main journals and the bearing shells were measured during the disassembly of the engine. No further checks are necessary if the crank pins of the crankshaft and the bearing shells were checked during the disassembly of the connecting rods. However, Plastic Gauge is an acceptable method if the technician still wants to measure the clearance of the bearing shell. Plastic Gauge is less accurate on journals with small diameters if clearances are less than 0.10 mm (0.004 inch).

NOTICE
Lead wire, shim stock or a dial bore gauge can damage the bearing surfaces.

The technician must be very careful to use Plastic Gauge correctly. The following points must be remembered:

- Ensure that the backs of the bearing shells and the bores for the bearing shells are clean and dry.
- If the bearing shells have locking tabs ensure that the locking tabs are properly seated in the tab grooves.
- The crankshaft must be free of oil at the contact points of Plastic Gauge.

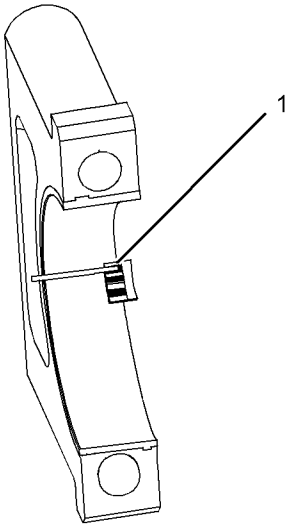


Illustration 227 g01010832
Typical example

1. Put a piece of Plastic Gauge (1) on the crown of the bearing that is in the cap.

Note: Do not allow the Plastic Gauge (1) to extend beyond the edge of the bearing shell.

2. Use the correct torque-turn specifications in order to install the bearing cap. Do not use an impact wrench. Be careful not to dislodge the bearing shell when the cap is installed.

Note: Do not turn the crankshaft when the Plastic Gauge (1) is installed.

3. Carefully remove the bearing cap, but do not remove the Plastic Gauge (1). Measure the width of the Plastic Gauge (1) while the Plastic Gauge is in the bearing cap or on the crankshaft journal. Refer to illustration 227.

4. Remove all of the Plastic Gauge (1) before you install the bearing cap.

Note: When Plastic Gauge is used, the readings can sometimes be unclear. For example, all parts of the Plastic Gauge are not the same width. Measure the major width in order to ensure that the parts are within the specification range. Refer to the Specifications Manual, “Connecting Rod Bearing Journal” and refer to the Specifications Manual, “Main Bearing Journal” for the correct clearances.

i01846906

Coolant Temperature Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system to a level below the engine coolant temperature sensor into a suitable container for storage or disposal.

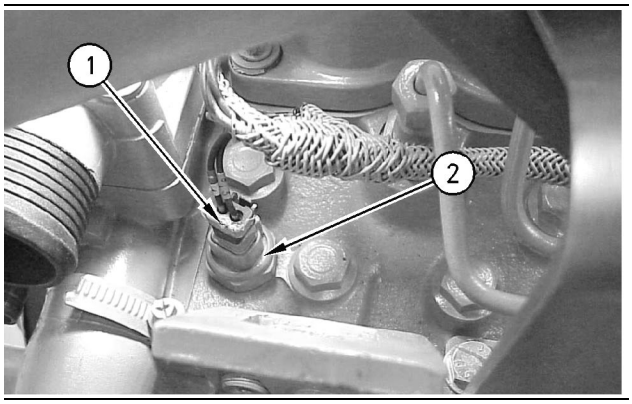


Illustration 228 g00906586

2. Disconnect the harness assembly (1).

3. Remove the coolant temperature sensor (2).

4. Remove the O ring from the sensor and discard the O ring.

Installation Procedure

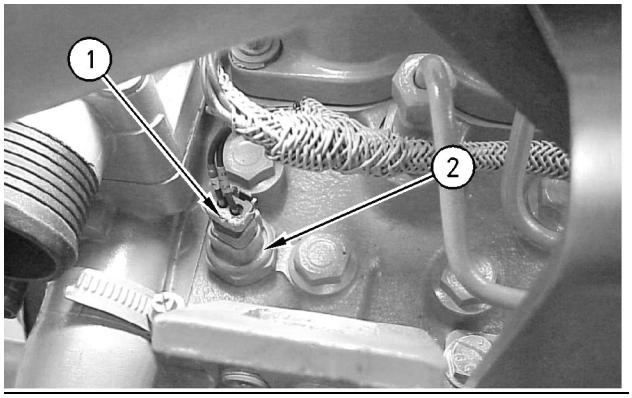


Illustration 229 g00906586

1. Ensure that the threads of the sensor and the thread in the cylinder head are clean and free from damage.

2. Install a new O ring to the engine coolant temperature sensor.

3. Install the engine coolant temperature sensor (2).

4. Tighten the engine coolant temperature sensor to a torque of 20 N·m (15 lb ft).

5. Carefully connect the harness assembly (1). Lightly pull the harness connector in order to ensure that the two halves of the connector are locked together.

6. Fill the cooling system to the correct level.

i01853423

Engine Oil Pressure Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

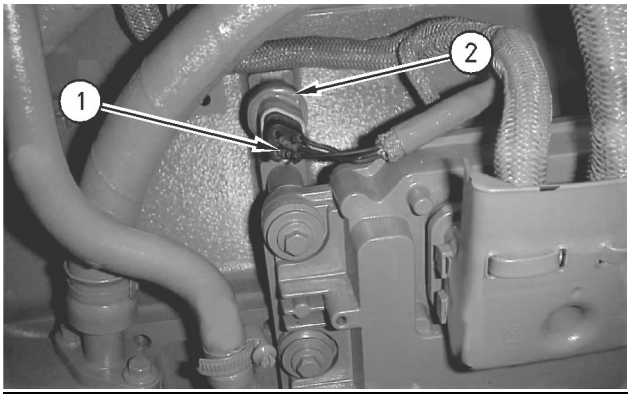


Illustration 230 g00906761

1. Remove the harness assembly (1) from the engine oil pressure sensor (2).

2. Remove the engine oil pressure sensor (2).

3. Remove the O ring from the sensor and discard the O ring.

Installation Procedure

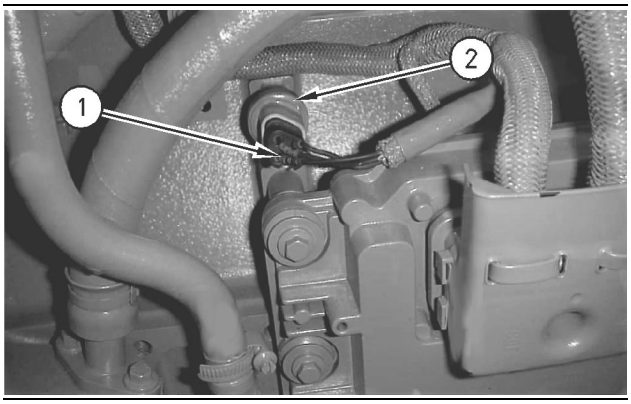


Illustration 231 g00906761

1. Ensure that the threads of the sensor and the thread in the cylinder block are clean and free from damage.
2. Install a new O ring to the engine oil pressure sensor.
3. Install the engine oil pressure sensor (2).
4. Tighten the engine oil pressure sensor to a torque of 10 N·m (7 lb ft).
5. Carefully connect the harness assembly (1) to the engine oil pressure sensor (2). Lightly pull the harness connector in order to ensure that the two halves of the connector are locked together.

i01920074

Speed/Timing Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

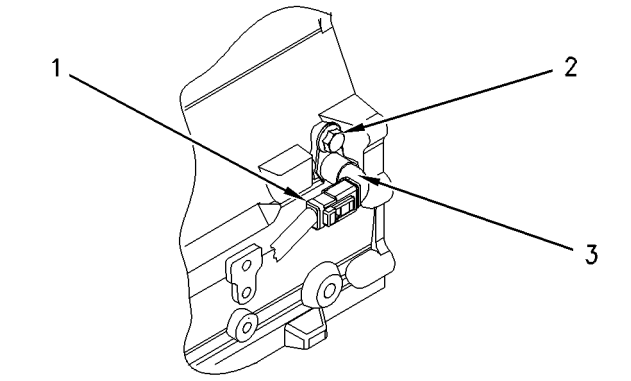


Illustration 232 g00990748

1. Disconnect the harness assembly (1).
2. Remove the setscrew (2).
3. Carefully remove speed/timing sensor (3) from the cylinder block.
4. Remove the O ring from the sensor and discard the O ring.

Installation Procedure

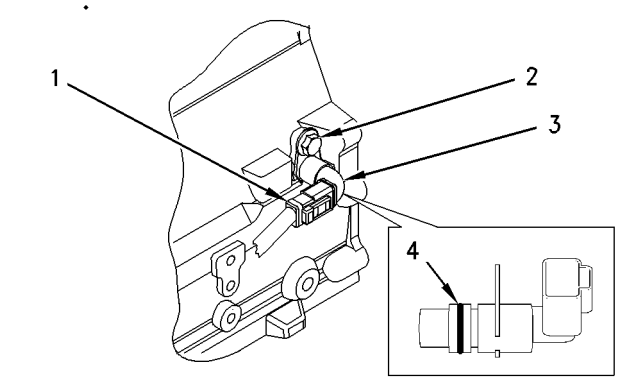


Illustration 233 g00990801

1. Ensure that the sensor and the hole in the cylinder block for the sensor are clean.
2. Install a new O-ring seal (4) in the first groove on the speed/timing sensor (3). Lubricate the O-ring seal with clean engine oil.
3. Position the speed/timing sensor (3) completely against the cylinder block. Align the hole in the bracket with the hole in the cylinder block.

Note: Do Not use setscrew (2) to pull the speed/timing sensor into position against the cylinder block.

4. Install the setscrew (2). Tighten the setscrew (2) to a torque of 22 N·m (16 lb ft).

5. Carefully connect the harness assembly (1). Lightly pull the harness connector in order to ensure that the two halves of the connector are locked together.

i01920120

Inlet Air Temperature Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

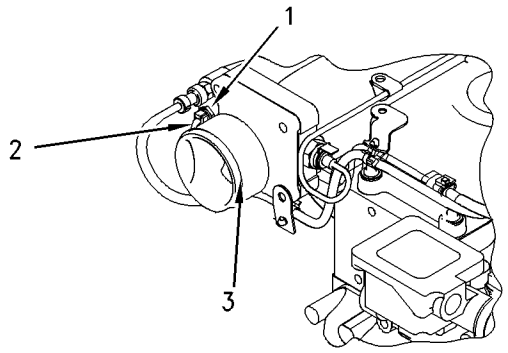


Illustration 234 g00935885

1. Disconnect the harness assembly (1).

2. Remove the intake manifold air temperature sensor (2) from the adapter of the air intake (3).

3. Remove the O ring from the sensor and discard the O ring.

Installation Procedure

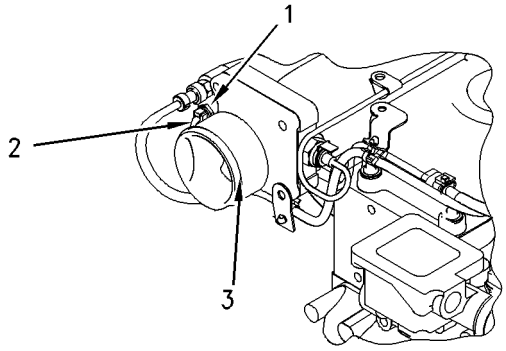


Illustration 235 g00935885

1. Ensure that the threads of the sensor and the thread in the intake manifold are clean and free from damage.

2. Install a new O ring to the intake manifold air temperature sensor (2).

3. Tighten the intake manifold air temperature sensor (2) to a torque of 20 N·m (15 lb ft).

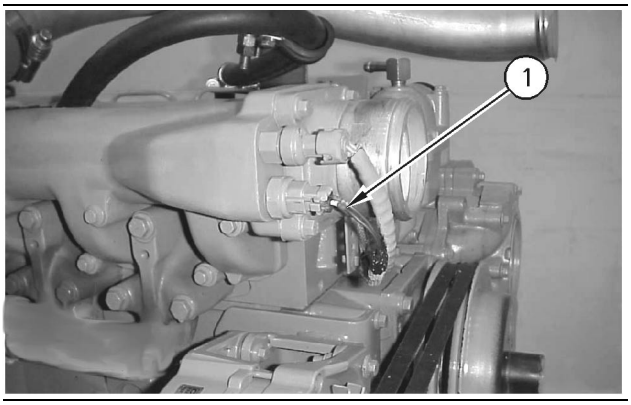


Illustration 236 g00906813

4. Carefully connect the harness assembly (1) to the intake manifold air temperature sensor (2). Lightly pull the harness connector in order to ensure that the two halves of the connector are locked together.

i01857456

V-Belts - Remove and Install

Removal Procedure

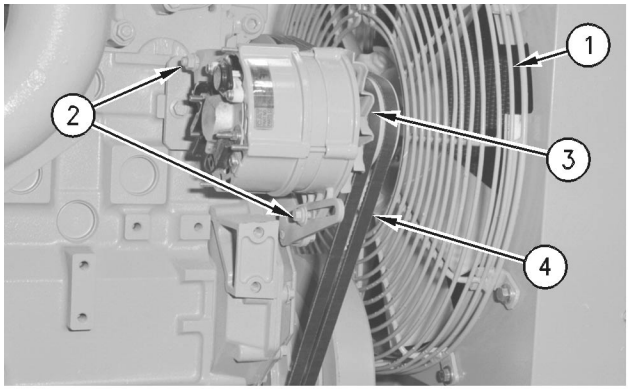


Illustration 237 g00540870

Typical example

1. If equipped, loosen all of the setscrews that fasten the fan guard assembly to the fan shroud. If equipped, remove the fan guard assembly (1) from the fan shroud.
2. Loosen the bolts (2) and slide the alternator (3) toward the engine.
3. Maneuver the V-belts (4) around the fan and remove the V-belts.

Note: Never replace one V-belt. Always replace sets of V-belts.

Installation Procedure

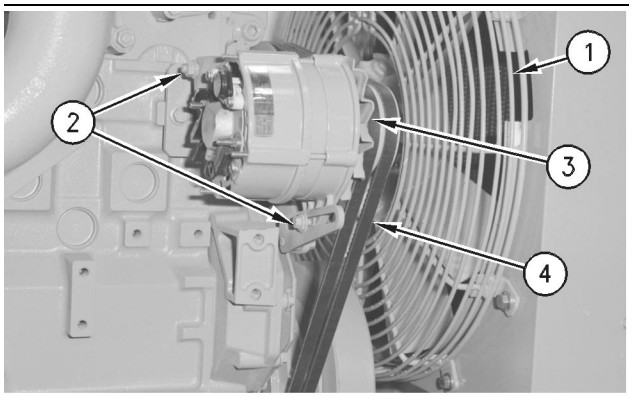


Illustration 238 g00540870

Typical example

1. Install the V-belts (4) behind the fan and on the correct pulleys.
2. Slide the alternator (3) away from the engine. Tighten the bolts (2) and check the belt tension. Refer to the Systems Operation/Testing and Adjusting Manual, “V-Belt - Test” for the correct belt tension.
3. If equipped, put the fan guard assembly (1) in position on the fan shroud. Install the setscrews that fasten the fan guard assembly to the fan shroud.

i01913127

Fan - Remove and Install

Removal Procedure

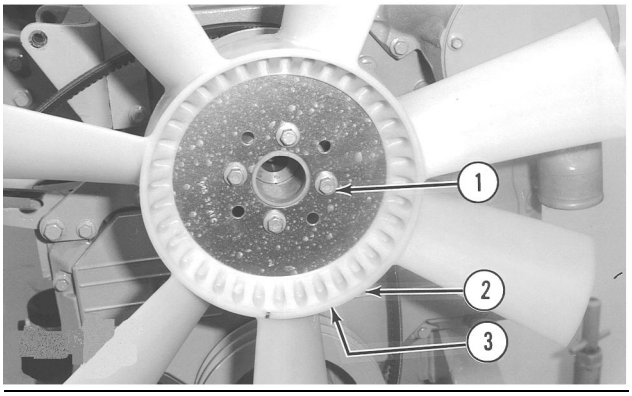


Illustration 239 g00542576

1. Remove the setscrews (1).
2. Remove the fan (2).
3. Remove the extension (3).

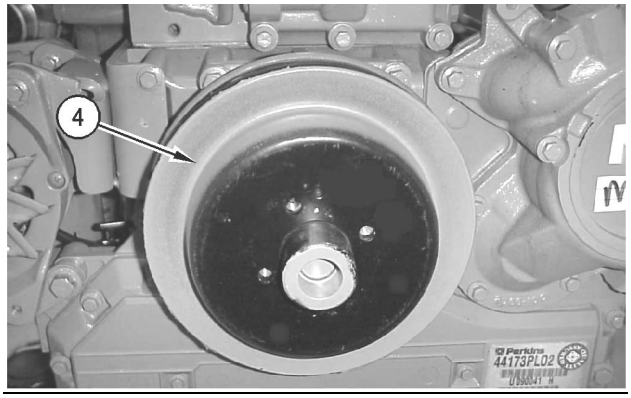


Illustration 240 g00907071

4. Remove the fan pulley (4).

Installation Procedure

1. Inspect the condition of the fan pulley (4).

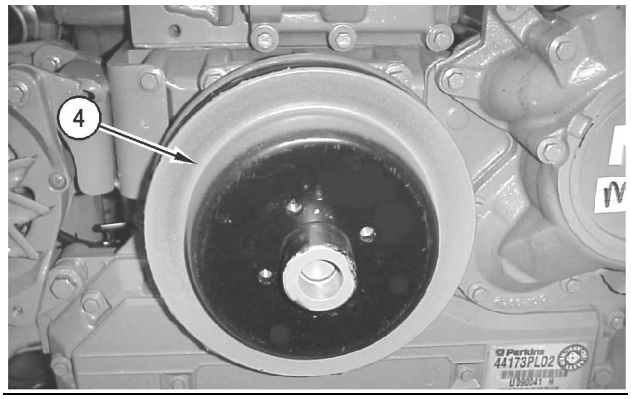


Illustration 241 g00907071

2. Replace the fan pulley (4) or install a new fan pulley if it is necessary.

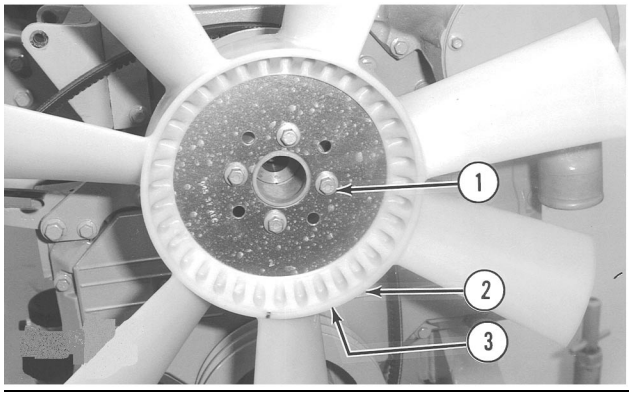


Illustration 242 g00542576

3. Install the extension (3).

4. Install the fan (2).

5. Install the setscrews (1). Tighten the setscrews to a torque of 12 N·m (9 lb ft).

i01913218

Fan Drive - Remove and Install

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

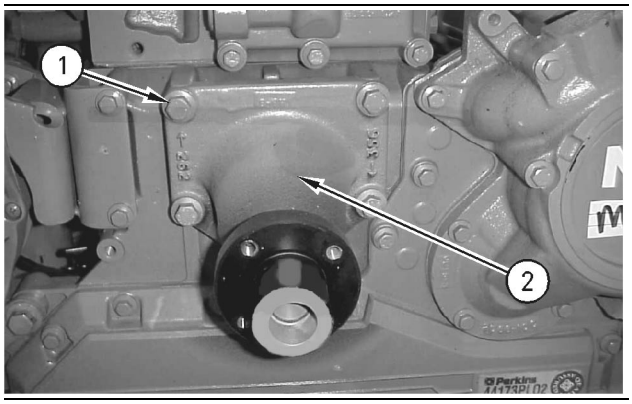


Illustration 243 g00907103

1. Remove the setscrews (1) from the fan drive (2).

2. Remove the fan drive (2).

Installation Procedure

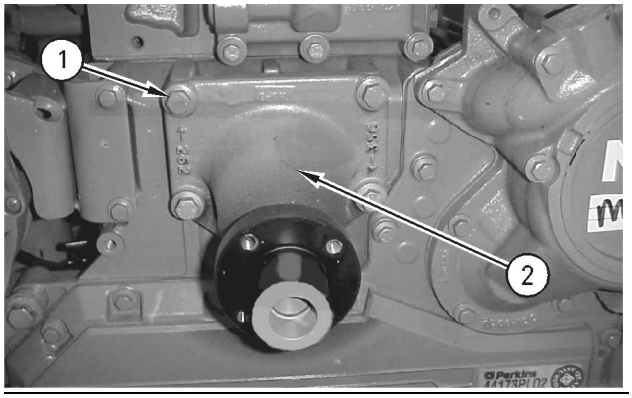


Illustration 244 g00907103

1. Install the fan drive (2).

2. Install the setscrews (1) for the fan drive (2).

3. Tighten the setscrews (1) to a torque of 44 N·m (32 lb ft).

End By:

a. Install the fan. Refer to Disassembly and Assembly Manual, “Fan - Remove and Install”.

i01895190

Alternator - Remove

Removal Procedure

1. Disconnect the electrical wires from the alternator.

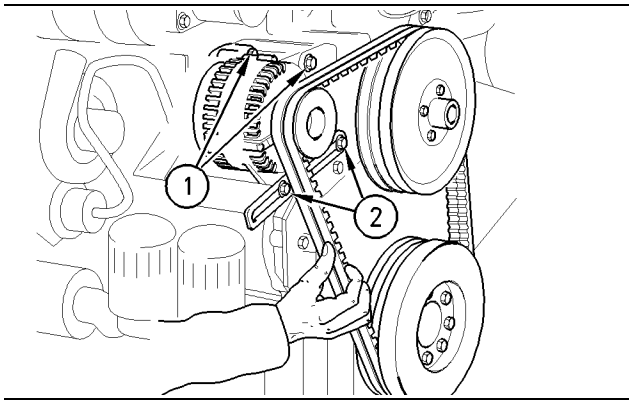


Illustration 245 g00999586

2. Loosen the fasteners for the pivot (1) from the alternator bracket.

3. Loosen the fasteners for the adjustment link (2) and slide the alternator toward the engine in order to slacken the V-belts. Remove the V-belts from the pulley.

4. Remove the fasteners for the adjustment link (2) and remove the adjustment link from the alternator.

5. Support the alternator. Remove the fasteners for the pivot (1) and remove the alternator from the engine.

i01844640

Alternator - Install

Installation Procedure

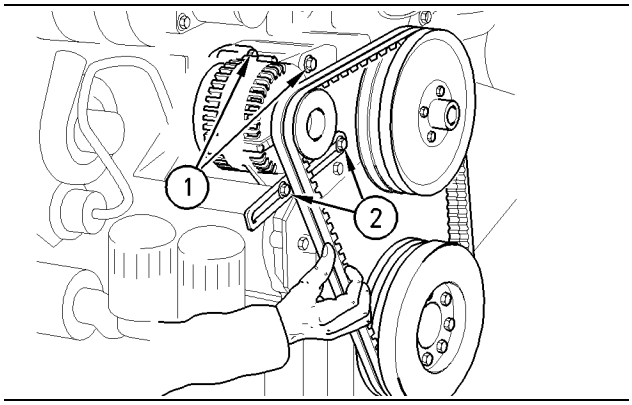


Illustration 246 g00999586

1. Put the alternator in position on the alternator bracket on the engine.

2. Install the fasteners for the pivot (1) and tighten finger tight.

3. Install the adjustment link and the fasteners (2) for the adjustment link. Tighten the fasteners (2) finger tight.

4. Install the V-belts in position on the pulley. Adjust the tension on the V-belts by moving the alternator away from the engine. Tighten the fasteners (2) for the adjustment link after the correct belt tension has been set. Refer to the Systems Operation/Testing and Adjusting Manual, “V-Belt Test” for the correct tension of the V-belts. Tighten fasteners (2) for the adjustment link to a torque of 78 N·m (58 lb ft).

5. Tighten the fasteners for the pivot (1) in order to secure the alternator in position on the engine to a torque of 22 N·m (16 lb ft).

6. Reconnect the electrical wires to the alternator. Refer to the Specifications Manual, “Alternator” for the correct torques for the terminal nuts.

i01851731

Electronic Control Module - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

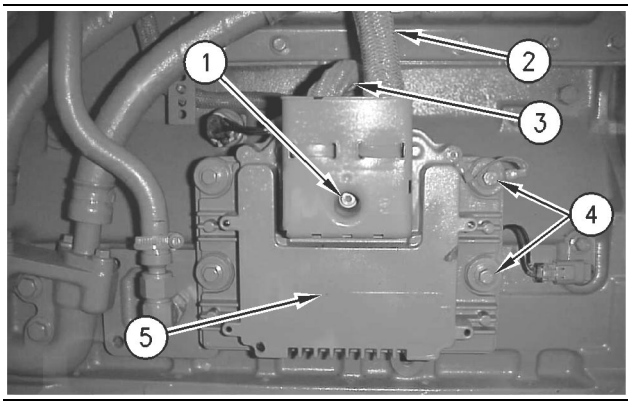


Illustration 247 g00906885

1. Loosen the screw (1). Carefully separate the connector assemblies (2) and (3) from the electronic control module in order to ensure that the connector pins are not damaged.

2. Remove the four setscrews (4), washers and rubber bushes. Ensure that the ECM ground strap is safely secured in order to prevent any damage.

3. Remove the electronic control module (5) from the engine.

Installation Procedure

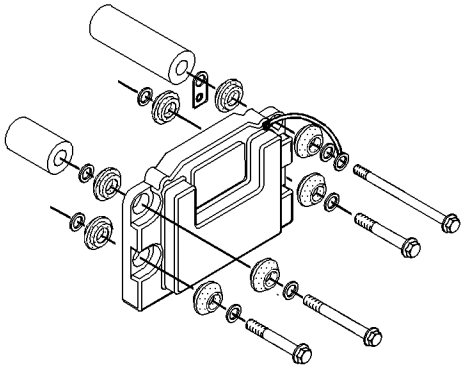


Illustration 248 g00938787

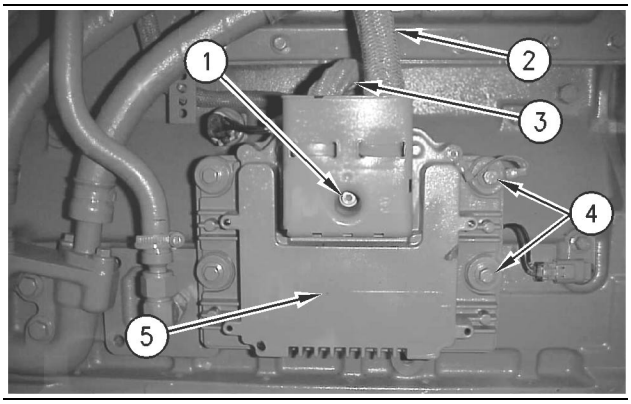


Illustration 249 g00906885

1. Inspect the rubber bushes. If necessary, renew the rubber bushes. Install the rubber bushes and install the washers. Install the electronic control module (5).

2. Reconnect the ECM ground strap. Install the setscrews (4). Tighten the setscrews to a torque of 22 N·m (16 lb ft).

3. Carefully reconnect the harness assemblies (3) and (2) in order not to damage the connector pins.

Note: Do not use the screw (1) to pull the connectors together as this will damage the connectors.

4. Carefully tighten the screw (1) to a torque of 6 N·m (4 lb ft).

i01978001

Voltage Load Protection Module - Remove and Install

Removal Procedure

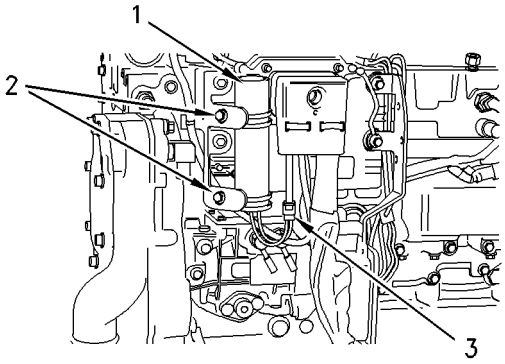


Illustration 250 g01001810

1. Disconnect harness assembly (3).

2. Remove setscrews (2).

3. Remove voltage load protection module (1).

Installation Procedure

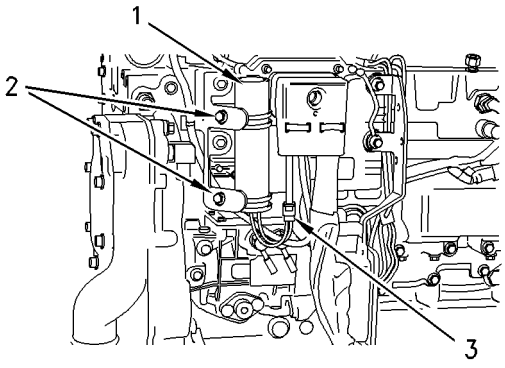


Illustration 251 g01001810

1. Position voltage load protection module (1) and install setscrews (2). Tighten the bolts to a torque of 22 N·m (16 lb ft).

2. Connect harness assembly (3).

i01851643

Electric Starting Motor - Remove and Install

Removal Procedure

⚠ WARNING

To avoid personal injury from electrical shock, ensure that the negative battery cable is disconnected first.

NOTICE
Care must be taken to avoid damage to the engine speed and timing sensor fitted to the cylinder block when a starter motor is removed from, or fitted to, the left side of the engine.

Note: The starter motor may be fastened to the flywheel housing by either setscrews or studs and nuts.

1. Disconnect the electrical wires from the electric starter motor.
2. Remove the fasteners and remove the starter motor from the flywheel housing.

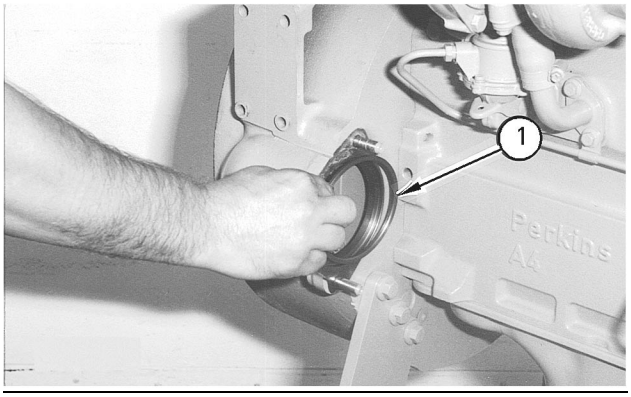


Illustration 252 g00996231

Note: The starter motor may have an O ring on the flange of the starter motor.

3. Remove the O ring (1) (if equipped) from the flywheel housing.

Installation Procedure

1. Inspect the O ring (1) (if equipped). If necessary, renew the O ring. Install the O ring into the flywheel housing.
2. Install the starter motor on the flywheel housing.
3. Install the fasteners for the starter motor. Tighten the fasteners for the starter motor to a torque of 44 N·m (32 lb ft).
4. Connect the electrical wires to the starter motor.

i01933335

Air Compressor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

1. Drain the engine cooling system.

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

2. Release the air pressure in the system.

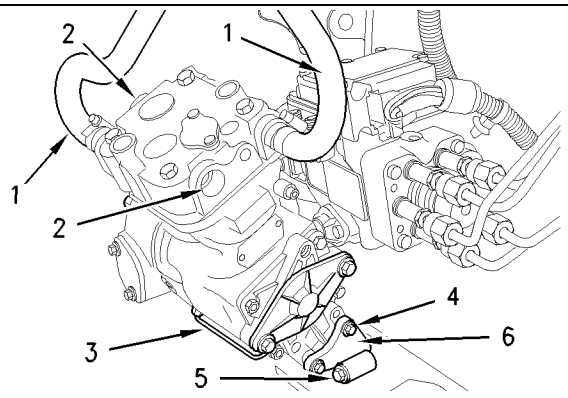


Illustration 253 g01006202

Typical example

3. Disconnect the two coolant hoses (1) and the two air lines from the ports (2) in the cylinder head of the air compressor. Remove the supply pipe for the lubricating oil (3) from the air compressor.

4. Remove the hydraulic pump if one is installed from the rear of the air compressor.

5. Ensure that the No. 1 cylinder is at top dead center on the compression stroke. Refer to the Systems Operation, Testing and Adjusting Manual, “Finding Top Center Position for No. 1 Piston”.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

6. Remove the two setscrews (4) at the rear of the air compressor. Remove the two setscrews (5) from the support bracket (6) and remove the support bracket.

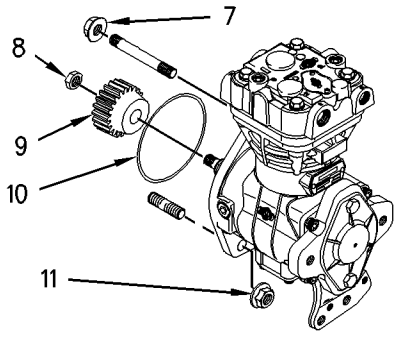


Illustration 254 g00947132

Typical example

7. Support the air compressor. Remove the nut (7) from the front cover of the housing (front) if the nut was not previously removed.

8. Remove the nut (11) from the flange of the air compressor and withdraw the air compressor from the housing (front).

9. Remove the O-ring (10) from the face of the flange on the air compressor.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the product. Be prepared to collect the fluid with suitable containers before opening any compartment or disassembling any component containing fluids.

Dispose of all fluids according to local regulations and mandates.

Note: These engines are usually equipped with one of two types of air compressor: an air compressor with a DIN drive and an air compressor with a SAE drive.

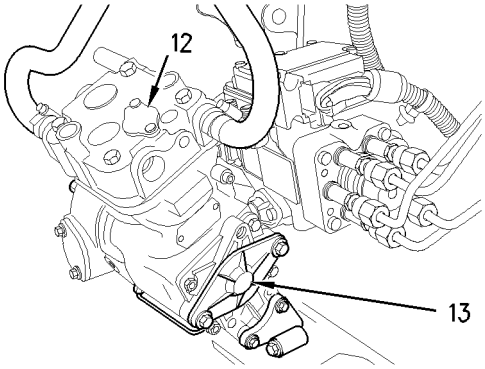


Illustration 255 g01006225

Illustration 255 is an air compressor with a top unloader valve (12) and a DIN drive (13). The air compressor may not be equipped with the unloader valve (12). The unloader valve may be installed in the air line.

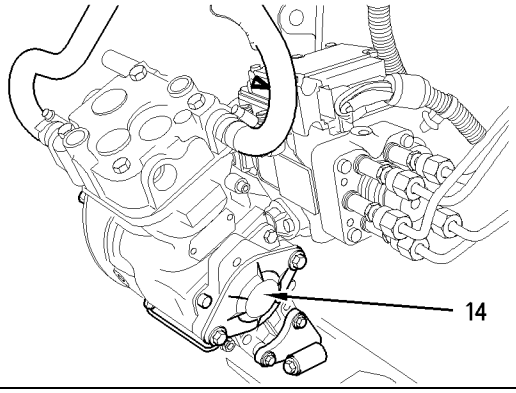


Illustration 256 g01006235

Illustration 256 is an air compressor with a SAE drive (14).

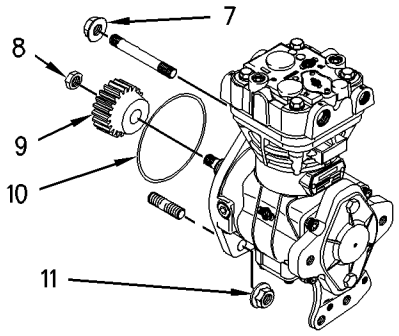


Illustration 257 g00947132

Typical example

1. Ensure that the No. 1 cylinder is at top dead center on the compression stroke. Refer to the Systems Operation, Testing and Adjusting Manual, “Finding Top Center Position for No. 1 Piston”.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

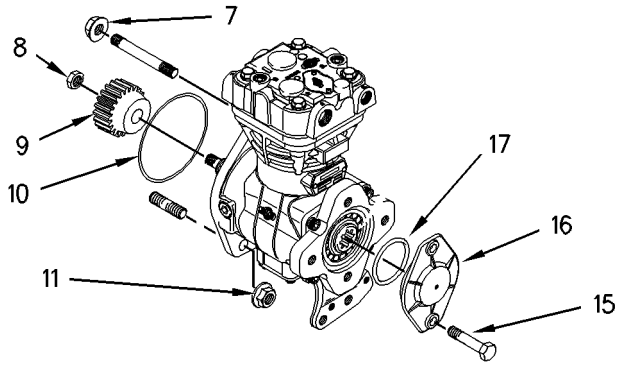


Illustration 258 g01006286

Typical example

2. Lubricate a new O-ring (10) with clean engine lubricating oil. Install the O-ring (10) into the recess in the flange of the air compressor.

3. Remove the setscrews (15) and remove the cover (16) from the mounting bracket. Remove the O-ring (17).

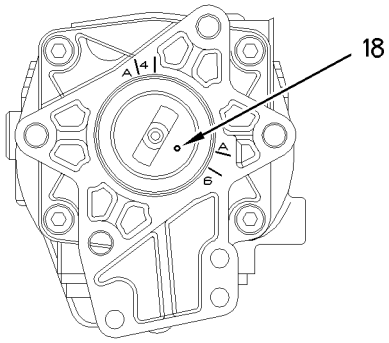


Illustration 259 g01006296

Typical air compressor with a DIN drive

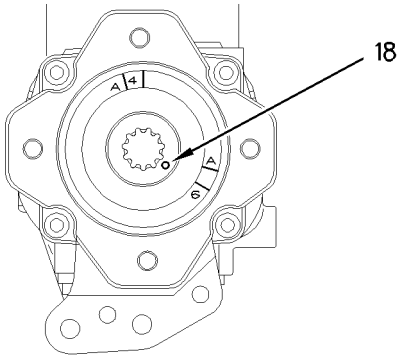


Illustration 260 g01006298

Typical air compressor with a SAE drive

4. Rotate the air compressor crankshaft until the Timing Mark (18) on the rear face of the air compressor crankshaft is aligned with the Timing Mark A that is closest to the timing mark 6 on the air compressor. Refer to illustration 259 for DIN air compressors and refer to illustration 260 for SAE air compressors.

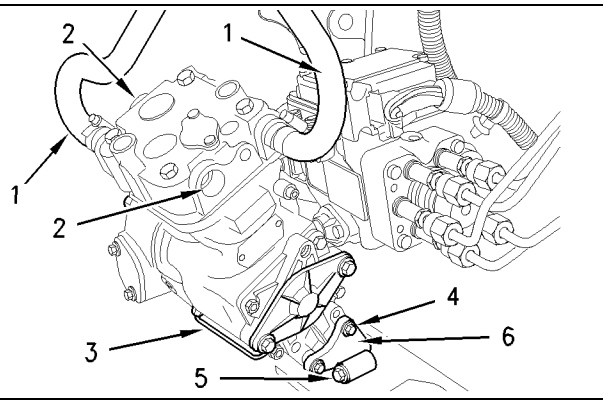
5. Align the mounting studs with the air compressor and the front housing. Slide the air compressor into the front housing. Rotate the crankshaft of the air compressor in a clockwise direction in order to mesh the air compressor drive gear and the air compressor idler gear. Carefully push the air compressor against the front housing.

Note: Refer to illustration 259 or 260. The timing mark 6 should now align with the timing mark (18) after the air compressor gear (8) has meshed with the idler gear for the air compressor.

6. Ensure that Timing Mark (18) on the rear face of the air compressor crankshaft is aligned with the Timing Mark (6). If the alignment is not correct, pull the air compressor away from the front housing. Rotate the air compressor crankshaft in the pertinent direction in order to allow the air compressor drive gear to mesh with the next tooth of the air compressor idler gear. Carefully push the air compressor against the front housing.

7. Install the nut (11) and the nut (7) in order to secure the air compressor to the front housing. Tighten the nuts to a torque of 75 N·m (55 lb ft).

8. Inspect the O-ring seal (17) and replace the seal if it is necessary. Install the O-ring seal (17) and the cover (16) on the air compressor. Install the setscrews (15).



g01006202

Illustration 261

Typical example

9. Position the bracket (6) and install the two setscrews (4) in order to secure the bracket to the air compressor. Tighten the setscrews (4) to a torque of 22 N·m (16 lb ft). Install the setscrews (5) in order to secure the bracket (6) to the cylinder block. Tighten the setscrews (5) to a torque of 44 N·m (32 lb ft).

10. Connect the oil supply tube assembly (3) to the air compressor. Tighten the nut to a torque of 9 N·m (80 lb in).

11. If equipped, install the hydraulic pump to the rear of the air compressor.

12. Connect the coolant hoses (1) to the air compressor. Connect the air lines to the ports (2) in the air compressor.

13. Fill the cooling system with coolant to the correct level. Refer to the Operation and Maintenance Manual.

14. Operate the engine in order to ensure that there is sufficient air pressure for the machine. The machine should not be started before there is sufficient air pressure in the system.

i01929802

Air Compressor Idler Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the front cover. Refer to this Disassembly and Assembly Manual, “Front Cover - Remove and Install”.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Ensure that the No. 1 piston is at top dead center on the compression stroke. Refer to the Systems Operation, Testing and Adjusting Manual, “Finding Top Center Position for No. 1 Piston”.

Note: The air compressor is timed to the engine in order to reduce engine vibration. Do not rotate the engine crankshaft or the air compressor crankshaft if the air compressor idler gear has been removed from the engine. The timing of the air compressor must be reset if either the engine crankshaft or the air compressor crankshaft is rotated prior to the installation of the air compressor idler gear.

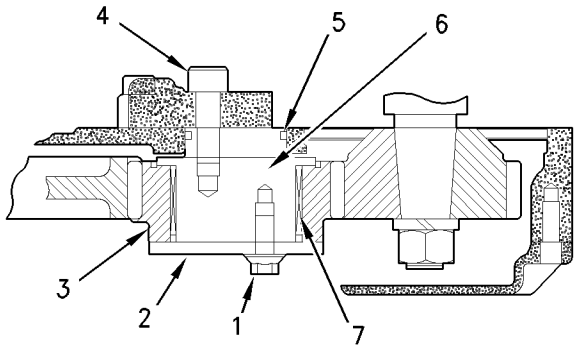


Illustration 262 g01003933

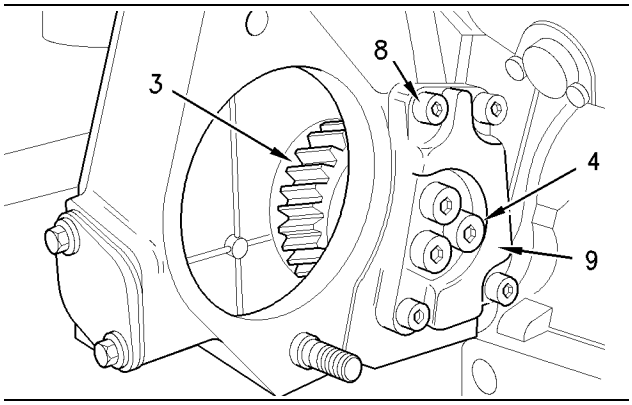


Illustration 263 g01004020

1. Remove the three setscrews (1) and the retainer plate (2). Remove the air compressor idler gear (3) and the needle bearing (7) from the idler gear hub (6). Remove the three Allen head screws (4) and the idler gear hub (6). Remove the O-ring (5) and discard the O-ring.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

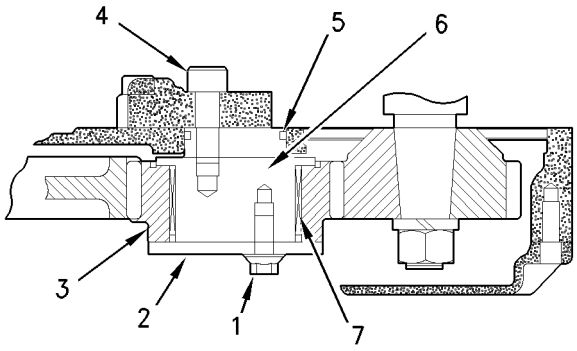


Illustration 264 g01003933

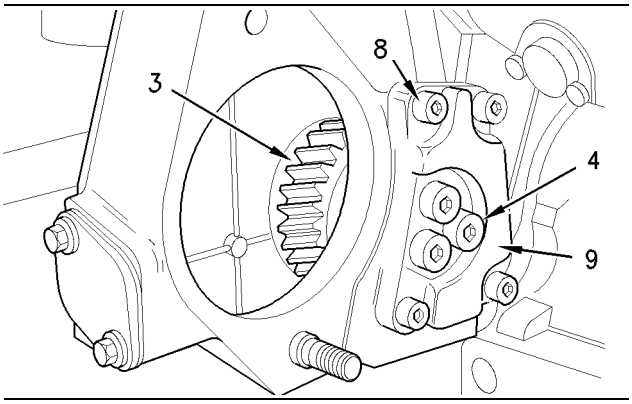


Illustration 265 g01004020

1. Inspect the condition of the idler gear hub (6), the air compressor idler gear (3), and the needle bearings (7) for wear and for damage.

a. The diameter of the bore of the air compressor idler gear should be within 55.010 mm (2.1657 inch) to 55.025 mm (2.1663 inch).

b. The outside diameter of the hub for the air compressor idler gear should be within 49.990 mm (1.9681 inch) to 50.000 mm (1.9685 inch).

Replace any damaged components or worn components.

Note: The air compressor is timed to the engine in order to reduce engine vibration. Do not rotate the engine crankshaft or the air compressor crankshaft if the air compressor idler gear has been removed from the engine. The timing of the air compressor must be reset if either the engine crankshaft or the air compressor crankshaft is rotated prior to the installation of the air compressor idler gear (3).

2. Ensure that the four Allen head screws (8) that secure the bracket (9) for the idler gear hub to the housing (front) are tightened to the correct torque of 35 N·m (26 lb ft).

3. Install a new O-ring (5) into the idler gear hub (6). Install the idler gear hub (6) with the O-ring (5) toward the housing (front). Install the Allen head screws (4) and tighten to a torque of 60 N·m (44 lb ft).

4. Lightly lubricate all of the components with clean engine lubricating oil before the components are assembled onto the idler gear hub.

5. Install the needle bearing (7) and install the air compressor idler gear (3) onto the idler gear hub (6). By using the setscrews (1), install the retainer plate (2). Tighten the setscrews (1) to a torque of 22 N·m (16 lb ft).

6. Check the end play for the air compressor idler gear (3). The end play for the air compressor idler gear should be within 0.12 mm (0.005 inch) to 0.16 mm (0.006 inch).

7. Check the backlash between the air compressor idler gear (3) and the air compressor gear (10). The backlash should be within 0.072 mm (0.0028 inch) to 0.127 mm (0.0050 inch).

8. Check the backlash between the air compressor idler gear (3) and the main idler gear. The backlash should be within 0.072 mm (0.0028 inch) to 0.122 mm (0.0048 inch).

End By:

a. Install the front cover. Refer to this Disassembly and Assembly Manual, “Front Cover - Remove and Install”.

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