Perkins®

SENR9835-02
May 2006

Disassembly and Assembly

800C Industrial Engine

UE (Engine)
UF (Engine)

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

i01967847

Fuel Priming Pump and Fuel Filter Base - Remove and Install

Removal Procedure

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.

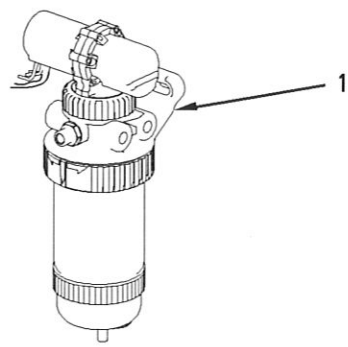

Illustration 1 g01002410

1. Disconnect the tube assemblies for the fuel inlet and the fuel outlet from the fuel filter base.
2. Disconnect the fuel return line from the fuel filter base.
3. Disconnect the harness assembly from the fuel priming pump.
4. Remove the setscrews that hold fuel filter base (1). Remove the fuel filter base (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

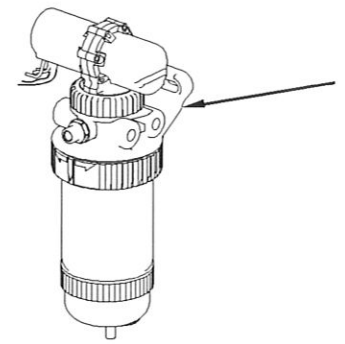

Illustration 2 g01002410

Note: The fuel filter is remotely mounted by the OEM and the torques for the mounting setscrews (1) may vary. Check with the OEM for the correct torque setting.

1. Position the fuel filter base (1) and install the setscrews. Tighten the setscrews evenly.
2. Connect the tube assemblies for the fuel inlet and the fuel outlet to the fuel filter base.
3. Connect the fuel return line to the fuel filter base.
4. Connect the harness assembly to the fuel priming pump.
5. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, “Fuel System - Prime”.

i01972549

Fuel Injection Lines - Remove and Install (Naturally Aspirated Engines)

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.

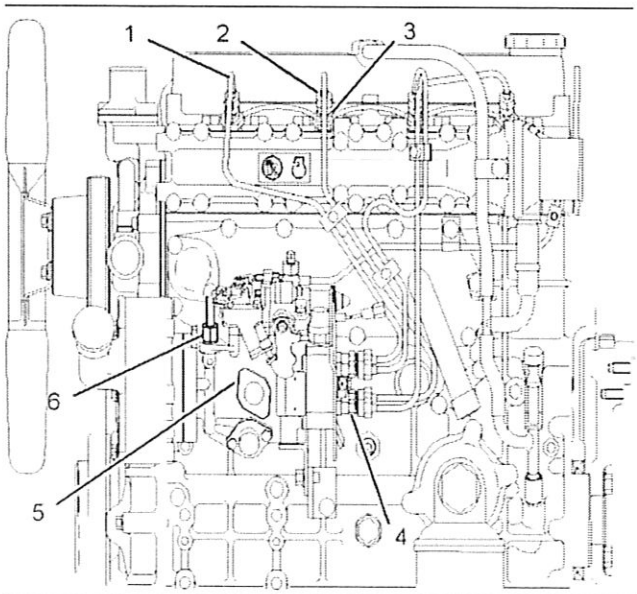

Illustration 3 g01024434

Note: If necessary, remove the dipstick tube.

1. Disconnect the fuel injection lines (1) from the fuel injector (2). Plug all openings immediately.

2. Disconnect the fuel injection lines (1) at the fuel injection pump (5).

Note: Use two spanner wrenches in order to remove each fuel injection line (1) at the fuel injection pump (5). Do not allow each union (4) for the fuel injection pump to turn.

3. Remove the fuel injection lines (1) from the engine.

Note: If necessary, loosen the clamps that tie the fuel injection lines together in order to maneuver the lines off the engine.

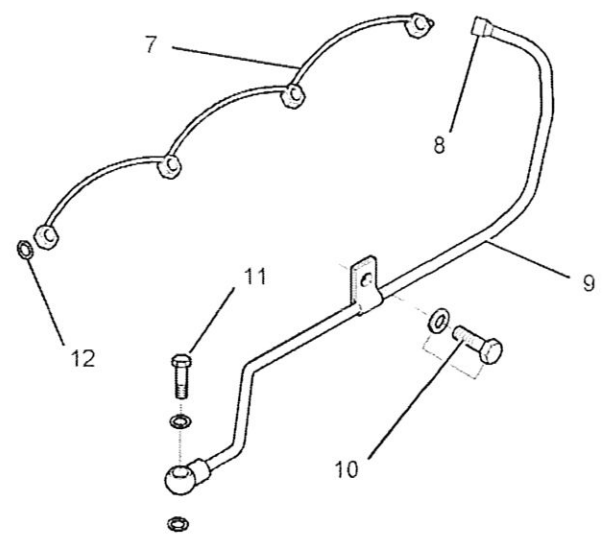

Illustration 4 g01024433

4. Disconnect the union nut (8). Remove the banjo bolt (11) and remove the sealing washers. Remove the setscrew for the clamp (10). Remove the fuel return line (9).

5. Remove the nut (3) from each fuel injector. Remove the fuel return line (7) from the engine. Also remove the sealing washers (12) that are located under the fuel return line (7).

6. Remove the fuel inlet line (6) from the fuel injection pump (5).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

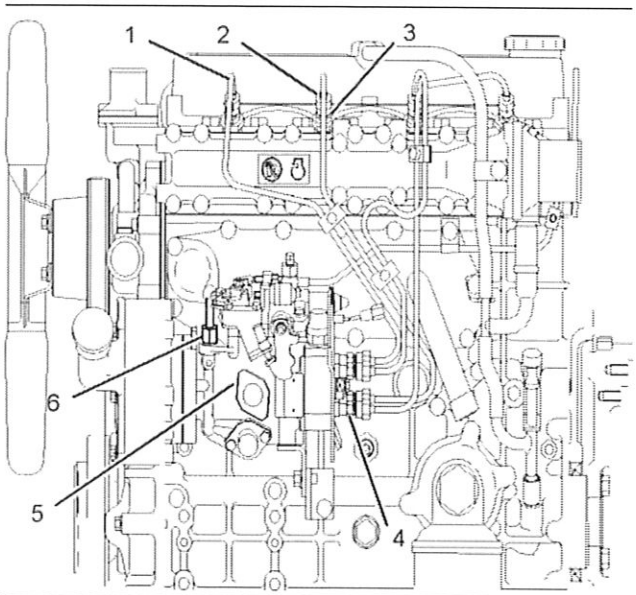

Illustration 5 g01024434

1. Install the new sealing washers (12) onto the fuel injectors (2). Locate the fuel return line (7) onto the fuel injectors (2).

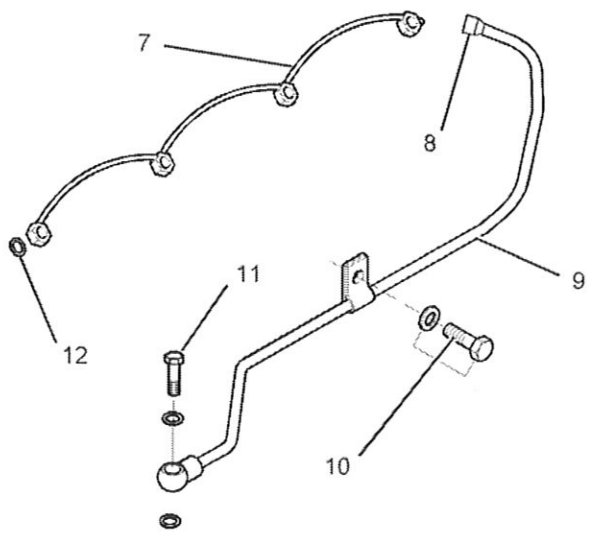

Illustration 6 g01024433

2. Install the nuts (3) onto each fuel injector. Tighten the nuts (3) to a torque of 20 to 24 N·m (15 to 18 lb ft).

3. Locate the fuel return line (7) onto the engine. Connect the union nut (8). Install the banjo bolt (11).

4. Tighten the banjo bolt (11) to a torque of 22 to 31 N·m (16 to 23 lb ft). Install the clamp bolt (10).

Note: If necessary, replace the sealing washer on the banjo bolt (11).

5. Position the fuel injection lines (1) on the engine.

6. Connect the fuel injection lines (1) at the fuel injection pump (5). Tighten the union nuts to a torque of 27 to 32 N·m (20 to 24 lb ft).

Note: Use two spanner wrenches in order to install the fuel injection lines (1) at the fuel injection pump (5). Do not allow the unions (4) for the fuel injection pump to turn.

7. Connect the fuel injection lines (1) to the fuel injectors (2). Tighten the union nuts to a torque of 27 to 32 N·m (20 to 24 lb ft).

8. If the clamps that tie the fuel injection lines together were loosened for removal purposes, tighten the clamps securely.

9. Install the fuel inlet line (6).

Note: If the dipstick tube was removed, install the dipstick tube and tighten to 22 N·m (16 lb ft).

i01968274

Fuel Injection Lines - Remove and Install (Turbocharged Engines)

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.

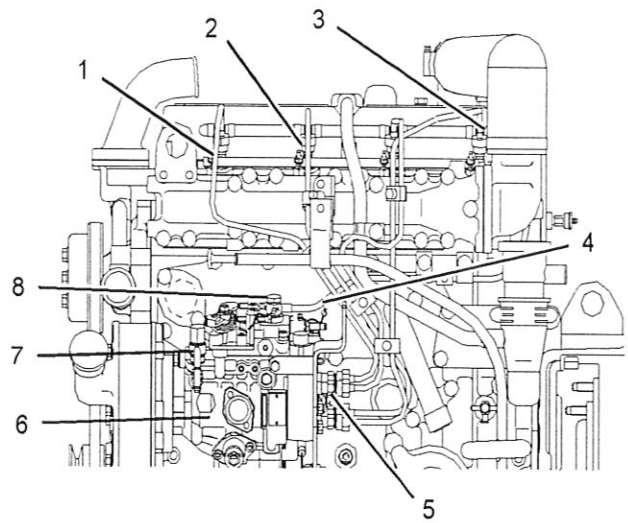

Illustration 7 g01021961

Note: If necessary, remove the dipstick tube.

1. Disconnect the fuel injection lines (1) from the fuel injectors (2). Plug all the openings immediately.

2. Disconnect the fuel injection lines (1) from the fuel injection pump (6). Plug all openings immediately.

Note: Use two spanner wrenches in order to remove the fuel injection lines (1) at the fuel injection pump (6). Do not allow the union (5) for the fuel injection pump to turn.

3. Remove the fuel injection lines (1) from the engine.

Note: If necessary, loosen the clamps that tie the fuel injection lines together in order to maneuver the lines off the engine.

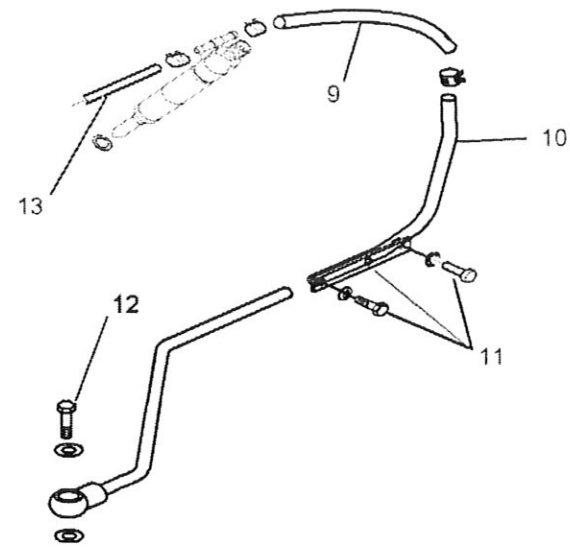

Illustration 8 g01023626

4. Disconnect the fuel hoses (9) from the fuel return line (10) and disconnect the fuel hose (9) from the fuel injector (2). Disconnect the hose (13) that connects the individual injectors (2) to each other.

5. Remove the banjo bolt (12) and the sealing washers for the banjo bolt from the fuel injection pump (6).

6. Remove the clamping arrangement (11). Remove the fuel return line (10) from the engine.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

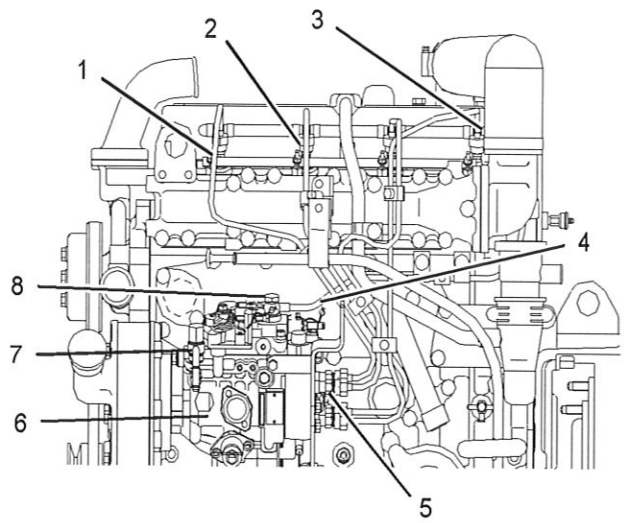

Illustration 9 g01021961

Note: Install the individual fuel hoses (13) between the fuel injectors. Check that the hose clamps (2) are secure.

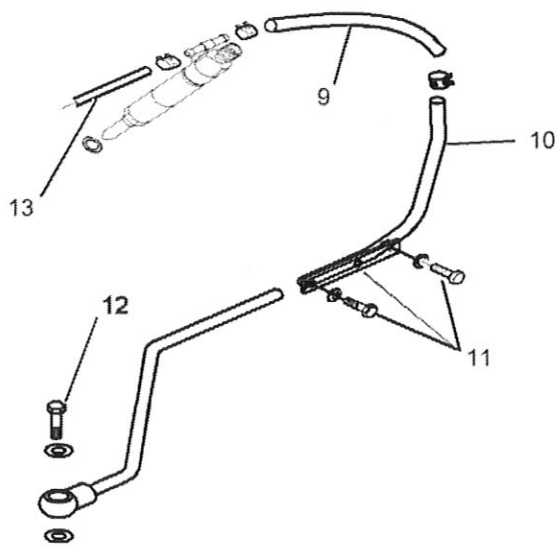

Illustration 10 g01023626

1. Install the fuel hose (9) onto the fuel injector (2). Locate the fuel return line (10) onto the engine.

2. Connect the fuel hose (9) to the return line (10). Install the clamp arrangement (11) and install the banjo bolt (12). Tighten banjo bolt (12) to a torque of 22 to 31 N·m (16 to 23 lb ft).

Note: If necessary, replace the sealing washers on the banjo bolt (12). Ensure that all the hose clamps are secure.

3. Position the fuel injection lines (1) on the engine.

4. Connect fuel injection lines (1) at the fuel injection pump (6). Tighten the union nuts to a torque of 27 to 32 N·m (20 to 24 lb ft).

Note: Use two spanner wrenches in order to install the fuel injection lines (1) at the fuel injection pump (6). Do not allow the union (5) for the fuel injection pump to turn.

5. Connect the fuel injection lines (1) to the fuel injectors (2). Tighten the union nuts to a torque of 27 to 32 N·m (20 to 24 lb ft).

6. Install the fuel inlet line to the banjo bolt (7) on the fuel injection pump (6).

7. If the clamps that tie the fuel injection lines together were loosened for removal purposes, tighten the clamps securely.

Note: If the dipstick tube was removed, install the dipstick tube and tighten to 22 N·m (16 lb ft).

i02295882

Fuel Injection Pump - Remove

Removal Procedure

Start By:

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

b. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: There are two types of fuel injection pump that may be installed on the engine. The pumps are manufactured by either Bosch or Denso and the same process is used to install both pumps.

1. Ensure that the No. 1 cylinder is at the top center compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

2. Disconnect the connection to the fuel shutoff solenoid.

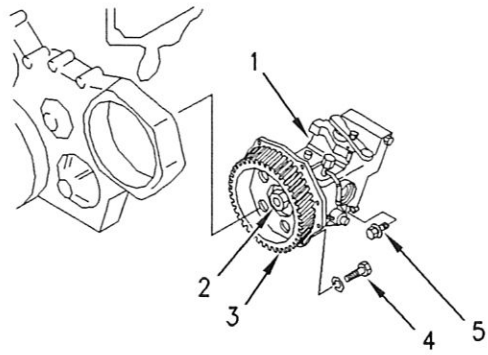

Illustration 11 g01002553

3. Remove setscrew (5) that secures the fuel injection pump (1) to the support bracket. Remove the setscrew (4) from the flange.

4. Remove the fuel injection pump (1) from the front housing.

5. Remove the nut (2) from the shaft of fuel injection pump (1).

Note: Ensure that the fuel injection pump is correctly supported before removing the nut for the fuel injection pump gear.

6. Use a suitable tool to remove the fuel injection pump gear (3).

7. Remove the O-ring seal from the flange.

Note: Check the condition of the O-ring seal for wear or damage. Replace the O-ring seal, if necessary.

8. If a Denzo fuel injection pump was installed on the engine, remove the two nuts from the studs that secure the flange to the fuel injection pump body. Remove the joint. Discard the joint.

9. If a Bosch fuel injection pump was installed on the engine, remove the three nuts from the studs that secure the flange to the fuel injection pump body. Remove the joint. Discard the joint.

i01976208

Fuel Injection Pump - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the No. 1 cylinder is at the top center compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

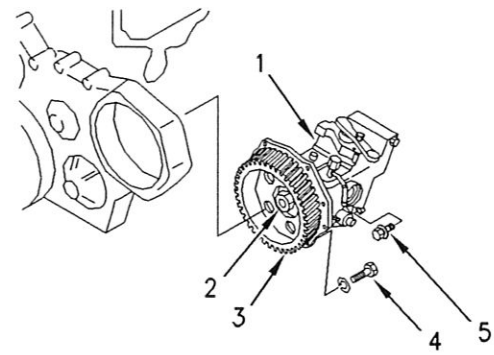

Illustration 12 g01002553

2. Install a new joint on the flange. Position the flange on the fuel injection pump (1). If aBoschfuel injection pump was removed, install the three nuts that secure the flange to the fuel injection pump and tighten evenly to 22 N·m (16 lb ft).

   If a Denso fuel injection pump was removed, install the two nuts that secure the flange to the fuel injection pump and tighten evenly to 22 N·m (16 lb ft).

3. Position the O-ring seal on the flange of the fuel injection pump.

Note: Ensure that the mating surfaces of the fuel injection pump gear and the shaft of the fuel injection pump are clean. Lubricate the threads of the shaft for the fuel injection pump. The nut must turn freely until contact is made with the fuel injection pump gear.

4. Install fuel injection pump gear (3) to the shaft of the fuel injection pump (1).

Note: Be sure that the fuel injection pump is properly supported before installing the nut for the fuel injection pump gear.

5. Install the nut (2) and tighten the nut to the following torque:

   Naturally aspirated engines ..... 59 to 69 N·m (43 to 51 lb ft)

   Turbocharged engines ..... 83 to 98 N·m (61 to 72 lb ft)

6. Position the fuel injection pump (1) to the front housing of the engine. Install the setscrew (4) and tighten securely. Install the setscrew (5) for the support bracket and tighten evenly to 22 N·m (16 lb ft).

7. Install the connection to the fuel shutoff solenoid.

End By:

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

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

i01974273

Turbocharger - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

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NOTICE
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Dispose of all fluids according to local regulations and mandates.

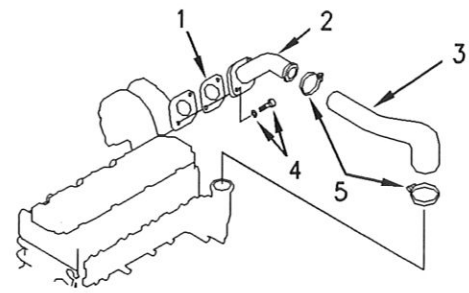

Illustration 13 g00999677

1. Loosen the hose clamps (5) and remove the air inlet hose (3) from the inlet manifold and from the air pipe (2).

2. Remove the setscrews (4). Remove the air pipe (2) and the gasket (1) from the turbocharger compressor housing.

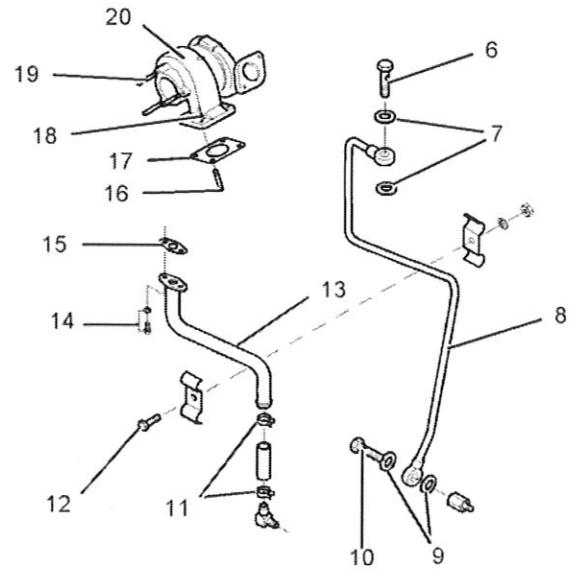

Illustration 14 g01025765

3. Remove the banjo bolt (6) and the sealing washers (7). Remove the oil supply tube assembly (8) from the turbocharger (20).

4. Remove the setscrews (14). Remove the oil drain tube assembly (13) and the joint (15) from the turbocharger.

5. If necessary, loosen the hose clamps (11) and remove the setscrew (12) in order to remove the oil supply tube assembly (8) and the oil drain tube assembly (13) from the cylinder block.

6. If necessary, remove studs (19) from the turbocharger housing.

7. Remove the locknuts (18). Remove the turbocharger (20) and the joint (17) from the exhaust manifold.

8. If necessary, remove the studs (16) from the exhaust manifold.

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

i01974250

Fuel Injector - Remove (Turbocharged Engines)

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.

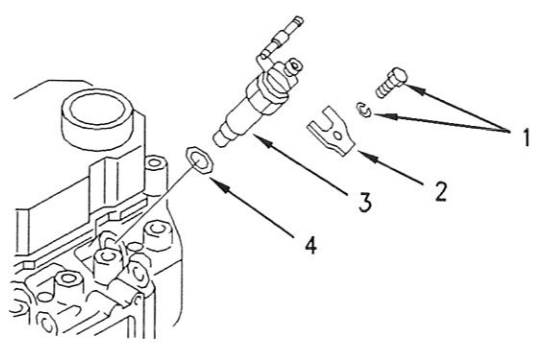

Illustration 15 g01002464

1. Remove the setscrew (1). Remove the clamp (2) from the fuel injector (3).

2. Remove the fuel injector (3) and sealing washer (4) from the cylinder head.

3. Repeat the procedure in order to remove the remaining fuel injectors.

i01974249

Fuel Injector - Remove (Naturally Aspirated Engines)

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.

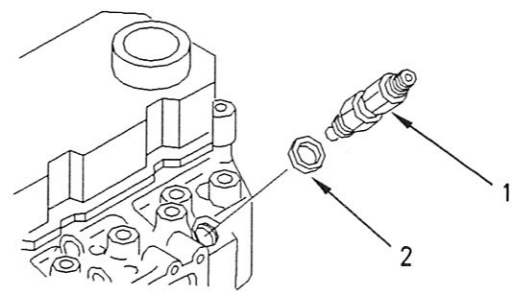

Illustration 16 g01002452

1. Remove the fuel injector (1) and the sealing washer (2) from the cylinder head.

2. Repeat the procedure in order to remove the remaining fuel injectors.

i01974251

Fuel Injector - Install (Turbocharged Engines)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

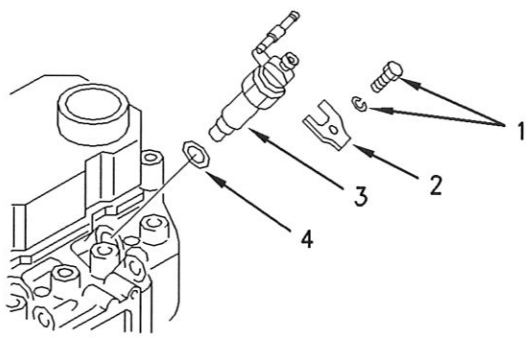

Illustration 17 g01002464

1. Position the sealing washer (4) onto the fuel injector (3).
2. Position the fuel injector (3) into the cylinder head.
3. Position the clamp (2) onto the fuel injector. Install the setscrew (1) and tighten to a torque of 21 to 23 N·m (16 to 17 lb ft).
4. Repeat the procedure in order to install the remaining fuel injectors.

End By:

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

i01976055

Fuel Injector - Install (Naturally Aspirated Engines)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

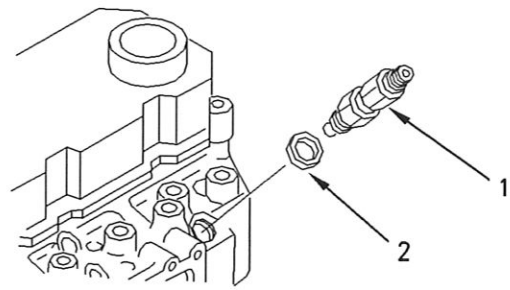

Illustration 18 g01002452

1. Position the washer (2) onto the fuel injector (1).
2. Install the fuel injector (1) into the cylinder head and tighten to a torque of 53 to 65 N·m (40 to 48 lb ft).
3. Repeat the procedure in order to install the remaining fuel injectors (1).

End By:

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

i01978805

Turbocharger - 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 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. Ensure that the turbocharger inlet and outlet ports are clean and free from restrictions. The turbocharger shaft must rotate freely.

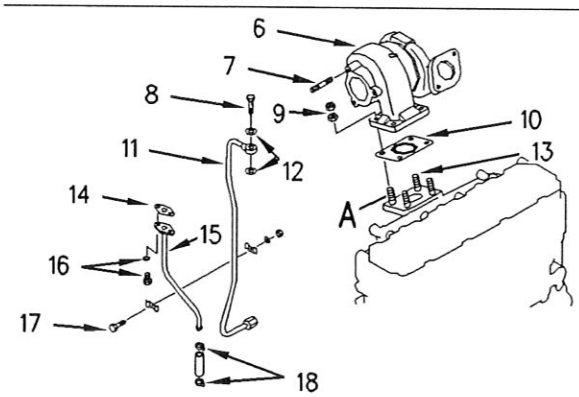

Illustration 19 g00999706

3. If necessary, install studs (13) in the exhaust manifold. Install gasket (10) over the studs.

Note: Do not use any sealant on the gasket.

4. Position turbocharger (6) on the exhaust manifold.

5. Apply a suitable anti-seize compound to the threads of studs (13). Install locknuts (9) and tighten evenly.

6. Position a new gasket (14) and oil drain tube assembly (15) on the bottom of the turbocharger. Tighten bolts (16) evenly to 22 N·m (16 lb ft).

7. If necessary, install oil drain tube assembly (15) to the cylinder block. Tighten hose clamps (18) securely.

8. Position new sealing washers (12) and oil supply tube assembly (11) on the turbocharger. Install banjo bolt(8) and tighten securely.

9. If necessary, install oil supply tube assembly (11) to the cylinder block and tighten the bolts evenly. Install bolt (17) and the clamp in order to secure the two tube assemblies (11) and (15) together.

10. If necessary, install studs (7) in the turbocharger housing.

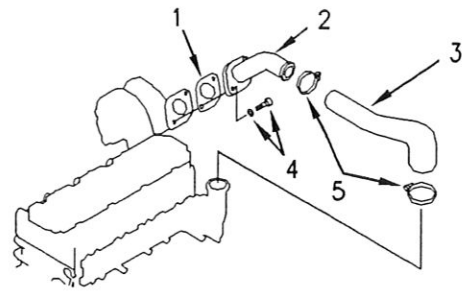

Illustration 20 g00999677

11. Install gasket (1) and air pipe (2) on the turbocharger compressor housing. Install bolts (4) and tighten evenly to 22 N·m (16 lb ft).

12. Install air inlet hose (3) on the air inlet manifold and on air pipe (2). Tighten hose clamps (5) securely.

i01978806

Exhaust Manifold - Remove and Install

Removal Procedure

Start By:

a. Remove the turbocharger, if equipped. Refer to Disassembly and Assembly, "Turbocharger - Remove".

⚠ WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

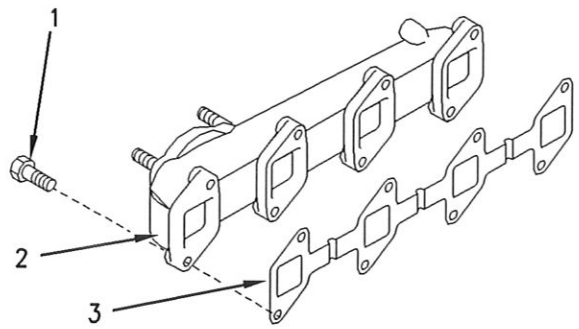

Illustration 21 g00998953

1. Remove the setscrews (1) that secure the exhaust manifold (2) to the cylinder head. Begin at the ends of the exhaust manifold (2) and work toward the center.

2. Remove the exhaust manifold (2) from the cylinder head.

3. Remove the joint (3) from the cylinder head. Discard the joint.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

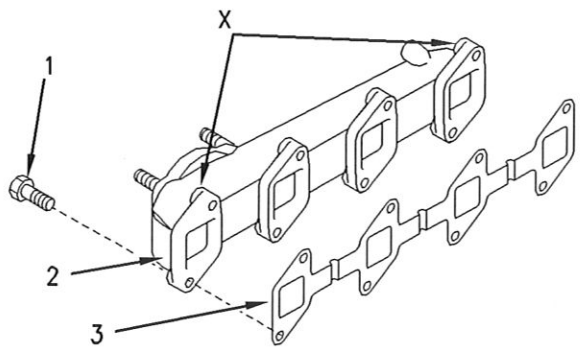

Illustration 22 g01000656

1. Clean the flange face of the cylinder head. Install a guide stud "M8 x 1.25 by 100 mm" into the cylinder in order to align with the holes (X). Position a new joint (3) on the guide studs.

Note: Do not use any sealant on the joint.

2. Position the exhaust manifold (2) on the guide studs.

3. Ensure that all of the setscrews (1) are clean. Install the setscrews (1) into the holes that do not have a guide stud. Remove the guide stud and install the remainder of the setscrews (1).

4. Begin at the center of the exhaust manifold and work toward the ends. Tighten the setscrews to the following torque:

   Naturally aspirated engines ..... 15 to 22 N·m (11 to 16 lb ft)

   Turbocharged engines ..... 28 to 33 N·m (21 to 24 lb ft)

End By:

a. Install the turbocharger, if equipped. Refer to Disassembly and Assembly, "Turbocharger - Install".

i02001084

Inlet Manifold - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the engine is equipped with a turbocharger, remove the air inlet hose that is above the valve mechanism cover. Refer to Disassembly and Assembly, "Turbocharger - Remove".

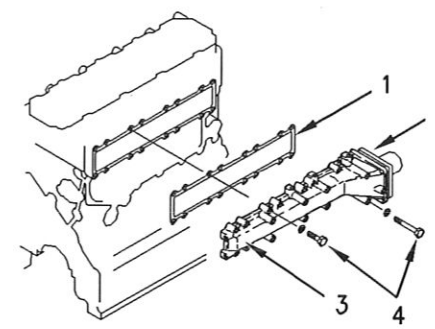

Illustration 23 g01001495

2. Remove the setscrews (4) from the inlet manifold (3).

3. Remove the inlet manifold (3) and the gasket (1) from the cylinder head. Discard the gasket.

4. If necessary, remove the setscrews for the air inlet elbow (2). Remove the air inlet elbow (2) and the gasket from the inlet manifold (3).

i02001105

Inlet Manifold - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all the mounting surfaces are clean and free from debris.

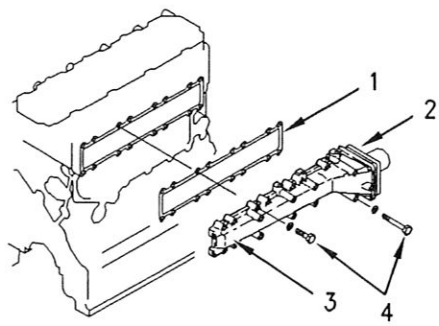

Illustration 24 g01001495

2. If necessary, position a new gasket and the air inlet elbow (2) onto the inlet manifold (3). Install the setscrews and tighten evenly.

3. Position the gasket (1) onto the back of the inlet manifold (3).

4. Position the inlet manifold (3) onto the cylinder head.

5. Install the setscrews (4) and tighten evenly.

6. If the engine is equipped with a turbocharger, install the air inlet hose that is above the valve mechanism cover. Refer to Disassembly and Assembly, "Turbocharger - Install".

i01978832

Inlet and Exhaust Valve Springs - Remove and Install (Installed Cylinder Head)

Removal Procedure

Table 1

Required Tools		
Part Number	Part Description	Qty
21825666	Valve Spring Compressor	1
21825931	Stud Adapter	1
21825932	Setscrew Adapter	1
27610261	Installer for the Valve Stem Seal	1

Start By:

a. Remove the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector - Remove (Naturally Aspirated Engines) " and Disassembly and Assembly, "Fuel Injector - Remove (Turbocharged Engines) ".

b. 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.

Note: The following procedure is for the removal of the inlet and exhaust valve springs without removing the cylinder head. Perform the removal and installation procedures for one cylinder at a time in order to avoid dropping a valve into the engine.

Note: Before you begin the removal of the valve springs, refer to Specifications, "Cylinder Head Valves" for appropriate information on the valve springs.

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

Note: If the rocker shaft assembly has been removed, use the following procedure in order to find the top center position. Go to Step 2 if the rocker arm assembly is installed.

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

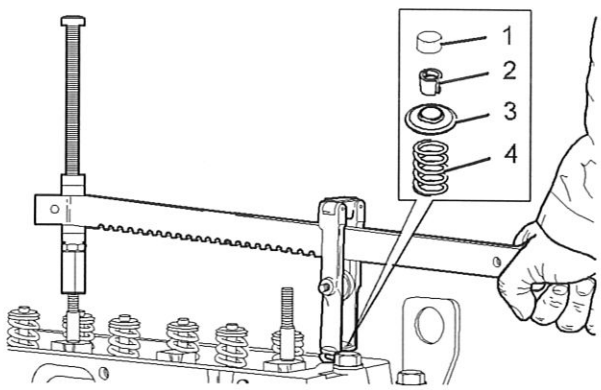

Illustration 25 g01038636

⚠ 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 21825666 Valve Spring Compressor with the 21825931 Adapter for the Valve Spring or the 21825932 Adapter for the Setscrew .

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 Valve Spring Compressor until the piston is at the Top Center position.

2. Use the Valve Spring Compressor in order to compress the valve spring (4). Use a suitable magnetic tool to remove the valve caps (1) and the valve keepers (2).

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

3. Carefully release all the pressure on the Valve Spring Compressor . Remove the valve spring retainer (3) and the valve spring (4).

4. If it is necessary, use a suitable tool to remove the valve stem seals.

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 4, and on cylinder 2 and cylinder 3.

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

Installation Procedure

Table 2

Required Tools		
Part Number	**Part Description**	**Qty**
21825666	Valve Spring Compressor	1
21825931	Adapter for the stud	1
21825932	Adapter for the setscrew	1
27610261	Installer for the Valve Stem Seal	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

1. Use the 27610261 Installer for the Valve Stem Seals to install the new valve stem seals into the cylinder head (not shown).

2. Place the new valve spring (4) into position.

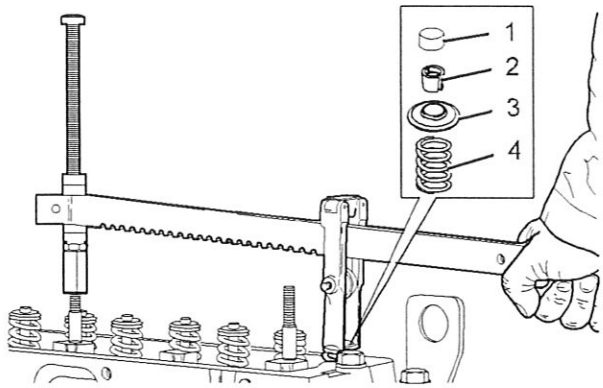

Illustration 26 g01038636

⚠ 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.

3. Install the valve spring retainer (3).

4. Install the Valve Spring Compressor in order to compress the valve spring (4).

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

5. Install the valve keepers (2).

6. Carefully release the pressure on the Valve Spring Compressor. Remove the Valve Spring Compressor.

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 4, and on cylinder 2 and cylinder 3.

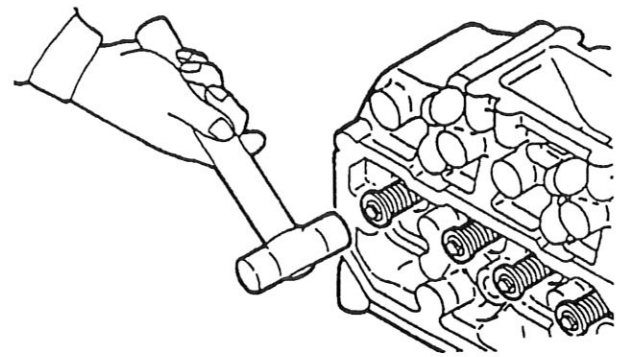

Illustration 27 g00999950

7. Tap the top of the valves with a soft hammer in order to ensure that the valve keepers are properly installed. Install the valve caps (1).

8. Perform Steps 2 through 8 for the installation of the remaining inlet and exhaust valve springs.

End By:

a. Install the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injectors - Install (Naturally Aspirated Engines)" and Disassembly and Assembly, "Fuel Injectors - Install (Turbocharged Engines).".

b. Install the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Install".

i01980533

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 3

Required Tools		
Part Number	**Part Description**	**Qty**
21825666	Valve Spring Compressor	1

Start By:

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Support the cylinder head assembly on a suitable engine repair stand.
2. Clean the bottom face of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Testing and Adjusting, "Valve Depth - Inspect" for the correct procedure.
3. Place an index mark on the heads of the inlet valves and the exhaust valves for installation purposes.

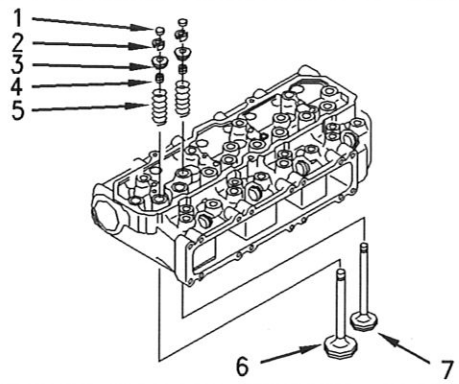

Illustration 28 g00999978

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

Note: The procedure that follows refers to both the inlet and exhaust valves.

4. Use a 21825666 Valve Spring Compressor to compress the spring (5).
5. Use a suitable magnetic tool to remove the cap (1) and the valve keepers (2).
6. Carefully release the pressure and remove the 21825666 Valve Spring Compressor.
7. Remove the valve spring retainer (3) and the valve spring (5). Use a suitable slide hammer and a suitable removal tool to remove the valve stem seals (4) for the inlet and/or exhaust valves.
8. Remove inlet valve (6) and/or exhaust valve (7) through the bottom of the cylinder head assembly.
9. Repeat Steps 4 through 8 in order to remove the remaining inlet and/or exhaust valves from the cylinder head.
10. Use a suitable spring tester to check the valve spring force. Refer to Specifications, "Cylinder Head Valves" for information on the valve springs.

Installation Procedure

Table 4

Required Tools		
Part Number	**Part Description**	**Qty**
21825666	Valve Spring Compressor	1
27610261	Seal Installer	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

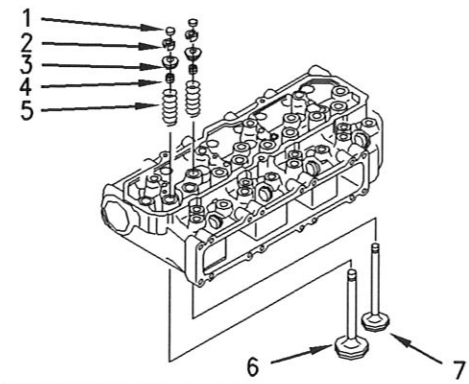

Illustration 29 g00999978

⚠ 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.

1. Support the cylinder head assembly on a suitable engine repair stand.
2. Lubricate the stems of all the inlet valves (6) and/or the stems of all the exhaust valves (7) with clean engine oil.
3. Install the inlet valves (6) and/or the exhaust valves (7) in the appropriate positions.

Note: The valve guides must be clean and dry before installing the valve stem seal.

4. Use a 227610261 Seal Installer and a suitable driver to install new valve stem seals (4) for the inlet valves and/or the exhaust valves onto the valve guides.
5. Position a valve spring (5) onto the cylinder head. Position valve spring retainer (3) onto the spring.

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

6. Use a 21825666 Valve Spring Compressor to compress the spring (5).
7. Use a suitable tool to install the valve keepers (2) and the cap (1) on the valve stem.
8. Carefully release the pressure and remove 21825666 Valve Spring Compressor. Tap the top of the valves with a soft hammer in order to ensure that the valve keepers are properly installed.
9. Repeat Steps 5 through 8 in order to install the remaining inlet and exhaust valve springs in the cylinder head.
10. Check the depth of the valves below the face of the cylinder head. Refer to Testing and Adjusting, "Valve Depth - Inspect" for the correct procedure. If the depth of the new valves are 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".

i01981177

Inlet and Exhaust Valve Guides - Remove and Install

Removal Procedure

Table 5

Required Tools		
Part Number	**Part Description**	**Qty**
27610262	Valve Guide Driver	1
27610263	Valve Guide Collar	1

Start By:

a. Remove the inlet and 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.

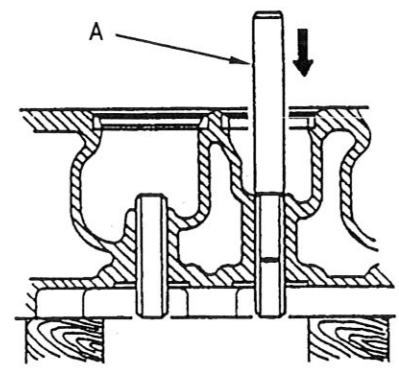

Illustration 30 g01000170

1. Use a 27610262 Valve Guide Driver to remove the valve guides from the cylinder head.
2. Repeat the procedure for the remaining valve guides.

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

3. Remove the valve seat inserts. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Seat Inserts - Remove and Install".

Installation Procedure

Table 6

Required Tools		
Part Number	**Part Description**	**Qty**
27610262	Valve Guide Driver	1
27610263	Valve Guide Collar	1
21825938	Valve Seat Cutter	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

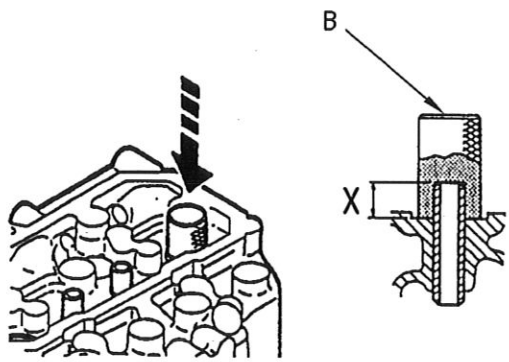

Illustration 31 g01000172

1. Position the valve guide in the cylinder head. Carefully tap the valve guide in order to start the installation. Use a 27610262 Valve Guide Driver and a 27610263 Valve Guide Collar to seat the valve guide into the cylinder head.

Note: The counterbore in the 27610263 Valve Guide Collar installs the valve guide to the correct Height (X).

2. Check the protrusion of the valve guides. Refer to Specifications, "Cylinder Head Valves" for the protrusion of the valve guide above the valve spring recess.

3. Repeat the procedure to install the remaining valve guides.

4. Install the valve seat inserts. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Seat Inserts - Remove and Install".

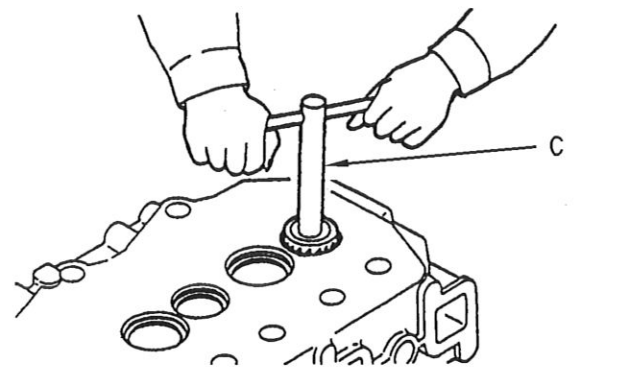

Illustration 32 g01000177

Note: 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.

5. Position a suitable reamer for the valve guide and a 21825938 Valve Seat Cutter 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.

6. 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.

7. Remove the 21825938 Valve Seat Cutter. Clean the debris from the valve guide and the valve seat.

End By:

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

i02001012

Inlet and Exhaust Valve Seat Inserts - Remove and Install

Removal Procedure

Start By:

a. Remove the inlet and 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.

1. Use a suitable tool to remove the valve seat inserts from the cylinder head.

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

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

3. Remove the valve guides. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Guides - Remove and Install".

Installation Procedure

Table 7

Required Tool		
Part Number	**Part Description**	**Qty**
27610264	Inlet Valve Seat Driver	1
27610265	Exhaust Valve Seat Driver	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

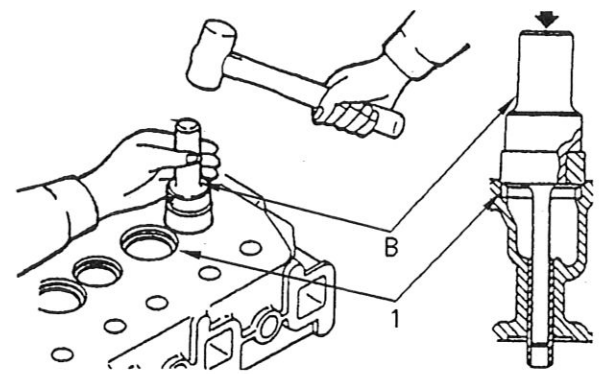

Illustration 33 g01000464

1. Lower the temperature of the new valve seat insert (1).

2. Position the valve seat insert (1) in the cylinder head. Use the correct Valve Seat Driver to seat the valve seat insert (1) into the cylinder head.

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

4. Install the new valve guides. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Guides - Remove and Install".

End By:

a. In order to install the inlet and the exhaust valves. Refer to Disassembly and Assembly, "Inlet and Exhaust Valves - Remove and Install".

i01981281

Engine Oil Filter Base - 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.

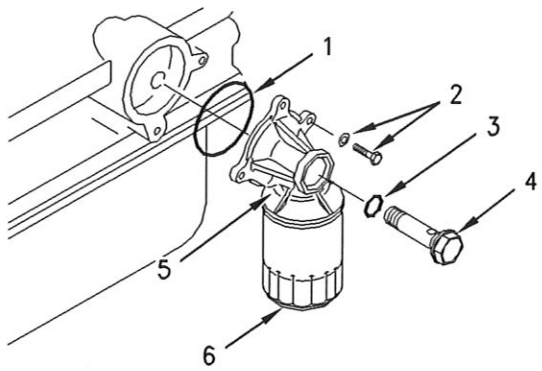

Illustration 34 g00999033

1. Use a suitable strap wrench to remove the engine oil filter (6) from the engine oil filter base (5).
2. Remove the setscrews (2) and (4) that secure the engine oil filter base (5) to the cylinder block. Remove the O-ring seal (3).
3. Remove the engine oil filter base (5) from the cylinder block. Remove the O-ring seal (1) and plug all the openings immediately.

Installation Procedure

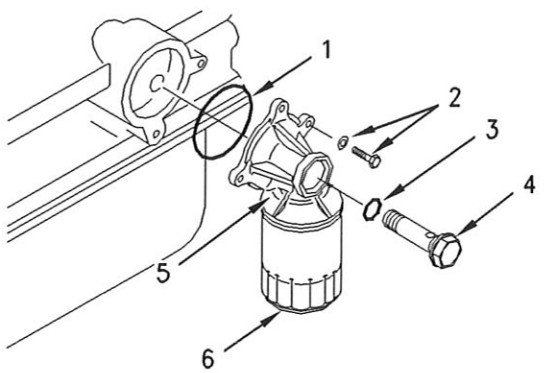

Illustration 35 g00999033

1. Clean the mating surfaces of the cylinder block and the engine oil filter base (5).
2. Check the condition of the O-ring seals (1) and (3). Replace the O-ring seals, if necessary.
3. Position the engine oil filter base (5) on the cylinder block.
4. Install the setscrews (2) and tighten to 22 N·m (16 lb ft).
5. Install the central setscrew (4). Tighten to 25 N·m (18.4 lb ft).
6. Install a new engine oil filter (6) and hand tighten the engine oil filter (6).

i01981344

Engine Oil Cooler - Remove

Removal Procedure

Start By:

a. Remove the fuel injection pump. Refer to Disassembly and Assembly, "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.

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

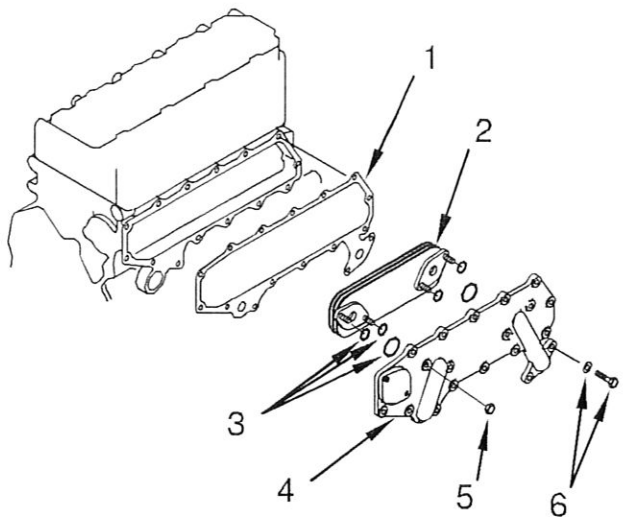

Illustration 36 g01042559

2. Remove the setscrews (6) from the cover (4).
3. Remove the cover (4) from the cylinder block.
4. Remove the nuts (5). Remove the engine oil cooler (2) from the cover (4). Remove the O-ring seals (3) from the engine oil cooler (2).
5. Remove the joint (1) from the cylinder block. Discard the joint.

i02016613

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 cover and the cylinder block.

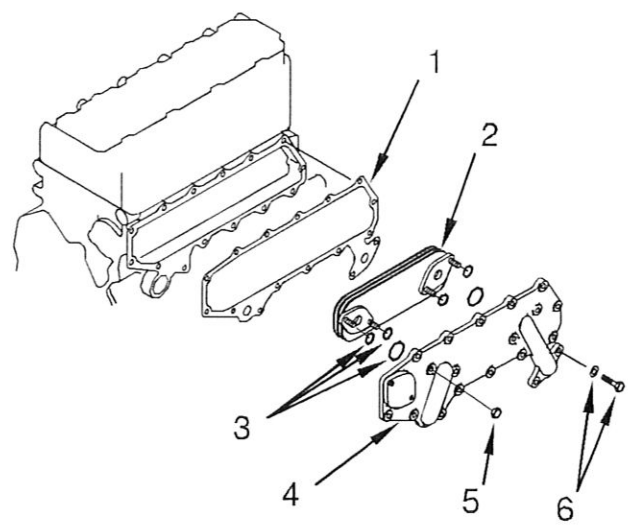

Illustration 37 g01042559

2. Position the new O-ring seals (3) on the engine oil cooler (2).
3. Position the engine oil cooler (2) in the cover (4). Install the nuts (5) and tighten evenly to 22 N·m (16 lb ft).
4. Position the cover (4) and the joint (1) on the cylinder block.

Note: Do not use sealants on the joint.

5. Install setscrews (6) and tighten evenly to 22 N·m (16 lb ft) in order to secure the cover (4) to the cylinder block.
6. Fill the cooling system with coolant. Fill the lubrication system with engine oil.

Note: Refer to Operation and Maintenance Manual, "Refill Capacities" for the cooling system and the lubrication system capacities.

End By:

a. Install the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".

i02016665

Engine Oil Relief Valve - 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.

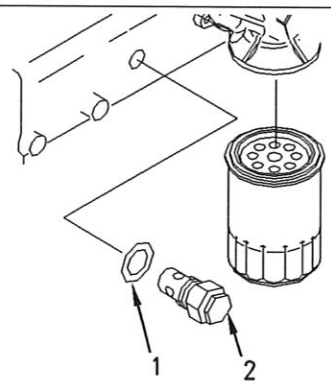

Illustration 38 g00999119

1. Drain the engine oil. Refer to "Operation and Maintenance Manual" for the procedure to drain the engine oil.
2. Remove the engine oil filter.
3. Remove the engine oil relief valve (2) and the joint (1) from the left side of the cylinder block.

Note: Check the oil relief valve and the valve seat for any abnormal contact pattern. Inspect the spring for weakness or damage. Replace the oil relief valve if it is necessary. Refer to "Specifications Manual "for oil pressures.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

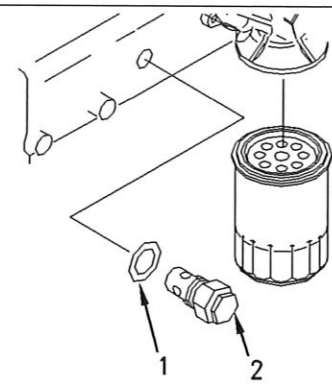

Illustration 39 g00999119

1. Install the engine oil relief valve (2) and the joint (1) and tighten to a torque of 44 to 54 N·m (33 to 40 lb ft).
2. Install the engine oil filter hand tight.
3. Refill the oil system, refer to "Operations and Maintenance Manual, Engine Oil Level - Check".

i02017834

Engine Oil Bypass Valve - Remove and Install

Removal Procedure

Start By:

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

Note: The Engine Oil Bypass Valve is installed into Turbocharged engines only.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

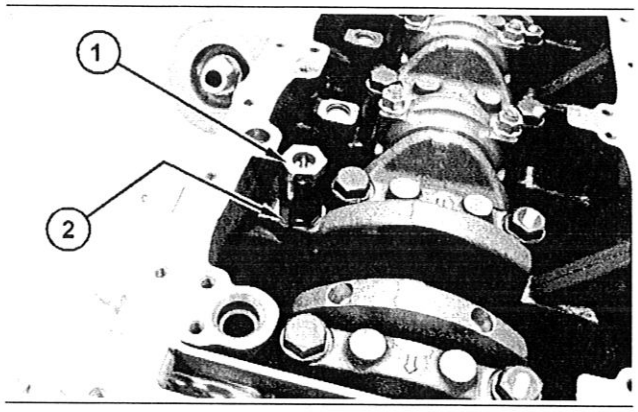

Illustration 40 g01034580

1. Remove the engine oil bypass valve (1) and joint (2).

Note: Check the valve and the valve seat for an abnormal contact pattern. Inspect the spring for weakness or damage. Replace the engine oil bypass valve, if necessary. Refer to the Specifications Manual, "Engine Oil Bypass Valve ".

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

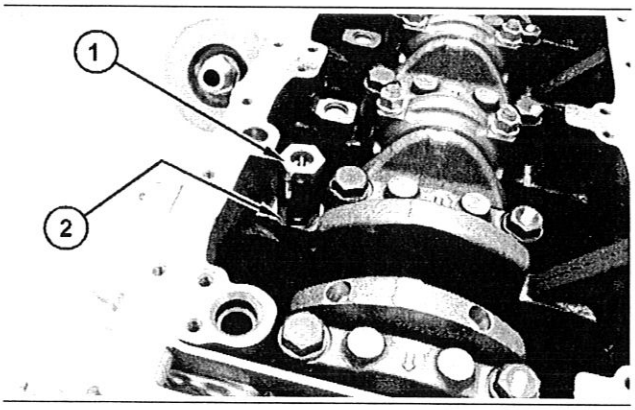

Illustration 41 g01034580

1. Install the engine oil bypass valve (1) and joint (2).

2. Tighten the cap of engine oil bypass valve (2) to a torque of 64 to 74 N·m (47 to 55 lb ft).

End By:

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

i01981410

Engine Oil Pump - Remove

Removal Procedure

Start By:

a. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".

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. Ensure that the No. 1 cylinder is at the top center compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No.1 Piston".

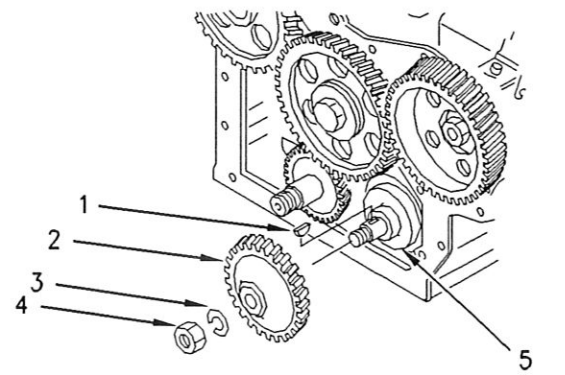

Illustration 42 g01000291

2. Remove the nut (4) and the washer (3). Remove the oil pump gear (2) and key (1) from the shaft of the engine oil pump.

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

4. Remove the setscrews that secure the engine oil pump (5) to the cylinder block. Remove the engine oil pump (5) and the O-ring seal.

5. Check the condition of the bushing in the cylinder block for the engine oil pump. If the bushing is damaged or worn, replace the bushing. Refer to Specifications Manual , "Engine Oil Pump" for the clearance between the shaft and the bushing.

i02021424

Engine Oil Pump - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Check the condition of the O-ring seal. Replace the O-ring seal, if necessary.

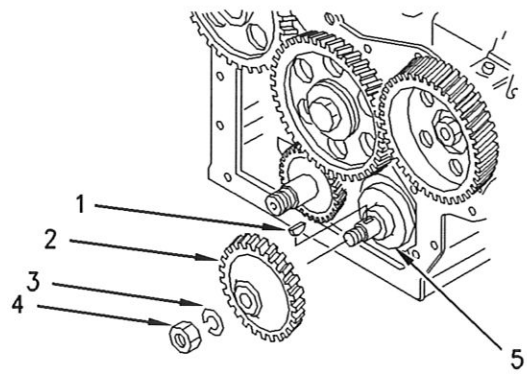

Illustration 43 g01000291

2. Position the engine oil pump (5) onto the cylinder block. Install the setscrews that secure the engine oil pump (5) to the cylinder block. Tighten the setscrews evenly to 22 N·m (16 lb ft).

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

Note: Ensure that the timing marks on the timing gears are in alignment.

4. Install the key (1) onto the shaft of the engine oil pump. Position the oil pump gear (2) onto the shaft. Ensure that the keyway and the key (1) are aligned. Install the washer (3) and the nut (4) and tighten to a torque of 28 to 38 N·m (21 to 28 lb ft).

5. Inspect the timing gear backlash and the end play. Refer to Testing and Adjusting, "Gear Group - Inspect".

End By:

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

i01981442

Water Pump - Remove and Install

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

⚠ WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

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.

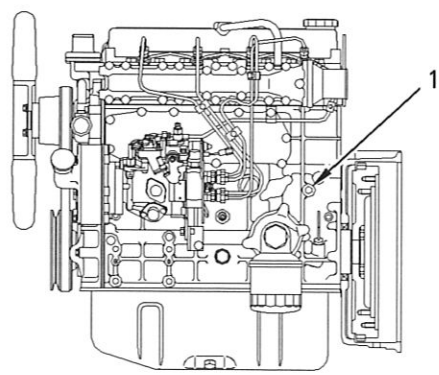

Illustration 44 g00999135

Note: Some engines may be equipped with a drain cock instead of a drain plug.

1. Remove the drain plug (1) in order to drain the coolant into a proper container for proper storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change" for the correct procedure.

2. Install the drain plug (1) and tighten to a torque of 35 to 43 N·m (26 to 32 lb ft).

Note: If the engine is equipped with a drain cock, ensure that the drain cock is completely closed.

3. Loosen the hose clamps and disconnect the lower radiator hose and the bypass hose from the water pump.

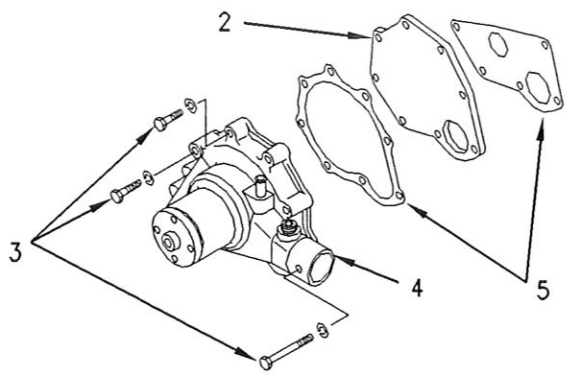

Illustration 45 g00999154

4. Remove setscrews (3) that secure the water pump (4) to the engine. Remove water pump (4) from the engine.

5. Remove the joints (5) and the cover (2). Discard the joints.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

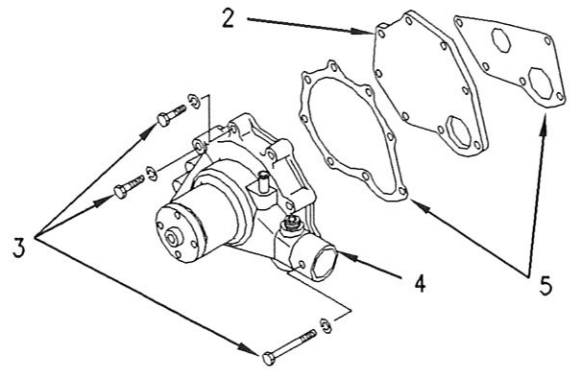

Illustration 46 g00999154

1. Position new joints (5) on the water pump (4) and the cover (2). Position the water pump (4) onto the front of the engine.

2. Install the setscrews (3) and tighten evenly.

3. Install the lower radiator hose and the bypass hose on the water pump. Secure the hoses with the hose clamps.

4. Fill the cooling system to the proper level. Refer to Operation and Maintenance Manual, "Cooling System Coolant (Extended Life Coolant) - Change" for the correct procedure.

End By:

a. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install ".

i01981459

Water Temperature Regulator Housing - 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 cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change".

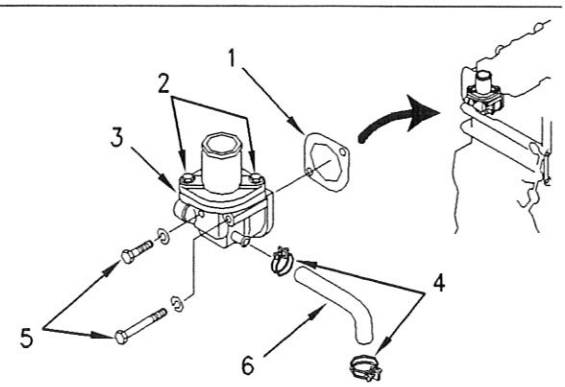

Illustration 47 g00999187

2. Loosen the hose clamps (4). Disconnect the bypass hose (6) from the water temperature regulator housing (3) and from the water pump.

3. Remove the setscrews (5) that secure the water temperature regulator housing (3) to the cylinder head.

4. Remove the water temperature regulator housing (3) from the cylinder head.

5. Remove the joint (1). Discard the joint.

6. If necessary, remove the setscrews (2) in order to remove the water temperature regulator from the housing.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

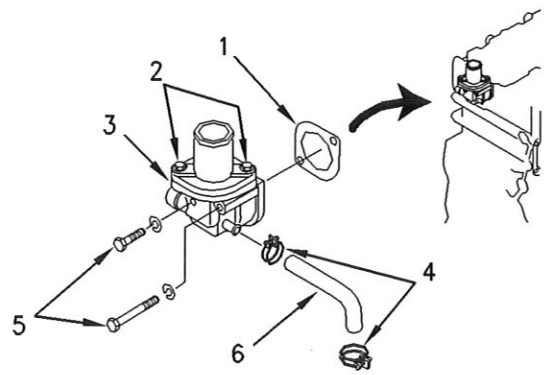

Illustration 48 g00999187

1. If necessary, position the water temperature regulator in the housing. Install the setscrews (2) and tighten evenly to 22 N·m (16 lb ft).

2. Position the new joint (1) onto the back of the water temperature regulator housing (3). Position the water temperature regulator housing (3) onto the front of the cylinder head.

3. Install the setscrews (5) and tighten evenly to 22 N·m (16 lb ft).

4. Connect the bypass hose (6) and tighten the hose clamps (4) securely.

5. Fill the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change".

6. Operate the engine. Check for leakage.

i01981466

Flywheel - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

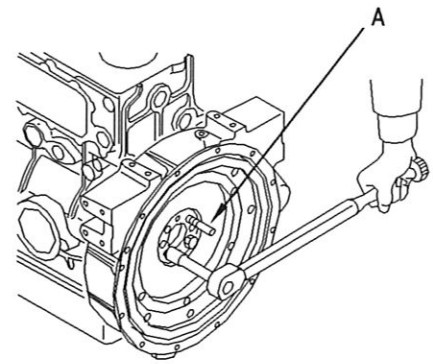

Illustration 49 g01000507

1. Remove one setscrew from the flywheel.

2. Install a suitable guide pin (A) into the crankshaft flange.

3. Install a suitable lifting eye and a suitable lifting device onto the flywheel.

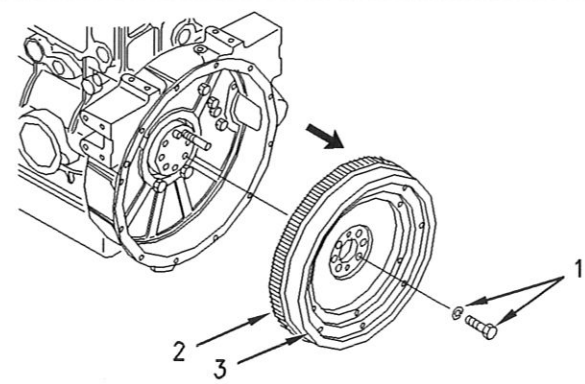

Illustration 50 g01000526

4. Remove the remaining setscrews (1) that secure flywheel (3) to the crankshaft flange.

5. Remove the flywheel (3) from the crankshaft. The weight of the flywheel is approximately 50 kg (110 lb).

6. Check the condition of the dowel pins in the crankshaft flange. Check the condition of the holes for the dowel pins in the flywheel. Ensure that the dowel pins are secure in the crankshaft. Replace the dowel pins if the dowel pins are worn or damaged.

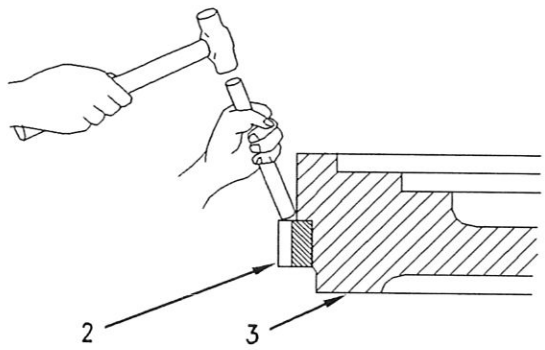

Illustration 51 g01000522

7. Check the condition of the ring gear (2). Replace the ring gear (2) with a new part if the 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.

8. Place the flywheel (3) and the ring gear (2) on a suitable support. Use a hammer and a punch in order to remove the ring gear (2) from the flywheel (3).

i01981499

Flywheel - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

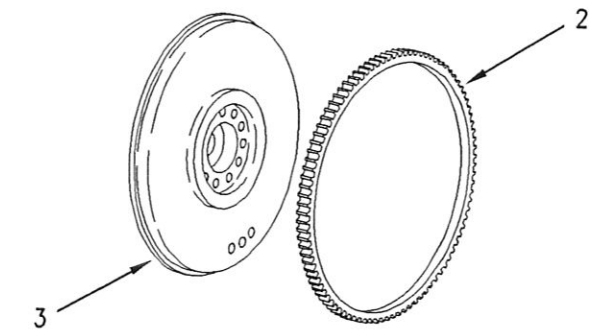

Illustration 52 g01000551

1. Install the ring gear (2) if the ring gear was removed from the flywheel (3). If the ring gear is installed then proceed to step 3.

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

2. Raise the temperature of the ring gear (2) up to a maximum of 195 °C (383 °F) in order to install the ring gear (2) on the flywheel (3).

Note: Do not use an oxyacetylene torch to heat the ring gear.

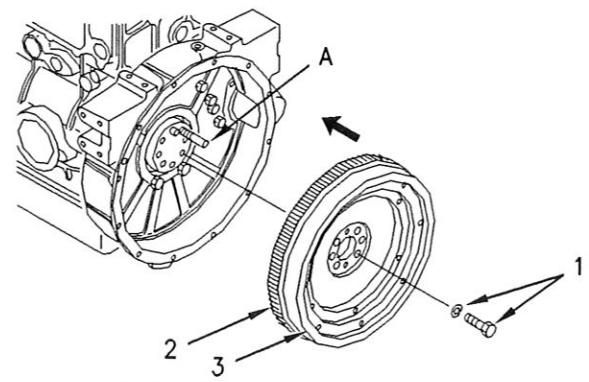

Illustration 53 g01000559

3. Install a suitable guide pin into the crankshaft. Install a suitable lifting eye and a suitable lifting device onto the flywheel. Position the flywheel (3) in the flywheel housing and onto the dowel pins. The weight of the flywheel is approximately 50 kg (110 lb).

4. Install the setscrews (1) and tighten finger tight.

5. Remove the guide pin and install the last setscrew. Tighten all the setscrews of the flywheel to a torque of 79 to 88 N·m (58 to 65 lb ft).

6. Remove the lifting eye.

7. Check the radial eccentricity of the flywheel. Refer to Testing and Adjusting, "Flywheel - Inspect".

i01981743

Crankshaft Rear Seal - Remove

Removal Procedure

Start By:

a. Remove the flywheel. Refer to Disassembly and Assembly, "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.

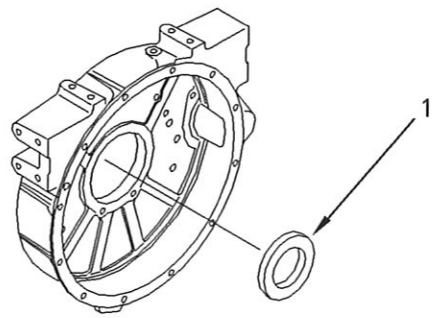

Illustration 54 g01000601

1. Use a 4.1 mm drill bit to drill three evenly spaced holes into the crankshaft rear seal (1).

2. Use a suitable slide hammer puller in each of the three holes to evenly remove the crankshaft rear seal (1).

i01981753

Crankshaft Rear Seal - Install

Installation Procedure

Table 8

Required Tools		
Part Number	**Part Description**	**Qty**
27610266	Oil Seal Installer	1
27610266	Oil Seal Locator	1
27610266	Bolt	1
27610266	Hard Washer	1
27610266	Bolts	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft flange and the inside of the flywheel housing are clean and free of debris.

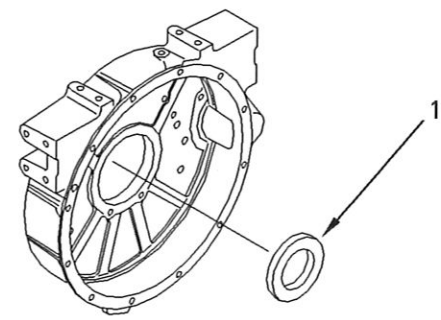

Illustration 55 g01000601

2. Apply a thin coat of clean engine oil to the crankshaft rear seal (1).

3. Install the crankshaft rear seal (1) with the 27610266 Oil Seal Installer, as follows:

   a. Install the Oil Seal Locator onto the crankshaft.

   b. Position crankshaft rear seal (1) in the Oil Seal Installer.

   c. Put the Bolt and the Washer through the Oil Seal Installer and thread into the Oil Seal Locator.

d. Turn the bolt clockwise in order to push the Oil Seal Installer with the new seal toward the Oil Seal Locator that is mounted on the end of the crankshaft.

e. Push crankshaft rear seal (1) onto the crankshaft until the Oil Seal Installer bottoms out.

f. Remove the Bolt, the Washer and the Oil Seal Installer and check the crankshaft rear seal (1) for correct installation.

g. Remove the Oil Seal Locator from the crankshaft.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, "Flywheel - Install".

i01981906

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.

i01981965

Crankshaft Wear Sleeve (Rear) - Install

Installation Procedure

Table 9

Required Tools		
Part Number	**Part Description**	**Qty**
21820518	POWERPART Gasket and Flange sealant	-

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).

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

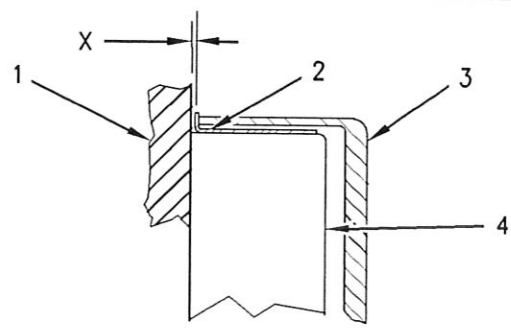

Illustration 56 g00948238

3. Apply a small continuous bead of POWERPART 21820518 Gasket and Flange Sealant to the inner surface 5.00 mm (0.197 inch) from the flange end of crankshaft wear sleeve (2).

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.

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 (X) 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".

i01981996

Flywheel Housing - Remove and Install

Removal Procedure

Start By:

a. Remove the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

b. 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.

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. Support the engine with blocks or with a suitable lifting device on a flat level surface.

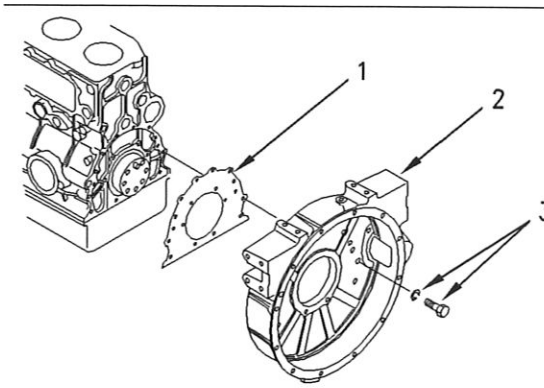

Illustration 57 g01000632

2. Install a suitable lifting eye and a suitable lifting device onto the flywheel housing (2).

3. Remove the setscrews (3) that secure the flywheel housing (2) to the cylinder block.

4. Remove the flywheel housing (2) and the joint (1). The weight of the flywheel housing is approximately 30 kg (66 lb).

Note: If necessary, tap the flywheel housing with a soft faced hammer in order to separate the flywheel housing from 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.

2. Inspect the dowels on the cylinder block that align the flywheel housing. Replace the dowels, if necessary.

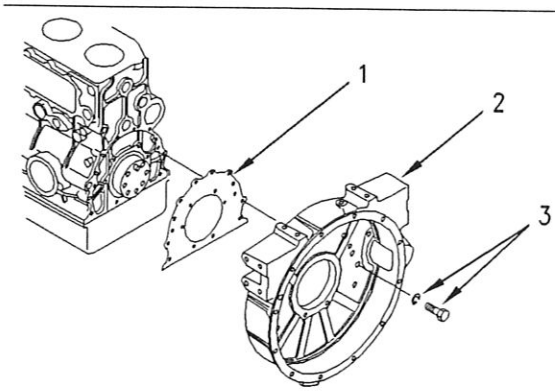

Illustration 58 g01000632

3. Position a new joint (1) on the dowels that are in the cylinder block.

4. Install a suitable lifting eye and a suitable lifting device in order to position the flywheel housing (2) on the dowels that are on the cylinder block. The weight of the flywheel housing is approximately 30 kg (66 lb).

5. Install the setscrews (3) and tighten evenly.

6. Remove the lifting eye and the lifting device from the flywheel housing.

End By:

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

b. Install the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

i01982047

Crankshaft Pulley - Remove and Install

Removal Procedure

Table 10

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1

Start By:

a. Remove the V-belt. 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.

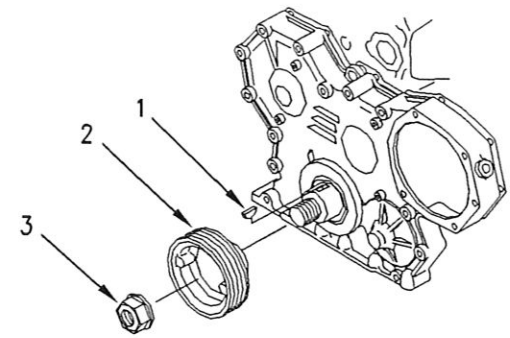

Illustration 59 g01000639

1. Use a 27610267 Socket (46 mm) to remove the nut (3) and the washer from the crankshaft.

2. If necessary, use a suitable puller to remove the crankshaft pulley (2). Remove the key (1) from the crankshaft.

Installation Procedure

Table 11

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

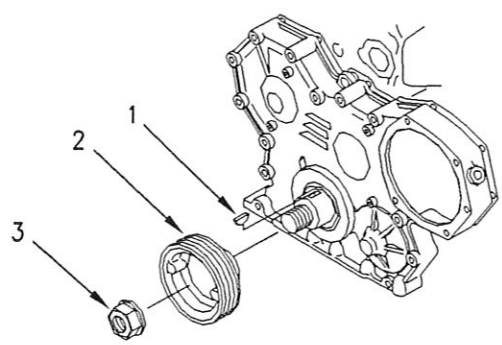

Illustration 60 g01000639

1. Position the key (1) and the crankshaft pulley (2) on the crankshaft.

2. Install the nut (3). Use a 27610267 Socket (46 mm) and tighten the nut (3) to a torque of 480 to 500 N·m (354 to 369 lb ft).

End By:

a. Install the V-belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

i01982073

Crankshaft Front Seal - Remove

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft 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.

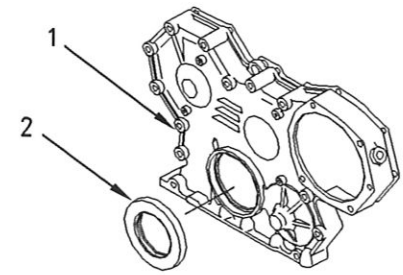

Illustration 61 g01000737

1. Use a 4.1 mm drill bit to drill three evenly spaced holes in the crankshaft front seal (2).

2. Use a suitable slide hammer puller in each of the three holes to evenly remove the crankshaft front seal (2) from the front housing (1).

NOTICE
Ensure that the main lip of the seal is used in order to remove the crankshaft front seal. Do not damage the edge of the housing for the crankshaft front seal.

i01982314

Crankshaft Front Seal - Install

Installation Procedure

Table 12

Required Tools		
Part Number	**Part Description**	**Qty**
27610268	Oil Seal Installer	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the housing for the crankshaft front seal and inspect the housing for damage.

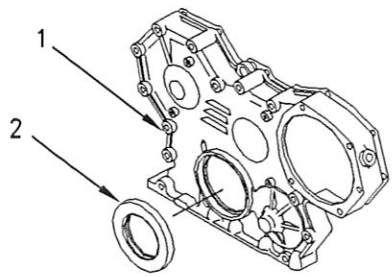

Illustration 62 g01000737

2. Apply a thin coat of clean engine oil to a new crankshaft front seal (2).

3. Use the 27610268 Oil Seal Installer to install the crankshaft front seal (2) into the front housing (1).

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.

4. Remove the Oil Seal Installer and check for the correct installation of the oil seal. The front seal must contact the bottom face of the front housing (1).

5. Apply clean engine oil onto the area of the crankshaft pulley that will be in contact with the crankshaft front seal (2).

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

i02001528

Front Cover - Remove and Install

Removal Procedure

Start By:

a. Remove the V-Belt. 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.

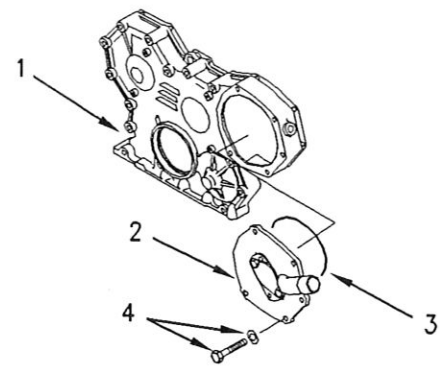

Illustration 63 g01000759

1. Remove the setscrews (4) from the front cover (2).

2. Remove the front cover (2) and the O-ring seal (3) from the front housing (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Check the condition of the O-ring seal. Replace the O-ring seal, if necessary.

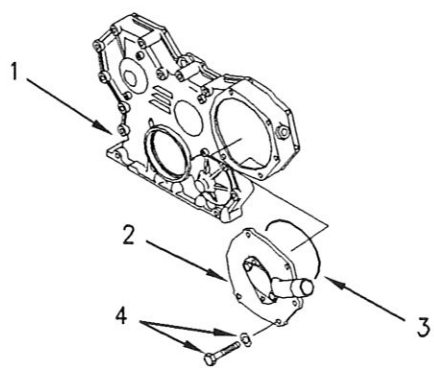

Illustration 64 g01000759

2. Clean the mounting surface of the front housing (1) and clean the front cover (2) thoroughly.

3. Position the O-ring seal (3) onto the front cover (2).

4. Position the front cover (2) onto the front housing (1).

5. Install the setscrews (4) and tighten evenly to 22 N·m (16 lb ft).

End By:

a. Install the V-Belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

i01982315

Idler Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the front housing. 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. Ensure that the No. 1 cylinder is at the top center compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

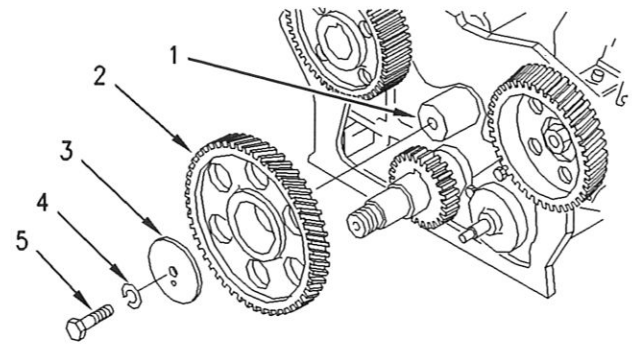

Illustration 65 g01000849

2. Remove the setscrew (5), the washer (4), and the retaining plate (3). Remove the idler gear (2) from the idler gear hub (1).

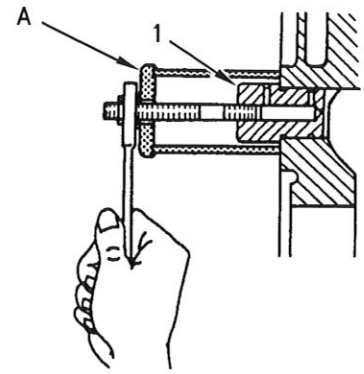

Illustration 66 g01000852

3. Use a suitable puller to remove the idler gear hub (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

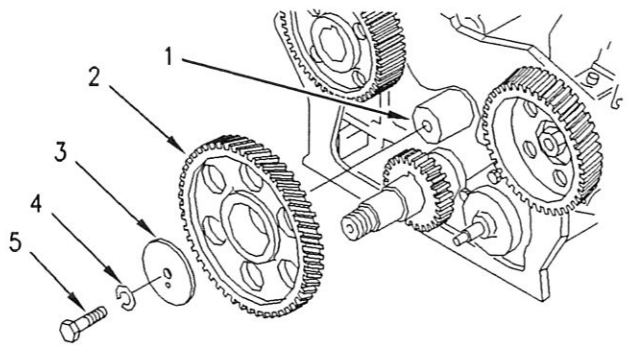

Illustration 67 g01000849

Note: The lubrication hole of the idler gear hub (1) must be positioned at the top.

1. Install the idler gear hub (1) into the cylinder block. Use a soft hammer to seat the idler gear hub (1).

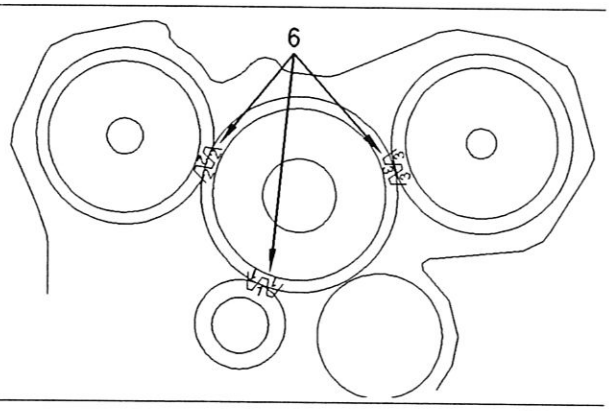

Illustration 68 g01000859

Note: When you install the idler gear (2), ensure that the marked teeth are facing toward the front.

2. Align the timing marks (6) on the teeth with the timing marks on the crankshaft gear, the fuel injection pump gear, and the camshaft gear. Position the idler gear (2) on idler gear hub (1).

3. Install retaining plate (3), the washer (4), and the setscrew (5) and tighten to a torque of 29 to 39 N·m (21 to 29 lb ft).

4. Inspect the backlash and the end play of the gear group. Refer to Testing and Adjusting, "Gear Group - Inspect".

End By:

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

i01982316

Housing (Front) - Remove

Removal Procedure

Start By:

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

b. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

c. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

d. Remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".

e. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - 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.

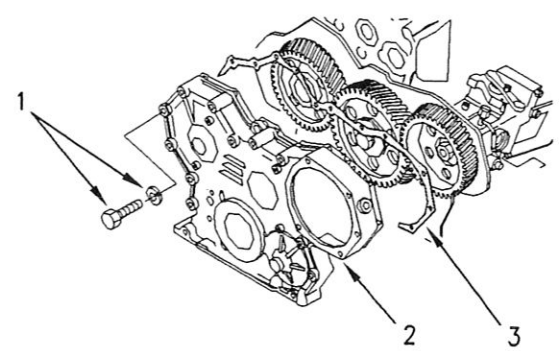

Illustration 69 g01000873

1. Remove the setscrews (1) from the front housing (2).

Note: Be careful not to damage the crankshaft front seal when you remove the front housing (2) from the cylinder block.

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

i02015960

Housing (Front) - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all mating surfaces thoroughly.

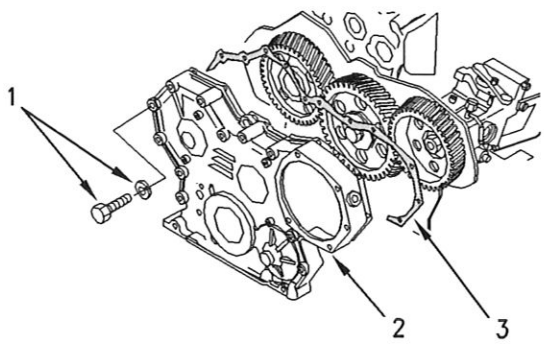

Illustration 70 g01000873

2. Install a new joint (3) onto the front plate. Be sure that the joint (3) correctly fits onto the dowel pins.

Note: Do not use sealant on the joint.

3. Apply clean engine oil to the lip of the crankshaft front seal.

Note: If a new crankshaft front seal needs to be installed, refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove" and Disassembly and Assembly, "Crankshaft Front Seal - Install".

4. Position the front housing (2) on the front of the cylinder block.

5. Install the setscrews (1) and tighten to a torque of 10 to 13 N·m (7 to 10 lb ft).

End By:

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

b. Install the alternator. Refer to Disassembly and Assembly, "Alternator - Remove and Install".

c. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

d. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

e. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

i02015961

Crankcase Breather - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

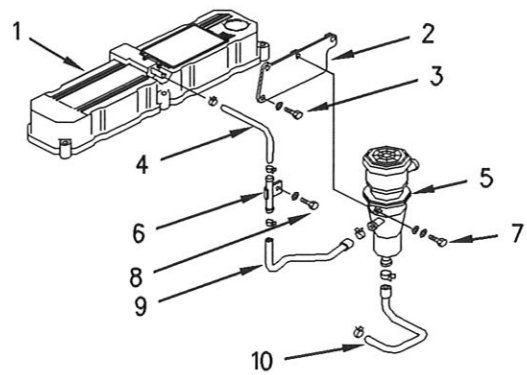

Illustration 71 g01000890

1. Loosen the hose clamps and disconnect the upper breather hose (4) and the lower breather hose (9) from the breather pipe (6) and from the valve mechanism cover (1). Remove the setscrew (8) and remove the breather pipe (6).

2. Loosen the hose clamps and disconnect the oil drain hose (10) from the breather body (5) and from the oil gauge assembly. Remove the setscrews (7) and remove the breather body (5).

3. Remove the setscrews (3) and remove the plate (2).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

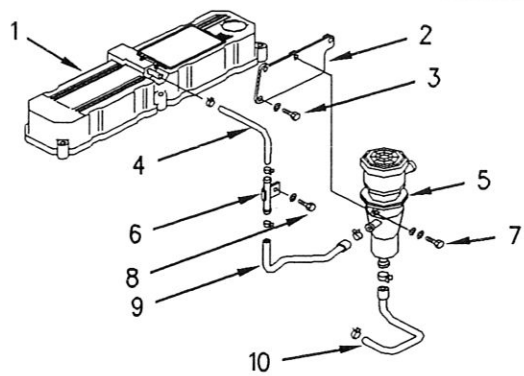

Illustration 72 g01000890

1. Position the plate (2). Install the setscrews (3) and tighten evenly.

2. Position the breather body (5). Install the setscrews (7) and tighten evenly. Install the oil drain hose (10) to the breather body (5) and to the oil gauge assembly and tighten the hose clamps securely.

3. Install the breather pipe (6) in the lower breather hose (9) and in the upper breather hose (4). Tighten the hose clamps securely.

4. Install the lower breather hose (9) in the breather body (5) and tighten the hose clamp securely. Install the upper breather hose (4) in the valve mechanism cover (1) and tighten the hose clamp securely.

5. Install the setscrew (8) and tighten evenly.

i01982329

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.

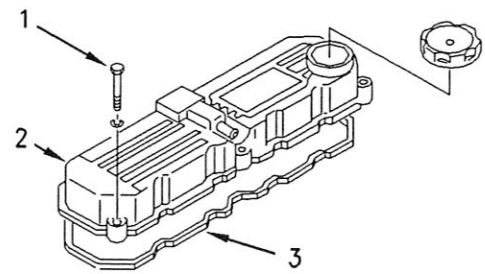

Illustration 73 g01000971

1. If the engine is equipped with a turbocharger, remove the air inlet hose that is positioned above the valve mechanism cover (2). Refer to Disassembly and Assembly, "Turbocharger - Remove".

2. Loosen the hose clamp and disconnect the breather hose from valve mechanism cover (2).

3. Remove the setscrews (1) from the valve mechanism cover (2). Remove the valve mechanism cover (2) and the joint (3) from the cylinder head.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

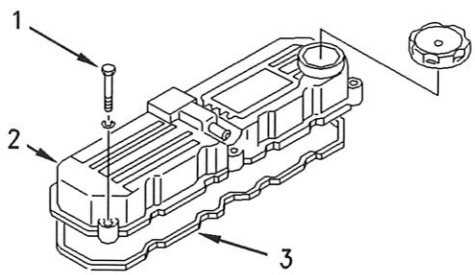

Illustration 74 g01000971

1. Check the condition of the joint (3). Replace the joint, if necessary.
2. Position the joint (3) in the valve mechanism cover (2). Position the valve mechanism cover (2) onto the cylinder head.
3. Install the setscrews (1) and tighten to a torque of 10 to 13 N·m (7 to 10 lb ft).
4. Connect the breather hose to the valve mechanism cover (2) and tighten the hose clamp securely.
5. If the engine is equipped with a turbocharger, install the air inlet hose that routes above valve mechanism cover (2). Refer to Disassembly and Assembly, "Turbocharger - Install".

i02015962

Rocker Shaft and Pushrod - Remove

Removal Procedure

Start By:

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

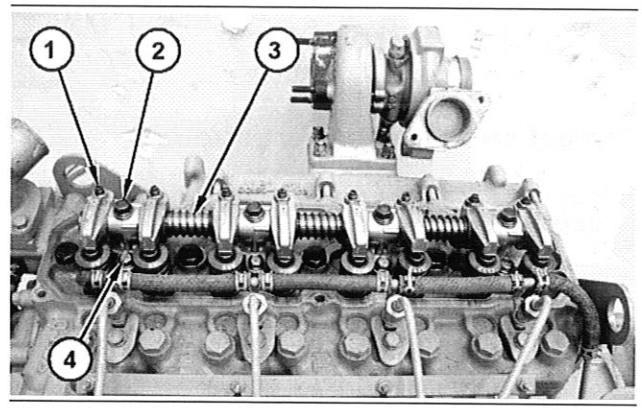

Illustration 75 g01035049

1. Loosen each nut and adjustment screw (1) by one rotation.
2. Remove the short setscrews (4) from the rocker shaft brackets.
3. Remove the long setscrews (2) from the rocker shaft brackets.

Note: Damage to the rocker shaft may occur if the long setscrews are loosened first.

4. Remove rocker shaft assembly (3) from the cylinder head.

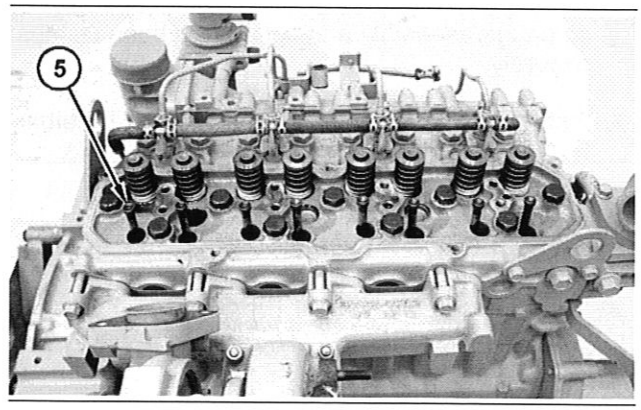

Illustration 76 g01035051

5. Remove the pushrods (5) from the cylinder head. Place an identification mark on the pushrods for installation purposes.

i01982361

Rocker Shaft - Disassemble

Disassembly Procedure

Start By:

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

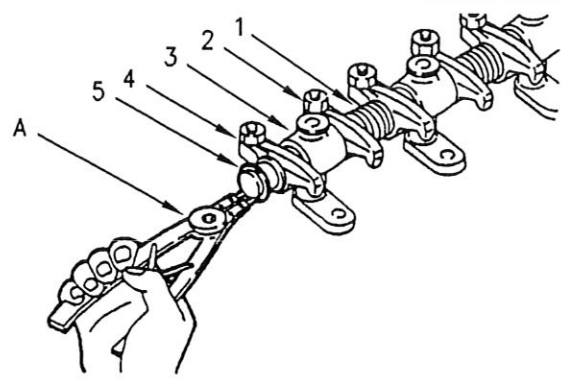

Illustration 77 g01001045

⚠ 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.

1. Use suitable retaining ring pliers to remove the retaining ring (5) from both ends of the rocker shaft assembly.
2. Place an identification mark on each of the components for installation purposes.
3. Remove the rocker arm assembly (4) for the inlet valve from the rocker shaft.
4. Remove the bracket (3) from the rocker shaft.
5. Remove the rocker arm assembly (2) for the exhaust valve from the rocker shaft.
6. Remove the spring (1) from the rocker shaft.
7. Repeat Steps 3 through 6 in order to completely disassemble the rocker shaft assembly.

i01982381

Rocker Shaft - Assemble

Assembly Procedure

Note: if a new rocker shaft is installed, 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. If the original rocker shaft is reused, clean the rocker shaft and ensure that all of the oil holes are free from debris or dirt.

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

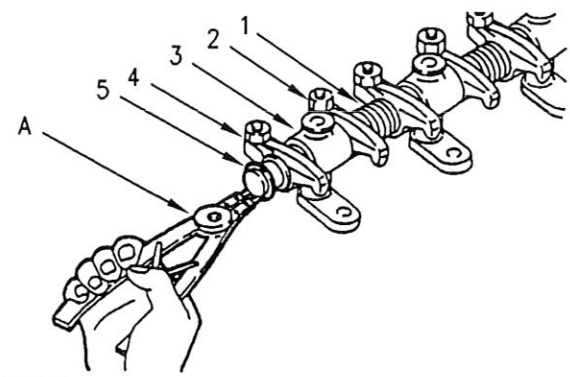

Illustration 78 g01001045

⚠ 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.

2. Install the rocker arm assembly (2) for the exhaust valve onto the rocker shaft.

Note: If the clearance between the rocker arm bushing and the rocker shaft is greater than 0.070 mm (0.0028 inch), replace the rocker arm assembly.

3. Install the spring (1) on the rocker shaft.
4. Install the bracket (3) onto the rocker shaft.
5. Install the rocker arm assembly (4) for the inlet valve onto the rocker shaft.

Note: If the clearance between the rocker arm bushing and the rocker shaft is greater than 0.070 mm (0.0028 inch), replace the rocker arm assembly.

6. Repeat Steps 2 through 6 in order to assemble the rocker shaft assembly.

7. Use suitable retaining ring pliers to install a retaining ring (5) onto both ends of the rocker shaft assembly.

End By:

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

i01982416

Rocker Shaft and Pushrod - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

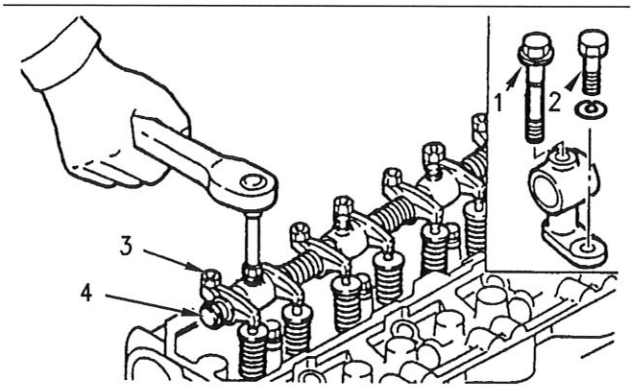

Illustration 79 g01001023

1. Install the pushrods into the cylinder head.

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

2. Loosen the nut and the adjustment screw (3) on each rocker arm. This will help prevent a bent valve or a bent pushrod during the installation of the rocker shaft assembly (4).

3. Position the rocker shaft assembly (4) onto the cylinder head.

4. Ensure that each adjustment screw (3) is properly seated in the ends of the pushrods. Also ensure that the valve caps are in position under the rocker arms.

Note: Damage to the rocker shaft may occur if the short bolts are installed and tightened first.

5. Install the long setscrews (1) into the rocker shaft brackets and tighten to a torque of 10 to 20 N·m (7 to 15 lb ft).

6. Install the short setscrews (2) into the rocker shaft brackets and tighten to a torque of 10 to 20 N·m (7 to 15 lb ft).

7. Adjust the inlet valve lash and the exhaust valve lash to 0.250 mm (0.0098 inch). Refer to Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for more information on adjusting the valve lash.

End By:

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

i01982472

Cylinder Head - Remove

Removal Procedure

Start By:

a. Remove the turbocharger, if equipped. Refer to Disassembly and Assembly, "Turbocharger - Remove".

b. Remove the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injectors - Remove (Naturally Aspirated) or Fuel Injectors - Remove (Turbocharged)".

c. Remove the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

d. Remove the rocker shaft and the pushrods. 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.

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 drain plug of the radiator into a suitable container for storage or disposal. Drain the engine oil from the engine drain plug into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual for the procedure on draining the engine coolant and the engine oil.

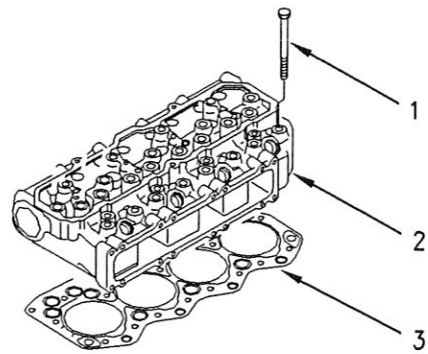

Illustration 80 g01001098

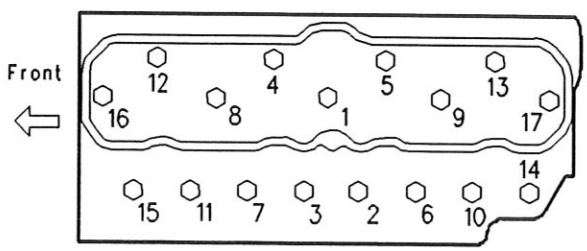

Illustration 81 g01001090

2. Loosen the setscrews for the cylinder head (1) in the reverse numerical order that is shown in Illustration 81. This will help prevent distortion of the cylinder head.

3. Remove the setscrews for the cylinder head (1) from cylinder head (2).

4. Use suitable lifting eyes and a suitable lifting device and carefully lift the cylinder head (2) off the cylinder block. The weight of the cylinder head is approximately 50 kg (110 lb).

Note: Do not use a lever to separate the cylinder head from the cylinder block.

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

5. Remove the cylinder head gasket (3).

Note: Be careful not to damage the top surface of the cylinder block and note the location of the dowels on the cylinder block.

i01983141

Cylinder Head - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean the top of the cylinder block and the bottom of the cylinder head. Ensure that there is no debris in the cylinder bores.

2. Inspect the cylinder head for damage. Refer to System Operations, Testing and Adjusting Manual, "Cylinderhead - Inspect"for further information.

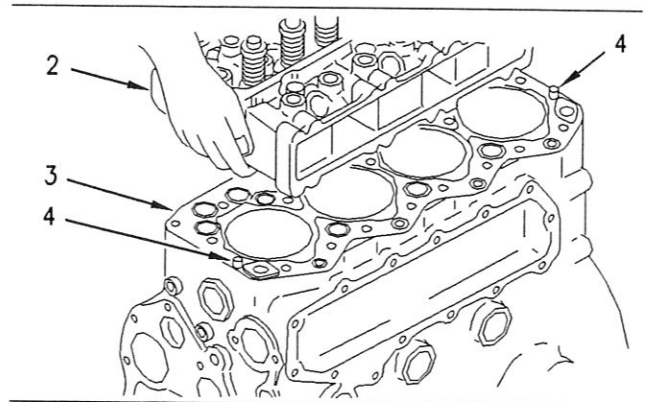

Illustration 82 g01001103

3. Position the cylinder head gasket (3) onto dowels (4) on top of the cylinder block.

Note: Do not use any sealant or compound on the cylinder head gasket.

4. Install two suitable guide pins in the cylinder block near the dowels (4).

5. Use a suitable lifting eye and a suitable lifting device to position cylinder head (2). The weight of cylinder head (2) is approximately 50 kg (110 lb).

Note: Ensure that cylinder head (2) is positioned correctly onto the dowels (4).

6. Remove the lifting eye and the lifting device.

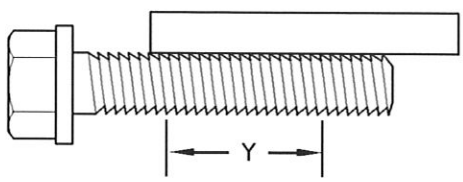

Illustration 83 g00951563

7. Clean the threads and inspect the threads of the setscrews for the cylinder head (1).

Note: Do not use the setscrews (1) 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 setscrews (1).

8. Lubricate the threads and the shoulder of the setscrews for the cylinder head (1) with clean engine oil before installation.

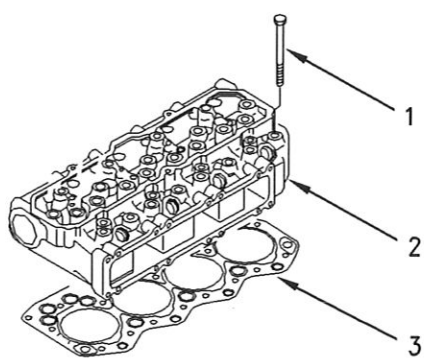

Illustration 84 g01001098

9. Install the rest of the setscrews for the cylinder head (1) in the cylinder head (2).

10. Remove the two guide pins and install the remaining setscrews (1).

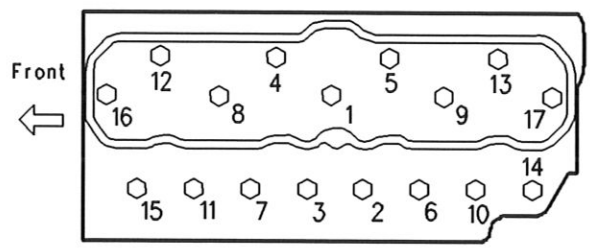

Illustration 85 g01001090

11. Tighten the setscrews for the cylinder head (1) in the numerical order that is shown in Illustration 85 to a torque of 113 to 123 N·m (83 to 91 lb ft).

12. Fill the cooling system with coolant. Fill the lubrication system with engine oil.

Note: Refer to Operation and Maintenance Manual, "Refill Capacities" for the cooling system capacity and the lubrication system capacity of the engine.

End By:

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

b. Install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

c. Install the fuel injection nozzles. Refer to Disassembly and Assembly, "Fuel Injectors - Install (Naturally Aspirated) or Fuel Injectors - Install (Turbocharged)".

d. Install the turbocharger, if equipped. Refer to Disassembly and Assembly, "Turbocharger - Install".

i01983142

Lifter Group - Remove and Install

Removal Procedure

Start By:

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

b. 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.

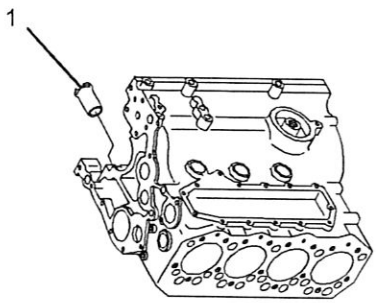

Illustration 86 g01040370

1. Use a suitable telescoping magnet to remove the lifters (1).

Note: Place an identification mark on the lifters 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 before installing the lifters in the cylinder block.

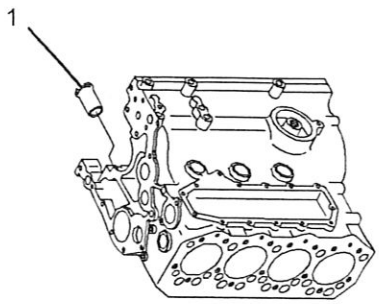

Illustration 87 g01040370

2. Use a suitable telescoping magnet to install lifters (1).

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

End By:

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

b. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".

i01983143

Camshaft - Remove and Install

Removal Procedure

Start By:

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

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

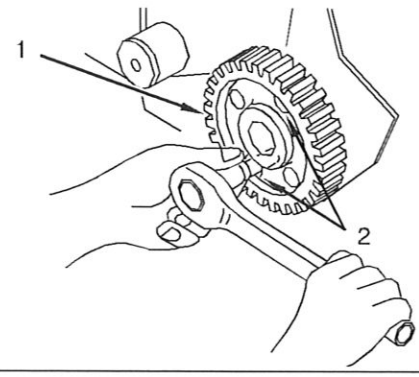

Illustration 88 g01036212

2. Position the camshaft gear (1) so that two of the holes (2) come to the top and the bottom position. Remove the two setscrews for the thrust washer through the two holes (2).

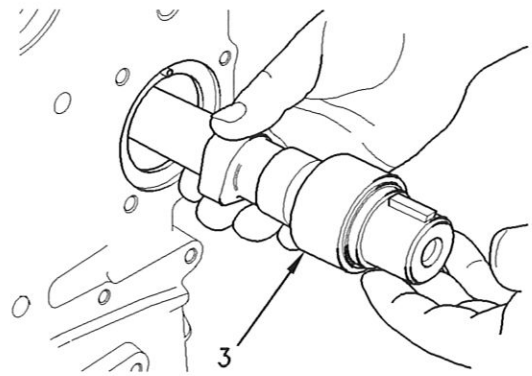

Illustration 89 g00951934

Shown without the gear and the thrust washer (typical example)

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

3. Carefully remove the camshaft (3), the thrust washer, and camshaft gear (1) as an assembly from the cylinder block.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

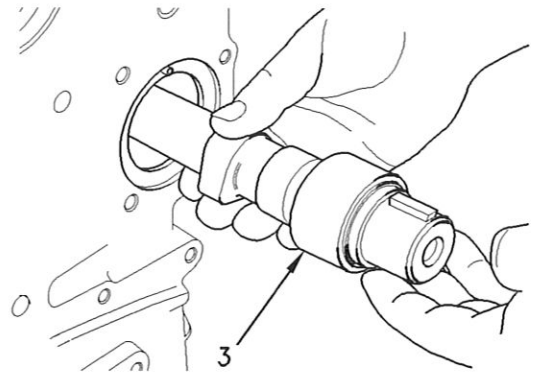

Illustration 90 g00951934

Shown without the gear and the thrust washer (typical example)

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

2. Carefully install the camshaft (3) as an assembly into the cylinder block.

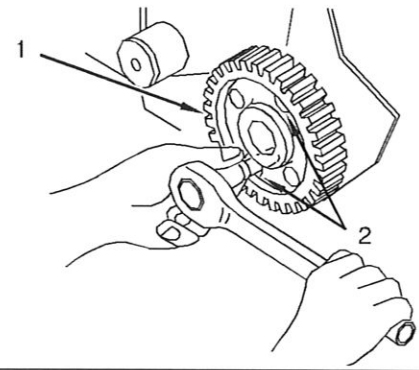

Illustration 91 g01036212

3. Position the camshaft gear (1) so that two of the holes (2) come to the top and the bottom position. Install the setscrews for the thrust washer and tighten to a torque of 10 to 13 N·m (7 to 10 lb ft).

End By:

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

b. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrods - Install".

i01983144

Camshaft Gear - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

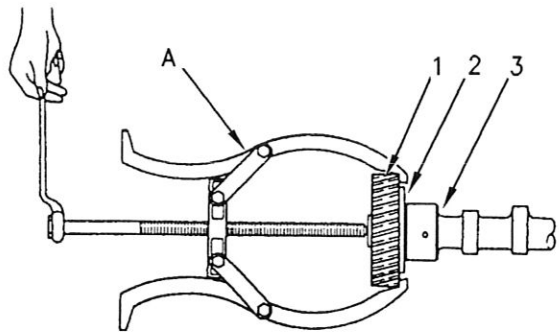

Illustration 92 g01001235

1. Use a suitable puller to remove the camshaft gear (1) from camshaft (3). Remove the key and thrust washer (2).

Note: Do not lose the key from the camshaft gear.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the camshaft gear (1), the key, and the thrust washer (2) for wear or damage.
2. Install the key for the camshaft gear (1) into the camshaft (3).

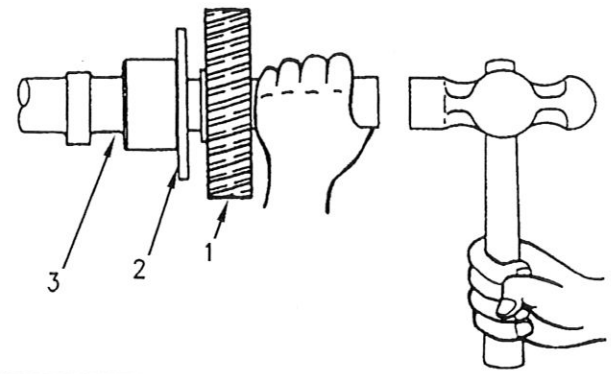

Illustration 93 g01001244

3. Install thrust washer (2) and camshaft gear (1) onto camshaft (3).

Note: Ensure that the thrust washer is installed correctly. When you install the camshaft gear, ensure that the marked teeth are facing toward the front. If necessary, tap the gear with a soft hammer in order to seat the key in the keyway.

i01984172

Camshaft Bearings - Remove and Install

Removal Procedure

Table 13

Required Tools		
Part Number	**Part Description**	**Qty**
27610271	Camshaft Bearing Installation and Removal Tool	1

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.

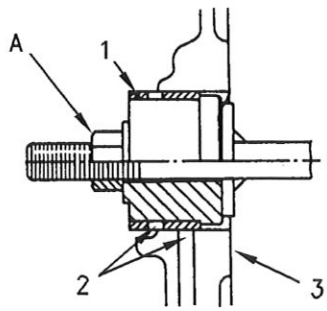

Illustration 94 g01001451

1. Use the 27610271 Camshaft Bearing Installation and Removal Tool to remove camshaft bearing (1) from the cylinder block.

Installation Procedure

Table 14

Required Tools		
Part Number	**Part Description**	**Qty**
27610271	Camshaft Bearing Installation and Removal Tool	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the bore in the cylinder block for the camshaft bearing is clean and free of debris.

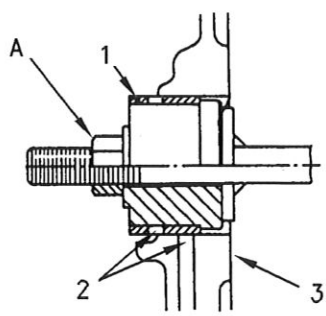

Illustration 95 g01001451

2. Use the 27610271 Camshaft Bearing Installation and Removal Tool to install the camshaft bearing (1) into the cylinder block.

Note: Align the oil holes (2) in the camshaft bearing and the cylinder block. The camshaft bearing (1) should be installed to a depth that is flush with the face of the recess in the cylinder block (3).

End By:

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

i02295885

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.

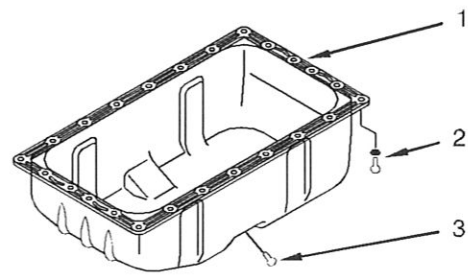

Illustration 96 g01029063

1. Remove the oil drain plug (3). Drain the engine oil into a suitable container for storage or disposal.

2. Install the oil drain plug (3) and tighten to a torque of 34 to 44 N·m (25 to 33 lb ft).

3. Remove the setscrews (2) from the engine oil pan (1).

4. Remove the engine oil pan (1) from the cylinder block.

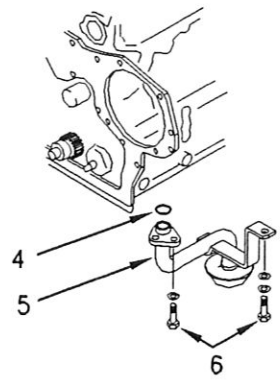

Illustration 97 g01001550

5. Remove the setscrews (6).

6. Remove the engine oil suction tube (5) and the O-ring seal (4).

Engines that have a Balancer

Note: This engine is installed with a different type of suction pipe.

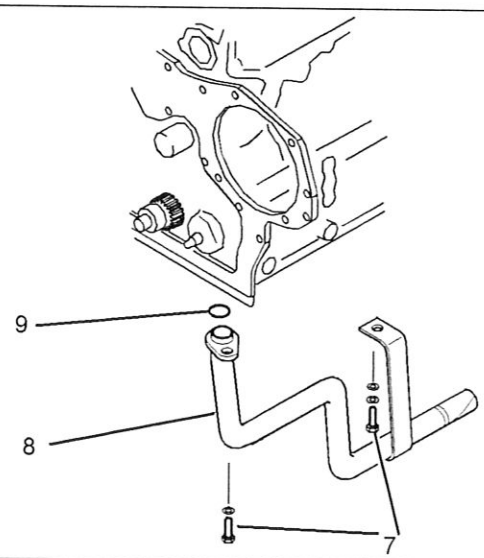

Illustration 98 g01149838

1. Remove the setscrews and washers (7). Remove the suction pipe (8) and the O-ring seal (9).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all of the surfaces thoroughly.

2. Check the condition of the O-ring seal (4). Replace the O-ring seal, if necessary.

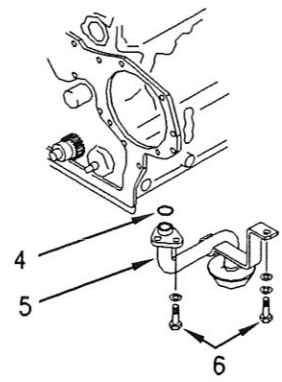

Illustration 99 g01001550

3. Position the O-ring seal (4) on the engine oil suction tube (5). Position the engine oil suction tube (5) onto the cylinder block.

4. Install the setscrews (6) and tighten evenly.

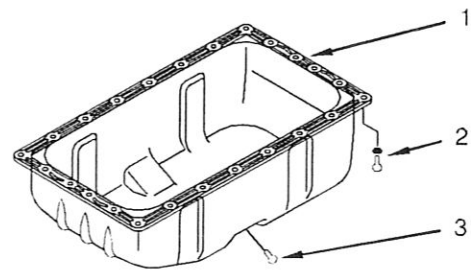

Illustration 100 g01029063

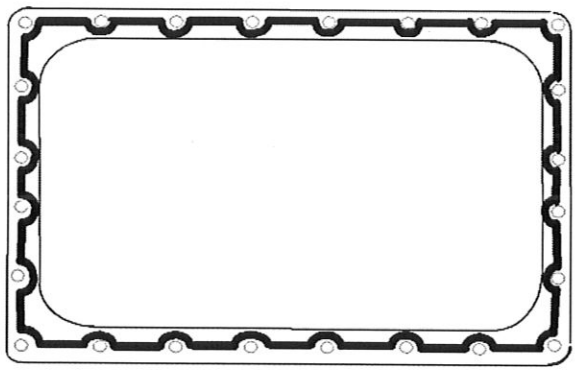

Illustration 101 g01020644

5. Apply 21820117 POWERPART Threadlock and Nutlock to the flange of the oil pan on the inside of the pattern for the setscrew holes. Refer to illustration 101.

Note: Apply the sealant in a continuous bead in order to help prevent an oil leak.

6. Position the engine oil pan (1) onto the cylinder block.

7. Install the setscrews (2) in order to secure the engine oil pan (1) to the cylinder block. Tighten the setscrews finger tight.

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.

8. Tighten the setscrews (2) to a torque of 10 to 13 N·m (7 to 10 lb ft).

9. Fill the engine oil pan to the correct level that is indicated on the engine oil level gauge.

Note: Refer to the Operation and Maintenance Manual, "Refill Capacities" for the lubrication system capacity of the engine.

Engines that have a Balancer

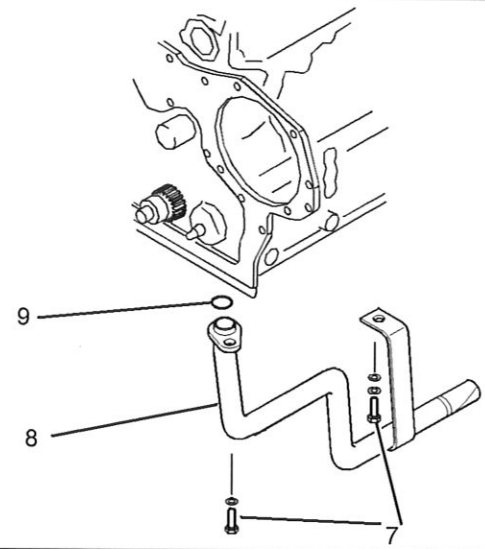

Illustration 102 g01149838

1. Replace the O-ring seal (9), if necessary. Align the suction pipe (8) and install the setscrews (7).

2. In order to install the oil pan , refer to step 5.

i02293799

Balancer - Remove (If equipped)

Removal Procedure

Table 15

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610275	Bearing installer	1

Start By:

a. Remove the engine oil pan. Refer to this manual Disassembly and Assembly manual , "Engine Oil Pan - Remove and Install".

b. Ensure that the No. 1 cylinder is at top dead center on the compression stroke. Refer to the Testing and Adjusting Manual, "Finding Top Center Position for No. 1 Piston".

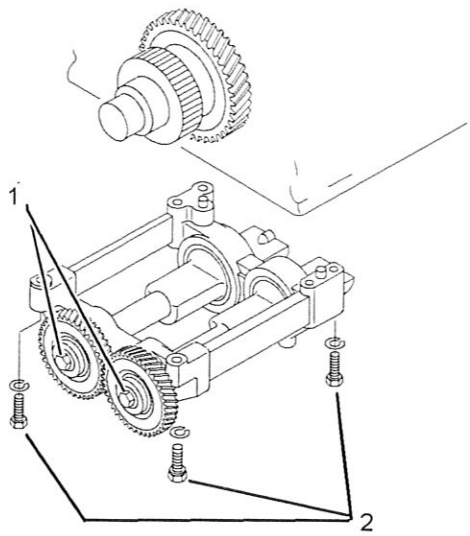

Illustration 103 g01151728

1. If necessary, loosen the setscrews (1). Remove the setscrews (2) and remove the balancer from the engine.

Disassembly Procedure

Note: In order to remove the balancer gears, with a suitable puller, ensure that the balancer shaft is protected from damage.

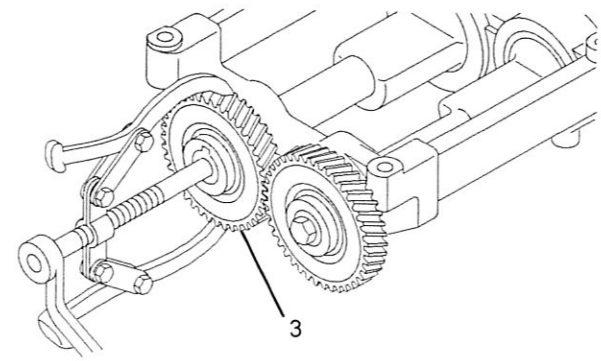

Illustration 104 g01152038

1. Remove the two setscrews and washers (1). Use a suitable puller in order to remove the balancer gears (3).

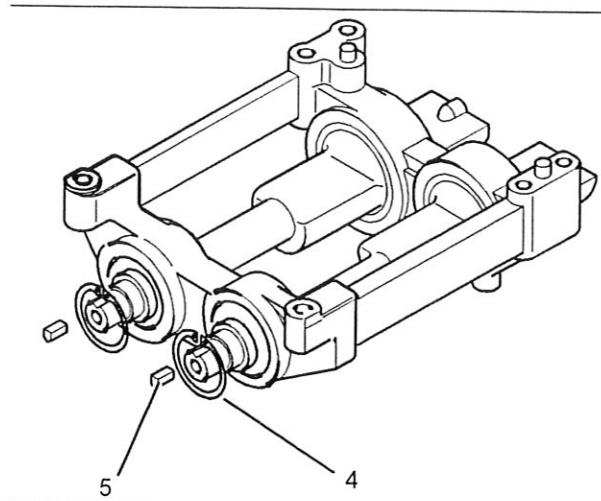

Illustration 105 g01152039

2. Remove the woodruff keys (5). Use suitable pliers in order to remove the spring clips (4).

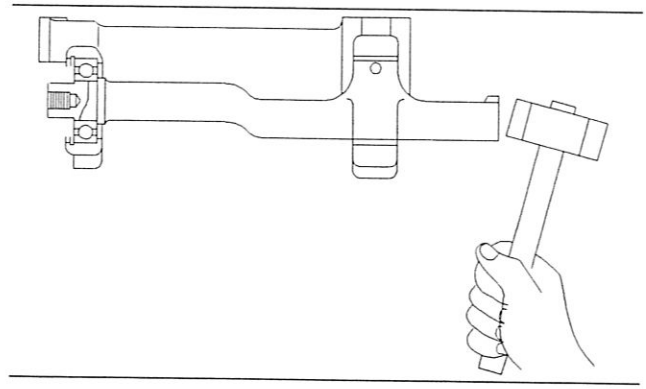

Illustration 106 g01152040

3. Use a rubber hammer in order to remove the balancer shafts from the housing. Ref to illustration 106

Note: In order to remove the balancer shaft bearings, with a suitable puller, ensure that the balancer shaft is protected from damage.

4. Use a suitable puller in order to remove the roller bearing from the balancer shaft.

5. Inspect the bushing in the housing and inspect the balancer shaft. For more information, refer to Testing and Adjusting, " Gear Group-Inspect".

6. Install tooling (A). Remove the bushing from the balancer.

i02294289

Balancer - Install

Assembly Procedure

Table 16

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610275	Bearing installer	1

1. Ensure that all the components are clean and dry.

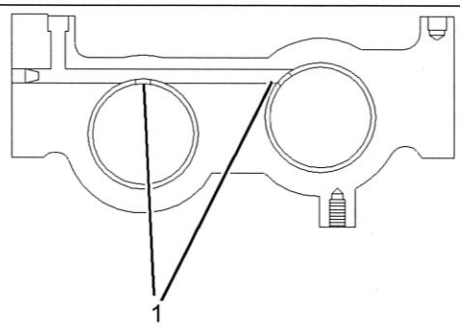

Illustration 107 g01152409

2. Align the bushing (6) to the housing for the balancer. Ensure that the oil holes (1) are correctly aligned to the bushing.

3. Assemble the tooling (A) and install the bushing.

4. Assemble the tooling (A) and press fit the roller bearings (3) onto both the shafts (5).

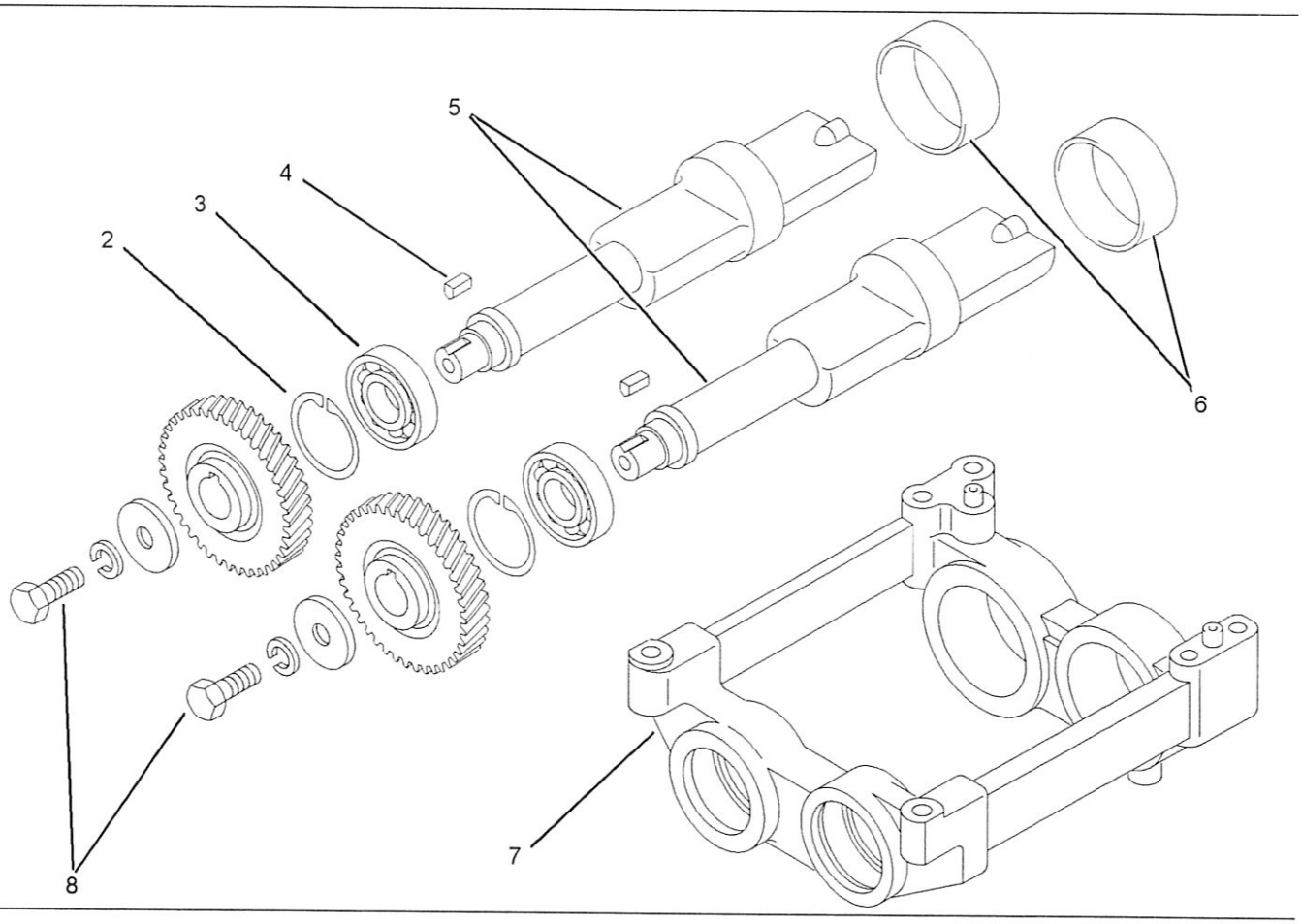

Illustration 108 g01152458

5. Lubricate the bushing and the shaft with clean lubricating engine oil. Press fit both the balancer shafts (5) into the housing (7).

6. Use suitable pliers in order to insert the spring clips (2). Ensure that the spring clips are fully located into the recess.

Note: Ensure that both balancer shafts can rotate freely.

7. Install both the woodruff keys (4).

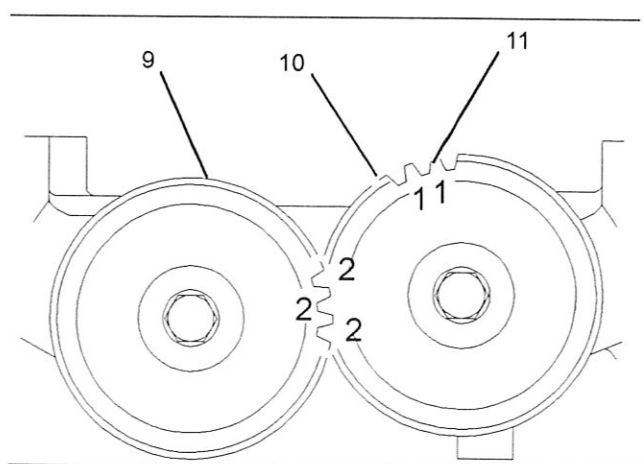

Illustration 109 g01149573

Note: The balancer gears (9 and 10) have different marking in order to time the balancer to the engine. The right hand gear (10) is marked 1,1 and 2,2. The left hand gear (9) is marked 2.

8. Align the right hand gear (10) to the key to the right hand side shaft and install the gear.

9. Align the left hand gear (9) to the key on the left hand side shaft. Also align the mark 2 on the gear (9) to the marks 2,2 on the gear teeth (10). Install the gear (9). Ensure that the marks on both gears are correctly aligned.

10. Install both the setscrews (8). Tighten the setscrews temporarily.

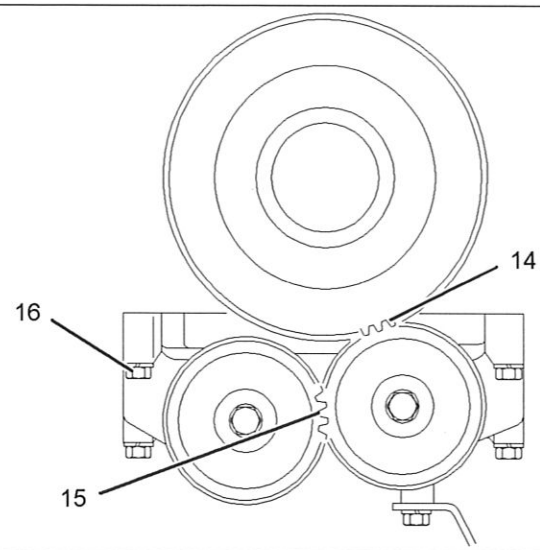

Illustration 110 g01152417

Note: Ensure that the marks on both the gears (15) are aligned.

11. Align the mark 1,1 on the gear teeth (10) to the mark 1 on the gear (14). Install the balancer to the engine. Tighten the setscrews (16) that hold the balancer to the engine block to 30 N·m (22 lb ft).

12. Remove the two setscrews (8). Apply 21820120 Stud and Bearing Lock to both the thread on the setscrews. Install both the setscrews and tighten both the setscrews to 33 N·m (24 lb ft).

13. Check the backlash on the gear train for the balancer. Refer to Specifications Manual , "Gear Group (Front)".

End By:

a. Install the engine oil pan. Refer to this manual Disassembly and Assembly, " Engine Oil Pan - Remove and Install".

i02296760

Pistons and Connecting Rods - Remove

Removal Procedure

Table 17

Required tools		
Part Number	**Part Description**	**Qty**
27610274	Ridge Reamer	1
27610267	Socket (46 mm)	1

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".

b. 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.

1. Use a 27610274 Ridge Reamer to remove the carbon ridge from the top inside surface of the cylinders.

2. Use a 27610267 Socket (46 mm) to rotate the crankshaft in a clockwise direction until the pistons that are being removed are at the bottom center position.

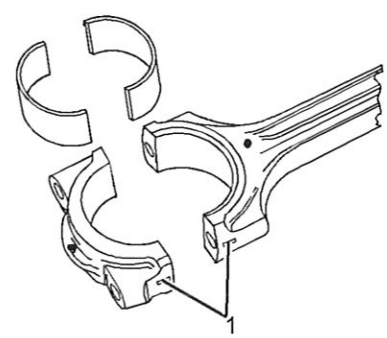

Illustration 111 g01032611

3. Inspect the connecting rod and the connecting rod cap for the correct identification marks.

Note: The connecting rod and the connecting rod cap should have matching Marks (1) on the side. Mark the connecting rod and the connecting rod cap, if necessary.

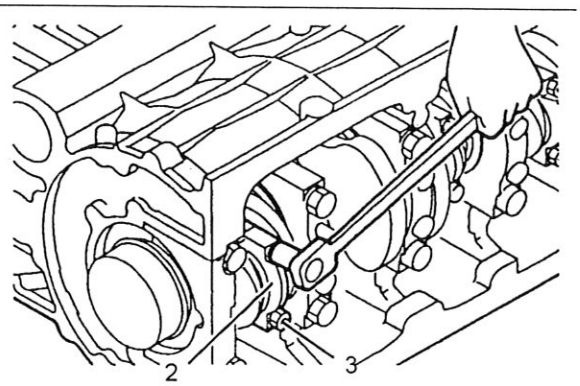

Illustration 112 g01032411

4. Remove the nuts (3) that hold the connecting rod cap (2) to the connecting rod.

5. Remove the connecting rod cap (2) and the lower bearing shell for the connecting rod. Keep the bearing shell with the cap.

Note: Use tape or rubber tubing on the bolts for the connecting rod to protect the crankshaft journals from damage.

6. Push the piston and the connecting rod through the top of the cylinder block.

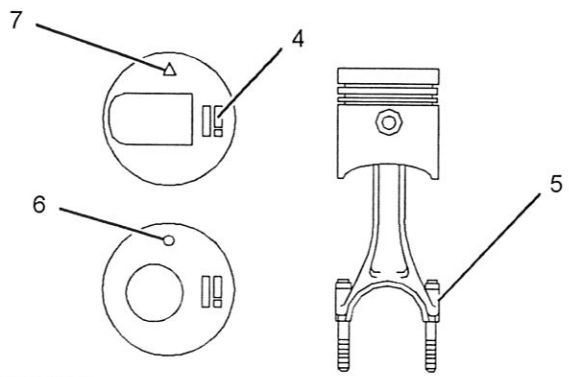

Illustration 113 g01032649

A typical example of a piston for a Turbocharged engine (7) and a piston for a Direct injection engine (6)

7. Note that the Mark (4) on the top of the piston is on the same side as the Mark (5) on the connecting rod for the purpose of reassembly.

8. Repeat Steps 1 through 7 in order to remove the remaining pistons and the connecting rods.

i01986392

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 18

Required Tools		
Part Number	**Part Description**	**Qty**
27610275	Driver Group	1

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.

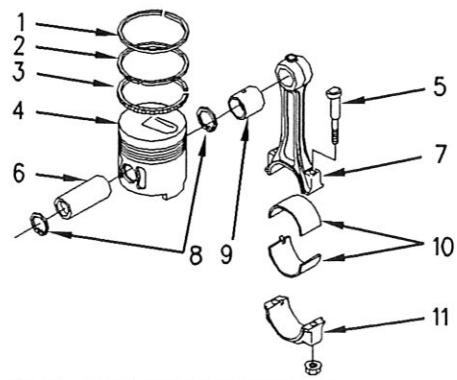

Illustration 114 g01001576

1. Remove the connecting rod bolts (5) from connecting rod (7).

2. Remove the bearing shells for the connecting rod (10) from the connecting rod cap (11) and the connecting rod (7). Keep the connecting rod, the connecting rod cap and the two bearing shells as a set.

3. Use a suitable ring expander to remove the compression rings (1) and (2), and the oil control ring (3) from the piston (4).

4. Use suitable retaining pliers to remove the retaining rings (8) that hold the piston pin (6) in position.

5. Remove the piston pin (6) from the piston (4).

Note: If the piston pin cannot be removed by hand, raise the temperature of the piston to 45 ± 5 °C (113 ± 9 °F) in hot water. Do not use a torch to heat the piston.

6. Use the 27610275 Driver Group and a suitable press to remove the piston pin bearing (9) from the connecting rod (7).

7. Repeat Steps 1 through 6 in order to disassemble the remaining pistons and the connecting rods.

i01986462

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 19

Required Tools		
Part Number	**Part Description**	**Qty**
27610275	Driver Group	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The connecting rod controls the piston height above the cylinder block. The correct connecting rod and the correct piston must be assembled and installed in the correct cylinder.

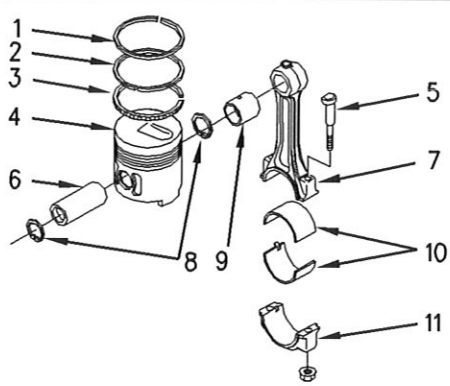

Illustration 115 g01001576

1. Use the 27610275 Driver Group and a suitable press to install piston pin bearing (9) into the connecting rod (7).

Note: Ensure that the oil hole in the piston pin bearing is aligned with the oil hole at the top of the connecting rod.

Note: If the clearance between the piston pin (6) and the piston pin bearing (9) exceeds 0.080 mm (0.0031 inch), replace the piston pin or the piston pin bearing with a new part.

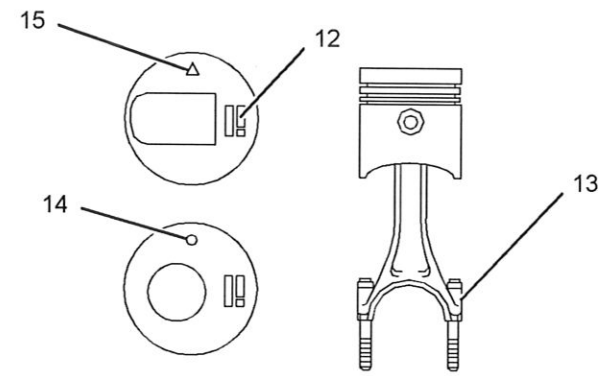

Illustration 116 g01032868

Note: The piston with the triangle (15) is for the turbocharged engine. When the engine is assembled, the triangle (15) must point toward the front of the engine. The piston crown of the direct injection engine is stamped with a circle (14). When the engine is correctly assembled, the circle (14) must point toward the front of the engine.

Note: Position the piston and the connecting rod so that the Marks (12) and (13) are on the same side.

2. Install the piston pin (6) into the piston (4) and through the connecting rod (7).

Note: If the piston pin cannot be installed by hand, raise the temperature of the piston to 45° ± 5°C (113° ± 9°F) in hot water. Do not use a torch to heat the piston.

3. Use suitable retaining pliers to install the retaining rings (8) that hold the piston pin (6) in position.

Note: Position the ends of the retaining rings toward the bottom of the piston.

4. Use a suitable ring expander to install the piston rings onto the piston (4) with the following steps.

Note: Ensure that the latch pin that is on the oil control ring is 180 degrees from the oil control ring gap.

   a. Install the oil control ring (3) into the groove that is lowest on the piston. The latch pin that is on the oil control ring must be inside the ends of the spring.

Note: The stamp "R" or "T" must be toward the top of the piston.

b. Install the intermediate compression ring (2) with the tapered face into the second groove on the piston.

Note: The stamp "R" or "T" must be toward the top of the piston.

c. Install the top compression ring (1) into the top groove on the piston.

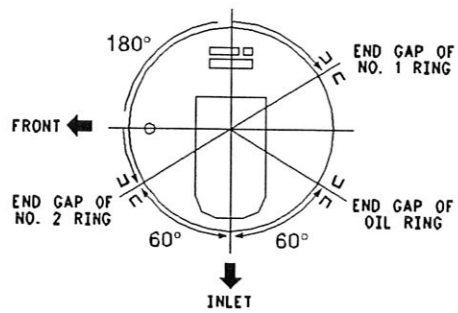

Illustration 117 g01003972

d. Refer to Illustration 117 in order to position the piston ring gaps.

5. Install the bearing shells for the connecting rod (10) into the connecting rod (7) and into the connecting rod cap (11).

6. Install the connecting rod bolts (5) into the connecting rod (7).

7. Repeat Steps 1 through 6 in order to assemble the remaining pistons and the connecting rods.

End By:

a. Install the pistons and connecting rods. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

i02296769

Pistons and Connecting Rods - Install

Installation Procedure

Table 20

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1
21825491	Piston Ring Compressor	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 walls with clean engine oil.

Note: The piston and connecting rod are matched to a specific cylinder. Ensure that the connecting rod and pistons are installed in the correct cylinder.

3. Use a 27610267 Socket (46 mm) to rotate the crankshaft until the connecting rod journal is at the bottom center position. Lubricate the connecting rod journal with clean engine oil.

4. Lubricate the bearing shell for the upper connecting rod with clean engine oil.

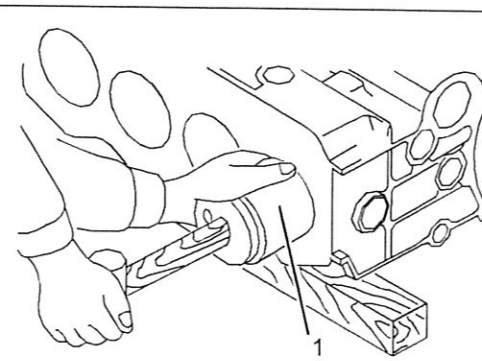

Illustration 118 g01032344

5. Use a 21825491 Piston Ring Compressor in order to install the piston.

Note: The mark "O" or the "triangle " that is on the top of the piston must be toward the front of the engine.

Note: Use tape or rubber tubing on the connecting rod bolts to protect the crankshaft journals from damage.

6. Push the piston (1) and the connecting rod assembly into the cylinder and onto the connecting rod journal.

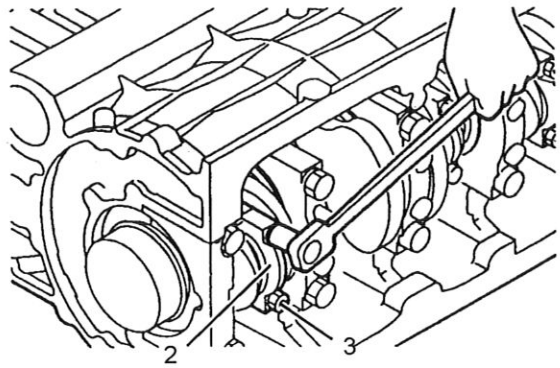

Illustration 119 g01032411

7. Lubricate the lower bearing shell for the connecting rod with clean engine oil.

Note: Remove the tape or rubber tubing from the connecting rod bolts.

8. Install the connecting rod cap (2).

Note: Ensure that the mark on the connecting rod cap matches the mark on the connecting rod. Ensure that the marks are on the same side.

9. Install the nuts (3) and tighten to a torque of 49 to 59 N·m (36 to 44 lb ft).

10. Use a 27610267 Socket (46 mm) to rotate the crankshaft in order to ensure that there is no binding.

11. Repeat Steps 2 through 10 in order to install the remaining pistons and connecting rods.

12. Always ensure that the crankshaft rotates freely after each piston assembly has been installed.

13. Ensure that the piston height is correct for each cylinder. Refer to Testing and Adjusting, "Piston Height - Inspect" for the correct procedure on checking the height of the piston above the cylinder block.

End By:

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

b. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i01989034

Connecting Rod Bearings - Remove

Removal Procedure

Table 21

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1

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.

1. In order to remove the connecting rod caps, use a 27610267 Socket (46 mm) to rotate the crankshaft in a clockwise direction until the piston is at the bottom center position.

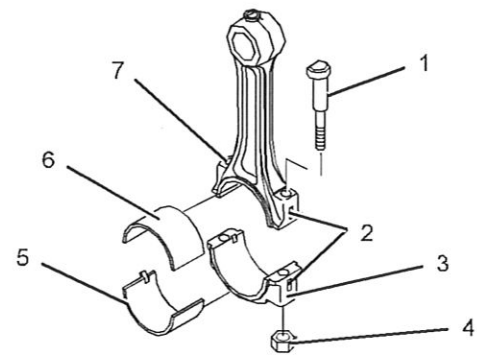

Illustration 120 g01032255

2. Inspect the connecting rod (7) and the connecting rod cap (3) for the correct identification mark (2).

Note: The connecting rod and the connecting rod cap should have matching marks (2) on the side. Mark the connecting rod and the connecting rod cap, if necessary.

3. Remove the nuts (4) from the connecting rod bolts (1). Remove connecting rod cap (3). Remove the lower bearing shell of the connecting rod (5) from the connecting rod cap (3).

4. Carefully push the connecting rod (7) into the cylinder bore. Remove the upper bearing shell of the connecting rod (6) from the connecting rod (7).

5. Repeat Steps 1 through 4 for the remaining connecting rod bearings.

i02296784

Connecting Rod Bearings - Install

Installation Procedure

Table 22

Required Tools		
Part Number	Part Description	Qty
27610267	Socket (46 mm)	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

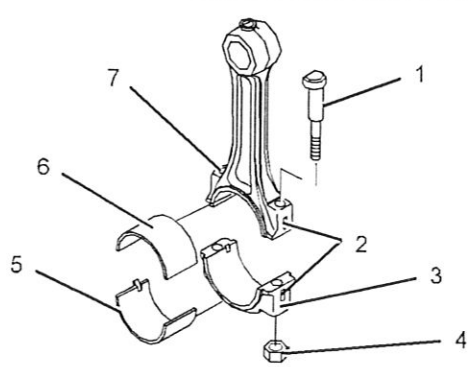

Illustration 121 g01032255

1. Install the upper bearing shell for the connecting rod (6) in the connecting rod (7). The upper bearing shell for the connecting rod must be centered in the connecting rod. Lubricate the bearing face with clean engine oil.

2. Pull the connecting rod (7) into position against the crankshaft.

3. Install the lower bearing shell for the connecting rod (5) in connecting rod cap (4). The lower bearing shell for the connecting rod must be centered in the connecting rod cap. Lubricate the bearing face with clean engine oil.

Note: Do not mix the connecting rod caps and the connecting rods.

4. Install the connecting rod cap (3).

Note: The connecting rod and the connecting rod cap should have matching Marks (2) on the side. Ensure that the marks are on the same side.

5. Install the nuts (4) onto the connecting rod bolts (1). Tighten the nuts evenly to a torque of 49 to 59 N·m (36 to 44 lb ft).

6. Repeat Steps 1 through 5 for the remaining connecting rod bearings.

7. Use a 27610267 46 mm socket to rotate the crankshaft in order to ensure that there is no binding.

End By:

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

i01990505

Crankshaft Main Bearings - Remove

Removal Procedure

Table 23

Required Tools		
Part Number	Part Description	Qty
27610267	Socket (46 mm)	1

Start By:

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

b. Remove the flywheel housing in order to remove the rear main bearing. Refer to Disassembly and Assembly, "Flywheel Housing - Remove and Install".

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: If the engine is still installed in the equipment or the vehicle, ensure that the weight of the crankshaft is fully supported, before any of the bearing caps are loosened.

1. Make sure that the main bearing caps are marked for the location and direction for installation. The main bearings and the main bearing caps must be installed in the same location.

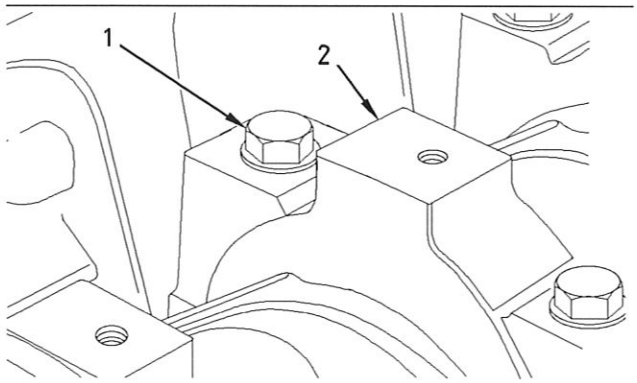

Illustration 122 g00947823

2. Remove the setscrews (1) and the main bearing cap (2).

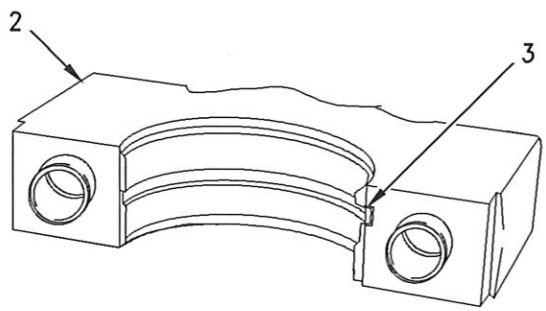

Illustration 123 g00934803

3. Remove the lower main bearing shell (3) from the main bearing cap (2). Keep the respective main bearing shell and the main bearing cap together for proper installation.

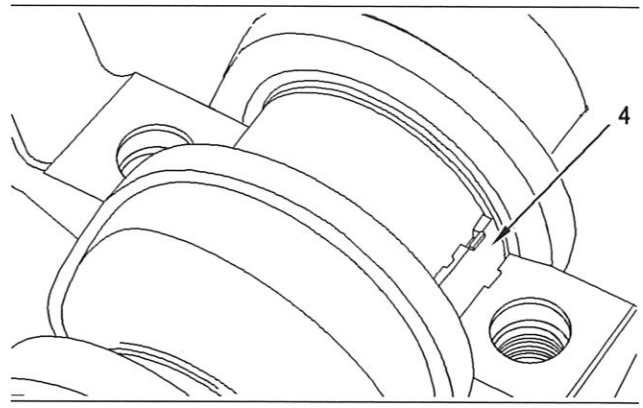

Illustration 124 g00934767

4. Push the upper main bearing shell (4) from the opposite side of the bearing tab with a suitable tool. Use a 27610267 46 mm Socket to carefully rotate the crankshaft while you push on the bearing shell. Remove the upper main bearing shell (4) from the cylinder block. Keep the upper bearing halves together in order to ensure proper installation.

5. Repeat Step 2 through Step 4 for the remaining main bearings.

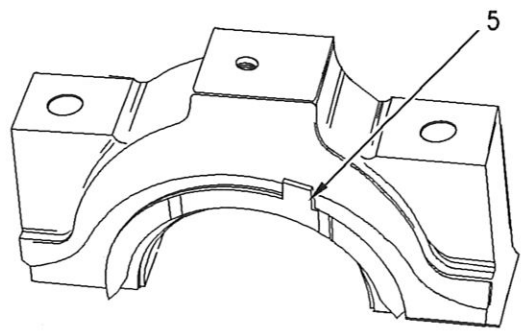

Illustration 125 g00934744

6. Remove the lower half of thrust washers (5) from both sides of the rear main bearing cap. Remove the seals from the rear main bearing cap.

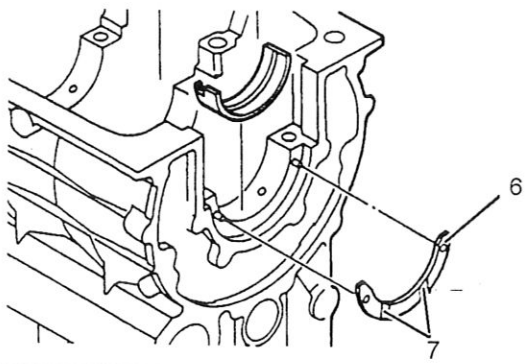

Illustration 126 g01032979

Shown without the crankshaft

7. Remove the upper half of the thrust washer (6) from the rear of the cylinder block with a suitable tool. Use a 27610267 46 mm Socket to 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.

i02296802

Crankshaft Main Bearings - Install

Installation Procedure

Table 24

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1
21825617	Dial Indicator Gp	1
27610013	Seal Installer	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

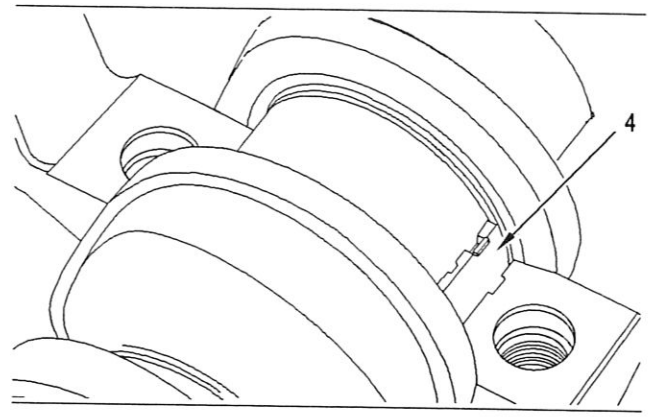

Illustration 127 g00934767

Note: Do not install the rear main bearing cap yet.

1. Clean the upper main bearing shell (4) and lubricate the bearing surface with clean engine oil.

Note: Do not put oil on the back sides of the main bearing shells for the crankshaft.

Note: Ensure that the upper halves of the main bearing shells are installed so that the bearing tabs fit into the notch 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.

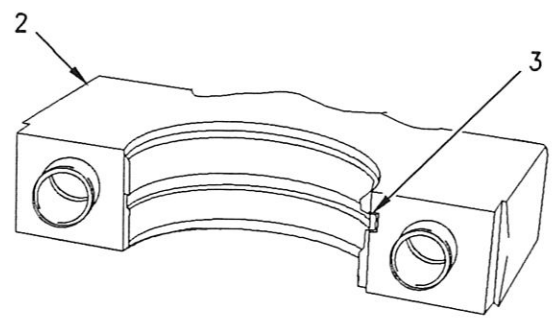

Illustration 128 g00934803

3. Clean the main bearing cap (2) and the lower main bearing shell (3). Lubricate the bearing 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 notch in the main bearing cap.

4. Install the lower main bearing shell (3) in the main bearing cap (2).

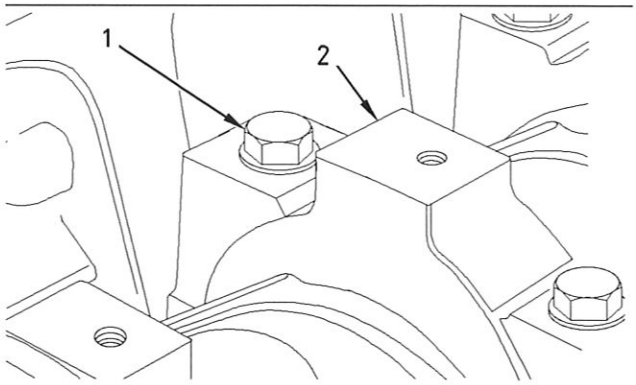

Illustration 129 g00947823

5. Install the main bearing cap (2). Lubricate the threads of the setscrews (1) with clean engine oil. Install setscrews (1) and tighten finger tight.

Note: Do not install the rear main bearing cap yet.

6. Repeat Steps 1 through 5 for the remaining main bearings.

Note: Do not install the rear main bearing cap yet.

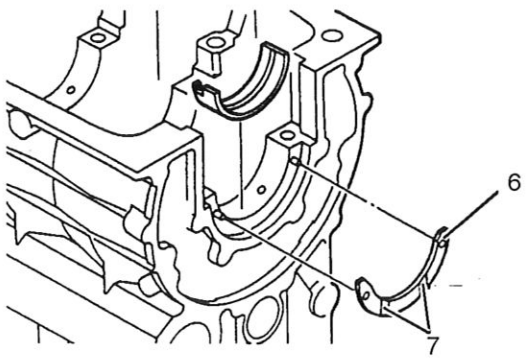

Illustration 130 g01032979

Shown without the crankshaft

7. Install the upper half of the thrust washer (6) on the rear of the cylinder block with the oil grooves (7) toward the outside. If necessary, move the crankshaft to the front or to the rear in order to install the thrust washer.

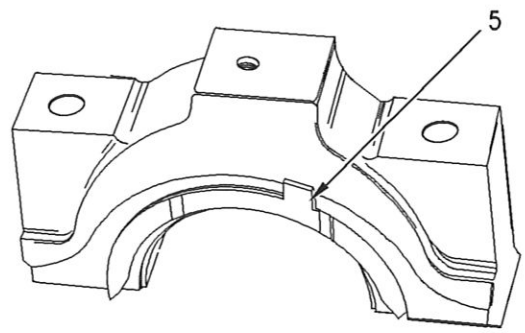

Illustration 131 g00934744

8. Install the lower half of the thrust washer (5) on each side of the rear main bearing cap. The grooves on the thrust washer must be located against the crankshaft.

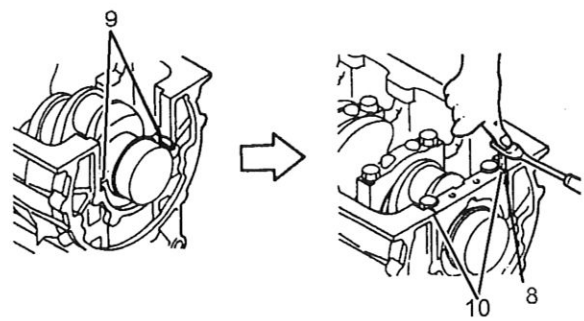

Illustration 132 g01041431

9. Apply 21826038 POWERPART Silicon Sealant Adhesive to the corners of the rear main bearing cap (9). Install the rear main bearing cap to the cylinder block so that the rear face is even with the rear face of the cylinder block(10).

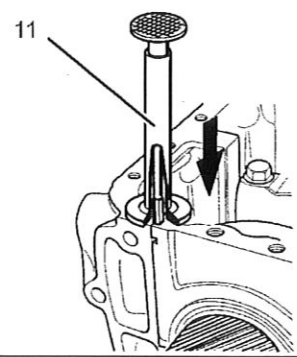

Illustration 133 g01041433

10. Apply soapy water to the side seals (8). Position the side seals (8) in the grooves on the rear main bearing cap with the rounded edges of the seals toward the outside. Use a 27610013 Seal Installer (10) to push the seal into position in order to reduce the risk of damaging the seal's metal core. Apply a suitable silicon sealant around the side seals (8).

11. Install the setscrews for the rear main bearing cap. Tighten all of the setscrews for the main bearing caps to a torque of 98 to 108 N·m (72 to 80 lb ft).

12. Use a 27610267 46 mm Socket to rotate the crankshaft in order to ensure that the crankshaft turns freely.

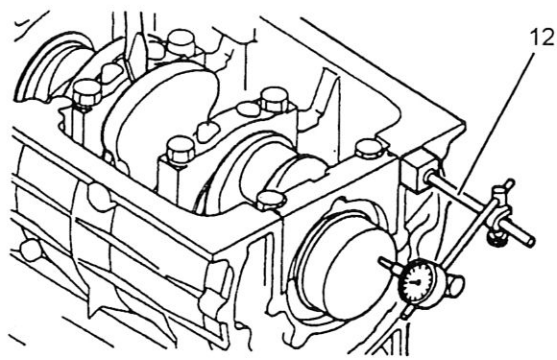

Illustration 134 g01041435

13. Check the crankshaft end play. Use a prybar to move the crankshaft toward the front of the engine. Use a 21825617 Dial Indicator Group (12) to measure the end play. The maximum permissible crankshaft end play is 0.300 mm (0.0118 inch).

End By:

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

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

i02296811

Crankshaft - Remove

Removal Procedure

Table 25

Required Tools		
Part Number	Part Description	Qty
27610267	Socket (46 mm)	1

Start By:

a. Remove the engine 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".

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Use a 27610267 46 mm Socket to rotate the crankshaft.

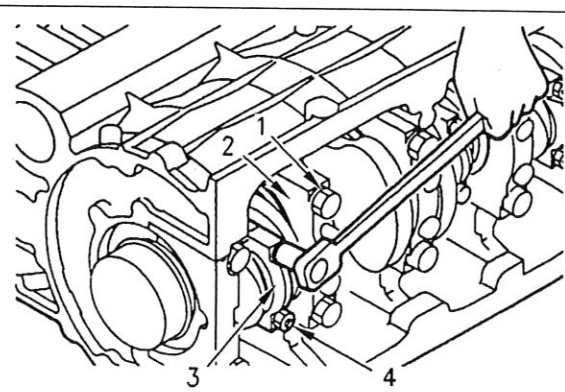

Illustration 135 g01002059

Note: Make sure that the main bearing caps and the connecting rod caps are marked for the location and direction for installation.

2. Remove the nuts (4) from the connecting rod bolts.

3. Remove the connecting rod caps (3) from the connecting rods. Remove the bearing shells from the connecting rod caps. Keep the connecting rod bearings with the respective connecting rod cap.

4. Push the piston assemblies into the cylinder bores.

5. Remove the setscrews for the main bearing cap (1).

6. Remove the main bearing caps (2) from the cylinder block. Remove the bearing shell from the main bearing caps. Remove the lower thrust washers from the rear main bearing cap. Keep the main bearings with the respective main bearing cap.

NOTICE
Do not allow the connecting rods to strike the piston cooling jets. Damage or misalignment may occur.

Note: Use tape or rubber tubing on the connecting rod bolts to protect the crankshaft journals from damage.

7. Attach a suitable lifting device to the crankshaft. Lift the crankshaft out of the cylinder block. The weight of the crankshaft is approximately 32 kg (70 lb).

Note: Be careful not to damage the finished surfaces on the crankshaft.

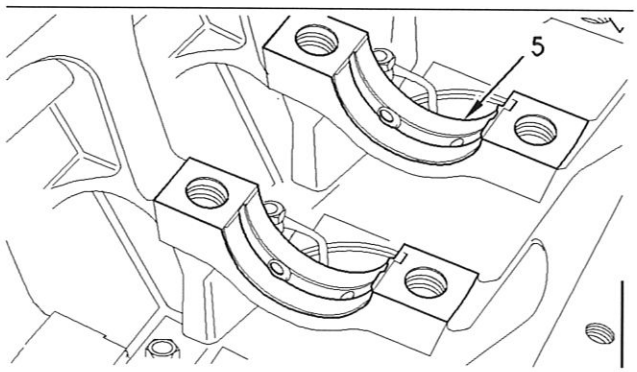

Illustration 136 g01002061

8. Remove the upper main bearing shells (5). If necessary, remove the upper thrust washer from the rear of the cylinder block. Keep the upper main bearing shells with the respective main bearing caps.

i01996085

Crankshaft - Install

Installation Procedure

Table 26

Required Tools		
Part Number	**Part Description**	**Qty**
27610267	Socket (46 mm)	1
21825617	Dial Indicator Gp	1
27610013	Seal Installer	1

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.

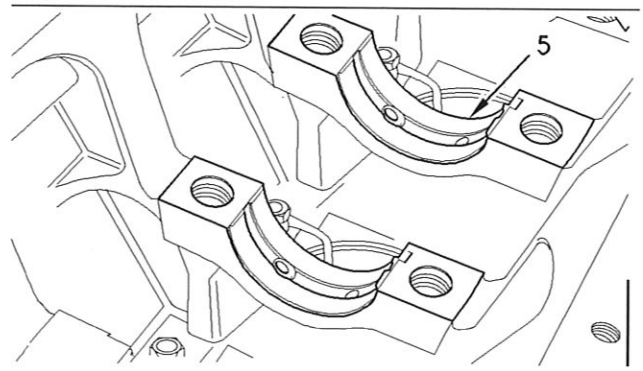

Illustration 137 g01002061

2. Install the bearing shells for the upper main bearings (5). The bearing tabs for the upper main bearings must be located in the correct position in the cylinder block. Lubricate the upper main bearing shells (5) with clean engine oil.

3. Lubricate the upper half of the thrust washer. Place the upper half of the thrust washer on the rear of the cylinder block with the oil grooves toward the outside.

4. Ensure that the main bearing journals and the connecting rod bearing journals of the crankshaft are clean. Attach a suitable lifting device in order to position the crankshaft in the cylinder block. The weight of the crankshaft is approximately 32 kg (70 lb).

Note: Be careful not to damage the finished surfaces on the crankshaft.

5. Lubricate the lower half of the thrust washers. Place the lower half of the thrust washers on both sides of the rear main bearing cap. The grooves on the thrust washers must be positioned toward the crankshaft.

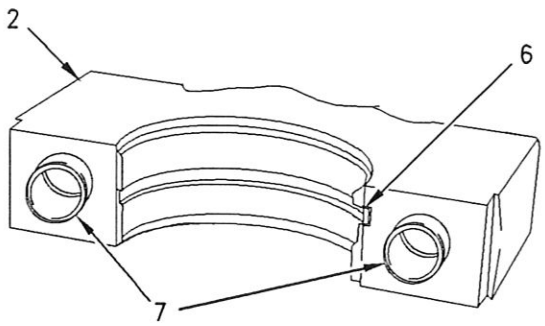

Illustration 138 g01002115

6. Clean the lower bearing shells (6). and then install in the main bearing caps(2 main bearing caps with clean engine oil.)

Note: Do not install the rear main bearing cap yet.

7. Ensure that locating dowels (7) for main bearing caps (2) are in the correct position in the main bearing caps or in the cylinder block.

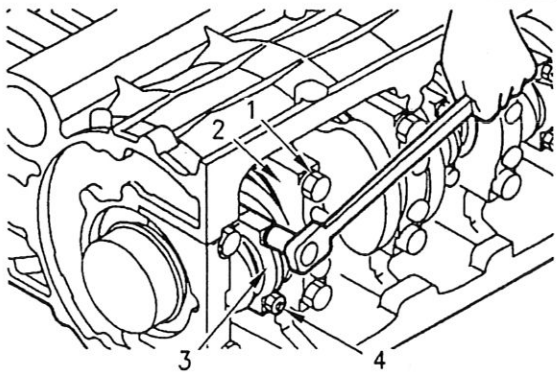

Illustration 139 g01002059

8. Install the main bearing caps (2) in the position that was marked during the removal process. All of the bearing tabs for the main bearings should be on the same side. Install the main bearing setscrews (1) and tighten finger tight.

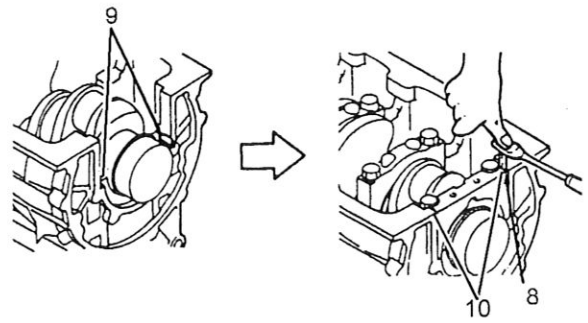

Illustration 140 g01041431

9. Apply 21826038 POWERPART Silicon Sealant Adhesive to the corners of the rear main bearing cap (9). Install the rear main bearing cap to the cylinder block so that the rear face is even with the rear face of the cylinder block .

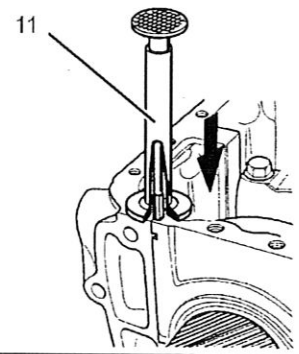

Illustration 141 g01041433

10. Apply soapy water to the side seals (8). Position the side seals (8) in the grooves on the rear main bearing cap with the rounded edges of the seals toward the outside. Use the 27610013 Seal Installer (11) to push the seal into position in order to reduce the risk of damaging the seal's metal core. Apply 21826038 POWERPART Silicon Sealant Adhesive around side seals (10).

11. Install the setscrews for the rear main bearing cap. Tighten all of the setscrews for the main bearing caps to a torque of 98 to 108 N·m (72 to 80 lb ft). Ensure that the crankshaft rotates freely.

12. Ensure that the upper connecting rod bearings are centered in the connecting rod. Ensure that the shells for the lower connecting rod bearing are centered in the connecting rod caps. Lubricate the bearing faces with clean engine oil.

Note: Remove the tape or rubber tubing on the connecting rod bolts.

Note: Ensure that the mark on the connecting rod cap matches the mark on the connecting rod. Ensure that the marks are on the same side.

13. Install the connecting rod caps (3). Install the nuts (4) and tighten to a torque of 49 to 59 N·m (36 to 44 lb ft).

14. Use a 271610267 46 mm Socket to rotate the crankshaft in order to ensure that the crankshaft turns freely.

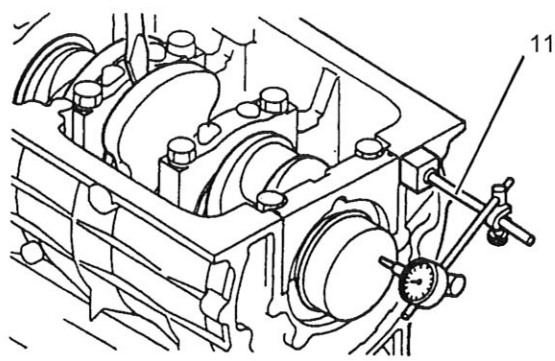

Illustration 142 g01033009

15. Check the crankshaft end play. Use a prybar to move the crankshaft toward the front of the engine. Use a 21825617 Dial Indicator Group (11) to measure the end play. The maximum permissible crankshaft end play is 0.300 mm (0.0118 inch).

End By:

a. Install the flywheel housing. Refer to Disassembly and Assembly, "Flywheel Housng - Remove and Install".

b. Install the front housing. Refer to Disassembly and Assembly, "Housng (Front) - Install".

c. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

i01996194

Crankshaft Gear - Remove and Install

Removal Procedure

Start By:

a. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".

Note: In this removal procedure, the crankshaft gear is removed with the crankshaft in the engine.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the No. 1 cylinder is at the top center compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

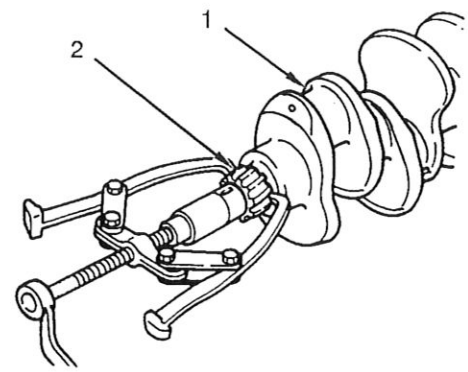

Illustration 143 g01033205
The cylinder block is not shown.

2. Use a suitable combination puller to remove the crankshaft gear (2) from the crankshaft (1). Remove the key from the crankshaft.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

1. Ensure that the key is correctly installed in the crankshaft.

2. Raise the temperature of the crankshaft gear in an oven to 100 °C (212 °F).

Note: Ensure that the timing marks on the timing gears are in alignment.

3. Align the keyway in the gear with the key in the crankshaft (1). Install the crankshaft gear (2). Tap the end of the gear with a rubber mallet or a brass hammer. Ensure that the crankshaft gear is seated against the shoulder on the crankshaft.

End By:

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

i01996219

Bearing Clearance - Check

Measurement Procedure

Table 27

Required Tools	
Part 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 bearing clearances particularly on small engines. This is because of the possibility of obtaining inaccurate results and the possibility of damaging the bearing or the journal surfaces. Each Perkins engine bearing is quality checked for specific wall thickness.

Note: The measurements should be within specifications and the correct bearings should be used. If the crankshaft journals and the bores for the block and the rods were measured during disassembly, no further checks are necessary. However, if the technician still wants to measure the bearing clearances, the use of Plastic Gauge is an acceptable method. 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 bearings and the bores are clean and dry.
- Ensure that the bearing locking tabs are properly seated in the tab grooves.
- The crankshaft must be free of oil at the contact points of the Plastic Gauge.

1. Put a piece of the Plastic Gauge on the crown of the bearing that is in the cap.

Note: Do not allow the Plastic Gauge to extend over the edge of the bearing.

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 when the cap is installed.

Note: Do not turn the crankshaft when the Plastic Gauge is installed.

3. Carefully remove the cap, but do not remove the Plastic Gauge. Measure the width of the Plastic Gauge while the Plastic Gauge is in the bearing cap or on the crankshaft journal. Refer to Illustration 144.

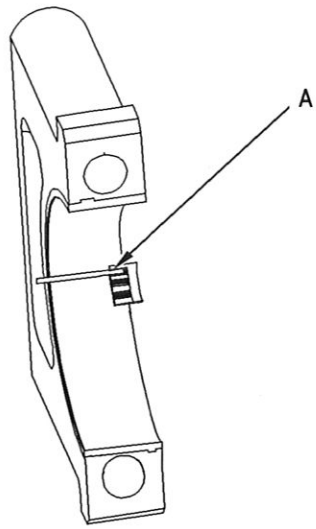

Illustration 144 g00953605
Typical Example

4. Remove all of the Plastic Gauge before you install the bearing cap.

Note: When the 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 Specifications Manual, "Connecting Rod Bearing Journal" and Specifications Manual, "Main Bearing Journal" for the correct clearances.

i02551066

Coolant Temperature Switch - 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 into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change".

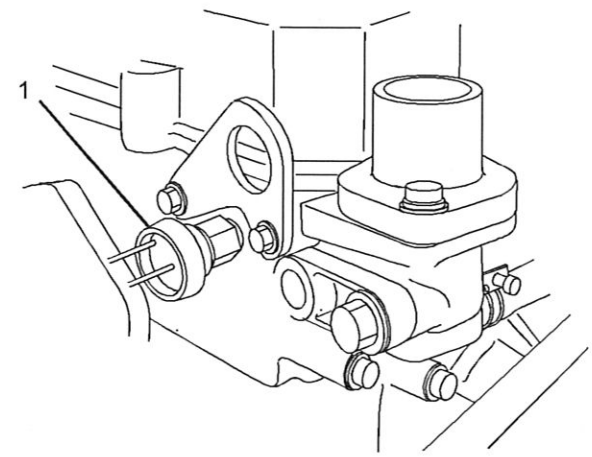

Illustration 145 g01277080

2. Disconnect the electrical connections from the coolant temperature switch (1).

3. Remove coolant temperature switch (1) from the cylinder head.

Installation Procedure

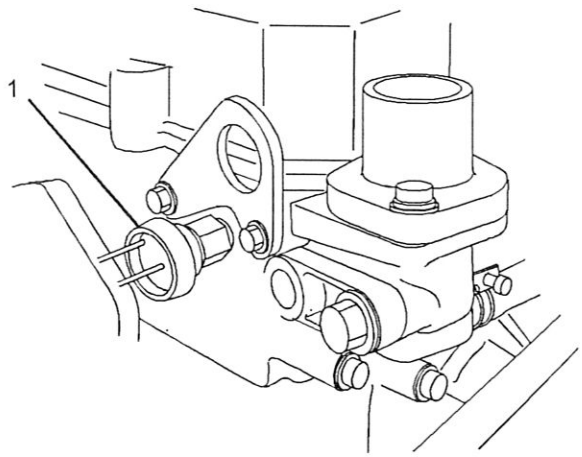

Illustration 146 g01277080

1. Install the coolant temperature switch (1) into the cylinder head.
2. Connect the electrical connections to the coolant temperature switch (1).
3. Fill the cooling system to the proper level. Refer to Operation and Maintenance Manual, "Cooling System Coolant (ELC) - Change".

i02551067

Engine Oil Pressure Switch - 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.

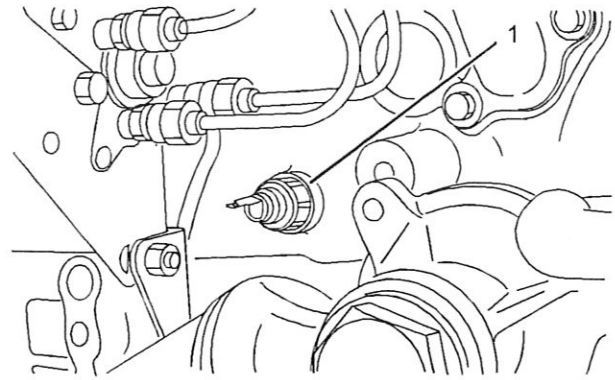

Illustration 147 g01277091

1. Remove the electrical connections from the engine oil pressure switch (1). Note the position of the electrical connections for installation.
2. Remove the engine oil pressure switch (1) from the cylinder block. Plug the opening immediately.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

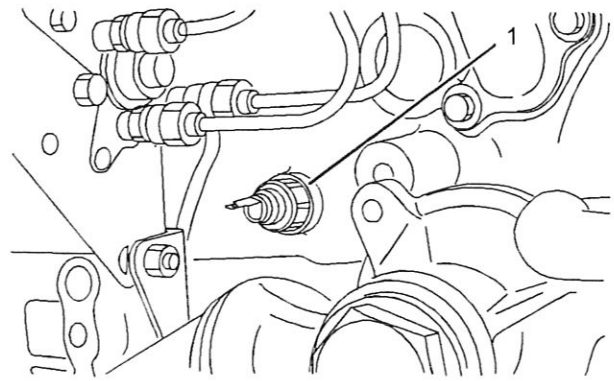

Illustration 148 g01277091

1. Install the engine oil pressure switch (1) into the cylinder block and tighten evenly.

2. Connect the electrical connections to engine oil pressure switch (1).

i02015947

Glow Plugs - Remove and Install (Naturally Aspirated Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

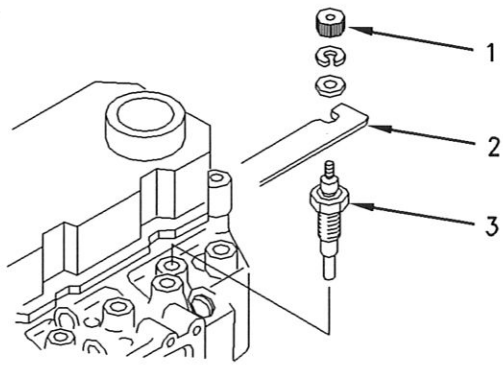

Illustration 149 g01002268

1. Disconnect the electrical connection to the bus bar (2).

2. Loosen the nuts (1). Remove the nuts (1) and the washers from the bus bar (2).

3. Remove the bus bar (2) from the glow plugs (3).

4. Remove the glow plugs (3) from the cylinder head.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

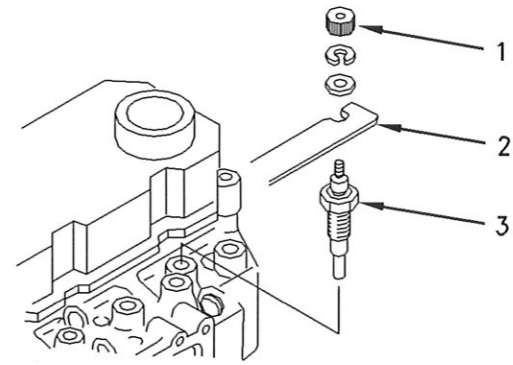

Illustration 150 g01002268

1. Clean the threads of the glow plugs (3).

2. Install the glow plugs (3) into the cylinder head and tighten to a torque of 15 to 20 N·m (11 to 15 lb ft).

3. Position the bus bar (2) onto the glow plugs (3).

4. Install the washers and the nuts (1) onto the glow plug (3). Tighten the nuts securely.

5. Connect the electrical connection to bus bar (2).

i02015986

Glow Plugs - Remove and Install (Turbocharged Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

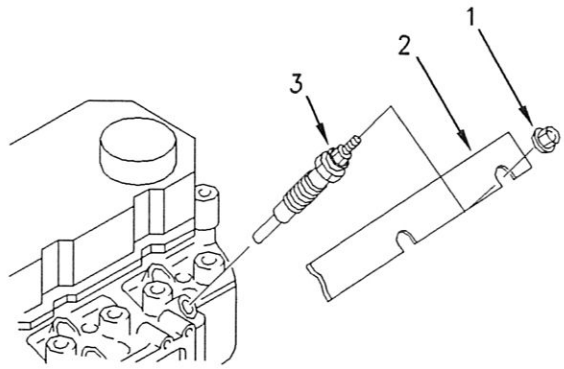

Illustration 151 g01002269

1. Disconnect the electrical connection to the bus bar (2).
2. Loosen the nut (1). Remove the nut (1) from the bus bar (2) and the glow plug (3).
3. Remove the bus bar (2) from the glow plugs (3).
4. Remove the glow plug (3) from the cylinder head.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

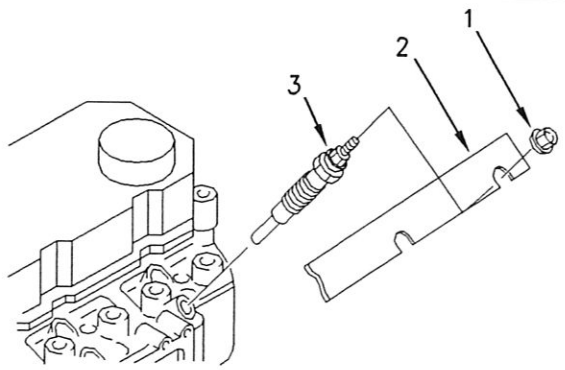

Illustration 152 g01002269

1. Clean the threads of the glow plug (3).
2. Install the glow plug (3) in the cylinder head and tighten to a torque of 20 to 30 N·m (15 to 22 lb ft).
3. Position the bus bar (2) on the glow plugs (3).
4. Install the nut (1) on the glow plug (3) and the bus bar (2). Tighten the nut securely.
5. Connect the electrical connection to the bus bar (2).

i02551068

V-Belts - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

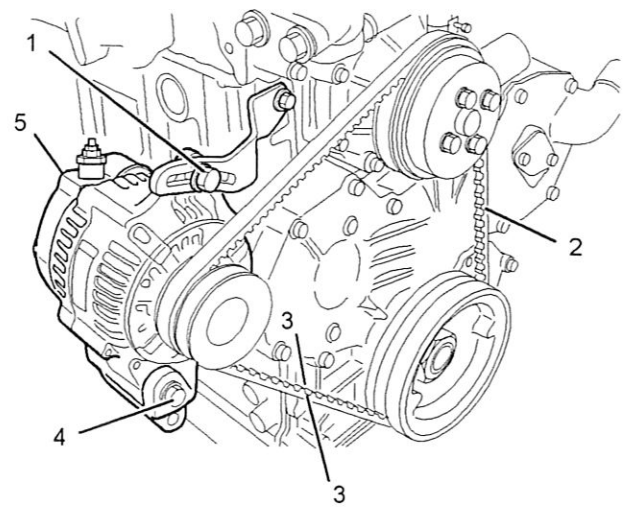

Illustration 153 g01277092
The fan is not shown.

1. Loosen the mounting setscrew (4) and loosen the tension on the setscrew (1). Slide the alternator (5) toward the engine.
2. Remove the V-belt.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

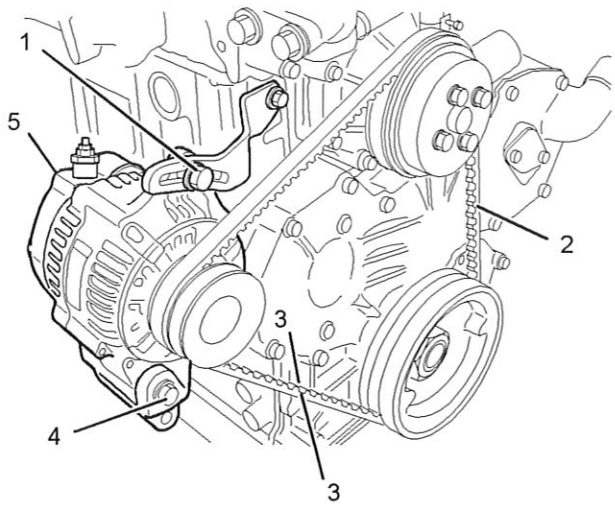

Illustration 154 g01277092

The fan is not shown.

1. Install the V-belt (2) behind the fan and onto the correct pulleys.
2. Adjust the tension on the V-belt (2) by moving the alternator (5) away from the engine. Tighten the tension on the adjuster (1) and the mounting setscrew (4) after the correct belt tension is made. Refer to Specifications, "Belt Tension Chart" for the correct deflection (3) of the V-belt.

i01999828

Fan - Remove and Install

Removal Procedure

Start By:

a. Remove the V-Belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

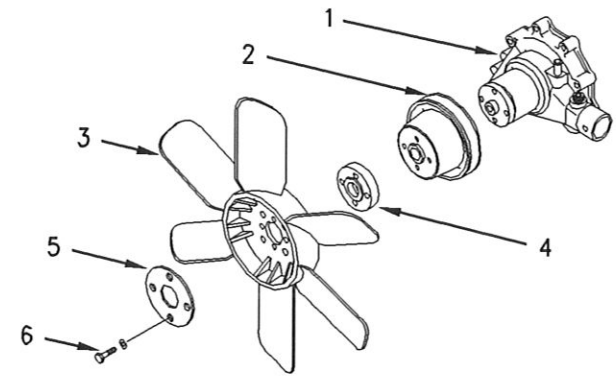

Illustration 155 g01002348

1. Remove the setscrews (6), the washers and the plate (5).
2. Remove the fan (3).
3. Remove the fan spacer (4).
4. Remove the fan pulley (2) from the water pump (1).

Installation Procedure

1. Inspect the condition of the fan pulley (2). Replace the fan pulley, if necessary.

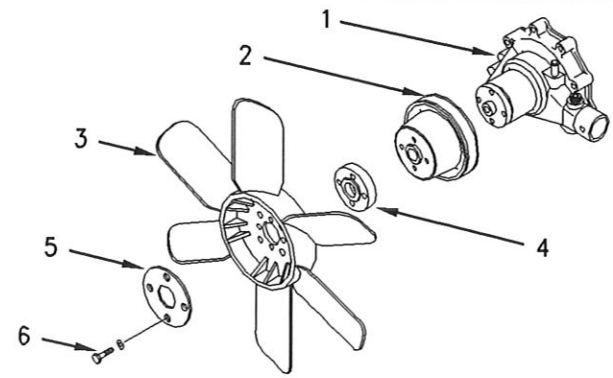

Illustration 156 g01002348

2. Position the fan pulley (2) onto the water pump (1).
3. Position the fan spacer (4) onto the fan pulley (2).
4. Position the fan (3) onto the fan spacer (4).
5. Install the plate (5), the setscrews (6) and the washers. Tighten the setscrews (6) evenly.

End By:

a. Install the V-Belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

i02551122

Alternator - Remove

Removal Procedure

Start By:

a. Remove the V-Belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

1. Turn the battery disconnect switch to the OFF position.

2. Place an index mark on all of the electrical wires that are connected to the alternator. Disconnect the electrical wires from the alternator.

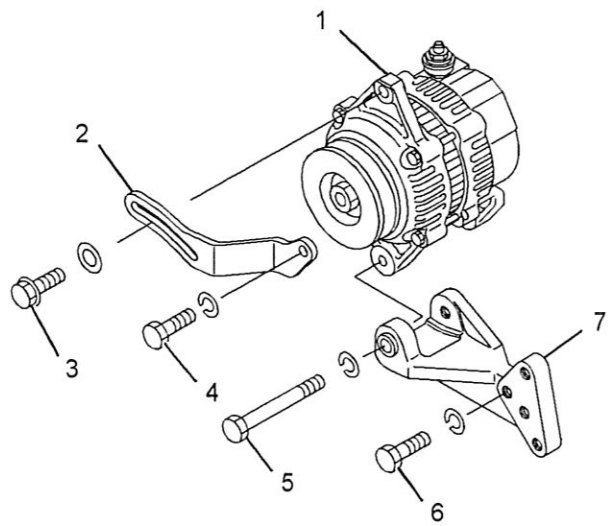

Illustration 157 g01277119

3. Remove the setscrew for adjusting the tension (3) and mounting setscrew (5).

4. Remove the alternator (1) from the engine.

5. If necessary, remove the setscrews (4) and (6). Remove the adjustment bracket (2) and the mounting bracket (7) from the engine.

i02551164

Alternator - Install

Installation Procedure

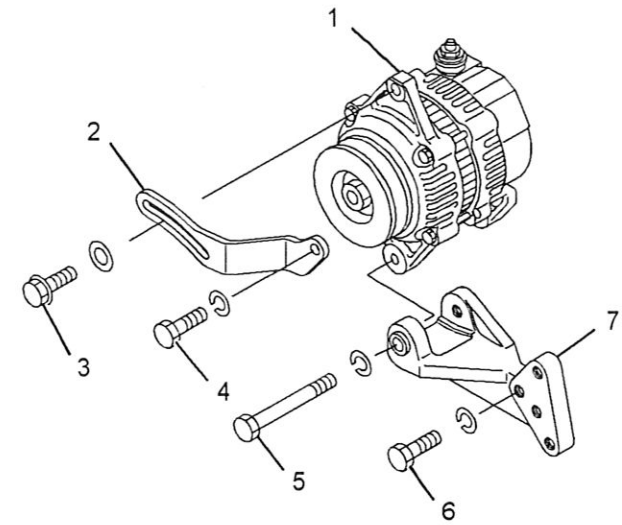

Illustration 158 g01277119

1. If necessary, install the mounting bracket (7) and the adjustment bracket (2) onto the engine. Install the setscrews (4) and (6) and tighten securely.

2. Put the alternator (1) in position on the engine.

3. Install the mounting setscrew (5) and tighten finger tight.

4. Install the setscrew for the tensioner (3) through the adjustment bracket (2) and into the alternator (1) and tighten finger tight.

5. Connect the electrical wires to the alternator (1).

End By:

a. Install the V-Belt. Refer to Disassembly and Assembly, "V-Belts- Remove and Install".

b. Turn the battery disconnect switch to the ON position.

i02017967

Electric Starting Motor - Remove and Install

Removal Procedure

1. Turn the battery disconnect switch to the OFF position.
2. Place an identification mark on all electrical wires that are connected to the electrical starting motor. Disconnect the electrical wires from the electrical starting motor.

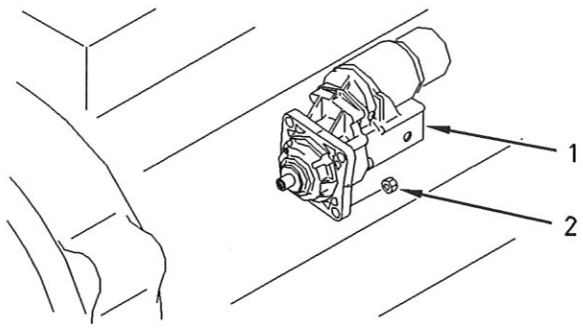

Illustration 159 g01002389

3. Remove the nuts (2) from the studs that are in the flywheel housing.
4. Remove the electric starting motor (1) from the flywheel housing.

Note: Check the condition of the joint. If the joint is damaged, replace the joint.

Installation Procedure

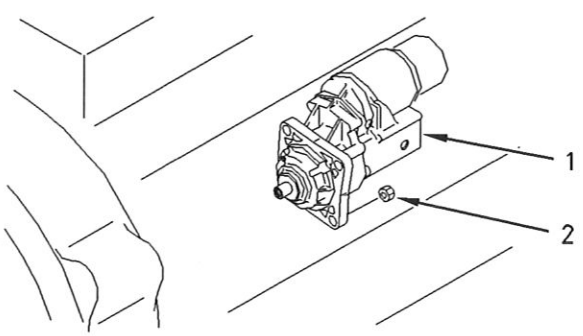

Illustration 160 g01002389

Note: If necessary, put a new gasket in position on the studs.

1. Position the electric starting motor (1) onto the studs in the flywheel housing.
2. Install the nuts (2) onto the studs and tighten evenly.
3. Connect the electrical wires to electric starting motor (1).

Note: Refer to Specifications, "Electric Starting Motor" for the torques of the terminal nuts.

4. Turn the battery disconnect switch to the ON position.

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