



# Disassembly and Assembly

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## **C11 and C13 On-highway Engines**

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KCA1-Up (Engine)  
KCB1-Up (Engine)  
JAM1-Up (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.



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.

**Caterpillar 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 Caterpillar 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. Caterpillar dealers have the most current information available.



**When replacement parts are required for this product Caterpillar recommends using Caterpillar replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.**

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

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# Disassembly and Assembly Section

i01940463

## Fuel Filter Base - Remove and Install

SMCS Code: 1262-010

### Removal Procedure

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

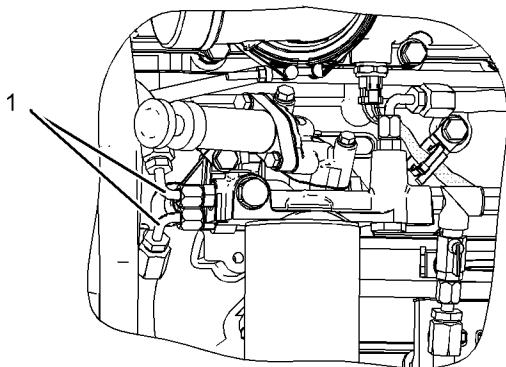


Illustration 1

g01009668

1. Disconnect hose assemblies (1).

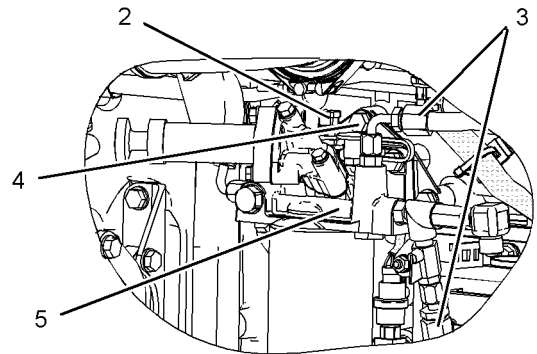


Illustration 2

g01009669

2. Disconnect hose assemblies (3) and harness assemblies (2).
3. Remove bolts (4).
4. Remove fuel filter base (5).

### Installation Procedure

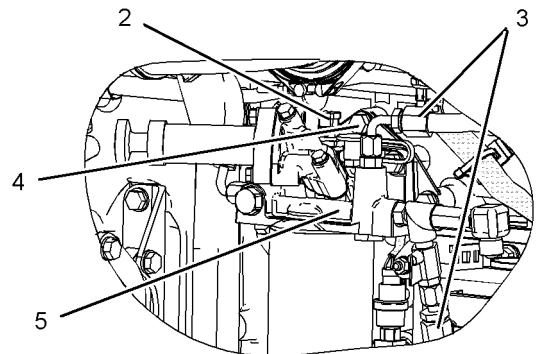


Illustration 3

g01009669

1. Position fuel filter base (5).
2. Install bolts (4).
3. Connect hose assemblies (3) and harness assemblies (2).

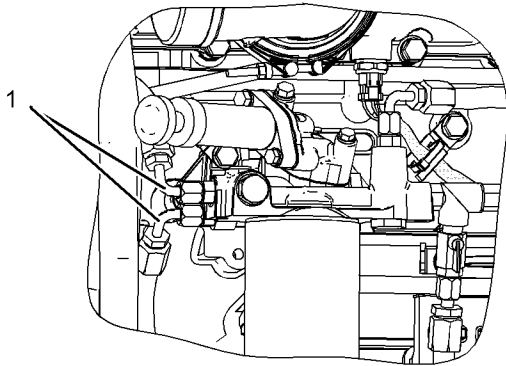


Illustration 4

g01009668

4. Connect hose assemblies (1).

i02247172

## Fuel Transfer Pump - Remove

**SMCS Code:** 1256-011

### Removal Procedure

**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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

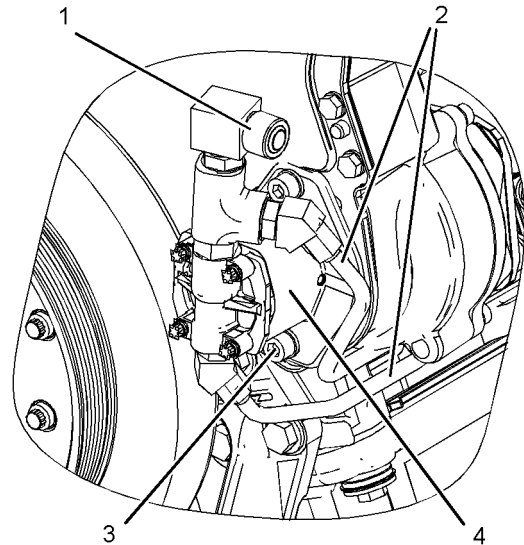


Illustration 5

g01131526

1. Disconnect hose assembly (1).
2. Disconnect tube assemblies (2).
3. Remove bolts (3).
4. Remove fuel transfer pump (4).

i02247178

## Fuel Transfer Pump - Install

**SMCS Code:** 1256-012

### Installation Procedure

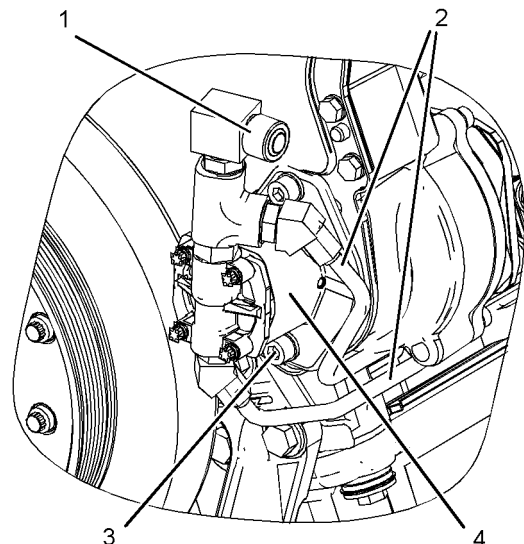


Illustration 6

g01131526

1. Position fuel transfer pump (4).

2. Install bolts (3).
3. Connect tube assemblies (2).
4. Connect hose assembly (1).

i01940112

## Electronic Unit Injector - Remove

SMCS Code: 1290-011

### Removal Procedure

Table 1

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 5F-4764     | Pry Bar          | 1   |

#### Start By:

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

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

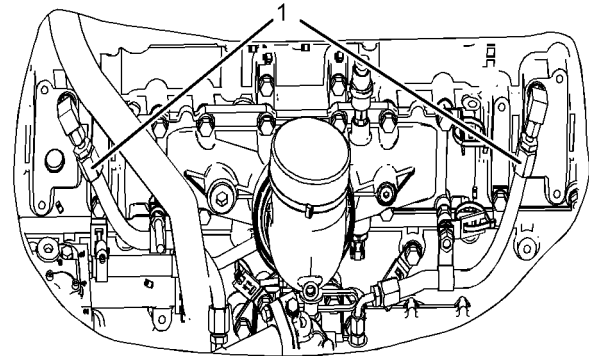


Illustration 7

g01009601

1. Disconnect hose assemblies (1).
2. Drain the fuel from the cylinder head.

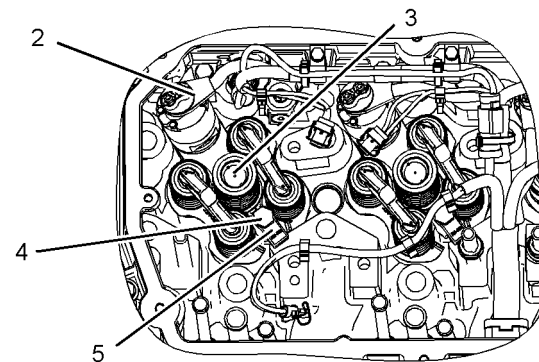


Illustration 8

g01009613

3. Disconnect harness assembly (2) from unit injector (3).
4. Remove bolt (4).
5. Position a Tooling (A) under bracket (5) in order to remove the unit injector (3).

i01940330

# Electronic Unit Injector - Install

SMCS Code: 1290-012

## Installation Procedure

Table 2

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| B              | 9U-6862     | Tapered Brush    | 1   |
|                | 9U-7237     | Brush Extension  | 1   |
| C              | 9U-6863     | Small Bore Brush | 1   |
|                | 9U-7237     | Brush Extension  | 1   |
| D              | 8T-2998     | Lubricant        | 1   |

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

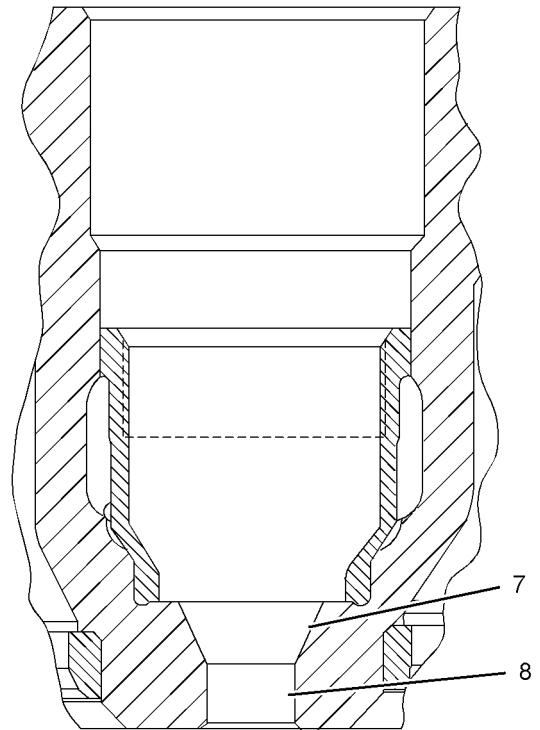


Illustration 9

g01009642

(7) Injector seating  
(8) Tip bore

1. Use Tooling (B) to clean injector seating (7).
2. Use Tooling (C) to clean tip bore (8).

**Note:** Do not reuse seals. Use new seals for installation.

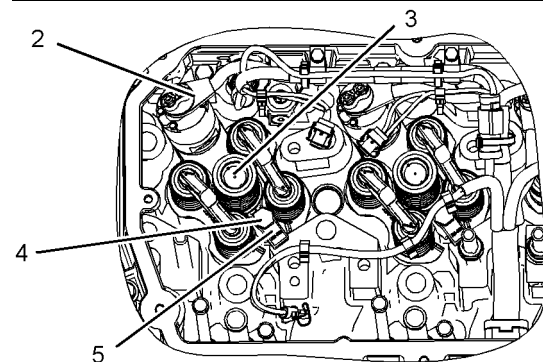


Illustration 10

g01009613

3. Lubricate the bore lightly with a 50/50 mix of clean engine oil and Tooling (D).

**Note:** The injector code will be used later if the injectors have been changed. Write down the injector code which is located on the solenoid.

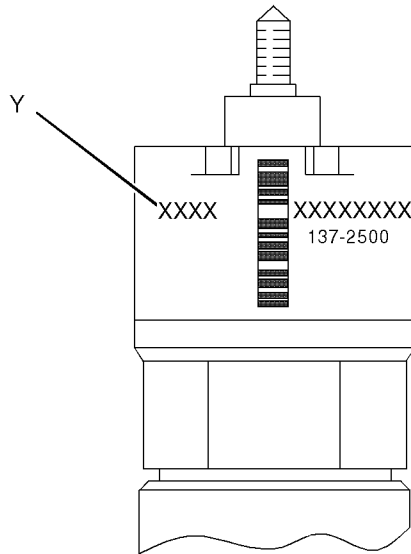


Illustration 11  
(Y) Electronic injector code

**NOTICE**

When a fuel injector group is serviced, the new fuel injector group's electronic injector code must be programmed into the engine's personality module software by using the calibration menu on the Electronic Service Tool. If the new fuel injector group's electronic code is not entered, the previous fuel injector group's characteristics are assumed.

If it is not possible to immediately reprogram the electronic injector code of the injector into the personality module software, the engine will not be severely harmed. The new electronic injector code should be reprogrammed as quickly as possible in order to optimize engine performance.

4. Install unit injector (3) and bracket (5).
5. Install bolt (4). tighten bolt (4) to a torque of  $55 \pm 10 \text{ N}\cdot\text{m}$  ( $41 \pm 7 \text{ lb ft}$ ).
6. Connect harness assembly (2) to unit injector (3).

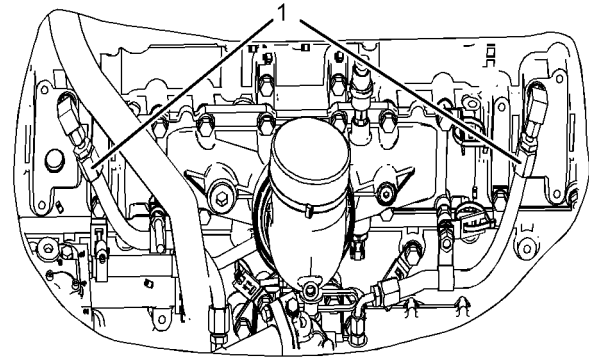


Illustration 12  
g01009601

7. Connect hose assemblies (1).

**End By:**

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

i02370015

## Electronic Unit Injector Sleeve - Remove

**SMCS Code:** 1713-011

### Removal Procedure

#### Type 1

Table 3

| Required Tools |             |                     |     |
|----------------|-------------|---------------------|-----|
| Tool           | Part Number | Part Description    | Qty |
| A              | 9U-6891     | Injector Tool Group | 1   |

**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.

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.



**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Remove the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Remove".
2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Capacities (Refill)" for the capacity of the cooling system. Refer to the Operation and Maintenance Manual, "Cooling System Coolant (DEAC) - Change" or Operation and Maintenance Manual, "Cooling System Extended Life Coolant - Change".

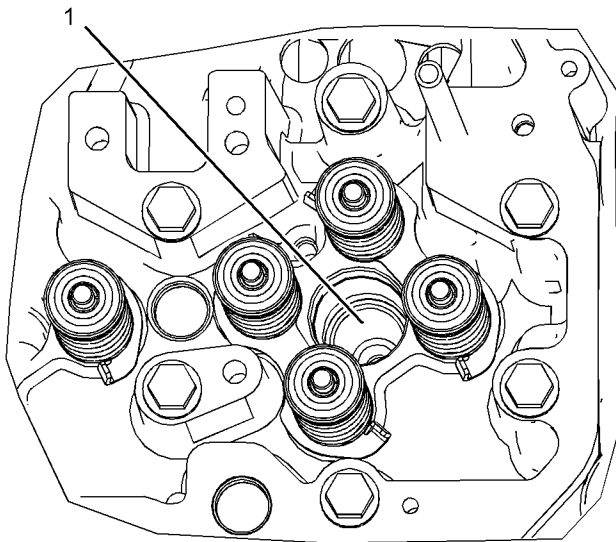


Illustration 13

g01016237

3. Install Tooling (A) into electronic unit injector sleeve (1).
4. Tighten the nut until electronic unit injector sleeve (1) is pulled free of the cylinder head assembly.

**Type 2**

Table 4

| Required Tools   |             |                  |     |
|------------------|-------------|------------------|-----|
| Tool             | Part Number | Part Description | Qty |
| A <sup>(1)</sup> | 221 - 9778  | Puller Stud      | 1   |
|                  | 128 - 7889  | Bridge Puller    | 1   |
|                  | 9U - 6877   | Thrust Bearing   | 1   |
|                  | 5P - 8247   | Hard Washer      | 1   |
|                  | 4K - 0367   | Nut              | 1   |

<sup>(1)</sup> The tools that are listed in the chart are part of the 9U - 6891 Injector Tool Group.

1. Remove the electronic unit injector. Refer to Disassembly and Assembly , "Electronic Unit Injector - Remove".
2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Capacities (Refill)" for the capacity of the cooling system. Refer to the Operation and Maintenance Manual, "Cooling System Coolant (DEAC) - Change" or Operation and Maintenance Manual, "Cooling System Extended Life Coolant - Change".

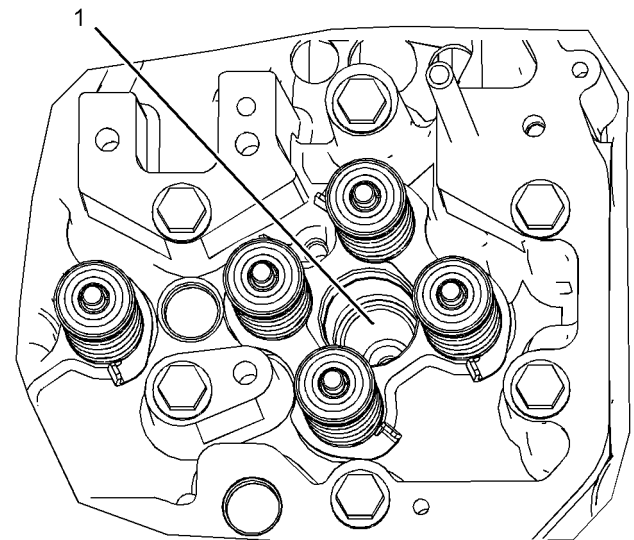


Illustration 14

g01016237

3. Install the puller stud from Tooling (A) into unit injector sleeve (1).
4. Install the following parts from Tooling (A) over the stud: bridge puller, thrust bearing, hard washer, and nut.
5. Tighten the nut until unit injector sleeve (1) is pulled free of the cylinder head assembly.

i02370001

## Electronic Unit Injector Sleeve - Install

SMCS Code: 1713-012

### Installation Procedure

#### Type 1

Table 5

| Required Tools |             |                    |     |
|----------------|-------------|--------------------|-----|
| Tool           | Part Number | Part Description   | Qty |
| B              | 4C-5552     | Large Bore Brush   | 1   |
| C              | 9U-7237     | Brush Extension    | 1   |
|                | 9U-7244     | End Brush          | 1   |
| D              | 9U-7258     | Driver Cap         | 1   |
| E              | 4C-9507     | Retaining Compound | 1   |

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

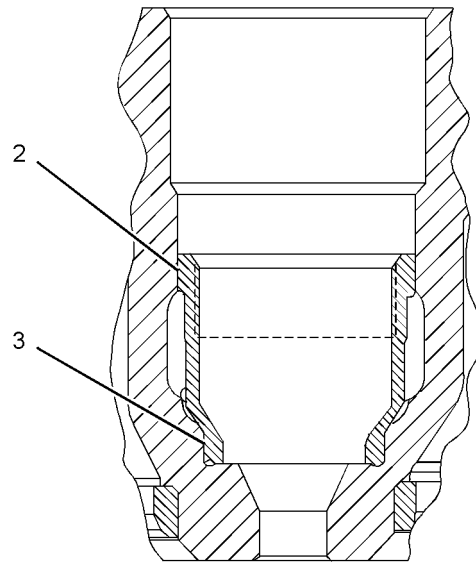


Illustration 15

g01131579

1. Use Tooling (B) to clean the electronic unit injector bore.
2. Use Tooling (C) to clean the electronic unit injector seat.
3. Apply Tooling (E) to upper land (2) and lower land (3) on the electronic unit injector sleeve.

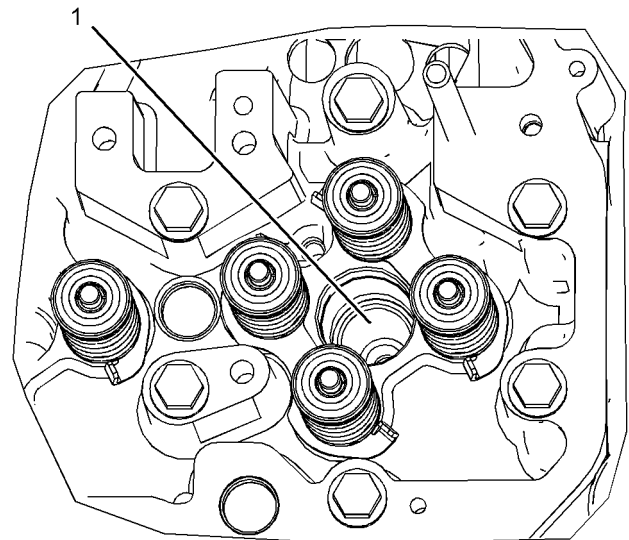


Illustration 16

g01016237

4. Position electronic unit injector sleeve (1) in the cylinder head assembly. Use Tooling (D) and a hammer to seat the sleeve.

5. Install the electronic unit injectors. Refer to Disassembly and Assembly , “Electronic Unit Injector - Install”.
6. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Capacities (Refill)” for the cooling system capacity. Refer to Operation and Maintenance Manual, “Cooling System Coolant (DEAC) - Change” or Operation and Maintenance Manual, “Cooling System Extended Life Coolant - Change” for the proper filling procedure.

**Type 2**

Table 6

| Required Tools   |             |                    |     |
|------------------|-------------|--------------------|-----|
| Tool             | Part Number | Part Description   | Qty |
| B                | 9U - 6862   | Tapered Brush      | 1   |
|                  | 9U - 6863   | Small Bore Brush   | 1   |
|                  | 9U - 7244   | End Brush          | 1   |
|                  | 9U - 7237   | Brush Extension    | 1   |
|                  | 4C - 5552   | Large Bore Brush   | 1   |
| C <sup>(1)</sup> | 221 - 9778  | Puller Stud        | 1   |
| D <sup>(1)</sup> | 9U - 7258   | Driver Cap         | 1   |
| E                | 4C - 9507   | Retaining Compound | -   |

<sup>(1)</sup> Part of the 9U - 6891 Injector Tool Group

1. Use Tooling (B) to clean the bore in the cylinder head for the electronic unit injector sleeve.

**NOTICE**

Ensure that the electronic unit injector sleeve and the cylinder head bore are completely free of oil, dirt, and sealant debris.

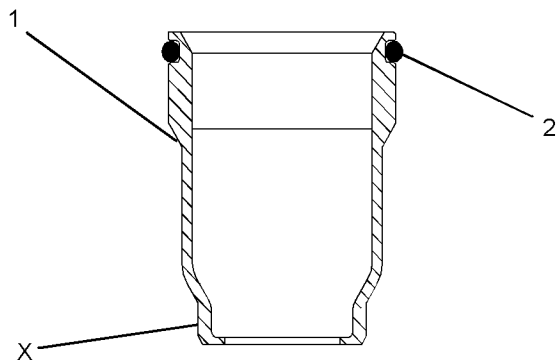


Illustration 17

g01120522

2. Install new O-ring seals (2) on electronic unit injector sleeve (1).

**Note:** Do not apply Tooling (E) to the cylinder head surfaces. Apply Tooling (E) on the electronic unit injector sleeve only.

3. Apply Tooling (E) to the contact surface of electronic unit injector sleeve (1) on the surface that is marked “X”.
4. Lubricate O-ring seals (2) with clean engine oil.

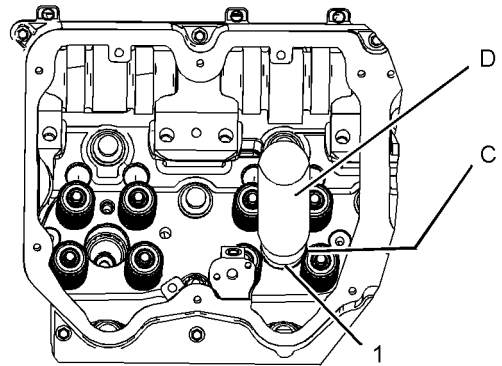


Illustration 18

g01076119

5. Install Tooling (C) into the threads of electronic unit injector sleeve (1).
6. Position Tooling (C) and the electronic unit injector sleeve in the cylinder head. Use care not to damage the O-ring seal on the electronic unit injector sleeve.
7. Use Tooling (D) and a hammer to install electronic unit injector sleeve (1) in the cylinder head.

**NOTICE**

Ensure that the electronic unit injector sleeve is properly seated in the cylinder head. The Tooling will “RING” when the electronic unit injector sleeve is fully seated in the bore of the cylinder head.

8. Remove Tooling (D) and Tooling (C). Use a clean towel and remove excess Tooling (E).
9. Install the electronic unit injector. Refer to Disassembly and Assembly , “Electronic Unit Injector - Install”.
10. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Capacities (Refill)” for the cooling system capacity. Refer to Operation and Maintenance Manual, “Cooling System Coolant (DEAC) - Change” or Operation and Maintenance Manual, “Cooling System Extended Life Coolant - Change” for the proper filling procedure.

i01942651

## Turbocharger - Remove (Low Pressure Turbocharger)

SMCS Code: 1052-011

### Removal Procedure

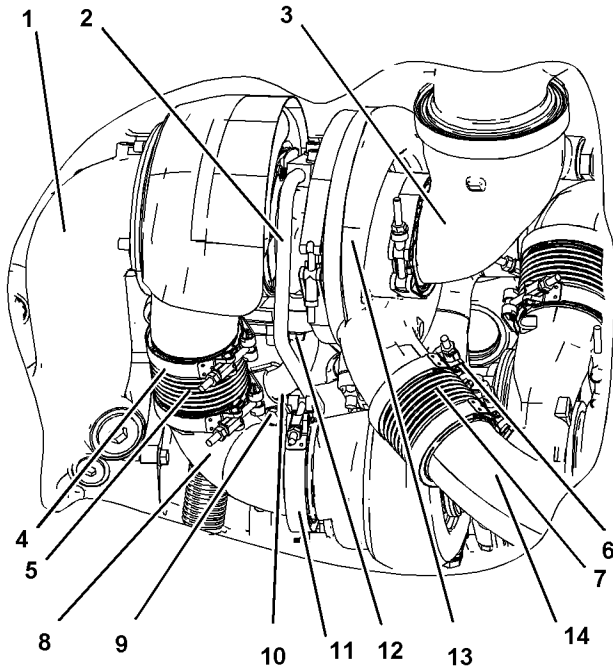


Illustration 19

g01010976

1. Place identification marks on the bellows for alignment and orientation during the installation.

#### NOTICE

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

#### CAUTION

**The ends of the bellows are very sharp. Injury could occur if the bellows are not handled properly. Handle the bellows by the convolutions.**

**Note:** Refer to Special Instruction, REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

2. Loosen clamp (4).
3. Position clamp (4) over bellows (5).
4. Loosen clamp (11).
5. Loosen clamp (6).
6. Position clamp (6) over bellows (7).
7. Remove elbow (14), elbow (8), and elbow (3).
8. Disconnect elbow (1).
9. Remove clamp (9).
10. Disconnect oil supply tube assembly (2) and oil drain tube assembly (10).
11. Remove nuts (12).
12. Use a suitable lifting device. The weight of the turbocharger is approximately 29 kg (65 lb). Remove turbocharger (13).

i01942232

## Turbocharger - Remove (High Pressure Turbocharger)

SMCS Code: 1052-011

### Removal Procedure

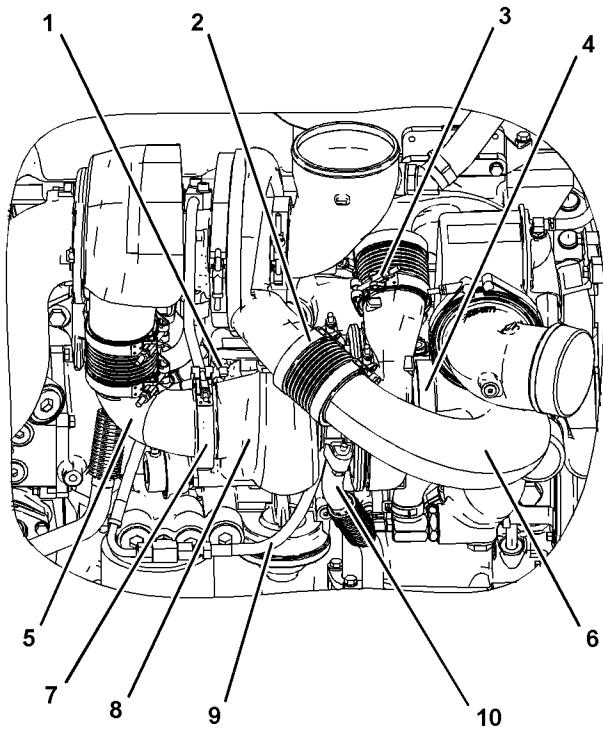


Illustration 20

g01010642

1. Place identification marks on the bellows for alignment and orientation during the installation.

#### NOTICE

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

### CAUTION

The ends of the bellows are very sharp. Injury could occur if the bellows are not handled properly. Handle the bellows by the convolutions.

**Note:** Refer to Special Instruction , REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

2. Loosen clamp (2).

3. Position clamp (2) over bellows.
4. Loosen clamp (3).
5. Position clamp (3) over bellows.
6. Loosen clamp (4).
7. Loosen clamp (7).
8. Remove elbow (5) and elbow (6).
9. Disconnect oil supply tube assembly (9) and oil drain tube assembly (10).
10. Remove nuts (1).
11. Use a suitable lifting device. The weight of the turbocharger is approximately 29 kg (65 lb). Remove turbocharger (8).

i01942655

## Turbocharger - Install (Low Pressure Turbocharger)

SMCS Code: 1052-012

### Installation Procedure

Table 7

| Required Tools |             |                     |     |
|----------------|-------------|---------------------|-----|
| Tool           | Part Number | Part Description    | Qty |
| A              | 5P-3931     | Anti-Seize Compound | 1   |

#### NOTICE

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

#### NOTICE

The alignment of the bellows is important. Improper alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the convolutions for uniformity of compression.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. Minor damage to the ends of the bellows may be repaired. However, if there is any difficulty in installation after the repair, discard the bellows.

**Note:**

**Note:** Refer to Special Instruction, REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

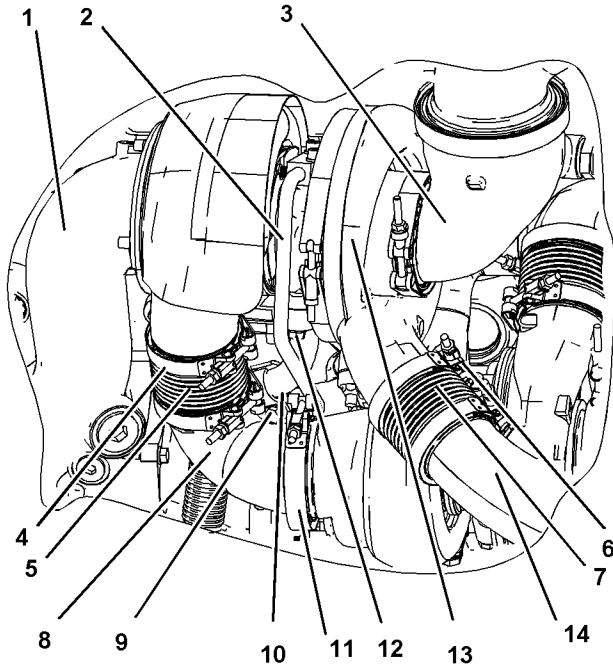


Illustration 21

g01010976

1. Use a suitable lifting device. The weight of the turbocharger is approximately 29 kg (65 lb). Position turbocharger (13) on the engine.
2. Apply Tooling (A) to the threads of the studs and install nuts (12).
3. Connect oil supply tube assembly (2) and oil drain tube assembly (10).
4. Install clamp (9).
5. Connect elbow (1).
6. Install elbow (3).
7. Install elbow (8) and elbow (14).
8. Apply Tooling (A) to the threads of the studs of clamp (6).
9. Position clamp (6) on bellows (7).
10. Tighten clamp (6) to a torque of 12 N·m (106 lb in).
11. Install clamp (11).

12. Apply Tooling (A) to the threads of the studs of clamp (4).
13. Position clamp (4) on bellows (5).
14. Tighten clamp (4) to a torque of 12 N·m (106 lb in).

i01942236

## Turbocharger - Install (High Pressure Turbocharger)

SMCS Code: 1052-012

### Installation Procedure

Table 8

| Required Tools |             |                     |     |
|----------------|-------------|---------------------|-----|
| Tool           | Part Number | Part Description    | Qty |
| A              | 5P-3931     | Anti-Seize Compound | 1   |

#### NOTICE

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

#### NOTICE

The alignment of the bellows is important. Improper alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the convolutions for uniformity of compression.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. Minor damage to the ends of the bellows may be repaired. However, if there is any difficulty in installation after the repair, discard the bellows.

i01942438

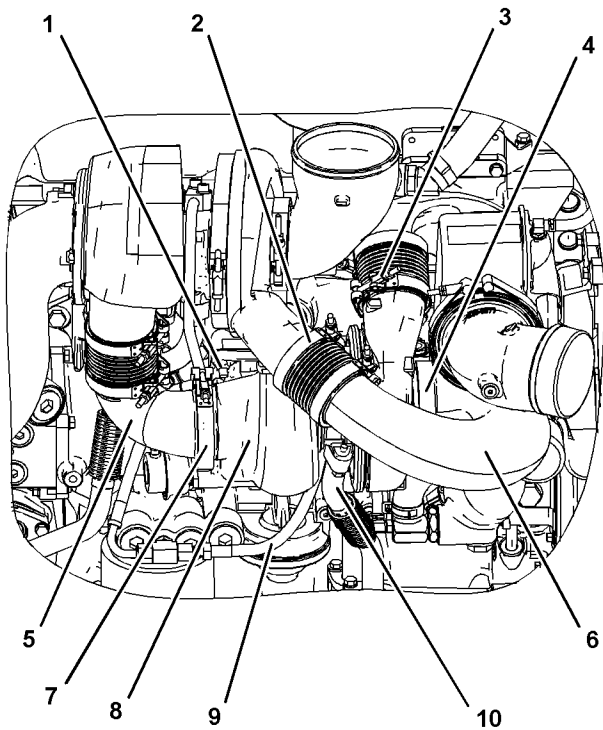


Illustration 22

g01010642

**Note:** Refer to Special Instruction, REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

1. Use a suitable lifting device. The weight of the turbocharger is approximately 29 kg (65 lb). Position turbocharger (8) on the engine.
2. Apply Tooling (A) to the threads of the studs and install nuts (1).
3. Connect oil supply tube assembly (9) and oil drain tube assembly (10).
4. Install elbow (5) and elbow (6).
5. Install clamp (7).
6. Install clamp (4).
7. Apply Tooling (A) to the threads of the studs of clamp (3).
8. Position clamp (3) on bellows.
9. Tighten clamp (3).
10. Apply Tooling (A) to the threads of the studs of clamp (2).
11. Position clamp (2) on bellows.
12. Tighten clamp (2).

## Exhaust Manifold - Remove and Install

SMCS Code: 1059-010

### Removal Procedure

#### Start By:

- a. Remove the high pressure turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove".
- b. Remove the pre-cooler. Refer to Disassembly and Assembly, "Pre-cooler - Remove".
- c. Remove the low pressure turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove".

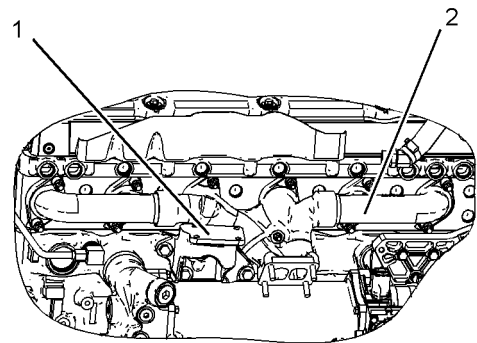


Illustration 23

g01010797

1. Remove the lower bracket for the pre-cooler, the upper bracket for the pre-cooler, and the middle bracket for the pre-cooler.
2. Remove bracket (1).
3. Remove exhaust manifold (2).

## Installation Procedure

i02247521

Table 9

| Required Tools |             |                     |     |
|----------------|-------------|---------------------|-----|
| Tool           | Part Number | Part Description    | Qty |
| A              | 5P-3931     | Anti-Seize Compound | 1   |

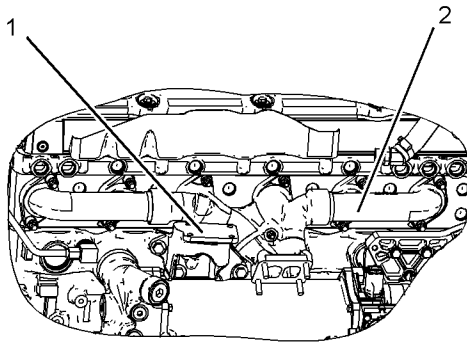


Illustration 24

g01010797

1. Apply Tooling (A) to the studs.
2. Install exhaust manifold (2). Tighten nuts to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft).
3. Install bracket (1).
4. Remove the lower bracket for the precooler, the upper bracket for the precooler, and the middle bracket for the precooler.

### End By:

- a. Install the low pressure turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install".
- b. Install the precooler. Refer to Disassembly and Assembly, "Precooler - Install".
- c. Install the high pressure turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install".

## Inlet and Exhaust Valve Springs - Remove and Install

SMCS Code: 1108-010

### Removal Procedure

Table 10

| Required Tools |             |                                |     |
|----------------|-------------|--------------------------------|-----|
| Tool           | Part Number | Part Description               | Qty |
| A              | 235-0518    | Valve Spring Compression Group | 1   |

### Start By:

- a. Remove the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - 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 valve springs and the exhaust valve springs without removing the cylinder head. This procedure can be performed on only one cylinder at a time. This will prevent the inlet valves and the exhaust valves from falling into the cylinder.

1. Rotate the crankshaft in order to bring the piston to the top center position in the cylinder.



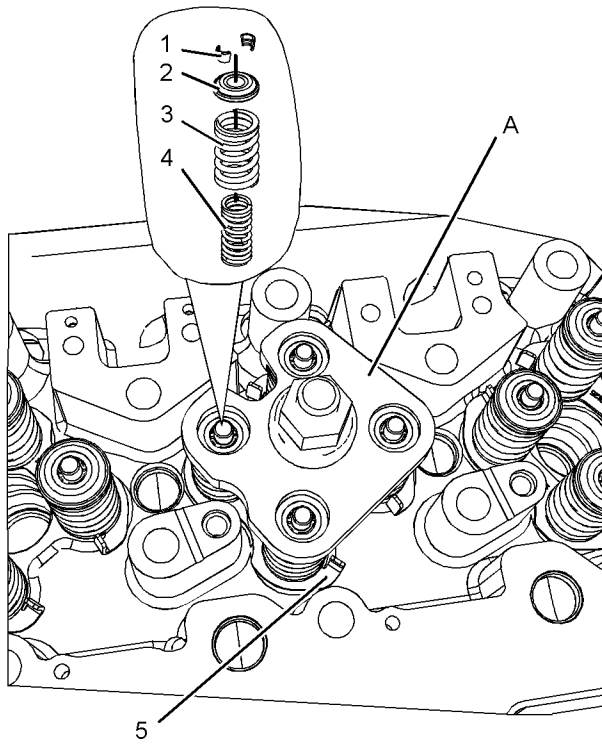


Illustration 25

g01136330

**⚠ 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.

2. Install Tooling (A) on the cylinder head.
3. Remove retainer locks (1).
4. Remove Tooling (A).
5. Remove valve rotators (2).
6. Remove valve springs (3) and valve springs (4) from each valve.
7. Remove bases (5) from the cylinder head.

**Note:** Install the valve springs before you rotate the crankshaft.

## Installation Procedure

Table 11

| Required Tools |             |                                |     |
|----------------|-------------|--------------------------------|-----|
| Tool           | Part Number | Part Description               | Qty |
| A              | 235-0518    | Valve Spring Compression Group | 1   |

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

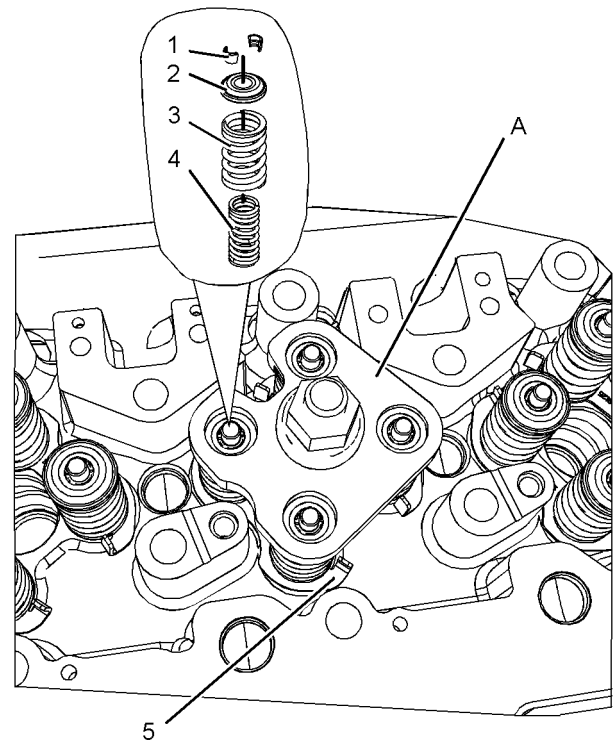


Illustration 26

g01136330

**⚠ 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. Install bases (5) for the valve springs.
2. Install valve springs (4) and valve springs (3).
3. Install valve rotators (2).

4. Install Tooling (A).
5. Install retainer locks (1).
6. Remove Tooling (A).

**End By:**

- a. Install the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Install".

i02247841

## Inlet and Exhaust Valves - Remove and Install

SMCS Code: 1105-010

### Removal Procedure

Table 12

| Required Tools |             |                         |     |
|----------------|-------------|-------------------------|-----|
| Tool           | Part Number | Part Description        | Qty |
| A              | 5S-1330     | Valve Spring Compressor | 1   |

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

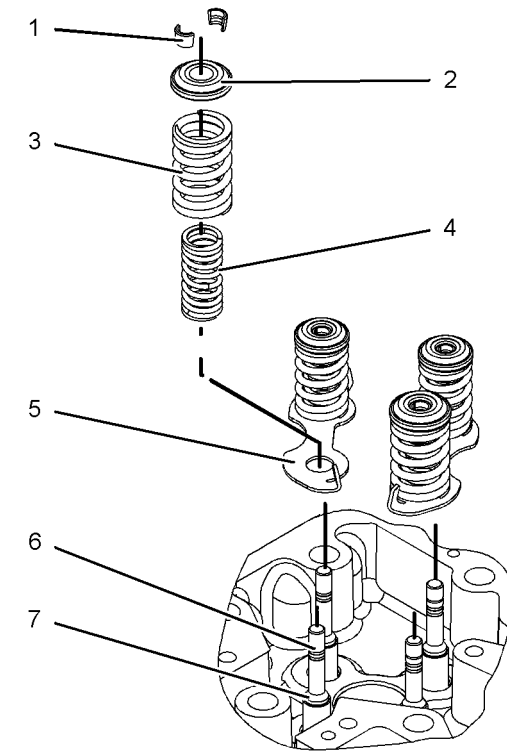


Illustration 27

g01131781

**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 Tooling (A) to remove retainer locks (1).
2. Remove valve rotators (2).
3. Remove valve springs (3) and valve springs (4).
4. Remove base (5).
5. Remove valves (6) from the cylinder head.
6. Remove valve seals (7).

## Installation Procedure

Table 13

| Required Tools |             |                         |     |
|----------------|-------------|-------------------------|-----|
| Tool           | Part Number | Part Description        | Qty |
| A              | 5S-1330     | Valve Spring Compressor | 1   |

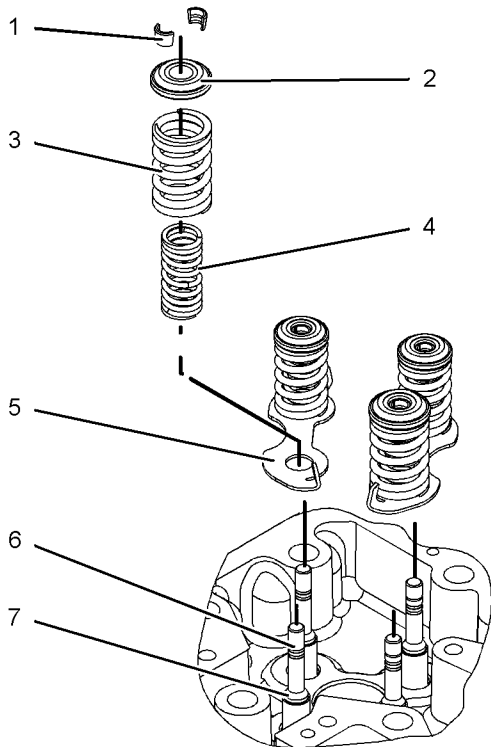


Illustration 28

g01131781

### 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.

**Note:** A small amount of grease can be used to hold the retainer locks in position during installation.

1. Lubricate valves (6) with clean engine oil. Install the valves in the cylinder head assembly.
2. Install valve seals (7).
3. Install base (5).
4. Install valve springs (3) and valve springs (4).
5. Install valve rotators (2).

6. Use Tooling (A) to install retainer locks (1).

### End By:

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

i02261758

## Inlet and Exhaust Valve Guides - Remove and Install

SMCS Code: 1104-010

### Removal Procedure

Table 14

| Required Tools |             |                    |     |
|----------------|-------------|--------------------|-----|
| Tool           | Part Number | Part Description   | Qty |
| A              | 1U-9169     | Valve Guide Driver | 1   |

### Start By:

- a. Remove the inlet valves 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.

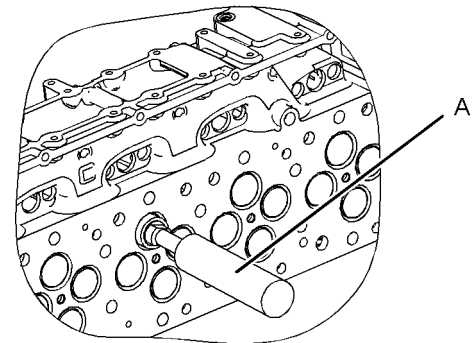


Illustration 29

g01015291

1. Use Tooling (A) to remove the valve guides from the cylinder head assembly.

## Installation Procedure

i02247876

Table 15

| Required Tools |             |                                 |     |
|----------------|-------------|---------------------------------|-----|
| Tool           | Part Number | Part Description                | Qty |
| A              | 1U-9169     | Valve Guide Driver              | 1   |
| B              | 9U-6460     | Valve Guide and Seat Tool Group | 1   |

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

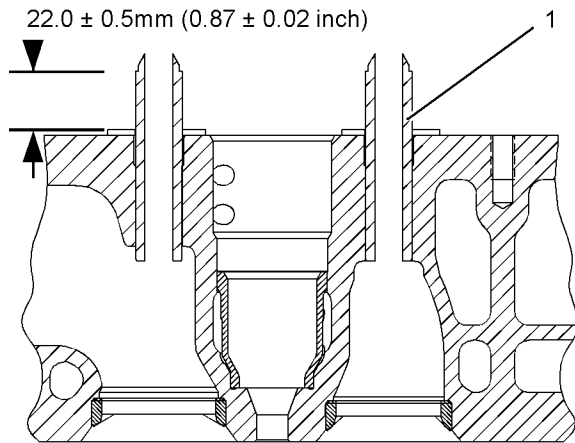


Illustration 30

g01015292

1. Use Tooling (A) and Tooling (B) to install valve guides (1). Install the valve guides until the protrusion is  $22.0 \pm 0.5$  mm ( $0.87 \pm 0.02$  inch) above the cylinder head assembly.

### End By:

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

## Inlet and Exhaust Valve Seat Inserts - Remove and Install

SMCS Code: 1103-010

### Removal Procedure

Table 16

| Required Tools |             |                           |     |
|----------------|-------------|---------------------------|-----|
| Tool           | Part Number | Part Description          | Qty |
| A              | 166-7441    | Valve Seat Extractor Tool | 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.

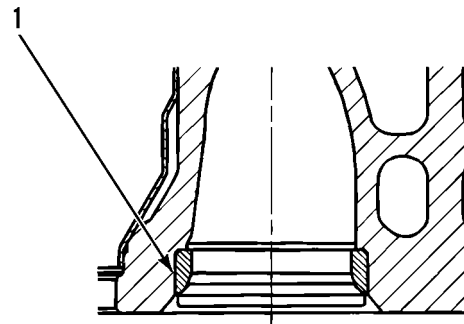


Illustration 31

g00513644

1. Use Tooling (A) to remove valve seat inserts (1).

### Installation Procedure

Table 17

| Required Tools |             |                   |     |
|----------------|-------------|-------------------|-----|
| Tool           | Part Number | Part Description  | Qty |
| B              | 1U-9170     | Valve Seat Driver | 1   |

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

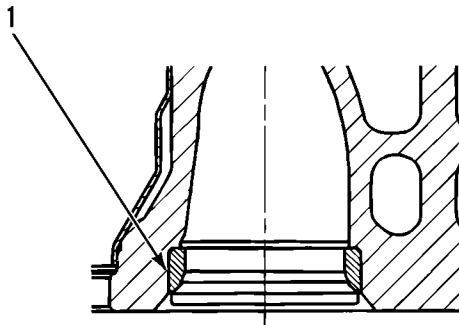


Illustration 32

g00513644

**Note:** Do not machine the prefinished valve seat inserts in order to correct the valve stem projection. An excessive valve stem projection indicates that the valve seat insert is not seated or material was not cleaned from the bottom of the counterbore.

1. Lower the temperature of new valve seat inserts (1).
2. Use Tooling (B) to install the new valve seat inserts in the cylinder head assembly.

**End By:**

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

i01942430

## Engine Oil Filter Base - Remove

SMCS Code: 1306-011

### Removal Procedure

Table 18

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 185-3630    | Strap Wrench As  | 1   |

**Start By:**

- a. Remove the engine oil cooler. Refer to Disassembly and Assembly, "Engine Oil Cooler - 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

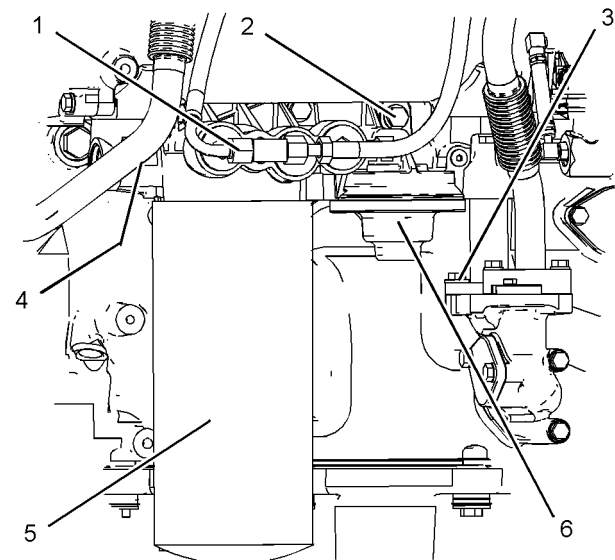


Illustration 33

g01010791

1. Use Tooling (A) in order to remove oil filter (5).
2. Disconnect hose assemblies (1).
3. Remove bolts (2).
4. Remove bolts (4).
5. Remove bolts (3).
6. Remove oil filter base (6).

i01942432

i01942433

## Engine Oil Filter Base - Disassemble

SMCS Code: 1306-015

### Disassembly Procedure

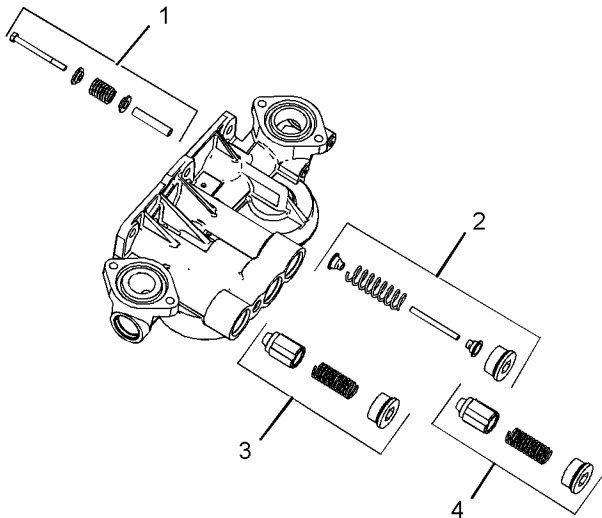


Illustration 34

g01010792

#### **⚠ WARNING**

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

- (1) High Pressure Relief Valve
- (2) Pump Bypass Valve
- (3) Oil Filter Bypass Valve
- (4) Oil Cooler Bypass Valve

## Engine Oil Filter Base - Assemble

SMCS Code: 1306-016

### Assembly Procedure

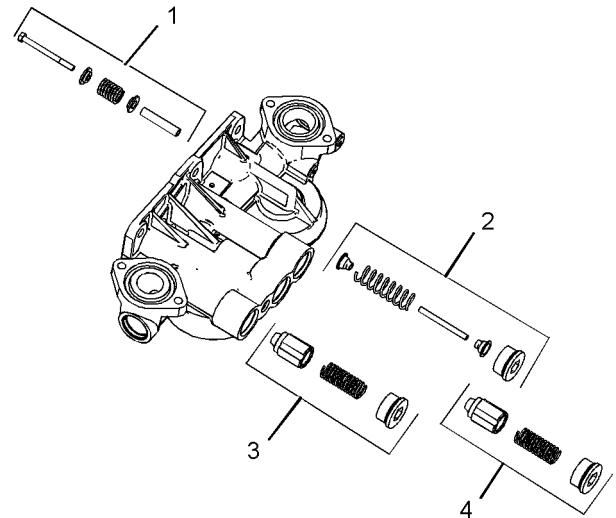


Illustration 35

g01010792

#### **⚠ WARNING**

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

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

- (1) High Pressure Relief Valve
- (2) Pump Bypass Valve
- (3) Oil Filter Bypass Valve
- (4) Oil Cooler Bypass Valve

i01942431

## Engine Oil Filter Base - Install

SMCS Code: 1306-012

### Installation Procedure

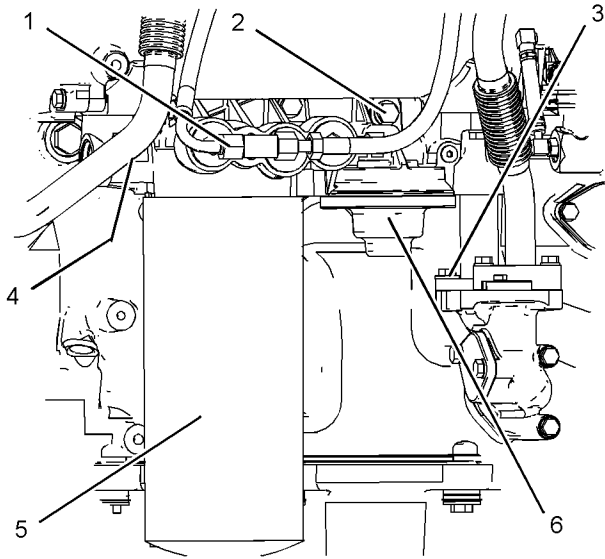


Illustration 36

g01010791

1. Position oil filter base (6).
2. Install bolts (2).
3. Install bolts (4).
4. Install bolts (3).
5. Connect hose assemblies (1).
6. Install oil filter (5).

#### End By:

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

i01946825

## Engine Oil Cooler - Remove

SMCS Code: 1378-011

### Removal Procedure

#### Start By:

- a. Remove the turbochargers. Refer to Disassembly and Assembly, "Turbocharger - 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

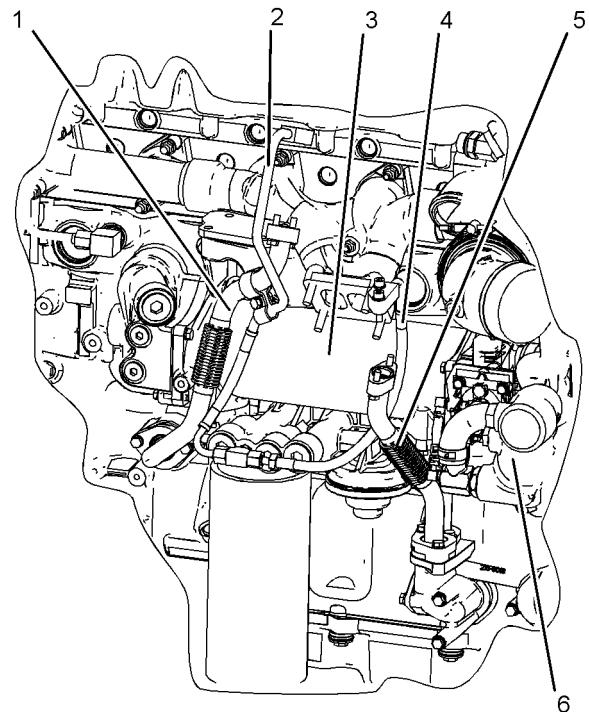


Illustration 37

g01013590

1. Remove tube assembly (1) and tube assembly (5).
2. Remove hose assembly (2).
3. Position hose assembly (4) out of the way.
4. Remove elbow (6).

i01953469

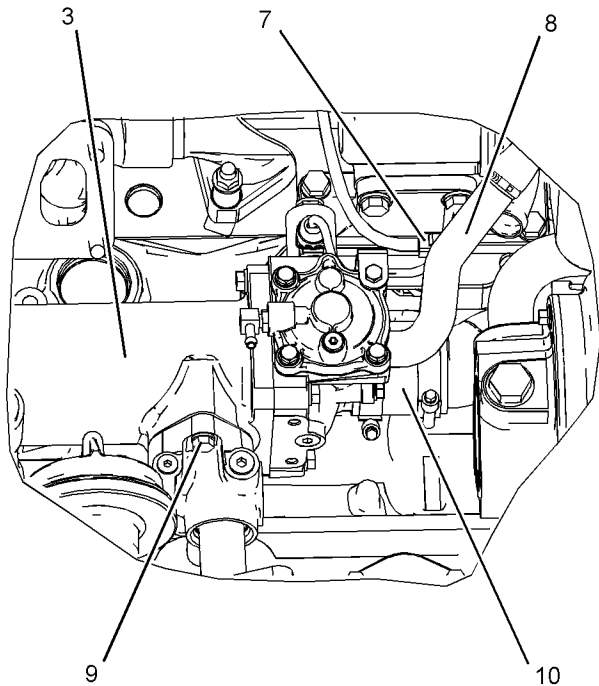


Illustration 38

g01013646

5. Disconnect hose (8) and hose (10).
6. Disconnect harness assembly (7).
7. Remove bolts (9) from the oil filter base.
8. Pull engine oil cooler (3) away from the cylinder block. Slide engine oil cooler (3) to the rear of the engine.

## Engine Oil Cooler - Install

SMCS Code: 1378-012

### Installation Procedure

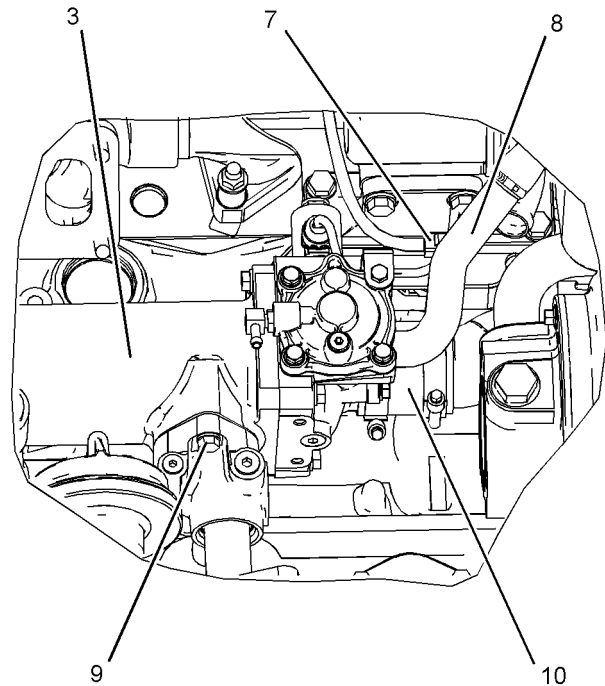


Illustration 39

g01013646

1. Slide engine oil cooler (3) to the front of the engine. Position engine oil cooler (3) onto the cylinder block.
2. Install bolts (9) on the oil filter base.
3. Connect harness assembly (7).
4. Connect hose (8) and hose (10).



i02290926

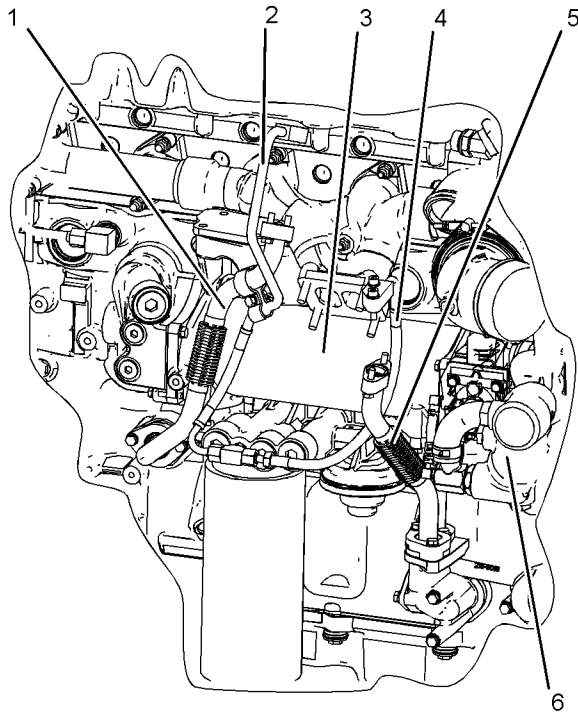


Illustration 40

g01013590

- 5. Install elbow (6).
- 6. Install hose assembly (2).
- 7. Install tube assembly (1) and tube assembly (5).

**End By:**

- a. Install the turbochargers. Refer to Disassembly and Assembly, "Turbocharger - Install".

## Engine Oil Pump - Remove

SMCS Code: 1304-011

### Removal Procedure

**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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

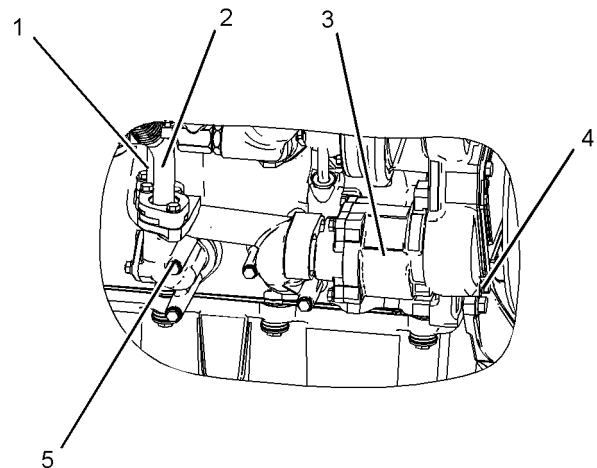


Illustration 41

g01010793

- 1. Disconnect tube assembly (1) and tube assembly (2).
- 2. Remove bolts (5).
- 3. Remove bolts (4).
- 4. Remove engine oil pump (3).

i02248248

## Engine Oil Pump - Disassemble

SMCS Code: 1304-015

### Disassembly Procedure

Table 19

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 5F-7344     | Puller Block     | 1   |
|                | 7S-7786     | Puller Leg       | 1   |
|                | 5F-7345     | Screw            | 1   |

#### Start By:

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

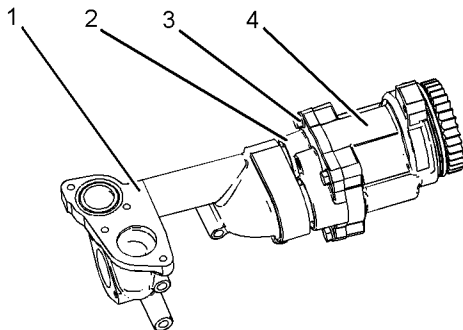


Illustration 42

g01146930

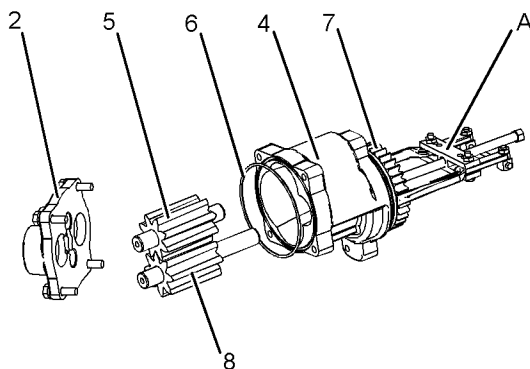


Illustration 43

g01146931

1. Remove elbow (1) from cover (2).
2. Remove bolts (3).

3. Remove cover (2) from engine oil pump (4).
4. Use Tooling (A) in order to remove gear (7).
5. Remove shaft assembly (5) and shaft assembly (8) from engine oil pump (4).
6. Remove oil seal (6).

i02248255

## Engine Oil Pump - Assemble

SMCS Code: 1304-016

### Assembly Procedure

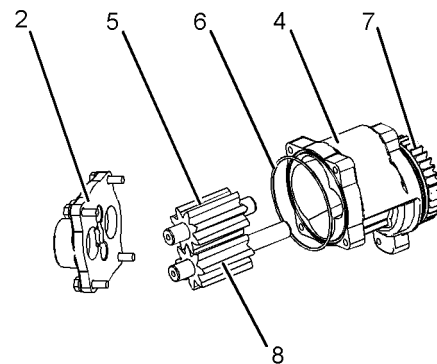


Illustration 44

g01146941

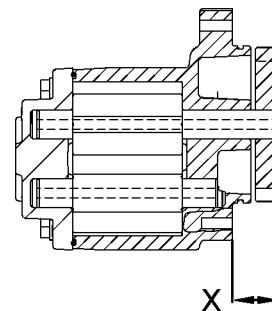


Illustration 45

g01146945

i02290931

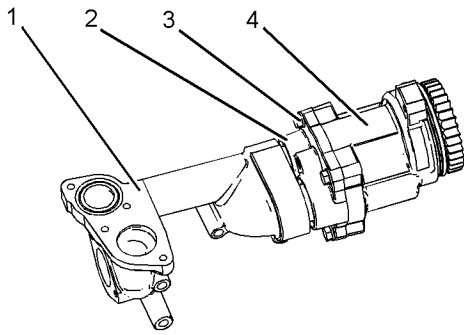


Illustration 46

g01146930

1. Install shaft assembly (5) and shaft assembly (8) into engine oil pump (4).
2. Install oil seal (6).
3. Install cover (2) onto engine oil pump (4).
4. Install bolts (3).
5. Raise the temperature of gear (7).
6. Install gear (7). Dimension (X) is  $29.40 \pm 0.50$  mm ( $1.158 \pm 0.020$  inch).
7. Install elbow (1) onto cover (2).

**End By:**

- a. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

## Engine Oil Pump - Install

SMCS Code: 1304-012

### Installation Procedure

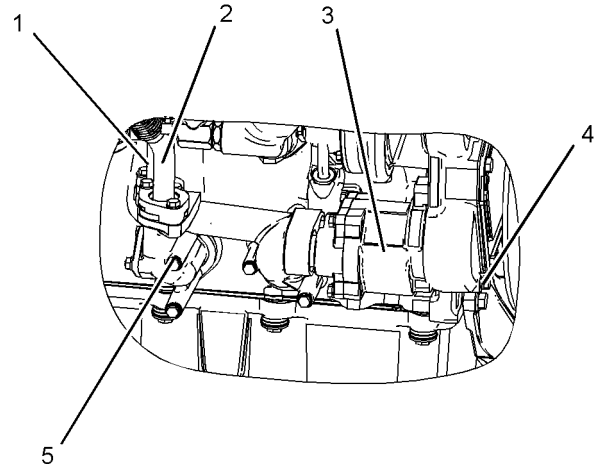


Illustration 47

g01010793

1. Position engine oil pump (3).
2. Install bolts (4).
3. Install bolts (5).
4. Connect tube assembly (1) and tube assembly (2).

i01942447

## Diverter Valve (Oil) - Remove

SMCS Code: 5066-011-OC

### Removal Procedure

**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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

i02481412

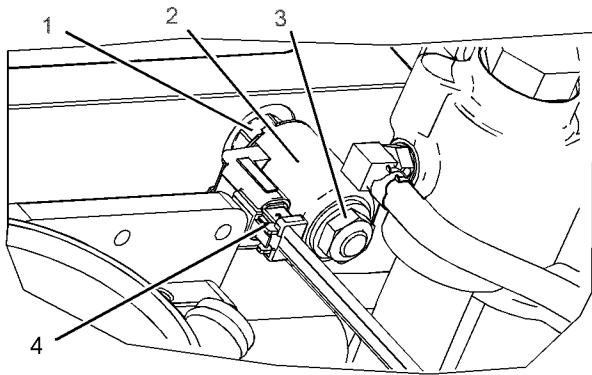


Illustration 48 g01010801

1. Disconnect harness assembly (4).
2. Loosen nut (3) in order to allow cartridge (1) to rotate the inside of coil (2).
3. Remove the diverter valve.

i01942448

## Diverter Valve (Oil) - Install

SMCS Code: 5066-012-OC

### Installation Procedure

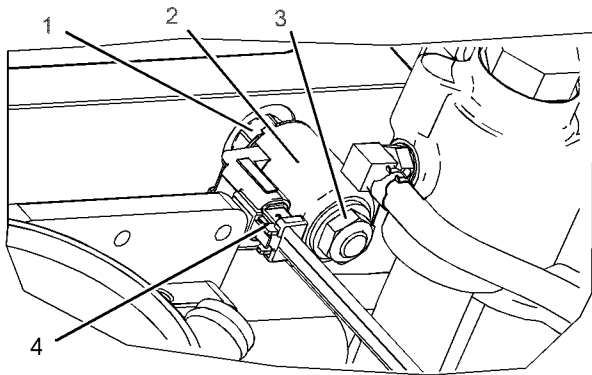


Illustration 49 g01010801

1. Position the diverter valve.
2. Position coil (2), cartridge (1), and nut (3).
3. Tighten cartridge (1) to a torque of  $50 \pm 5$  N·m ( $37 \pm 4$  lb ft). Tighten nut (3) to a torque of  $20 \pm 2.5$  N·m ( $15 \pm 2$  lb ft).
4. Connect harness assembly (4).

## Diverter Valve (Coolant) - Remove

SMCS Code: 135D-011

### Removal Procedure

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

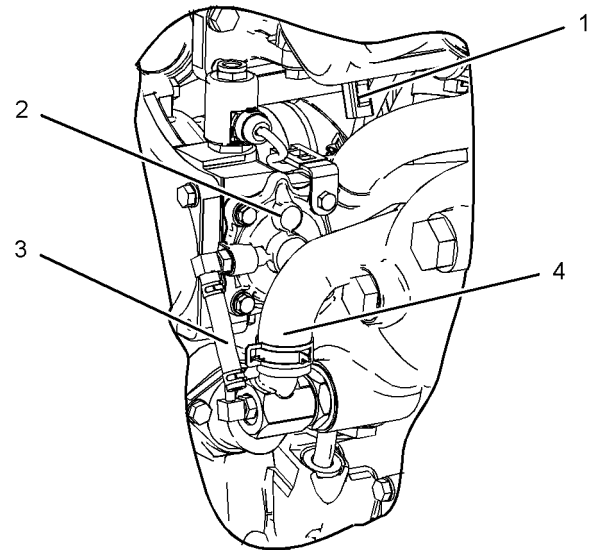


Illustration 50

g01013685

2. Disconnect harness assembly (1).
3. Disconnect hose (3) and hose (4).

i02481414

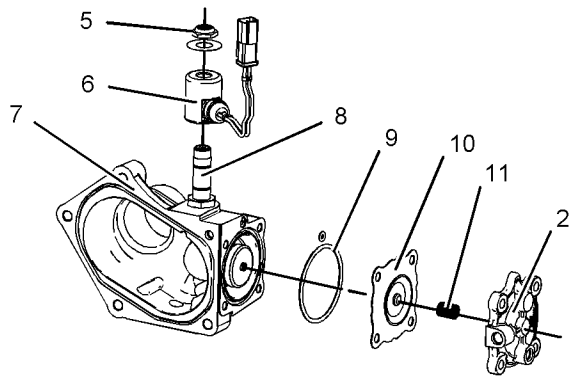


Illustration 51

g01013962

### **⚠ WARNING**

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

4. Remove cover (2) from housing (7).
5. Remove spring (11).
6. Remove diaphragm (10).
7. Remove O-ring seals (9).
8. Remove nut (5).
9. Remove coil assembly (6).
10. Remove cartridge group (8) from housing (7).

## Diverter Valve (Coolant) - Install

SMCS Code: 135D-012

### Installation Procedure

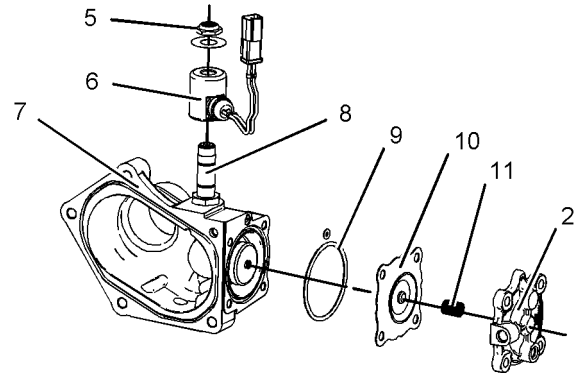


Illustration 52

g01013962

### **⚠ WARNING**

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

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

1. Install cartridge group (8) on housing (7). Tighten the cartridge group to a torque of  $50 \pm 5$  N·m ( $37 \pm 4$  lb ft).
2. Position coil assembly (6) on cartridge group (8).
3. Install nut (5). Tighten the nut to a torque of  $20 \pm 3$  N·m ( $15 \pm 2$  lb ft).
4. Install O-ring seals (9).
5. Install diaphragm (10).
6. Install spring (11).

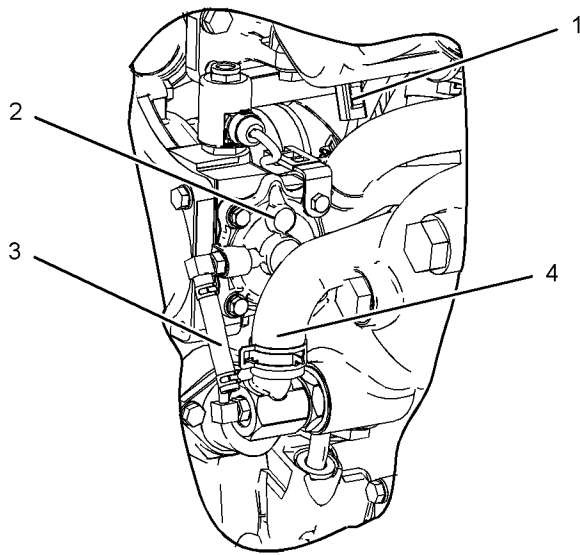


Illustration 53

g01013685

7. Install cover (2).
8. Connect hose (3) and hose (4).
9. Connect harness assembly (1).
10. Fill the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

i02459919

## Water Pump - Remove

SMCS Code: 1361-011

### Removal Procedure

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Dealer Service Tool Catalog" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".
2. Remove the fan drive belt.
3. Disconnect the lower radiator hose from the water pump.

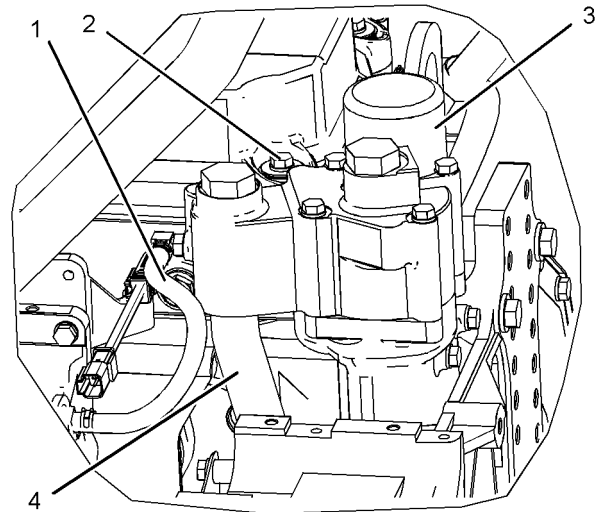


Illustration 54

g01009921

4. Disconnect hose assembly (1).
5. Remove bolts (2).
6. Raise housing (3) in order to disconnect tube assembly (4).

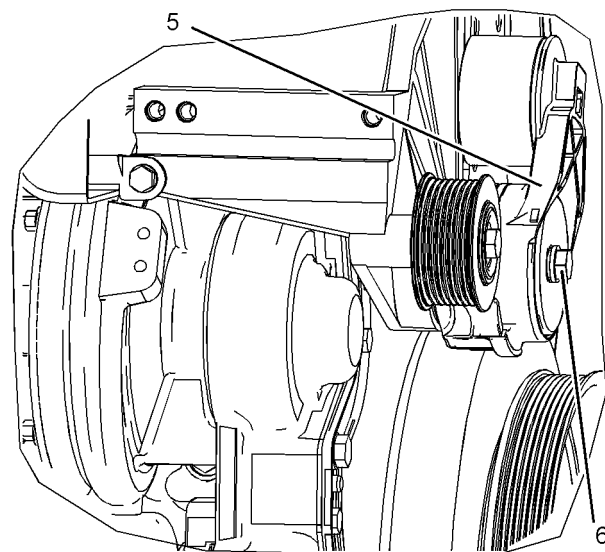


Illustration 55

g01009922

7. Remove bolt (6) and pulley (5).

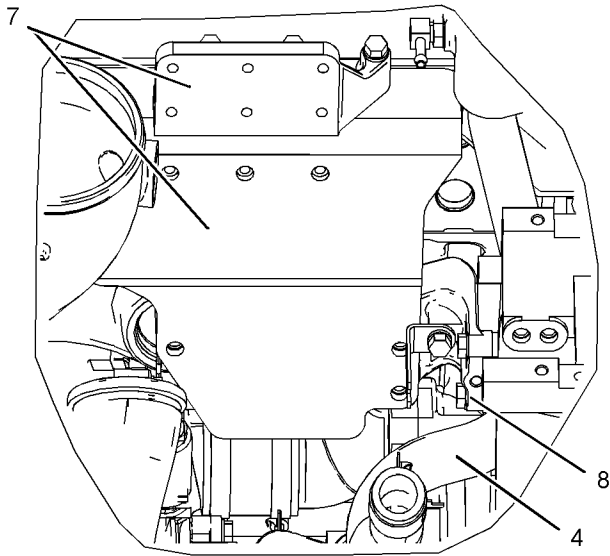


Illustration 56

g01010397

8. Remove brackets (7) and bracket (8).

9. Disconnect tube assembly (4).

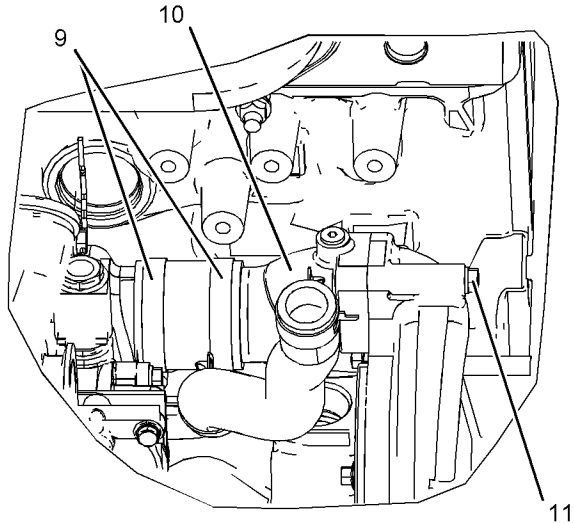


Illustration 57

g01010398

10. Remove bolts (11).

11. Loosen clamps (9).

12. Remove adapter (10).

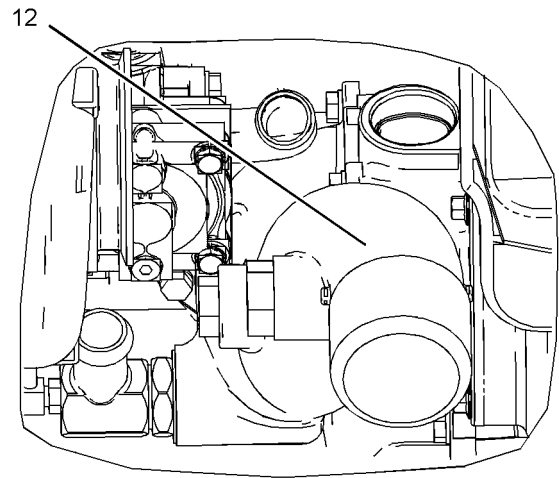


Illustration 58

g01010400

13. Remove inlet housing (12).

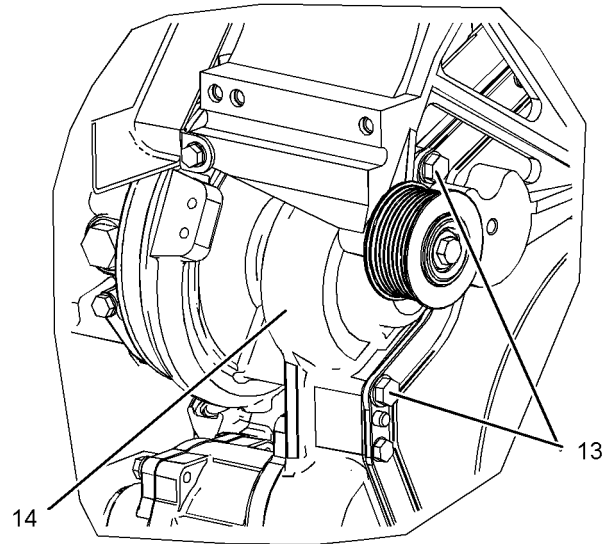


Illustration 59

g01010401

14. Remove bolts (13).

15. Remove water pump (14).

i02459920

## Water Pump - Install

SMCS Code: 1361-012

### Installation Procedure

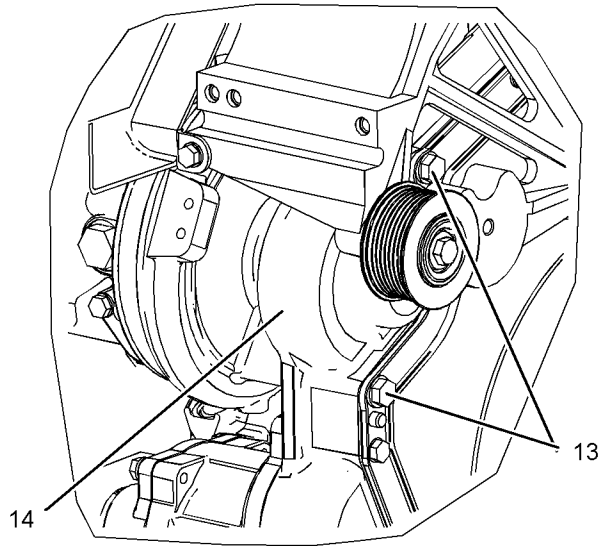


Illustration 60

g01010401

1. Position water pump (14).
2. Install bolts (13).

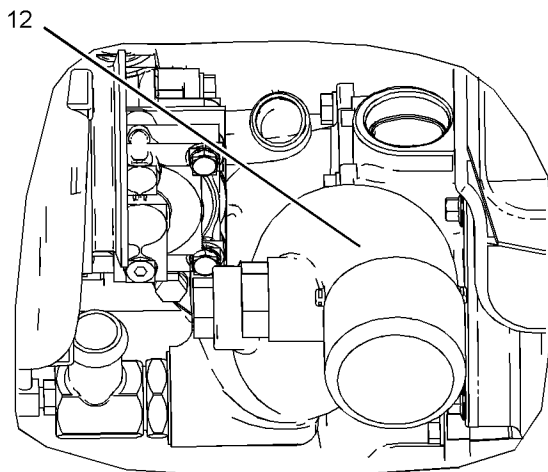


Illustration 61

g01010400

3. Install inlet housing (12).

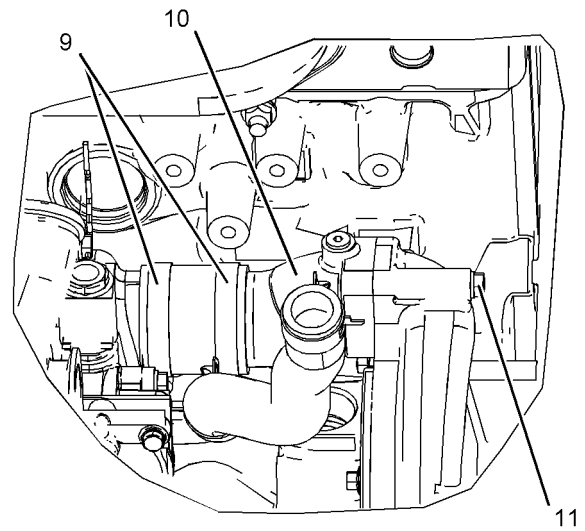


Illustration 62

g01010398

4. Install adapter (10).
5. Tighten clamps (9).
6. Install bolts (11).

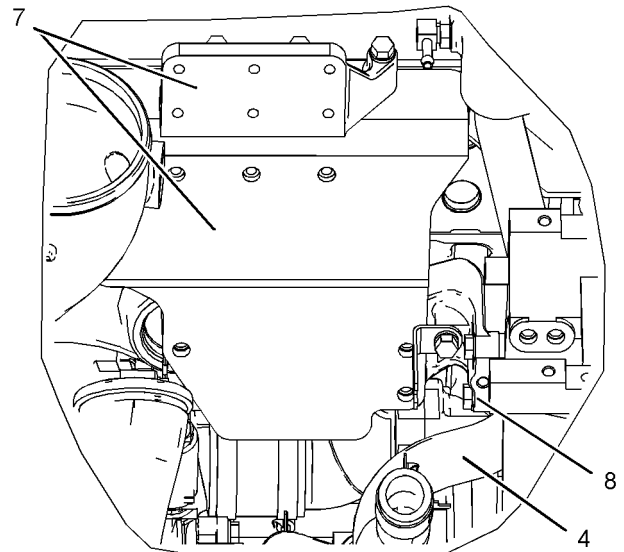


Illustration 63

g01010397

7. Connect tube assembly (4).
8. Install brackets (7) and bracket (8).



i01942449

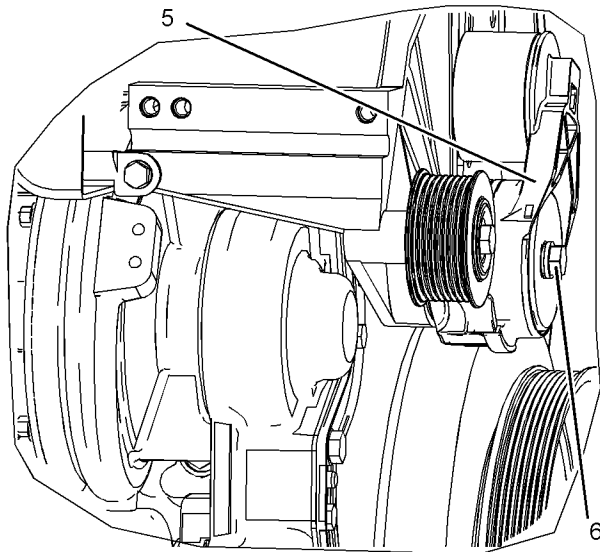


Illustration 64

g01009922

9. Install pulley (5) and bolt (6).

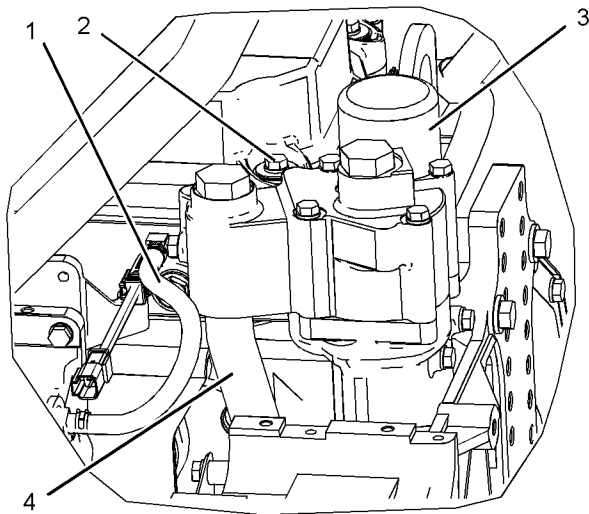


Illustration 65

g01009921

10. Connect tube assembly (4) to housing (3).

11. Install bolts (2).

12. Connect hose assembly (1).

13. Connect the lower radiator hose to the water pump.

14. Install the fan drive belt.

15. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Refill Capacities".

## Water Temperature Regulator - Remove and Install

SMCS Code: 1355-010

### Removal Procedure

1. Drain the coolant. Refer to Operation and maintenance Manual, "Cooling System Coolant - Change".
2. Disconnect the radiator hose.

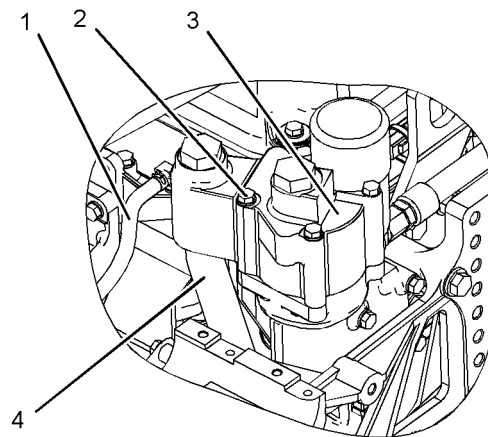


Illustration 66

g01010802

3. Disconnect hose (1).

4. Remove bolts (2).

5. Remove housing (3) from tube assembly (4).

6. Remove the water temperature regulator and the seal.

## Installation Procedure

Table 20

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 221 - 8647  | Installer        | 1   |

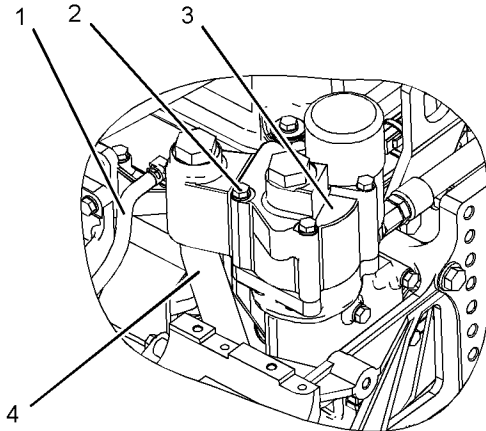


Illustration 67

g01010802

1. Use Tooling (A) in order to install the seal. Install the water temperature regulator.
2. Install housing (3) onto tube assembly (4).
3. Install bolts (2).
4. Connect hose (1).
5. Connect the radiator hose.
6. Fill the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

i01949408

## Precooler - Remove

SMCS Code: 1050-011

### Removal Procedure

1. Drain the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

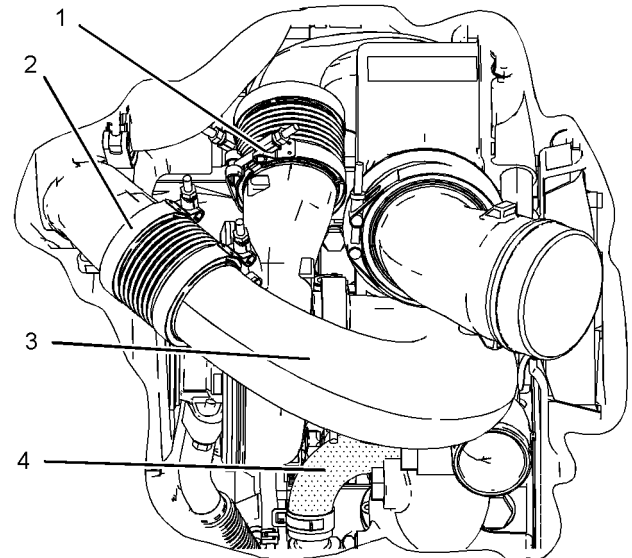


Illustration 68

g01014499

### NOTICE

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

### CAUTION

The ends of the bellows are very sharp. Injury could occur if the bellows are not handled properly. Handle the bellows by the convolutions.

**Note:** Refer to Special Instruction, REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

2. Loosen clamp (1) and clamp (2).
3. Remove elbow (3).
4. Disconnect hose (4).

i01949744

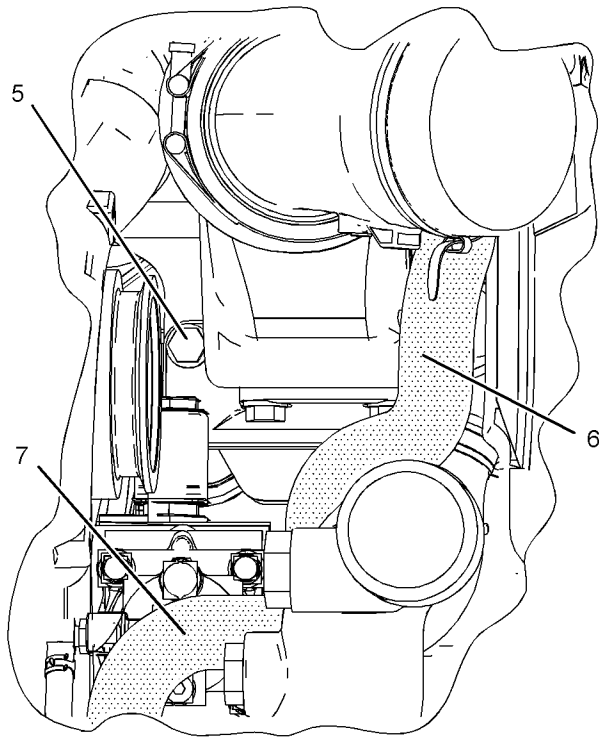


Illustration 69

g01014501

5. Disconnect hose (6) and hose (7).
6. Remove bolts (5).

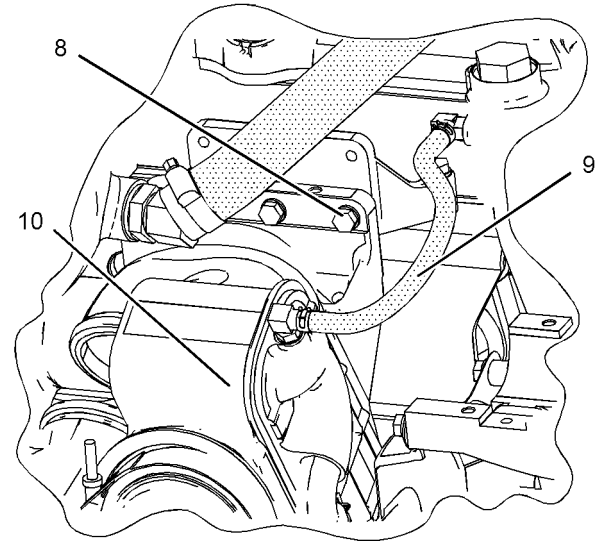


Illustration 71

g01014503

**NOTICE**

Failure to follow established procedures can lead to damage of the parts.

To avoid damage to the parts, always identify and mark the parts so that the parts can be installed in the same location.

**NOTICE**

The alignment of the bellows is important. Improper alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the convolutions for uniformity of compression.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. Minor damage to the ends of the bellows may be repaired. However, if there is any difficulty in installation after the repair, discard the bellows.

**Note:** Refer to Special Instruction, REHS1728, "Application Guideline for the Bellows" for additional information on handling the bellows.

1. Position pre-cooler (10) on the mounting brackets.
2. Install bolts (8).
3. Connect hose (9).

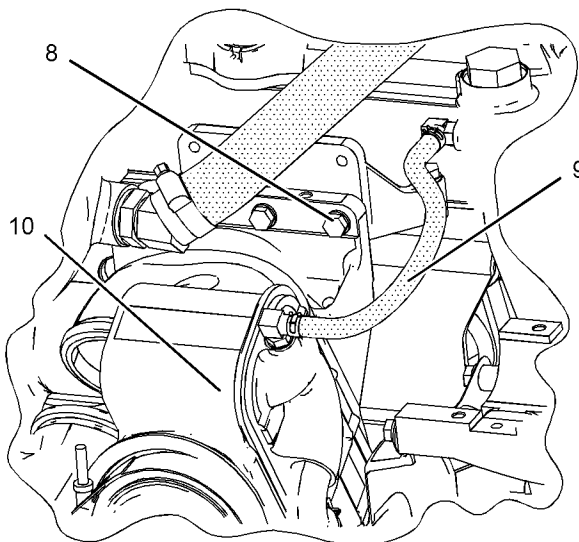


Illustration 70

g01014503

7. Disconnect hose (9).
8. Remove bolts (8).
9. Remove pre-cooler (10).

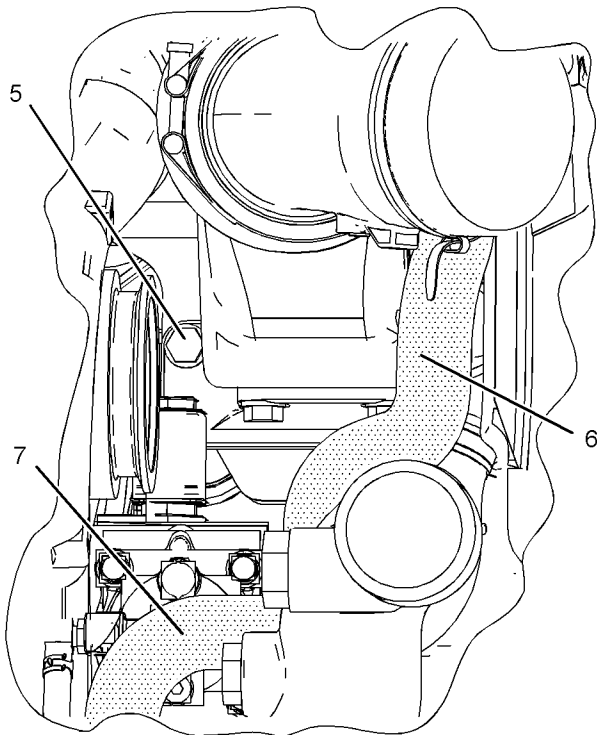


Illustration 72

g01014501

4. Install bolts (5).
5. Connect hose (6) and hose (7).

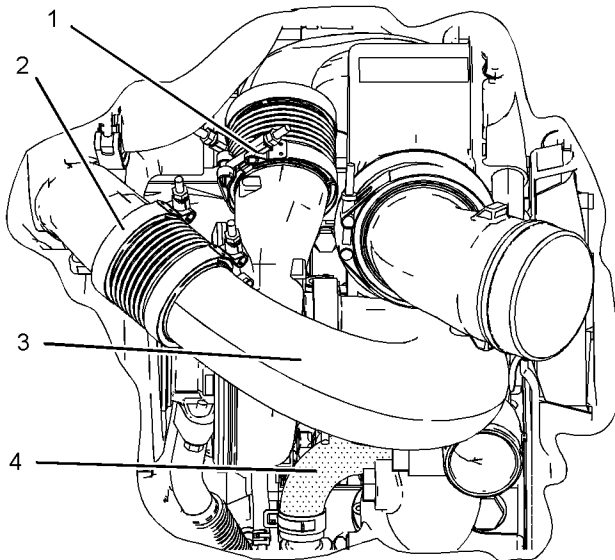


Illustration 73

g01014499

6. Connect hose (4).
7. Install elbow (3).

**NOTICE**

The alignment of the bellows is important. Improper alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the convolutions for uniformity of compression.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. Minor damage to the ends of the bellows may be repaired. However, if there is any difficulty in installation after the repair, discard the bellows.

8. Tighten clamp (1) and clamp (2).
9. Fill the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

i01942452

**Flywheel - Remove**

SMCS Code: 1156-011

**Removal Procedure**

Table 21

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 138-7573    | Link Bracket     | 2   |
| B              | FT2712      | Guide Stud       | 2   |

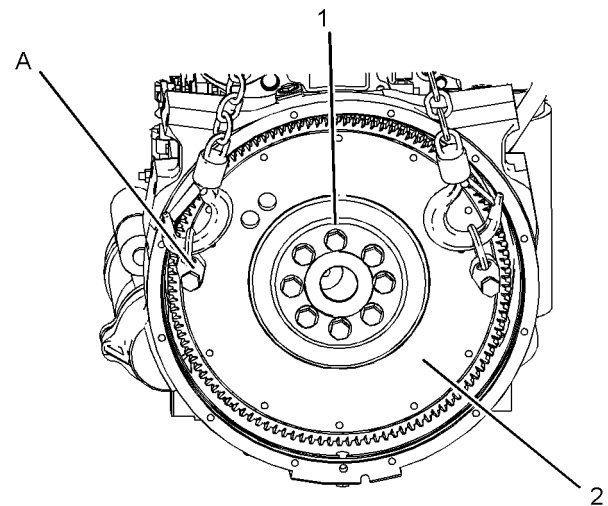


Illustration 74

g01010803

1. Install Tooling (A) on flywheel (2). Fasten a suitable lifting device to flywheel (2). The weight of the flywheel is approximately 41 kg (90 lb).
2. Remove two bolts (1) that are 180 degrees from the first bolt. Install Tooling (B).
3. Remove the remaining six bolts (1).
4. Remove flywheel (2).
5. Inspect the flywheel ring gear. Replace the ring gear, if necessary. Place the flywheel on a wood block. Use a hammer and a punch in order to remove the ring gear.

i01942453

## Flywheel - Install

SMCS Code: 1156-012

### Installation Procedure

Table 22

| Required Tools |             |                        |     |
|----------------|-------------|------------------------|-----|
| Tool           | Part Number | Part Description       | Qty |
| A              | 138-7573    | Link Bracket           | 2   |
| B              | FT2712      | Guide Stud             | 2   |
| C              | 7M-7456     | Bearing Mount Compound | 1   |

#### **WARNING**

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

1. Raise the temperature of the ring gear to a maximum temperature of 315 °C (599 °F). Position the ring gear with the part number toward the crankshaft. Install the ring gear on the flywheel. Allow the ring gear to cool. Use a soft hammer in order to seat the ring gear against the shoulder of the flywheel.

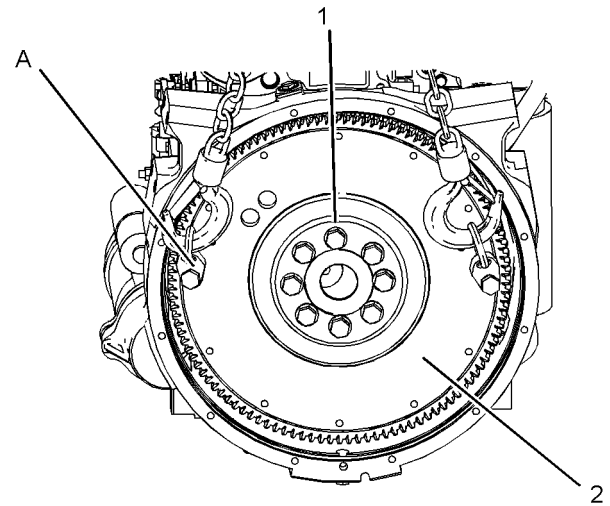


Illustration 75

g01010803

2. Install Tooling (A) on flywheel (2). Fasten a suitable lifting device to flywheel (2). The weight of the flywheel is approximately 41 kg (90 lb).
3. Place flywheel (2) on the crankshaft. Slide the flywheel over Tooling (B).
4. Apply Tooling (C) to the threads of bolts (1).
5. Install six of the eight bolts (1). Remove Tooling (B) from the end of the crankshaft and replace with the two remaining bolts. Tighten the bolts evenly to a torque of 300 ± 40 N·m (221 ± 30 lb ft).
6. Check the flywheel runout. Refer to Testing and Adjusting, “Flywheel - Inspect” for the correct procedure.

i01942458

## Flywheel Housing - Remove and Install

SMCS Code: 1157-010

### Removal Procedure

#### Start By:

- a. Remove the flywheel. Refer to Disassembly and Assembly, “Flywheel - Remove”.
1. Support the engine with blocks or a suitable lifting device.

## Installation Procedure

Table 23

| Required Tools |             |                          |     |
|----------------|-------------|--------------------------|-----|
| Tool           | Part Number | Part Description         | Qty |
| A              | 1U-6396     | O-Ring Assembly Compound | 1   |
| B              | 1U-8846     | Gasket Sealant           | 1   |

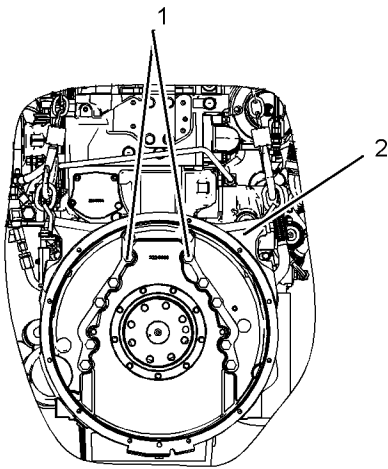


Illustration 76

g01011078

2. Remove bolts (1).
3. Remove flywheel housing (2). The weight of the flywheel housing is approximately 23 kg (50 lb).

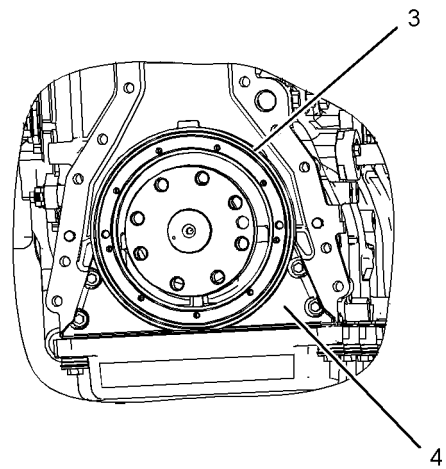


Illustration 78

g01011079

1. Apply Tooling (A) to O-ring seal (4). Install O-ring seal (3) onto rear seal carrier (4).
2. Apply Tooling (B) to the face of the cylinder block.

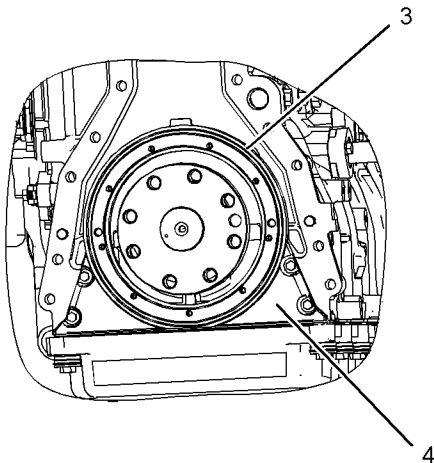


Illustration 77

g01011079

4. Remove O-ring seal (3) from rear seal carrier (4).

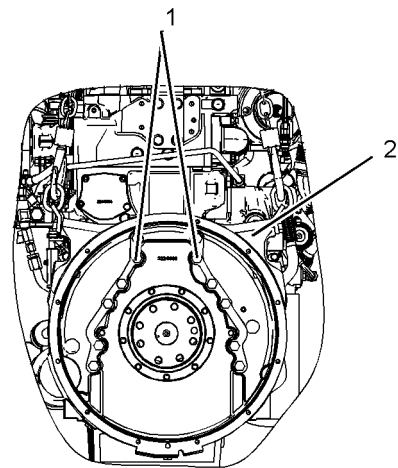


Illustration 79

g01011078

3. Position flywheel housing (2) on the rear of the cylinder block. The weight of flywheel housing (2) is approximately 23 kg (50 lb).
4. Install bolts (1).

**End By:**

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

i02249423

## Front Cover - Remove

**SMCS Code:** 1166-011

### Removal Procedure

**Start By:**

- a. Remove the fuel transfer pump. Refer to Disassembly and Assembly, "Fuel Transfer Pump - Remove".
- b. Remove the fan drive mounting group. Refer to Disassembly and Assembly, "Fan Drive Mounting Group - Remove and Install".
- c. Remove the crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

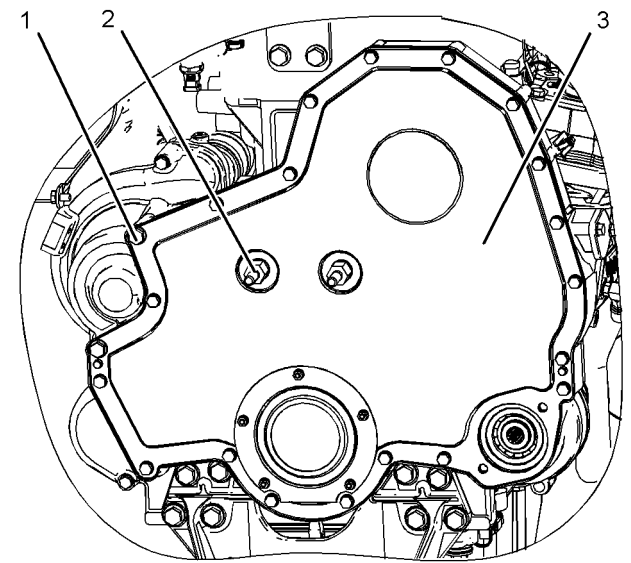


Illustration 80

g01015022

1. Remove bolts (1).
2. Remove studs (2).
3. Remove cover (3) and the gasket.

i02249943

## Front Cover - Install

**SMCS Code:** 1166-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

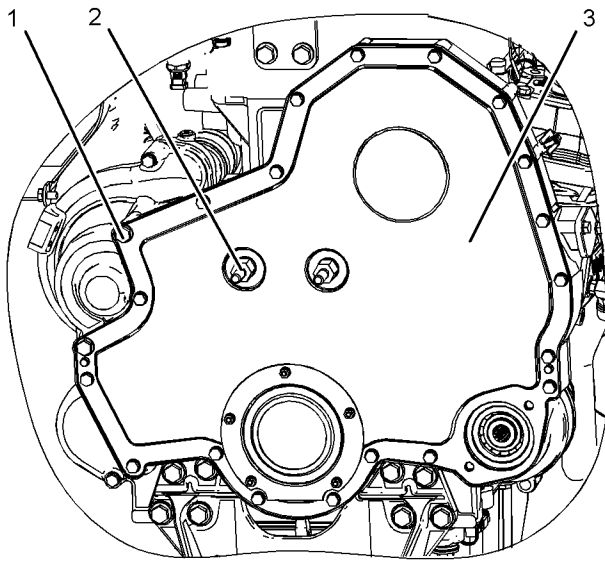


Illustration 81 g01015022

1. Position the gasket and cover (3) on the front housing.
2. Install studs (2).
3. Install bolts (1).

**End By:**

- a. Install the crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Install".
- b. Install the fan drive mounting group. Refer to Disassembly and Assembly, "Fan Drive Mounting Group - Remove and Install".
- c. Install the fuel transfer pump. Refer to Disassembly and Assembly, "Fuel Transfer Pump - Install".

i02250108

## Gear Group (Front) - Remove

**SMCS Code:** 1206-011

### Removal Procedure

**Start By:**

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

---

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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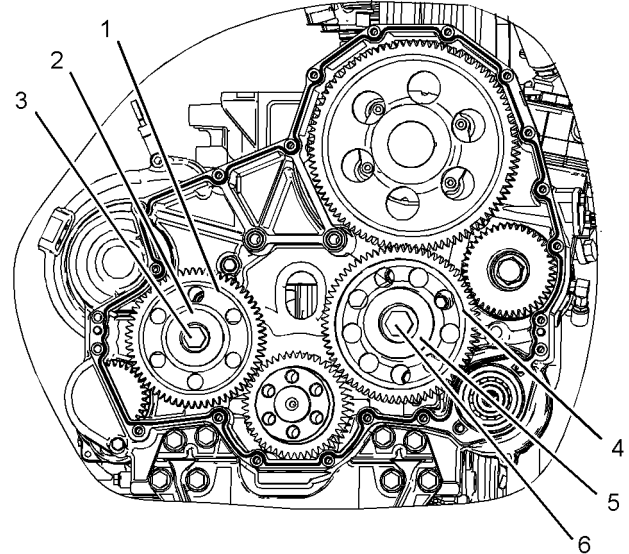


Illustration 82 g01014874

1. Remove the following items from the front housing: bolt (3), the bearing and shaft (2), and gear (1).
2. Remove the following items from the front housing: bolt (6), the bearing and shaft (5), and gear (4).

i01950583

## Gear Group (Front) - Install

**SMCS Code:** 1206-012

### Installation Procedure

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**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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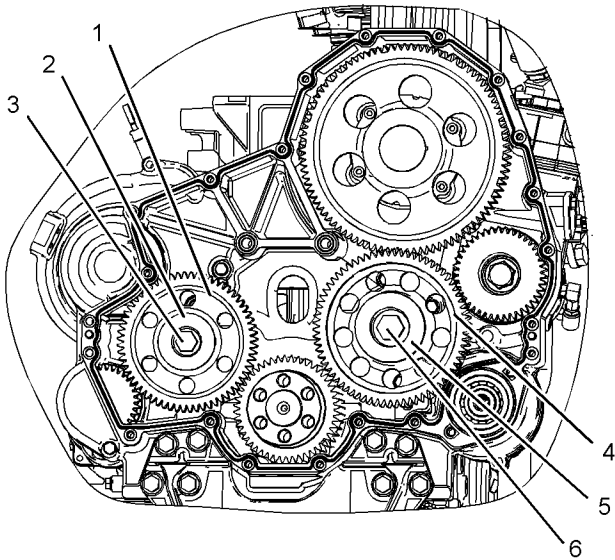


Illustration 83 g01014874

1. Install the following items in the front housing: gear (4), the bearing and shaft (5), and bolt (6).
2. Install the following items in the front housing: gear (1), the bearing and shaft (2), and bolt (3).

**Note:** Make sure that the timing marks on the gears are in alignment.

**End By:**

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

i01943208

## Housing (Front) - Remove

**SMCS Code:** 1151-011

### Removal Procedure

**Start By:**

- a. Remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- c. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove".
- d. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove".

- e. Remove the front gear group. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove".
- f. Remove the crankshaft sensor. Refer to Disassembly and Assembly, "Engine Sensors - Remove and Install".

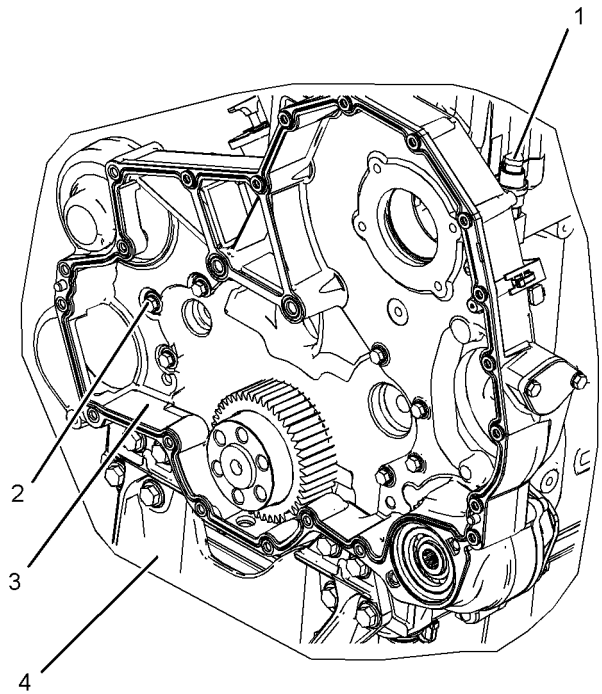


Illustration 84 g01011130

1. Disconnect sensor (1).
2. Attach a suitable lifting device to the lifting bracket on the front of the engine. The weight of the engine is approximately 680 kg (1500 lb).
3. Remove front engine mount (4).
4. Loosen the oil pan bolts in order to allow the front of the oil pan to drop.
5. Remove bolts (2).
6. Remove front housing (3).

i02220412

## Housing (Front) - Install

SMCS Code: 1151-012

### Installation Procedure

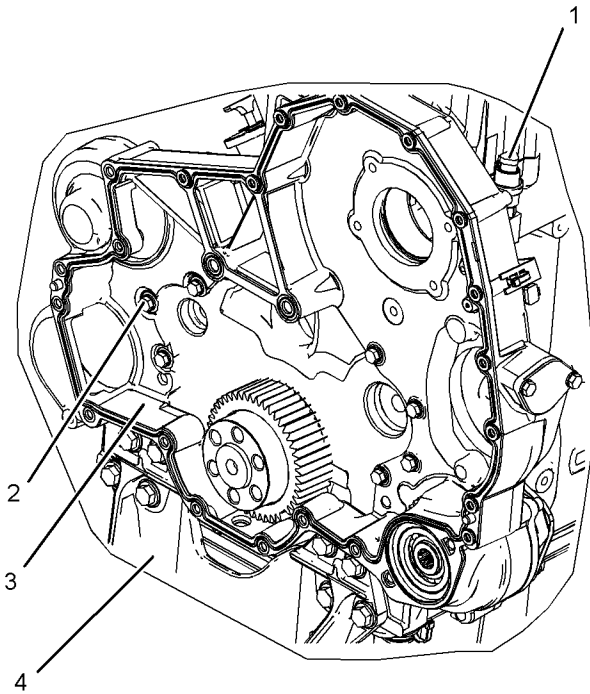


Illustration 85

g01011130

1. Position front housing (3).
2. Install bolts (2).
3. Tighten the oil pan bolts.
4. Install front engine mount (4).
5. Connect sensor (1).

#### End By:

- a. Install the engine crankshaft sensor. Refer to Disassembly and Assembly, "Engine Sensors - Remove and Install".
- b. Install the front gear group. Refer to Disassembly and Assembly, "Gear Group (Front) - Install".
- c. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Install".
- d. Install the water pump. Refer to Disassembly and Assembly, "Water Pump - Install".

- e. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- f. Install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".

i02250527

## Accessory Drive - Remove

SMCS Code: 1207-011

### Removal Procedure

Table 24

| Required Tools |             |                   |     |
|----------------|-------------|-------------------|-----|
| Tool           | Part Number | Part Description  | Qty |
| A              | 8H-0663     | Bearing Puller Gp | 1   |
|                | 8B-7551     | Bearing Puller Gp | 1   |

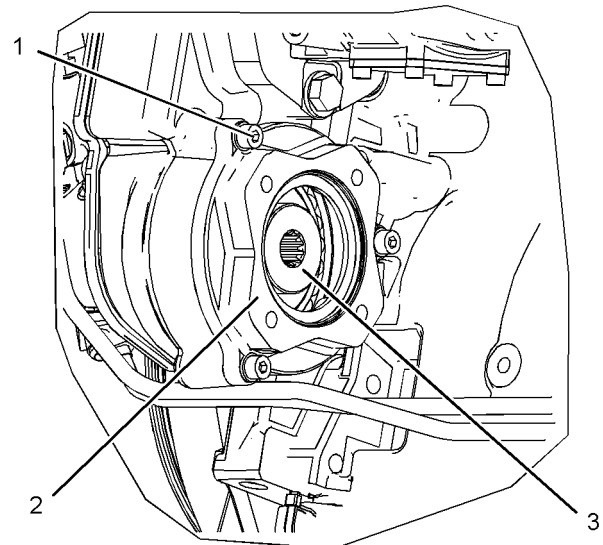


Illustration 86

g01011209

1. Remove bolts (1), cover (2), and gear (3).
2. Use Tooling (A) and a suitable press in order to remove the bearings from gear (3).

i01943324

## Accessory Drive - Install

SMCS Code: 1207-012

### Installation Procedure

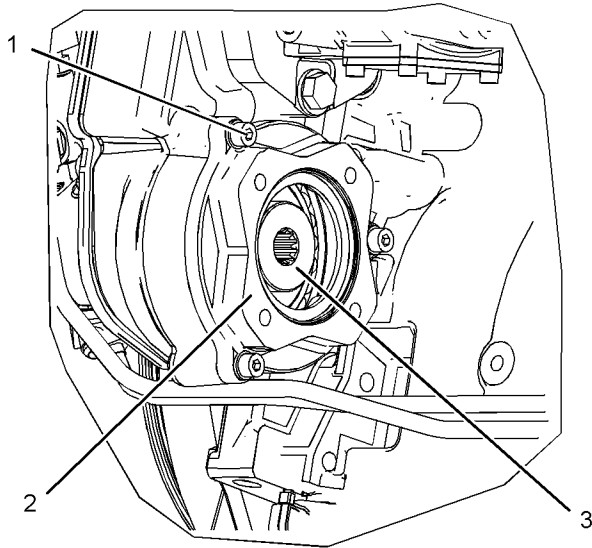


Illustration 87

g01011209

1. Raise the temperature of the bearing.
2. Lower the temperature of gear (3).
3. Install the bearing into gear (3).
4. Install gear (3), cover (2), and bolts (1).

i01941837

## Valve Mechanism Cover Base - Remove and Install

SMCS Code: 1120-010

### Removal Procedure

#### Start By:

- a. Remove the valve actuator. Refer to Disassembly and Assembly, "Valve Actuator (Variable) - Remove".

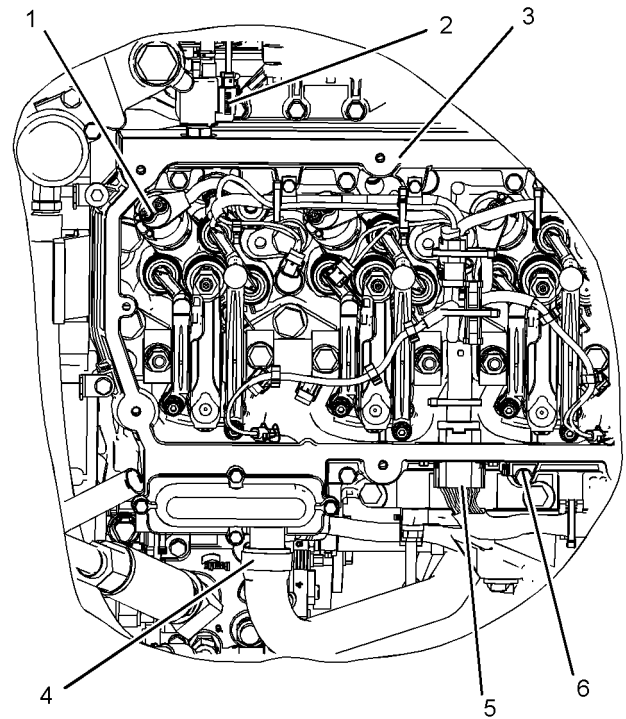


Illustration 88

g01010524

1. Disconnect harness assembly (1), harness assembly (2), and harness assembly (5).
2. Disconnect hose assembly (4).
3. Remove bolts (6).
4. Remove valve cover base (3).

## Installation Procedure

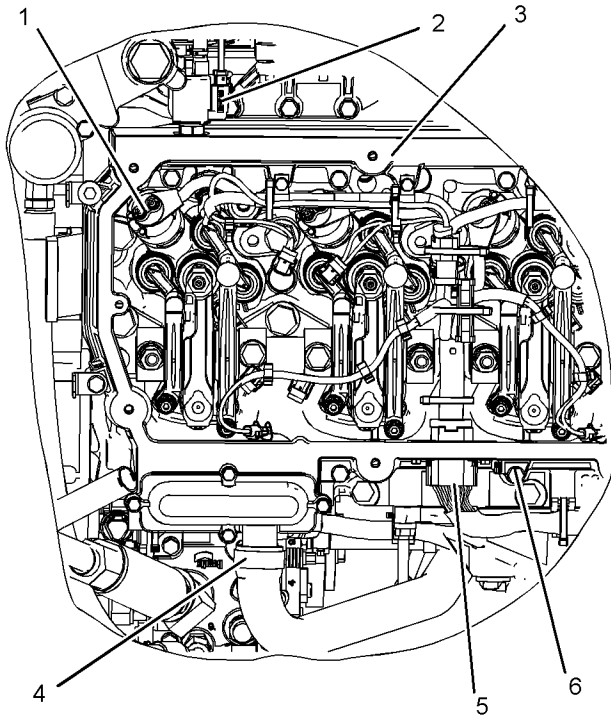


Illustration 89

g01010524

1. Position valve cover base (3).
2. Install bolts (6).
3. Connect hose assembly (4).
4. Connect harness assembly (1), harness assembly (2), and harness assembly (5).

### End By:

- a. Install the valve actuator. Refer to Disassembly and Assembly, "Valve Actuator (Variable) - Install".

i01949945

## Valve Actuator (Variable) - Remove

SMCS Code: 1105-011

### Removal Procedure

1. Remove the valve cover.

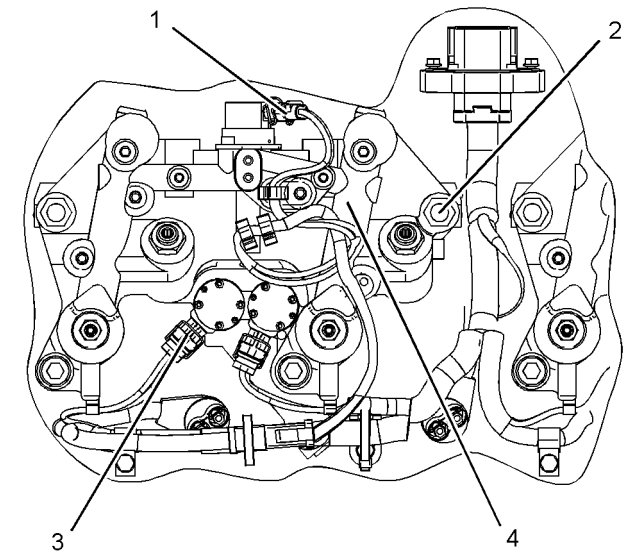


Illustration 90

g01014810

2. Disconnect harness assembly (1) and harness assemblies (3).
3. Remove nuts (2).
4. Remove valve actuator (variable) (4).

i01949953

## Valve Actuator (Variable) - Install

SMCS Code: 1105-012

### Installation Procedure

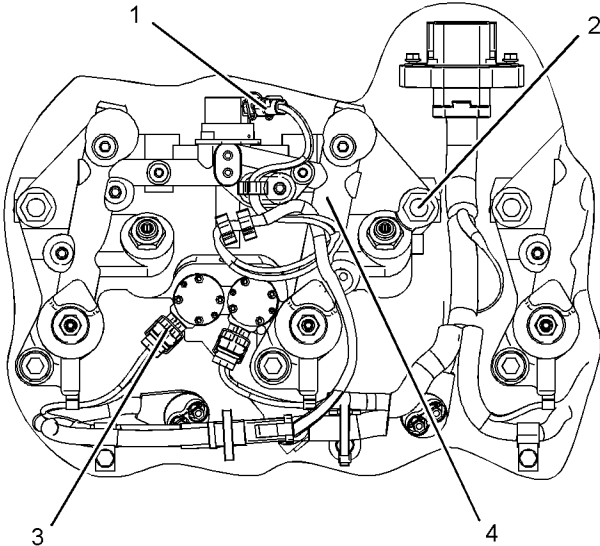


Illustration 91

g01014810

1. Position valve actuator (variable) (4) on the engine.
2. Install nuts (2).
3. Connect harness assembly (1) and harness assemblies (3).
4. Adjust the variable valve actuators. Refer to Testing and Adjusting, "Variable Valve Actuators - Inspect/Adjust".
5. Install the valve cover.

i02270635

## Rocker Shaft and Pushrod - Remove

SMCS Code: 1102-011; 1208-011

### Removal Procedure

#### Start By:

- a. Remove the valve actuator. Refer to Disassembly and Assembly, "Valve Actuator (Variable) - Remove".

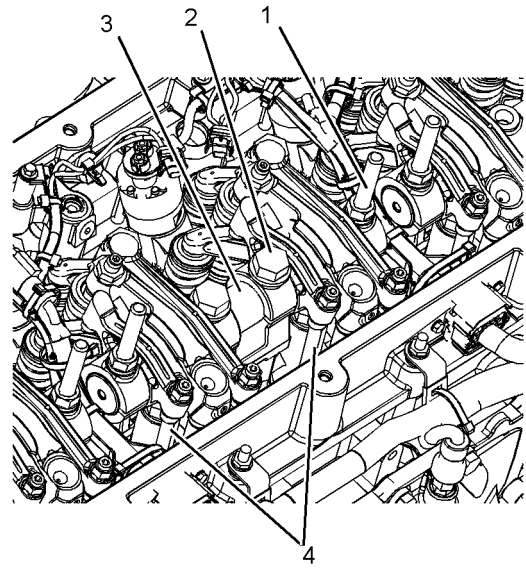


Illustration 92

g01137519

1. Remove the studs and nuts (1).
2. Remove bolts (2).
3. Remove rocker arm shaft (3) and pushrods (4).

i02251334

## Rocker Shaft - Disassemble

SMCS Code: 1102-015

### Disassembly Procedure

Table 25

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 1P-0510     | Driver Gp        | 1   |

#### Start By:

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

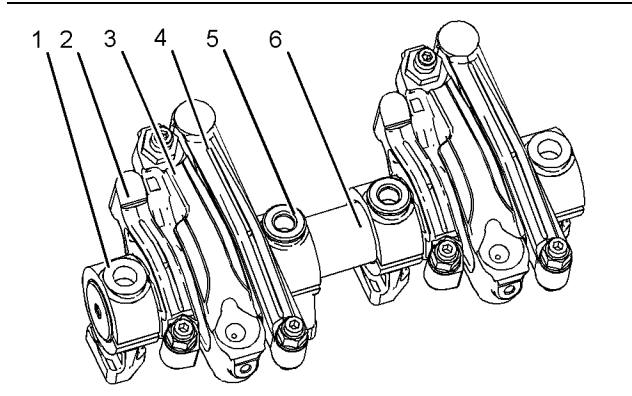


Illustration 93 g01015498

**Note:** Place an identification mark on all components for assembly purposes.

**Note:** Stand (5) has an offset hole.

1. Remove stands (1).
2. Remove rocker arms (2), rocker arms (3), rocker arms (4), and stand (5) from shaft (6).
3. Use Tooling (A) to remove the bushings from the rocker arms.

i02251352

## Rocker Shaft - Assemble

SMCS Code: 1102-016

### Assembly Procedure

Table 26

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 1P-0510     | Driver Gp        | 1   |

1. Use Tooling (A) to install the bushings for the rocker arms. For correct bearing dimensions, refer to Specifications, "Electronic Unit Injector Rocker Arm" and Specifications, "Valve Mechanism".

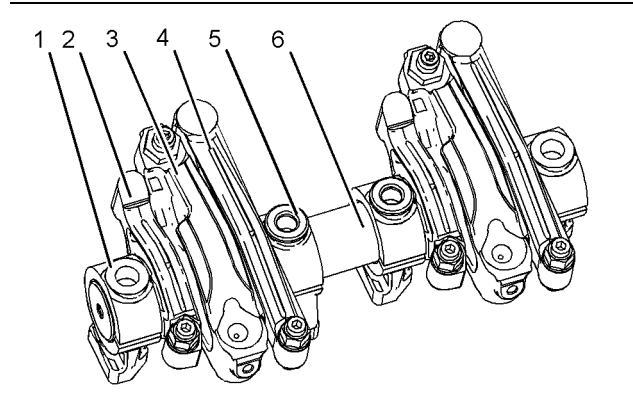


Illustration 94 g01015498

2. Install stand (5), rocker arms (4), rocker arms (3), and rocker arms (2) onto shaft (6).

**Note:** Stand (5) has an offset hole.

3. Install stands (1).

**End By:**

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

i02270626

## Rocker Shaft and Pushrod - Install

SMCS Code: 1102-012; 1208-012

### Installation Procedure

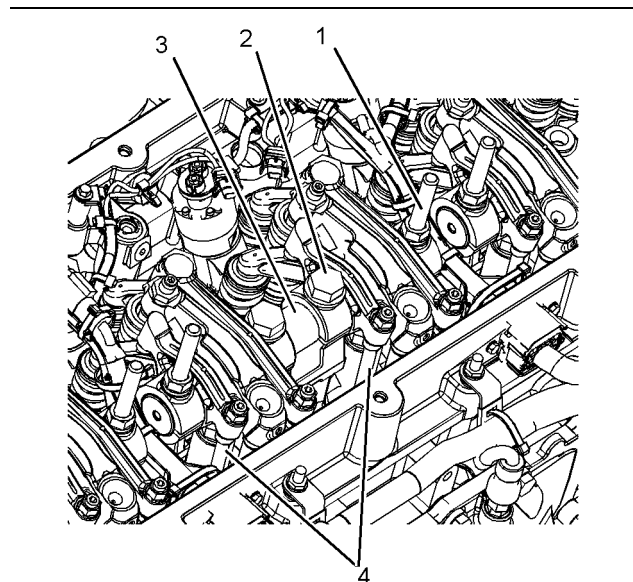


Illustration 95

g01137519

1. Position pushrods (4) and rocker shaft assembly (3).
2. Install bolts (2), the studs and nuts (1).

**End By:**

- a. Install the valve actuator. Refer to Disassembly and Assembly, "Valve Actuator (Variable) - Install".
- b. Adjust the engine valve lash. Refer to Testing and Adjusting, "Valve lash Adjustment".

i01955122

## Cylinder Head - Remove

**SMCS Code:** 1100-011

### Removal Procedure

Table 27

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 138-7575    | Link Bracket     | 2   |

**Start By:**

- a. Remove the fan drive mounting group. Refer to Disassembly and Assembly, "Fan Drive Mounting Group - Remove and Install".
- b. Remove the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Remove and Install".
- c. Remove the turbochargers. Refer to Disassembly and Assembly, "Turbocharger - Remove".
- d. Remove the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Remove".
- e. Remove the precoolers. Refer to Disassembly and Assembly, "Precooler - 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

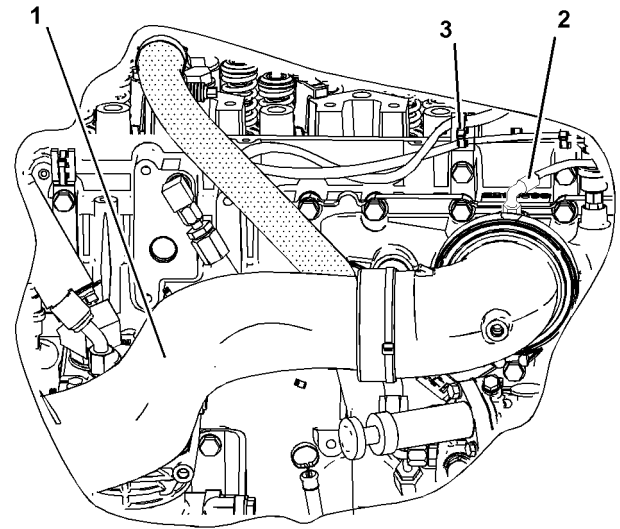


Illustration 96

g01018266

1. Remove air tube assembly (1). Disconnect hose assembly (2). Cut all cable straps that connect harness assembly (3) to the cylinder head. Move harness assembly aside.

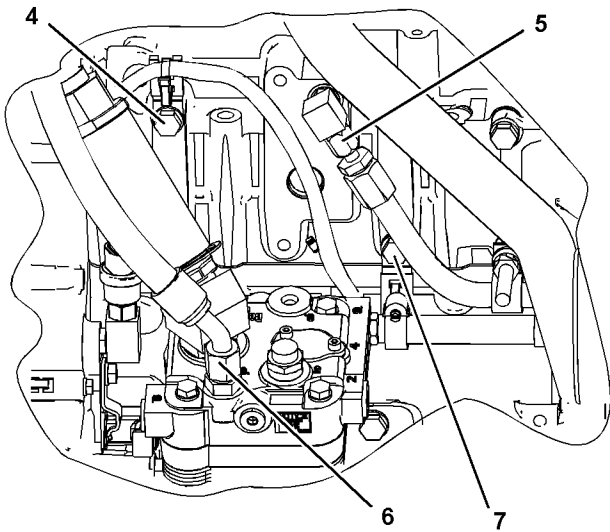


Illustration 97

g01018267

2. Disconnect hose assemblies (5) and (6). Disconnect clamp (4) from the cylinder head. Remove bolts (7).

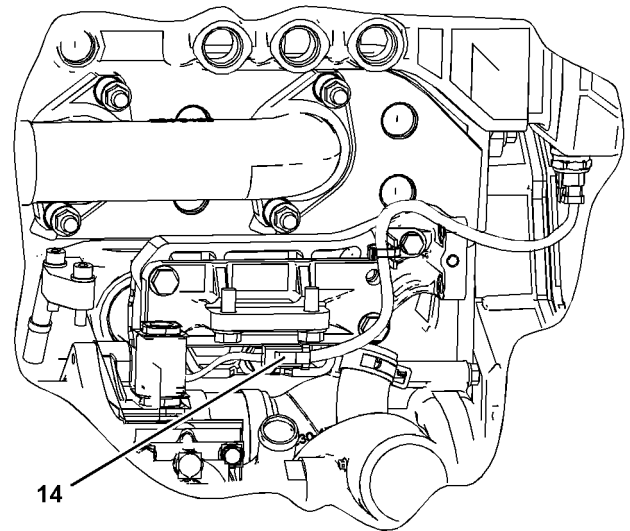


Illustration 99

g01018271

4. Disconnect harness assembly (14).

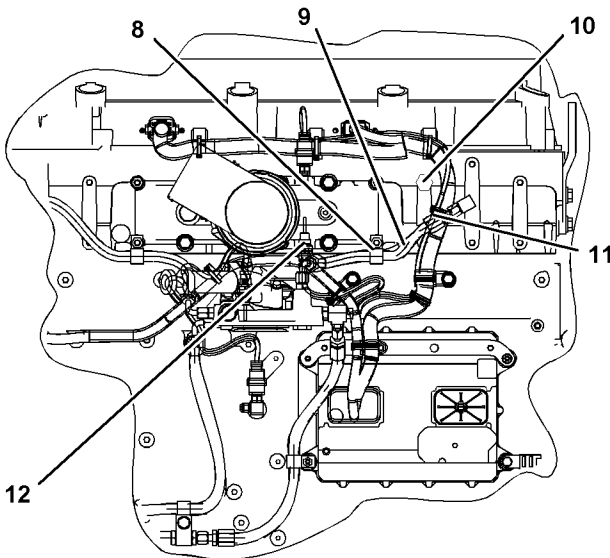


Illustration 98

g01018269

3. Disconnect the following items: clip (8), wire assembly (10), and harness assembly from sensor (12). Disconnect hose assembly (9) from the cylinder head. Remove bolt (11).

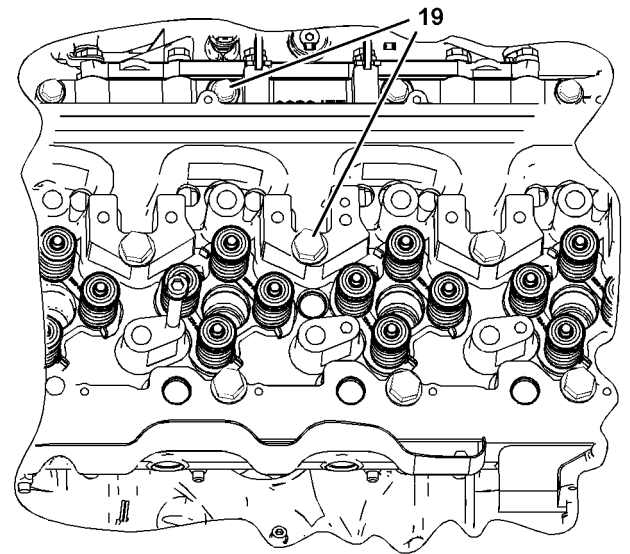


Illustration 100

g01018505

5. Remove cylinder head bolts (19).
6. Attach Tooling (A) and a suitable lifting device to the cylinder head. Carefully remove the cylinder head from the cylinder block. The weight of the cylinder head is approximately 184 kg (405 lb).



i02337430

# Cylinder Head - Install

SMCS Code: 1100-012

## Installation Procedure

Table 28

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 138-7575    | Link Bracket     | 2   |
| B              | 6V-4876     | Lubricant        | -   |
| C              | 8T-3096     | Hand Tap         | 1   |
| D              | 6V-6640     | Sealant          | -   |

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean the mating surfaces of the cylinder head and the cylinder block.
2. Clean all 26 head bolt holes on the cylinder block with Tooling (C).
3. After cleaning the threads, remove any debris from the head bolt holes on the cylinder block with a vacuum hose.
4. Visually inspect the head bolt holes on the cylinder block for thread damage.
5. If a damaged head bolt thread is observed, repair the damaged head bolt thread with a Heli-Coil thread repair kit.
6. Inspect the cylinder head and the cylinder block for flatness. Refer to Guideline for Reusable Parts and Salvage Operations, SEBF8162, "Procedure to Measure and Salvage Cylinder Head Assemblies and Related Components".
7. Install the correct cylinder head gasket and new O-ring seals on the cylinder block.

**Note:** To avoid damage to the cylinder head gasket, use guide bolts of an appropriate size to install the cylinder head.

8. Use Tooling (A) and a suitable lifting device to install the cylinder head on the cylinder block. The weight of the cylinder head is approximately 184 kg (405 lb).

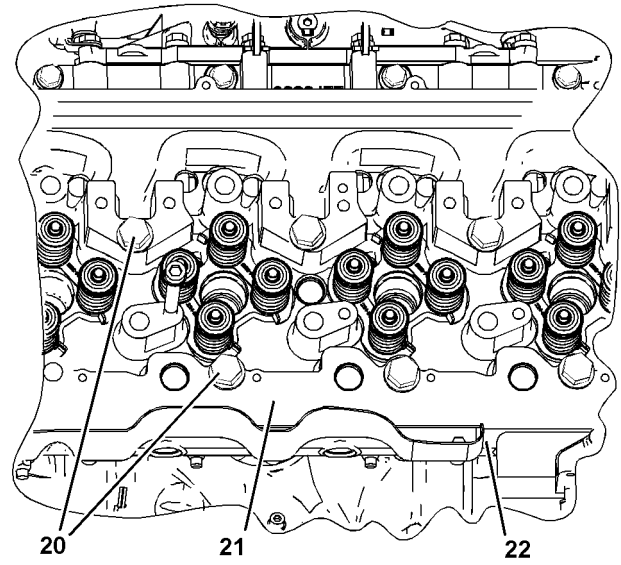


Illustration 101

g01018700

9. Install gasket (21) on cylinder head (22).
10. Install new cylinder head bolts (20). If the engine is equipped with a compression brake, then also install new head bolt studs.
11. Lubricate the bolt threads, the underside of the bolt heads, and the washers with Tooling (B) prior to assembly. Follow Step 12 for the correct tightening procedure.

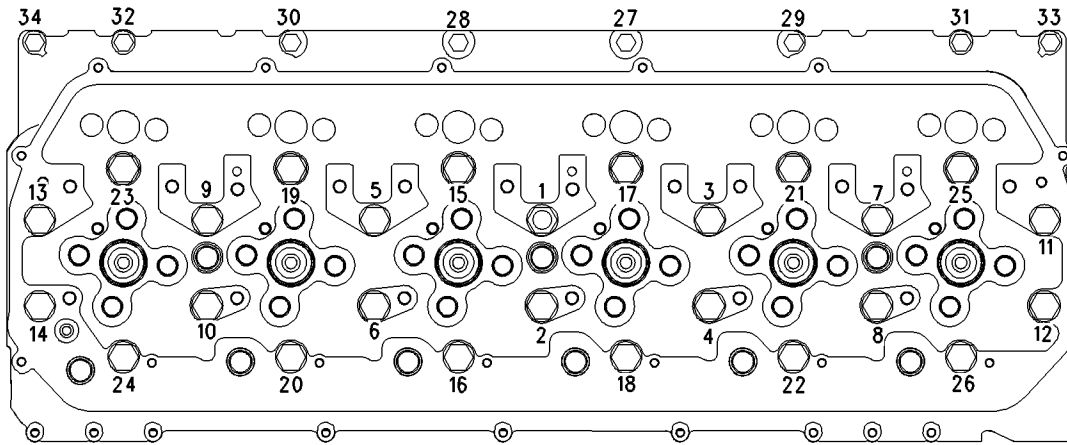


Illustration 102

g00950659

**12.** Tighten the cylinder head bolts according to the following procedure:

- a. Tighten bolt (1) through bolt (26) in a numerical sequence to a torque of  $170 \pm 10$  N·m ( $125 \pm 7$  lb ft).
- b. Tighten bolt (1) through bolt (26) again in a numerical sequence to a torque of  $170 \pm 10$  N·m ( $125 \pm 7$  lb ft).
- c. Place a mark on bolt (1) through bolt (26). Rotate bolt (1) through bolt (26) in a numerical sequence for an additional  $120 \pm 5$  degrees ( $1/3$  turn).
- d. Loosen bolt (1) through bolt (26) until the washers are loose under the bolt heads.
- e. Tighten bolt (1) through bolt (26) in a numerical sequence to a torque of  $170 \pm 10$  N·m ( $125 \pm 7$  lb ft).
- f. Tighten bolt (1) through bolt (26) again in a numerical sequence to a torque of  $170 \pm 10$  N·m ( $125 \pm 7$  lb ft).
- g. Place a mark on bolt (1) through bolt (26). Rotate bolt (1) through bolt (26) in a numerical sequence for an additional  $120 \pm 5$  degrees ( $1/3$  turn).
- h. Tighten bolt (27) through bolt (34) in a numerical sequence to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft).

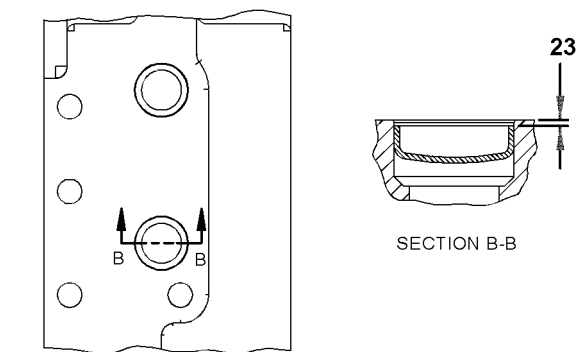


Illustration 103

g01018718

View A-A

**Note:** Lubricate the bores for the cup plugs with Tooling (D) prior to installing the cup plugs. The cup plugs are measured from the head face to the top edge of the plug.

- i. Install the cup plugs to a depth (23) of  $1.25 \pm 0.25$  mm ( $0.049 \pm 0.010$  inch).

**Note:** The minimum permissible thickness of cylinder head should be the following value 104.35 mm (4.108 inch). The flatness of the cylinder head should be within 0.15 mm (0.006 inch). The flatness should also be a maximum of 0.05 mm (0.002 inch) for any 150.00 mm (5.906 inch) span.

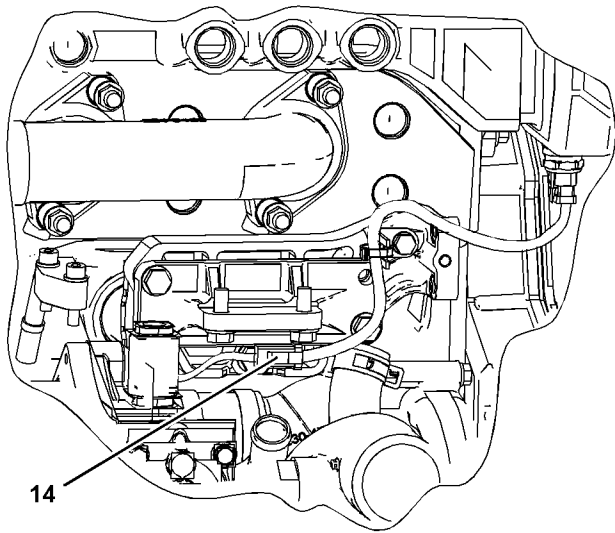


Illustration 104

g01018271

**13.** Connect harness assembly (14).

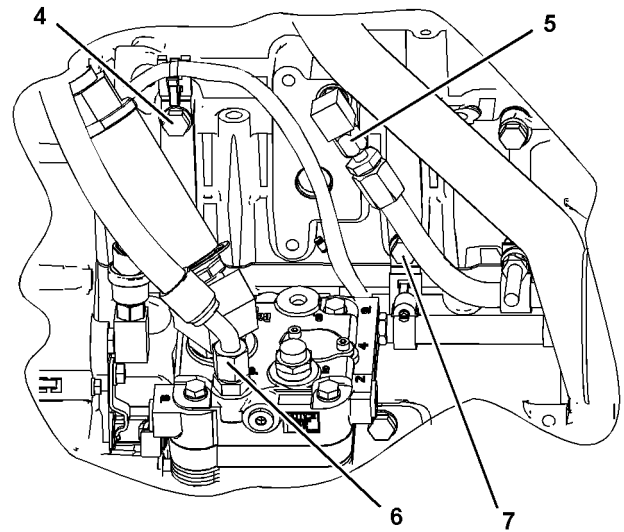


Illustration 106

g01018267

**15.** Connect hose assemblies (5) and (6). Connect clamp (4) to the cylinder head. Install bolts (7).

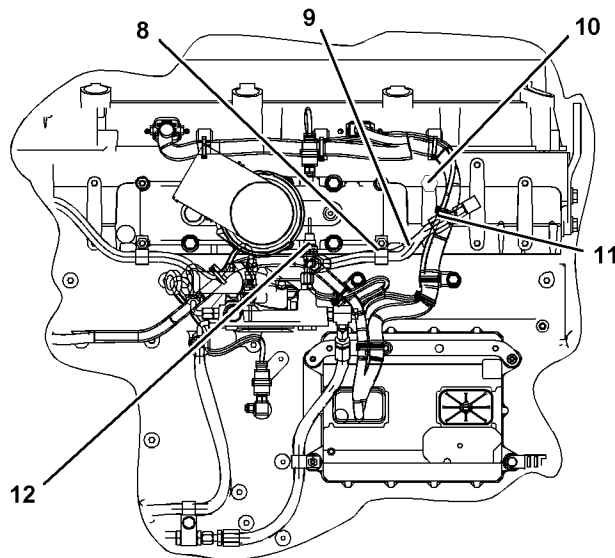


Illustration 105

g01018269

**14.** Connect the following items: clip (8), wire assembly (10), and harness assembly to sensor (12). Connect hose assembly (9) to the cylinder head. Install bolt (11).

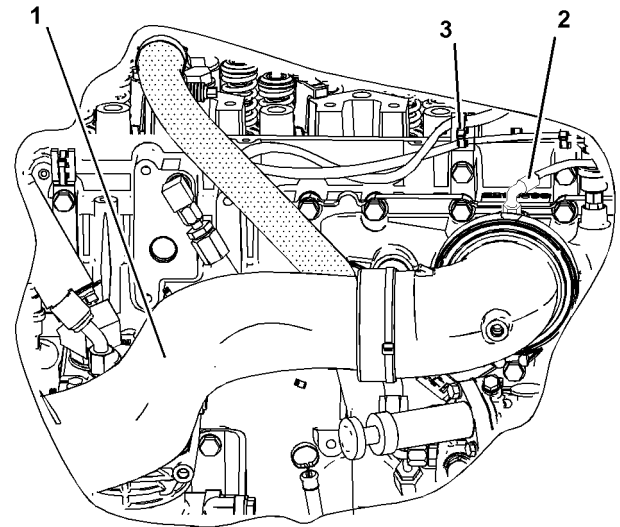


Illustration 107

g01018266

**16.** Install air tube assembly (1). Connect hose assembly (2). Move harness assembly (3) in place. Install all cable straps that connect harness assembly (3) to the cylinder head.

**End By:**

- a. Install the precooler. Refer to Disassembly and Assembly, "Precooler - Install".
- b. Install the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Install".

- c. Install the turbochargers. Refer to Disassembly and Assembly, "Turbocharger - Install".
- d. Install the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Remove and Install".
- e. Install the fan drive mounting group. Refer to Disassembly and Assembly, "Fan Drive Mounting Group - Remove and Install".

i01943702

## Lifter Group - Remove and Install

SMCS Code: 1209-010

### Removal Procedure

**Start By:**

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

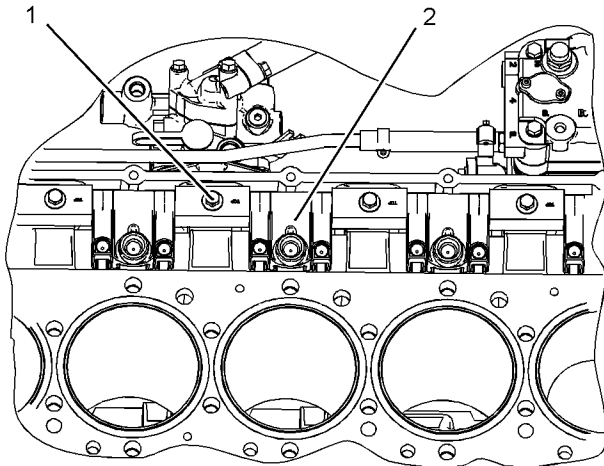


Illustration 108

g01011606

- 1. Remove bolts (1).
- 2. Remove lifter group (2).

## Installation Procedure

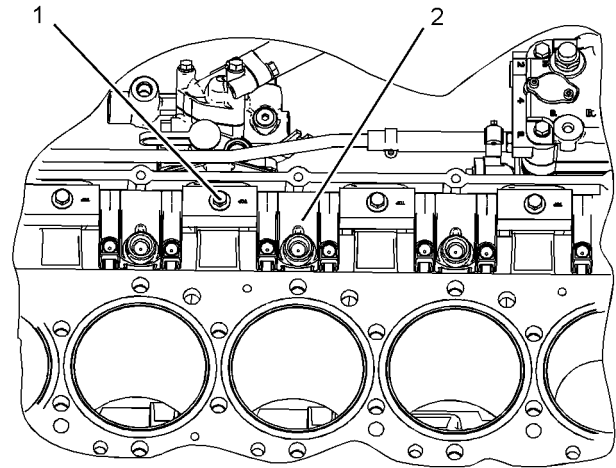


Illustration 109

g01011606

- 1. Position lifter group (2) on the engine.
- 2. Tighten bolts (1) to a torque of  $60 \pm 12$  N·m ( $45 \pm 9$  lb ft).

**End By:**

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

i01942720

## Camshaft - Remove

SMCS Code: 1210-011

### Removal Procedure

Table 29

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 201-4211    | Camshaft Pilot   | 1   |
|                | 201-4212    | Camshaft Pilot   | 1   |

**Start By:**

- a. Remove the rocker shaft and the pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".
- b. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove".

- c. Remove the camshaft position sensor. Refer to Disassembly and Assembly, "Engine Sensors - 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Turn the crankshaft to top center compression stroke for the No. 1 piston. Install the timing bolt in the flywheel. This is for timing during installation.
2. Ensure that the timing marks on the following gears are aligned: the camshaft drive gear, the idler gear, and the crankshaft gear.

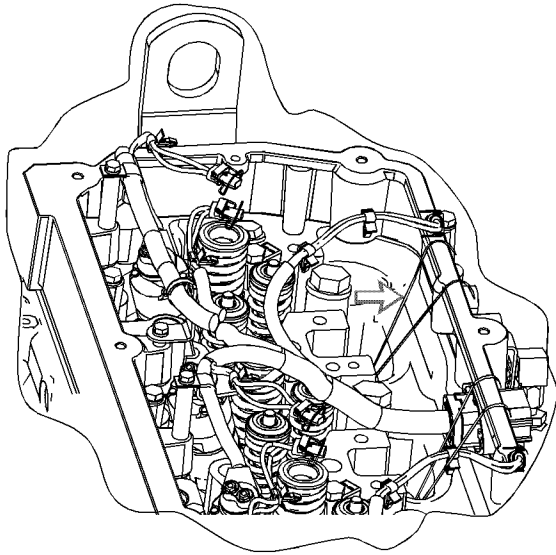


Illustration 110

g01011038

**Note:** It is not necessary to remove the cylinder head for removal of the camshaft.

3. Wire the valve lifters away from the camshaft. See Illustration 110.

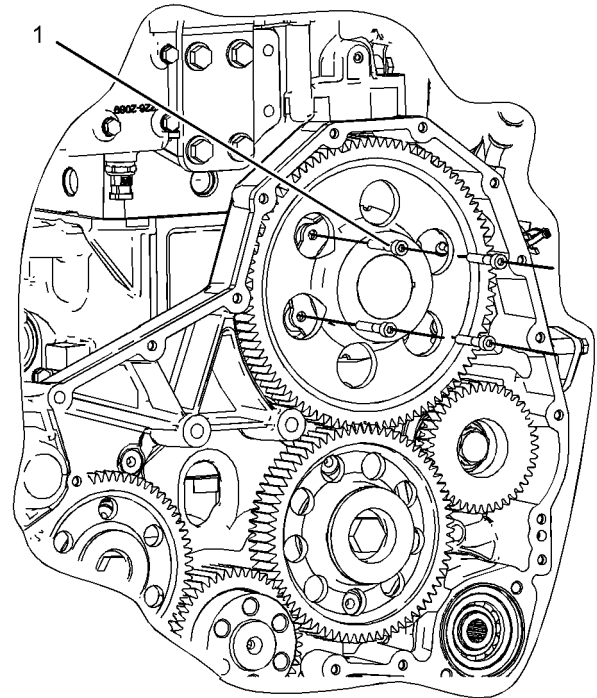


Illustration 111

g01011039

4. Remove bolts (1).

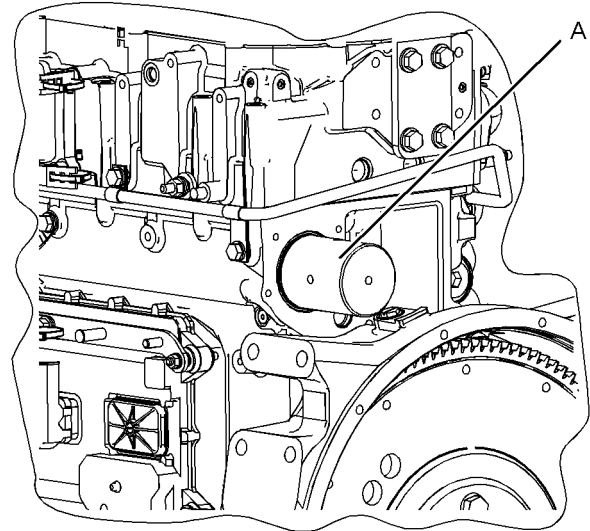


Illustration 112

g01011040

5. Install Tooling (A) into the camshaft.

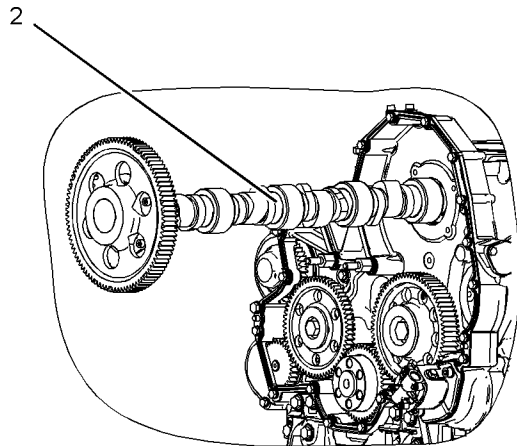


Illustration 113

g01011042

**Note:** Lubricate Tooling (A) for easier removal of the camshaft. Lubrication also prevents damaging the camshaft lobes and the camshaft bearings.

6. Carefully remove camshaft (2) from the engine.

i01943503

## Camshaft - Install

**SMCS Code:** 1210-012

### Installation Procedure

Table 30

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 201 - 4211  | Camshaft Pilot   | 1   |
|                | 201 - 4212  | Camshaft Pilot   | 1   |

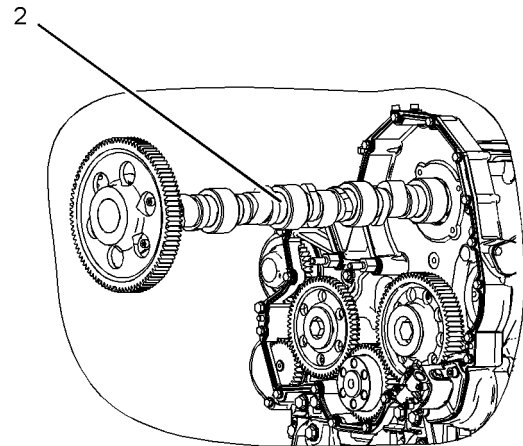


Illustration 114

g01011042

1. Install Tooling (A).

**Note:** Ensure that camshaft (2) and Tooling (A) are clean. Apply clean engine oil to the lobes and journals of camshaft (2) and Tooling (A).

**Note:** During installation of camshaft (2), rotate the camshaft in both directions in order to prevent binding in the camshaft bearing bores.

2. Carefully install camshaft (2) in the engine.

#### NOTICE

When installing the camshaft, make sure the number one cylinder is at top center of the compression stroke with the timing bolt installed in the flywheel. The camshaft timing is very important. The timing mark on the camshaft drive gear must line up with the timing mark on the idler gear. Refer to the Specifications Manual for more information.

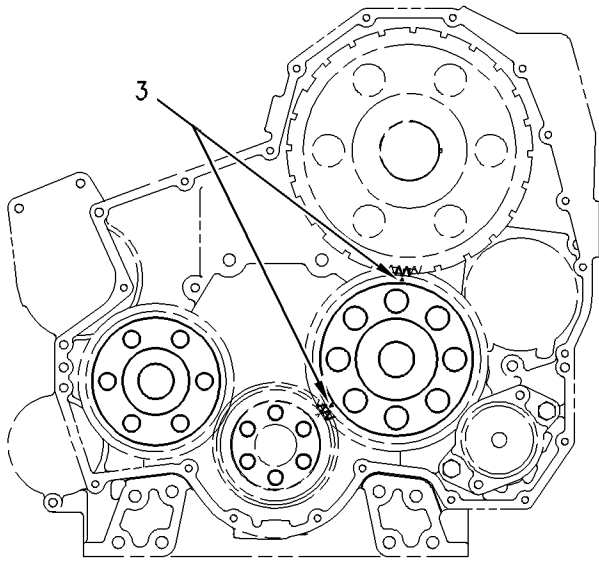


Illustration 115

g00813917

3. Ensure that the timing marks (3) on the idler gear are aligned with the timing marks on the crankshaft gear and the camshaft drive gear.

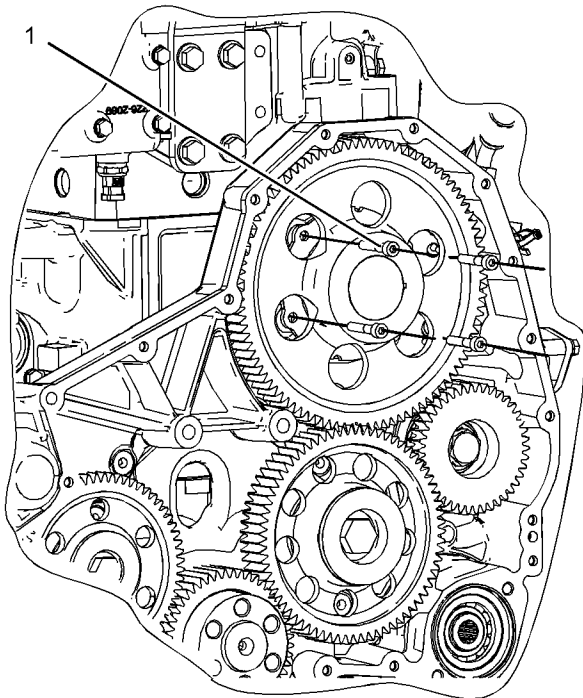


Illustration 116

g01011039

4. Install bolts (1). Remove the wires that were used to hold the valve lifters.

**End By:**

- a. Install the camshaft position sensor. Refer to Disassembly and Assembly, "Camshaft Position Sensor - Remove and Install".
- b. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Install".
- c. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Install".

i02259928

**Camshaft Gear - Remove and Install**

**SMCS Code:** 1210-010-GE

**Removal Procedure**

**Start By:**

- a. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove".
1. Wrap the camshaft with a protective covering in order to prevent damage to the camshaft.

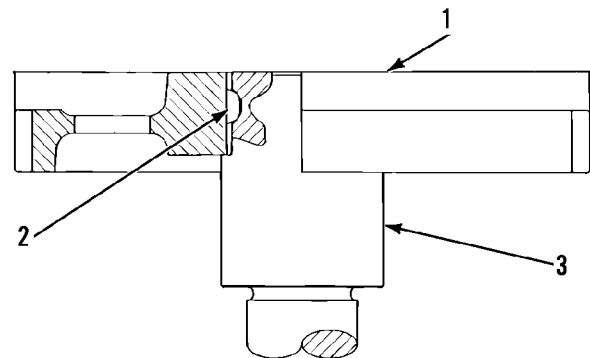


Illustration 117

g00522082

**NOTICE**

Do not allow the camshaft to fall to the floor when pressing it from the drive gear. Also make sure that the camshaft lobes do not catch on the press plates.

2. Use a suitable press to remove drive gear (1) from camshaft (3).
3. Remove woodruff key (2).

## Installation Procedure

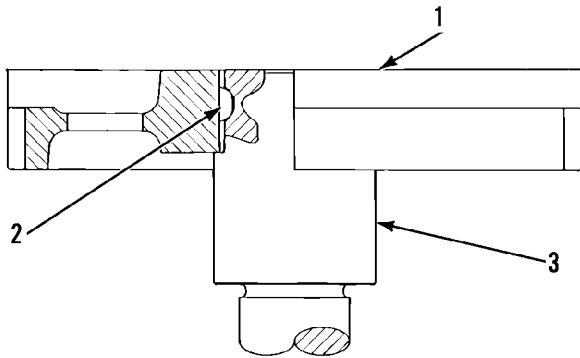


Illustration 118

g00522082

1. Install woodruff key (2) in camshaft (3).
2. Raise the temperature of drive gear (1).
3. Install drive gear (1) on the end of camshaft (3).

### End By:

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

i02251414

## Camshaft Bearings - Remove

SMCS Code: 1211-011

### Removal Procedure

Table 31

| Required Tools |             |                   |     |
|----------------|-------------|-------------------|-----|
| Tool           | Part Number | Part Description  | Qty |
| A              | 201 - 4214  | Receiving Sleeve  | 1   |
|                | 201 - 4213  | Puller Plate      | 1   |
|                | 201 - 4209  | Bearing Pilot     | 1   |
|                | 201 - 4208  | Backup Plate      | 1   |
|                | 6F - 7032   | Bolt              | 1   |
|                | 1P - 5542   | Taperlock Stud    | 1   |
|                | 8S - 8292   | Extension (Short) | 2   |
|                | 8S - 8293   | Extension (Long)  | 1   |
| B              | 185 - 3989  | Thread Lubricant  | 1   |

### Start By:

- a. Remove the lifter group. Refer to Disassembly and Assembly, "Lifter Group - Remove and Install".

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

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

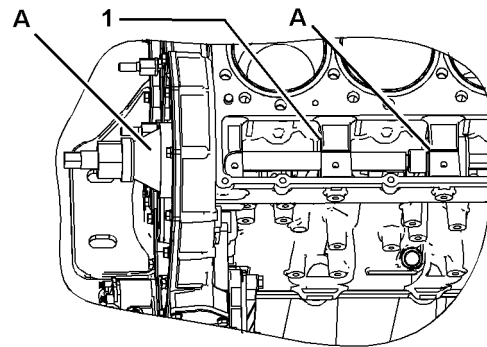


Illustration 119

g01016694

1. Install Tooling (A). Apply Tooling (B) on the threads.
2. Remove camshaft bearings (1).

i02251423

## Camshaft Bearings - Install

SMCS Code: 1211-012

### Installation Procedure

Table 32

| Required Tools |             |                   |     |
|----------------|-------------|-------------------|-----|
| Tool           | Part Number | Part Description  | Qty |
| A              | 201 - 4214  | Receiving Sleeve  | 1   |
|                | 201 - 4213  | Puller Plate      | 1   |
|                | 201 - 4209  | Bearing Pilot     | 1   |
|                | 201 - 4208  | Backup Plate      | 1   |
|                | 6F - 7032   | Bolt              | 1   |
|                | 1P - 5542   | Taperlock Stud    | 1   |
|                | 8S - 8292   | Extension (Short) | 2   |
|                | 8S - 8293   | Extension (Long)  | 1   |



**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

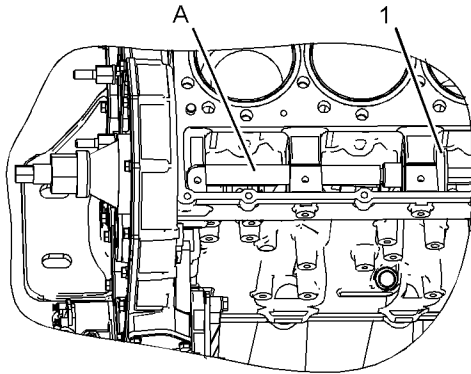


Illustration 120

g01133376

1. Position new camshaft bearing (1) in Tooling (A) and install the bearing from the rear to the front of the engine.

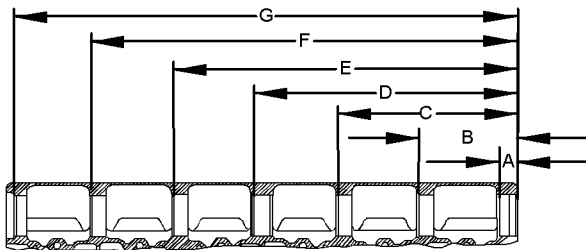


Illustration 121

g01133395

2. The camshaft bearings are installed with Tooling (A). Measure the depth of the camshaft bearings from the front face of the cylinder block to the following distances:
  - a. Dimension (A) is 36.50 mm (1.437 inch).
  - b. Dimension (B) is 192.50 mm (7.579 inch).
  - c. Dimension (C) is 348.50 mm (13.720 inch).
  - d. Dimension (D) is 504.50 mm (19.862 inch).
  - e. Dimension (E) is 660.50 mm (26.004 inch).
  - f. Dimension (F) is 816.50 mm (32.146 inch).
  - g. Dimension (G) is 972.50 mm (38.287 inch).

**NOTICE**

Camshaft bearings must be installed into their correct position. Failure to do so will result in engine damage.

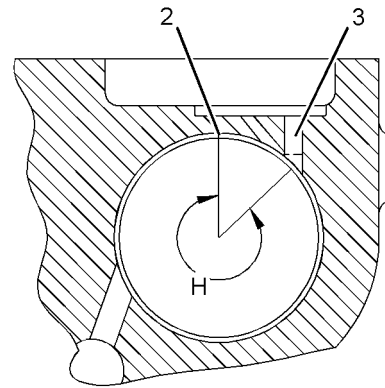


Illustration 122

g01133403

- (2) Bearing joint
- (3) Oil hole
- (H) Bearing oil hole is located at a 45 degree angle from vertical. All seven bearings have the same angle.

**End By:**

- a. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Install".
- b. Install the lifter group. Refer to Disassembly and Assembly, "Lifter Group - Remove and Install".

i02251652

## Engine Oil Pan - Remove and Install

**SMCS Code:** 1302-010

### Removal Procedure

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the oil into a suitable container. Refer to Operation and Maintenance Manual, "Refill Capacities and Recommendations".

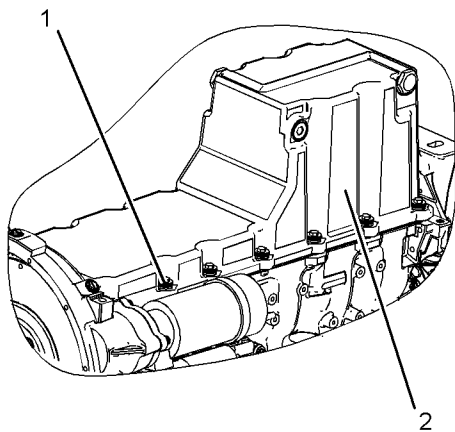


Illustration 123

g01011201

2. Remove bolts (1).
3. Remove engine oil pan (2) and the gasket.

## Installation Procedure

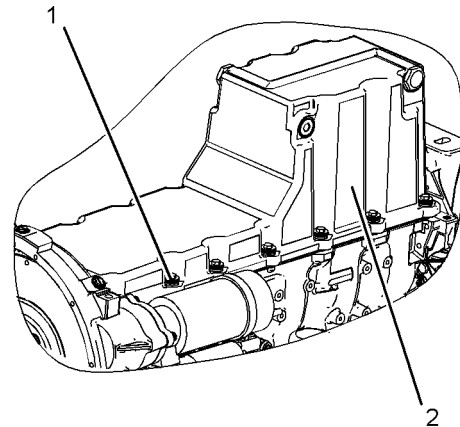


Illustration 124

g01011201

1. Position the gasket and engine oil pan (2) on the engine.
2. Install bolts (1).
3. Fill the engine with oil. Refer to Operation and Maintenance Manual, "Refill Capacities and Recommendations".

i02251662

## Cylinder Liner - Remove

**SMCS Code:** 1216-011

### Removal Procedure

Table 33

| Required Tools   |                         |                          |     |
|------------------|-------------------------|--------------------------|-----|
| Tool             | Part Number             | Description              | Qty |
| A                | 5P-8665                 | Cylinder Liner Puller Gp | 1   |
| B <sup>(1)</sup> | 1U-9593 <sup>(2)</sup>  | Cylinder Pack Puller     | 1   |
|                  | 129-6675 <sup>(3)</sup> | Cylinder Pack Puller     | 1   |
|                  | 1U-9897                 | Bridge                   | 1   |
|                  | 1U-6319                 | Socket                   | 1   |

<sup>(1)</sup> Tooling (B) is used to remove pistons and cylinder liners together.

<sup>(2)</sup> The 1U-9593 Cylinder Pack Puller is for use on C11 Engines.

<sup>(3)</sup> The 129-6675 Cylinder Pack Puller is for use on C13 Engines.

**Start By:**

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

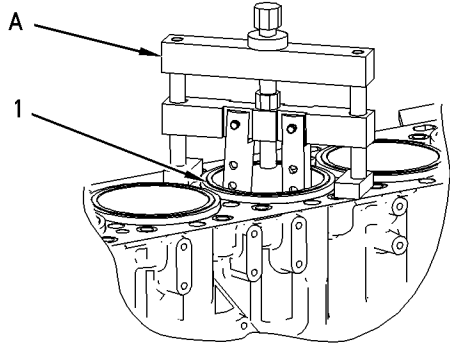


Illustration 125 g01005579

- 1. Use Tooling (A) to remove cylinder liner (1).
- 2. Remove the O-ring seals from cylinder liner (1).

i02251694

## Cylinder Liner - Install

**SMCS Code:** 1216-012

### Installation Procedure

Table 34

| Required Tools |             |                          |     |
|----------------|-------------|--------------------------|-----|
| Tool           | Part Number | Part Description         | Qty |
| C              | 2P-8260     | Cylinder Liner Installer | 1   |
| D              | 5P-3975     | Rubber Lubricant         | 1   |

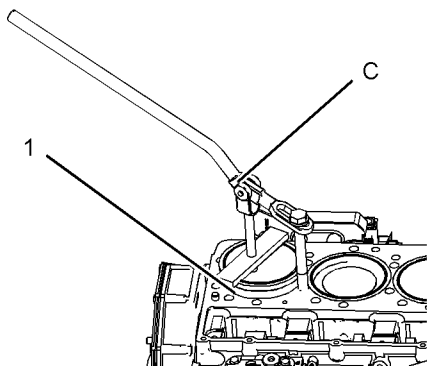


Illustration 126 g01133518

- 1. Install the O-ring seals on cylinder liner (1).
- 2. Apply Tooling (D) on the O-ring seals.

**Note:** Refer to Testing and Adjusting, "Cylinder Liner Projection" for more information.

**Note:** If you are installing a cylinder pack, ensure that the corresponding crankshaft throw is at bottom center.

- 3. Use Tooling (C) to install cylinder liner (1).

**End By:**

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

i02251702

## Piston Cooling Jets - Remove and Install

**SMCS Code:** 1331-010

### Removal Procedure

**Start By:**

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

**NOTICE**

Special care must be taken not to bend the piston cooling jets because the piston cooling jets are precision aligned with a coolant passage in the pistons.

There is only one position for each cooling jet. The notch in the bottom of the piston allows clearance for the piston cooling jet when the piston is at bottom dead center.

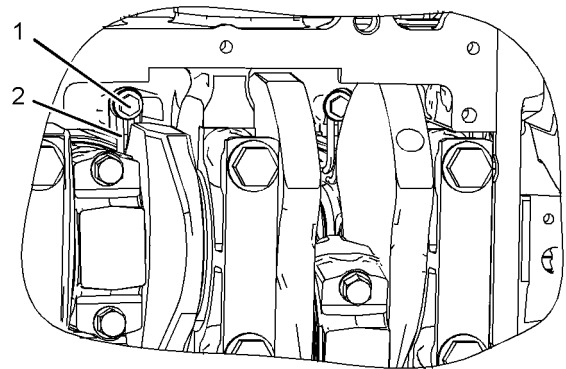


Illustration 127 g01133547

- 1. Remove bolt (1) and piston cooling jet (2).

## Installation Procedure

### NOTICE

Special care must be taken not to bend the piston cooling jets because the piston cooling jets are precision aligned with a coolant passage in the pistons.

There is only one position for each cooling jet. The notch in the bottom of the piston allows clearance for the piston cooling jet when the piston is at bottom dead center.

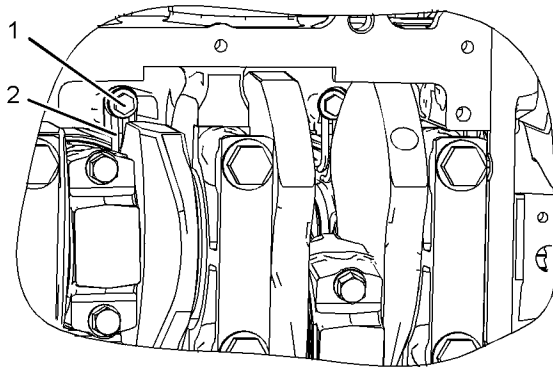


Illustration 128

g01133547

1. Position piston cooling jet (2) and install bolt (1). Tighten bolt (1) to a torque of  $35 \pm 3$  N·m ( $26 \pm 2$  lb ft).

### End By:

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

i02251722

## Pistons and Connecting Rods - Remove

SMCS Code: 1225-011

### Removal Procedure

#### Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".
- b. Remove the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

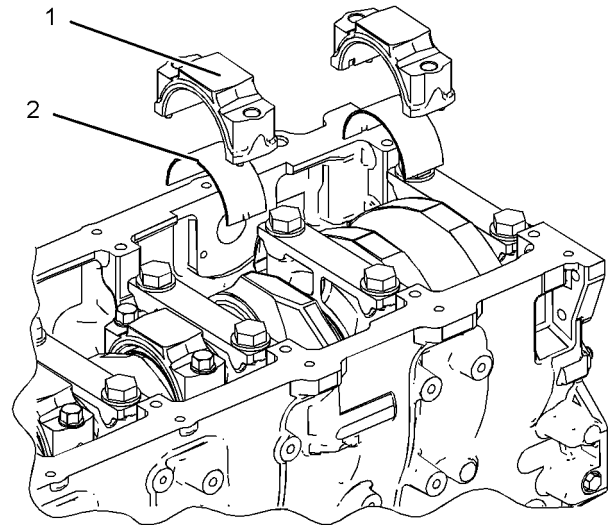


Illustration 129

g01011732

1. Place an identification mark on the connecting rod and connecting rod cap (1). The number should match the cylinder number. The bearing retainer notch should be on the right side.
2. Remove connecting rod cap (1). Remove the lower half of connecting rod bearing (2) from connecting rod cap (1).
3. Push the piston and connecting rod away from the crankshaft. Remove the upper half of the connecting rod bearing.
4. Remove the piston and connecting rod from the cylinder block.

i02251757

# Pistons and Connecting Rods - Disassemble

SMCS Code: 1225-015

## Disassembly Procedure

Table 35

| Required Tools |             |                      |     |
|----------------|-------------|----------------------|-----|
| Tool           | Part Number | Part Description     | Qty |
| A              | 4C-3601     | Piston Ring Expander | 1   |
| B              | 5P-8639     | Hydraulic Press      | 1   |
|                | 8F-0024     | Hose Assembly        | 1   |
|                | 1P-2375     | Connecting Coupler   | 1   |
|                | 1P-2376     | Connecting Coupler   | 1   |
|                | 5P-9725     | Hydraulic Cylinder   | 1   |
|                | 5P-8651     | Spacer               | 1   |
|                | 5P-8649     | Adapter              | 1   |
|                | 5P-8650     | Adapter              | 1   |

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

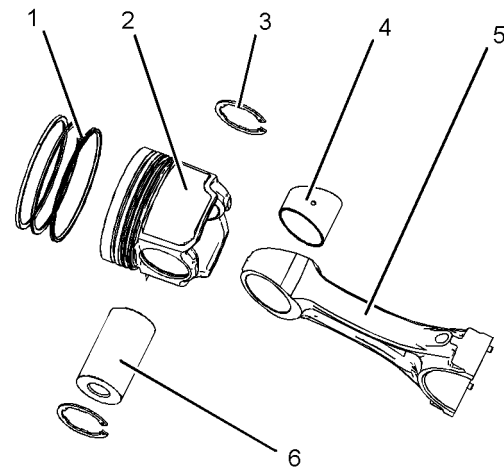


Illustration 130

g01011931

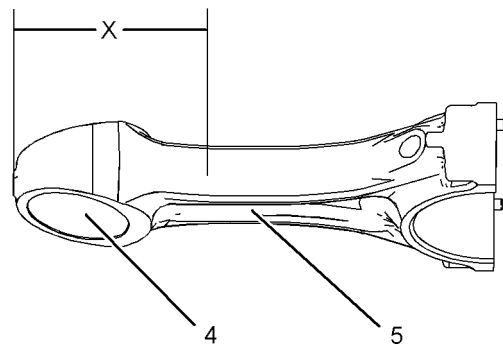


Illustration 131

g01142147

1. Use Tooling (A) in order to remove piston rings (1) from piston (2).
2. Remove retaining ring (3).
3. Remove piston pin (6) from connecting rod (5).

**NOTICE**

The connecting rod must be heated for the installation of the piston pin bearing. Do not use a torch.

4. Raise the temperature of connecting rod (5) in the indicated Area (X). The maximum distance of Area (X) is 85.0 mm (3.35 inch).
5. Use Tooling (B) in order to remove old bearing (4) and install new bearing (4) at the same time. Refer to Specifications, "Connecting Rod".

i02251783

## Pistons and Connecting Rods - Assemble

SMCS Code: 1225-016

### Assembly Procedure

Table 36

| Required Tools |                         |                          |     |
|----------------|-------------------------|--------------------------|-----|
| Tool           | Part Number             | Part Description         | Qty |
| A              | 4C-3601                 | Piston Ring Expander     | 1   |
| C              | 4C-8165 <sup>(1)</sup>  | Piston Ring Groove Gauge | 1   |
|                | 208-7630 <sup>(2)</sup> | Piston Ring Groove Gauge | 1   |

<sup>(1)</sup> Use with C11 Engines only

<sup>(2)</sup> Use with C13 Engines only

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

Verify correct assembly of the pistons and the connecting rods. Ensure that the etched numbers on the rod and the rod cap are in the correct positions. The etched number on the rod and the rod cap correspond to the cylinder in which it should be installed.

**Note:** The word "FRONT" may be stamped on the pistons in some engines. Ensure that the word "FRONT" is toward the front of the engine when the piston is installed. The etched number on the connecting rod must be on the right side of the engine in the corresponding cylinder. Ensure that the piston and the etched number are correctly positioned.

**Note:** Inspect condition of all piston ring grooves. Use Tooling (C) to verify diameter of top ring groove. Refer to Tool Operating Manual, NEHS0840 for additional information.

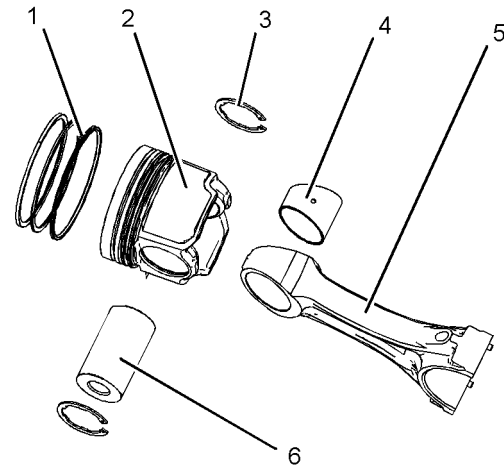


Illustration 132

g01011931

**Note:** Ensure that new bearing (4) is installed prior to assembly of the piston.

1. Place piston (2) on connecting rod (5). Apply clean engine oil to piston pin (6) and install the pin.
2. Install retaining rings (3).
3. Check the clearance between the ends of piston rings (1). Refer to Specifications, "Piston and Rings".

**Note:** The oil ring must be installed over the spring with the end gap 180 degrees from the oil ring spring joint.

4. Install the oil control piston ring. The ends of the spring should be rotated 180 degrees from the ring end gap. The white colored portion of the spring must be visible at the ring end gap.
5. Install the intermediate piston ring with the side marked "UP-2" toward the top of the piston. Use Tooling (A) in order to install the ring.
6. Install the top piston ring with the side marked "UP-1" toward the top of the piston. Use Tooling (A) in order to install the ring.
7. After installation, all three of the piston rings should be placed 120 degrees away from each other.

#### End By:

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

i02251940

# Pistons and Connecting Rods - Install

SMCS Code: 1225-012

## Installation Procedure

Table 37

| Required Tools |                                 |                           |     |
|----------------|---------------------------------|---------------------------|-----|
| Tool           | Part Number                     | Part Description          | Qty |
| A              | 161 - 4163 <sup>(1)</sup><br>or | Piston Ring Compressor Gp | 1   |
|                | 161 - 4164 <sup>(2)</sup>       | Piston Ring Compressor Gp | 1   |

<sup>(1)</sup> Use with C11 Engines

<sup>(2)</sup> Use with C13 Engines

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Apply clean engine oil on the following items: the piston, the piston rings, and the cylinder bore.

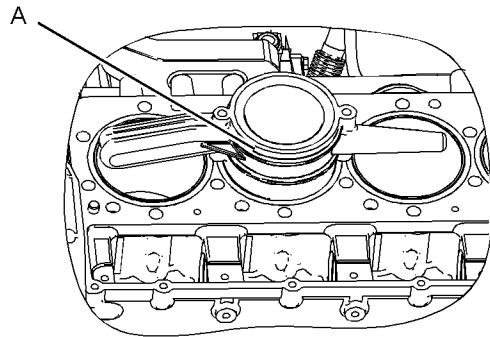


Illustration 133

g01011856

2. Use Tooling (A) in order to compress the piston rings.
3. With the number one crankshaft throw at the bottom center, install the piston and connecting rod in the engine. Ensure that the proper piston and connecting rod are in the corresponding cylinder with the bearing retainer notch toward the right side of the engine.

**Note:** The word “FRONT” may be stamped on the crown of the pistons in some engines. Ensure that the word “FRONT” is toward the front of the engine when the piston is installed. The etched number on the connecting rod must be on the right side of the engine in the corresponding cylinder.

4. Line up the piston and connecting rod with the crankshaft. Use a soft hammer and tap the piston into the cylinder bore until Tooling (A) comes off of the piston.
5. Before the connecting rod comes in contact with the crankshaft, install the upper half of the connecting rod bearing. Ensure that the bearing tab engages with the slot in the connecting rod.
6. Apply clean engine oil to the surface of the upper half of the connecting rod bearing. Use a soft hammer in order to tap the piston into the cylinder bore while you guide the connecting rod onto the crankshaft.

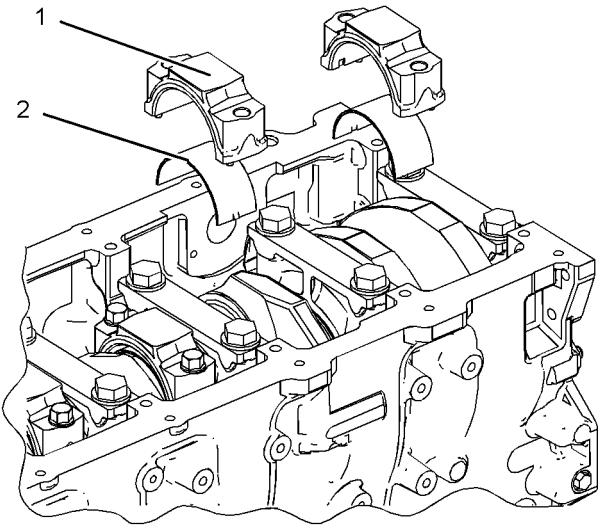


Illustration 134

g01011732

7. Place the lower half of connecting rod bearing (2) in corresponding connecting rod cap (1). Ensure that the bearing tab engages with the groove in connecting rod cap (1).
8. Apply clean engine oil to the surface of the lower half of connecting rod bearing (2). Install connecting rod cap (1) on the connecting rod. Ensure that the number on connecting rod cap (1) matches the number on the connecting rod. Ensure that the numbers are on the same side.
9. Install the connecting rod cap bolts. Tighten the bolts to a torque of  $130 \pm 7$  N·m ( $95 \pm 5$  lb ft).
10. Place an index mark on each bolt head. Tighten each bolt for an additional  $60 \pm 5$  degrees ( $1/6$  turn).

**End By:**

- a. Install the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".
- b. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i01957323

## Connecting Rod Bearings - Remove

**SMCS Code:** 1219-011

### Removal Procedure

**Start By:**

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

---

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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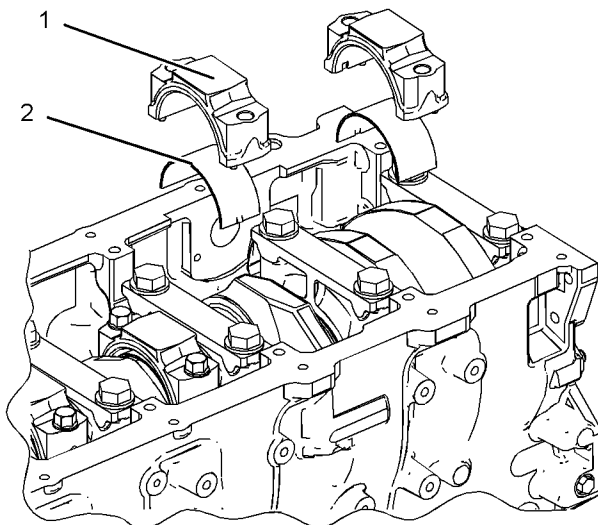


Illustration 135

g01011732

1. Remove the suction bell assembly.

2. Inspect the connecting rod and connecting rod cap (1) for the proper identification mark. The connecting rod and connecting rod cap (1) should have an etched number on the side that is toward the right side of the engine. The number should match the cylinder number. The bearing retainer notch should also be on the right side. Mark the connecting rod and connecting rod cap (1), if necessary.
3. Remove the connecting rod cap bolts and connecting rod cap (1).
4. Remove the lower half of the connecting rod bearing (2) from connecting rod cap (1).
5. Push the connecting rod away from the crankshaft. Remove the upper half of connecting rod bearing.
6. Repeat Steps 2 through 5 in order to remove the remaining connecting rod bearings.

i01957348

## Connecting Rod Bearings - Install

**SMCS Code:** 1219-012

### Installation Procedure

---

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

---

1. Install the upper half of connecting rod bearing into the connecting rod. Ensure that the bearing tab engages with the slot in the connecting rod.
2. Apply clean engine oil on the surface of the upper half of connecting rod bearing.
3. Position the connecting rod and the connecting rod bearing on the crankshaft.



i02251985

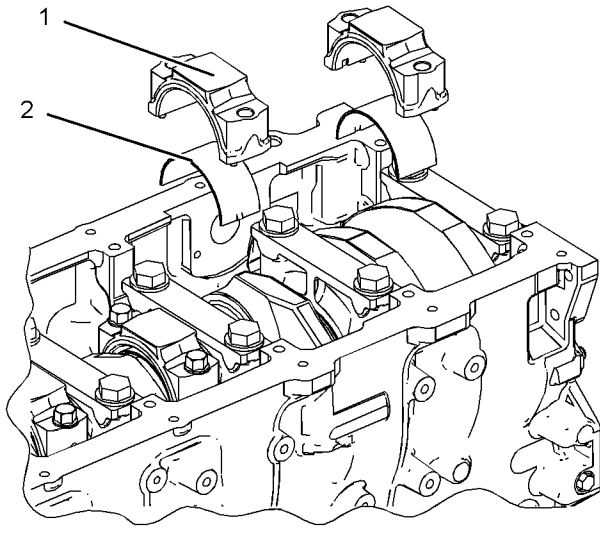


Illustration 136

g01011732

4. Install the lower half of the connecting rod bearing (2) in corresponding connecting rod cap (1). Ensure that the bearing tab engages with the groove in connecting rod cap (1).
5. Apply clean engine oil on the surface of the lower half of the connecting rod bearing (2).
6. Install connecting rod cap (1) on the corresponding connecting rod. Ensure that the numbers are on the same side.
7. Install the connecting rod cap bolts. Tighten the bolts to a torque of  $130 \pm 7$  N·m ( $95 \pm 5$  lb ft).
8. Place an index mark on each bolt head. Tighten each bolt for an additional  $60 \pm 5$  degrees ( $1/6$  turn).
9. Repeat Steps 1 through 8 in order to install the remaining connecting rod bearings.
10. Install the suction bell assembly.

**End By:**

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

## Crankshaft Main Bearings - Remove

SMCS Code: 1203-011

### Removal Procedure

Table 38

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 2P-5518     | Bearing Tool     | 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.

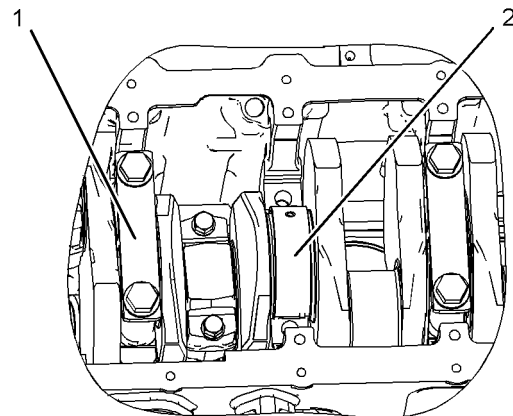


Illustration 137

g01011713

1. Remove crankshaft main bearing cap (1).

**Note:** Remove No. 1 and No. 7 crankshaft main bearing caps (1) after No. 2 through No. 6 crankshaft main bearing caps have been installed.

2. Remove the lower half of crankshaft main bearing (2) from crankshaft main bearing cap (1).

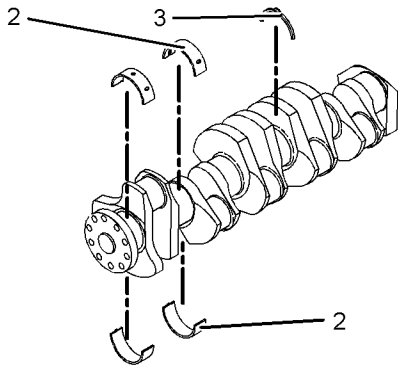


Illustration 138

g01147837

**NOTICE**

If the crankshaft is turned in the wrong direction, the tab of the crankshaft main bearing will be pushed between the crankshaft and the cylinder block. This can cause damage to either or both the crankshaft and the cylinder block.

3. Install Tooling (A) into the crankshaft journal.
4. Turn the crankshaft in order to remove the upper half of crankshaft main bearing (2). In order to get the tab out first, the crankshaft must be turned in the correct direction.
5. Check the condition of the crankshaft main bearings. Refer to the Guideline For Reusable Parts, SEBF8009, "Main and Connecting Rod Bearings" or refer to the Guideline For Reusable Parts, SEBV0544, "Engine Bearings and Crankshafts".
6. Remove thrust plate (3).

i02251977

## Crankshaft Main Bearings - Install

SMCS Code: 1203-012

### Installation Procedure

Table 39

| Required Tools |             |                      |     |
|----------------|-------------|----------------------|-----|
| Tool           | Part Number | Part Description     | Qty |
| A              | 2P-5518     | Bearing Tool         | 1   |
| B              | 8T-5096     | Dial Indicator Group | 1   |

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Apply clean engine oil to the crankshaft main bearings prior to assembly. Do not apply oil to the back of the crankshaft main bearing. Ensure that the tabs on the back side of the crankshaft main bearings fit in the grooves of the crankshaft main bearing caps and the cylinder block.

**NOTICE**

Ensure that the crankshaft main bearings are installed in the correct locations. Two different part numbers are used in quantities of three and four. The part number having the quantity of four is to be installed on crankshaft main bearings 2, 3, 5, and 6. The part number having the quantity of three is to be installed on crankshaft bearing 1, 4, and 7. The thrust plate is to be installed on the center crankshaft main bearing only.

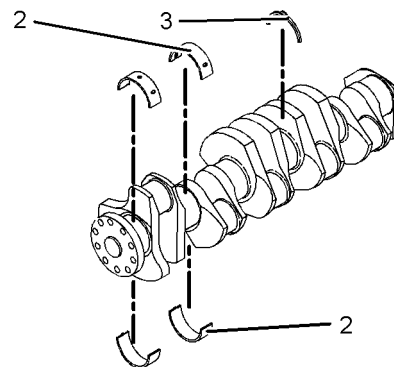


Illustration 139

g01147837

**Note:** The crankshaft end play is controlled by thrust plate (3). Thrust plate (3) is located at the center of the crankshaft.

1. Install thrust plate (3).
2. Use Tooling (A) to install the new upper halves of crankshaft main bearings (2) in the cylinder block. This half of the bearing has an oil hole.

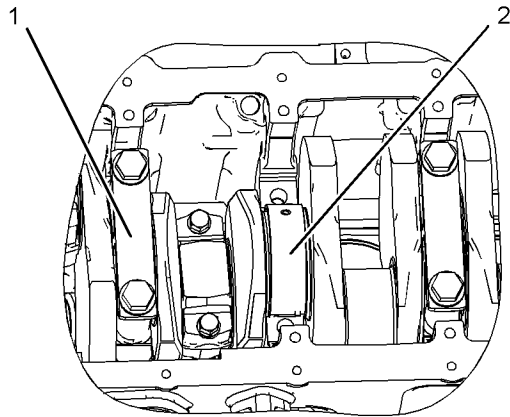


Illustration 140

g01011713

3. Install the new lower halves of crankshaft main bearings (2) in crankshaft main bearing caps (1). Do not apply oil to the back of the crankshaft main bearing.

**Note:** Crankshaft main bearing caps should be installed with the part number toward the right side of the engine. The crankshaft main bearing caps are identified by stamped numbers 1 through 7 that are located on the bottom surface. The thrust plate is used on the number 4 crankshaft main bearing only.

**NOTICE**

Crankshaft main bearing caps should be installed with the part number toward the right side of the engine. Crankshaft main bearing caps are to be identified by stamped numbers 1 through 7 located on the bottom surface. The thrust plate is used on the number 6 crankshaft main bearing only.

4. Position crankshaft main bearing caps (1) in the cylinder block. Apply clean engine oil or Molylube to the bolt threads and the washer face.
5. Use the following procedure in order to install the main bearing cap bolts:
6. Orient the main bearing cap correctly. The part number on the main bearing cap must face to the right and to the front face of the block. Also, the tab slots that are in the block and the main bearing caps must be adjacent.

**Note:** The main bearing caps are marked with identification numbers 1 through 7. Install the main bearing caps into the correct positions.

7. Lubricate the main bearing cap bolts. Use "SAE 30W" oil or molybdenum grease to lubricate the threads and the washer face.
8. Tighten the main bearing cap bolts.  
Tighten bolts to the following torque. ... 150 ± 5 N·m (111 ± 4 lb ft)
9. Put an alignment mark on each cap and bolt.  
Rotate the bolts in the clockwise direction. .... 60 degrees
10. Check the end play of the crankshaft with Tooling (B). The end play must be 0.10 to 0.50 mm (0.004 to 0.020 inch).

**End By:**

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

i02253121

**Crankshaft - Remove**

**SMCS Code:** 1202-011

**Removal Procedure**

Table 40

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 138-7574    | Link Bracket     | 2   |

**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.

i02253140

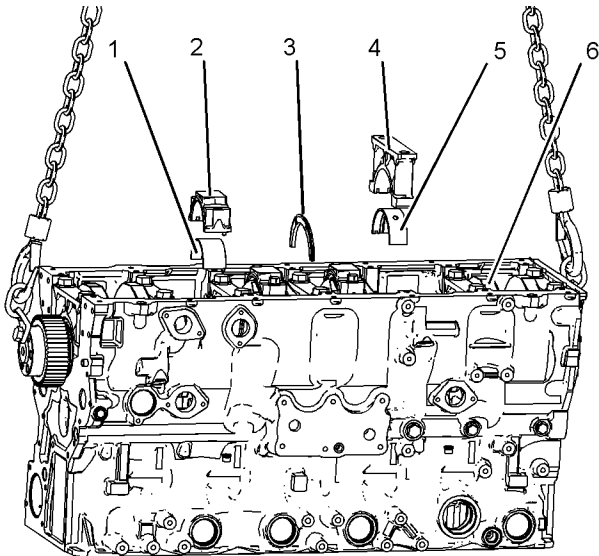


Illustration 141

g01013519

**Note:** Place an identification mark on all connecting rod caps (2). Connecting rod caps (2) should be marked with the corresponding cylinder number.

1. Remove connecting rod caps (2) and connecting rod bearings (1).

**Note:** Crankshaft main bearing caps (4) are marked with the numbers 1 through 7. Crankshaft main bearing caps (4) that are not marked should be marked with the corresponding cylinder number on the side that is toward the right side of the engine.

2. Remove crankshaft main bearing caps (4) and the lower half of crankshaft main bearings (5).
3. Remove crankshaft thrust bearings (3).
4. Attach Tooling (A) and a suitable lifting device to crankshaft (6). The weight of crankshaft (6) is approximately 129 kg (285 lb).
5. Remove crankshaft (6) and the upper half of the crankshaft main bearings.

## Crankshaft - Install

SMCS Code: 1202-012

### Installation Procedure

Table 41

| Required Tools |             |                      |     |
|----------------|-------------|----------------------|-----|
| Tool           | Part Number | Part Description     | Qty |
| A              | 138-7574    | Link Bracket         | 2   |
| B              | 8T-5096     | Dial Indicator Group | 1   |

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

Ensure that the crankshaft main bearing tabs engage with the grooves in the block and the crankshaft main bearing cap.

1. Place the upper halves of the crankshaft main bearings in the cylinder block. Place the lower halves of the crankshaft main bearings in crankshaft main bearing caps.

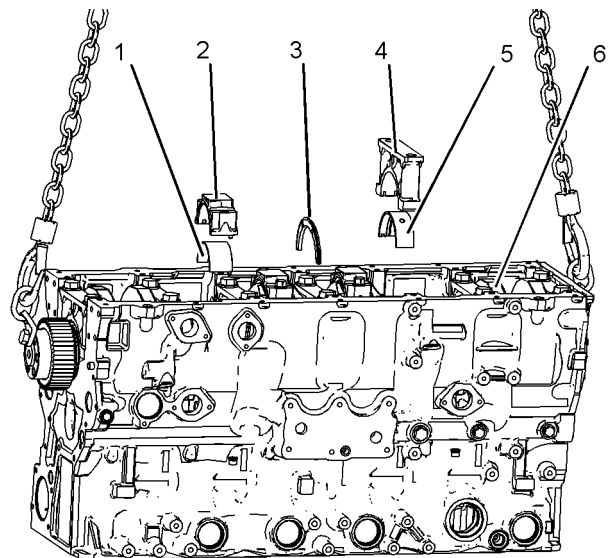


Illustration 142

g01013519

i02253161

2. Attach Tooling (A) and a suitable lifting device to crankshaft (6). The weight of crankshaft (6) is approximately 129 kg (285 lb). Position the upper half of the crankshaft main bearings and crankshaft (6) in the cylinder block.
3. Install crankshaft thrust bearings (3).
4. Install the lower half of crankshaft main bearings (5).
5. Install crankshaft main bearing caps (4) with the part numbers toward the right hand side of the cylinder block. Install crankshaft main bearing caps (4) in a numerical sequence. Apply clean engine oil or Molylube to the bolt threads and the washers. Install the bolts. Tighten the bolts to a torque of  $150 \pm 5$  N·m ( $110 \pm 4$  lb ft).
6. Place an index mark on each bolt head. Turn the bolts for an additional  $60 \pm 5$  degrees ( $1/6$  turn).
7. Check the end play of the crankshaft with Tooling (B). The end play must be 0.10 to 0.50 mm (0.004 to 0.020 inch).
8. Install connecting rod bearings (1) and connecting rod caps (2).
9. Install the connecting rod cap bolts. Tighten the bolts to a torque of  $130 \pm 7$  N·m ( $95 \pm 5$  lb ft).
10. Place an index mark on each bolt head. Tighten each bolt for an additional  $60 \pm 5$  degrees ( $1/6$  turn).

**End By:**

- a. Install the flywheel housing. Refer to Disassembly and Assembly, "Flywheel Housing - Remove and Install".
- b. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- c. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".

## Crankshaft Gear - Remove and Install

**SMCS Code:** 1204-010-GE

### Removal Procedure

Table 42

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 1P-2326     | Forcing Screw    | 1   |
|                | 1P-2325     | Head             | 1   |
|                | 3H-0462     | Bolt             | 6   |
|                | 8H-0709     | Strap            | 6   |
|                | 5F-7373     | Jaw              | 3   |

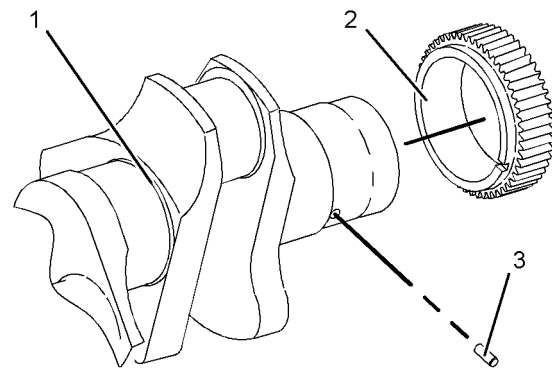


Illustration 143

g01134647

1. Use Tooling (A) to remove crankshaft gear (2) from crankshaft (1).
2. Remove drive pin (3).

### Installation Procedure

Table 43

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| B              | 6V-2098     | Press Sleeve     | 1   |
| C              | 8H-8581     | Gauge            | 1   |

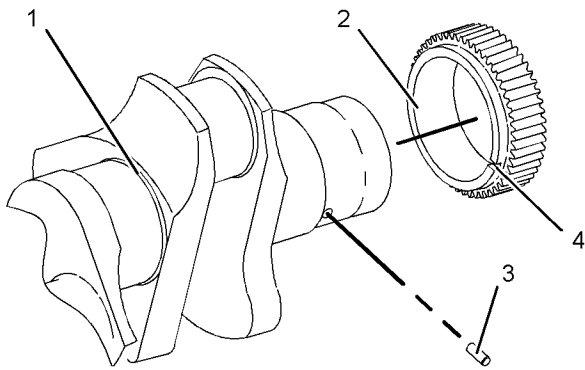


Illustration 144

g01134649

1. Install drive pin (3).

**⚠ WARNING**

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

2. Raise the temperature of crankshaft gear (2).
3. Install crankshaft gear (2) on the end of crankshaft (1). Ensure that slot (4) in crankshaft gear (2) is aligned with drive pin (3).

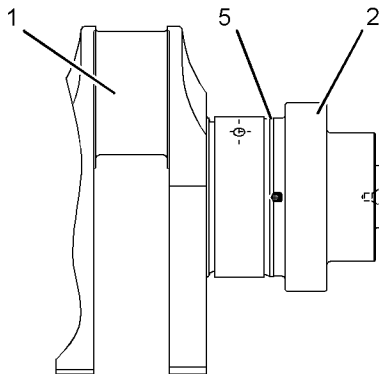


Illustration 145

g01134654

4. Use Tooling (B) to seat crankshaft gear (2) against shoulder (5) of crankshaft (1).
5. Use Tooling (C) to ensure that crankshaft gear (2) is seated against shoulder (5) on crankshaft (1).

**Note:** Check the crankshaft gear in three places with Tooling (C).

i02460266

# Engine Sensors - Remove and Install

**SMCS Code:** 1718-010; 1906-010; 1907-010;  
1912-010; 1917-010; 1921-010; 1922-010;  
1923-010; 1924-010; 1925-010; 1929-010

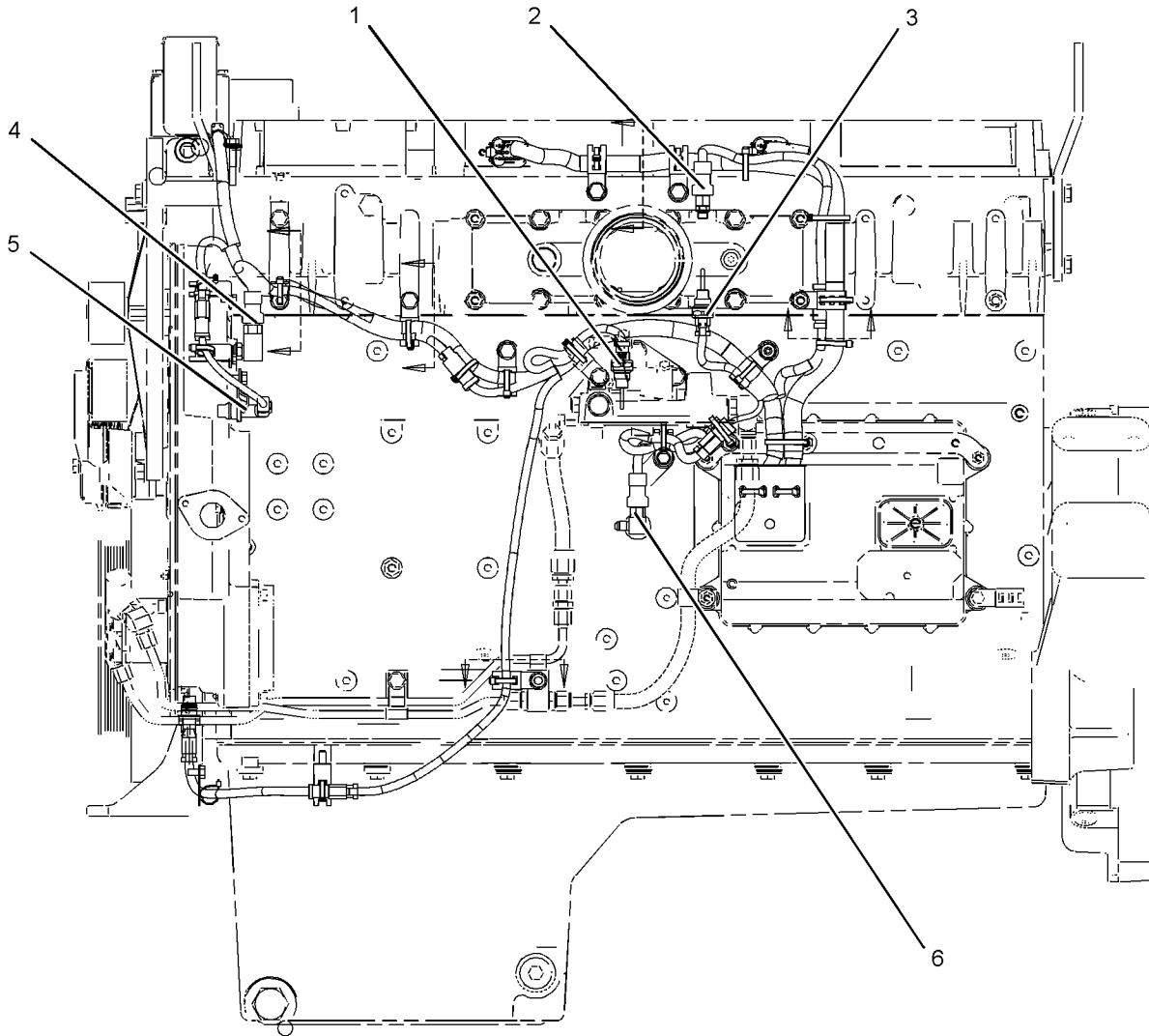


Illustration 146

g01010992

- |  |   |
|--|---|
| (1) Fuel temperature sensor ..... 20 ± 5 N·m<br>(14 ± 4 lb ft)         | (5) Camshaft speed/timing sensor ..... 28 ± 7 N·m<br>(21 ± 5 lb ft) |
| (2) Inlet manifold pressure sensor ..... 10 ± 2 N·m<br>(88 ± 18 lb in) | (6) Engine oil pressure sensor ..... 10 ± 2 N·m<br>(88 ± 18 lb in)  |
| (3) Inlet air temperature sensor ..... 20 ± 5 N·m<br>(14 ± 4 lb ft)    |   |
| (4) Atmospheric pressure sensor ..... 10 ± 5 N·m<br>(88 ± 18 lb in)    |   |

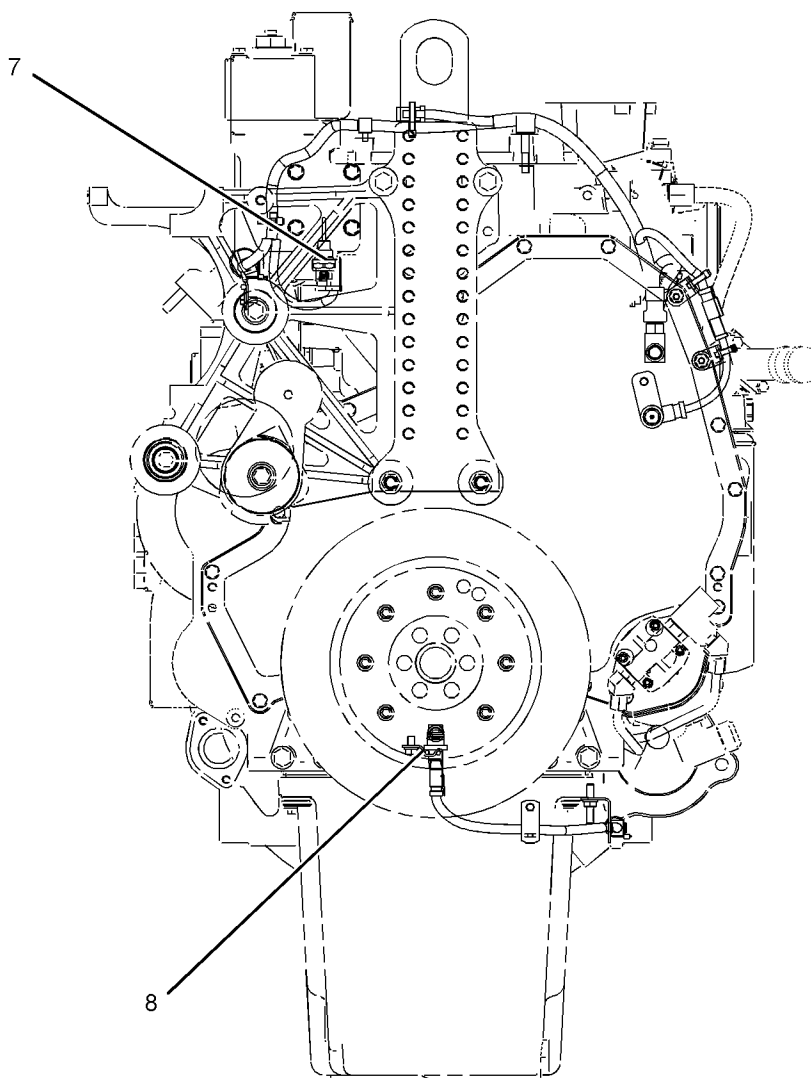


Illustration 147

g01011004

(7) Coolant temperature sensor .....  $20 \pm 5$  N·m  
( $14 \pm 4$  lb ft)

(8) Crankshaft position sensor .....  $28 \pm 7$  N·m  
( $21 \pm 5$  lb ft)



i01959186

# Fan Drive Mounting Group - Remove and Install

SMCS Code: 1359-010

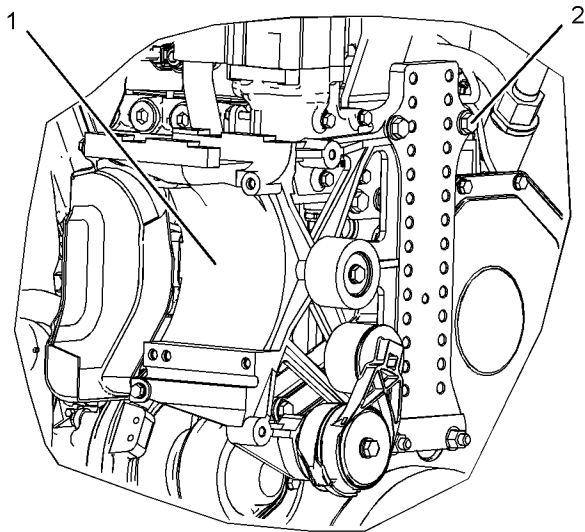


Illustration 148

g01018313

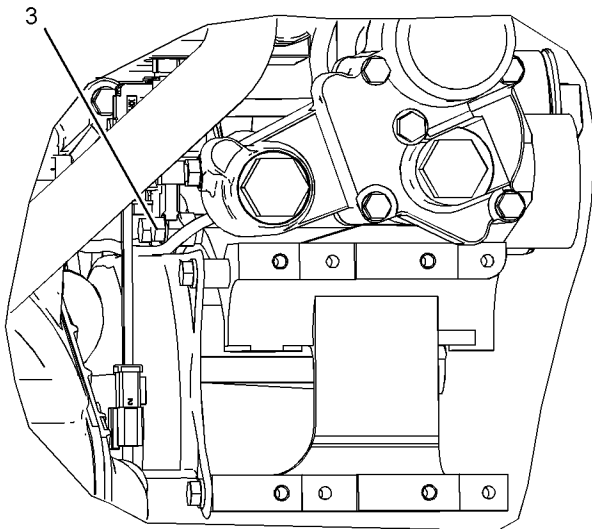


Illustration 149

Top view

1. Remove bolts (3).
2. Remove bolts (2).
3. Remove fan drive mounting group (1).

# Installation Procedure

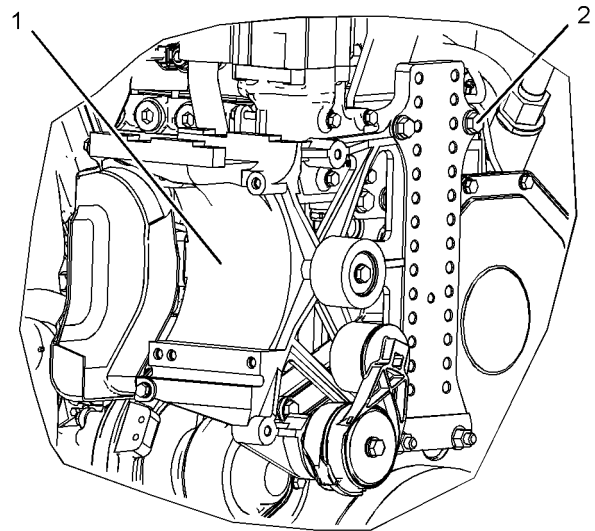


Illustration 150

g01018313

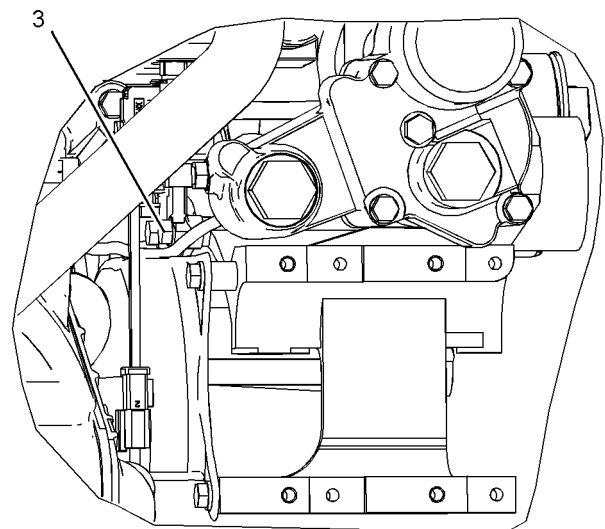


Illustration 151

Top view

g01018470

1. Position fan drive mounting group (1) on the engine.
2. Install bolts (2).
3. Install bolts (3).

i02253896

## Engine Control Module - Remove and Install

SMCS Code: 1901-010

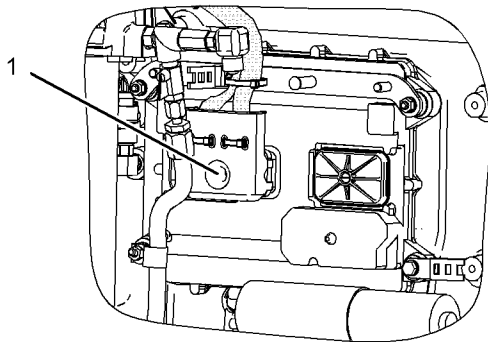


Illustration 152

g01135233

(1) Harness assembly .....  $6 \pm 1$  N·m ( $53 \pm 9$  lb in)

i01942442

## Air Compressor - Remove and Install

SMCS Code: 1803-010

### Removal Procedure

#### 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.

Refer to Special Publication, NENG2500, "Caterpillar Tools and Shop Products Guide" for tools and supplies suitable to collect and contain fluids on Caterpillar products.

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

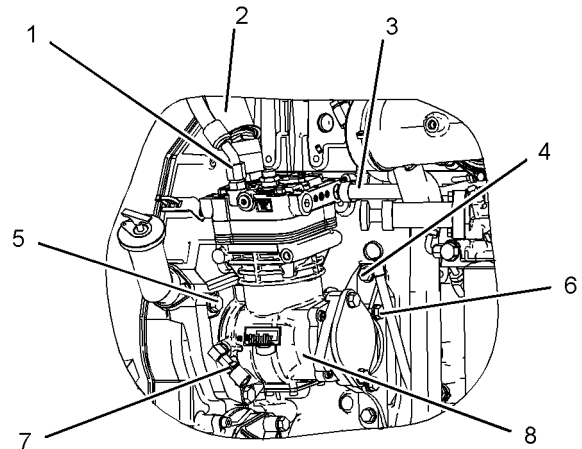


Illustration 153

g01010799

2. Disconnect hose assembly (1) and hose assembly (7).
3. Disconnect tube assembly (2).
4. Disconnect hose (3).
5. Remove bolts (4).
6. Remove bolts (6).
7. Remove bolts (5).
8. Remove air compressor (8).

## Installation Procedure

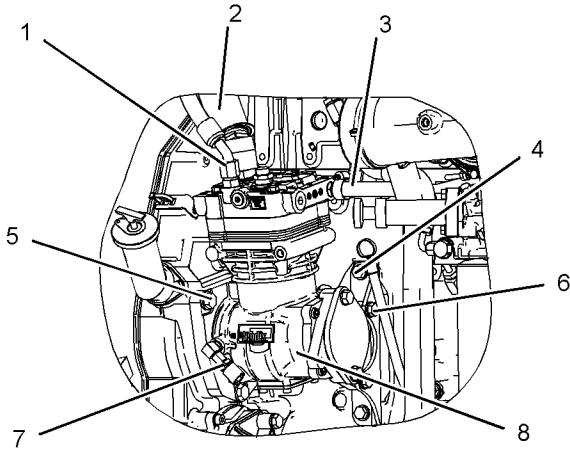


Illustration 154

g01010799

1. Position air compressor (8).
2. Install bolts (5).
3. Install bolts (4).
4. Install bolts (6).
5. Tighten bolts (4) to the proper torque.
6. Tighten bolts (6) to the proper torque.
7. Connect hose (3).
8. Connect tube assembly (2).
9. Connect hose assembly (1) and hose assembly (7).
10. Fill the cooling system. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change".

i01948322

## Air Compressor Drive Gear - Remove and Install

**SMCS Code:** 1803-010-GE

Table 44

| Required Tools |             |                  |     |
|----------------|-------------|------------------|-----|
| Tool           | Part Number | Part Description | Qty |
| A              | 132-5451    | Holding Fixture  | 1   |

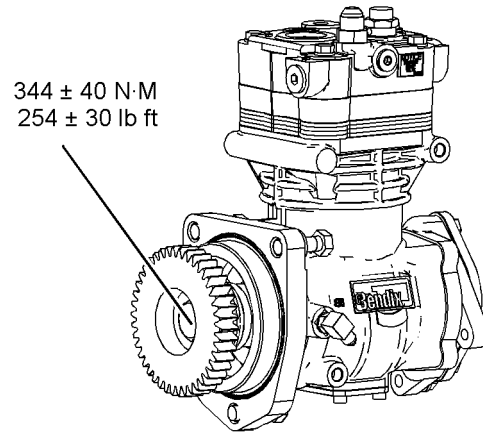


Illustration 155

g01010798

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