



# Disassembly and Assembly

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## **3406E On-Highway Engine**

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1MM1-Up (Engine)  
2WS1-Up (Engine)



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 **WARNING**

Accidental machine starting can cause injury or death to personnel working on the machine.

To avoid accidental machine starting, turn the battery disconnect switch to the OFF position and remove the key. If the machine is not equipped with a battery disconnect switch, disconnect the battery cables from the battery and tape the battery clamps.

Place a do not operate tag at the battery disconnect switch location to inform personnel that the machine is being worked on.

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# Disassembly and Assembly Section

## Fuel Priming Pump - Remove and Install

i02022754

SMCS Code: 1258-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.

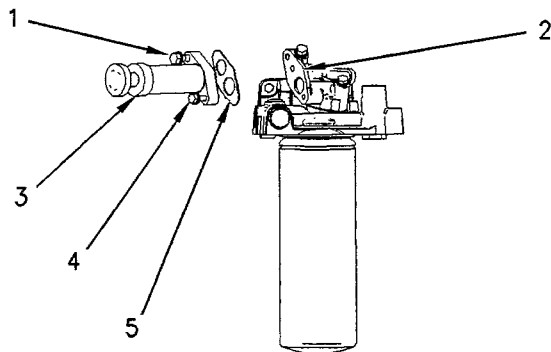


Illustration 1

g01002542

1. Remove bolt (1) and bolt (4). Remove fuel priming pump (3) from fuel filter base (2).
2. Remove gasket (5) for the fuel priming pump and the fuel filter base.

## Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

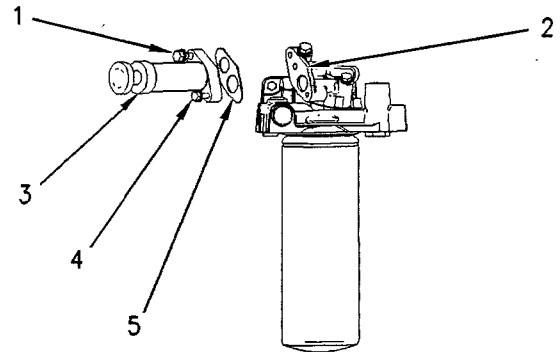


Illustration 2

g01002542

1. Ensure that gasket (5) is in position for the fuel priming pump.
2. Put fuel priming pump (3) in position on fuel filter base (2). Install bolt (1) and bolt (4).

i02110352

## Fuel Filter Base - Remove and Install

SMCS Code: 1262-010

### Removal Procedure

Table 1

Required Tools			
Tool	Part Number	Part Description	Qty
A	2P-8250	Strap Wrench	1

**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.

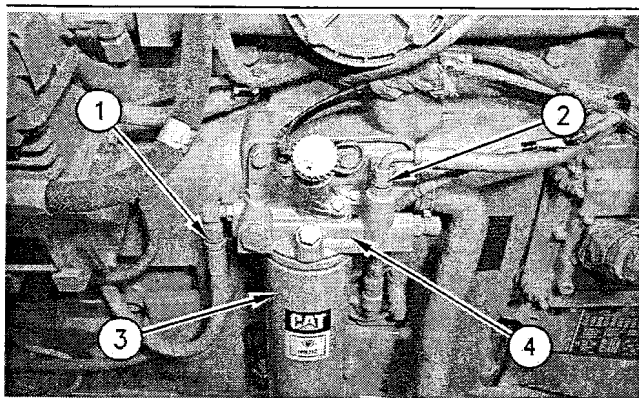


Illustration 3

g00516824

1. Turn the fuel supply to the "OFF" position.
2. Disconnect hose assemblies (1) and (2).
3. Use Tooling (A) to remove fuel filter (3) from the fuel filter base.
4. Remove the bolts that fasten the fuel filter base to the engine. Remove fuel filter base (4).

**Installation Procedure**

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

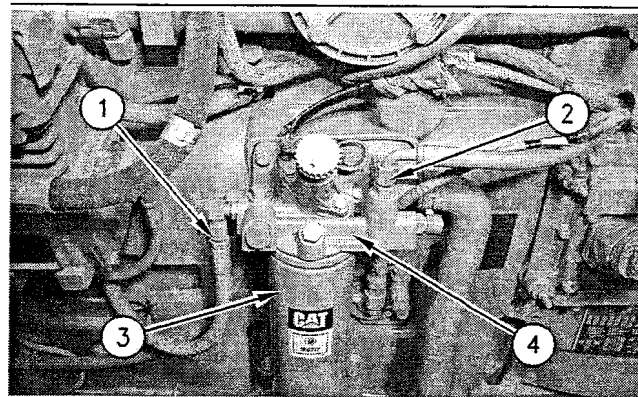


Illustration 4

g00516824

1. Install fuel filter base (4) on the engine.
2. Install fuel filter (3) on the fuel filter base. Follow the directions on the fuel filter for the correct installation procedure.
3. Connect hose assemblies (1) and (2) to the fuel filter base.
4. Turn the fuel supply to the "ON" position.
5. Remove the air from the system. Refer to Testing and Adjusting, "Fuel System - Prime".

i02110363

**Fuel Transfer Pump - Remove**

**SMCS Code:** 1256-011

**Removal Procedure**

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i01990706

**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.

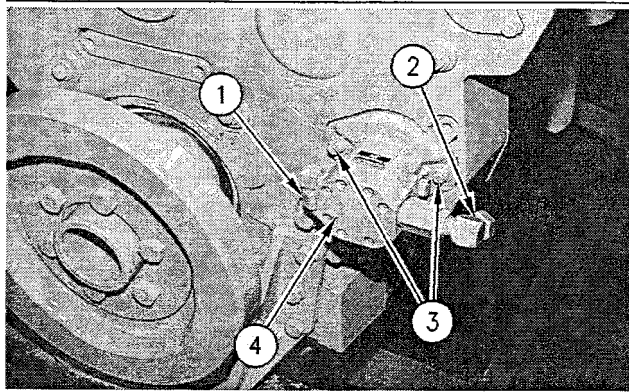


Illustration 5

g00488104

1. Disconnect hose assemblies (1) and (2). Plug and cap all openings in order to prevent debris and contamination from entering the system.
2. Remove bolts (3) and fuel transfer pump (4).

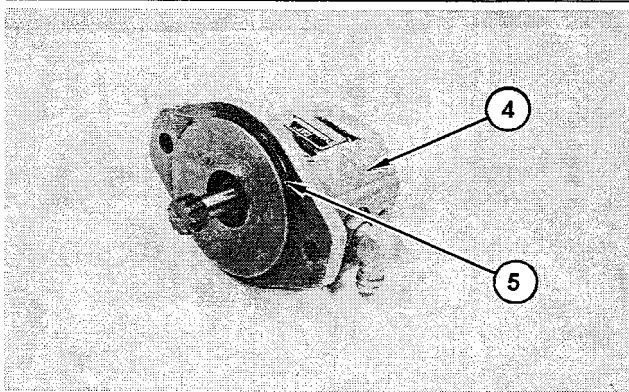


Illustration 6

g01039865

3. Check the condition of O-ring seal (5) on fuel transfer pump (4). If the O-ring seal is worn or damaged, use a new part for replacement.

## Fuel Transfer Pump - Install

SMCS Code: 1256-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

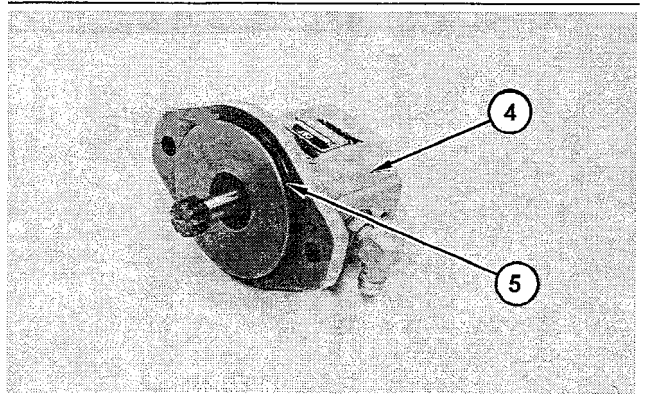


Illustration 7

g01039865

1. Install O-ring seal (5) on fuel transfer pump (4). Apply clean engine oil to O-ring seal (5).

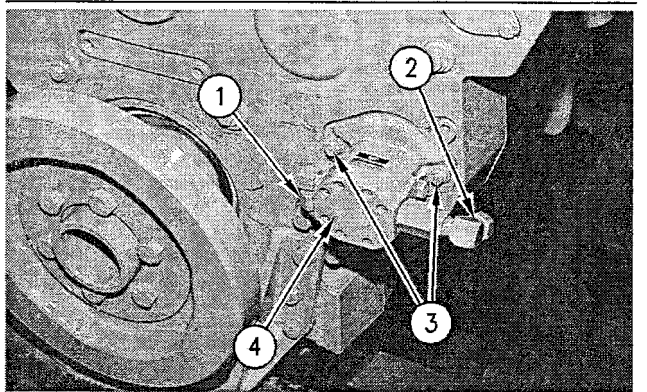


Illustration 8

g00488104

2. Position fuel transfer pump (4). Install bolts (3).
3. Remove the caps from the openings for the hose assemblies. Connect hose assemblies (1) and (2).

i02097659

## Electronic Unit Injector - Remove

SMCS Code: 1290-011

### Removal Procedure

Table 2

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

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

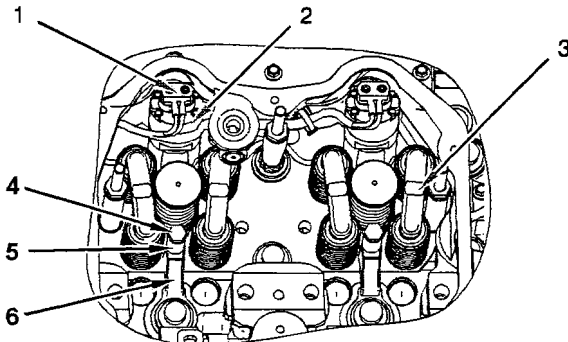


Illustration 9

g01026993

1. Disconnect harness assembly (1) from electronic unit injector (2).
2. Remove bridge assemblies (3).

#### NOTICE

Do not reuse the injector hold down bolts. New injector hold down bolts must be used.

#### NOTICE

If the injector hold down bolt is loose during the removal procedure, inspect the injector bore for wear and debris. Replace the clamp and spacer.

3. Remove bolt (4), spacer (5), and clamp (6).
4. Place an identification mark on the electronic unit injectors for installation purposes. Each electronic unit injector must be reinstalled in the original electronic unit injector sleeve.

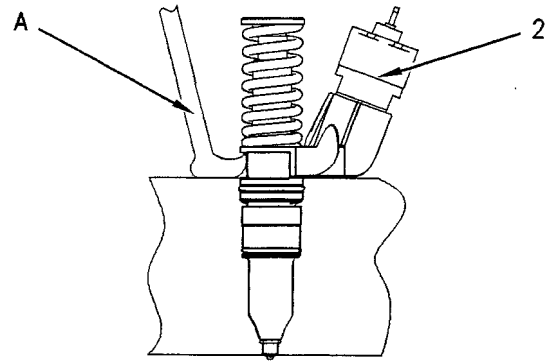


Illustration 10

g00996395

5. Use Tooling (A) in order to pry beneath the base and free electronic unit injector (2).
6. Remove electronic unit injector (2) from the cylinder head.

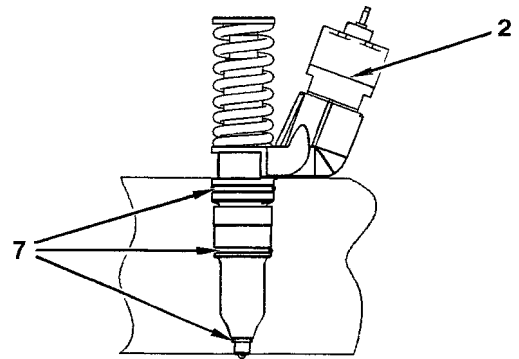


Illustration 11

g01039929

7. Remove O-ring seals (7) from electronic unit injector (2).

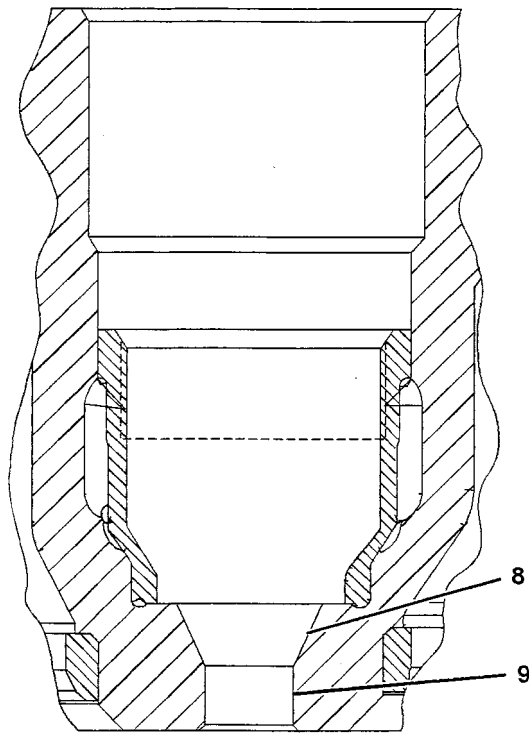


Illustration 12 g01054374

8. Inspect electronic unit injector seat (8) and electronic unit injector bore (9).

i02095281

## Electronic Unit Injector - Install

SMCS Code: 1290-012

### Installation Procedure

Table 3

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

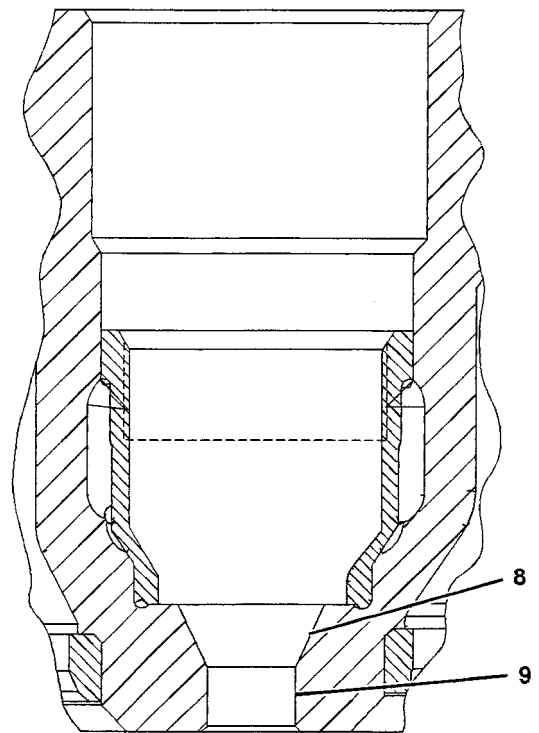


Illustration 13 g01054374

1. Use Tooling (B) and Tooling (D) in order to clean electronic unit injector seat (8).
2. Use Tooling (C) and Tooling (D) in order to clean electronic unit injector bore (9).

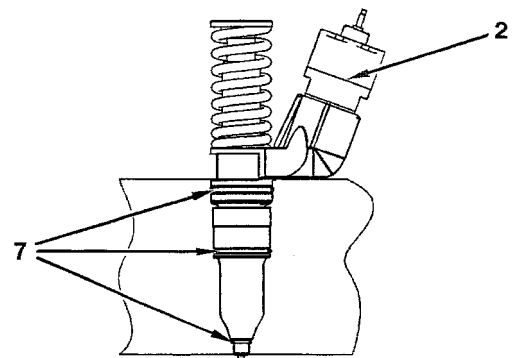


Illustration 14 g01039929

#### NOTICE

Do not reuse O-ring seals. New O-ring seals must be used.

3. Install O-ring seals (7). Lubricate the top two O-ring seals with a 50/50 mixture of clean engine oil and Tooling (E).



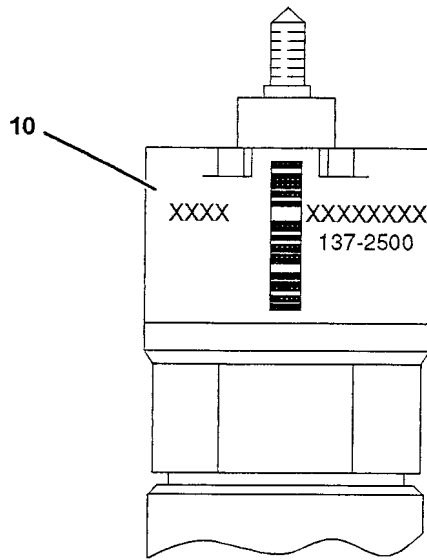


Illustration 15

g01019373

**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. The injector code (10) will be used later if the injectors have been changed. Write down injector code (10) which is located on the solenoid.

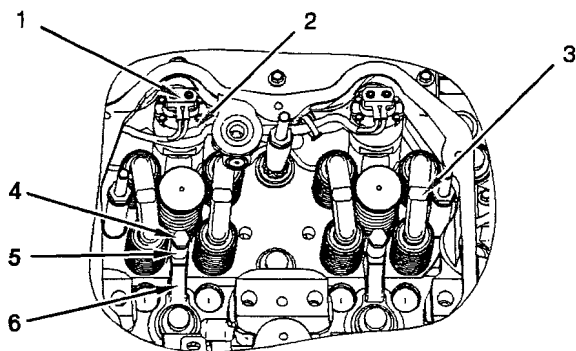


Illustration 16

g01026993

5. Install electronic unit injector (2) into the original location in the cylinder head.
6. Install clamp (6) and spacer (5).

**NOTICE**

Do not reuse the injector hold down bolts. New injector hold down bolts must be used.

**NOTICE**

If the injector hold down bolt is loose during the removal procedure, inspect the injector bore for wear and debris. Replace the clamp and spacer.

7. Install bolt (4). Tighten bolt (4) according to the following procedure.
  - a. Tighten the bolt for the electronic unit injector to  $50 \pm 10$  N·m ( $37 \pm 7$  lb ft).
  - b. Loosen the bolt until you can turn the bolt by hand.
  - c. Tighten the bolt for the electronic unit injector again to  $50 \pm 10$  N·m ( $37 \pm 7$  lb ft).
8. Install bridge assemblies (3) in the respective locations.
9. Connect harness assembly (1) on electronic unit injector (2). Install the nuts. Tighten the nuts to a torque of  $2.5 \pm 0.25$  N·m ( $22 \pm 2$  lb in).
10. Install the rocker arms and the rocker arm shaft. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Install".
11. Adjust the height of the electronic unit injector. Refer to Testing and Adjusting, "Electronic Unit Injector - Adjust" for information on adjusting the height of the injector.
12. Calibrate the electronic unit injector.
  - a. Connect Cat ET to the service tool connector.
  - b. Turn the keyswitch to the ON position.
  - c. Open the "Injector Codes Calibration" in "Calibrations" under the "Service" menu on Cat ET.
  - d. Enter the new injector trim code for the electronic unit injector in each cylinder.

i01983465

## Electronic Unit Injector Sleeve - Remove

SMCS Code: 1713-011

### Removal Procedure

Table 4

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

(1) Part of the 9U-6891 Injector Tool Group

#### 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.

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

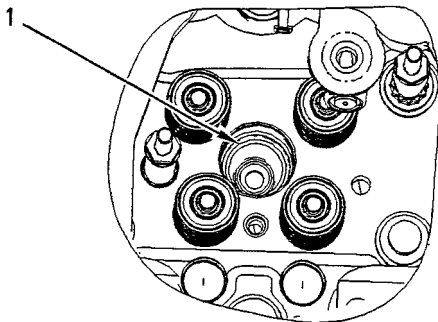


Illustration 17

g01002969

2. Use Tooling (A) to remove unit injector sleeve (1).

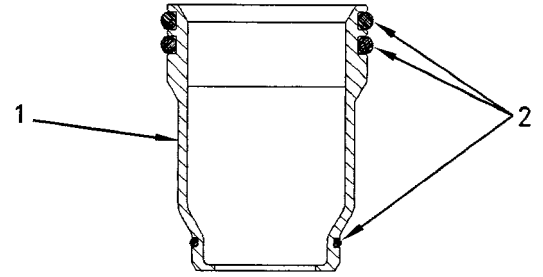


Illustration 18

g00948616

3. Remove O-ring seals (2) from unit injector sleeve (1).

i02015805

## Electronic Unit Injector Sleeve - Install

SMCS Code: 1713-012

### Installation Procedure

Table 5

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	-

(1) Part of the 9U-6891 Injector Tool Group

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

**NOTICE**

Before starting installation ensure that the unit injector sleeve and the cylinder head bore for the unit injector sleeve are completely free of oil, dirt, and sealant debris.

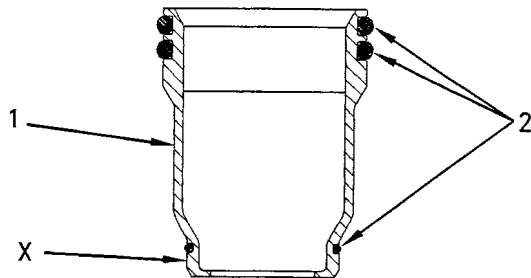


Illustration 19

g01003258

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

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

3. Apply Tooling (E) to the contact surface of unit injector sleeve (1) on the surface that is marked "X".
4. Lubricate O-ring seals (2) with clean engine oil.
5. Install Tooling (C) into the threads of unit injector sleeve (1).
6. Position Tooling (C) and unit injector sleeve (1) in the cylinder head. Use care not to damage the O-ring seals on the unit injector sleeve.

**NOTICE**

Ensure that the unit injector sleeve is properly seated in the cylinder head. The tool and the unit injector sleeve will "RING" when the unit injector sleeve is fully seated in the bore in the cylinder head.

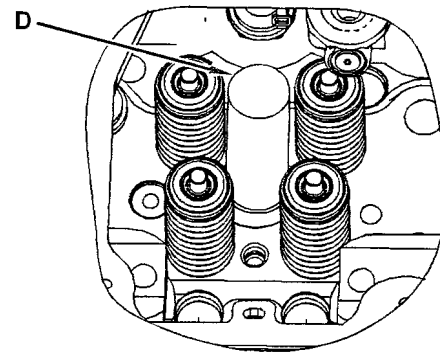


Illustration 20

g01027804

7. Use Tooling (D) and a hammer to install the unit injector sleeve.
8. Use a clean towel to remove any excessive retaining compound.
9. Fill the cooling system with coolant. Refer to Operation and Maintenance, "Refill Capacities" for the cooling system capacity.

**End By:**

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

i02110374

## Turbocharger - Remove

**SMCS Code:** 1052-011

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.

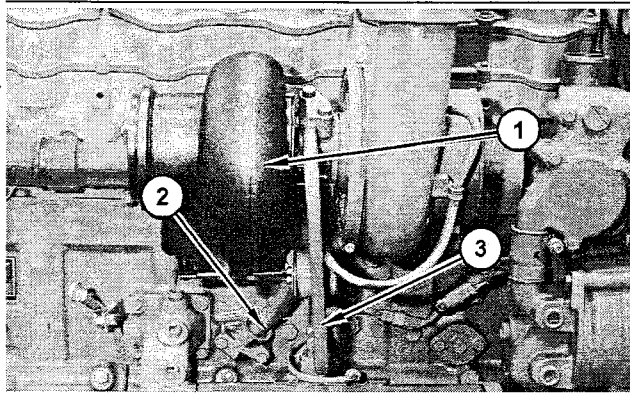


Illustration 21

g01031556

1. Remove tube assemblies (2) and (3) from turbocharger (1). Check the condition of the O-ring seals on tube assemblies (2) and (3). Use new parts for replacement if the O-ring seals are worn or damaged.

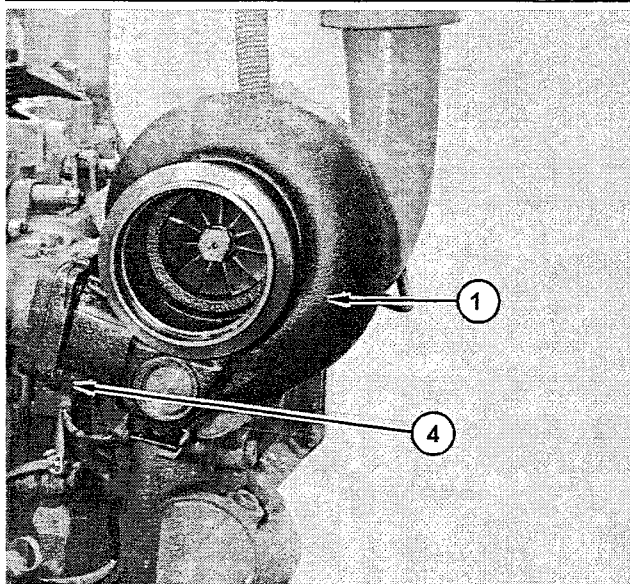


Illustration 22

g01031557

2. Attach a suitable lifting device to turbocharger (1).

3. Remove bolts (4) and turbocharger (1). The weight of the turbocharger is approximately 34 kg ( 75 lb).

i02010962

## Turbocharger - Disassemble

SMCS Code: 1052-015

### Disassembly Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

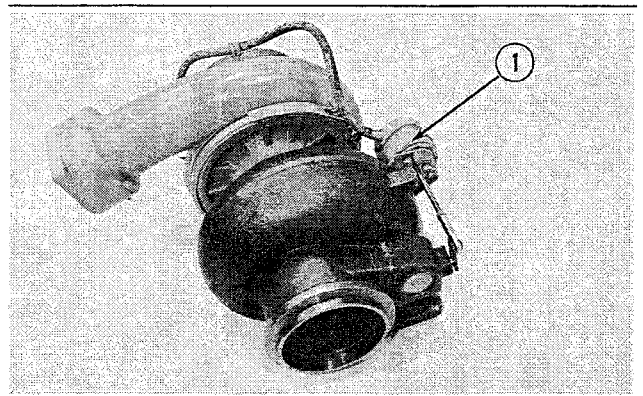


Illustration 23

g00513698

1. Position the turbocharger on a bench. Remove clamp (1) from waste gate.

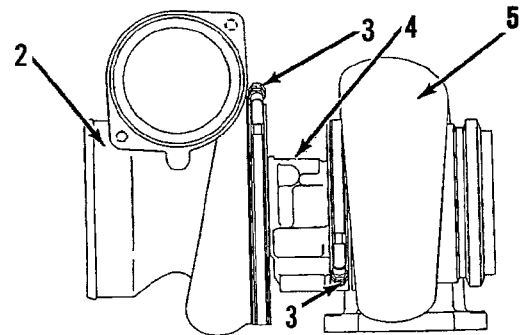


Illustration 24

g00513699

2. Loosen the nuts on V-band clamps (3).
3. Separate the compressor housing (2) and turbine housing (5) from turbocharger cartridge (4).

**NOTICE**

Do not attempt to disassemble the turbocharger cartridge assembly or wastegate. Do not remove the compressor wheel. The turbocharger cartridge assembly and the wastegate are not field serviced, and should be replaced only as a unit.

4. Check condition of all components. Use new parts to replace worn or damaged parts.

i01991697

## Turbocharger - Assemble

**SMCS Code:** 1052-016

### Assembly Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

Compressor housing must go straight on the turbocharger assembly without tilting. Tilting may cause compressor blade to tip, or the compressor shaft can be damaged.

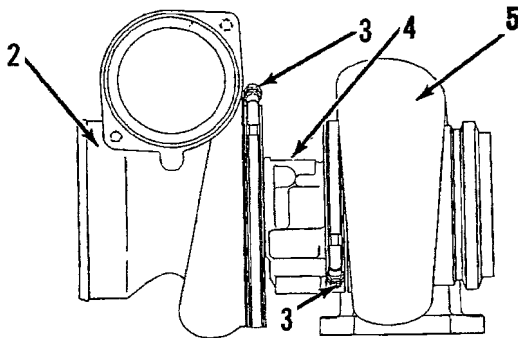


Illustration 25

g00513699

1. Check condition of all components. Use new parts to replace worn or damaged parts.
2. Connect compressor housing (2) and turbine housing (5) to turbocharger cartridge (4).
3. Tighten the nuts on V-band clamps (3) to a torque of  $14 \pm 3$  N·m ( $10 \pm 2$  lb ft). Use a soft hammer to lightly hit around the diameter of band clamps (3).

4. Tighten the nuts on V-band clamps (3) again. Tighten to a torque of  $14 \pm 3$  N·m ( $10 \pm 2$  lb ft).

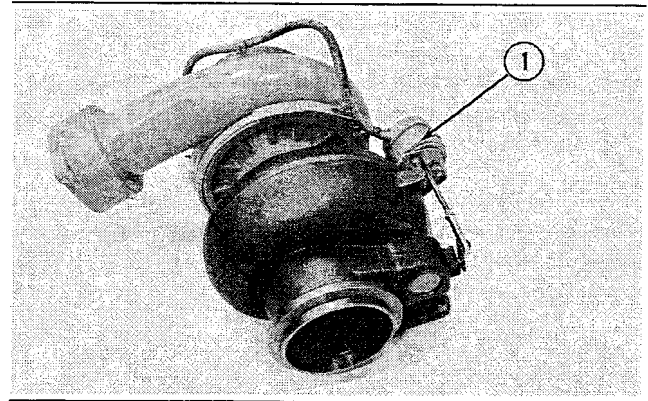


Illustration 26

g00513698

5. Install clamp (1) on waste gate.

i00978262

## Turbocharger - Install

**SMCS Code:** 1052-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. 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 in Caterpillar machines.

Dispose of all fluids according to local regulations and mandates.

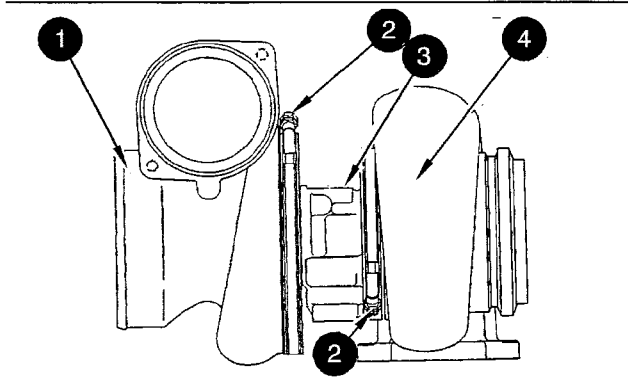


Illustration 27 g00513535

Typical Example

1. Loosen V-band clamps (2) enough to allow the compressor housing (1) and turbine housing (4) to rotate.

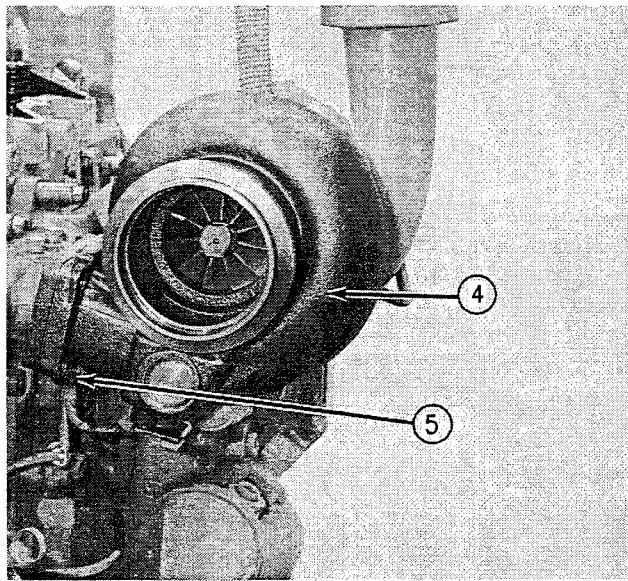


Illustration 28 g00513574

2. Use 5P-3931 Anti-Seize Compound on the turbocharger to manifold bolts (5).

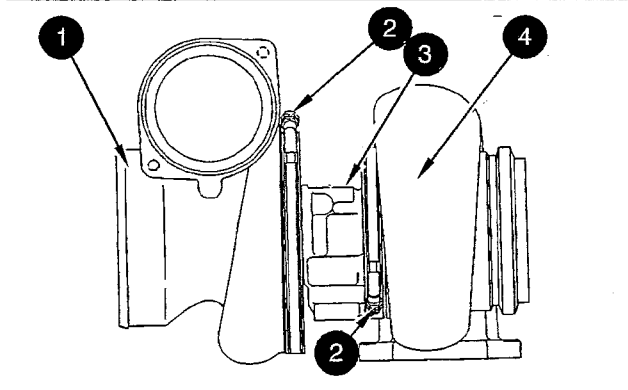


Illustration 29 g00513535

3. Align compressor housing (1) and turbine housing (4). Install the bolts(5) in the turbocharger and the manifold. Do not tighten bolts completely.
4. Tighten V-band clamp (2) to a torque of  $14 \pm 3 \text{ N}\cdot\text{m}$  ( $10 \pm 2 \text{ lb ft}$ ).
5. Tighten manifold bolts (5) to  $55 \pm 5 \text{ N}\cdot\text{m}$  ( $41 \pm 4 \text{ lb ft}$ ).
6. Position the compressor housing ( 1) so the air outlet is zero degrees from top vertical.
7. Install the V-band clamp (2 ) to  $90 \pm 10$  degrees outboard from the bottom vertical.
8. Tighten V-band clamp (2). Tighten the nuts to a torque of  $14 \pm 3 \text{ N}\cdot\text{m}$  ( $10 \pm 2 \text{ lb ft}$ ). Use a soft hammer to lightly hit around the diameter of the band clamps (2).

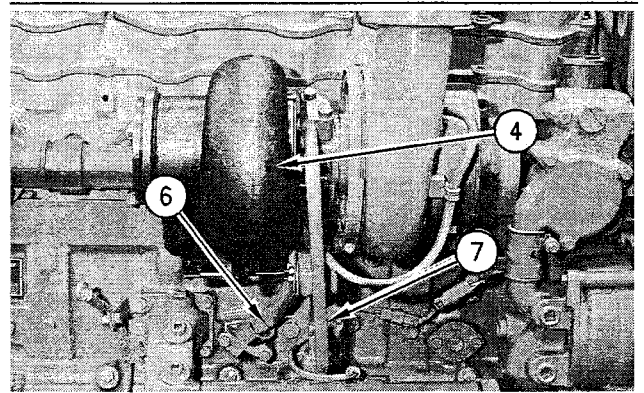


Illustration 30 g00513622

9. Install tube assembly (6) and (7).

i01806198

## Exhaust Manifold - Remove and Install

SMCS Code: 1059-010

### Removal Procedure

Start By:

- a. Remove the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove".
- b. Remove the water temperature regulator. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

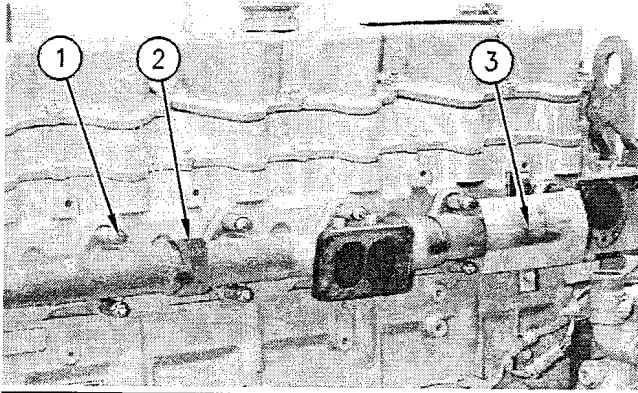


Illustration 31  
Typical example g00619289

1. Remove exhaust manifold shield (3). Remove the nuts and spacers from studs (1). Remove exhaust manifold (2).

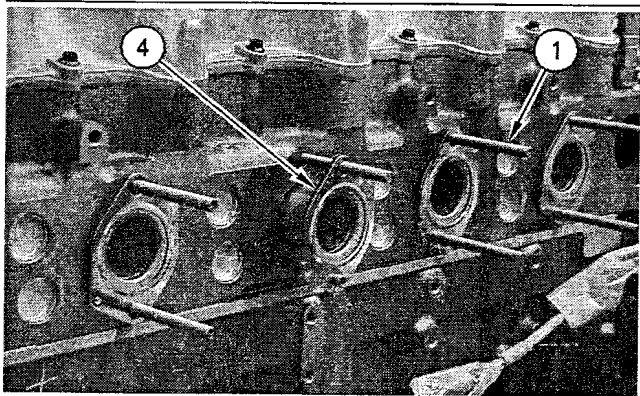


Illustration 32  
Typical example g00632595

2. Remove sleeve assemblies (4) from the cylinder head.

**Installation Procedure**

Table 6

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-3931	Anti-Seize Compound	1
B	2P-2333	High Temperature Sealer	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Before assembly, check the condition of the sleeve assemblies, the studs, and the nuts. If the part is worn or damaged, use new parts for replacement.

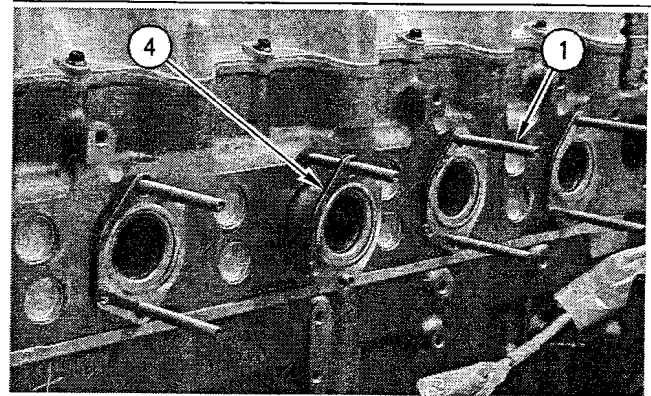


Illustration 33  
Typical example g00632595

1. Apply Tooling (A) to studs (1). If the studs were removed from the cylinder head, install the studs in the cylinder head. Tighten the studs to a torque of  $35 \pm 5$  N·m ( $26 \pm 4$  lb ft).
2. Install sleeve assemblies (4) in the cylinder head.

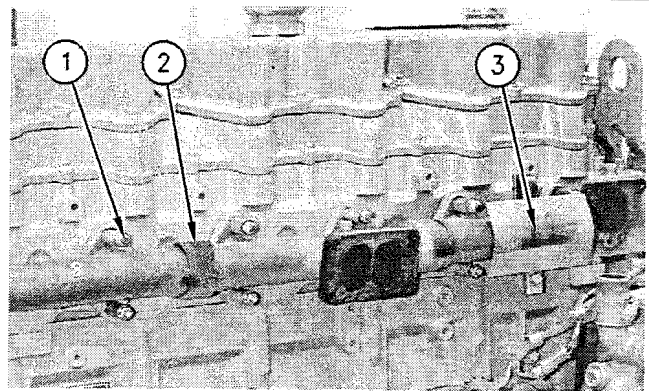


Illustration 34  
Typical example g00619289

3. Apply Tooling (B) to the outside diameter of the male ends of exhaust manifold (2). Put clean engine oil on the female ends of the exhaust manifold.
4. Apply Tooling (A) to the ends of studs (1). Put exhaust manifold (2) in position on the studs. Install the spacers and nuts on studs (1).

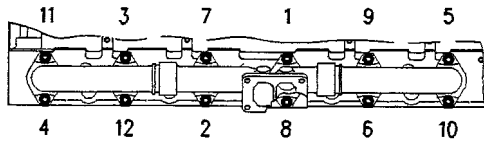


Illustration 35 g00498448

Tightening sequence for the exhaust manifold

5. Tighten the nuts for the exhaust manifold in a numeric sequence to a torque of  $38 \pm 5$  N·m ( $28 \pm 4$  lb ft).
6. Install exhaust manifold shield (3). Apply Tooling (A) to the nuts for the exhaust manifold shield. Tighten the nuts for the shield to a torque of  $25 \pm 7$  N·m ( $18 \pm 5$  lb ft).

**End By:**

- a. Install the water temperature regulator. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".
- b. Install the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install".

## Inlet and Exhaust Valve Springs - Remove and Install

SMCS Code: 1108-010

### Removal Procedure

Table 7

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	1U-8826	Thrust Bearing	1
	9U-7242	Compressor Plate	1
	9U-7548	Compressor Base	1
	2J-3506	Full Nut	1
	5P-8248	Hard Washer	1
	0L-1143	Bolt	1
B	8S-2263	Spring Tester	1

<sup>(1)</sup> Part of the 9U-7241 Valve Spring Compressor

**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:** Place the piston at the top of the compression stroke (TC). Remove the valve springs for that cylinder. If the valves fall into the cylinder liner, then the cylinder head must be removed.

1. Position the piston at the top of the compression stroke (TC) of the cylinder.

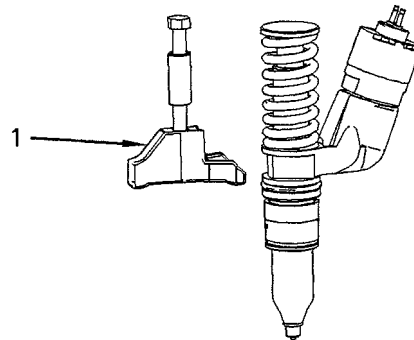


Illustration 36 g01003285

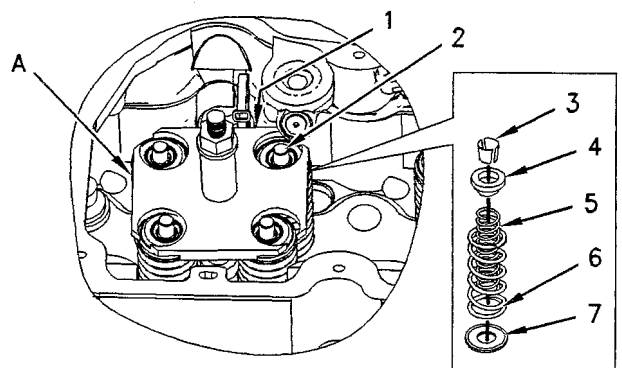


Illustration 37 g01003311

2. Secure Tooling (A) with unit injector clamp (1).



### ⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

3. Tighten full nut until valve spring retainers (3) are loose on valve (2).
4. Remove valve spring retainers (3) from valve (2).

### ⚠ 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.

5. Carefully remove Tooling (A) from valves (2).
6. Remove valve rotator (4).
7. Remove outer valve spring (6) and inner valve spring (5) from valve (2).
8. Remove washer (7) from the valve guide.
9. Use Tooling (B) to check the valve springs (spring force). Refer to Specifications, "Cylinder Head Valves" for additional information on the valve springs.
10. Repeat Steps 1 through 9 for the remaining valve springs.

## Installation Procedure

Table 8

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	1U-8826	Thrust Bearing	1
	9U-7242	Compressor Plate	1
	9U-7548	Compressor Base	1
	2J-3506	Full Nut	1
	5P-8248	Hard Washer	1
	0L-1143	Bolt	1

(1) Part of the 9U-7241 Valve Spring Compressor

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Lubricate the valve stems with clean engine oil.

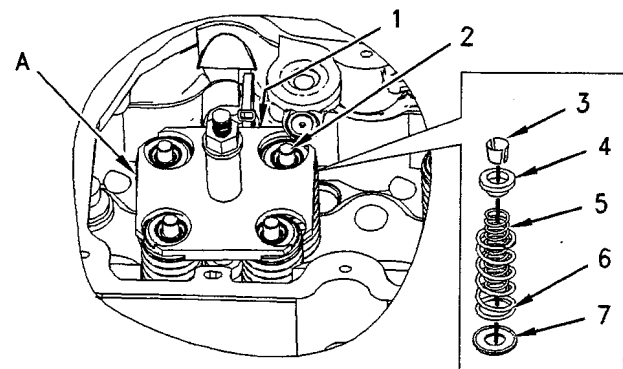


Illustration 38

g01003311

2. Ensure that washer (7) is installed on the valve guide.
3. Install inner valve spring (5) and outer valve spring (6) on valve (2).
4. Install valve rotator (4) on valve (2).

**⚠ 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.

5. Secure Tooling (A) with unit injector clamp (1). Use Tooling (A) to compress the valve springs. Install valve spring retainers (3) on each valve (2).

**⚠ WARNING**

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

6. Carefully remove Tooling (A). Strike the top of the valve with a soft faced hammer in order to ensure that valve spring retainers (3) are properly installed.
7. Repeat Steps 3 through 6 for the remaining valve springs.

**End By:**

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

i02015976

**Inlet and Exhaust Valves - Remove and Install**

SMCS Code: 1105-010

**Removal Procedure**

Table 9

Required Tools			
Tool	Part Number	Part Description	Qty
A	5S-1330	Valve Spring Compressor	1
B	8S-2263	Spring Tester	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.

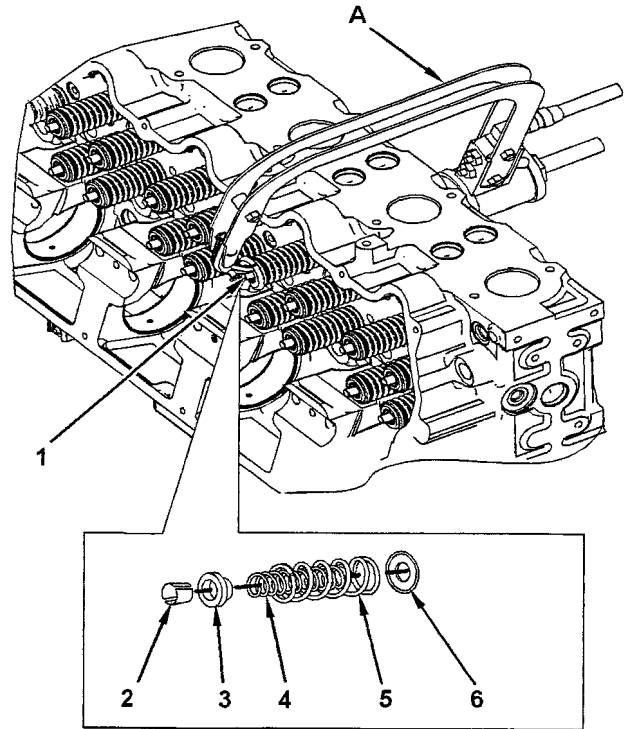


Illustration 39

g01042281

**⚠ 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 Tooling (A) and compress the valve springs. Remove valve spring retainers (2) from valve (1).
2. Carefully remove Tooling (A) from valve (1).
3. Remove valve rotator (3).
4. Remove outer valve spring (5) and inner valve spring (4) from valve (1).

5. Remove washer (6) and the valve from the valve guide.
6. Use Tooling (B) to check the valve springs (spring force). Refer to Specifications, "Cylinder Head Valves" for additional information on the valve springs.
7. Inspect the valve and the exhaust valves. Refer to Specifications, "Cylinder Head Valves" for additional information on the inlet and exhaust valves.

## Installation Procedure

Table 10

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

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Lubricate the inlet valves and the exhaust valves with clean engine oil. Install the inlet valves and the exhaust valves in the cylinder head.

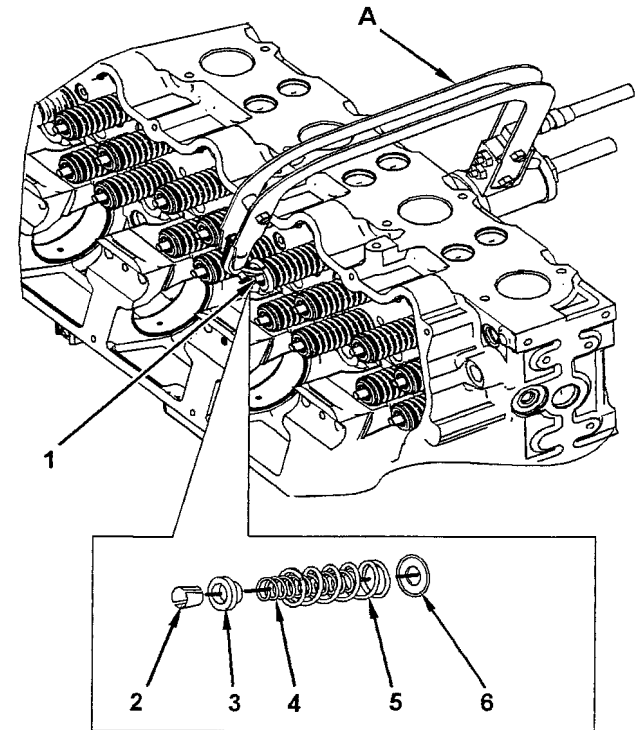


Illustration 40

g01042281

2. Ensure that washer (6) is installed on the valve guide.
3. Install inner valve spring (4) and outer valve spring (5) on valve (1).
4. Install valve rotator (3) on valve (1).
5. Use Tooling (A) to compress inner valve spring (4) and outer valve spring (5). Install valve spring retainers (2) on valve (1).

### WARNING

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

6. Carefully remove Tooling (A). Strike the top of the valve with a soft faced hammer in order to ensure that valve spring retainers (2) are properly installed.

**End By:**

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

i02015995

## Inlet and Exhaust Valve Guides - Remove and Install

SMCS Code: 1104-010

### Removal Procedure

Table 11

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	9U-6895	Valve Guide Driver	1

<sup>(1)</sup> Part of 9U-7530 Engine Tool Group

**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.

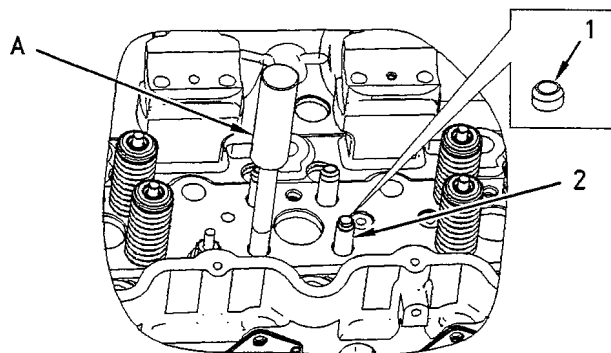


Illustration 41

g01003942

1. Remove valve stem seal (1) from valve guide (2).
2. Use Tooling (A) and a hammer to remove the valve guide from the cylinder head.

### Installation Procedure

Table 12

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	9U-6895	Valve Guide Driver	1
B <sup>(1)</sup>	9U-6894	Guide Collar	1

<sup>(1)</sup> Part of 9U-7530 Engine Tool Group

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

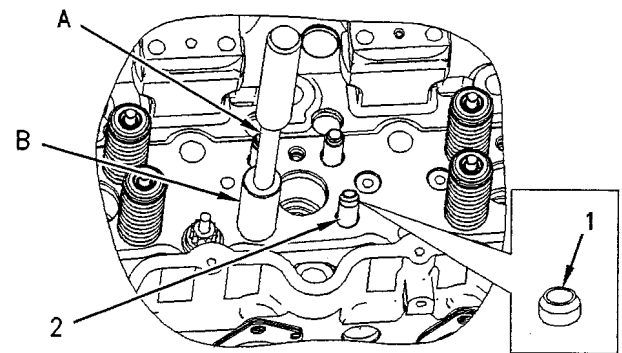


Illustration 42

g01003943

1. Lubricate the bores for the valve guides with clean engine oil.
2. Install valve guide (2) in the cylinder head with Tooling (A) and Tooling (B), as shown.

**Note:** Tooling (B) must be used in order to install the valve guide to the correct height.

Height to top of valve guide from cylinder head surface ..... 35.00 ± 0.50 mm (1.378 ± 0.020 inch)

**Note:** For more information, refer to Specifications, "Cylinder Head Valves".

3. Install valve stem seal (1) on the valve guide.

**End By:**

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

i02016026

# Inlet and Exhaust Valve Seat Inserts - Remove and Install

SMCS Code: 1103-010

## Removal Procedure

Table 13

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

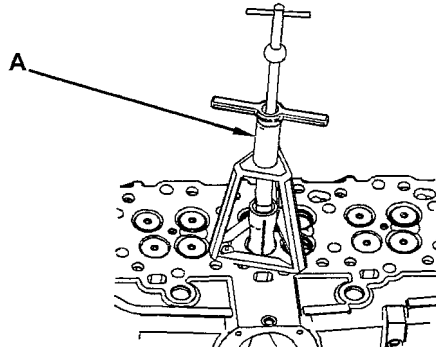


Illustration 43

g01042314

1. Use Tooling (A) to remove the valve seat inserts from the cylinder head.
2. Clean the bores in the cylinder head for the valve seat inserts. Remove any rough areas from the bores.

## Installation Procedure

Table 14

Required Tools			
Tool	Part Number	Part Description	Qty
B <sup>(1)</sup>	9U-6898	Valve Seat Driver (Exhaust)	1
	9U-6897	Valve Seat Driver (Inlet)	1

<sup>(1)</sup> Part of 9U-7530 Engine Tool Group

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

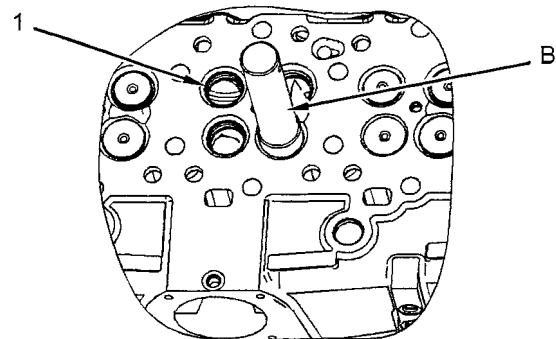


Illustration 44

g01042315

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.

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

### End By:

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

i02110458

# Inlet and Exhaust Valve Seals - Remove and Install

SMCS Code: 1104-010-SA

## Removal Procedure

Table 15

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-7414	Seal Pick	1
B <sup>(1)</sup>	9U-6890	Seal Installer	1
C <sup>(1)</sup>	9U-7216	Valve Seal Pin	1

<sup>(1)</sup> Part of the 9U-7226 Seal Installer

### Start By:

- a. Remove the inlet and exhaust valve springs. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Springs - Remove and Install".

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The valve seals can be replaced with the cylinder head on the engine or off the engine. The valves do not need to be installed in the cylinder head in order to install the valve seals.

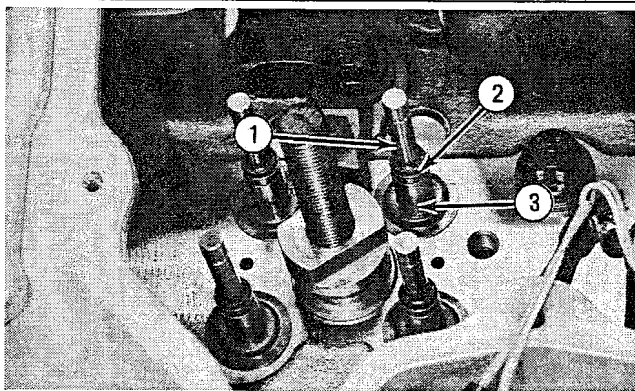


Illustration 45

g00516322

1. Use Tooling (A) to remove valve seals (2) from valves (1) and valve guides (3).

## Installation Procedure

Table 16

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-7414	Seal Pick	1
B <sup>(1)</sup>	9U-6890	Seal Installer	1
C <sup>(1)</sup>	9U-7216	Valve Seal Pin	1

<sup>(1)</sup> Part of the 9U-7226 Seal Installer

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

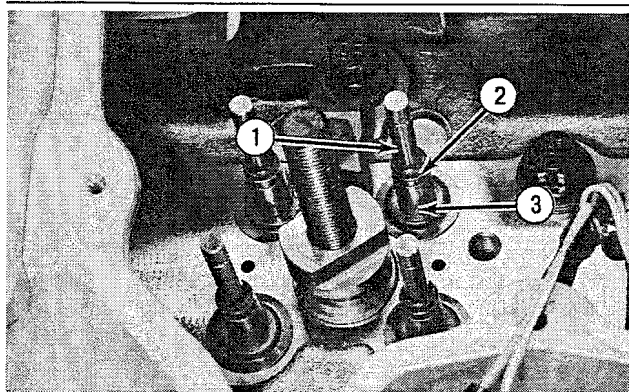


Illustration 46

g00516322

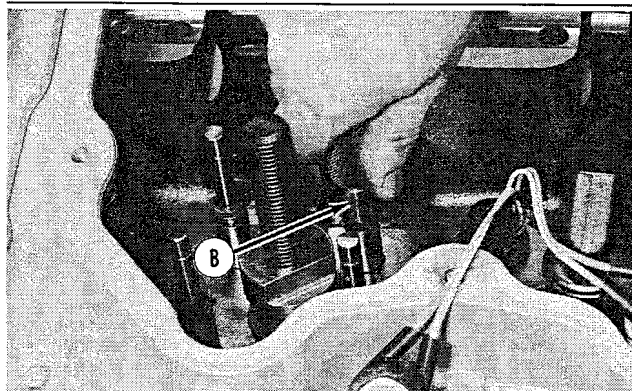


Illustration 47

g00516323

**Note:** Follow Steps 1 and 2 in order to install the valve seals with the valves in the cylinder head.

1. Apply a thin coat of clean engine oil on the valve stems. Position valve seals (2) on valves (1).
2. Use Tooling (B) to press valve seals (2) onto valve guides (3).

**Note:** Follow Steps 3 through 7 in order to install the valve seals when the valves are removed from the cylinder head. Use Tooling (C) instead of the valve stem to correctly position the new valve seal.

3. Position valve seal (2) on Tooling (B).
4. Insert Tooling (C) through Tooling (B) and the new valve seal.
5. Position Tooling (C) in the valve guide bore.
6. Use Tooling (B) to push valve seal (2) in position on valve guide (3).
7. Remove Tooling (B) and Tooling (C) from valve guide (3).
8. Repeat Steps 3 through 7 in order to install the remaining valve seals.

**End By:**

- a. Install the inlet and exhaust valve springs. Refer to Disassembly and Assembly, "Inlet and Exhaust Valve Spring - Remove and Install".

i01097969

## Engine Oil Filter Base - Remove

**SMCS Code:** 1306-011

### Removal Procedure

Table 17

Required Tools			
Tool	Part Number	Part Description	Qty
A	2P-8250	Strap Wrench Assembly	1

**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.

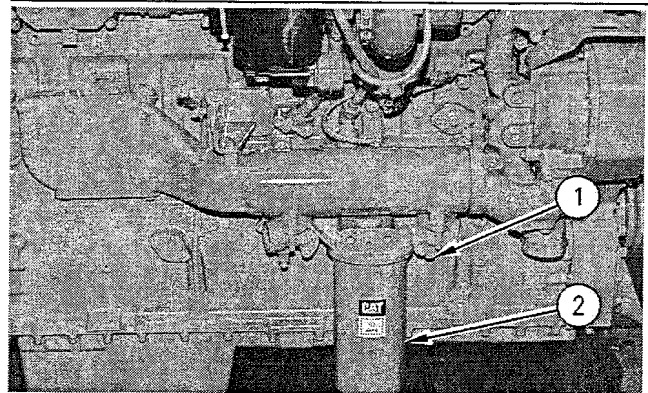


Illustration 48

g00497217

Typical example

1. Remove plug (1) and drain the oil from the engine oil filter base into a suitable container for storage or disposal.
2. Use Tool (A) to remove oil filter (2).

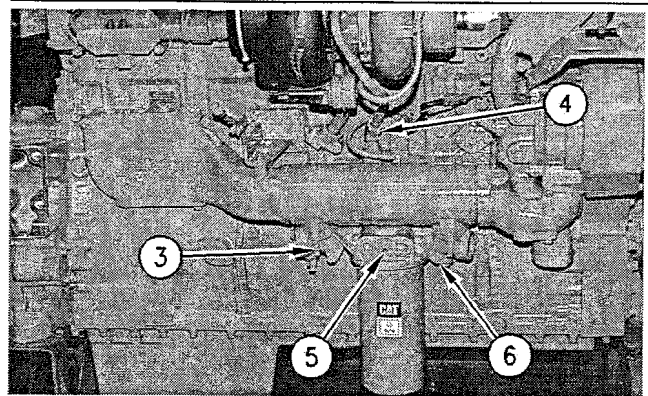


Illustration 49

g00497250

Typical example

3. Disconnect turbocharger oil line (4).

4. Remove nuts (3) that hold the engine oil filter base to the engine oil cooler and bolts (6) that hold the engine oil filter base to the cylinder block.
5. Remove engine oil filter base (5).

i01924925

## Engine Oil Filter Base - Disassemble

SMCS Code: 1306-015

### Disassembly Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

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.

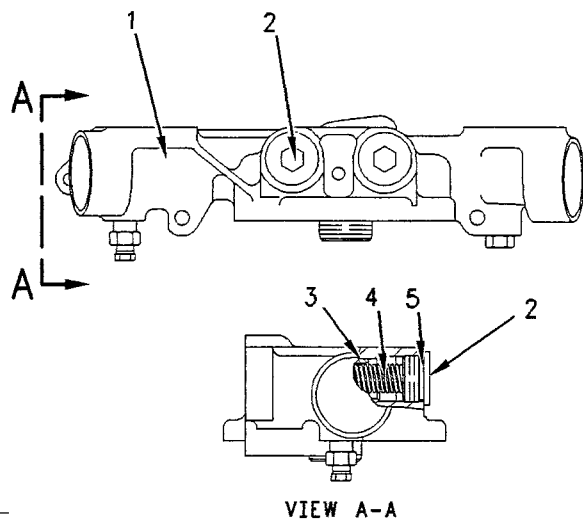


Illustration 50

g01001860

## **⚠ 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. Remove plugs (2) that hold the valves in engine oil filter base (1).
2. Remove spring (4).
3. Remove plunger (3).

i01989932

## Engine Oil Filter Base - Assemble

SMCS Code: 1306-016

### Assembly Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

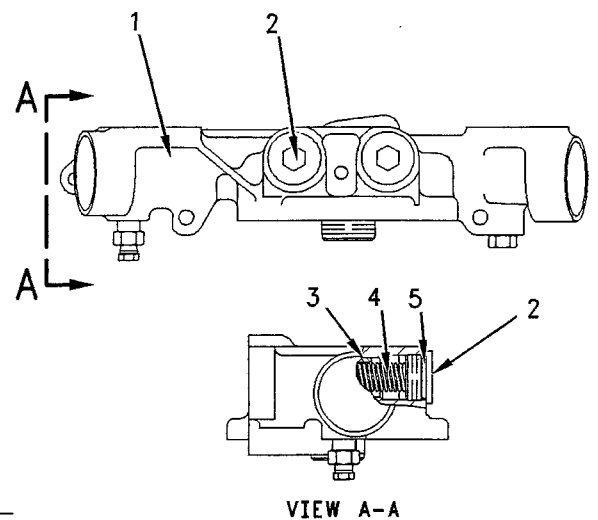


Illustration 51

g01001860



**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 plunger (3).
2. Install spring (4).
3. Install plugs (2) that hold the valves in engine oil filter base (1). Tighten plugs (2) to a torque of  $100 \pm 15 \text{ N}\cdot\text{m}$  ( $74 \pm 11 \text{ lb}\cdot\text{ft}$ ).

i01182405

## Engine Oil Filter Base - Install

SMCS Code: 1306-012

### Installation Procedure

Table 18

Required Tools			
Tool	Part Number	Part Description	Qty
A	2P-8250	Strap Wrench Assembly	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

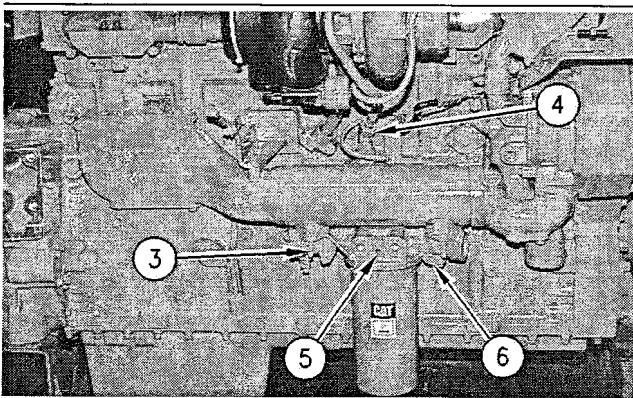


Illustration 52

g00497250

Typical example

**Note:** Before assembly, check the condition of the O-ring seals. If the O-ring seals are worn or damaged, use new parts for replacement.

1. Ensure that the O-ring seals are in position on the engine oil filter base. Put oil filter base (5) in position on the engine oil cooler and the cylinder block.
2. Install bolts (6) that hold the engine oil filter base to the engine oil cooler.
3. Install nuts (3) that hold the engine oil filter base to the engine oil cooler.
4. Connect turbocharger oil line (4).

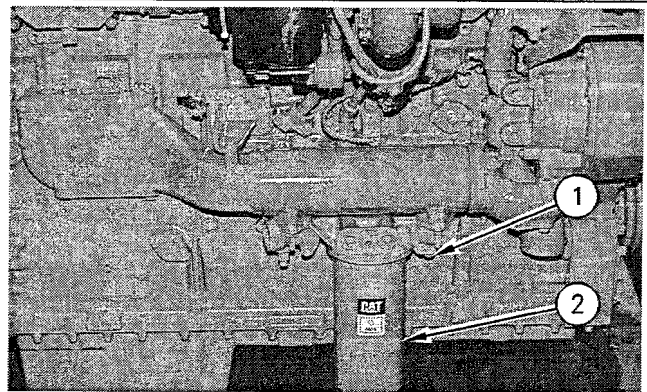


Illustration 53

g00497217

Typical example

5. Install plug (1).
6. Use Tool (A) to install oil filter (2).
7. Check the engine oil level.

i01933191

## Engine Oil Cooler - Remove

SMCS Code: 1378-011

### Removal Procedure

**Start By:**

- a. Remove the engine oil filter base. Refer to Disassembly and Assembly, "Engine Oil Filter Base - 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.

1. Drain the oil from the engine oil cooler into a suitable container for storage. Drain the coolant from the cooling system. Refer to Operation and maintenance Manual, "Cooling System Coolant (Deac) - Change" in order to drain the coolant.

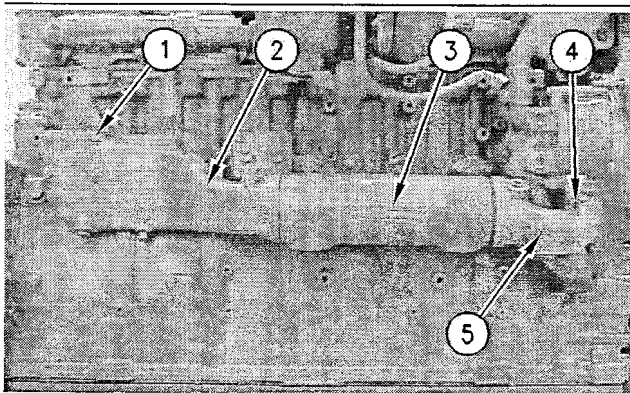


Illustration 54  
Typical example

g00619340

2. Remove bolts (1) that hold oil cooler bonnet (2) to the engine.
3. Remove bolts (4) that hold the oil cooler bonnet (5) to the water pump.
4. Use two technicians to remove oil cooler (3), oil cooler bonnet (2), and oil cooler bonnet (5) as an assembly. The weight of oil cooler (3), oil cooler bonnet (2), and oil cooler bonnet (5) is approximately 24 kg (53 lb).
5. Remove the gaskets from oil cooler bonnet (2) and from oil cooler bonnet (5).

## Engine Oil Cooler - Disassemble

**SMCS Code:** 1378-015

### Disassembly Procedure

**Start By:**

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

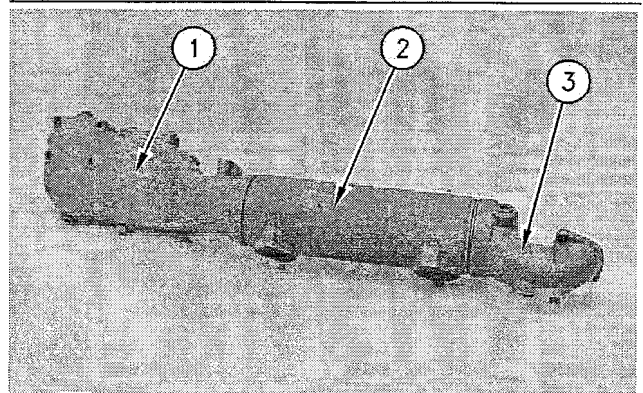


Illustration 55

g00619597

**Note:** Put identification marks on the oil cooler, the oil cooler bonnet, and the elbow for the oil cooler for proper alignment during assembly.

1. Separate oil cooler bonnet (1) and elbow (3) from oil cooler (2).

i01163135

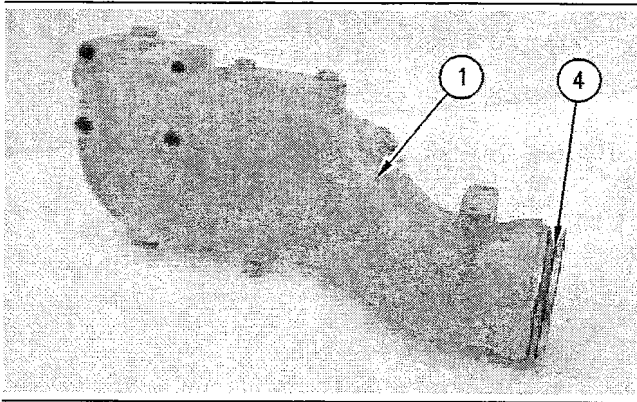


Illustration 56

g00619616

2. Remove O-ring seal (4) from oil cooler bonnet (1).

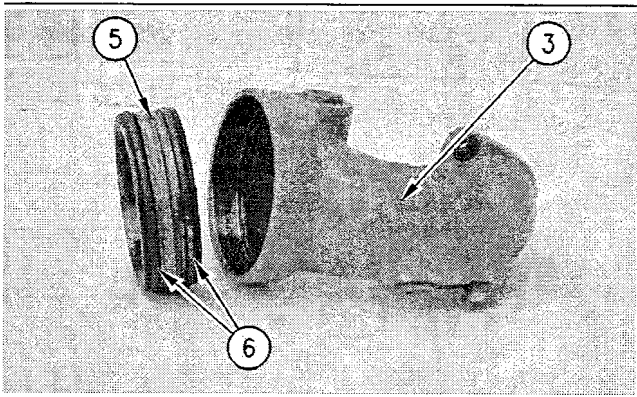


Illustration 57

g00619807

3. Remove adapter (5) from elbow (3). Remove O-ring seals (6) from adapter (5).

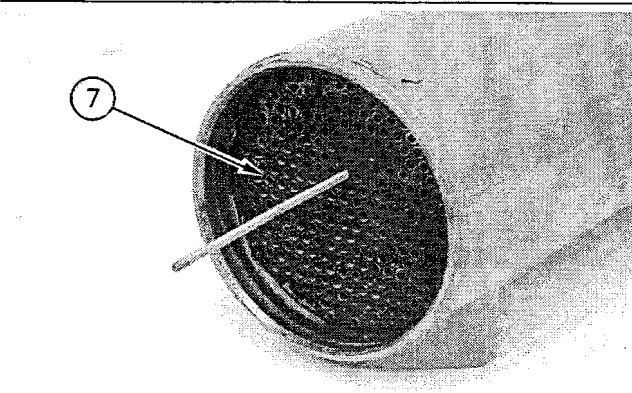


Illustration 58

g00619745

4. Clean tubes (7) for the oil cooler core with a 3.81 mm (0.150 inch) rod.

## Engine Oil Cooler - Assemble

SMCS Code: 1378-016

### Assembly Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Before assembly, check the condition of the gaskets and the O-ring seals. If the gaskets or the O-ring seals are worn or damaged, use new parts for replacement.

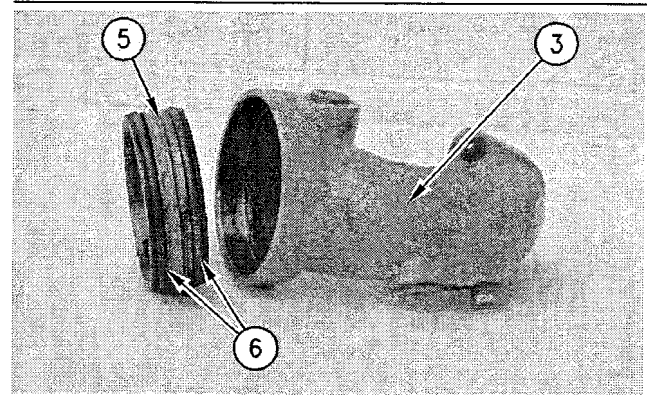


Illustration 59

g00619807

1. Put O-ring seals (6) in position on adapter (5). Put clean engine oil on the O-ring seals. Install adapter (5) in elbow (3).

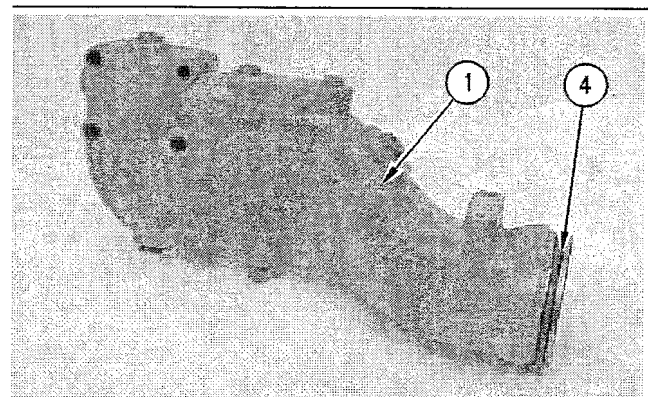


Illustration 60

g00619616

2. Put O-ring seal (4) in position on oil cooler bonnet (1). Put clean engine oil on O-ring seal (4).

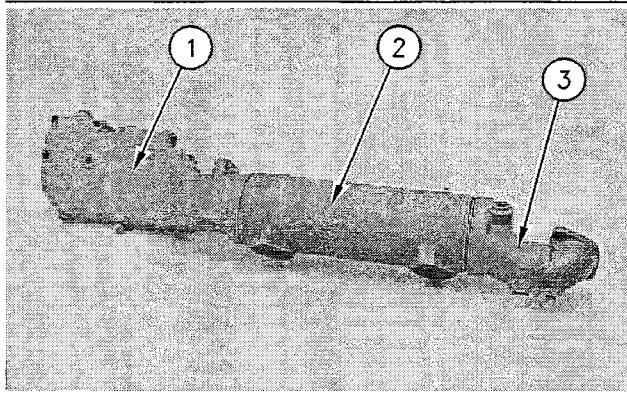


Illustration 61

g00619597

3. Align oil cooler bonnet (1) with oil cooler (2). Lubricate the bore of oil cooler (2) with clean engine oil. Install oil cooler bonnet (1) into the oil cooler.
4. Lubricate the bore of oil cooler (2) with clean engine oil. Install elbow (3) into the oil cooler.

**End By:**

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

i01933200

## Engine Oil Cooler - Install

**SMCS Code:** 1378-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

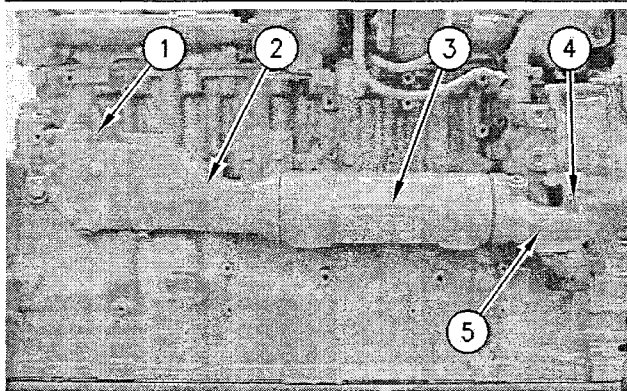


Illustration 62

g00619340

Typical example

1. Use two technicians to put oil cooler (33), oil cooler bonnet (1) and oil cooler bonnet (5) for the oil cooler into position on the engine as an assembly. The weight of the oil cooler assembly is approximately 24 kg (53 lb).
2. Put the oil cooler assembly in position on the engine and install bolts (1) that hold oil cooler bonnet (2) to the engine.
3. Install bolts (4) that hold oil cooler bonnet (5) for the oil cooler to the water pump.

**End By:**

- a. Install the engine oil filter base. Refer to Disassembly and Assembly, "Engine Oil Filter Base - Install".

i02009149

## Engine Oil Pump - Remove

**SMCS Code:** 1304-011

### 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.

**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.

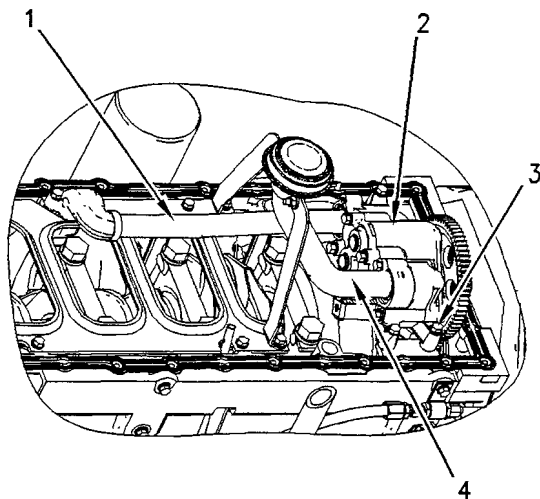


Illustration 63

g01001911

1. Remove oil supply tube assembly (1). Remove suction bell and tube assembly (4).
2. Remove bolts (3) and remove engine oil pump (2) from the cylinder block.

102110543

## Engine Oil Pump - Disassemble

SMCS Code: 1304-015

### Disassembly Procedure

Table 19

Required Tools			
Tool	Part Number	Part Description	Qty
A	1P-2321	Combination Puller	1
B	1P-0510	Driver Group	1

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

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.

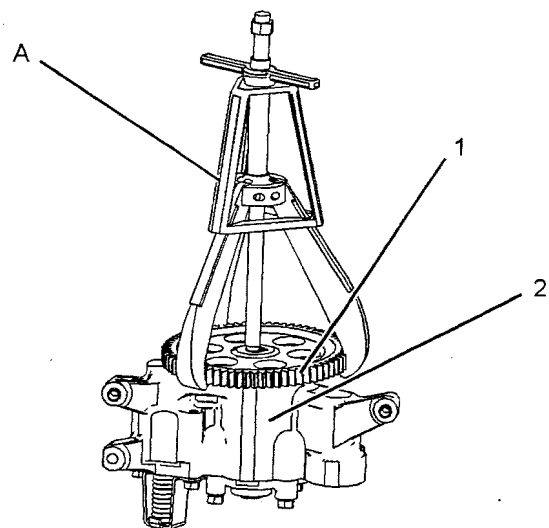


Illustration 64

g01001918

1. Remove the bolt that holds drive gear (1) to the shaft of body assembly (2).
2. Use Tooling (A) in order to remove drive gear (1) from the shaft. Remove the key from the shaft.

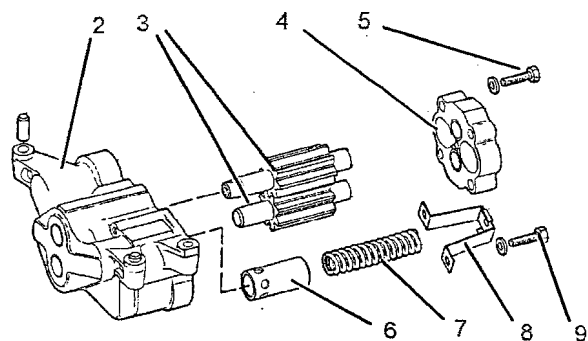


Illustration 65

g01001929

**⚠ 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.

3. Remove bolts (9) that hold retainer (8) to body assembly (2).
  4. Remove retainer (8), spring (7), and bypass valve (6) from the body assembly.
  5. Remove bolts (5) and cover (4) from body assembly (2).
- Note:** Inspect the bores in the cover. The aluminum cover does not have bearings. If the bores in the cover are damaged, replace the cover with a new part.
6. Remove idler gear and drive gear (3) from body assembly (2).
  7. Use Tooling (B) in order to remove the bearings from body assembly (2).

i02110558

## Engine Oil Pump - Assemble

SMCS Code: 1304-016

### Assembly Procedure

Table 20

Required Tools			
Tool	Part Number	Part Description	Qty
B	1P-0510	Driver Group	1

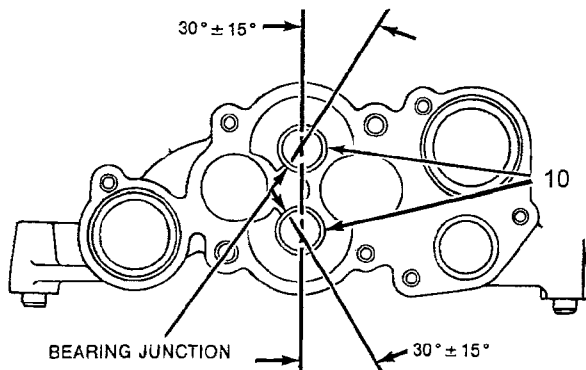


Illustration 66

g01017356

1. Install bearings (10) in the body assembly with Tooling (B). The bearing joint should be  $30 \pm 15$  degrees from the center line of the two bearing bores. Install the bearings so the bearings are even with the outside of the body assembly.
2. Before final assembly, check the condition and specifications of all of the parts of the engine oil pump. Refer to Specification, "Engine Oil Pump".

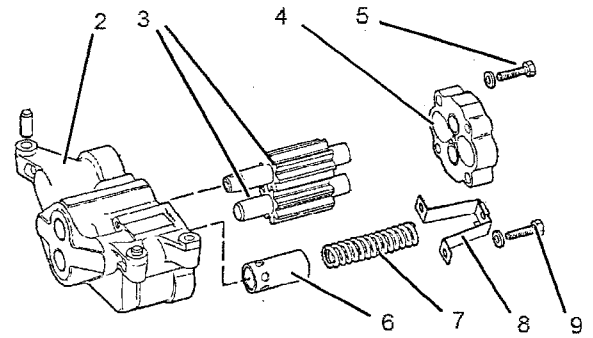


Illustration 67

g01001929

**⚠ 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.

3. Lubricate the bearings and idler gear and drive gear (3) with clean engine oil. Install the idler gear and drive gear in body assembly (2).
  4. Install cover (4). Install bolts (5) in order to secure the cover to body assembly (2).
- Note:** The engine oil pump must turn freely after assembly. Turn the engine oil pump by hand. Reposition cover (4) if the pump does not turn freely.
5. Install bypass valve (6), spring (7), retainer (8), and bolts (9).
  6. Install the key on the shaft.

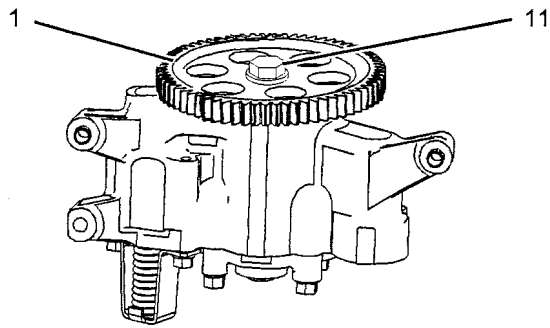


Illustration 68

g01017258

7. Install drive gear (1). Install bolt (11). Tighten the bolt to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft).

**End By:**

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

i01984303

## Engine Oil Pump - Install

SMCS Code: 1304-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

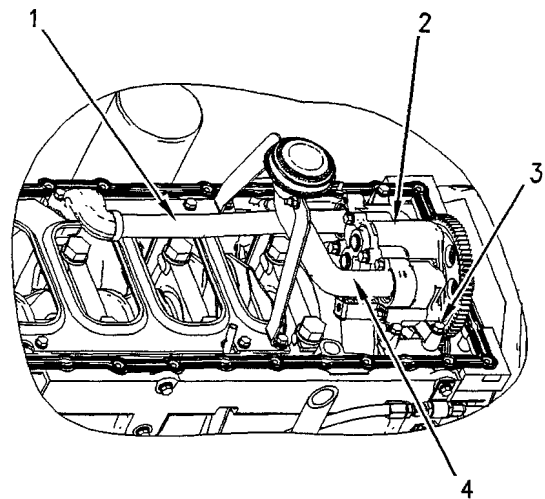


Illustration 69

g01001911

**Note:** Ensure that engine oil pump (2) is seated on the dowels before bolts (3) are tightened.

1. Position engine oil pump (2) on the dowels in the cylinder block. Install bolts (3).
2. Install oil supply tube assembly (1). Install suction bell and tube assembly (4).

**End By:**

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

i02110597

## Water Pump - Remove

SMCS Code: 1361-011

### Removal Procedure (Type 1)

**Start By:**

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

**Note:** Intermittent leakage of a small amount of coolant from the weep hole is not an indication of water pump seal failure. Seepage is normal to ensure proper lubrication of the face of the water pump seal. Replace the water pump if excessive leakage is observed from the weep hole in the water pump housing.

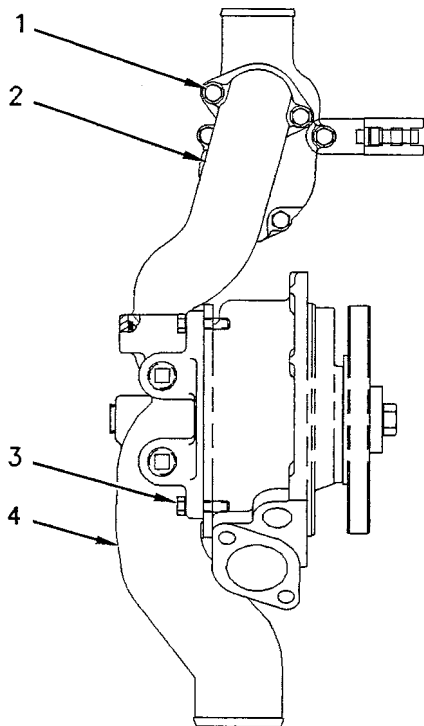


Illustration 70

g00569536

1. Remove bolts (1) and elbow assembly (2).
2. Remove the O-ring seal and the gasket on elbow assembly (2).
3. Remove bolts (3) and cover (4). Remove the O-ring seal between cover (4) and the water pump.

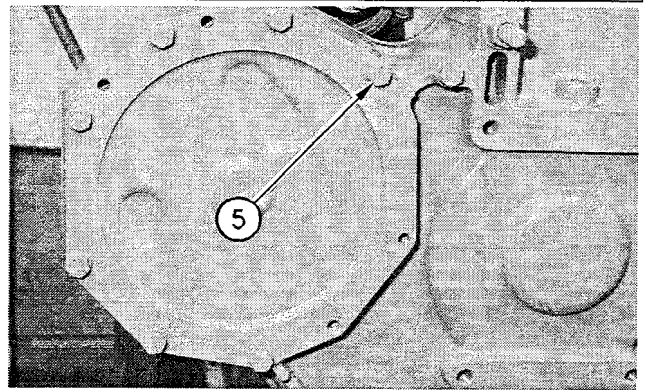


Illustration 71

g00569688

4. Remove bolts (5) and the water pump.

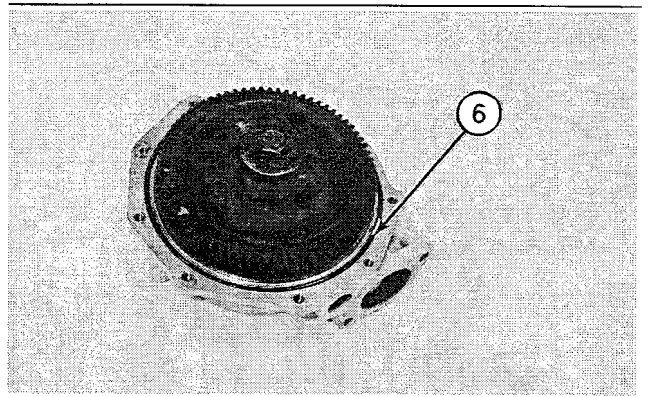


Illustration 72

g00499380

5. Remove O-ring seal (6) from the water pump.

**Removal Procedure (Type 2)****Start By:**

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

**Note:** Intermittent leakage of a small amount of coolant from the weep hole is not an indication of water pump seal failure. Seepage is normal to ensure proper lubrication of the face of the water pump seal. Replace the water pump if excessive leakage is observed from the weep hole in the water pump housing.

1. Remove the alternator and the alternator mounting bracket from the engine, if necessary.

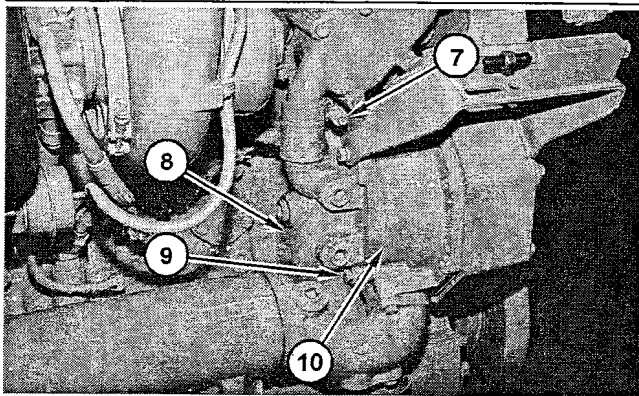


Illustration 73

g01040993

2. Loosen hose clamp (7).
3. Remove bolts (9) and water pump cover (8).
4. Remove the O-ring seal between water pump cover (8) and water pump (10).

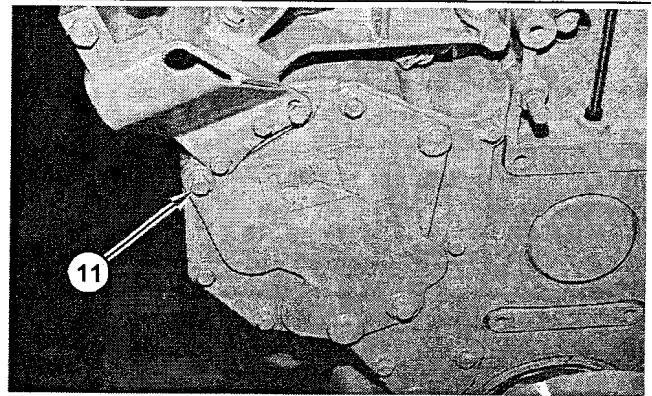


Illustration 74

g01040996

5. Remove bolts (11) and the water pump.

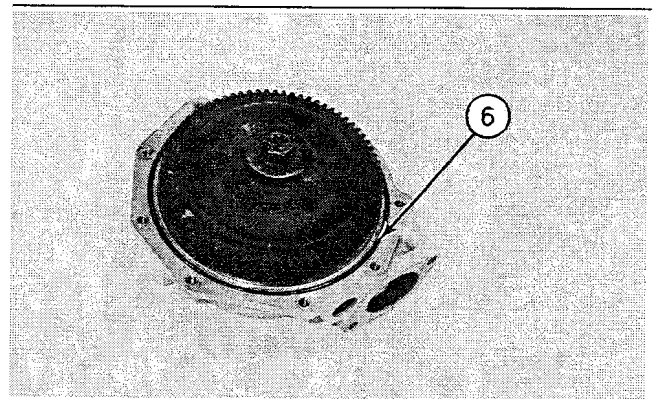


Illustration 75

g00499380

6. Remove O-ring seal (6) from the water pump.

i02006613

## Water Pump - Disassemble

SMCS Code: 1361-015

### Disassembly Procedure

Table 21

Required Tools			
Tool	Part Number	Part Description	Qty
A	8S-2264	Puller Group	1
	4B-3903	Bolt	2
	1P-0456	Plate	1
	4B-4277	Washer	2
B	9S-9152	Bearing Puller Gp	1

**Start By:**

- a. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove".

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The water pump seal can be replaced without removing the water pump from the engine.

- 4. Remove bolts (14) from bearing retainer (8). Remove bearing retainer (8). Remove bearing cone (6) and shaft (10) from housing (4) by inverting the pump assembly.
- 5. Invert the pump and drive or press seal (2) and oil seal (5) out of the housing.
- 6. Use a press and Tooling (B) to remove bearing assembly (6) from shaft (10).
- 7. Remove O-ring seal (16) from housing (4).

101993259

**Water Pump - Assemble**

SMCS Code: 1361-016

**Assembly Procedure**

Table 22

Required Tools			
Tool	Part Number	Part Description	Qty
C	1P-0510	Driver Group	1
D	138-9299	Oil Seal Tool	1
E	139-0088	Seal Tool	1
F	4C-9500	Quick Cure Primer	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

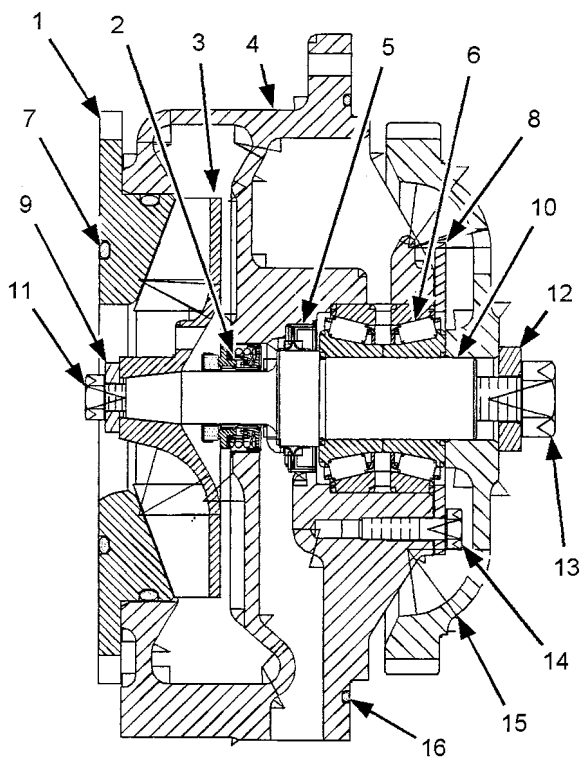


Illustration 76

g01009122

- 1. Remove O-ring seal (7) from adapter (1). Remove adapter (1) from housing (4). Remove the O-ring seal from the outside of adapter (1).
- 2. Remove bolt (11) and washer (9). Use Tooling (A) to remove impeller (3) from shaft (10).
- 3. Remove bolt (13) and washer (12) from shaft (10). Remove gear (15) from shaft (10).

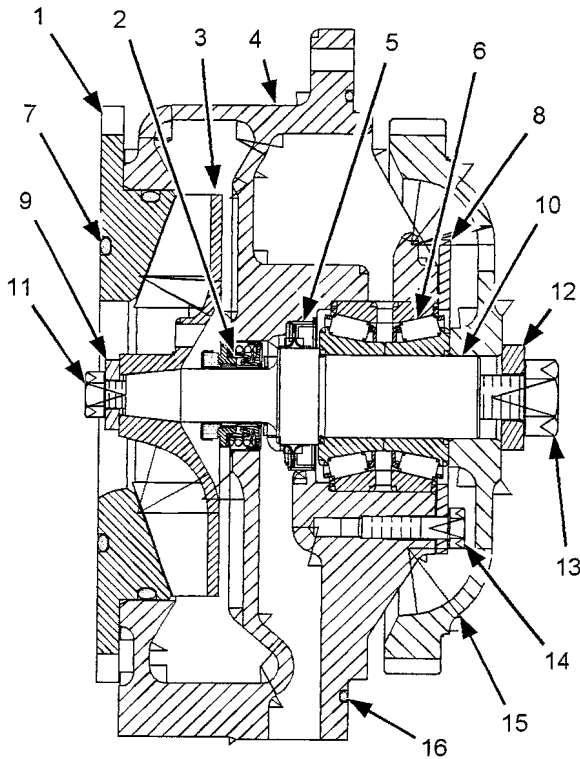


Illustration 77

g01009122

1. Use Tooling (F) to clean shaft (10) and the counterbore for oil seal (5) in housing (4).
2. Use Tooling (C) to install a new oil seal (5) in housing (4). Install the seal with the part number on the metal face of the seal toward the housing. Ensure that the oil seal is flush with the front edge of the counterbore of the housing. Do not lubricate the oil seal.
3. Install bearing cone (6) on shaft (10).
4. Position bearing retainer (8) with "this side out" markings toward the gear end of shaft (10). Install gear (15). Install washer (12) and bolt (13) on shaft (10). Tighten bolt (13) to a torque of  $215 \pm 40$  N·m ( $159 \pm 30$  lb ft).
5. Slide Tooling (D) over shaft (10). The tapered edge will be facing outward.

6. Install the gear and shaft assembly into housing (4). Use care not to damage the oil seal. Install bolts (14) that hold bearing retainer (8) to the housing.

7. Remove Tooling (D) from shaft (10).

8. Use a press and Tooling (E) to install a new seal (2) over shaft (10) and into housing (4). Ensure that the outer shell of the seal is fully seated in the housing.

9. Position impeller (3) on shaft (10). Install washer (9) and bolt (11). Tighten the bolt to a torque of  $39 \pm 3$  N·m ( $29 \pm 2$  lb ft).

10. Install a new O-ring seal on the outside of adapter (1). Lightly lubricate the seal with clean engine oil.

11. Install a new O-ring seal (7) on adapter (1).

12. Position adapter (1) on housing (4).

13. Install a new O-ring seal (16) in housing (4).

#### End By:

- a. Install the water pump. Refer to Disassembly and Assembly, "Water Pump - Install".

i01993484

## Water Pump - Install

SMCS Code: 1361-012

### Installation Procedure (Type 1)

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Check the condition of the gaskets and the O-ring seals. If the gaskets or the O-ring seals are worn or damaged, use new parts for replacement.

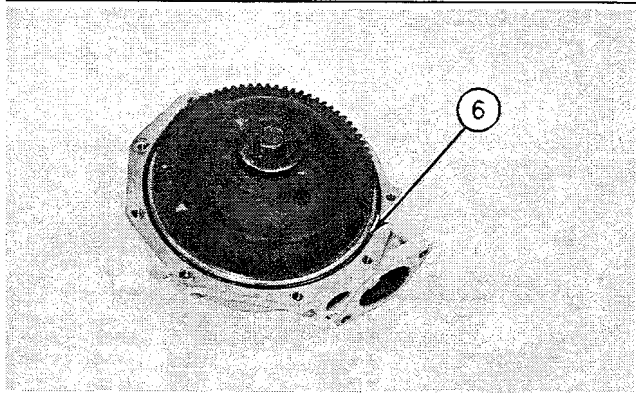


Illustration 78

g00499380

1. Install O-ring seal (6) on the water pump.

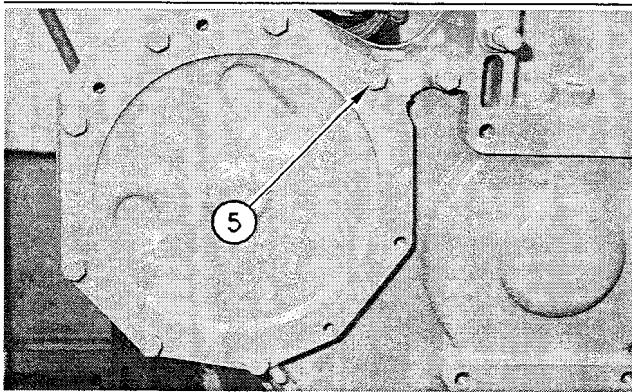


Illustration 79

g00569688

2. Position the water pump and install bolts (5).

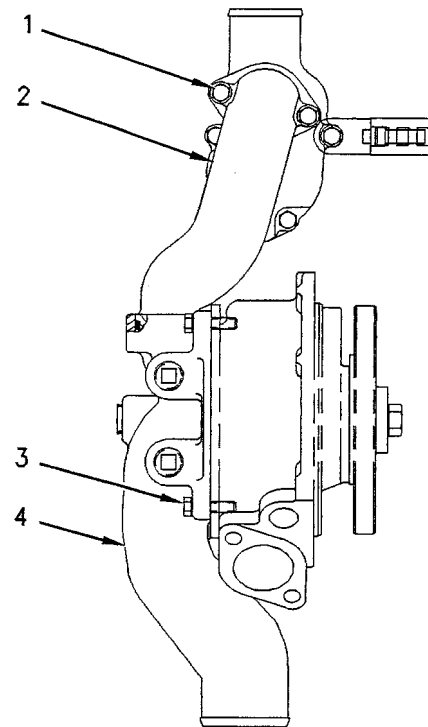


Illustration 80

g00569536

3. Install the O-ring seal between cover (4) and the water pump. Install cover (4) and bolts (3).
4. Install the O-ring seal and the gasket on elbow assembly (2). Lubricate the bore for the O-ring seal lightly with glycerin.
5. Install elbow assembly (2) and bolts (1).

#### End By:

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

### Installation Procedure (Type 2)

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Check the condition of the gaskets and the O-ring seals. If the gaskets or the O-ring seals are worn or damaged, use new parts for replacement.

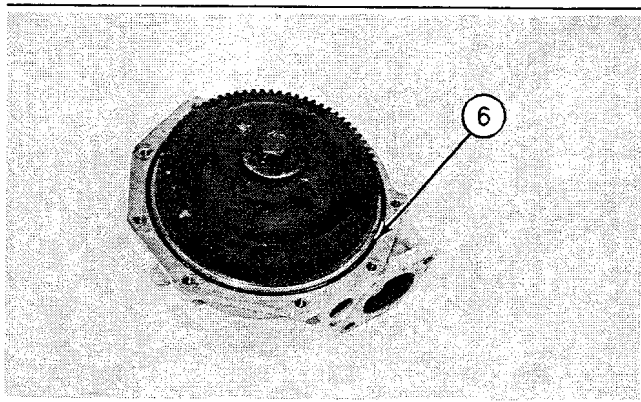


Illustration 81

g00499380

1. Install O-ring seal (6) on the water pump.

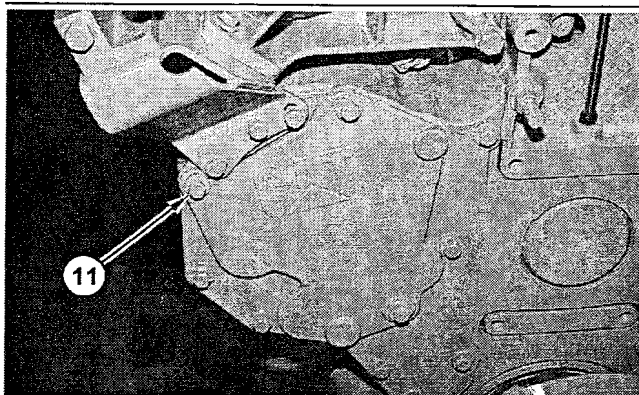


Illustration 82

g01040996

2. Position the water pump and install bolts (11).

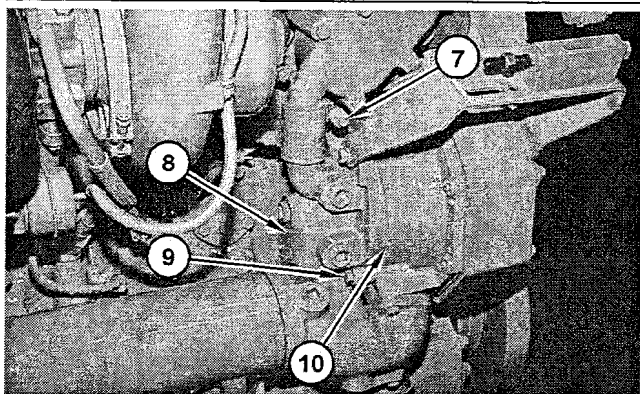


Illustration 83

g01040993

3. Install the O-ring seal between water pump cover (8) and water pump (10).
4. Install water pump cover (8) and bolts (9).
5. Tighten hose clamp (7).

6. Install the alternator bracket and the alternator, if these items were previously removed.

**End By:**

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

i00970894

## Water Temperature Regulator - Remove and Install

SMCS Code: 1355-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

Care must be taken to ensure that fluids are contained during performance of inspection, maintenance, testing, adjusting and repair of the machine. 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 in Caterpillar machines.

Dispose of all fluids according to local regulations and mandates.

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

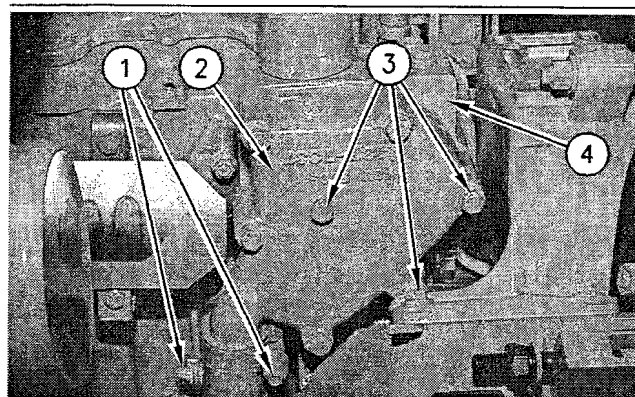


Illustration 84

g00494745

2. Loosen hose clamps (1). Remove three bolts (3).
3. Remove water temperature regulator housing (2) and manifold (4) for the water temperature regulator as a unit.

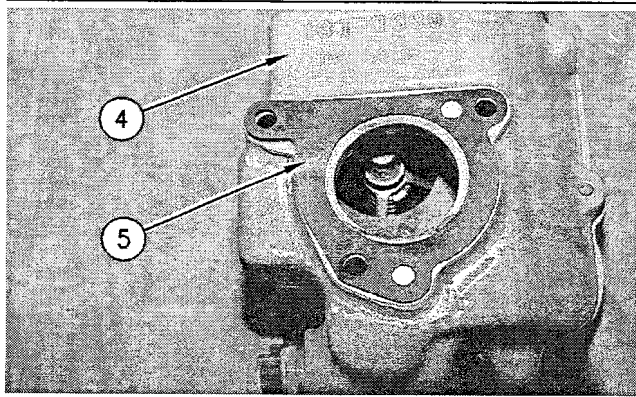


Illustration 85 g00494763

4. Remove gasket (5) from manifold (4) for the water temperature regulator.

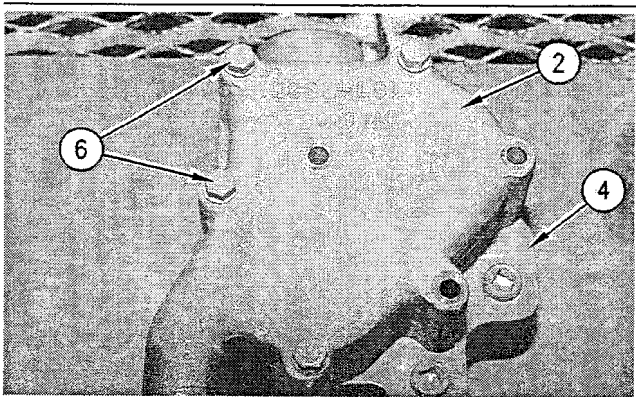


Illustration 86 g00494766

5. Remove four bolts (6). Separate water temperature regulator housing (2) from the manifold for the water temperature regulator.

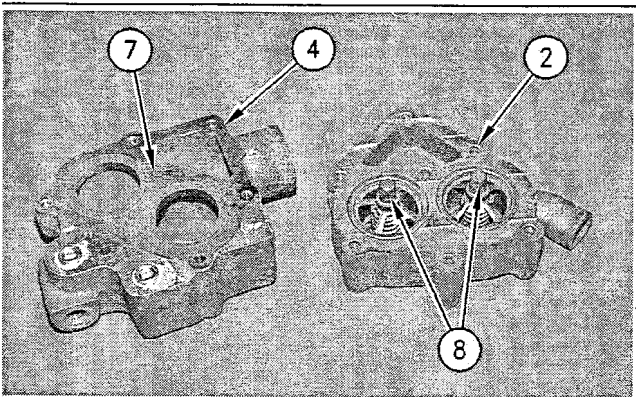


Illustration 87 g00494803

6. Remove gasket (7) from manifold (4) for the water temperature regulator.

7. Remove two water temperature regulators (8) from water temperature regulator housing (2).

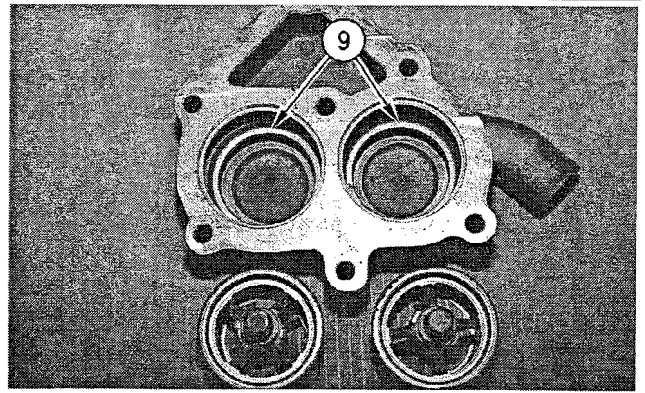


Illustration 88 g00494820

8. Remove two lip seals (9) from water temperature regulator housing (2).

## Installation Procedure

Table 23

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

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

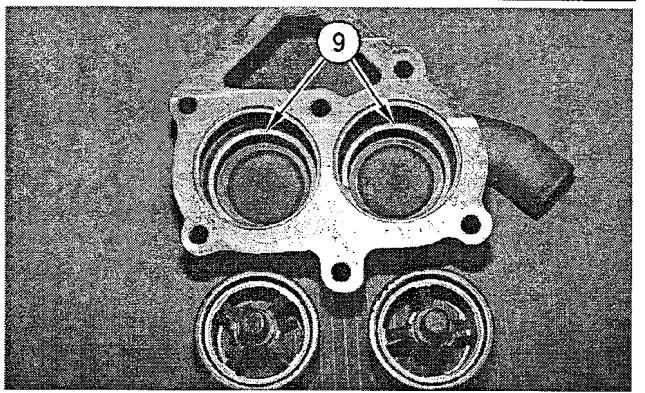


Illustration 89 g00494820

1. Install two lip type seals (9) in the water temperature regulator housing with Tool (A). Install the lip type seals until the seals are in the seat of the counterbore of the water temperature regulator housing.

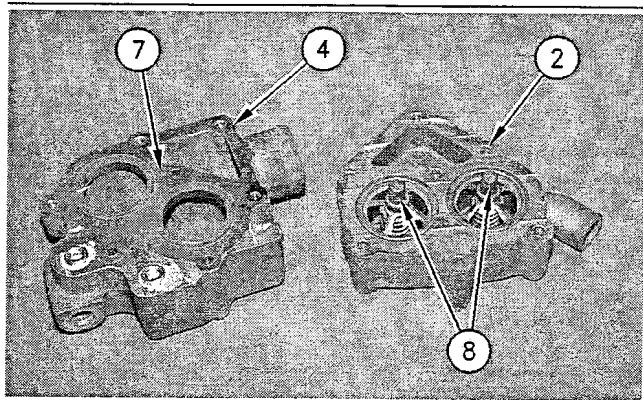


Illustration 90

g00494803

**NOTICE**

The water temperature regulators must be installed in the water temperature regulator housing, as shown, or the engine will overheat.

2. Install two water temperature regulators (8) in water temperature regulator housing (2).
3. Put gasket (7) in position between water temperature regulator housing (2) and manifold (4) for the water temperature regulator.

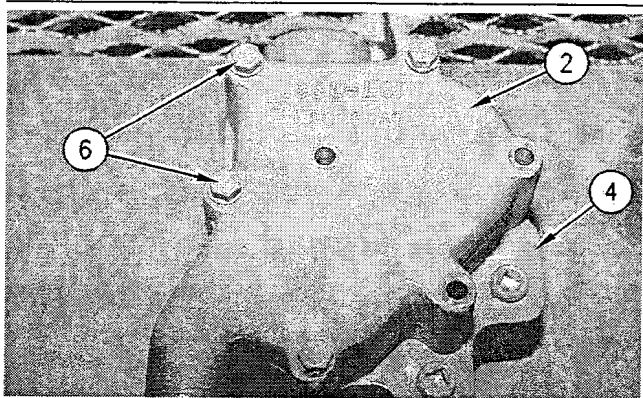


Illustration 91

g00494766

4. Put water temperature regulator housing (2) in position on manifold (4) for the water temperature regulator. Install four bolts 6 and tighten the bolts to a torque of  $50 \pm 9$  N·m ( $37 \pm 7$  lb ft).

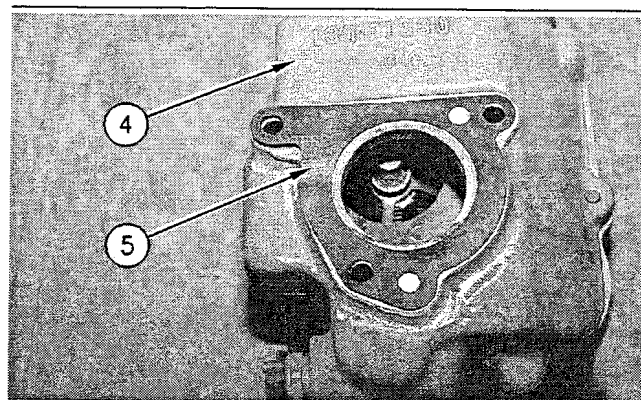


Illustration 92

g00494763

5. Install gasket (5) on manifold (4) for the water temperature regulator.

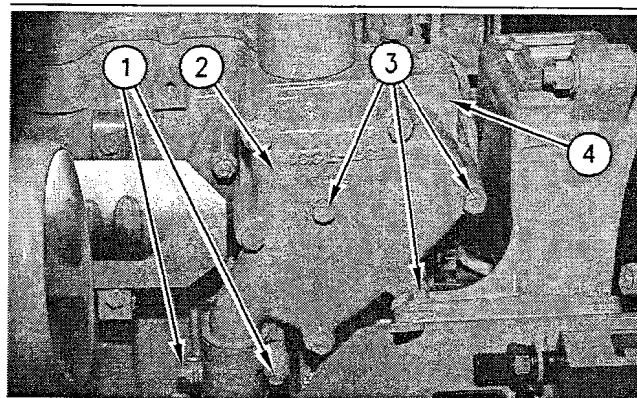


Illustration 93

g00494745

6. Put water temperature regulator housing (2) and manifold (4) for the water temperature regulator in position on the engine.
7. Install three bolts (3). Tighten hose clamps (1).
8. Fill the cooling system to the correct coolant level. Refer to Operation and Maintenance Manual, "Refill Capacities" in the Maintenance Section.

i01164962

i02110602

## Engine Support (Front) - Remove and Install

SMCS Code: 1154-010-FR

### Removal Procedure

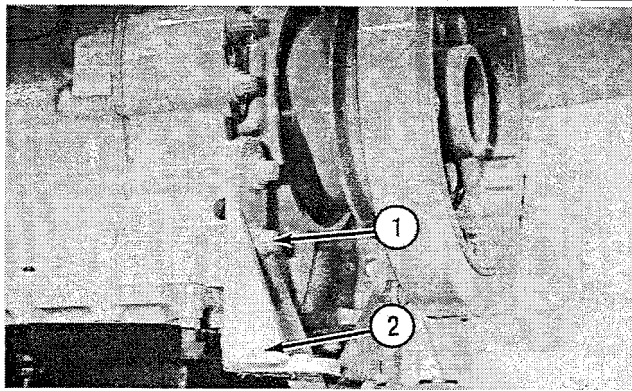


Illustration 94 g00621158

Typical example

1. Remove bolts (1) from engine support (front) (2).
2. Remove the engine support (front) from the engine.

### Installation Procedure

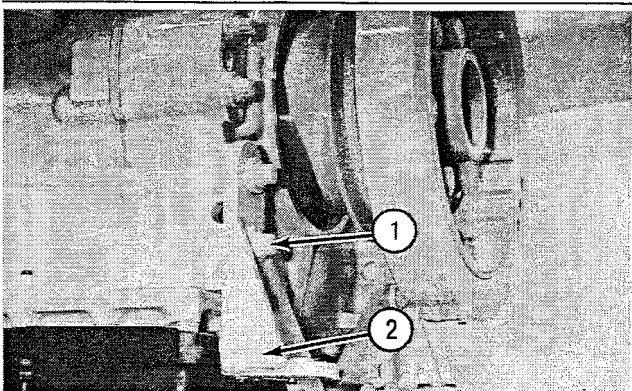


Illustration 95 g00621158

Typical example

1. Place engine support (front) (2) on the engine.
2. Install bolts (1).

**Note:** There are several variations on the types of engine supports. Refer to Specifications, "Engine Support (Front)" for the specifications for tightening the engine support.

## Flywheel - Remove

SMCS Code: 1156-011

### Removal Procedure

Table 24

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

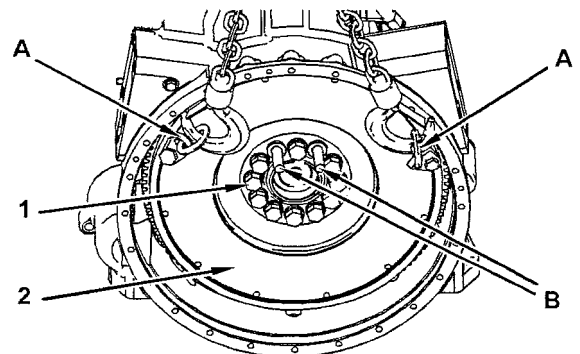


Illustration 96

g01042414

1. Install Tooling (A) on the flywheel. Use a suitable lifting device. The weight of the flywheel is approximately 65 kg (143 lb).
2. Remove two bolts (1). Install Tooling (B).
3. Remove remaining bolts (1) that hold the flywheel to the crankshaft. Remove flywheel (2).



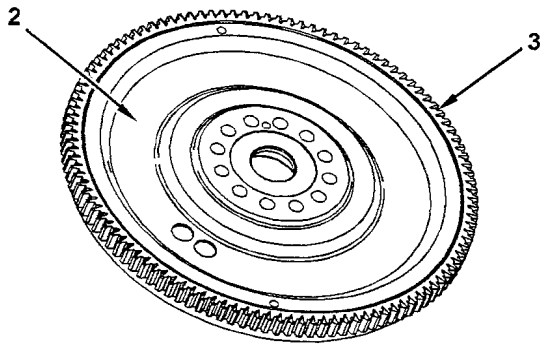


Illustration 97

g01042415

4. If necessary, use a hammer and a punch in order to remove ring gear (3) from flywheel (2).

i01993550

## Flywheel - Install

SMCS Code: 1156-012

### Installation Procedure

Table 25

Required Tools			
Tool	Part Number	Part Description	Qty
A	138-7573	Lifting Bracket	2
B	FT2712	Guide Stud	2
C	4C-5593	Anti-Seize Compound	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

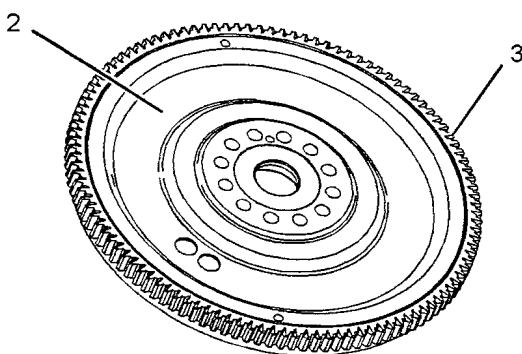


Illustration 98

g01018440

#### NOTICE

The ring gear must be installed with the chamfered side of the teeth upward. The chamfered side of the gear teeth will be facing toward the starter motor when the flywheel is installed so that the starter motor will engage correctly.

1. Raise the temperature of ring gear (3). Install ring gear (3) on flywheel (2).

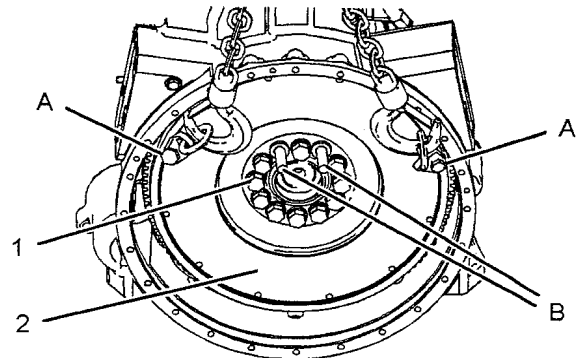


Illustration 99

g01018439

2. Install Tooling (B).
3. Fasten a suitable lifting device to flywheel (2). Use Tooling (A) to install flywheel (2) on Tooling (B).
4. Apply Tooling (C) to bolts (1) that hold the flywheel to the crankshaft. Tighten bolts (1) to a torque of  $270 \pm 40 \text{ N}\cdot\text{m}$  ( $200 \pm 30 \text{ lb ft}$ ).
5. Remove Tooling (A) and Tooling (B).
6. Install remaining bolts (1). Apply Tooling (C) to bolts (1) that hold the flywheel to the crankshaft. Tighten bolts (1) to a torque of  $270 \pm 40 \text{ N}\cdot\text{m}$  ( $200 \pm 30 \text{ lb ft}$ ).
7. Check the flywheel runout. Refer to Testing and Adjusting, "Flywheel - Inspect" and Testing and Adjusting, "Flywheel Housing - Inspect".

i02016240

i01993721

## Crankshaft Rear Seal - Remove

SMCS Code: 1161-011

### Removal Procedure

Table 26

Required Tools			
Tool	Part Number	Part Description	Qty
A	1U-7600	Slide Hammer Puller	1

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The rear seal and the wear sleeve must be replaced at the same time. Once the crankshaft rear seal and the wear sleeve are separated, these components can not be used again.

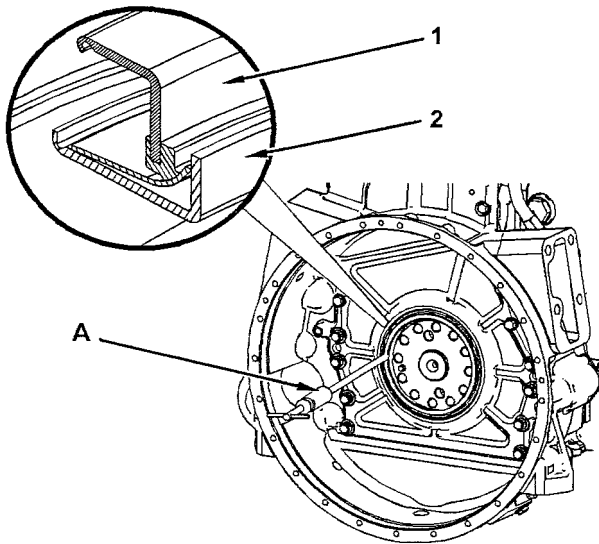


Illustration 100

g01042446

1. Use Tooling (A) to remove wear sleeve (2).
2. Use Tooling (A) to remove crankshaft rear seal (1).

## Crankshaft Rear Seal - Install

SMCS Code: 1161-012

### Installation Procedure

Table 27

Required Tools			
Tool	Part Number	Part Description	Qty
B <sup>(1)</sup>	5P-3594	Locator	1
C <sup>(1)</sup>	1T-0720	Bolts	3
D <sup>(1)</sup>	8T-2855	Sleeve Installer	1
E <sup>(1)</sup>	9S-8858	Nut (Seal Installer)	1
F <sup>(1)</sup>	9S-2856	Other Parts	1
G	4C-9500	Quick Cure Primer	1
H	4C-9507	Retaining Compound	1

<sup>(1)</sup> Use with a BrakeSaver

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The rear seal and the wear sleeve must be replaced at the same time. Once the seal and the wear sleeve are separated, these components cannot be used again. Refer to Special Instruction, SMHS8508, "Special Handling Information and Installation Instructions for Crankshaft Seal Groups that Have Hydrodynamic Grooves In the Sealing Lip" before the seal is serviced.

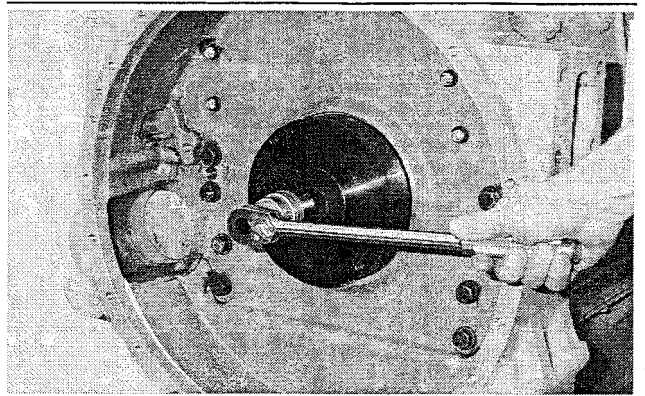


Illustration 101

g00558335

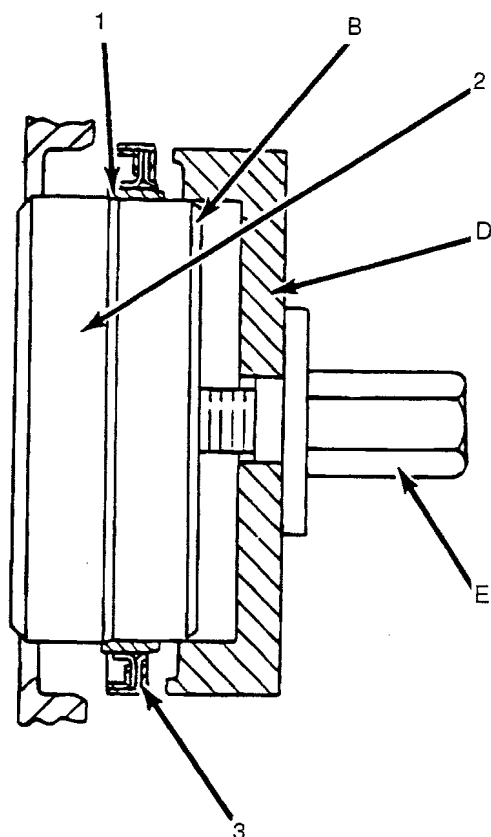


Illustration 102

g01032425

**Note:** Do not use any type of lubricant during the installation of the crankshaft seal and wear sleeve.

1. Before installation of the crankshaft seal and the wear sleeve, inspect the crankshaft for scratches. Also, inspect the crankshaft for any distortion on the surface that may lead to an out of round condition. Use a polishing cloth in order to remove any imperfections on the crankshaft.
2. Use Tooling (G) to clean the outside diameter of crankshaft (2) and the inside diameter of wear sleeve (1).
3. Apply Tooling (H) to the outside diameter of crankshaft (2). Apply Tooling (H) to the inside diameter of wear sleeve (1).
4. Fasten Tooling (B) to crankshaft (2) with Tooling (C).

### NOTICE

The front and rear seals and wear sleeves have different spiral grooves in the seal. Because of this type of design, the front seal group for an engine is different from the rear seal group. If a seal group is installed on the wrong end of the engine, oil can actually be taken out of the engine instead of moving oil back into the engine.

**Note:** Install the seal with the arrow that shows the direction of crankshaft rotation toward the rear of the engine.

5. Position wear sleeve (1) and seal (3) on Tooling (B). Install Tooling (D) on Tooling (B). Lubricate the face of the washer on Tooling (E). Install Tooling (E) on Tooling (B).
6. Tighten Tooling (E) until Tooling (D) contacts Tooling (B).
7. Remove Tooling (B), Tooling (C), Tooling (D), and Tooling (E). Check the crankshaft seal and the wear sleeve for the correct installation.

### End By:

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

i01162700

## Flywheel Housing - Remove and Install

SMCS Code: 1157-010

### Removal Procedure

Table 28

Required Tools			
Tool	Part Number	Part Description	Qty
A	138-7573	Link Bracket	1

### Start By:

- a. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".
- b. Remove the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

- c. 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.

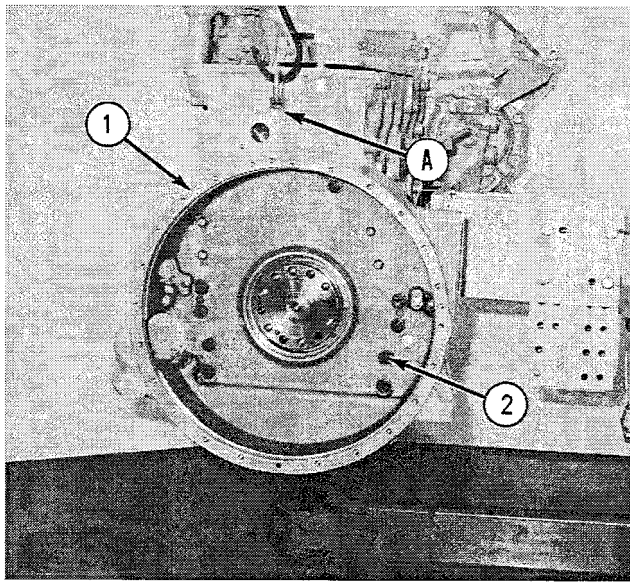


Illustration 103

g00516618

1. Install Tool (A) and a hoist to flywheel housing (2).
2. Remove bolts (1). Remove flywheel housing (2) from the dowels in the cylinder block. The weight of the flywheel housing is 32 kg (71 lb).

**Installation Procedure**

Table 29

Required Tools			
Tool	Part Number	Part Description	Qty
A	138-7573	Link Bracket	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

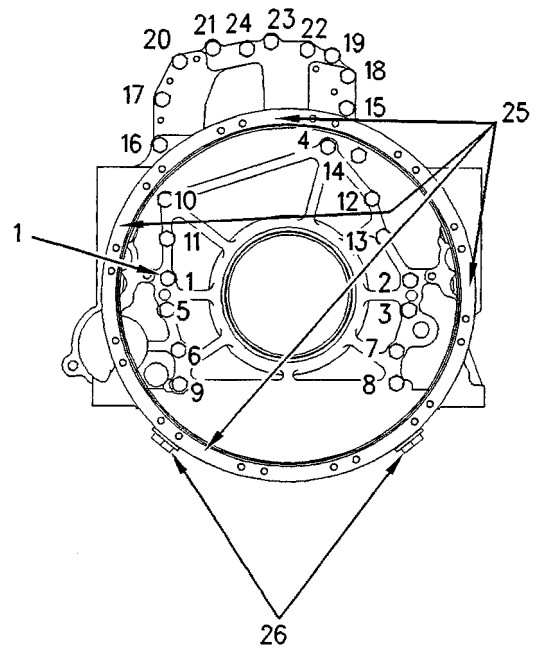


Illustration 104

g00633281

**Note:** During assembly, inspect the following components for any foreign materials: the front face of the flywheel housing, the two sides of the flywheel housing gasket, and the rear face of the cylinder block. These components must be free of the following substances: oil fuel, water, gasket adhesive, assembly compounds, and any other foreign material. Apply a small amount of 8T-9022 Silicone Gasket at joint of the following components: the flywheel housing, the engine oil pan, and the cylinder block.

1. Install Tool (A) and a hoist to the flywheel housing. Install bolt (1) through bolt (24). Use the following procedure in order to tighten the bolts:
  - a. In a numerical sequence, tighten bolt 1 through bolt 24 to a torque of  $40 \pm 10$  N·m ( $30 \pm 7$  lb ft).
  - b. In a numerical sequence, again tighten bolt 1 through bolt 9 to a torque of  $135 \pm 20$  N·m ( $100 \pm 15$  lb ft).
  - c. In a numerical sequence, again tighten bolt 10 through bolt 24 to a torque of  $55 \pm 10$  N·m ( $40 \pm 7$  lb ft).
2. The maximum permissible change from an exact vertical face at four points (25) is 0.38 mm (0.015 inch).

3. Apply 5P-3413 Pipe Sealant to the threads of plug (26). Tighten the plugs to a torque of  $9.5 \pm 1.5 \text{ N}\cdot\text{m}$  ( $84 \pm 13 \text{ lb in}$ ).

**End By:**

- a. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- b. Install the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".
- c. Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".

i02110604

## Vibration Damper and Pulley - Remove and Install

**SMCS Code:** 1205-010

### Removal Procedure

Table 30

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt 5/8 - 18 NF	1

**Start By:**

- a. Remove the fan drive belts. Refer to Disassembly and Assembly, "Fan Drive - Remove".

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

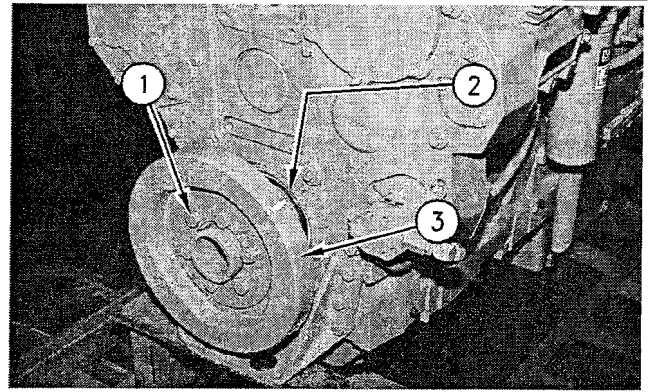


Illustration 105

g00514084

1. Remove top bolt (1) from the vibration damper and pulley assembly. Install Tooling (A) in place of the bolt.
2. Remove remaining bolts (1).
3. Remove vibration damper (3) from the crankshaft.
4. Remove pulley (2) from the crankshaft.

### Installation Procedure

Table 31

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt 5/8 - 18 NF	1
B	4C-5593	Anti-Seize Compound	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

Thoroughly inspect the viscous damper for signs of leakage or for signs of a dented (damaged) case. Either of these conditions can cause the weight to make contact with the case. This can affect the viscous damper's operation.

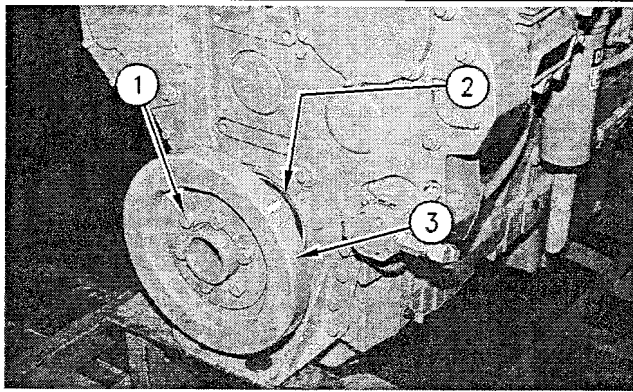


Illustration 106 g00514084

1. Install Tooling (A) in the bolt hole at the top of the crankshaft.
2. Install pulley (2) and vibration damper (3) on the crankshaft.
3. Apply Tooling (B) to bolts (1). Install bolts (1).
4. Remove Tooling (A). Install bolt (1) in place of Tooling (A).

**End By:**

- a. Install the fan drive belts. Refer to Disassembly and Assembly, "Fan Drive - Install".

i02016277

## Crankshaft Front Seal - Remove

SMCS Code: 1160-011

### Removal Procedure

Table 32

Required Tools			
Tool	Part Number	Part Description	Qty
A	1U-7600	Slide Hammer Puller	1

**Start By:**

- a. Remove the vibration damper and the pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove and Install".

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The crankshaft front seal and the wear sleeve must be replaced at the same time. Once the crankshaft front seal and the wear sleeve are separated, these components can not be used again.

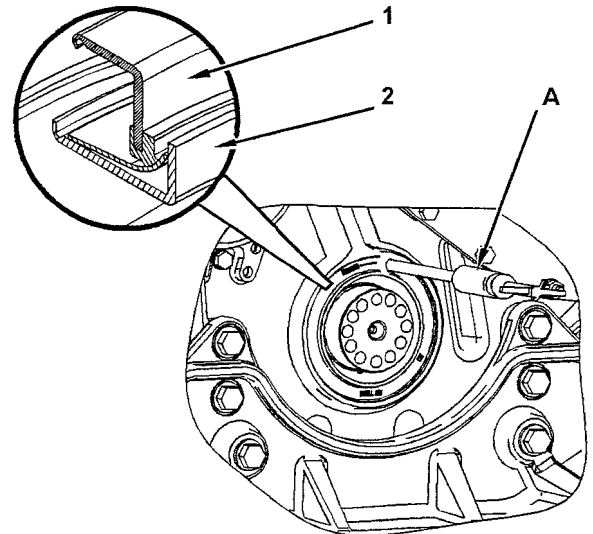


Illustration 107 g01042474

1. Use Tooling (A) or a punch and hammer in order to puncture three or more holes in wear sleeve (2) and crankshaft front seal (1).
2. Use Tooling (A) to remove the wear sleeve and the crankshaft front seal.

i02016329

## Crankshaft Front Seal - Install

SMCS Code: 1160-012

### Installation Procedure

Table 33

Required Tools			
Tool	Part Number	Part Description	Qty
B	5P-1733	Seal Locator	1
C	5P-1737	Bolt	3
D	9S-8858	Nut (Seal Installer)	1
E	6V-6142	Seal Installer	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** The crankshaft front seal and the wear sleeve must be replaced at the same time. Once the crankshaft front seal and the wear sleeve are separated, these components cannot be used again.

**Note:** Do not use any type of lubricant during the installation of the crankshaft front seal and the wear sleeve.

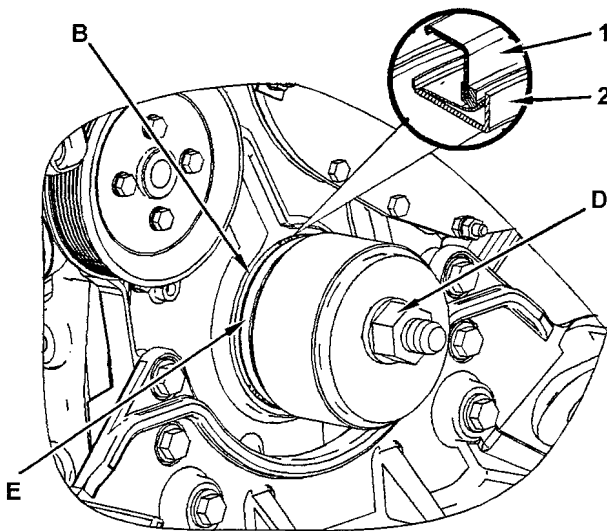


Illustration 108

g01042507

1. Fasten Tooling (B) to the crankshaft with Tooling (C).

**Note:** Install the crankshaft front seal with the arrow that shows the direction of crankshaft rotation toward the front of the engine.

2. Position wear sleeve (2) and crankshaft front seal (1) on Tooling (B). Install Tooling (E) on Tooling (B). Lubricate the face of the washer on Tooling (D). Install Tooling (D) on Tooling (B).
3. Tighten Tooling (D) until Tooling (E) contacts Tooling (B).
4. Remove Tooling (D), and Tooling (E) from Tooling (B).
5. Remove Tooling (C) and Tooling (B) from the crankshaft.

#### End By:

- a. Install the vibration damper and the pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove and Install".

i01163158

## Front Cover - Remove

SMCS Code: 1166-011

### Removal Procedure

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

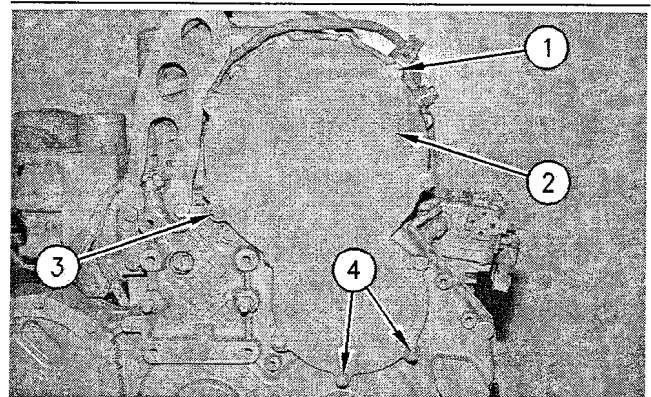


Illustration 109

g00619926

Typical example

1. Remove button head screw (3), bolts (1), and nuts (4).
2. Remove front cover (2).

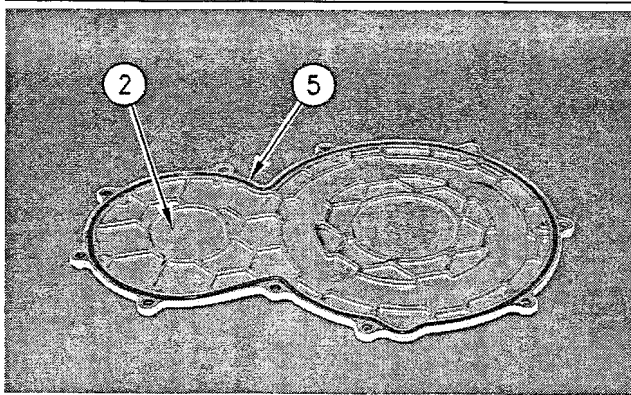


Illustration 110 g00579317

3. Remove seal (5) from front cover (2).

i01163170

## 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.

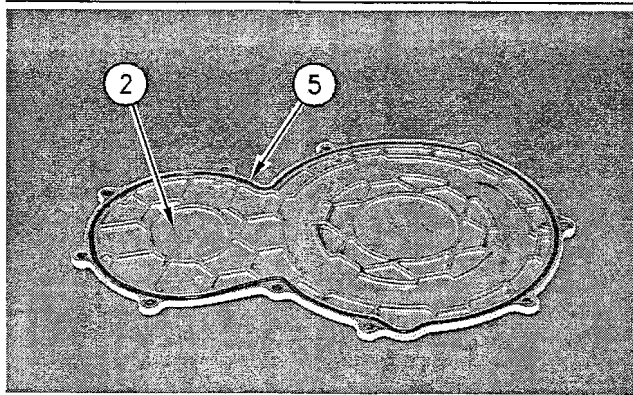


Illustration 111 g00579317

1. Inspect seal (5). If seal (5) is worn or damaged, replace the seal. Install seal (5) in front cover (2).

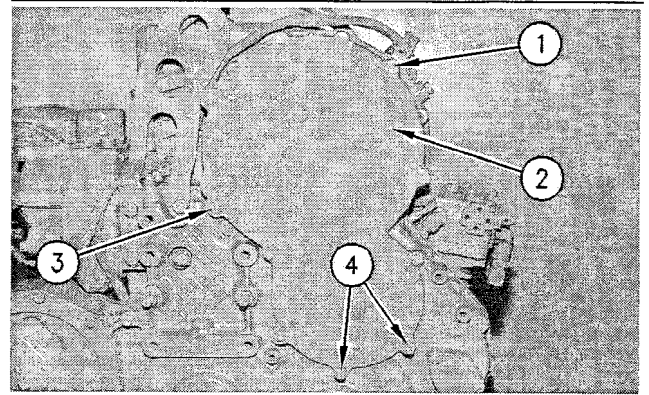


Illustration 112 g00619926

Typical example

2. Apply 7M-7456 Compound to the threads of the studs for nuts (4). Install front cover (2), button head screw (3), bolts (1), and nuts (4).

**Note:** Do not tighten button head screw (3) until bolts (1) and nuts (4) have been properly tightened.

3. Tighten bolts (1) and nuts (4).
4. Tighten button head screw (3) to a torque of  $13 \pm 3$  N·m ( $10 \pm 2$  lb ft).

**End By:**

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

i02241901

## Gear Group (Front) - Remove

SMCS Code: 1206-011

### Removal Procedure

Table 34

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

**Start By:**

- a. Set the No. 1 piston to top center on the compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".
- b. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".



**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**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.

**Note:** Be sure to mark the orientation of each of the gears for installation purposes.

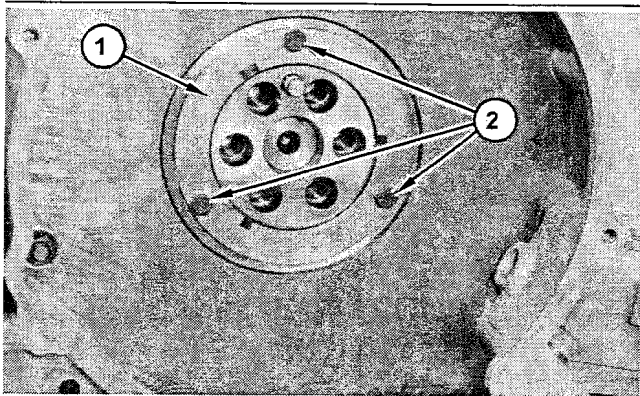


Illustration 113

g01039503

1. Remove bolts (2) and thrust plate (1).

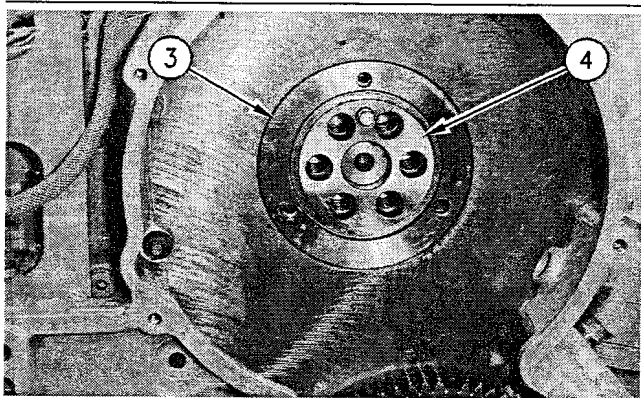


Illustration 114

g00576209

2. Remove seal assembly (3) and adapter (4).

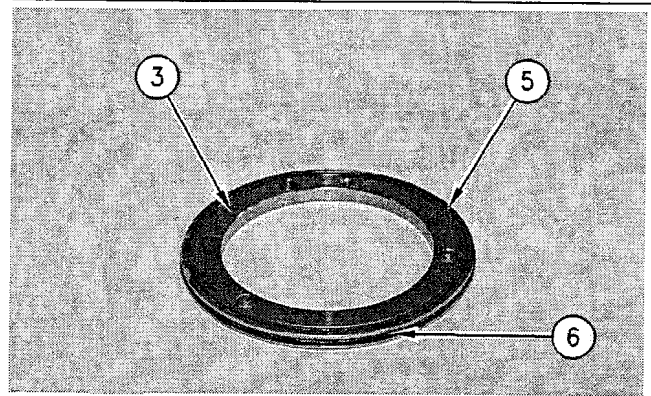


Illustration 115

g00576240

3. Remove O-ring seals (5) and (6) from seal assembly (3).

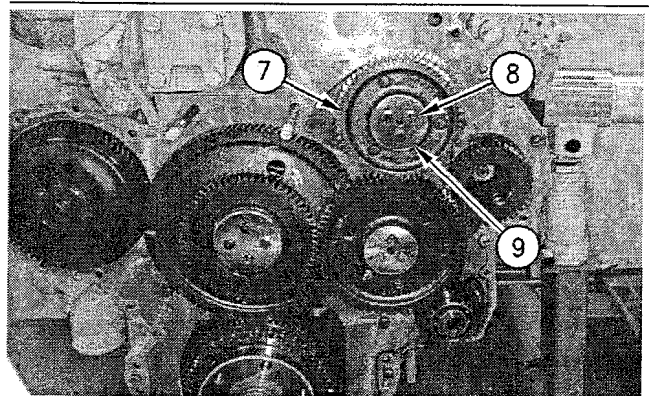


Illustration 116

g00576202

4. Remove bolts (8), plate (9), and adjustable idler gear (7).

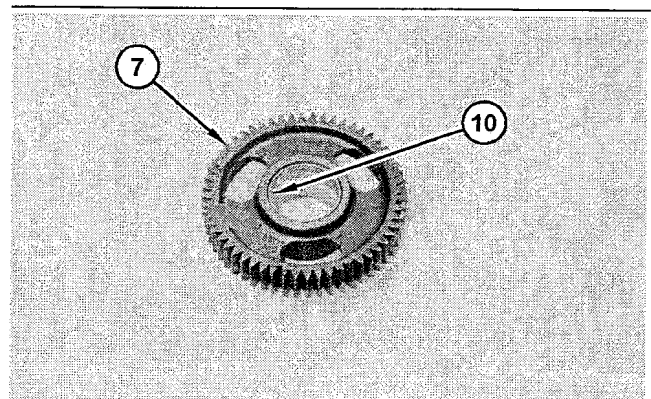


Illustration 117

g01039614

5. Check the condition of bearing (10) in adjustable idler gear (7). If bearing (10) is worn or damaged, use a new part for replacement. Use Tooling (A) to replace bearing (10) in adjustable idler gear (7).

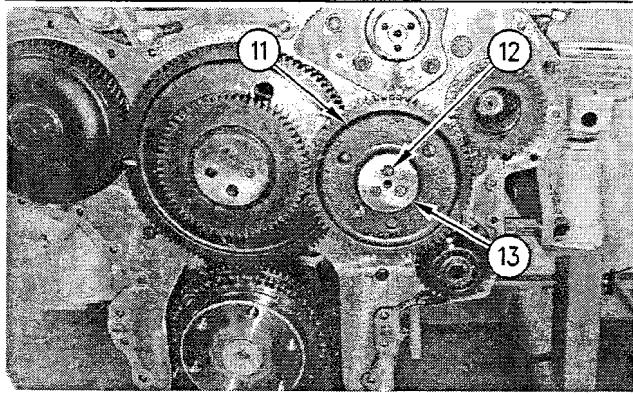


Illustration 118

g00576203

6. Remove bolts (12), plate (13), and idler gear (11).

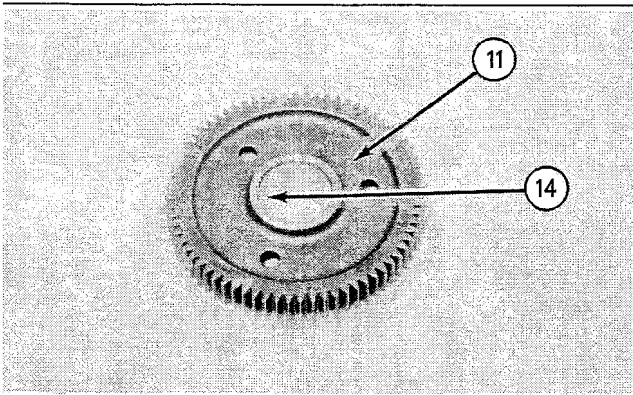


Illustration 119

g00576204

7. Check the condition of bearing (14) in idler gear (11). If bearing (14) is worn or damaged, use a new part for replacement. Use Tooling (A) to replace bearing (14) in idler gear (11).

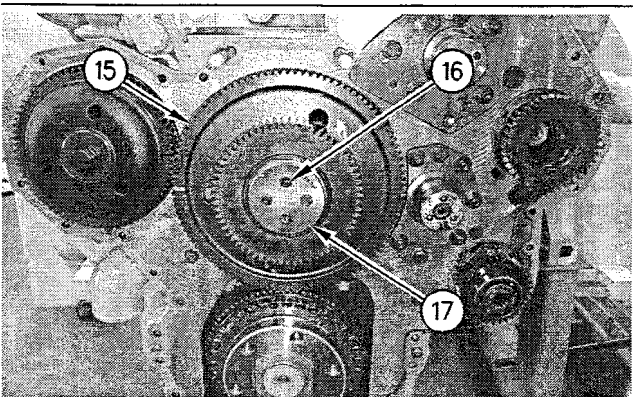


Illustration 120

g00576205

8. Remove bolts (16), plate (17), and cluster gear (15).

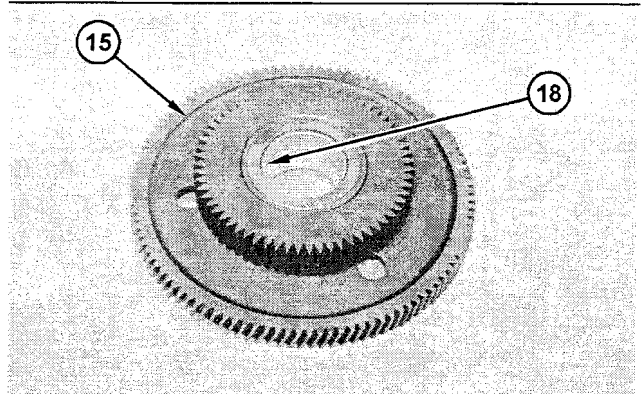


Illustration 121

g01039616

9. Check the condition of bearing (18) in cluster gear (15). If bearing (18) is worn or damaged, use a new part for replacement. Use Tooling (A) to replace bearing (18) in cluster gear (15).

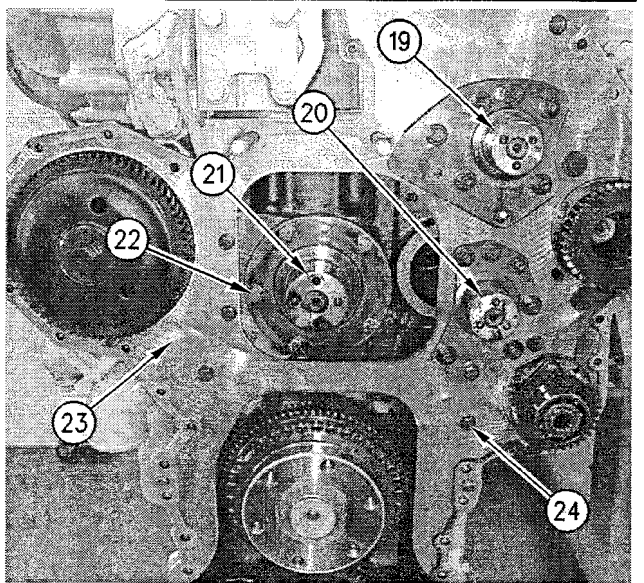


Illustration 122

g00576208

**Note:** Shaft assemblies (19) and (20) must be removed in order to remove plate (23).

**Note:** If the nuts and the bolt for shaft assembly (19) are loosened, or if shaft assembly (19) is removed or moved in any way, the backlash for the camshaft gear and adjustable idler gear (7) will need to be readjusted at assembly. The backlash will also need to be readjusted if the cylinder head was replaced. Refer to Testing and Adjusting, "Gear Group (Front - Time)".

10. Check the condition of shaft assembly (19). If the bearing diameter of the shaft is worn or damaged, remove the nuts and the bolt and replace shaft assembly (19) with a new part.

- 11. Check the condition of shaft assembly (20). If the bearing diameter of the shaft is worn or damaged, remove the nuts and the bolt and replace shaft assembly (20) with a new part.
- 12. Check the condition of shaft (21). If the bearing diameter of the shaft is worn or damaged, remove bolts (22) and replace shaft (21) with a new part.
- 13. Remove bolts (24) that hold plate (23) to the cylinder block. Remove plate (23).

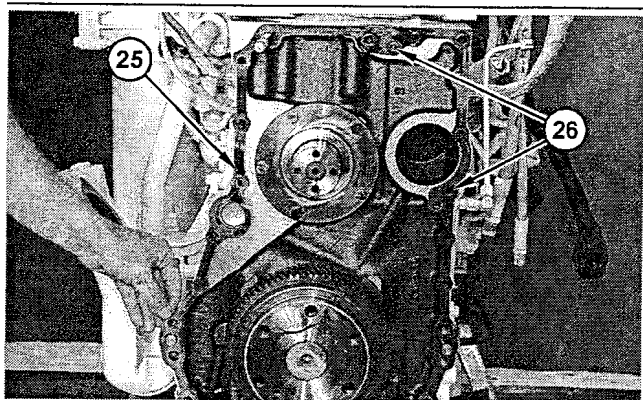


Illustration 123

g01039504

- 14. Remove gasket (25) and O-ring seals (26) from the cylinder block.

**Note:** On newer blocks, an integral seal is used instead of O-rings (26) and gasket (25).

i02241902

## Gear Group (Front) - Install

SMCS Code: 1206-012

### Installation Procedure

Table 35

Required Tools			
Tool	Part Number	Part Description	Qty
B	9S-3263	Thread Lock Compound	1
C	8T-2998	Lubricant	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

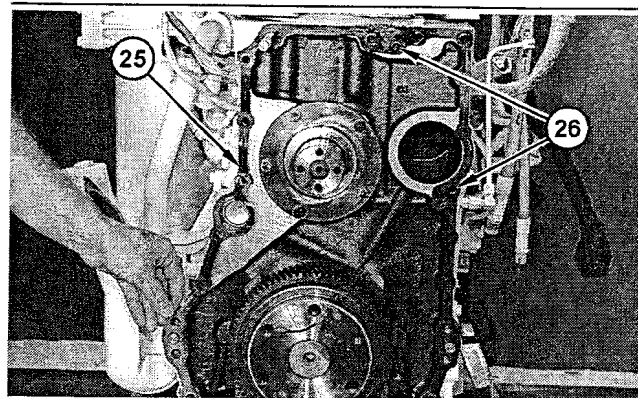


Illustration 124

g01039504

- 1. Thoroughly clean the gasket material from the cylinder block.
- 2. Install a new gasket (25) and O-ring seals (26) on the cylinder block.

**Note:** On newer blocks, an integral seal is used instead of O-ring seals (26) and gasket (25).

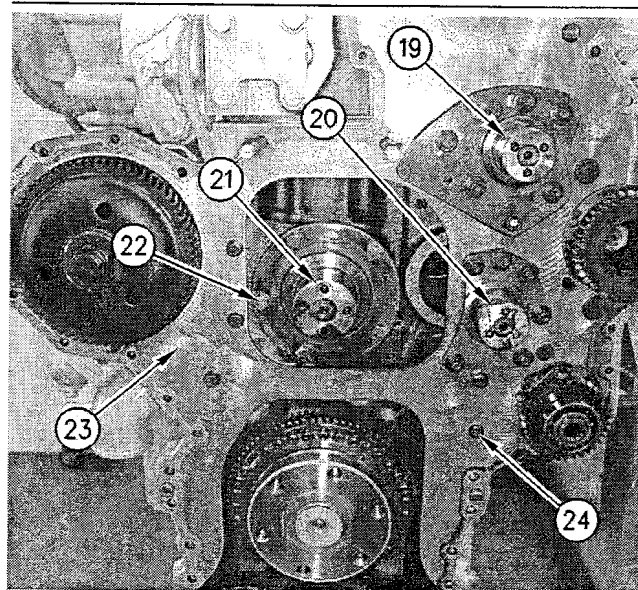


Illustration 125

g00576208

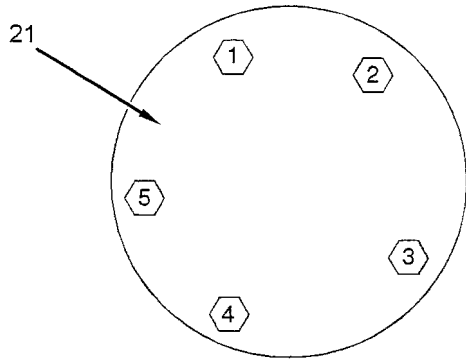


Illustration 126

g01032116

3. Thoroughly clean all gasket material from both sides of plate (23). Install plate (23) and bolts (24).
4. Install shaft assembly (20). Apply Tooling (B) to the studs and to the bolt for shaft assembly (20). Tighten the nuts and the bolt for shaft assembly (20) to a torque of  $55 \pm 10 \text{ N}\cdot\text{m}$  ( $41 \pm 7 \text{ lb ft}$ ).

**Note:** The backlash for the camshaft gear and for the adjustable idler gear will need to be readjusted if shaft assembly (19) has been removed, loosened, or moved in any way. The camshaft gear must be installed and the adjustable idler gear must be removed in order to perform the backlash adjustment procedure. Refer to Testing and Adjusting, "Gear Group (Front) - Time".

5. Install shaft assembly (19). Do not tighten the nuts and the bolt for shaft assembly (19) at this time. The nuts and the bolt for shaft assembly (19) will need to be tightened when the backlash is adjusted.
6. Apply Tooling (B) to bolts (22). Install shaft assembly (21). Tighten bolts (22) to a torque of  $55 \pm 10 \text{ N}\cdot\text{m}$  ( $41 \pm 7 \text{ lb ft}$ ) in the following sequence: (1, 3, 4, 5, 2, 1, 2, 3, 4, 5, 1).

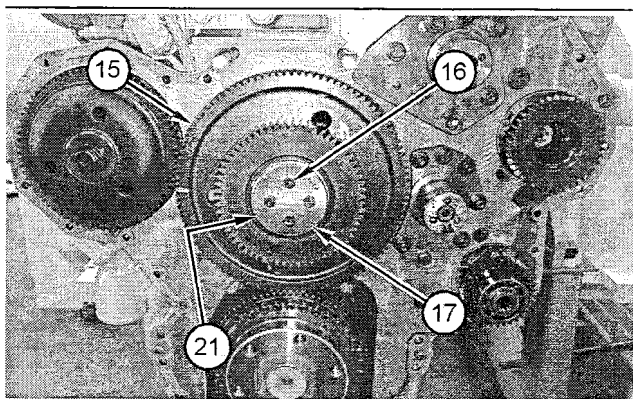


Illustration 127

g01074541

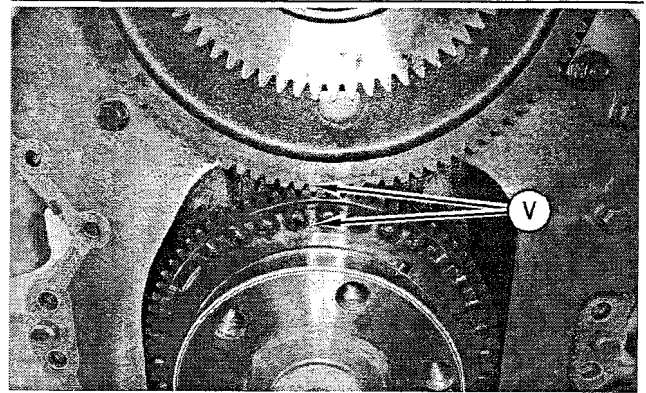


Illustration 128

g00516404

7. Put cluster gear (15) on shaft assembly (21). Ensure that Timing Marks (V) are aligned on the cluster gear and on the crankshaft gear. Apply Tooling (B) to bolts (16). Install plate (17) and bolts (16). Tighten bolts (16) to a torque of  $30 \pm 7 \text{ N}\cdot\text{m}$  ( $22 \pm 5 \text{ lb ft}$ ).

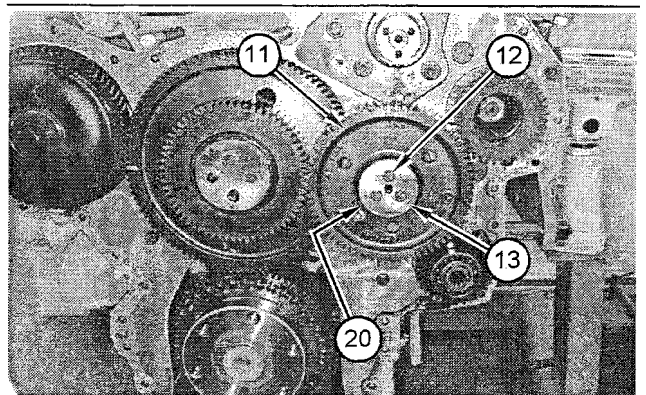


Illustration 129

g01074542

8. Position idler gear (11) on shaft assembly (20). Apply Tooling (B) to bolts (12). Install plate (13) with the oil groove toward the gear face. Install bolts (12) and tighten the bolts to a torque of  $30 \pm 7 \text{ N}\cdot\text{m}$  ( $22 \pm 5 \text{ lb ft}$ ).

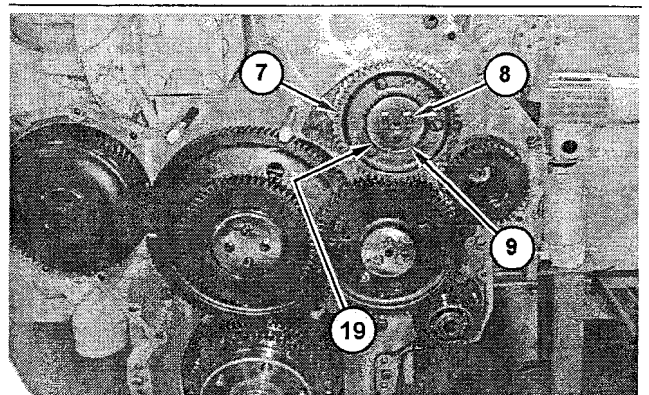


Illustration 130

g01074546

**Note:** Skip Step 9 if shaft assembly (19) has been removed, loosened, or moved in any way. The backlash for the camshaft gear and for the adjustable idler gear will need to be readjusted. The camshaft gear must be installed and the adjustable idler gear must be removed in order to perform the backlash adjustment procedure. Refer to Testing and Adjusting, "Gear Group (Front) - Time".

9. Position adjustable idler gear (7) on shaft assembly (19). Apply Tooling (B) to bolts (8). Install plate (9) and bolts (8). Tighten bolts (8) to a torque of  $30 \pm 7$  N·m ( $22 \pm 5$  lb ft).

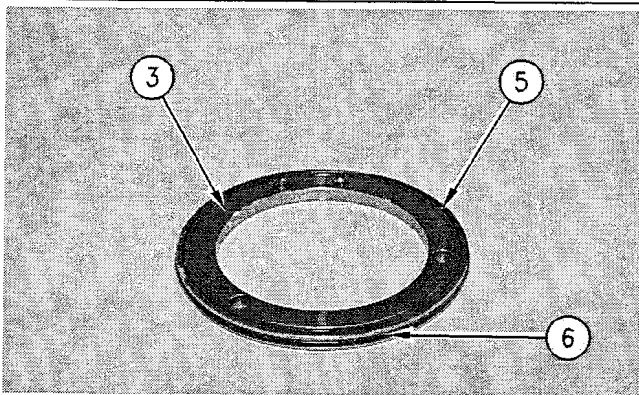


Illustration 131

g00576240

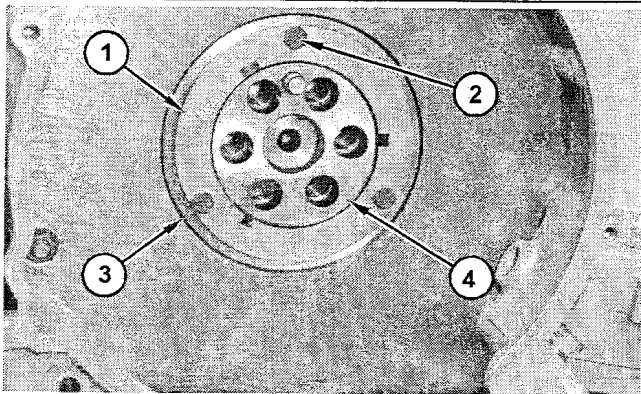


Illustration 132

g01039529

10. Install O-ring seals (5) and (6) in seal assembly (3). Lubricate seal (6) with a 50/50 mixture of Tooling (C) and engine oil.
11. Assemble thrust plate (1) and seal assembly (3). Apply Tooling (B) to bolts (2). Hold the assembly in position and install bolts (2). Evenly tighten bolts (2) until seal assembly (3) and O-ring seal (5) are seated against the cylinder head.

**Note:** Be careful in order to ensure that O-ring seal (5) stays in the groove in seal assembly (3).

12. Install adapter (4). Ensure that the dowel in adapter (4) engages the hole in the camshaft.

13. Adjust the backlash for the camshaft gear and for the adjustable idler gear, if necessary. Refer to Testing and Adjusting, "Gear Group (Front) - Time".

**Note:** The camshaft gear must be installed and the adjustable idler gear must be removed in order to perform the backlash adjustment procedure.

#### End By:

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

i01994402

## Housing (Front) - Remove

SMCS Code: 1151-011

### Removal Procedure

#### Start By:

- a. Remove the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
- b. Remove the crankshaft front seal and the wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove".
- c. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- d. Remove the fan drive. Refer to Disassembly and Assembly, "Fan Drive - Remove".
- e. Remove the fuel transfer pump. Refer to Disassembly and Assembly, "Fuel Transfer Pump - Remove".
- f. Remove the vibration damper and the pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove and Install".

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#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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**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.

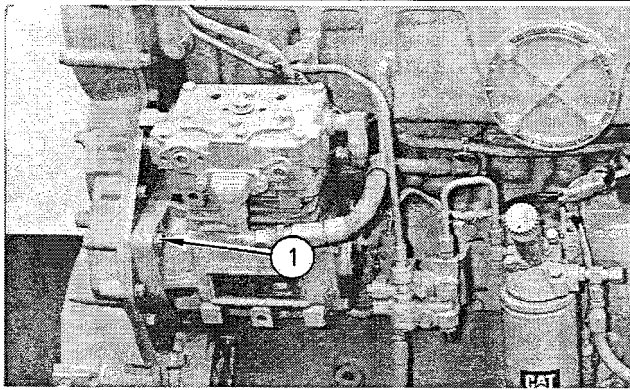


Illustration 133

g00579579

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

1. Remove nut (1) from the stud.

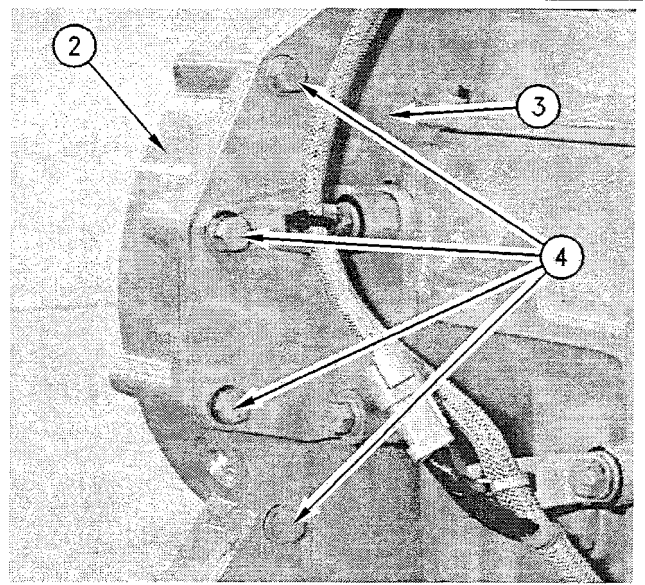


Illustration 134

g00579581

2. Remove bolts (4) that fasten front plate (3) to front housing (2).

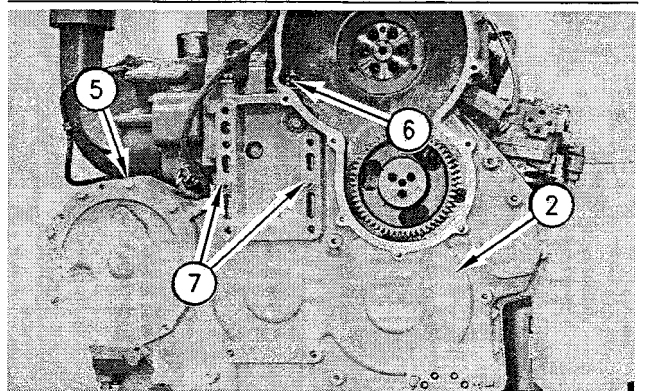


Illustration 135

g00579582

3. Remove bolts (5), nut (6), and nuts (7) from front housing (2).

i01994404

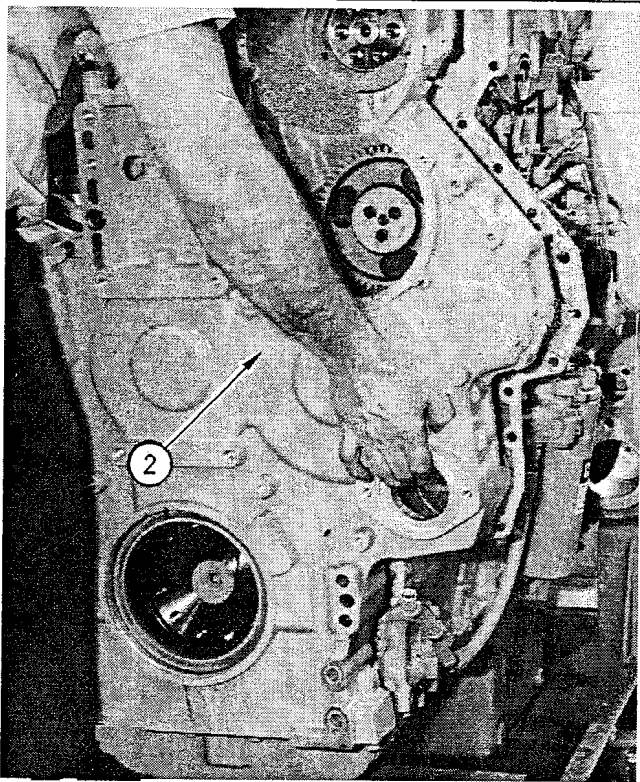


Illustration 136

g00579584

4. Remove front housing (2).

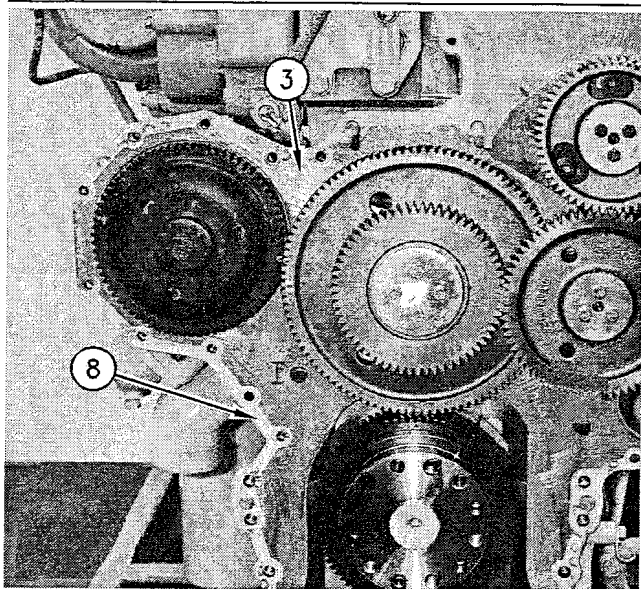


Illustration 137

g00579585

5. Remove gasket (8) from front plate (3).

## Housing (Front) - Install

SMCS Code: 1151-012

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

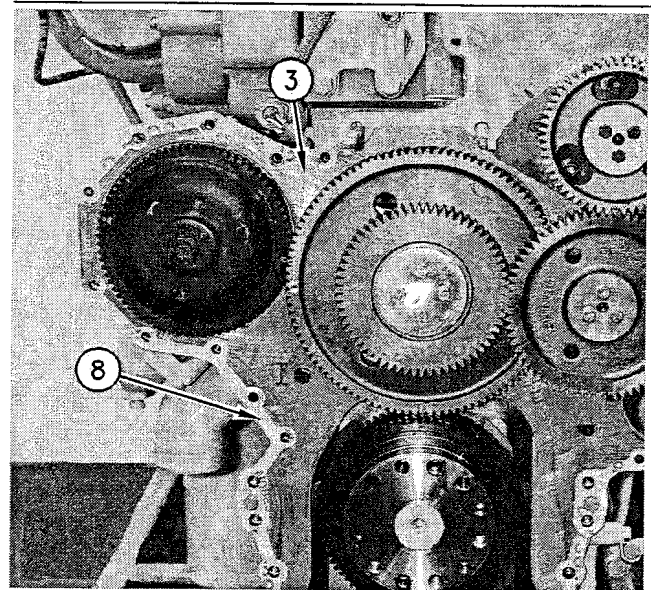


Illustration 138

g00579585

1. Thoroughly clean the old gasket material from front plate (3). Install a new gasket (8) on front plate (3).

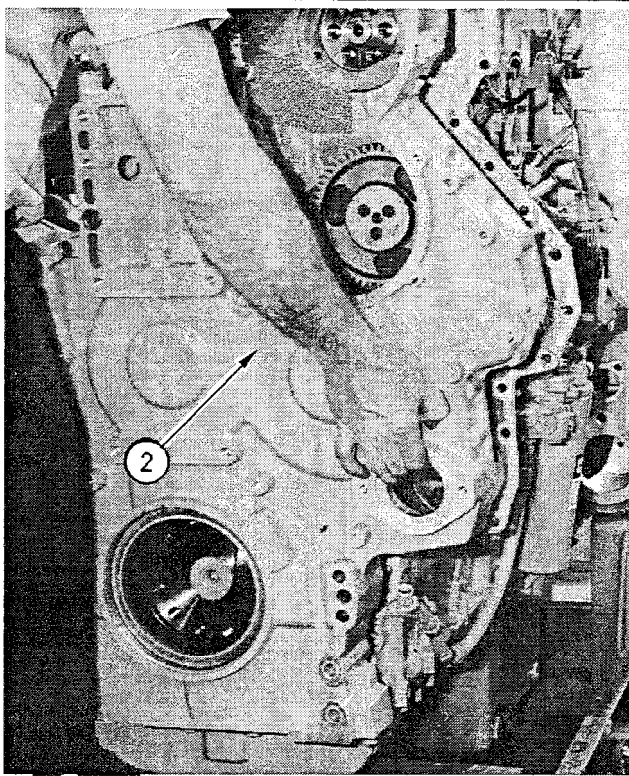


Illustration 139 g00579584

2. Thoroughly clean the old gasket material from front housing (2) and install front housing (2) on the two dowel pins.

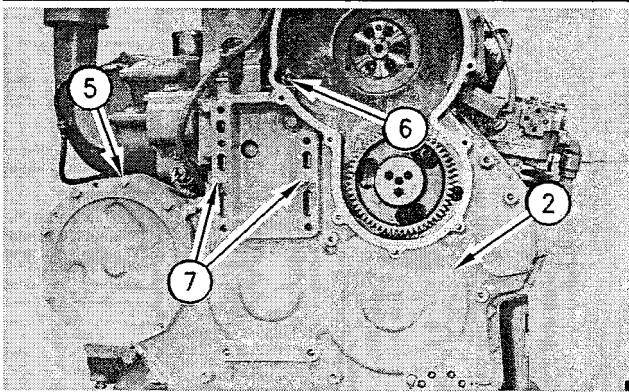


Illustration 140 g00579582

3. Install bolts (5), nut (6), and nuts (7) on front housing (2).

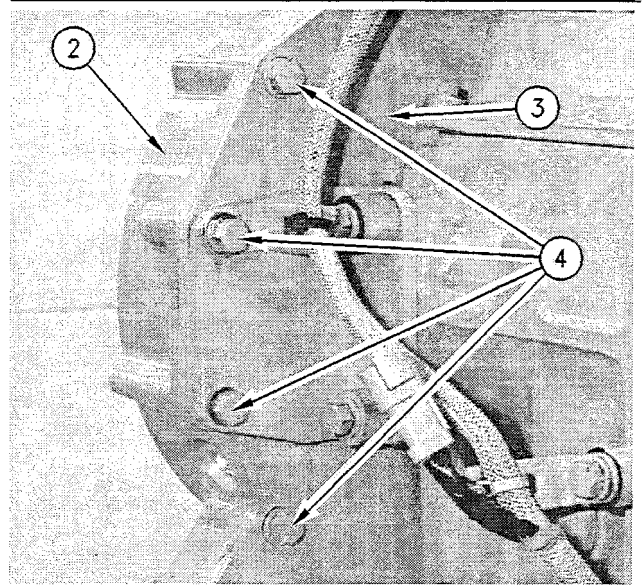


Illustration 141 g00579581

4. Install bolts (4) that fasten front plate (3) to front housing (2).

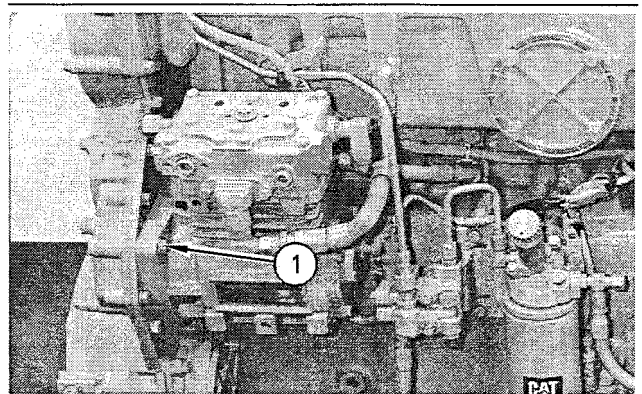


Illustration 142 g00579579

5. Install nut (1) on the stud.

**End By:**

- a. Install the vibration damper and the pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove and Install".
- b. Install the fuel transfer pump. Refer to Disassembly and Assembly, "Fuel Transfer Pump - Install".
- c. Install the fan drive. Refer to Disassembly and Assembly, "Fan Drive - Install".
- d. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- e. Install the crankshaft front seal and the wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Install".



- f. Install the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".

i01994409

## Valve Mechanism Cover - Remove and Install

SMCS Code: 1107-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

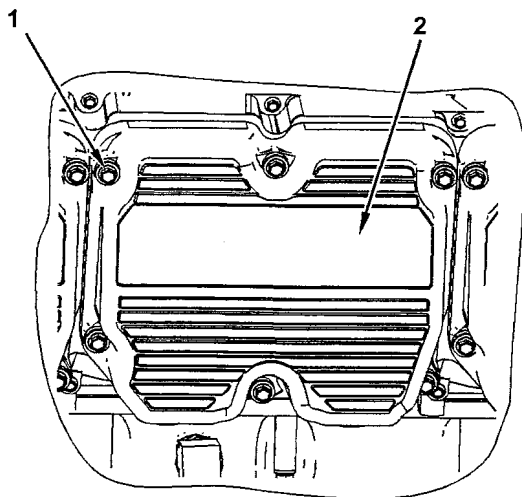


Illustration 143

g01033224

1. Remove bolts (1).
2. Remove valve mechanism cover (2).

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

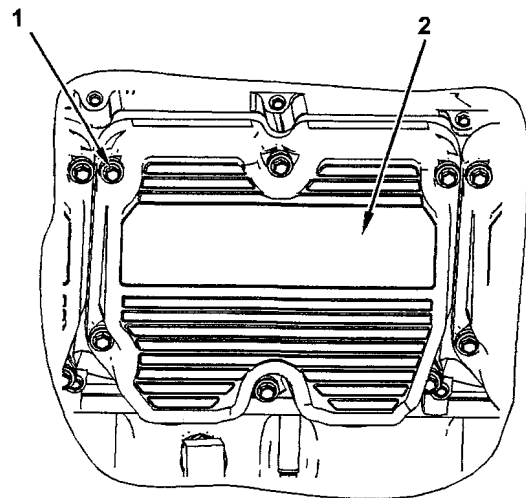


Illustration 144

g01033224

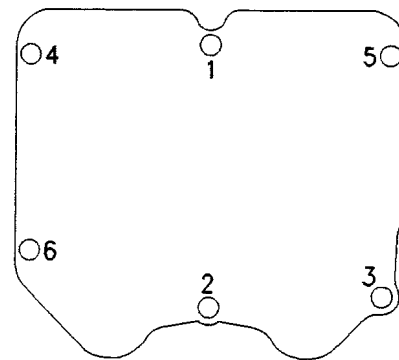


Illustration 145

g00579295

1. Position valve mechanism cover (2) on the valve cover base. Tighten bolts (1) to a torque of  $18 \pm 3$  N·m ( $13 \pm 2$  lb ft) in the numerical sequence that is shown in Illustration 145.

i01985327

## Valve Mechanism Cover Base - Remove and Install

SMCS Code: 1120-010

### Removal Procedure

#### Start By:

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

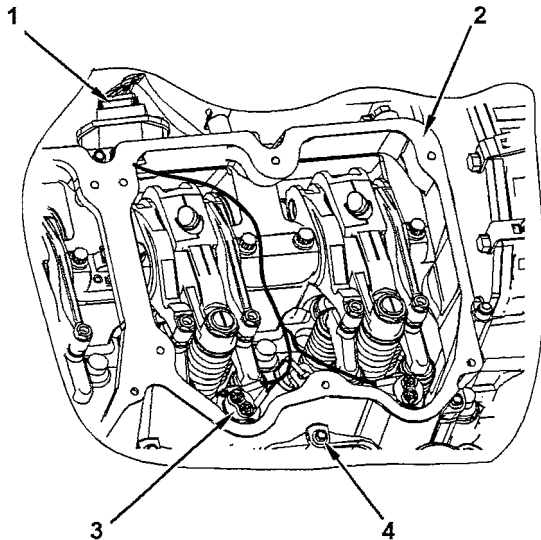


Illustration 146

g01028794

1. Disconnect harness assembly (3) from the electronic unit injector.
2. Disconnect harness assembly (1) from valve cover base (2).
3. Remove bolts (4).
4. Remove valve cover base (2).

**Installation Procedure**

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Before assembly, check the condition of the seal. If the seal is worn or damaged, use a new part for replacement.

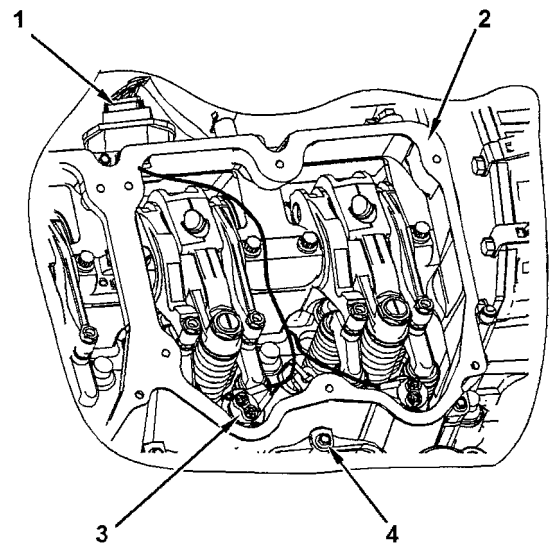


Illustration 147

g01028794

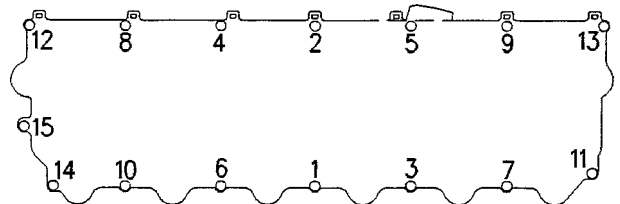


Illustration 148

g00579307

1. Position valve cover base (2) on the cylinder head and install bolts (4). Tighten bolts (4) to a torque of  $18 \pm 3 \text{ N}\cdot\text{m}$  ( $13 \pm 2 \text{ lb ft}$ ) in the numerical sequence that is shown in Illustration 148.
2. Connect harness assembly (1).
3. Position harness assembly (3) on the electronic unit injector. Tighten the cap nuts to a torque of  $2.5 \pm 0.25 \text{ N}\cdot\text{m}$  ( $22 \pm 2 \text{ lb in}$ ).

**End By:**

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

i01994416

## Compression Brake - Remove (If Equipped)

SMCS Code: 1119-011

### Removal Procedure

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### 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.

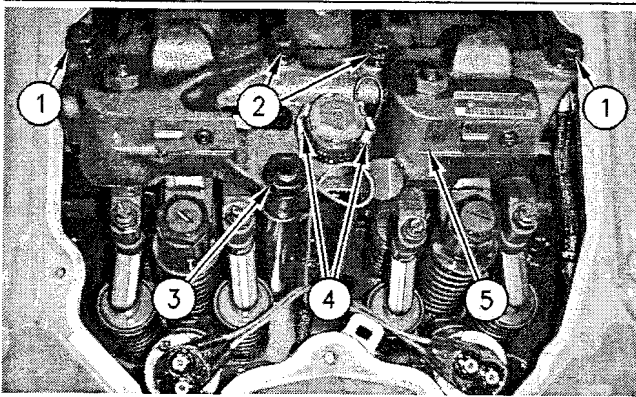


Illustration 149

g00619974

**Note:** The removal procedure is identical for all three compression brake housings.

1. Disconnect wires (4).
2. Remove bolts (1) and bolts (2).

3. Remove nut (3).

**Note:** Some of the early 340, 340A, and 340B compression brakes utilized two mounting studs that are located in the front of the brake housing.

4. Remove compression brake housing (5).

i01933918

## Compression Brake - Disassemble (If Equipped)

SMCS Code: 1119-015

### Disassembly Procedure

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
A	134-2837	Piston Compressor	1

#### Start By:

- a. Remove the compression brake. Refer to Disassembly and Assembly, "Compression Brake - 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.

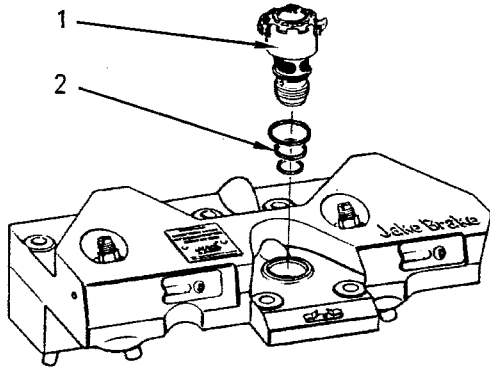


Illustration 150  
Typical example g00512487

**NOTICE**

Do not disassemble or tamper with the solenoid valve. Engine damage could result.

1. Remove solenoid valve (1).
2. Remove seals (2) from the solenoid valve. Remove seal (2) from the bottom of the bore for the solenoid valve. Discard the seals.
3. Wash solenoid valve (1) with approved cleaning solvent. Use a brush to clean the oil screen. Dry solenoid valve (1) with 103 to 138 kPa (15 to 20 psi) of compressed air.

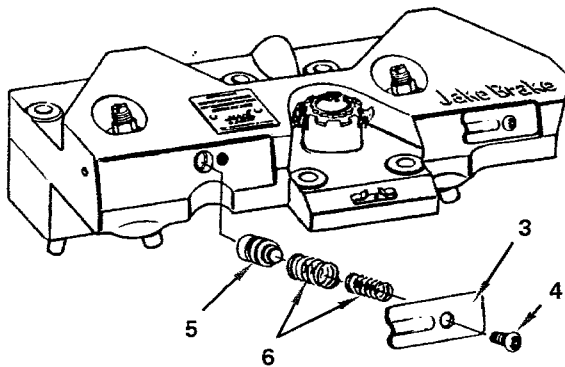


Illustration 151  
Typical example g01009776

**WARNING**

Remove control valve covers carefully. Control valve spring covers are under load from the control valve springs. Remove with care to avoid personal injury.

**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. Compress control valve cover (3) in order to relieve any spring pressure when allen head screw (4) is removed.
5. Remove allen head screw (4).
6. Slowly remove control valve cover (3) in order to relieve spring tension force. Then remove control springs (6).
7. Remove control valve (5).

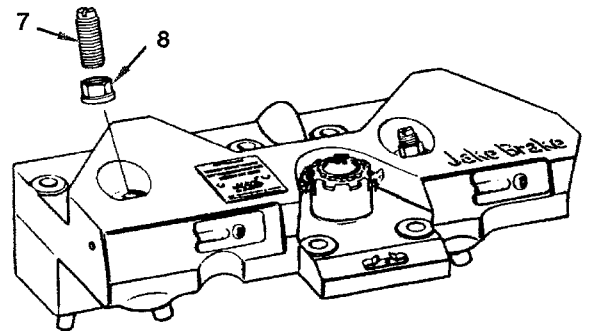


Illustration 152  
Typical example g01009783

**NOTICE**

Do not disassemble or tamper with slave piston adjusting screw. Engine damage could result.

8. Loosen slave piston adjustment screw locknut (8) and loosen slave piston adjustment screw (7) until the slave piston is fully retracted. Slave piston adjusting screw (7) should be loose.

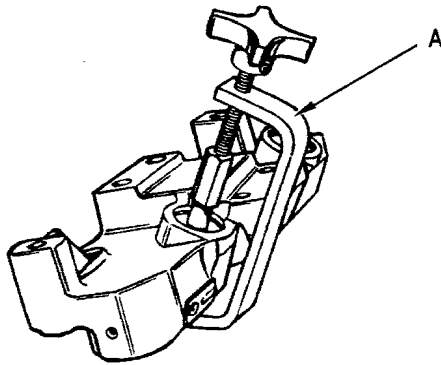


Illustration 153 g00512594

Typical example

9. Place Tooling (A) over slave piston adjusting screw (7).

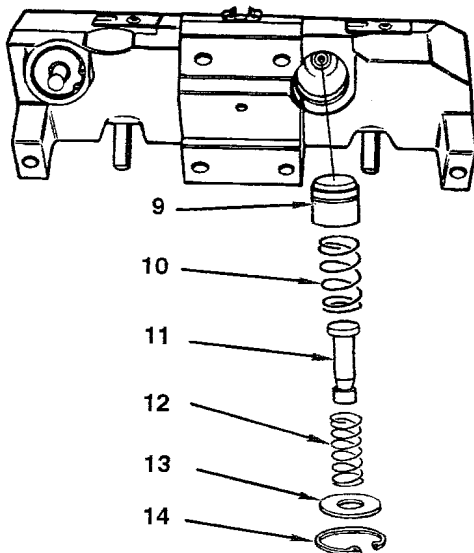


Illustration 154 g01009784

Typical example

**⚠ WARNING**

**Remove slave pistons carefully. The slave pistons are under spring pressure. Remove with care to avoid personal injury.**

10. Slowly turn the handle on Tooling (A) until retaining washer (13) is compressed approximately 1.00 mm (0.040 inch) in order to relieve the spring pressure from retaining ring (14).
11. Remove retaining ring (14) for the slave piston. Back out the handle on Tooling (A) until the springs are loose. Remove Tooling (A).

12. Remove retaining washer (13), and the inner spring (12), pushrod (11), outer spring (10), and slave piston (9). Ensure that the components are not in a bind. Components must be free of metal burrs.

13. Clean the components with an approved cleaning solvent. Inspect the contact point between slave piston (9) and pushrod (11). Inspect the other components for damage or wear. Components that are pitted, cracked, or galled should be replaced with new parts.

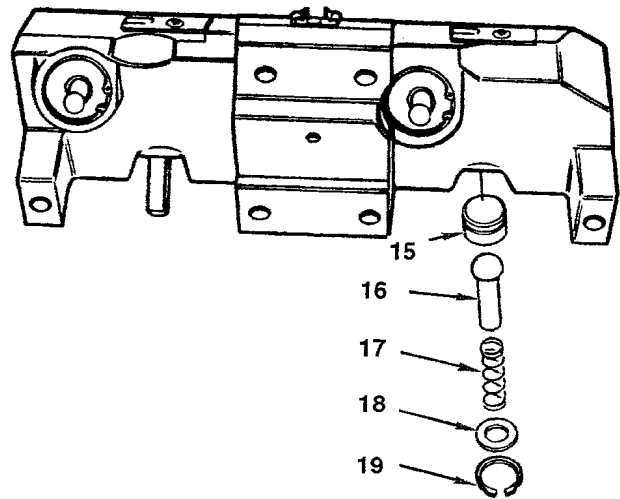


Illustration 155 g01009791

Typical example

14. Remove retaining ring (19) for the master piston. Remove retaining washer (18), master piston spring (17), master piston (15), and pushrod (16). If binding occurs, check for metal burrs or contaminants in the lube oil.

15. Clean the compression brake housing and the components in approved cleaning solvent. Inspect the contact point between master piston (15) and pushrod (16). Inspect the compression brake housing and the other components for damage or wear. Components that are pitted, cracked, or galled should be replaced with new parts.

i01933929

# Compression Brake - Assemble (If Equipped)

SMCS Code: 1119-016

## Assembly Procedure

Table 37

Required Tools			
Tool	Part Number	Part Description	Qty
A	134-2837	Piston Compressor	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

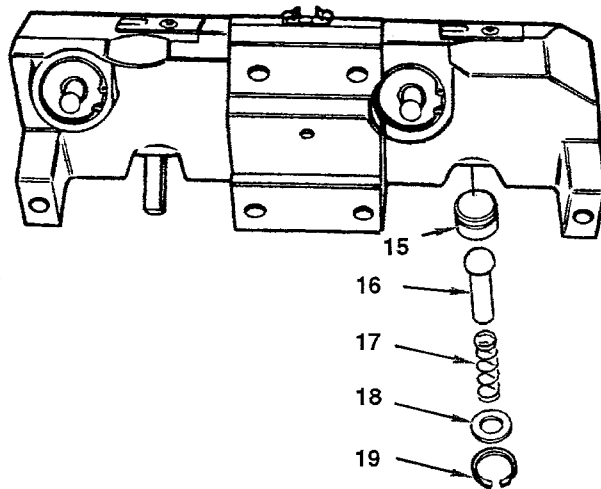


Illustration 156  
Typical example

g01009791

**WARNING**

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

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

**Note:** Never use rags to clean the compression brake housing or any of the components. Rags may leave lint or residue that can obstruct oil passages.

1. Thoroughly clean the compression brake housing and all of the components with an approved solvent. Dry the compression brake housing and the solenoid valve with 103 to 138 kPa (15 to 20 psi) of compressed air.
2. Install master piston (15), pushrod (16), master piston spring (17), retaining washer (18), and retaining ring (19).

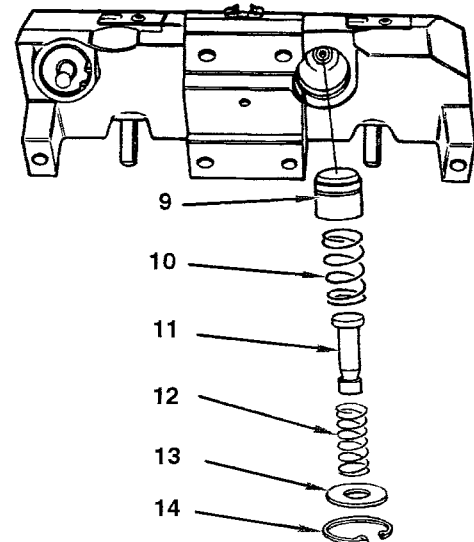


Illustration 157  
Typical example

g01009784

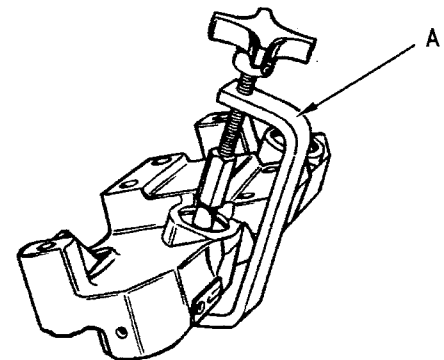


Illustration 158  
Typical example

g00512594

3. Install slave piston (9), outer spring (10), pushrod (11), inner spring (12), and retaining washer (13).
4. Use Tooling (A) to compress the assembly until retaining washer (13) is approximately 1.00 mm (0.039 inch) below the retaining ring groove. Install retaining ring (14). Ensure that retaining ring (14) is properly seated in the groove.
5. Remove Tooling (A).

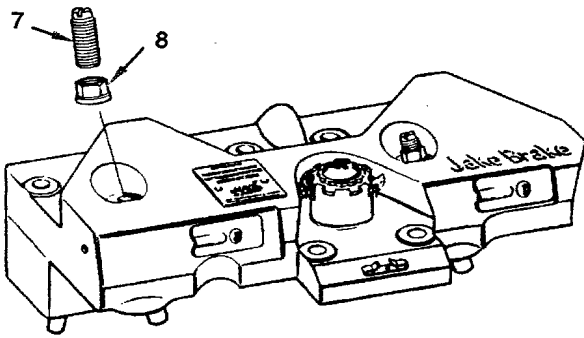


Illustration 159 g01009783

Typical example

6. Inspect slave piston adjustment screw (7). The plunger should protrude from the bottom of slave piston adjusting screw (7). Approximately 53 N (12 lb) of force is required to move the plunger. Ensure that the spring retaining pin for the plunger is seated.

7. Install slave piston adjusting screw (7) and slave piston adjustment screw locknut (8). Do not tighten the assembly at this time.

**Note:** Refer to Testing and Adjusting, "Slave Piston Lash - Adjust" for more information on the adjustment of the slave piston lash.

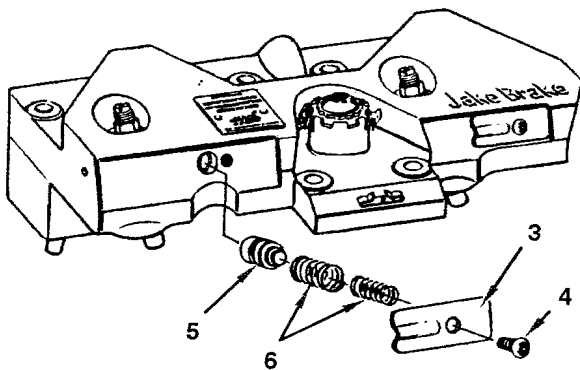


Illustration 160 g01009776

Typical example

8. Push a wire through the hole in the base of control valve (5) in order to ensure that the check ball is free. The check ball should unseat with slight pressure on the wire. If the check ball is stuck, replace the control valve.

9. Put clean engine oil on control valve (5) and install the control valve in the compression brake housing. If binding occurs, replace the control valve. Install control valve springs (6).

10. Put control valve cover (3) in position and install allen head screw (4).

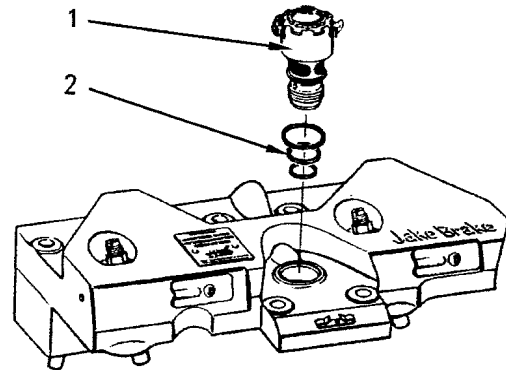


Illustration 161 g00512487

Typical example

11. Use new seals (2). Coat the seals with clean engine oil. Install the upper seal and the center seal on the solenoid body. Install the lower seal in the bottom of the bore for the solenoid valve in the compression brake housing.

12. Ensure that seals (2) are seated properly. Carefully install solenoid valve (1) in the compression brake housing. Tighten the solenoid valve to a torque of 12.4 N·m (110 lb in). Be careful not to twist the seals during installation.

**End By:**

- a. Install the compression brake. Refer to Disassembly and Assembly, "Compression Brake - Install".

i01994419

## Compression Brake - Install (If Equipped)

SMCS Code: 1119-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

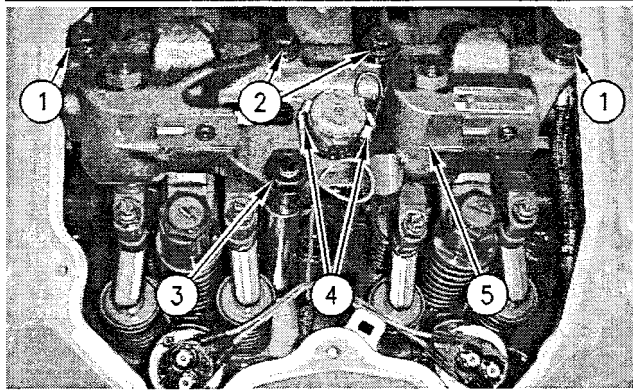


Illustration 162

g00619974

**Note:** The installation procedure is identical for all three compression brake housings.

1. Install the stud for nut (3) if the stud was removed. Tighten the stud to a torque of 88 N·m (65 lb ft).

**Note:** Some of the early 340, 340A, and 340B compression brakes utilized two mounting studs that are located in the front of the brake housing.

2. Place compression brake housing (5) over the stud.
3. Install bolts (1), bolts (2), and the washers. Install nut (2).
4. Use the following procedure in order to tighten the compression brake:
  - a. Tighten center bolts (2) to a torque of 54 N·m (40 lb ft).
  - b. Tighten nut (3) to a torque of 54 N·m (40 lb ft).
  - c. Tighten outer bolts (1) to a torque of 54 N·m (40 lb ft).
  - d. Tighten center bolts (2) to a torque of 109 N·m (80 lb ft).
  - e. Tighten nut (3) to a torque of 109 N·m (80 lb ft).
  - f. Tighten outer bolts (1) to a torque of 109 N·m (80 lb ft).

**Note:** If your application has two mounting studs, use a crisscross pattern in order to torque the mounting stud nuts and the center bolts.

5. Connect wires (4).
6. Set the lash for the slave piston. Refer to Testing and Adjusting, "Slave Piston Lash - Adjust".

**End By:**

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

i02109881

**Rocker Arm and Shaft - Remove**

SMCS Code: 1102-011

**Removal Procedure**

Table 38

Required Tools			
Tool	Part Number	Part Description	Qty
A	124-2946	Lifting Bracket	1

**Start By:**

- a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
- b. Remove the compression brake. Refer to Disassembly and Assembly, "Compression Brake - Remove".

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

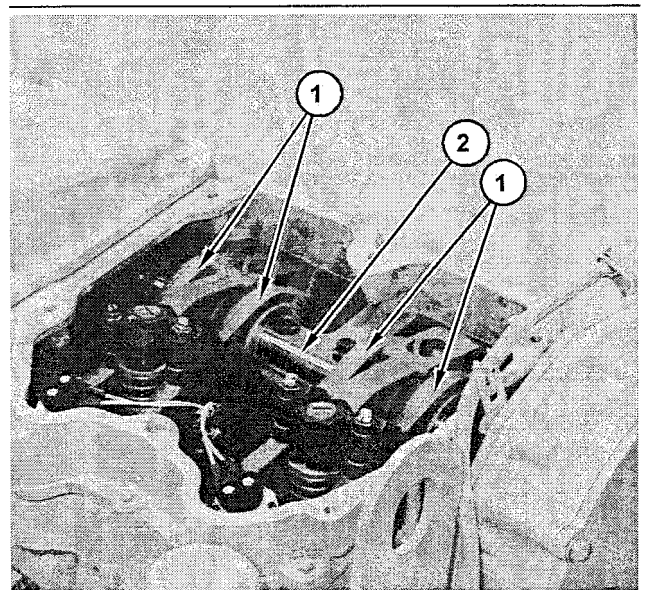


Illustration 163

g01074086



i01985468

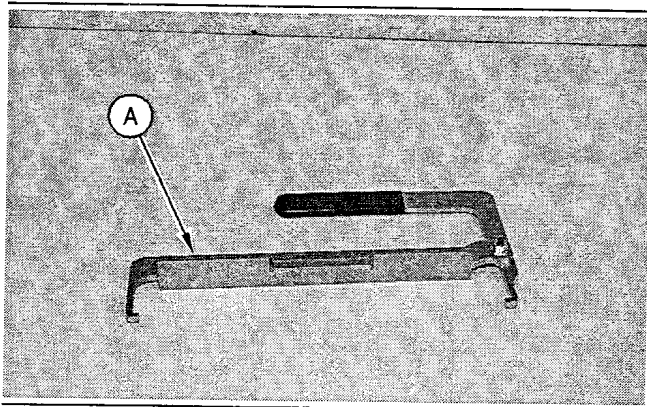


Illustration 164

g00517462

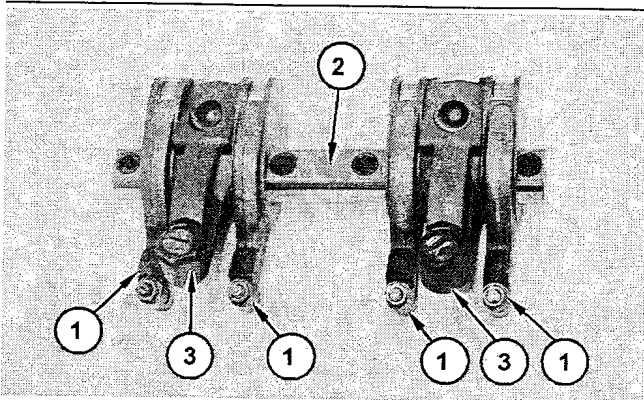


Illustration 165

g01074087

**⚠ WARNING**

Valve rocker arms and unit injector rocker arms can move on the shaft after the bolts have been removed. The shaft should be kept level when removed from the cylinder head. To avoid possible personal injury, keep fingers clear of the valve rocker arms and the unit injector rocker arms when lifting the assembly from the cylinder head.

1. Remove shaft (2), valve rocker arms (1), and unit injector rocker arms (3) as a unit with Tooling (A).
2. Repeat Step 1 for the remainder of the rocker arm assemblies.

## Rocker Arm - Disassemble

SMCS Code: 1123-015

### Disassembly Procedure

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

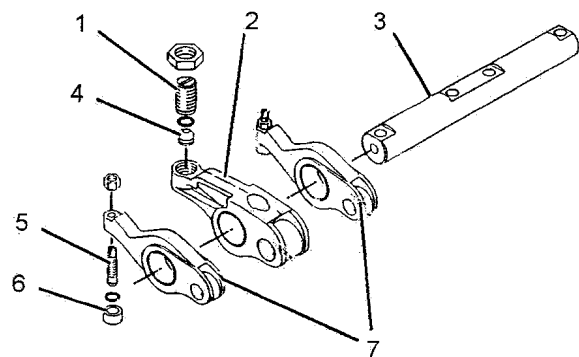


Illustration 166

g01028860

1. Remove valve rocker arms (7) and unit injector rocker arm (2) from rocker shaft (3).

**Note:** Check the condition of all components. Replace any worn components or damaged components with new parts.

**Note:** Do not reuse the O-ring seals on the rocker arm adjustment screws if the buttons have been removed from the adjustment screws.

2. Remove button (6) from adjuster screw (5) in valve rocker arm (7).
3. Remove button (4) from adjuster screw (1) in unit injector rocker arm (2).
4. Repeat Steps 1 through 3 for the remaining rocker arm assemblies.

i01985507

## Rocker Arm - Assemble

SMCS Code: 1123-016

### Assembly Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

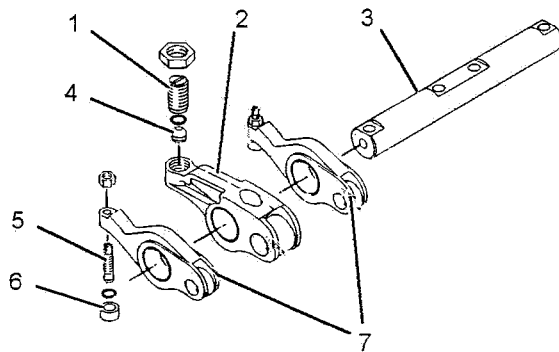


Illustration 167

g01028860

**Note:** Do not reuse the O-ring seals on the rocker arm adjustment screws if the buttons have been removed from the adjustment screws.

1. Install the O-ring seals in button (6) and button (4).
2. Install the O-ring seals and the buttons on the valve rocker arms, as follows:
  - a. Support valve rocker arm (7) in a vise with soft jaws.
  - b. Position the O-ring seal and button (6) on the round end of adjustment screw (5).
  - c. Use a soft hammer to seat button (6) on adjustment screw (5).
3. Install the O-ring seals and the buttons on the unit injector rocker arms, as follows:
  - a. Support unit injector rocker arms (2) in a vise with soft jaws.
  - b. Put the O-ring seal and button (4) in position on the end of adjustment screw (1).
  - c. Use a soft hammer to seat button (4) on adjustment screw (1).
4. Repeat Steps 1 through 3 for the remainder of the rocker arm assemblies.

5. Lubricate rocker shaft (3) with clean engine oil and install the assembled rocker arms on rocker shaft (3).

**End By:**

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

i02109979

## Rocker Arm and Shaft - Install

SMCS Code: 1102-012

### Installation Procedure

Table 39

Required Tools			
Tool	Part Number	Part Description	Qty
A	124-2946	Lifting Bracket	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**WARNING**

Valve rocker arms and unit injector rocker arms can move on the shaft after the bolts have been removed. The shaft should be kept level when removed from the cylinder head. To avoid possible personal injury, keep fingers clear of the valve rocker arms and the unit injector rocker arms when lifting the assembly from the cylinder head.

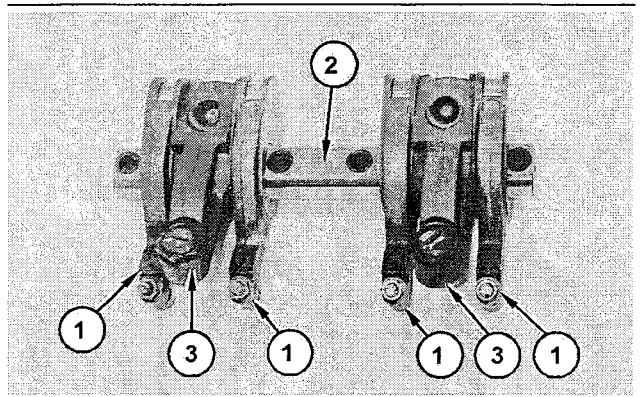


Illustration 168

g01074087

i01974407

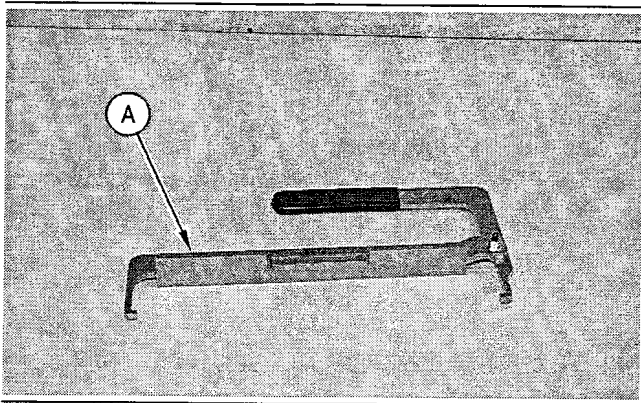


Illustration 169

g00517462

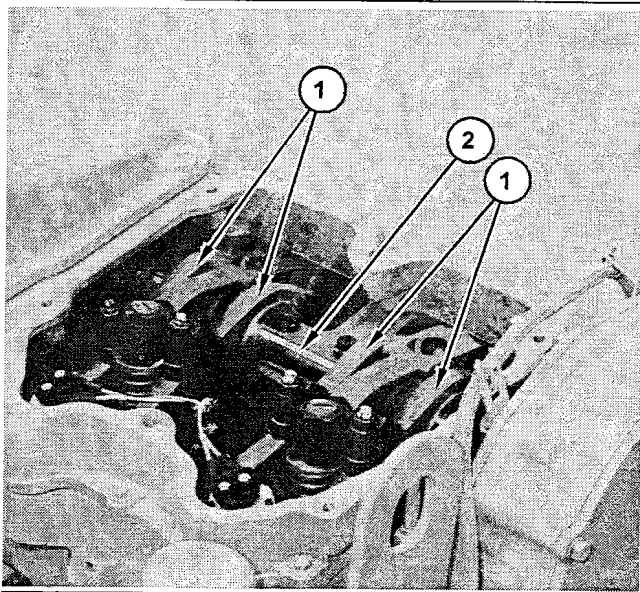


Illustration 170

g01074086

1. Install shaft (2), valve rocker arms (1), and unit injector rocker arms (3) as a unit with Tooling (A).

**Note:** Install shaft (2) with the flat side facing upward.

2. Repeat Step 1 for the remainder of the rocker arm assemblies.

**End By:**

- a. Install the compression brake. Refer to Disassembly and Assembly, "Compression Brake - Install".
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

## Cylinder Head - Remove

SMCS Code: 1100-011

### Removal Procedure

**Start By:**

- a. Remove the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
- b. Remove the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Remove".
- c. Remove the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- d. Remove the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Remove".
- e. Remove the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Remove and Install".
- f. Remove the water temperature regulator. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".

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**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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**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.

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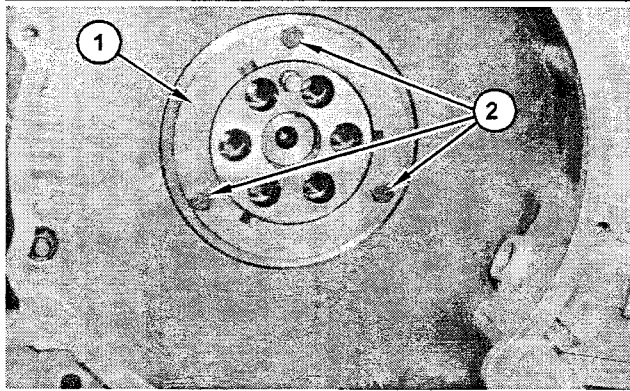


Illustration 171

g01028806

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

1. Remove bolts (2) and thrust plate (1).

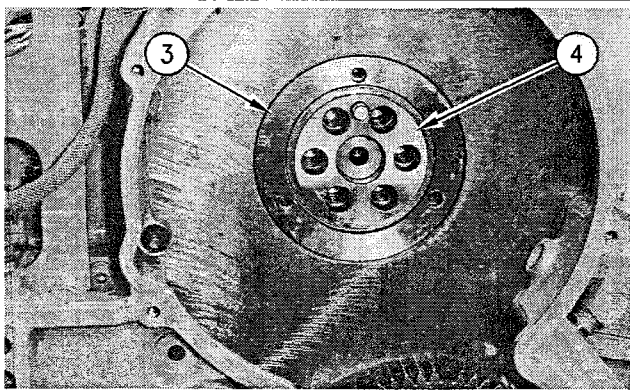


Illustration 172

g00576209

2. Remove seal assembly (3) and adapter (4).

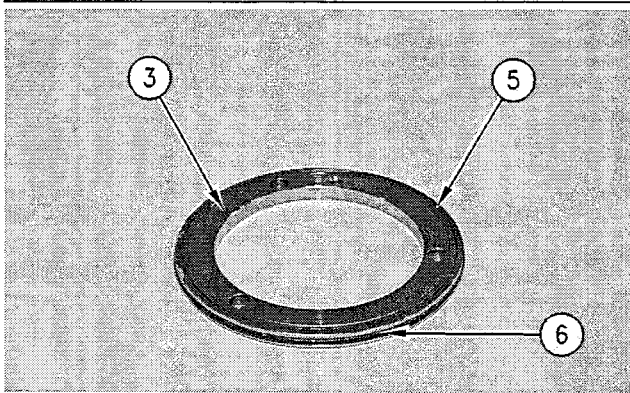


Illustration 173

g00576240

3. Remove O-ring seals (5) and (6) from seal assembly (3).

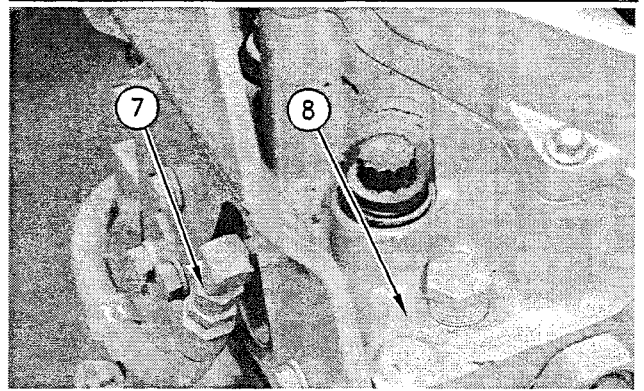


Illustration 174

g00580805

4. Disconnect hose assembly (7) from cylinder head (8).

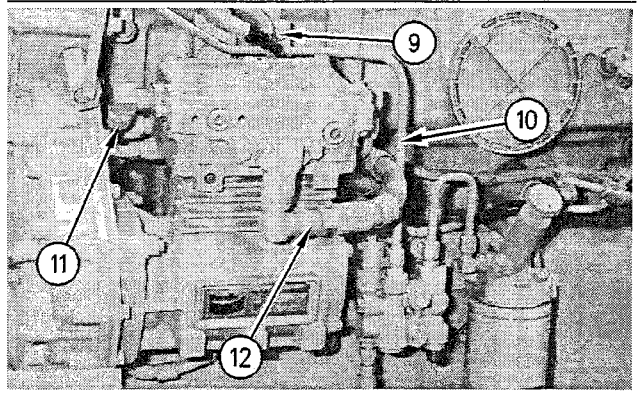


Illustration 175

g00580807

**Note:** If the engine is not equipped with an air compressor, skip Step 5.

5. Disconnect hose assemblies (11) and hose assemblies (12) from the air compressor.
6. Remove the bolt and clamp (9) from the hose assembly. Remove hose assembly (10).

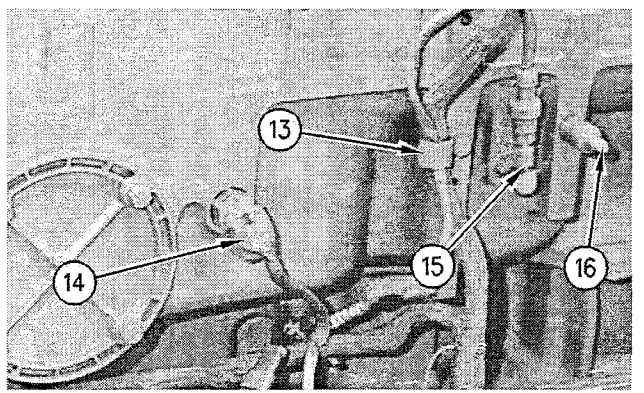


Illustration 176

g00580808

7. Remove the bolt and support clip (13) for the harness assembly.

8. Disconnect the harness assembly from sensor (14), sensor (15), and ground stud (16).

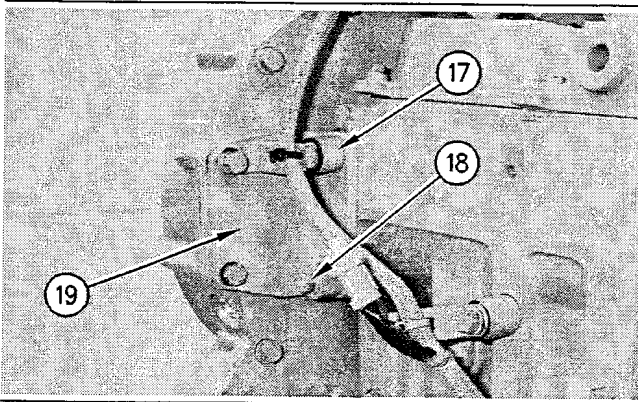


Illustration 177

g00580810

9. Remove bolts (18) and spacers (17) that fasten bracket (19) to the cylinder head.

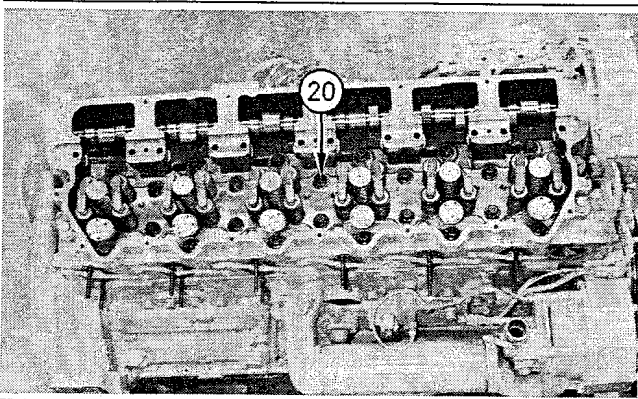


Illustration 178

g00580811

10. Remove cylinder head bolts (20).

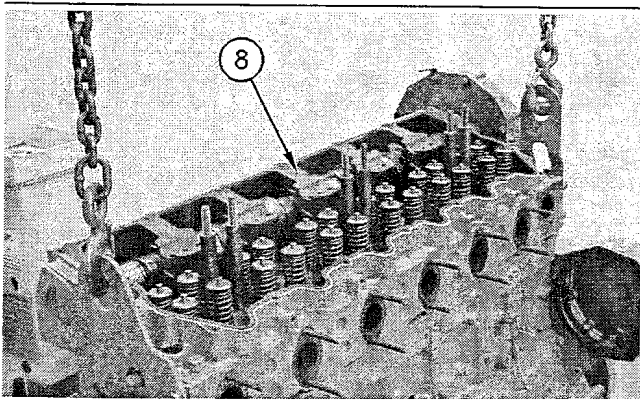


Illustration 179

g00580812

11. Attach a suitable lifting device to cylinder head (8). Ensure that all of the following items are clear from the cylinder head: harness assemblies, tube assemblies, and hose assemblies.

12. Carefully remove cylinder head (8). The weight of the cylinder head is approximately 235 kg (518 lb).

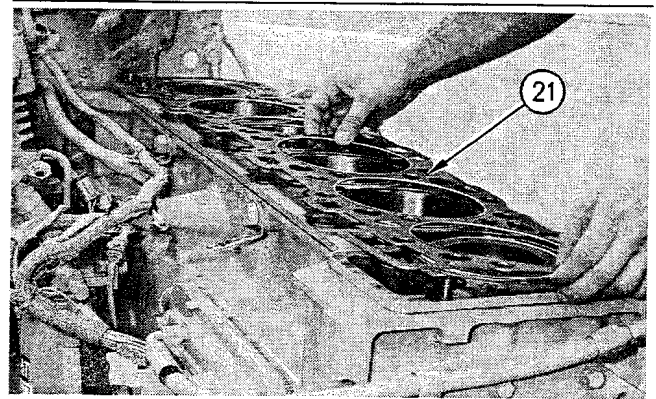


Illustration 180

g00580833

13. Remove cylinder head gasket (21).

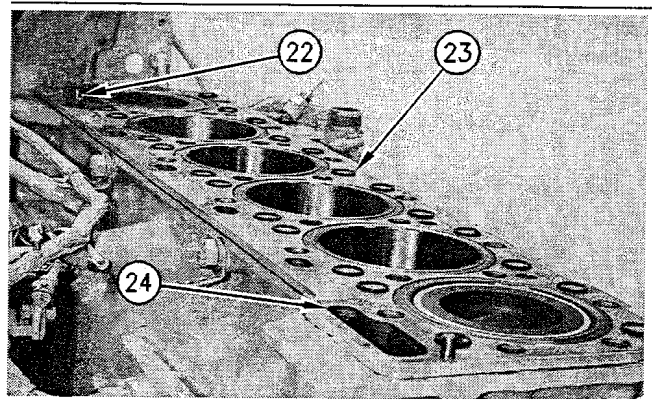


Illustration 181

g00632047

14. Remove O-ring seal (22) and water seals (23). Remove seal (24).

15. Remove the spacer plate from the engine.

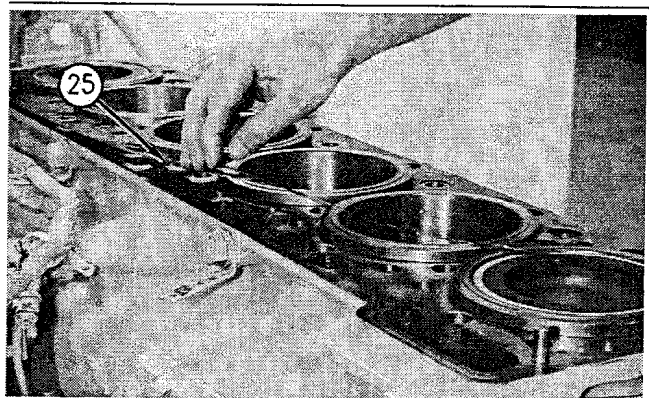


Illustration 182

g00632048

16. Remove spacer plate gasket (25).

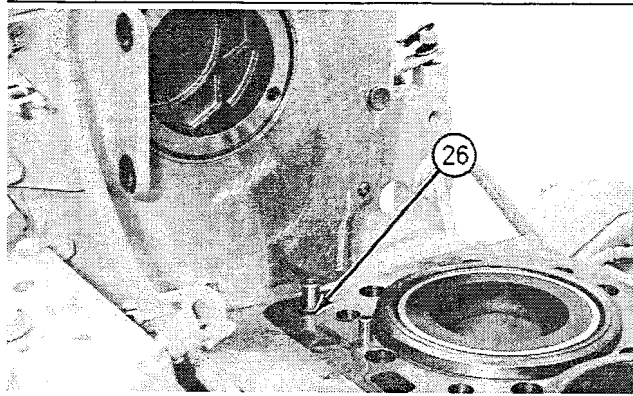


Illustration 183 g00632049

17. Remove O-ring seal (26).

**Note:** If the cylinder head was removed from the cylinder block as a result of a failed head gasket, refer to Special Instruction, SEHS9564, "3400 Cylinder Head Joint Repair Procedure" for additional information.

i01985424

## Cylinder Head - Install

SMCS Code: 1100-012

### Installation Procedure

Table 40

Required Tools			
Tool	Part Number	Part Description	Qty
A	6V-4876	Lubricant	1
B	8T-2998	Lubricant	1
C	9S-3263	Thread Lock Compound	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Thoroughly clean the spacer plate and the bottom surface of the cylinder head. A new spacer plate gasket must be installed when the cylinder head is removed.

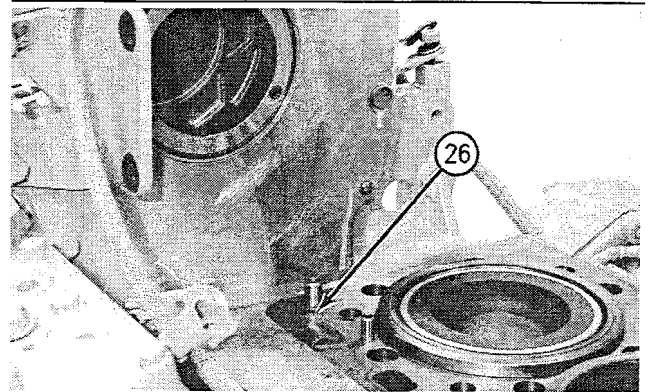


Illustration 184 g00632049

1. Apply a thin film of clean engine oil to O-ring seal (26). Install O-ring seal (26).

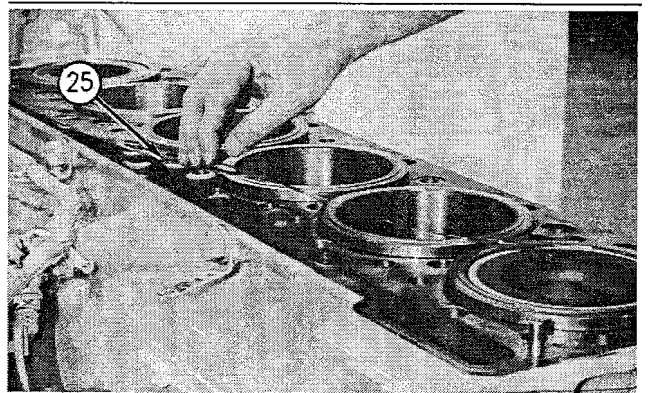


Illustration 185 g00632048

2. Install a new spacer plate gasket (25).
3. Install the spacer plate on the engine.

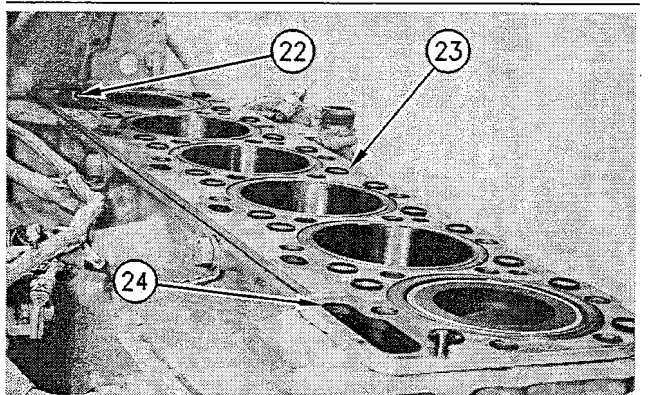


Illustration 186 g00632047

4. Apply a thin film of clean engine oil to O-ring seal (22). Install O-ring seal (22).
5. Install water seals (23) dry.
6. Install seal (24) in the spacer plate.

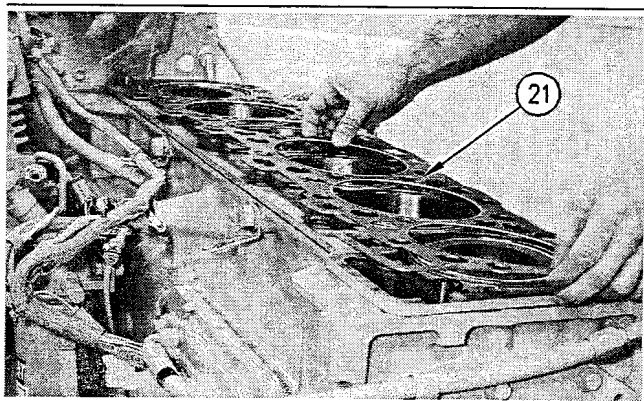


Illustration 187

g00580833

7. Install a new cylinder head gasket (21).

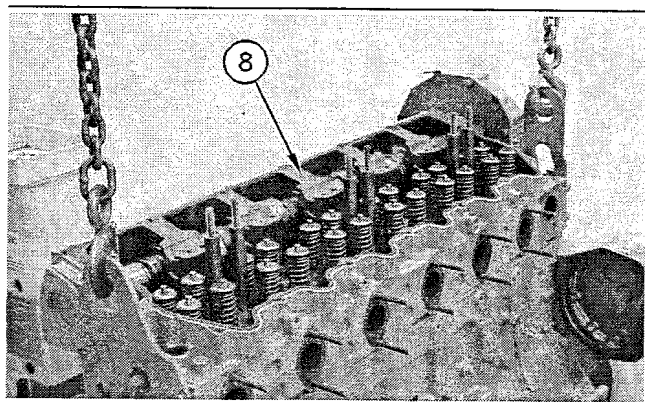


Illustration 188

g00580812

8. Attach a suitable lifting device to cylinder head (8). Carefully position cylinder head (8) on the spacer plate. The weight of the cylinder head is approximately 235 kg (518 lb).

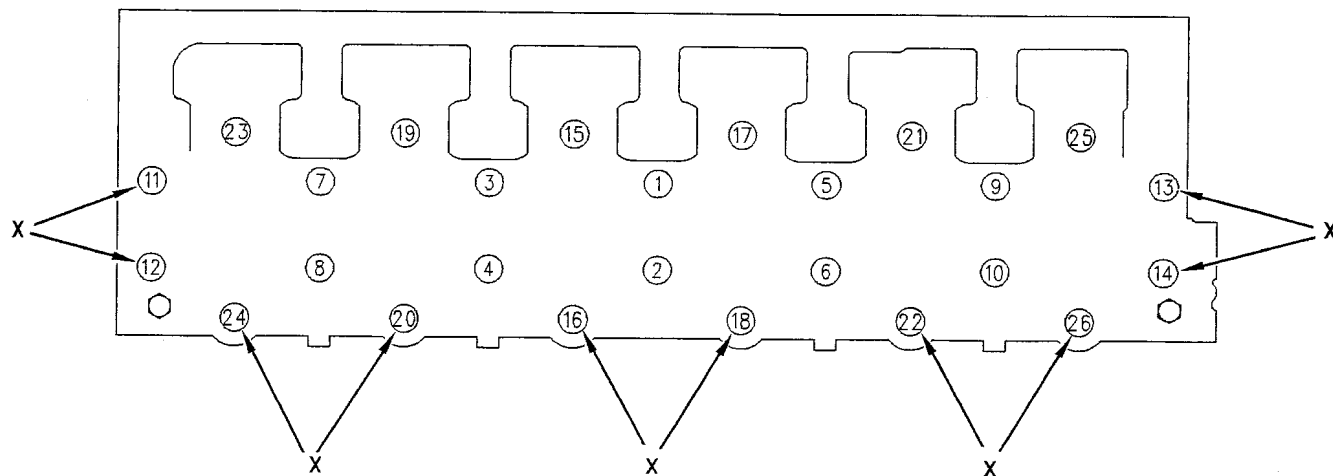


Illustration 189

g00513934

**Note:** The bolts that are Marked "X" are 216 mm (8.5 inch) long. The remainder of the bolts are 194 mm (7.6 inch) in length.

9. Apply Tooling (A) to the bolt threads and both sides of the washers. Install the cylinder head bolts. Tighten the cylinder head bolts, as follows.
  - a. In a numerical sequence, tighten bolts 1 through 26 to a torque of  $270 \pm 15$  N·m ( $200 \pm 11$  lb ft).
  - b. In a numerical sequence, tighten bolts 1 through 26 to a torque of  $450 \pm 15$  N·m ( $330 \pm 11$  lb ft).
  - c. In a numerical sequence, again tighten bolts 1 through 26 to a torque of  $450 \pm 15$  N·m ( $330 \pm 11$  lb ft).

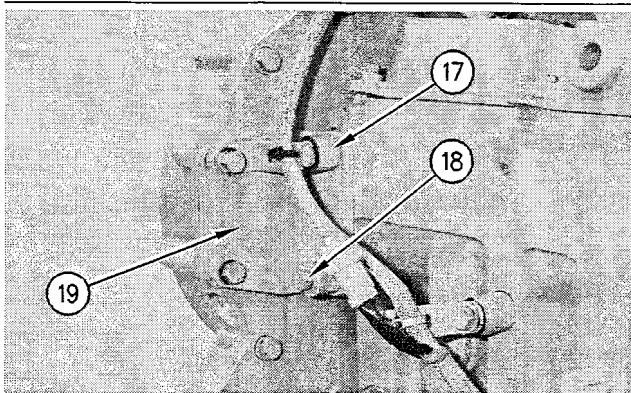


Illustration 190

g00580810

10. Install spacers (17) and bolts (18) that fasten bracket (19) to the cylinder head.

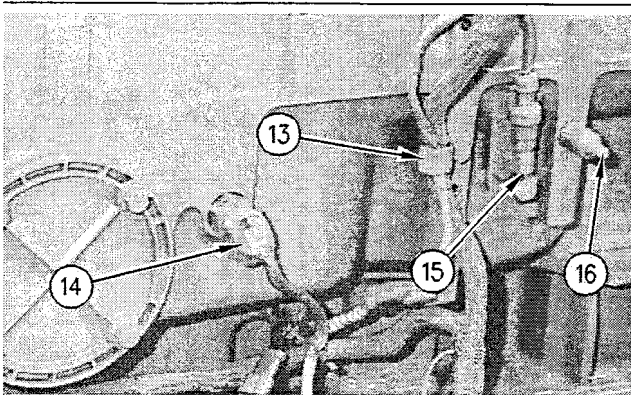


Illustration 191

g00580808

11. Connect the harness assembly to sensor (14), sensor (15), and ground stud (16).
12. Install the bolt and support clip (13) for the harness assembly.

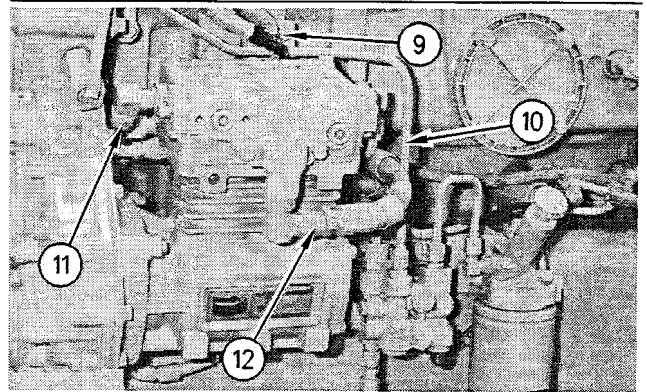


Illustration 192

g00580807

13. Install hose assemblies (10). Install the bolt and clamp (9).

**Note:** If the engine is not equipped with an air compressor, skip Step 14.

14. Connect hose assemblies (11) and hose assemblies (12) to the air compressor.

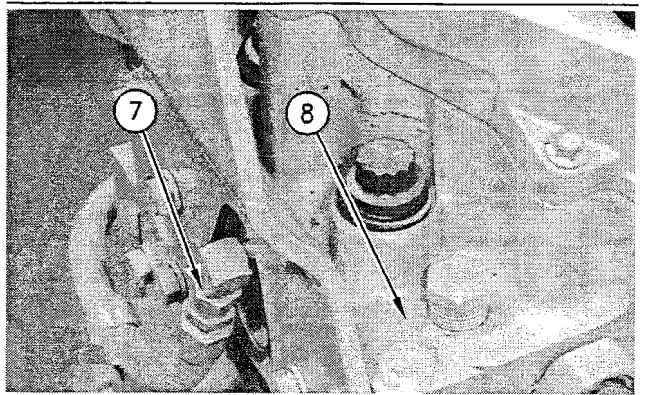


Illustration 193

g00580805

15. Connect hose assembly (7) to cylinder head (8).

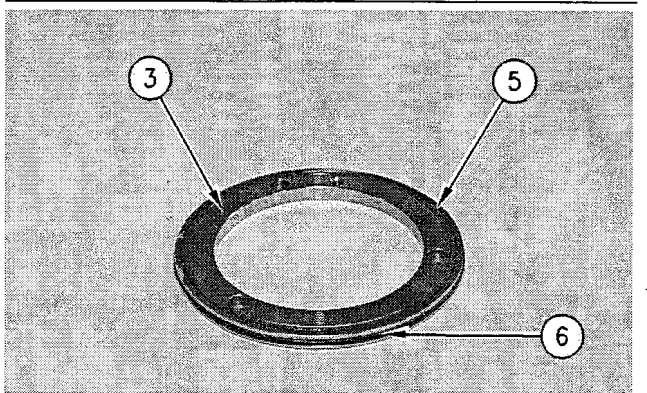


Illustration 194

g00576240



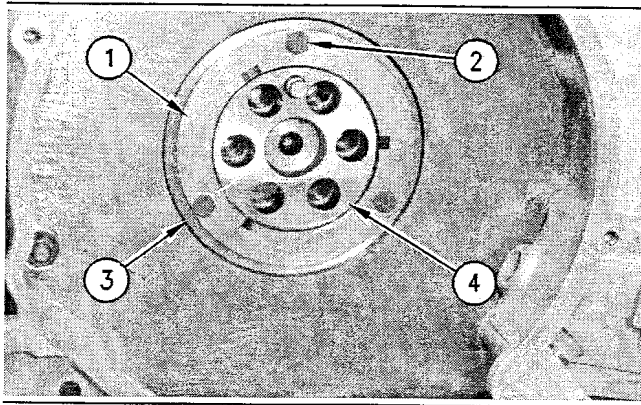


Illustration 195

g00576839

16. Install O-ring seals (5) and (6) in seal assembly (3). Lubricate seal (6) with Tooling (B).
17. Assemble thrust plate (1) and seal assembly (3). Apply Tooling (C) to bolts (2). Hold the assembly in position and install bolts (2). Evenly tighten bolts (2) until seal assembly (3) and O-ring seal (5) are seated against the cylinder head.

**Note:** Be careful in order to ensure that O-ring seal (5) stays in the groove in seal assembly (3).

18. Install adapter (4). Ensure that the dowel in adapter (4) engages the hole in the camshaft.

#### End By:

- a. Install the water temperature regulator. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".
- b. Install the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Remove and Install".
- c. Install the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Install".
- d. Install the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- e. Install the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Install".
- f. Install the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".

## Camshaft - Remove

SMCS Code: 1210-011

### Removal Procedure

Table 41

Required Tools			
Tool	Part Number	Part Description	Qty
A	9U-7257	Cradle	1
B	9U-7256	Guide	1
C	9U-7225	Camshaft Pilot	2
D	9U-7240	Camshaft Hook	2

#### Start By:

- a. Remove the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
- b. Remove the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - 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.

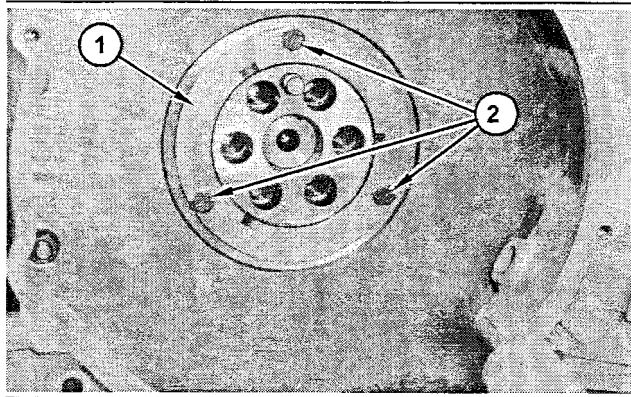


Illustration 196

g01028806

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

1. Remove bolts (2) and thrust plate (1).

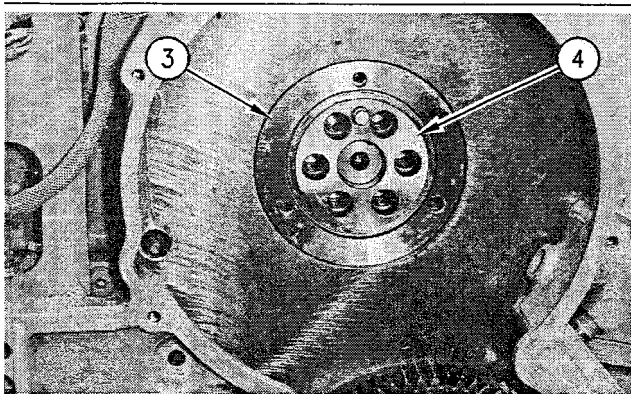


Illustration 197

g00576209

2. Remove seal assembly (3) and adapter (4).

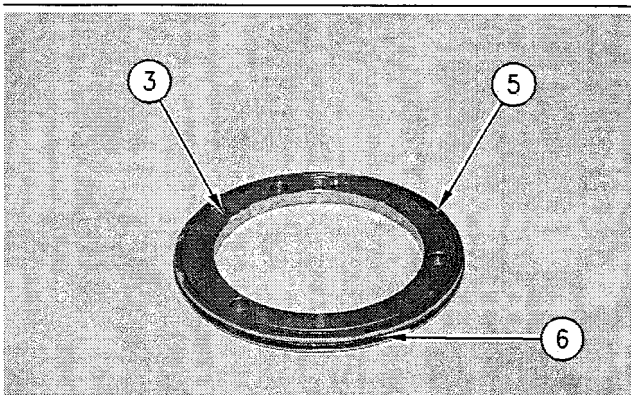


Illustration 198

g00576240

3. Remove O-ring seals (5) and (6) from seal assembly (3).

**NOTICE**

Care must be used when removing the camshaft to not damage the highly finished surfaces of both the camshaft and camshaft bearings

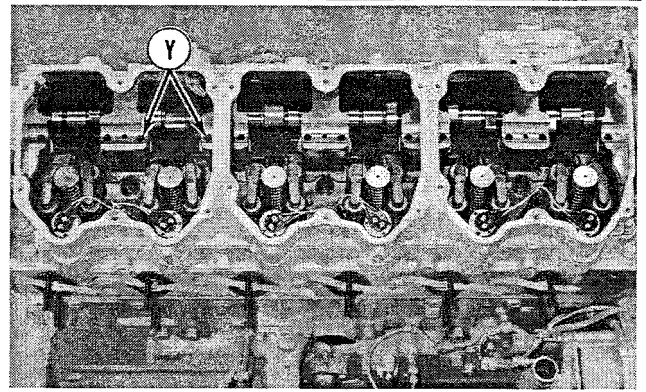


Illustration 199

g00509797

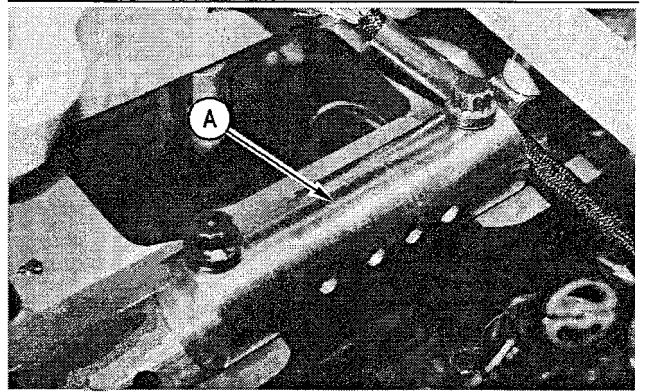


Illustration 200

g00581441

4. Use the bolts for the rocker arm shaft assembly to install Tooling (A) at Location (Y).

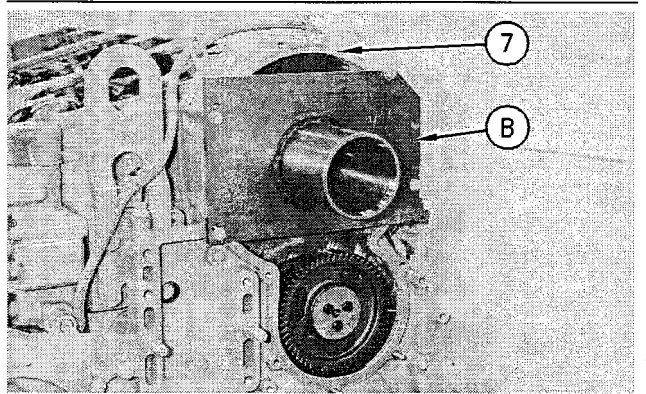


Illustration 201

g00581442

5. Install Tooling (B) on front housing (7). Do not tighten the bolts for Tooling (B) at this time.

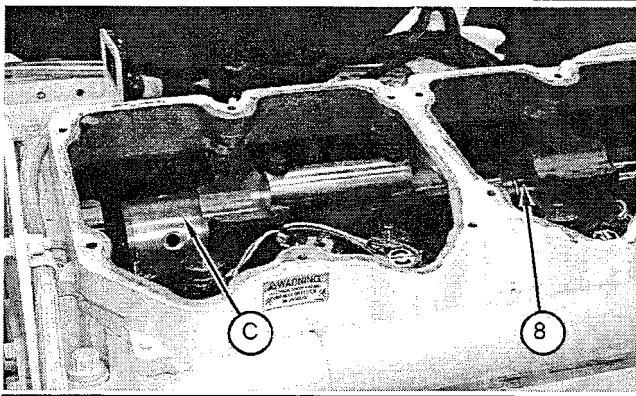


Illustration 202

g01074729

**Note:** It is necessary to install Tooling (C) on the camshaft. Tooling (C) will support the rear of camshaft (8) as the camshaft is moved out of the cylinder head and into Tooling (B).

6. Move camshaft (8) forward and install one Tooling (C) in the end of camshaft (8). Again, move the camshaft forward and install remaining Tooling (C) into the back of first Tooling (C).
7. Position camshaft (8) into the bore of Tooling (B). Tighten the bolts that hold Tooling (B) to the front housing.

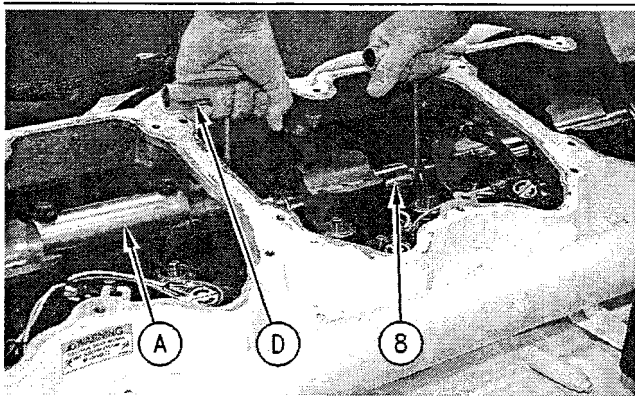


Illustration 203

g00581444

**Note:** Avoid lifting camshaft (8) with Tooling (D). The camshaft should rest on Tooling (A). Lifting of the camshaft can cause misalignment as the camshaft is removed, resulting in damage to the camshaft bearings.

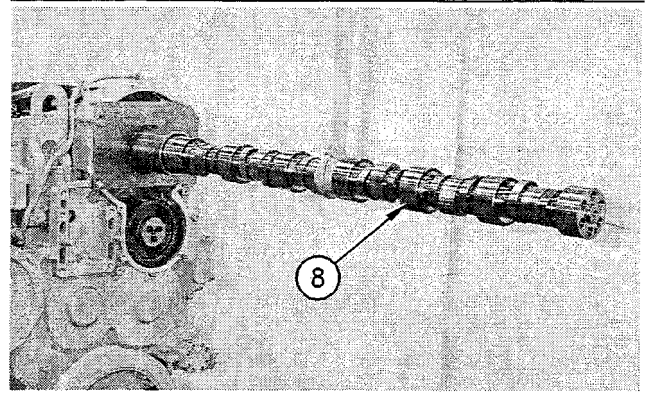


Illustration 204

g00581445

8. Remove camshaft (8), as follows:
  - a. Use Tooling (D) to move camshaft (8) toward the front of the engine. Reposition Tooling (D), as needed.
  - b. Move camshaft (8) far enough out of the cylinder head in order to attach a suitable lifting device.
  - c. Keep the camshaft level while the camshaft is being removed from the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).

## Alternative Removal Procedure

Table 42

Required Tools			
Tool	Part Number	Part Description	Qty
E <sup>(1)</sup>	177-8001	Sleeve	1
F	177-8002	Adapter	1
G	6L-4697	Bolts	3

(1) Part of 177-8003 Engine Tool Group

### Start By:

- a. Remove the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
- b. Remove the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Remove".

**Note:** This is an optional procedure to remove the camshaft. The preceding tool list shows the required tooling for removing the camshaft from the front of the engine or the rear of the engine.

**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.

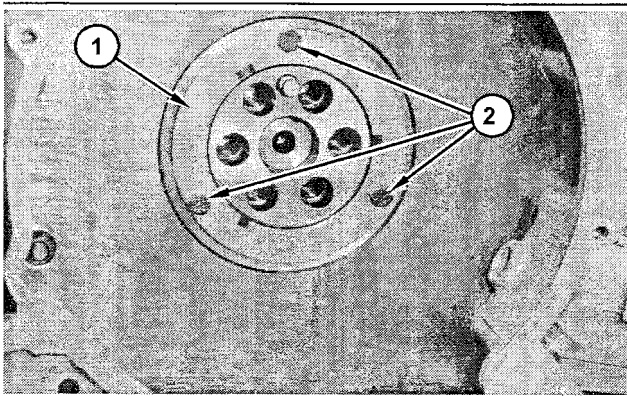


Illustration 205

g01028806

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

1. Remove bolts (2) and thrust plate (1).

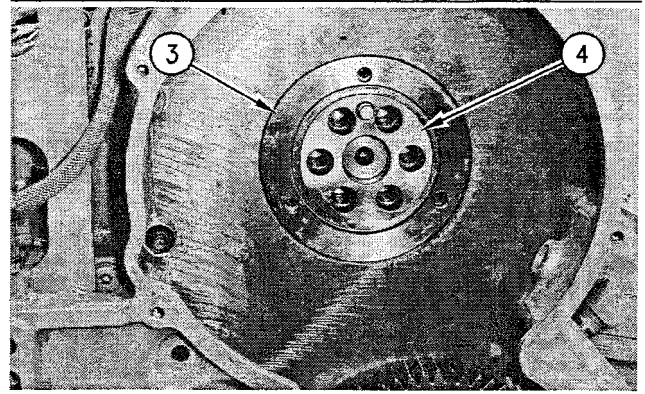


Illustration 206

g00576209

2. Remove seal assembly (3) and adapter (4).

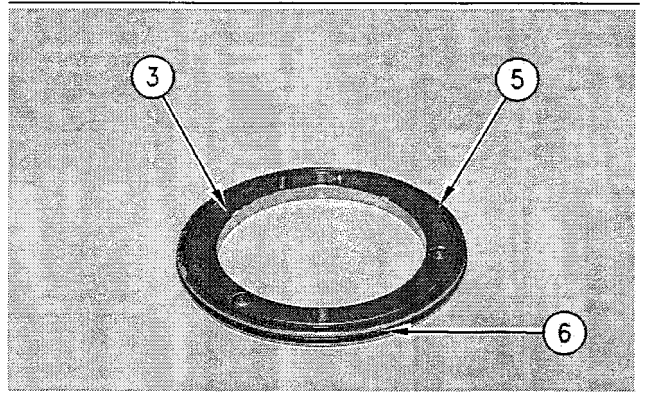


Illustration 207

g00576240

3. Remove O-ring seals (5) and (6) from seal assembly (3).

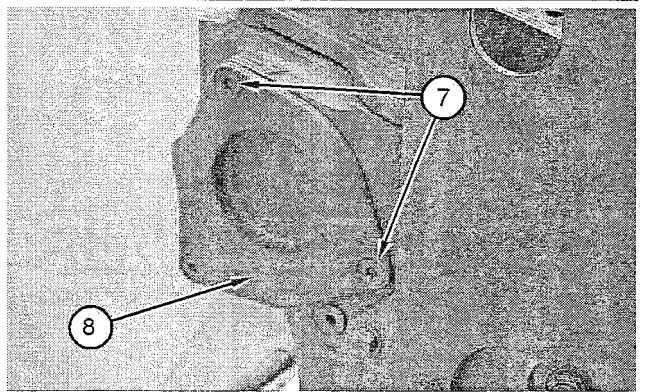


Illustration 208

g01043575

4. Remove screws (7) and cover (8).

**NOTICE**

Care must be used when removing the camshaft to not damage the highly finished surfaces of both the camshaft and camshaft bearings

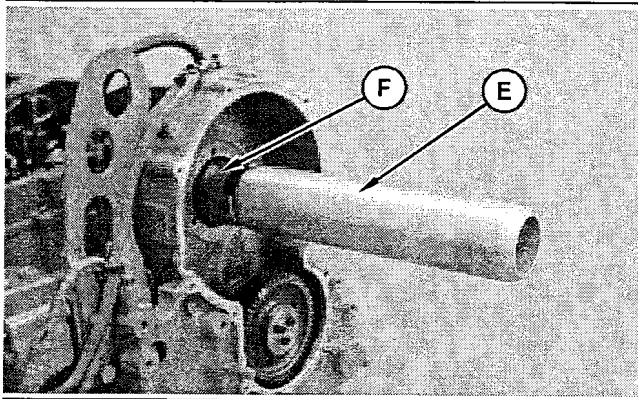


Illustration 209

g01024825

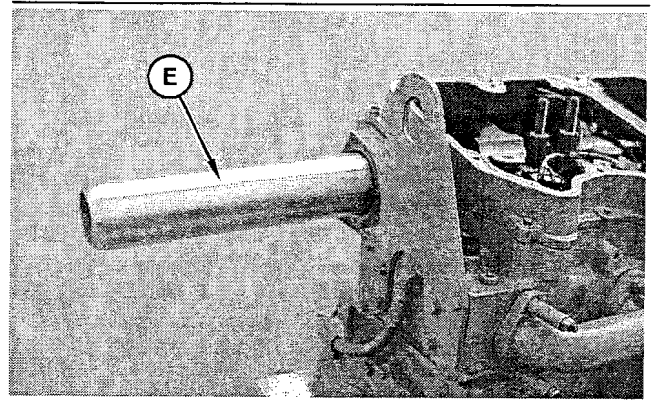


Illustration 211

g01024826

**Note:** Carefully align Tooling (F) with the end of the camshaft. If the adapter and the camshaft are not aligned, the camshaft may not be removed. The adapter and camshaft bearing will interfere.

5. To remove the camshaft from the rear of the engine, install Tooling (F) on the front of the camshaft with Tooling (G).
6. Install Tooling (E).

8. To remove the camshaft from the front of the engine, install Tooling (E) on the rear of the camshaft.
9. Carefully slide the camshaft to the front of the engine for removal. Use two technicians to remove the camshaft. Keep the camshaft level while the camshaft is being removed from the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).

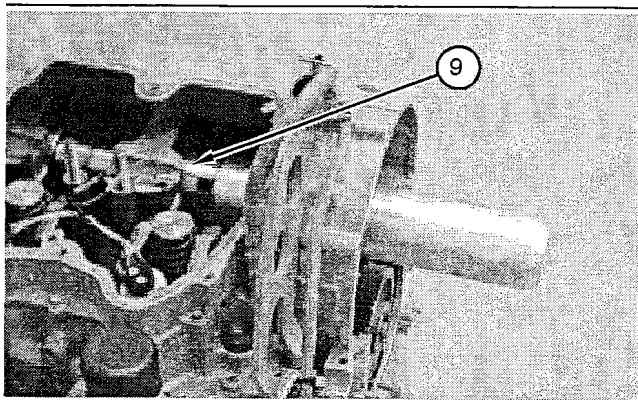


Illustration 210

g01043577

7. Carefully slide the camshaft to the rear of the engine for removal. Use two technicians to remove the camshaft. Keep the camshaft level while the camshaft is being removed from the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).

i02020749

## Camshaft - Install

SMCS Code: 1210-012

### Installation Procedure

Table 43

Required Tools			
Tool	Part Number	Part Description	Qty
A	9U-7257	Cradle	1
B	9U-7256	Guide	1
C	9U-7225	Camshaft Pilot	2
D	9U-7240	Camshaft Hook	2
H	9U-7243	Alignment Sleeve	1
J	9S-3263	Thread Lock Compound	1
K	8T-2998	Lubricant	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the camshaft and camshaft bearings are thoroughly clean. Lubricate the camshaft lobes with a 50/50 mixture of Tooling (K) and clean engine oil. Apply a thin coat of clean engine oil on the camshaft bearings.

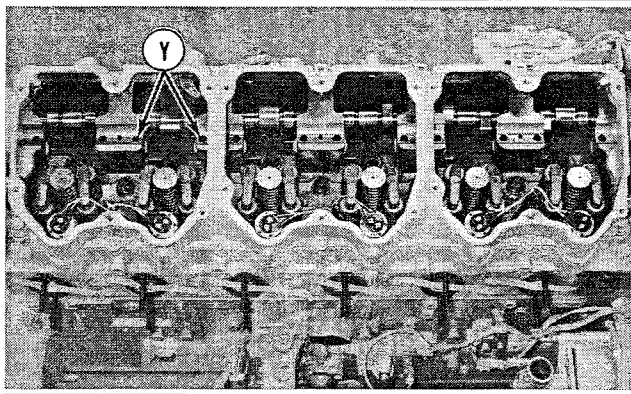


Illustration 212

g00509797

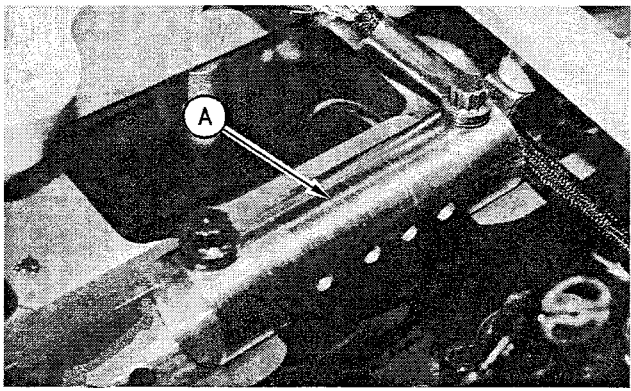


Illustration 213

g00581441

2. Install Tooling (A) on the cylinder head at Location (Y).

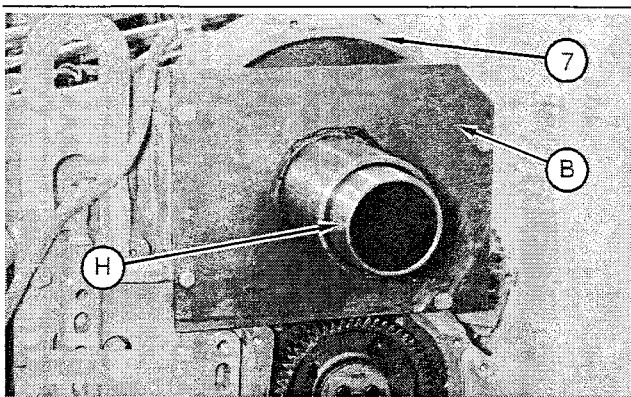


Illustration 214

g01024862

3. Install Tooling (B) on front housing (7). Do not tighten the bolts that hold Tooling (B) to front housing (7) at this time.

4. Use Tooling (H) to align Tooling (B) with the camshaft bearings. Tighten the bolts that hold Tooling (B) to front housing (7). Remove Tooling (H).

**Note:** Tooling (H) should move freely from the bore of Tooling (B).

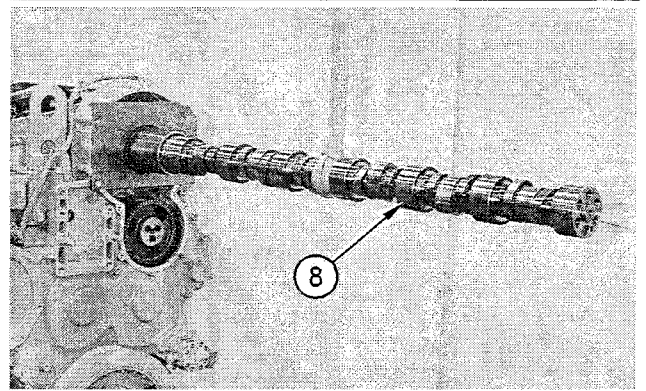


Illustration 215

g00581445

5. Install Tooling (C) in the end of camshaft (8).

**Note:** Rotate the camshaft during installation. This will prevent the camshaft from binding in the camshaft bearings.

6. Use a suitable lifting device in order to position camshaft (8) into Tooling (B) and the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).

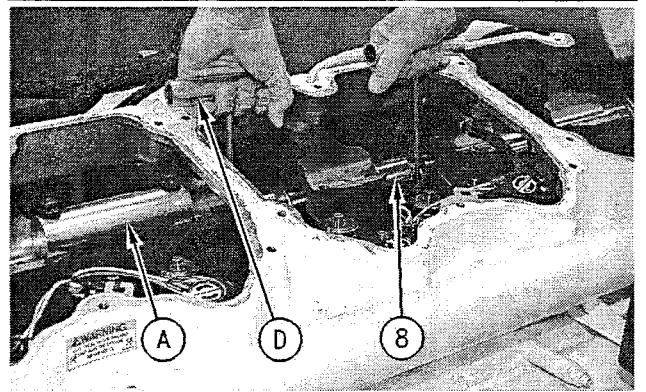


Illustration 216

g00581444

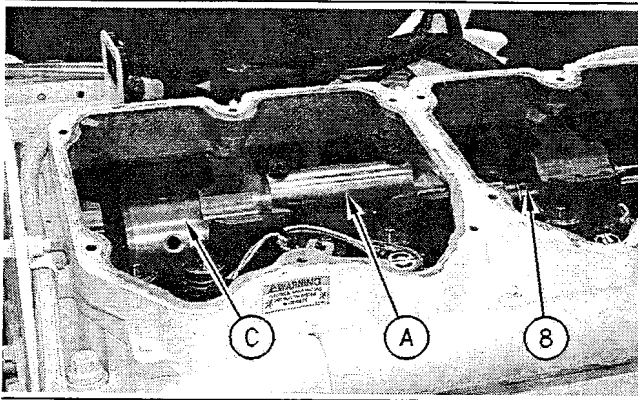


Illustration 217

g00581443

**Note:** Tooling (C) must be removed before the camshaft can be completely installed in the cylinder head.

7. Remove the lifting device. Rotate the camshaft during installation. Use care not to allow the end of the camshaft and Tooling (C) to drop. Use Tooling (D) to assist in aligning camshaft (8) with the camshaft bearings.
8. Remove Tooling (C) and finish installing camshaft (8) in the bore.
9. Remove Tooling (A) and Tooling (B).

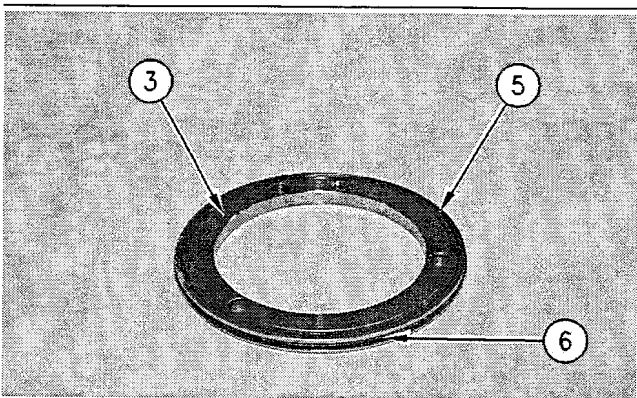


Illustration 218

g00576240

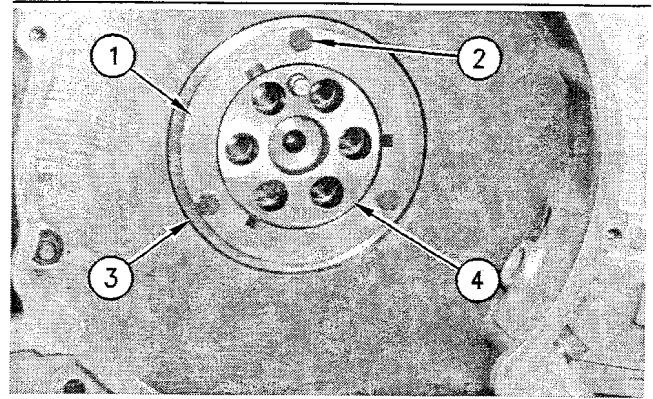


Illustration 219

g00576839

10. Install O-ring seals (5) and (6) in seal assembly (3). Lubricate seal (6) with Tooling (K).

11. Assemble thrust plate (1) and seal assembly (3). Apply Tooling (J) to bolts (2). Hold the assembly in position and install bolts (2). Evenly tighten bolts (2) until seal assembly (3) and O-ring seal (5) are seated against the cylinder head.

**Note:** Be careful in order to ensure that O-ring seal (5) stays in the groove in seal assembly (3).

12. Install adapter (4). Ensure that the dowel in adapter (4) engages the hole in the camshaft.

#### End By:

- a. Install the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Install".
- b. Install the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".

### Alternative Installation Procedure

Table 44

Required Tools			
Tool	Part Number	Part Description	Qty
E <sup>(1)</sup>	177-8001	Sleeve	1
F	177-8002	Adapter	1
G	6L-4697	Bolts	3
J	9S-3263	Thread Lock Compound	1
K	8T-2998	Lubricant	1

<sup>(1)</sup> Part of 177-8003 Engine Tool Group

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the camshaft and camshaft bearings are thoroughly clean. Lubricate the camshaft lobes with a 50/50 mixture of Tooling (K) and clean engine oil. Apply a thin coat of clean engine oil on the camshaft bearings.

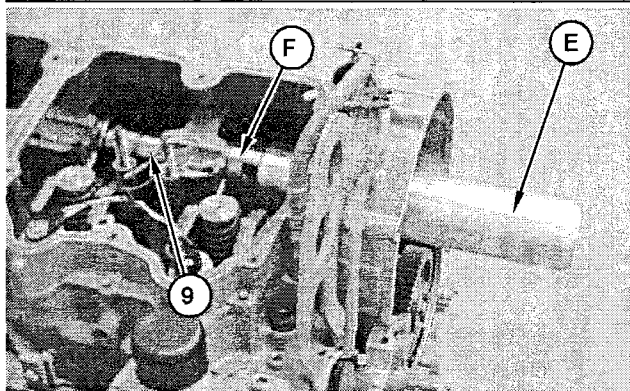


Illustration 220

g01043587

2. Install Tooling (F) on the front of camshaft (9) with Tooling (G).
3. Install Tooling (E).
4. Use two technicians to install the camshaft. Carefully slide camshaft (9) into the cylinder head from the rear of the engine. Keep the camshaft level while the camshaft is being installed in the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).
5. Remove Tooling (F).

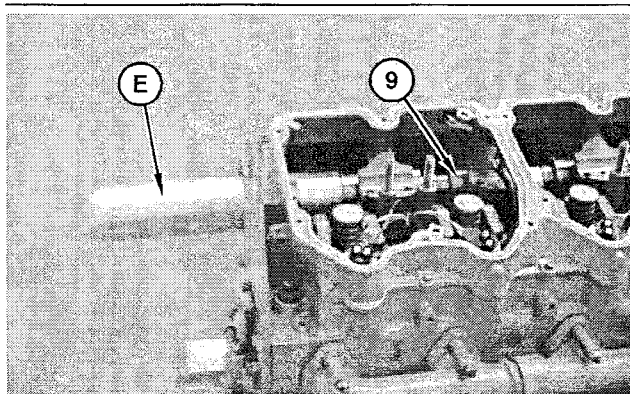


Illustration 221

g01043589

6. Install Tooling (F) on the end of the camshaft.

7. Use two technicians to install the camshaft. Carefully slide camshaft (9) into the cylinder head from the rear of the engine. Keep the camshaft level while the camshaft is being installed in the cylinder head. The weight of the camshaft is approximately 39 kg (86 lb).

8. Remove Tooling (F).

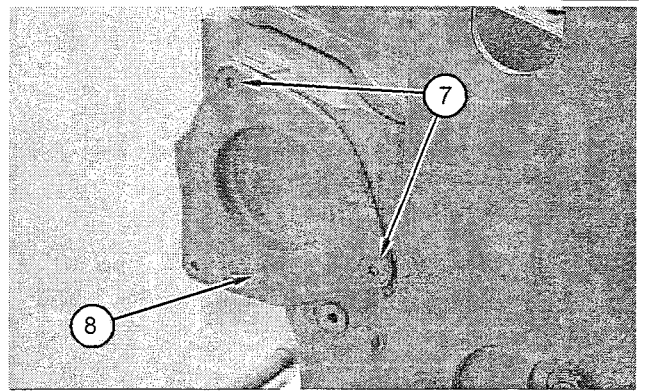


Illustration 222

g01043575

9. Position cover (8) on the rear of the cylinder head. Install bolts (7).

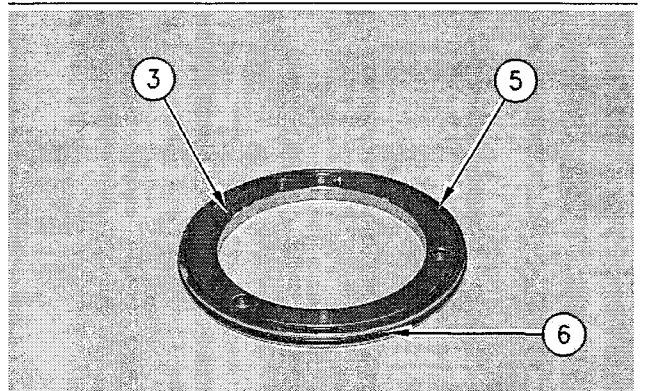


Illustration 223

g00576240

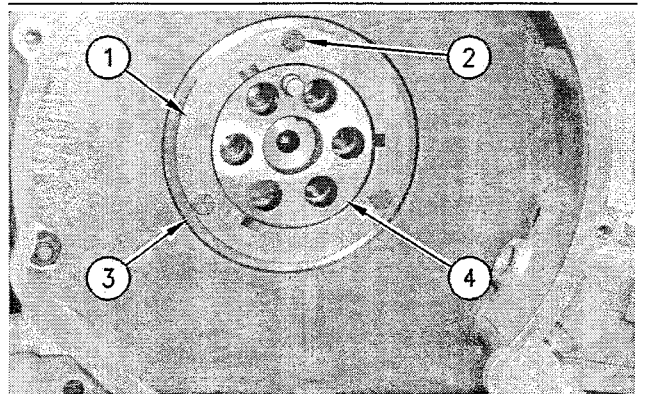


Illustration 224

g00576839

10. Install O-ring seals (5) and (6) in seal assembly (3). Lubricate seal (6) with Tooling (K).



11. Assemble thrust plate (1) and seal assembly (3). Apply Tooling (J) to bolts (2). Hold the assembly in position and install bolts (2). Evenly tighten bolts (2) until seal assembly (3) and O-ring seal (5) are seated against the cylinder head.

**Note:** Be careful in order to ensure that O-ring seal (5) stays in the groove in seal assembly (3).

12. Install adapter (4). Ensure that the dowel in adapter (4) engages the hole in the camshaft.

**End By:**

- a. Install the rocker arms and the rocker shafts. Refer to Disassembly and Assembly, "Rocker Arm and Shaft - Install".
- b. Install the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".

i02110882

## Camshaft Gear - Remove and Install

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

### Removal Procedure

Table 45

Required Tools			
Tool	Part Number	Part Description	Qty
A	9U-6896	Guide Bolt	1

**Start By:**

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

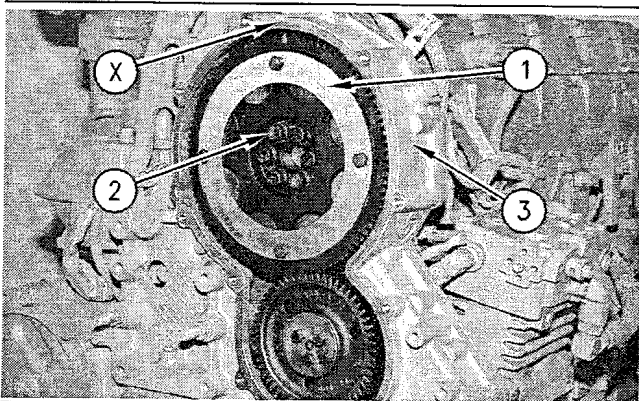


Illustration 225

g00579965

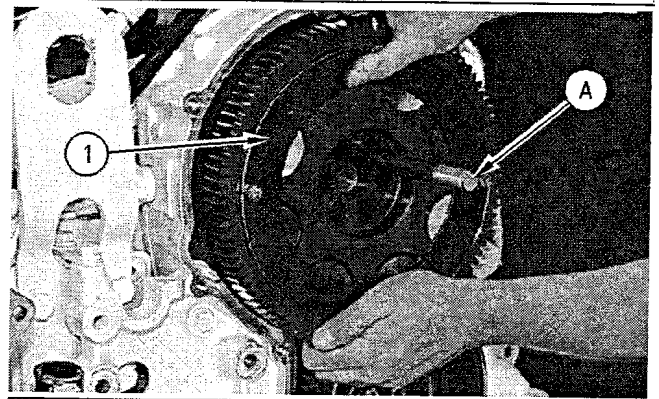


Illustration 226

g00579966

1. Position the No. 1 piston at the top center of the compression stroke. Refer to Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".
2. Verify that the timing mark on camshaft gear (1) is aligned with Timing Mark (X) on front housing (3).
3. Remove top bolt (2) from camshaft gear (1). Install Tooling (A) in place of the bolt.
4. Remove remaining bolts (2) and remove camshaft gear (1).

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

5. Remove Tooling (A).

## Installation Procedure

Table 46

Required Tools			
Tool	Part Number	Part Description	Qty
A	9U-6896	Guide Bolt	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

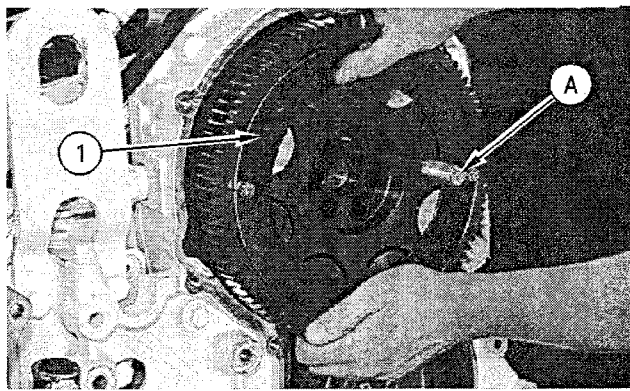


Illustration 227

g00579966

**NOTICE**

Do not turn the crankshaft or the camshaft while the camshaft gear is removed. If the front gear group is not correctly timed during installation, interference can occur between the pistons and the valves, resulting in damage to the engine.

1. Install Tooling (A) in the top hole in the camshaft.
2. Align the hole in the back of camshaft gear (1) with the dowel in the adapter. Install camshaft gear (1) over Tooling (A).

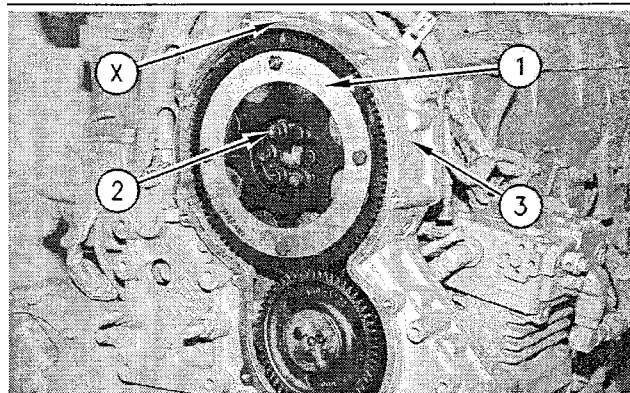


Illustration 228

g00579965

**Note:** Camshaft timing is critical. The timing mark on the camshaft gear must be aligned with the timing mark on the front cover when the No. 1 piston is at the top center of the compression stroke. Refer to Testing and Adjusting, "Gear Group (Front) - Time".

3. Verify that the timing mark on camshaft gear (1) is aligned with Timing Mark (X) on front housing (3).

**Note:** If the timing marks are not aligned, remove camshaft gear (1) and rotate the camshaft until the timing marks are aligned.

4. Install bolts (2). Remove Tooling (A) and install remaining bolt (2).

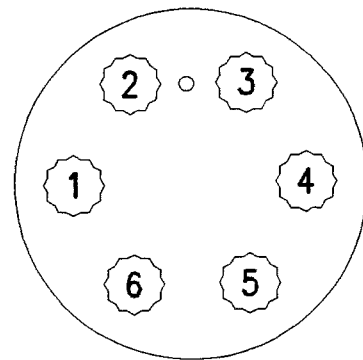


Illustration 229

g00593987

5. Tighten the bolts in a numeric sequence 1, 4, 2, 5, 3, 6, 1, 4 to a torque of  $240 \pm 40$  N·m ( $180 \pm 30$  lb ft).
6. Check the backlash between the camshaft gear and the adjustable idler gear. The backlash should be  $0.216 \pm 0.114$  mm ( $0.0085 \pm 0.0045$  inch). Refer to Testing and Adjusting, "Gear Group (Front) - Time" for the backlash adjustment procedure.

**End By:**

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

i01995165

## Camshaft Bearings - Remove

SMCS Code: 1211-011

### Removal Procedure

Table 47

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	8S-2241	Camshaft Bearing Tool Group	1
	8S-8290	Nut	1
	8S-8291	Threaded Shaft	1
	8S-8287	Thrust Bearing Assembly	1
	8S-8288	Cone	1
	8S-8292	Extension (Short)	2
	8S-8293	Extension (Long)	1
B	9U-7222	Camshaft Bearing Pilot	1
	8M-8778	Taperlock Stud (1/2 inch - 13 UNC by 1 9/16 inch)	1
C	9U-7223	Alignment Bushing	1
D	9U-7210	Puller Plate	1

(1) Part of the 8S-2241 Camshaft Bearing Tool Group

#### Start By:

- a. 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.

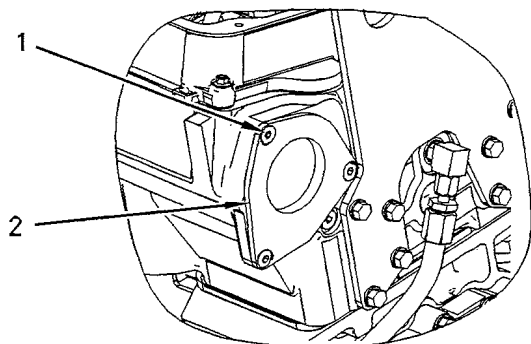


Illustration 230

g01005315

1. Remove bolts (1) from rear cover (2). Inspect the O-ring seal and replace the O-ring seal if the O-ring seal is worn or damaged.

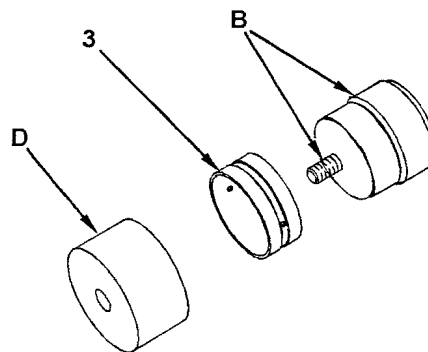


Illustration 231

g01034895

2. Remove the No. 7 camshaft bearing (rear). Work from the rear of the engine to the front of the engine.
  3. Install the small end of Tooling (B) in the camshaft bearing.
  4. Position Tooling (D) on Tooling (A). Install Tooling (A) on Tooling (B).
- Note:** Tooling (D) is installed on the outside of the cylinder head. Tooling (D) is required in order to remove the No. 7 camshaft bearing from the cylinder head.
5. Use Tooling (A) to remove camshaft bearing (3) from the cylinder head.
  6. Remove Tooling (B) from Tooling (A) and remove the camshaft bearing.
  7. Repeat Step 3 through Step 6 in order to remove the remaining camshaft bearings. Work from the rear of the engine to the front of the engine.

i01995166

# Camshaft Bearings - Install

SMCS Code: 1211-012

## Installation Procedure

Table 48

Required Tools			
Tool	Part Number	Part Description	Qty
A <sup>(1)</sup>	8S-2241	Camshaft Bearing Tool Group	1
	8S-8290	Nut	1
	8S-8291	Threaded Shaft	1
	8S-8287	Thrust Bearing Assembly	1
	8S-8288	Cone	1
	8S-8292	Extension (Short)	2
	8S-8293	Extension (Long)	1
B	9U-7222	Camshaft Bearing Pilot	1
	8M-8778	Taperlock Stud (1/2 inch - 13 UNC by 1 9/16 inch)	1
C	9U-7223	Alignment Bushing	1
D	9U-7210	Puller Plate	1
E	9U-7213	Backup Plate	1
	0S-1621	Bolt (1/2 inch - 13 UNC by 1 inch)	1
F	9U-7214	Spacer Plate	1

(1) Part of the 8S-2241 Camshaft Bearing Tool Group

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Ensure that the inside of the cylinder head is clean. Inspect the camshaft bore for metal burrs. Put a thin film of clean engine oil on the inside of the camshaft bearing bores and on each camshaft bearing prior to installation.

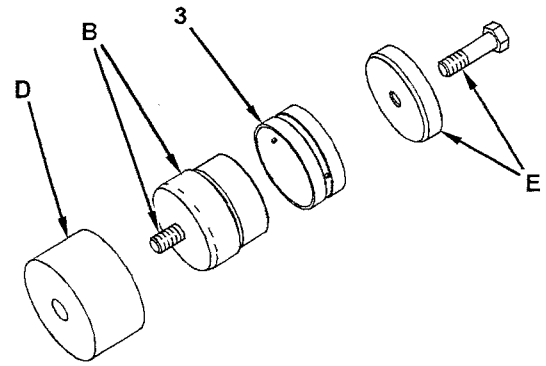


Illustration 232

g01034920

1. Install the No. 7 camshaft bearing (rear), as follows:
  - a. Insert the large end of Tooling (B) into the No. 7 camshaft bore. Position camshaft bearing (3) on Tooling (B).
  - b. Position Tooling (D) on Tooling (A). Install Tooling (A) in Tooling (B).
  - c. Position camshaft bearing (3) on Tooling (B). Install Tooling (E) on Tooling (B).

**Note:** Refer to Specifications, "Cylinder Head" for appropriate information for the orientation of the camshaft bearings in the cylinder head.

- d. Use Tooling (A) in order to pull camshaft bearing (3) into the camshaft bore.

**Note:** When the chamfer of Tooling (E) contacts the face of the camshaft bore, the camshaft bearing is properly installed.

- e. Remove Tooling (E) from Tooling (B). Remove Tooling (A) from Tooling (B). Remove Tooling (B) from the cylinder head.

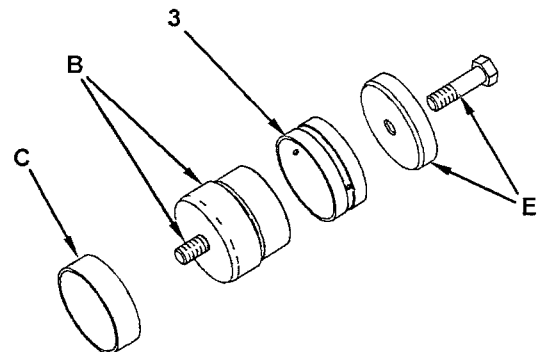


Illustration 233

g01034921

2. Install the No. 6 through No. 2 camshaft bearings, as follows:

- a. Insert the large end of Tooling (B) into the camshaft bore.

**Note:** Use Tooling (C) to align Tooling (A) and Tooling (B) with the camshaft bearing bores. Install Tooling (C) in the inside diameter of any installed camshaft bearing between Tooling (A) and Tooling (B).

- b. Install Tooling (A) in Tooling (B). Position camshaft bearing (3) on Tooling (B). Install Tooling (E) on Tooling (B).

**Note:** Refer to Specifications, "Cylinder Head" for appropriate information for the location and the orientation of the camshaft bearings in the cylinder head.

- c. Use Tooling (A) in order to pull camshaft bearing (3) into the camshaft bore.

**Note:** When the chamfer of Tooling (E) contacts the face of the camshaft bore, the camshaft bearing is properly installed.

- d. Remove Tooling (E) from Tooling (B). Remove Tooling (A) from Tooling (B).

- e. Remove Tooling (B) and Tooling (C) from the cylinder head.

3. Repeat Step 2 in order to install the No. 6 through No. 2 camshaft bearings.

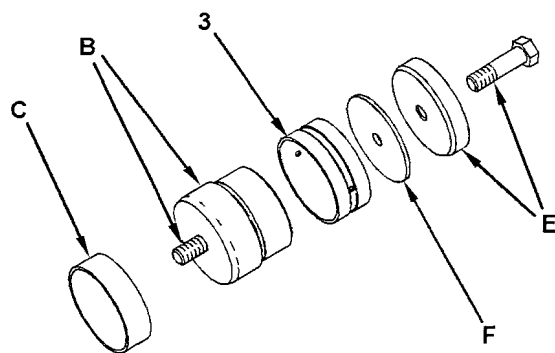


Illustration 234

g01034922

4. Install the No. 1 camshaft bearing (front), as follows:

- a. Insert the large end of Tooling (B) into the No. 1 camshaft bore. Assemble Tooling (A) and Tooling (C) on Tooling (B).
- b. Position camshaft bearing (3) on Tooling (B). Install Tooling (E) and Tooling (F) on Tooling (B).

**Note:** Refer to Specifications, "Cylinder Head" for appropriate information for the location and the orientation of the camshaft bearings in the cylinder head.

**Note:** Tooling (F) is used to seat the No. 1 camshaft bearing to the correct depth in the camshaft bore.

- c. Use Tooling (A) in order to pull the No. 1 camshaft bearing into the No. 1 camshaft bore. When the chamfer of Tooling (E) contacts the face of the camshaft bore, the camshaft bearing is properly installed.

- d. Remove Tooling (E) and Tooling (F) from Tooling (B). Remove Tooling (A) from Tooling (B).

- e. Remove Tooling (B) and Tooling (C) from the cylinder head.

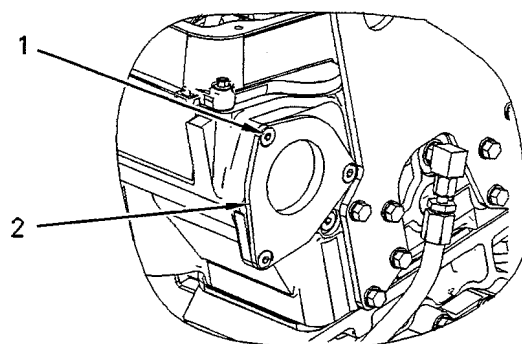


Illustration 235

g01005315

5. Inspect the O-ring seal. Replace the O-ring seal if the seal is worn or damaged. Position rear cover (2). Install bolts (1). Tighten the bolts to a torque of  $13 \pm 3$  N·m ( $10 \pm 2$  lb ft).

#### End By:

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

i01974881

# Engine Oil Pan - Remove and Install

SMCS Code: 1302-010

## Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.



**WARNING**

Hot oil and hot components can cause personal injury. Do not allow hot oil or hot components to contact the skin.

1. Drain the oil from the engine oil pan into a suitable container for storage or disposal.

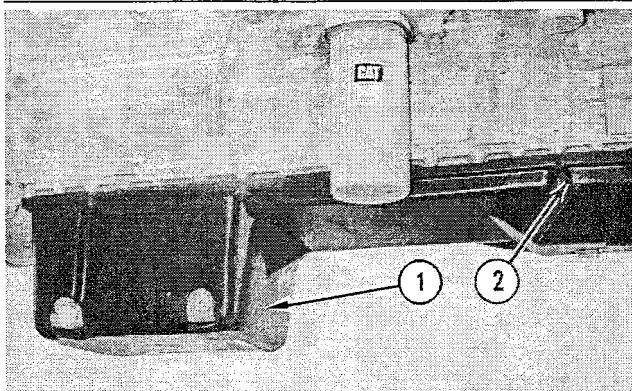


Illustration 236

g00516605

2. Remove bolts (2) and remove sound suppression panel (1), if equipped.

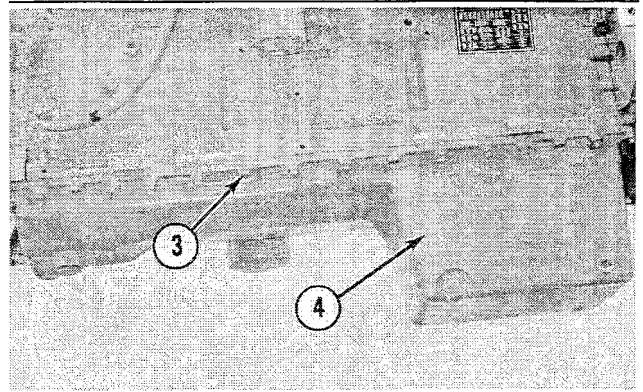


Illustration 237

g00516607

3. Remove bolts (3) that fasten engine oil pan (4) to the cylinder block.
4. Remove engine oil pan (4).
5. Some engines are equipped with a plate between the engine oil pan and the cylinder block. Remove the bolts and the plate from the cylinder block. Remove the plate gasket. The weight of the plate is approximately 24 kg (53 lb).

## Installation Procedure

Table 49

Required Tools			
Tool	Part Number	Part Description	Qty
A	8T-9022	Silicone Gasket	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Apply Tooling (A) on the sealing surface of the engine oil pan and on the connecting joints of the front plate, oil pan gasket, cylinder block, and the flywheel housing. Install a new gasket on the engine oil pan.
2. Position a new gasket on the cylinder block and install the plate, if equipped. The weight of the plate is approximately 24 kg (53 lb).

i02000204

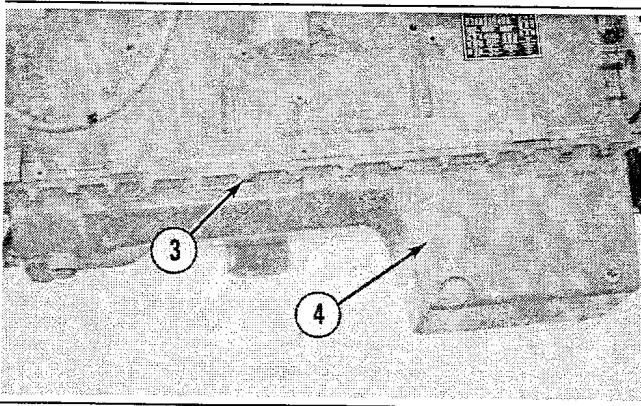


Illustration 238

g00516607

3. Position engine oil pan (4) and install bolts (3). Tighten bolts (3) to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft).
4. Tighten the drain plug to a torque of  $70 \pm 15$  N·m ( $52 \pm 11$  lb ft).

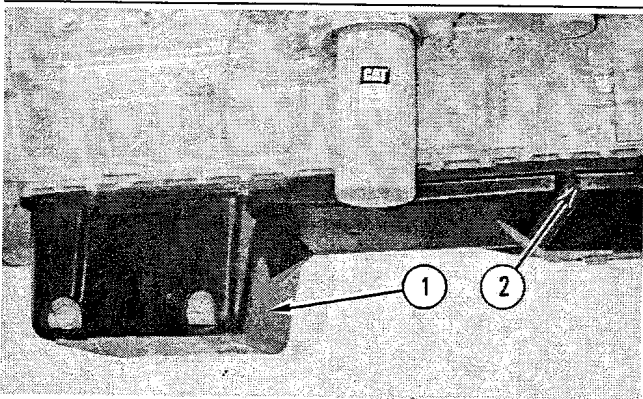


Illustration 239

g00516605

5. If the engine is equipped with a sound suppression panel, position sound suppression panel (1) and install bolts (2).
6. Fill the engine to the correct level with oil. Refer to Operation and Maintenance Manual, "Refill Capacities".

## Cylinder Liner - Remove

SMCS Code: 1216-011

### Removal Procedure

Table 50

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8665 <sup>(1)</sup>	Cylinder Liner Puller Gp	1

<sup>(1)</sup> The 6V-9448 Cylinder Pack Puller is an optional Tool for removing the cylinder liner.

#### Start By:

- a. Remove the pistons and 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.

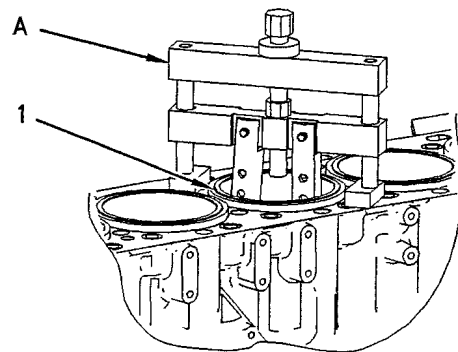


Illustration 240

g01005579

1. Remove cylinder liner (1) with Tooling (A).

i02110914

## Cylinder Liner - Install

SMCS Code: 1216-012

### Installation Procedure

Table 51

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Check the cylinder liner projection. Refer to Testing and Adjusting, "Cylinder Liner Projection - Inspect".

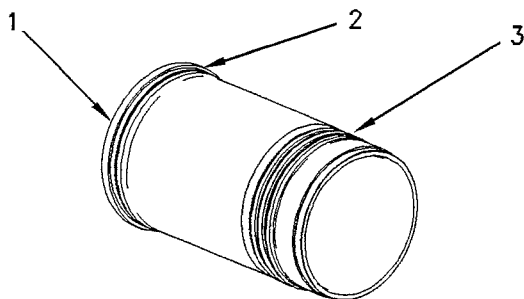


Illustration 241

g01004993

2. Install liner seals (3) in the respective grooves.
3. Apply Tooling (C) on the cylinder block liner bore surfaces and liner seals (3).
4. Dip filler band (2) in clean engine oil for a moment. Install filler band (2) and install cylinder liner (1) immediately.

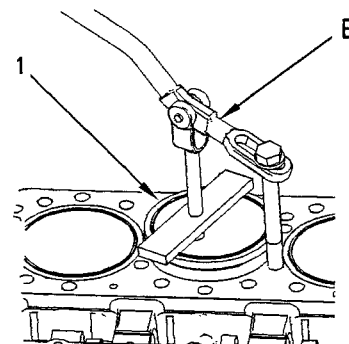


Illustration 242

g01005003

5. Use Tooling (B) to install cylinder liner (1) in the cylinder block. Ensure that any marks in relation to the cylinder liner projection are in alignment.

**Note:** Refer to Special Instruction, SEHS9564 for more information about cylinder liner installation.

#### End By:

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

i01974937

## Piston Cooling Jets - Remove and Install

SMCS Code: 1331-010

### Removal Procedure

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.



i01098970

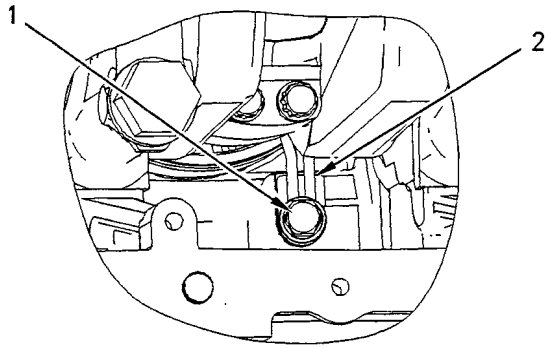


Illustration 243

g01004705

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

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

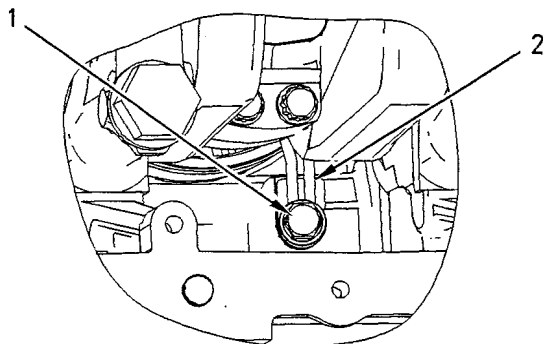


Illustration 244

g01004705

1. Install piston cooling jet (2) and bolt (1). Tighten bolt (1) to a torque of  $40 \pm 8$  N·m ( $30 \pm 6$  lb ft).
2. Check the clearance between the piston, the piston cooling jet, and the crankshaft.

Minimum permissible clearance between the piston, the piston cooling jet, and the crankshaft ..... 0.63 mm (0.025 inch)

#### End By:

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

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

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.

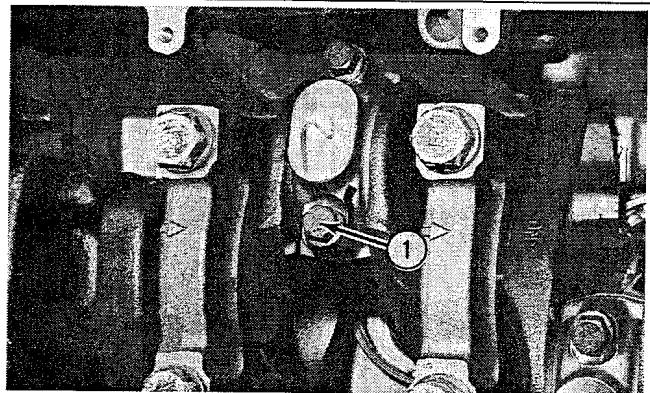


Illustration 245

g00506275

1. Turn the crankshaft until two pistons are at the bottom center.

2. Remove the carbon ridge from the top inside surface of the cylinder liner.
3. Remove bolts (1) and the connecting rod bearing caps. Push the connecting rods and pistons until the piston rings are out of the cylinder liners.

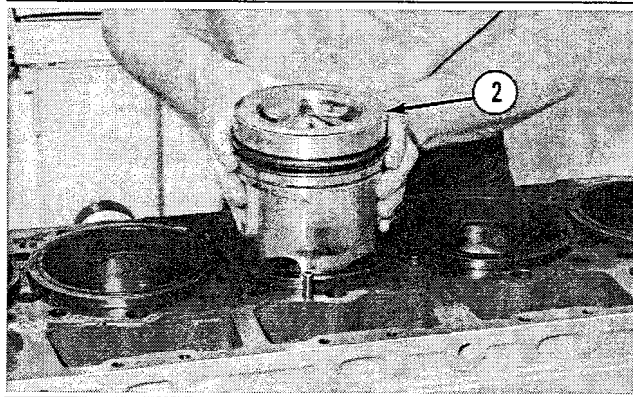


Illustration 246

g00506229

4. Remove pistons (2) and connecting rods from the cylinder liners.
5. Repeat Steps 1 through 4 in order to remove the remainder of the pistons and connecting rods.

i01974944

## Pistons and Connecting Rods - Disassemble

SMCS Code: 1225-015

### Disassembly Procedure

Table 52

Required Tools			
Tool	Part Number	Part Description	Qty
A	1P-1861 <sup>(1)</sup> or 139-9039 <sup>(2)</sup>	Retaining Ring Pliers	1
B	7M-3978 <sup>(3)</sup> or 149-7179 <sup>(4)</sup>	Ring Expander	1

<sup>(1)</sup> Use with one-piece piston

<sup>(2)</sup> Use with two-piece piston

<sup>(3)</sup> Use with C-15 Engines

<sup>(4)</sup> Use with C-16 Engines

#### Start By:

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

**Note:** Mark the components of each piston and connecting rod assembly. The components must be reinstalled in the original location. Do not interchange components.

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

### One-piece piston

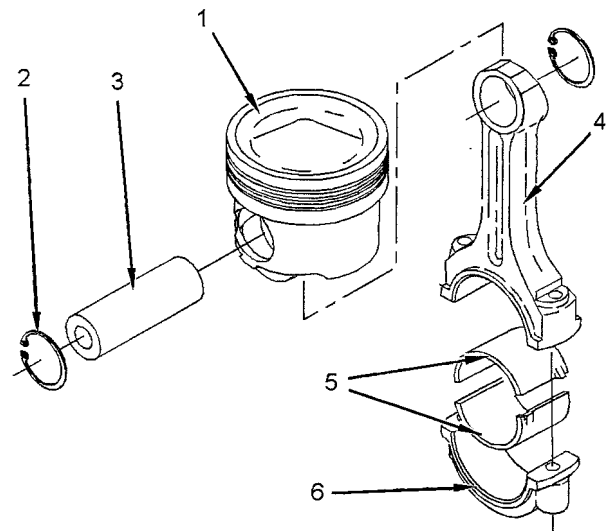


Illustration 247

g01033568

1. Remove bearings (5) from connecting rod (4) and connecting rod cap (6).
2. Use Tooling (A) to remove retaining ring (2).
3. Remove pin (3) and separate piston (1) from connecting rod (4).
4. Use Tooling (B) to remove the piston rings from piston (1).

## Two-piece piston

i02110984

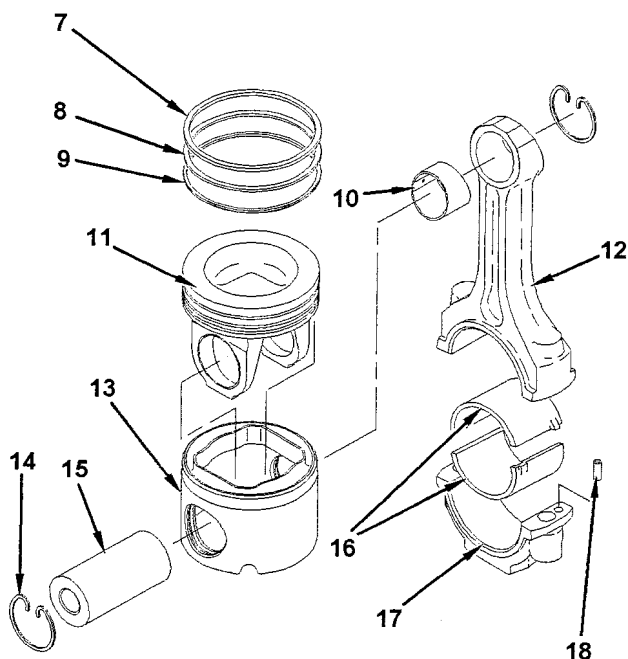


Illustration 248

g01033611

1. Remove bearings (16) from connecting rod (12) and connecting rod cap (17). Remove dowel (18) from connecting rod cap (17).
2. Use Tooling (A) to remove retaining ring (14).
3. Remove pin (15) and connecting rod (12) from the piston.
4. Use Tooling (B) to remove piston rings (7), (8), and (9) from the piston.
5. Separate piston crown (11) from piston skirt (13).

**Note:** Piston pin bearing (10) will be pushed out of connecting rod (12) during installation of the new bearing. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - Assemble" for the procedure.

## Pistons and Connecting Rods - Assemble

SMCS Code: 1225-016

### Assembly Procedure

Table 53

Required Tools			
Tool	Part Number	Part Description	Qty
A	1P-1861 <sup>(1)</sup> or 139-9039 <sup>(2)</sup>	Retaining Ring Pliers	1
	B	7M-3978 <sup>(3)</sup> or 149-7179 <sup>(4)</sup>	Ring Expander
C		5P-8639	Hydraulic Press (Connecting Rod Bearing)
	8F-0024	Hose Assembly	1
	1P-2375	Connecting Coupler	1
	1P-2376	Connecting Coupler	1
	5P-8651	Spacer	1
	5P-8649	Adapter	1
	8P-8650	Bushing Adapter	1
	9U-6600	Hydraulic Pump	1

<sup>(1)</sup> Use with one-piece piston

<sup>(2)</sup> Use with two-piece piston

<sup>(3)</sup> Use with C-15 Engines

<sup>(4)</sup> Use with C-16 Engines

**Note:** Prior to removal from the engine, the pistons and connecting rod assemblies were marked. The components must be reassembled together. The components must be installed in the original location in the engine. Do not interchange any of the components.

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**One-piece piston**

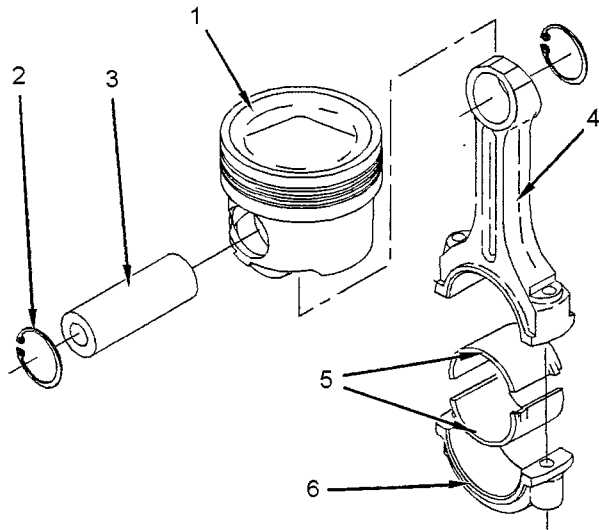


Illustration 249

g01033568

1. Use Tooling (B) to install the piston rings on piston (1). Position the rings so the gaps are 120 degrees from each other.
2. Assemble piston (1) and connecting rod (4). Install pin (3).
3. Use Tooling (A) to install retaining ring (2).
4. Install bearings (5) in connecting rod (4) and connecting rod cap (6).

**Two-piece piston**

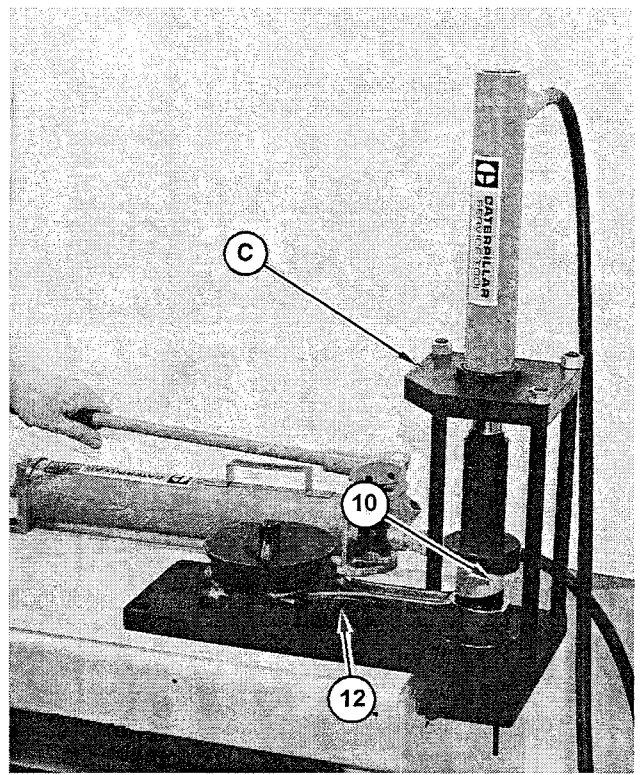


Illustration 250

g01033642

1. Install a new piston pin bearing (10) in connecting rod (12) and remove the old piston pin bearing, as follows:

**NOTICE**

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

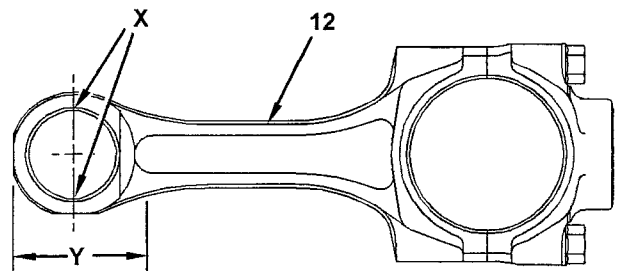


Illustration 251

g01033643

- a. Heat Length (Y) of connecting rod (12) to a temperature of 175 to 260 °C (347 to 468 °F).  
(Y) Maximum Length for heating the connecting rod ..... 85 mm (3.4 inch)

- b. Use Tooling (C) to remove the old bearing and install the new bearing at the same time. The adapter of Tooling (C) should make full contact with the surfaces of the connecting rod.

**Note:** Orient the bearing joint within  $\pm 5$  degrees of either Location (X).

- c. Allow the connecting rod and the bearing to cool to room temperature.

2. Use a pin boring machine to machine the bore of the piston pin bearing to the correct diameter.

Diameter of piston pin bore ...  $55.035 \pm 0.008$  mm  
( $2.1667 \pm 0.0003$  inch)

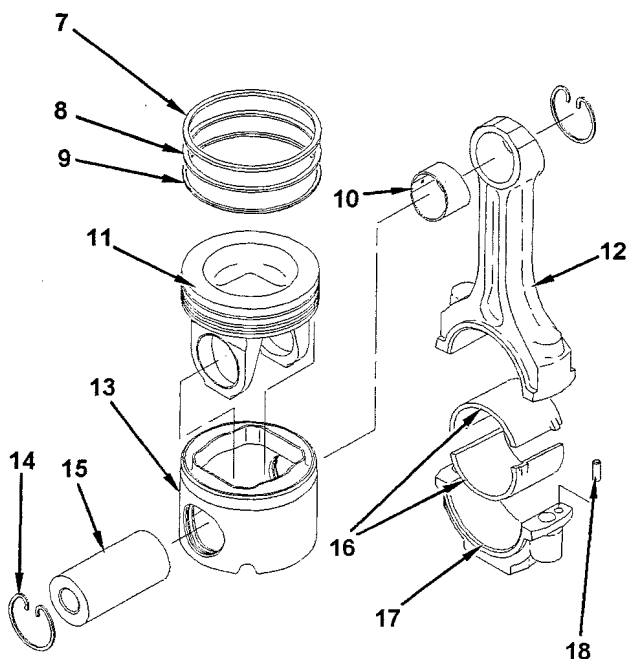


Illustration 252

g01033611

3. Check the clearance between the ends of piston rings (7), (8), and (9). Refer to Specifications, "Piston and Rings" for the specifications.
4. Install oil ring spring (9) in the oil ring groove of the piston.
5. Position oil ring (9) over the oil ring spring. Position the oil ring so that the gap is 180 degrees from the joint in the oil ring spring. Install the oil ring on the piston with Tooling (B).
6. Use Tooling (B) to install intermediate piston ring (8) with the side that has the identification "UP-2" toward the top of the piston.

7. Use Tooling (B) to install top piston ring (7) with the side that has the identification "UP-1" toward the top of the piston.

8. Position piston rings (7), (8), and (9) so the gaps are 120 degrees from each other.

9. Position piston crown (11) on piston skirt (13).

**Note:** Ensure that piston pin bearing (10) is in the correct position in connecting rod (12).

10. Position the piston on connecting rod (12). Apply clean engine oil to piston pin (15) and install the piston pin. Install retainer rings (14) with Tooling (A). Make sure that the retainer rings are fully seated in the grooves of the piston.

11. Install connecting rod bearings (16) in connecting rod (12) and connecting rod cap (17). Make sure that the bearings are installed so that the bearing tabs fit into the notches in the connecting rod and in the connecting rod cap.

12. Install dowel (18) in connecting rod cap (17).

#### End By:

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

i02018619

## Pistons and Connecting Rods - Install

SMCS Code: 1225-012

### Installation Procedure

Table 54

Required Tools			
Tool	Part Number	Part Description	Qty
B	5P-3526 or 149-7180	Piston Ring Compressor	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

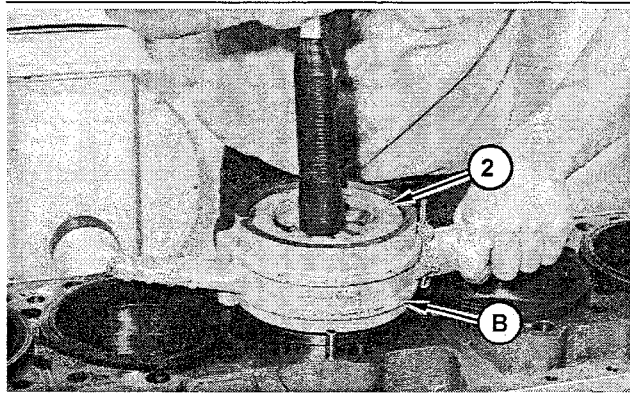


Illustration 253

g01032680

1. Apply clean engine oil to the cylinder liner bore, to the piston rings, and to the outer surface of the piston.

**Note:** Be careful not to damage the cylinder liners and/or the crankshaft journals during the installation of the pistons and the connecting rods.

2. Use Tooling (B) to install piston (2) and the connecting rod in the cylinder liner.

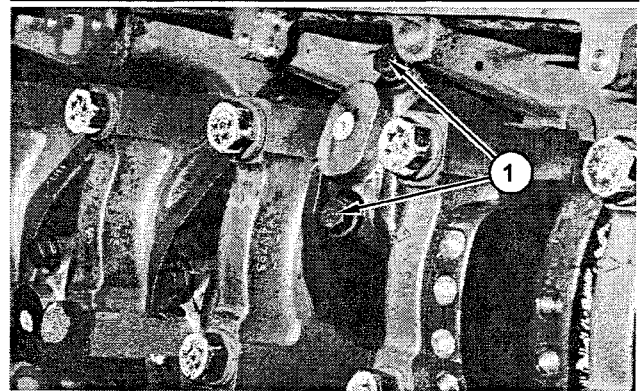


Illustration 254

g01032888

3. Install bolts (1) and the bearing caps. Refer to Specifications, "Connecting Rod" for the correct tightening procedure.

**End By:**

- a. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- b. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i01934239

## Connecting Rod Bearings - Remove

SMCS Code: 1219-011

### Removal Procedure

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i01974969

**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.

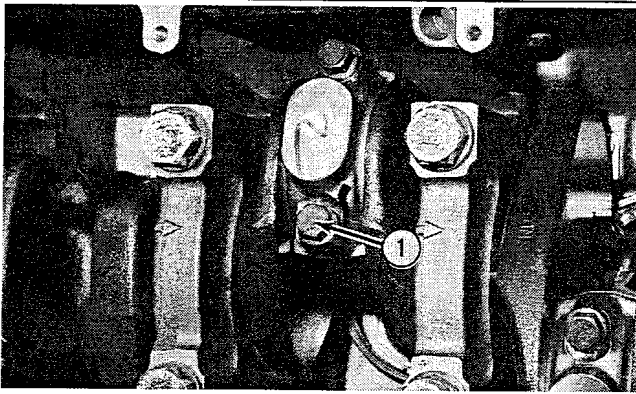


Illustration 255

g00506275

1. Turn the crankshaft until the connecting rod bearing caps are accessible.
2. Check the connecting rod and the connecting rod bearing caps for identification and for the location.
3. Remove bolts (1) and the connecting rod bearing cap from the connecting rod. Remove the lower half of the connecting rod bearing from the connecting rod bearing cap.
4. Push the connecting rod away from the crankshaft. Remove the upper half of the connecting rod bearing from the connecting rod.
5. Repeat Steps 1 through 4 for the removal of the remainder of the connecting rod bearings.

## Connecting Rod Bearings - Install

**SMCS Code:** 1219-012

### Installation Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
B	185 - 3989	Anti-Seize Compound	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

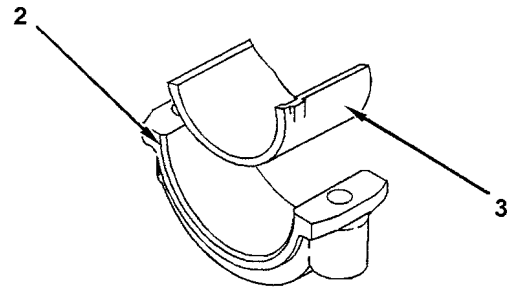


Illustration 256

g01029039

**Note:** Install the connecting rod bearings dry when clearance checks are performed. Apply clean engine oil on the connecting rod bearings for final assembly.

1. Install a new lower half connecting rod bearing (3) in connecting rod bearing cap (2).
2. Install a new upper half connecting rod bearing in the connecting rod.
3. Pull the connecting rod onto the crankshaft.

i01810421

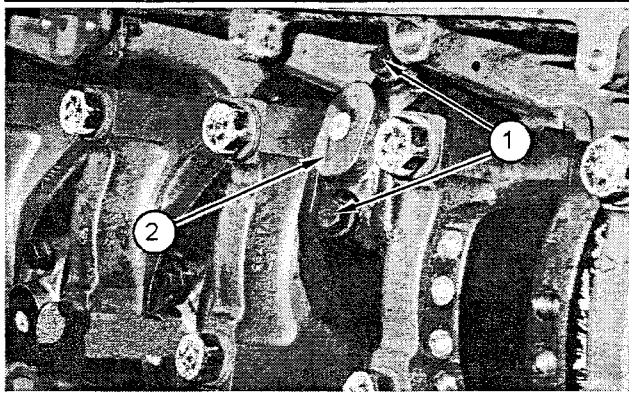


Illustration 257

g01032923

4. Check the connecting rod bearing clearances. Follow Steps 5 and 6 for the correct installation procedures and tightening procedures for the connecting rod bearing caps when the clearance check is performed. Refer to Disassembly and Assembly, "Bearing Clearance - Check".

Bearing clearance (new bearings) ..... 0.062 to 0.160 mm  
(0.0024 to 0.0063 inch)

Maximum permissible bearing clearance (used bearings) ..... 0.20 mm (0.008 inch)

5. Lubricate the threads of bolts (1) and the seating faces of connecting rod bearing cap (2) with Tooling (B). Install connecting rod bearing cap (2) and bolts (1). Ensure that the number on the side of the connecting rod bearing cap is on the same side as the number on the connecting rod.
6. Tighten bolts (1), as follows:
  - a. Tighten the bolts to a torque of  $90 \pm 8$  N·m ( $65 \pm 6$  lb ft).
  - b. Put a mark on each bolt and on each connecting rod bearing cap.
  - c. Tighten each bolt for an additional  $90 \pm 5$  degrees ( $1/4$  turn).
7. Repeat Steps 1 through 6 in order to install the remainder of the connecting rod bearings.

**End By:**

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

## Crankshaft Main Bearings - Remove

SMCS Code: 1203-011

### Removal Procedure

Table 56

Required Tools			
Tool	Part Number	Part Description	Qty
A	2P-5518	Bearing Tool	1

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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. Check the main bearing caps for identification of the location and check the direction of the main bearing caps in relation to the cylinder block. The main bearing caps must be installed in the original location and the original direction.



i01974984

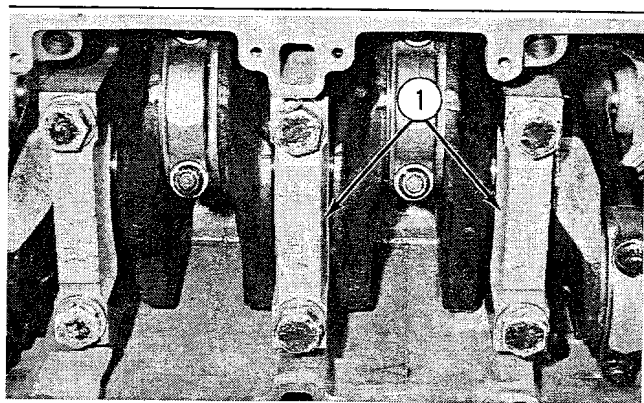


Illustration 258 g00503084

- Remove No. 2 through No. 6 main bearing caps (1). Remove the thrust plates from the No. 4 main bearing.

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

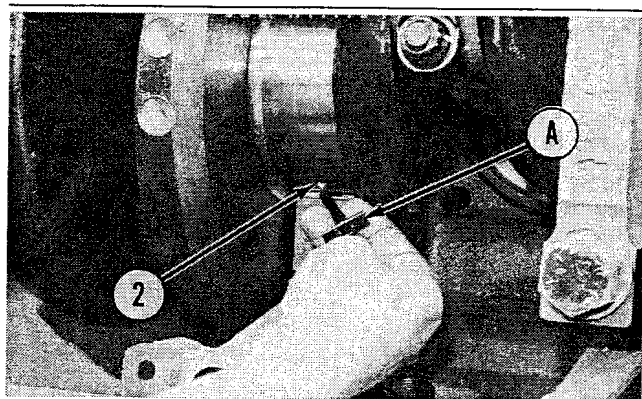


Illustration 259 g00503174

**Note:** If the crankshaft is turned in the wrong direction, the tab on the bearing will be pushed between the crankshaft and the bearing area of the cylinder block. This can result in damage to the cylinder block and/or the crankshaft. Turn the crankshaft so that the bearing tab is rotated out of the crankshaft.

- Remove the upper halves of the main bearings by putting Tooling (A) in oil hole (2) in the crankshaft. Turn the crankshaft in the direction which will remove the upper halves of the main bearings.
- Remove the lower halves of the main bearings from the main bearing caps.

## Crankshaft Main Bearings - Install

SMCS Code: 1203-012

### Installation Procedure

Table 57

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

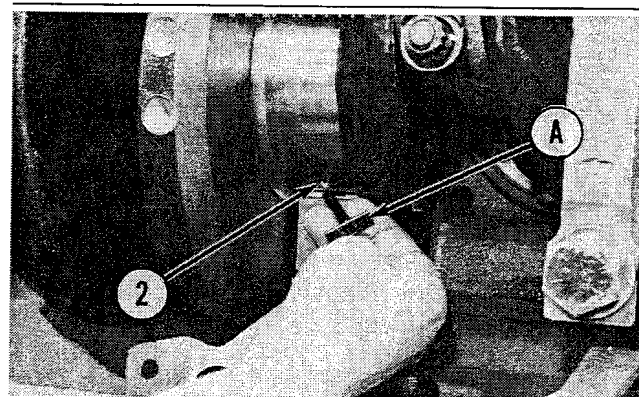


Illustration 260 g00503174

**Note:** Install the crankshaft main bearings dry when clearance checks are made. Put clean engine oil on the crankshaft main bearings for final assembly.

- Install new upper main bearings by putting Tooling (A) in oil hole (2) and turning the crankshaft in order to push the main bearing into the cylinder block. Insert the end of the bearing that does not have the tab into the cylinder block first.

**Note:** The upper halves of the main bearings have the oil groove and the oil hole.

**Note:** Ensure that the main bearings are installed so that the bearing tabs fit into the notch in the cylinder block and in the main bearing caps.

- Install new crankshaft main bearings in the main bearing caps.

**Note:** Refer to Special Publication, SEBD0531, "Engine Bearings and Crankshafts" for complete details concerning measuring of bearing clearances.

- 3. Check the crankshaft main bearing clearances. Follow Steps 4 and 5 for the correct installation procedures and tightening procedures for the main bearing caps when the clearance check is performed. Refer to Disassembly and Assembly, "Bearing Clearance - Check".

Bearing clearance (new bearings) ..... 0.091 to 0.186 mm  
(0.0036 to 0.0073 inch)

Maximum permissible bearing clearance (used bearings) ..... 0.25 mm (0.010 inch)

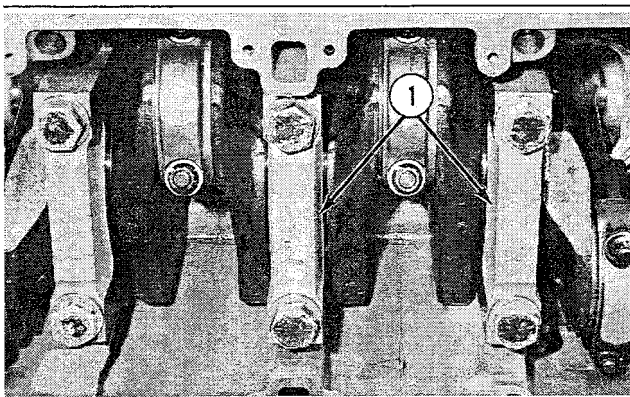


Illustration 261

g00503084

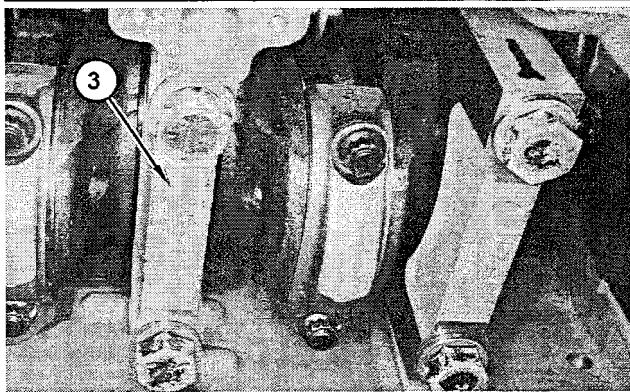


Illustration 262

g01029625

**Note:** Ensure that the numbers on main bearing caps (1) match the numbers on the cylinder block. Also ensure that arrows (3) on the main bearing caps are toward the front of the cylinder block.

- 4. Apply clean engine oil on the bolts. Install the thrust plates during installation of the No. 4 main bearing. Install the main bearing caps and the bolts.

**Note:** Install the thrust plates for the No. 4 main bearing with the words "Block Side" toward the cylinder block.

- 5. Tighten the bolts for the main bearing caps, as follows:
  - a. Tighten the bolt first on the bearing tab side of the main bearing cap to a torque of  $260 \pm 14$  N·m ( $190 \pm 10$  lb ft).
  - b. Tighten the bolt opposite the bearing tab side to a torque of  $260 \pm 14$  N·m ( $190 \pm 10$  lb ft).
  - c. Put a mark on each bolt and on each main bearing cap.
  - d. Tighten the bolt opposite the bearing tab side for an additional  $120 \pm 5$  degrees (2 flats).
  - e. Tighten the bolt on the bearing tab side for an additional  $120 \pm 5$  degrees (2 flats).
- 6. Use Tooling (B) to check the crankshaft end play. Ensure that Tooling (B) is against a machined surface. The end play is controlled by the thrust plates of No. 4 main bearing (center).

Crankshaft end play (new thrust plates) ..... 0.15 to 0.55 mm (0.006 to 0.022 inch)

Maximum permissible crankshaft end play (used thrust plates) ..... 0.89 mm (0.035 inch)

**End By:**

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

i01988142

# Crankshaft - Remove

SMCS Code: 1202-011

## Removal Procedure

Table 58

Required Tools			
Tool	Part Number	Part Description	Qty
A	1H-3110	Bearing Puller	1
	8B-7560	Step Plate	1
	9U-6600	Hand Hydraulic Pump	1
	1H-3108	Push-Puller Leg	2
	1H-3107	Bearing Puller	1
	3H-0468	Puller Plate	5
	3H-0465	Push-Puller Plate	2
	1P-0820	Hydraulic Puller	1
	5B-0637	Nut	1
	8S-6586	Forcing Screw	1
B	5P-0944	Dowel Puller Group	1
	5P-0939	Dowel Extractor	1

### Start By:

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

### 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. Check the main bearing caps for identification marks. Place identification caps marks on the main bearing caps, if necessary.

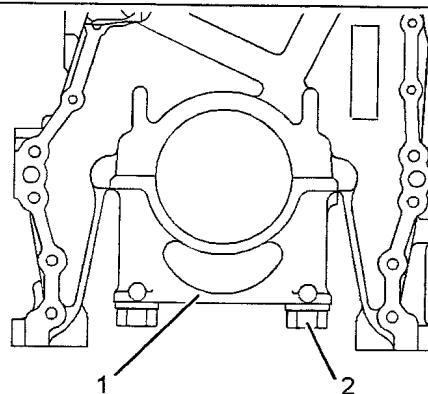


Illustration 263

g01029693

2. Remove bolts (2) for the main bearing caps. Remove main bearing caps (1).

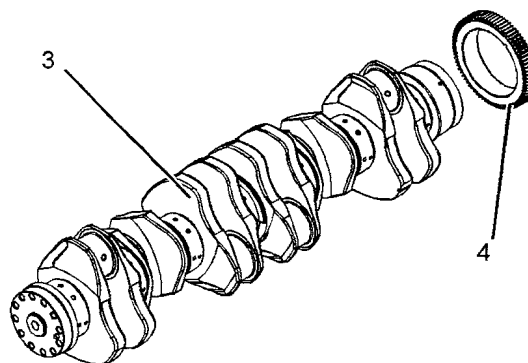


Illustration 264

g01029696

3. Remove the connecting rod caps.

4. Use a suitable lifting device. Remove the crankshaft (3) from the cylinder block. The weight of the crankshaft is approximately 159 kg (350 lb).
5. Use Tooling (A) to remove crankshaft gear (4).
6. Use Tooling (B) to remove the dowel and the pin.

Protrusion of dowel (6) from the crankshaft face ..... 4.1 ± 0.5 mm (0.16 ± 0.02 inch)

3. Raise the temperature of crankshaft gear (4). Install gear (4) on the crankshaft with the keyway in alignment with dowel (6). Timing Mark "V" should face away from the crankshaft.

**Note:** Install the main bearings dry when clearance checks are made. Refer to Disassembly and Assembly, "Bearing Clearance - Check". Put clean engine oil on the main bearings for final assembly.

4. Install the upper halves of the main bearings in the cylinder block.
5. Fasten a suitable lifting device to crankshaft (3). Install crankshaft (3) with the "V" mark on the crankshaft gear in alignment with the "V" mark on the cluster gear. The weight of the crankshaft is approximately 159 kg (350 lb).
6. Install the connecting rod caps.

i02110989

## Crankshaft - Install

SMCS Code: 1202-012

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

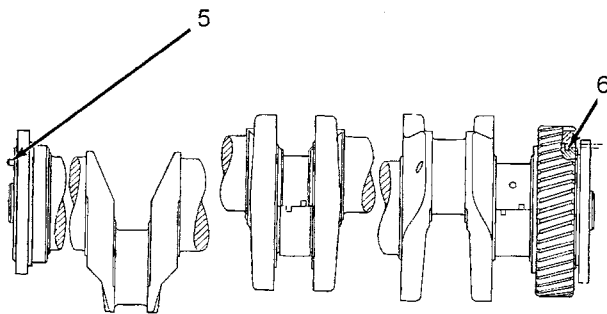


Illustration 265

g01018180

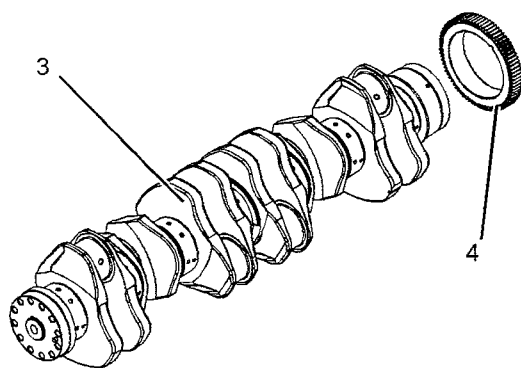


Illustration 266

g01029696

1. Install pin (5) in the crankshaft.

The maximum length of the dowel out of the crankshaft face ..... 6.4 mm (0.25 inch)

2. Install dowel (6) in the crankshaft.

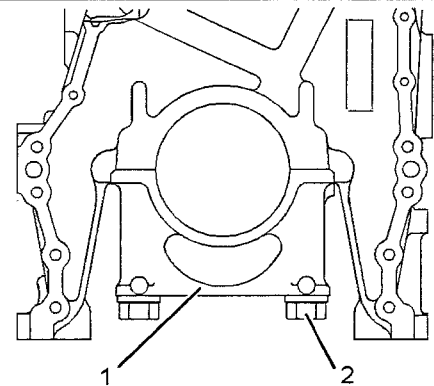


Illustration 267

g01029693

7. Place main bearing caps (1) in position. Install bolts (2) for the main bearing caps.

#### 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".

i01931507

## Bearing Clearance - Check

SMCS Code: 1203-535; 1219-535

### Measurement Procedure

Table 59

Required Tools			
Tool	Part Number	Part Description	Qty
A	198-9142	Plastic Gauge (Green) 0.025 to 0.076 mm (0.001 to 0.003 inch)	1
	198-9143	Plastic Gauge (Red) 0.051 to 0.152 mm (0.002 to 0.006 inch)	1
	198-9144	Plastic Gauge (Blue) 0.102 to 0.229 mm (0.004 to 0.009 inch)	1
	198-9145	Plastic Gauge (Yellow) 0.230 to 0.510 mm (0.009 to 0.020 inch)	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Caterpillar does not recommend the checking of the actual bearing clearances particularly on small engines. This is because of the possibility of obtaining inaccurate results and the possibility of damaging the bearing or the journal surfaces. Each Caterpillar engine bearing is quality checked for specific wall thickness.

**Note:** The measurements should be within specifications and the correct bearings should be used. If the crankshaft journals and the bores for the block and the rods were measured during disassembly, no further checks are necessary. However, if the technician still wants to measure the bearing clearances, Tooling (A) is an acceptable method. Tooling (A) is less accurate on journals with small diameters if clearances are less than 0.10 mm (0.004 inch).

#### NOTICE

Lead wire, shim stock or a dial bore gauge can damage the bearing surfaces.

The technician must be very careful to use Tooling (A) correctly. The following points must be remembered:

- Ensure that the backs of the bearings and the bores are clean and dry.
- Ensure that the bearing locking tabs are properly seated in the tab grooves.
- The crankshaft must be free of oil at the contact points of Tooling (A).

1. Put a piece of Tooling (A) on the crown of the bearing that is in the cap.

**Note:** Do not allow Tooling (A) to extend over the edge of the bearing.

2. Use the correct torque-turn specifications in order to install the bearing cap. Do not use an impact wrench. Be careful not to dislodge the bearing when the cap is installed.

**Note:** Do not turn the crankshaft when Tooling (A) is installed.

3. Carefully remove the cap, but do not remove Tooling (A). Measure the width of Tooling (A) while Tooling (A) is in the bearing cap or on the crankshaft journal. Refer to Illustration 268.

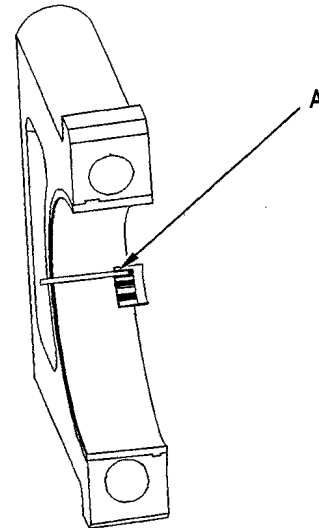


Illustration 268

g00953605

Typical Example

4. Remove all of Tooling (A) before you install the bearing cap.

**Note:** When Tooling (A) is used, the readings can sometimes be unclear. For example, all parts of Tooling (A) are not the same width. Measure the major width in order to ensure that the parts are within the specification range. Refer to Specifications Manual, "Connecting Rod Bearing Journal" and Specifications Manual, "Main Bearing Journal" for the correct clearances.

i01996101

## BrakeSaver - Remove

SMCS Code: 1155-011

### Removal Procedure

Table 60

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8718	Rotor Support	1
	0S-1594	Bolt	4

#### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

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.

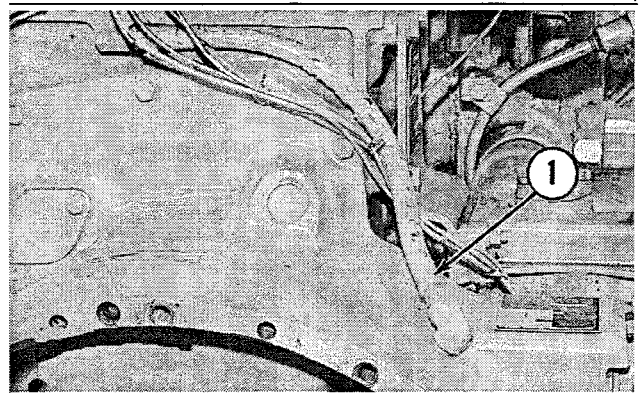


Illustration 269

g00523078

1. Disconnect hose assembly (1) from the fitting in the BrakeSaver housing.

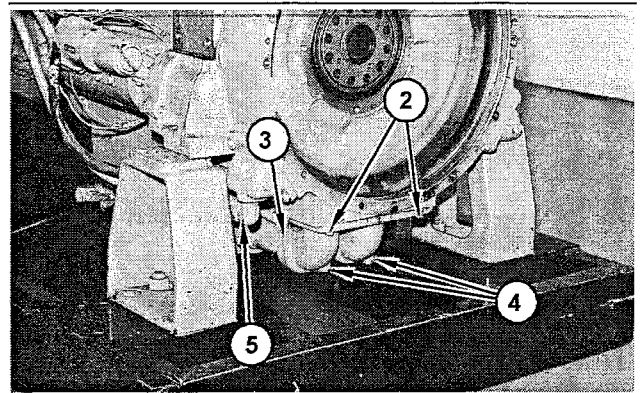


Illustration 270

g01039695

2. Disconnect the hose assembly from fitting (5).
3. Remove short bolts (2) and longer bolts (4) that hold manifold (3) to the BrakeSaver housing. Remove manifold (3) from the BrakeSaver housing.
4. Remove the O-ring seals from manifold (3).

**Note:** The longer bolts (4) from the manifold can be used as forcing screws in order to remove the BrakeSaver from the flywheel housing.

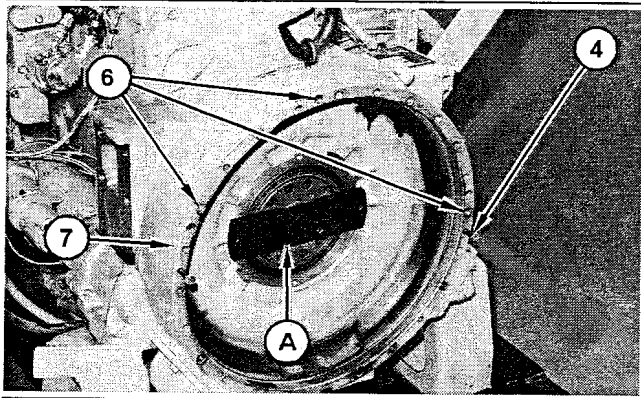


Illustration 271

g01039699

5. Install a suitable lifting device to the top of the BrakeSaver housing.
  6. Install Tooling (A) on BrakeSaver housing (7) and the rotor.
- Note:** Tooling (A) holds BrakeSaver housing (7) and the rotor assembly together during removal. This prevents damage to the rotor rings and seals.
7. Remove bolts (6) that hold BrakeSaver housing (7) to the flywheel housing.
  8. Use bolts (4) as forcing screws. Tighten bolts (4) in order to remove the BrakeSaver housing from the flywheel housing. The weight of the BrakeSaver housing is approximately 86 kg (190 lb).

i02101018

## BrakeSaver - Disassemble

SMCS Code: 1155-015

### Disassembly Procedure

Table 61

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8718	Rotor Support	1
	0S-1594	Bolt	4
B	8B-7561	Plate	1
	5F-7345	Screw	1
	1P-0490	Drive Plate	1

#### Start By:

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

1. Remove Tooling (A) from the BrakeSaver housing and the rotor.

**Note:** Tooling (A) prevents damage to the rotor rings and seals during removal of the BrakeSaver housing.

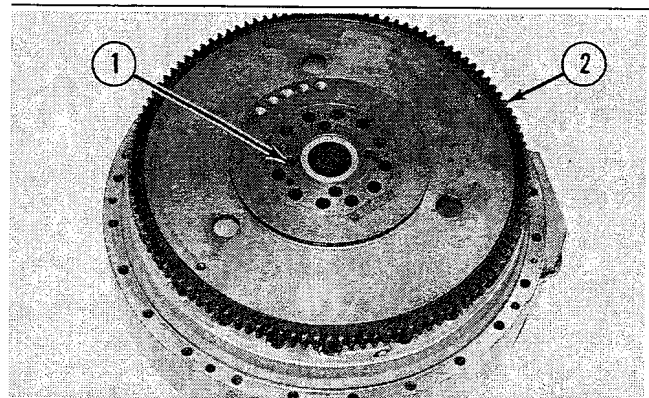


Illustration 272

g00523236

2. Remove bolts (1) from gear plate (2). Remove the gear plate.

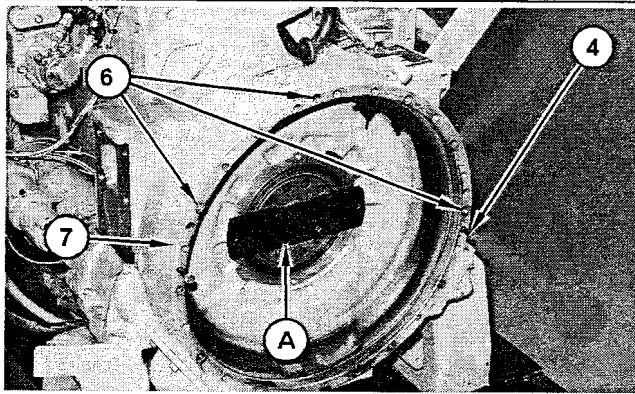


Illustration 271

g01039699

5. Install a suitable lifting device to the top of the BrakeSaver housing.
  6. Install Tooling (A) on BrakeSaver housing (7) and the rotor.
- Note:** Tooling (A) holds BrakeSaver housing (7) and the rotor assembly together during removal. This prevents damage to the rotor rings and seals.
7. Remove bolts (6) that hold BrakeSaver housing (7) to the flywheel housing.
  8. Use bolts (4) as forcing screws. Tighten bolts (4) in order to remove the BrakeSaver housing from the flywheel housing. The weight of the BrakeSaver housing is approximately 86 kg (190 lb).

i02101018

## BrakeSaver - Disassemble

SMCS Code: 1155-015

### Disassembly Procedure

Table 61

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8718	Rotor Support	1
	0S-1594	Bolt	4
B	8B-7561	Plate	1
	5F-7345	Screw	1
	1P-0490	Drive Plate	1

#### Start By:

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

1. Remove Tooling (A) from the BrakeSaver housing and the rotor.

**Note:** Tooling (A) prevents damage to the rotor rings and seals during removal of the BrakeSaver housing.

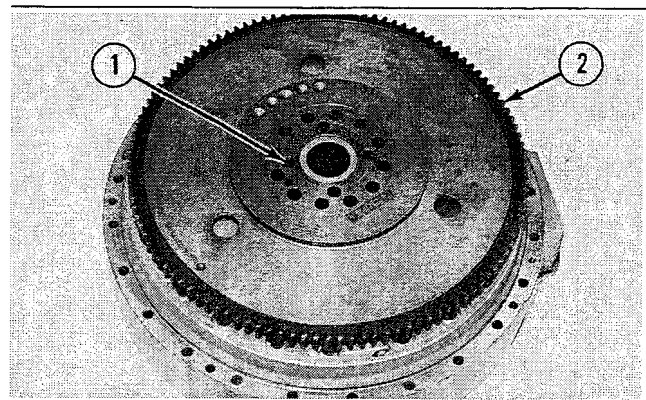


Illustration 272

g00523236

2. Remove bolts (1) from gear plate (2). Remove the gear plate.



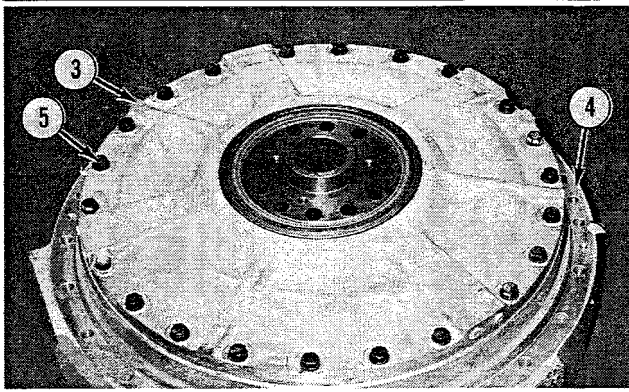


Illustration 273

g00523331

3. Put alignment marks on stator (3) and BrakeSaver housing (4) for assembly purposes. Remove bolts (5) and the stator.

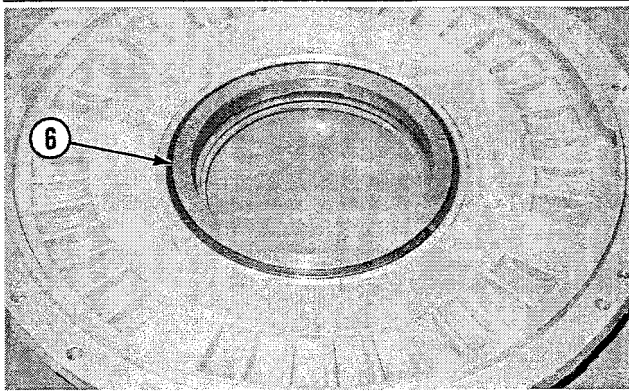


Illustration 274

g00523342

4. Rotate the stator and remove spiral ring (6).

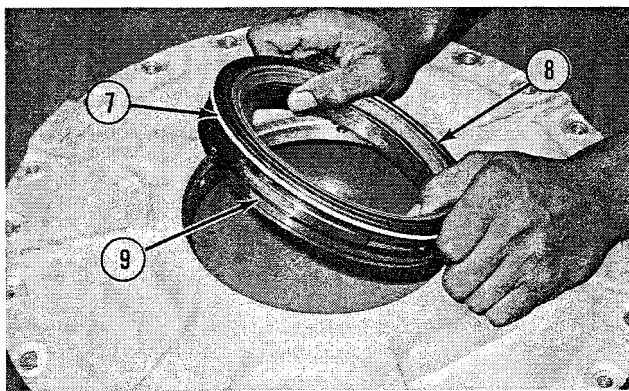


Illustration 275

g00523350

5. Rotate the stator again. Remove sleeve assembly (9). Remove O-ring seal (7) and lip seal (8) from the sleeve.

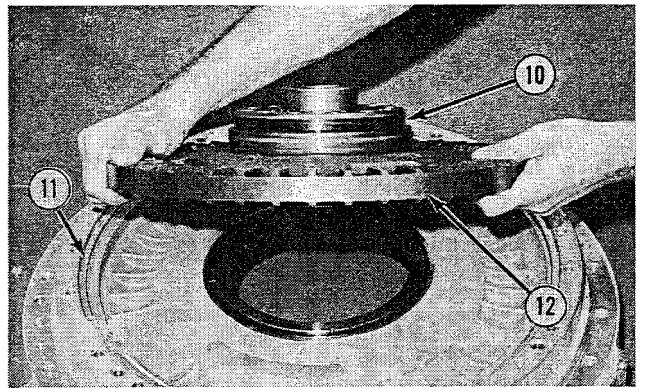


Illustration 276

g00523353

6. Remove O-ring seal (11) and the six smaller O-ring seals from the oil holes on the BrakeSaver housing.

7. Remove rotor assembly (12).

8. Remove seal ring (10) from both sides of the rotor.

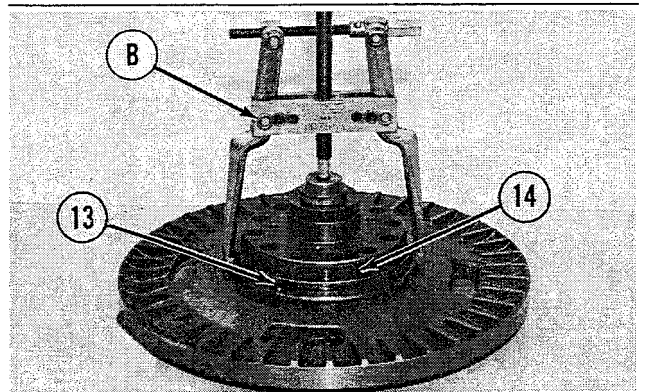


Illustration 277

g00523358

9. Remove carrier (13) and wear sleeve (14) with Tooling (B) from both sides of the rotor.

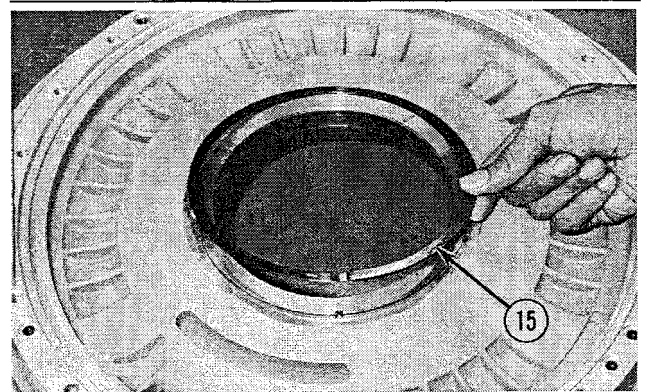


Illustration 278

g00523368

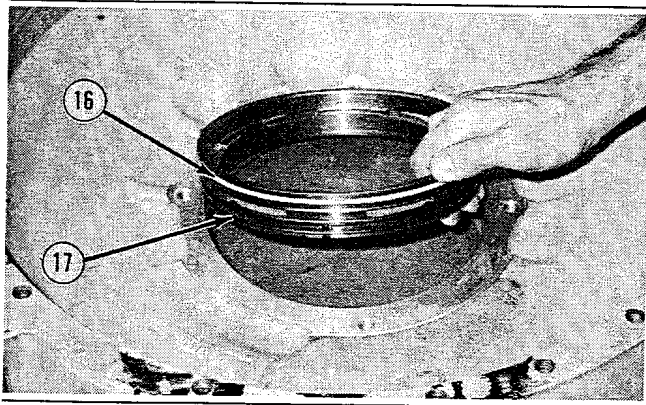


Illustration 279

g00523394

10. Remove spiral ring (15). Rotate the BrakeSaver, and remove sleeve assembly (17). Remove the lip seal and O-ring seal (16) from the sleeve.

i02101021

## BrakeSaver - Assemble

SMCS Code: 1155-016

### Assembly Procedure

Table 62

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8718	Rotor Support	1
	0S-1594	Bolt	4
C	5P-3594	Locator	1
D	1T-0720	Bolt	2
E	8T-2856	Retainer Bar	1
F	8T-2855	Sleeve Installer	1
G	0S-1594	Bolt	4
H	9S-8898	Nut	1
J	169-5464	Quick Cure Primer	1
K	4C-9507	Retaining Compound	1

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the O-ring seals. If the O-ring seals are worn or damaged, use new parts for replacement. Put clean engine oil on the O-ring seals.

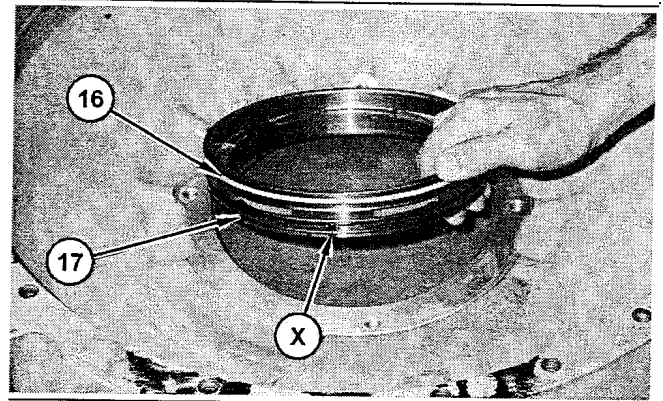


Illustration 280

g01070663

2. Install O-ring seal (16) on sleeve assembly (17).

3. Install the sleeve in the BrakeSaver housing. Align Notch (X) on the sleeve assembly with the notch in the BrakeSaver housing. Install the dowel.

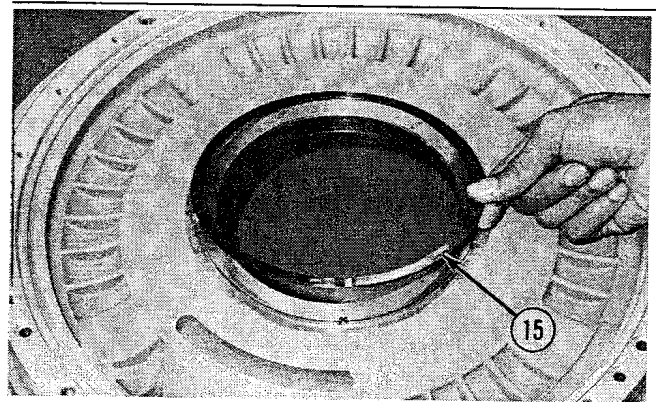


Illustration 281

g00523368

**Note:** Ensure that there is clearance behind spiral ring (15) when the spiral ring is correctly installed.

4. Rotate the BrakeSaver housing and install spiral ring (15) that holds the sleeve assembly in the BrakeSaver housing.

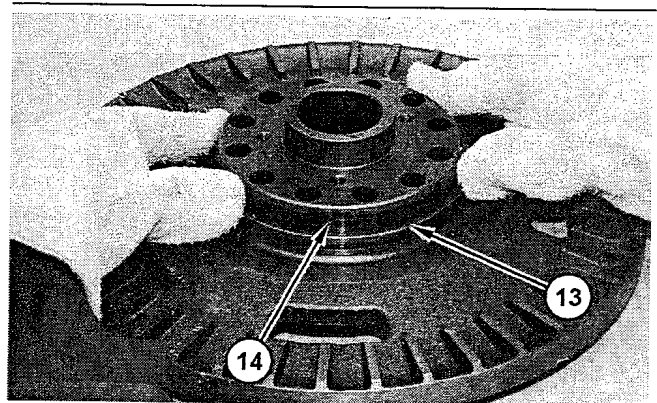


Illustration 282

g01070766

5. Raise the temperature of carrier (13).

**Note:** Ensure that the carrier is at the bottom on the rotor.

6. Install carrier (13) and wear sleeve (14) on each side of the rotor.

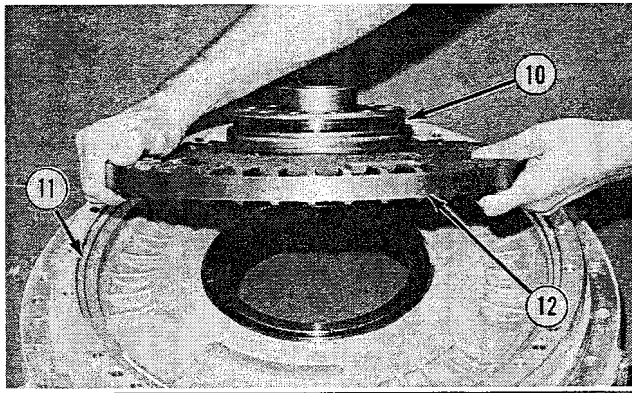


Illustration 283

g00523353

7. Install seal ring (10) on each of the carriers.

8. Install rotor assembly (12) in the BrakeSaver housing.

9. Install O-ring seal (11) and the six smaller O-ring seals for the oil holes on the BrakeSaver housing.

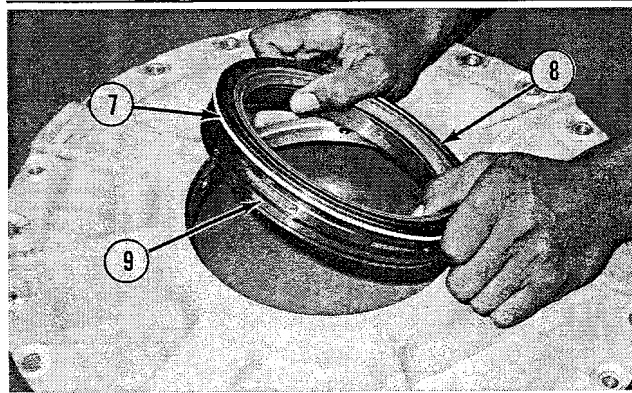


Illustration 284

g00523350

10. Install O-ring seal (7) and lip seal (8) on sleeve assembly (9). Install sleeve assembly (9) in the stator. Make an alignment of the notch in the sleeve with the dowel in the stator.

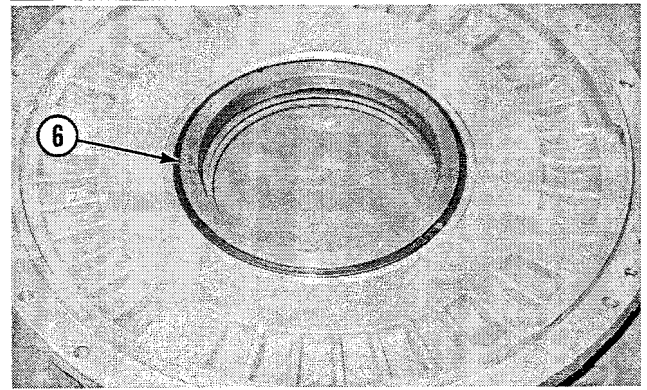


Illustration 285

g00523342

11. Rotate the stator and install spiral ring (6) that holds the sleeve in the stator.

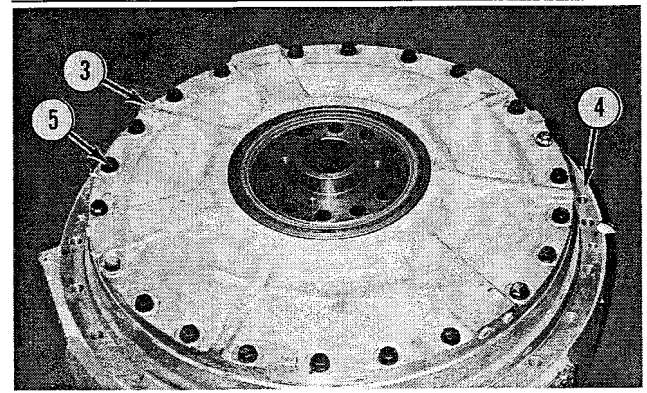


Illustration 286

g00523331

12. Put stator (3) in the correct location on BrakeSaver housing (4). Ensure that the oil holes in the stator and in the BrakeSaver housing are in alignment.

13. Install bolts (5) that hold the stator to the BrakeSaver housing. Tighten the bolts to a torque of  $55 \pm 7$  N·m ( $41 \pm 5$  lb ft).

14. Rotate the BrakeSaver housing. The weight of the BrakeSaver housing is approximately 73 kg (160 lb).

15. Do the following procedure with the appropriate Tooling to install the seals.

- a. Clean the wear sleeve inside diameter and the rotor outside diameter with Tooling (J). Apply Tooling (K) to the outside diameter of the rotor before the wear sleeve is installed on the rotor. Do not allow Tooling (K) to get on the lip of the seal.

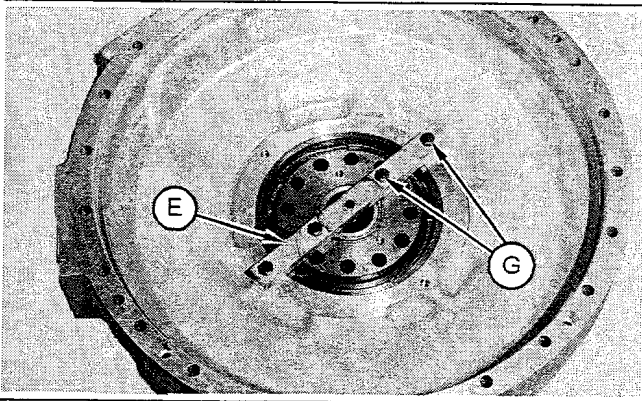


Illustration 287

g01070733

b. Install Tooling (E) with Tooling (G).

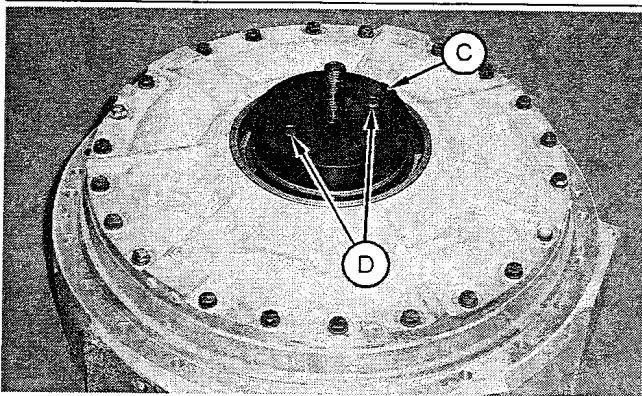


Illustration 288

g01070735

c. Rotate the BrakeSaver housing and install Tooling (C) and Tooling (D) on the rotor.

d. The wear sleeve and the seal are installed as a unit on Tooling (C).

**Note:** Once the seal and the wear sleeve are separated, these components cannot be used again.

#### NOTICE

The front and rear seals and wear sleeves have different spiral grooves in the seal. Because of this type of design, the front seal group for the BrakeSaver is different from the rear seal group. If a seal group is installed on the wrong end of the BrakeSaver, oil can actually be taken out of the BrakeSaver instead of moving oil back into the BrakeSaver.

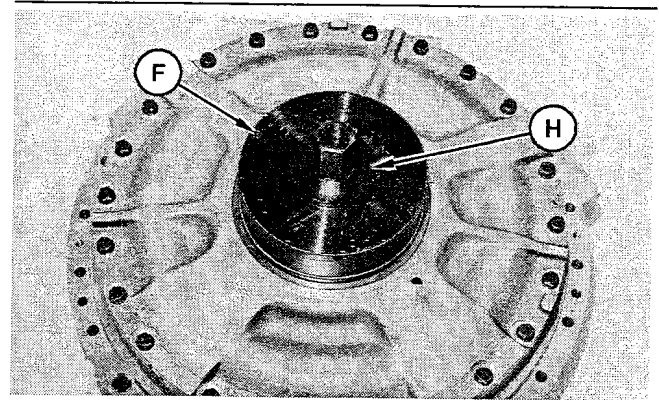


Illustration 289

g01070736

e. Put Tooling (F) in position on the locator.

f. Put clean engine oil on the face of Tooling (H). Install Tooling (H) on the locator.

g. Tighten Tooling (H) until Tooling (F) makes contact with the rotor.

h. The Tooling will install the seal and the wear sleeve to the correct depth.

16. Remove the Tooling from the BrakeSaver.

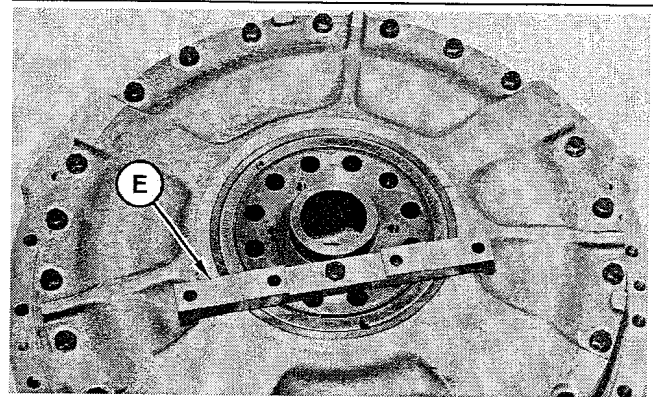


Illustration 290

g01070744

17. Install Tooling (E).

18. Rotate the BrakeSaver. Refer to Steps 15.c through 15.h in order to install the seal and the wear sleeve.

**Note:** It may be necessary to use a wrench to hold the retainer bar in order to prevent the rotor from turning during the installation of the seal and the wear sleeve.

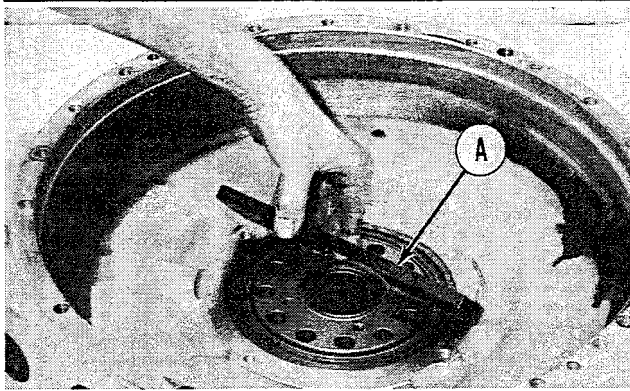


Illustration 291 g00523766

19. Install Tooling (A) on the rotor and the BrakeSaver housing.

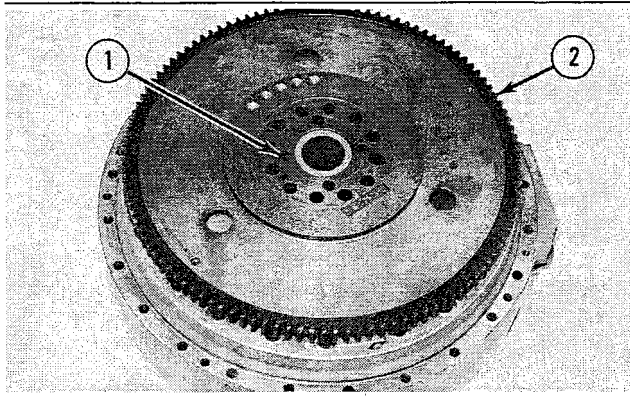


Illustration 292 g00523236

20. Rotate the BrakeSaver housing and install gear plate (2) and bolts (1) on the rotor.

**End By:**

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

i01996103

## BrakeSaver - Install

SMCS Code: 1155-012

### Installation Procedure

Table 63

Required Tools			
Tool	Part Number	Part Description	Qty
A	5P-8718	Rotor Support	1
	0S-1594	Bolt	4
B	-	Guide Bolts (5/8 -18 NF)	2

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

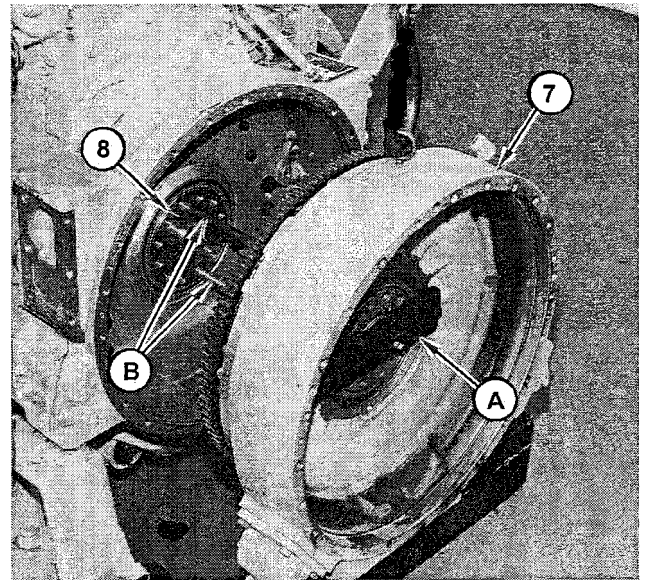


Illustration 293 g01039744

1. Install Tooling (A) on BrakeSaver housing (7) and the rotor.

**Note:** Tooling (A) holds BrakeSaver housing (7) and the rotor assembly together during installation. This prevents damage to the rotor rings and seals.

2. Install a suitable lifting device to the top of BrakeSaver housing (7).

3. Install Tooling (B) in the crankshaft. Ensure that dowel (8) is in alignment with the dowel hole in the rotor assembly. Position BrakeSaver housing (7) on the flywheel housing. The weight of the BrakeSaver housing is approximately 86 kg (190 lb).

4. Install the bolts that hold the BrakeSaver housing to the flywheel housing. Remove Tooling (A) and Tooling (B).

i01169133

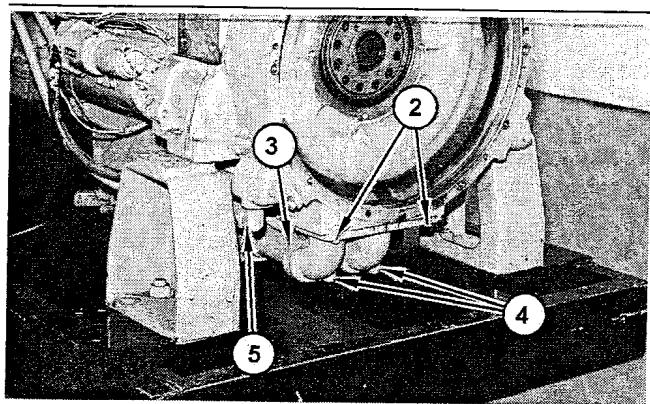


Illustration 294

g01039695

5. Connect the hose assembly to fitting (5).
6. Inspect the O-ring seals on manifold (3). If the O-ring seals are worn or damaged, use new parts for replacement. Install O-ring seals on manifold (3). Apply clean engine oil to the O-ring seals.
7. Install manifold (3) into the BrakeSaver housing and install short bolts (2) and longer bolts (4) that hold the manifold to the BrakeSaver housing.

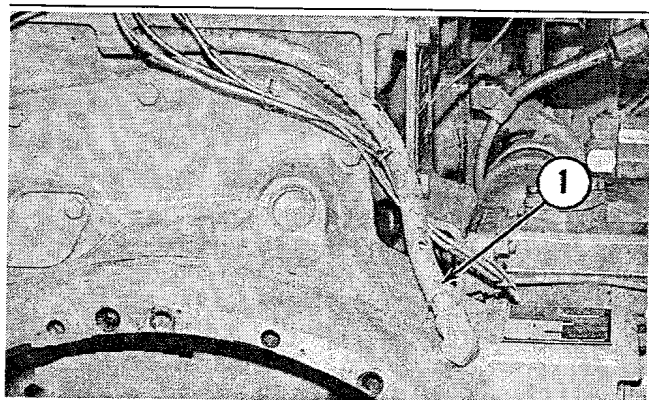


Illustration 295

g00523078

8. Connect hose assembly (1) to the fitting in the BrakeSaver housing.

**End By:**

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

## BrakeSaver Engine Oil Pan - Remove and Install

SMCS Code: 1155-010

### Removal Procedure

**Start By:**

- a. Remove the BrakeSaver control valve. Refer to Disassembly and Assembly, "BrakeSaver Control Valve - 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.

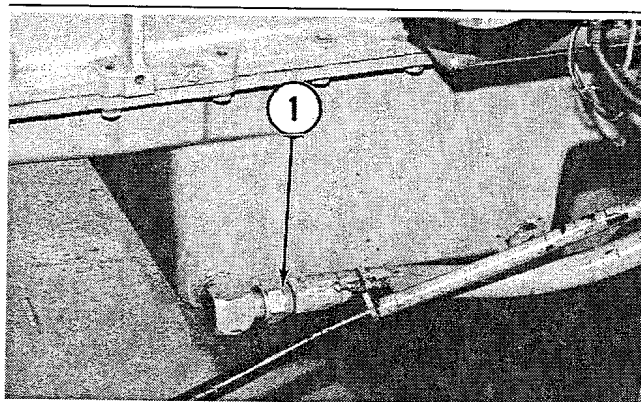


Illustration 296

g00523580

Typical example

1. Disconnect oil line (1) from the left side of the engine oil pan.

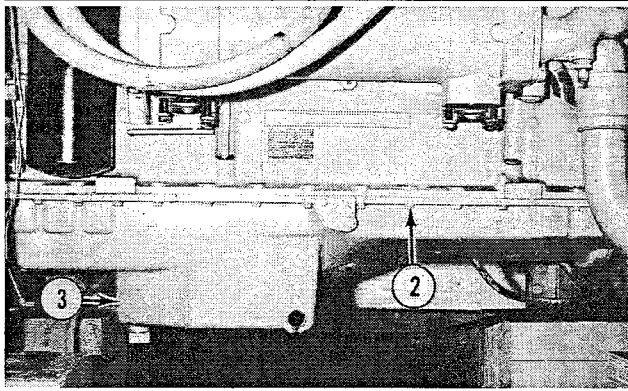


Illustration 297  
Typical example  
g00523581

2. Remove oil pan bolts (2). Remove BrakeSaver engine oil pan (3) from the cylinder block.

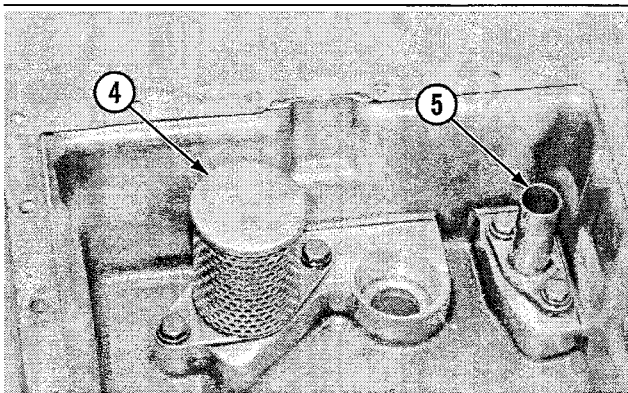


Illustration 298  
Typical example  
g00523583

3. Remove baffle assembly (4) and the O-ring seal from the oil pan.
4. Remove tube assembly (5) and the O-ring seal from the oil pan.

## Installation Procedure

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**Note:** Check condition of the O-rings. If the O-rings are worn or damaged, use new parts for replacement.

1. Ensure that the oil pan is free of oil and gasket material.

2. Apply 8T-9022 Silicone Gasket to the sealing surface of the engine oil pan. Also apply a small amount of 8T-9022 Silicone Gasket to the space at the joints of the following components: the front plate, the BrakeSaver engine oil pan, the cylinder block, and the flywheel housing.

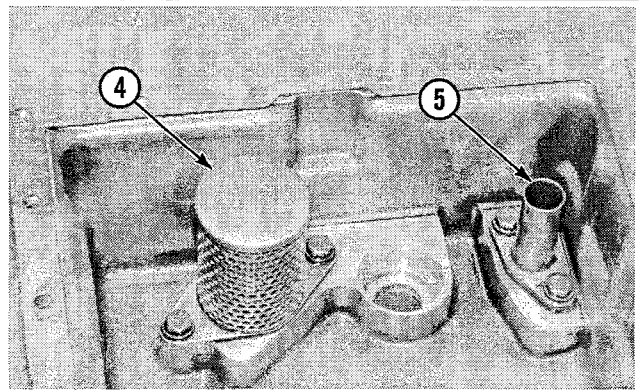


Illustration 299  
Typical example  
g00523583

3. Install the O-ring seal and the tube assembly (5) in the oil pan.
4. Install the O-ring seal and the baffle assembly (4) in the oil pan.

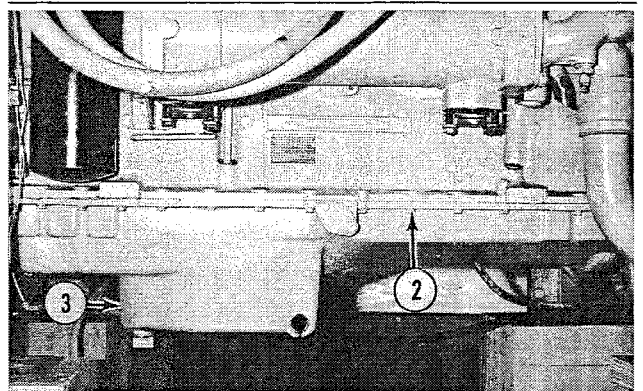


Illustration 300  
Typical example  
g00523581

5. Install two 3/8 - 16 NC guide bolts in the cylinder block. Install oil pan (3) and bolts (2). Tighten the bolts to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft). If the oil drain plug was removed, install the plug. Tighten the plug to a torque of  $70 \pm 15$  N·m ( $52 \pm 11$  lb ft).

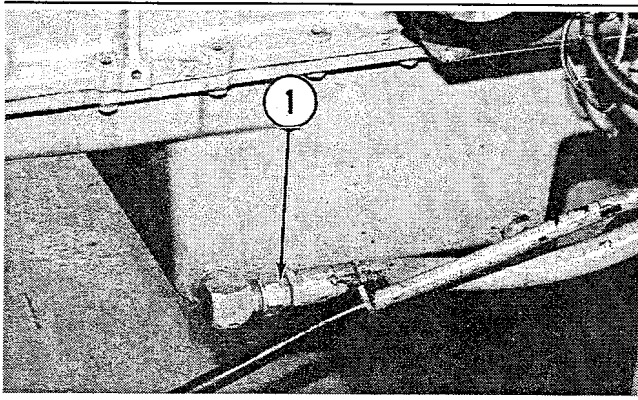


Illustration 301  
Typical example  
g00523580

6. Connect oil line (1) to the left side of the BrakeSaver engine oil pan.

**End By:**

- a. Install the BrakeSaver control valve. Refer to Disassembly and Assembly, "BrakeSaver Control Valve - Install".

i01995913

## BrakeSaver Engine Oil Pump - Remove

SMCS Code: 1155-011

### Removal Procedure

**Start By:**

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

**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.

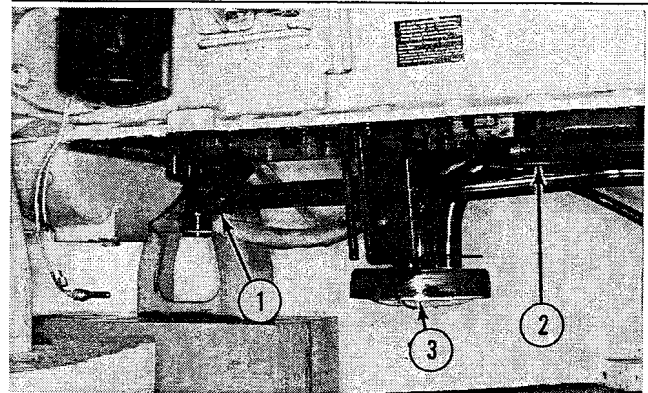


Illustration 302  
g00522996

1. Remove suction bell (3) from the oil pump.
2. Remove tube assembly (2) and BrakeSaver tube assembly (1) from the engine block and the engine oil pump.

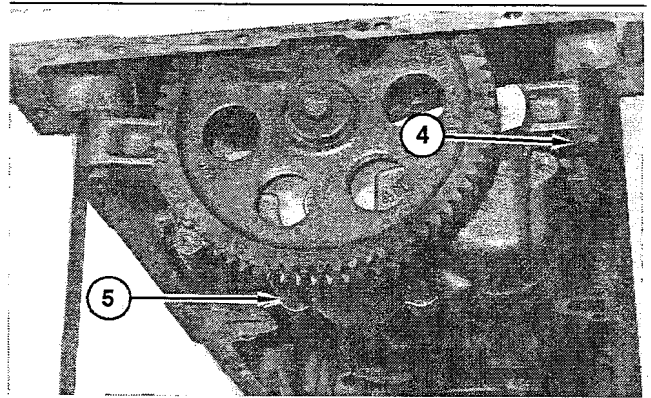


Illustration 303  
g01040833

3. Remove bolts (4) and engine oil pump (5) from the engine.



i02111000

# BrakeSaver Engine Oil Pump - Disassemble

SMCS Code: 1155-015

## Disassembly Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A	1P-2322	Puller Assembly	1
B	1P-0510	Driver Group	1

### Start By:

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

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

#### NOTICE

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

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.

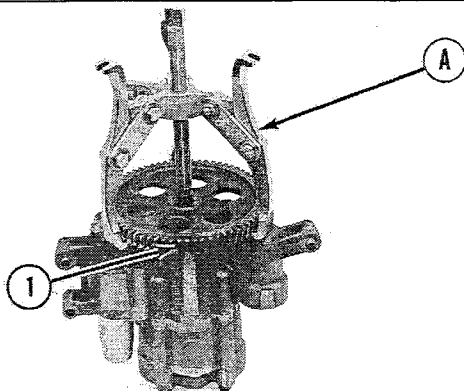


Illustration 304

g00523264

1. Remove the bolt and the washer that holds drive gear (1) on the shaft.
2. Use Tooling (A) to remove gear (1). Remove the key from the shaft. Place alignment marks on the pump in order to assemble the gear and the shaft properly.

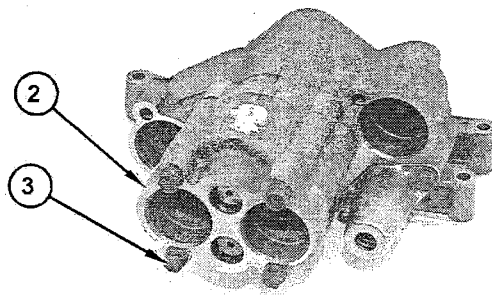


Illustration 305

g01033766

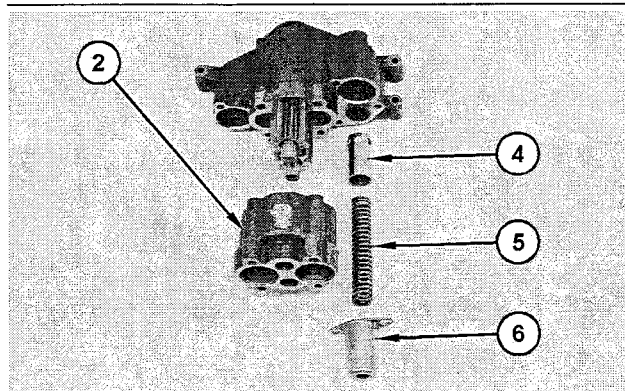


Illustration 306

g01033768

3. Remove bolts (3) from the pump body. Remove pump body (2).

### **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 retainer (6) from the bypass valve. Remove spring (5) and bypass valve (4).

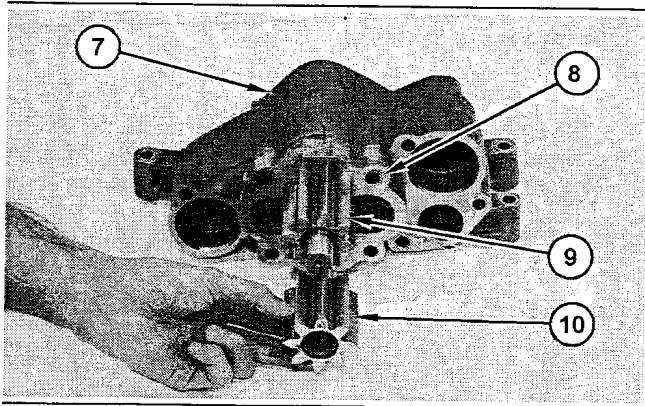


Illustration 307 g01033769

5. Remove idler gear (9) and drive gear (10). Place identifying marks on the gears in order to be installed properly.

6. Remove spacer (8) from main oil pump body (7). Use Tooling (B) to remove the bearings from spacer (8).

**Note:** Check condition of the spacer and the bearings. If the spacer or the bearings are damaged use new parts for replacement.

7. Use Tooling (B) to remove the bearings from main oil pump body (7).

i01995990

## BrakeSaver Engine Oil Pump - Assemble

SMCS Code: 1155-016

### Assembly Procedure

Table 65

Required Tools			
Tool	Part Number	Part Description	Qty
B	1P-0510	Driver Group	1

#### 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.

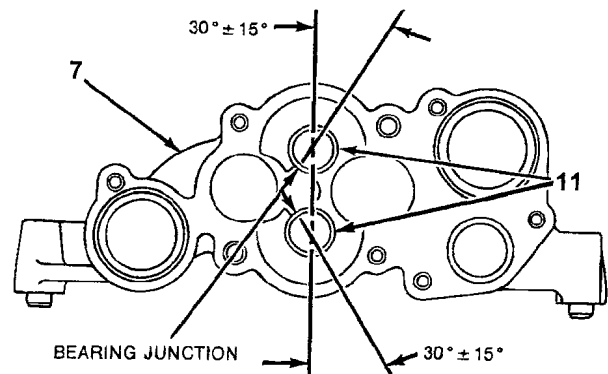


Illustration 308 g01033808

1. Use Tooling (B) to install bearings (11). Bearings should be installed with the outside surface of main oil pump body (7). The bearing joints on the bearings should be oriented in the pump body at a specific angle. Refer to Illustration 308.

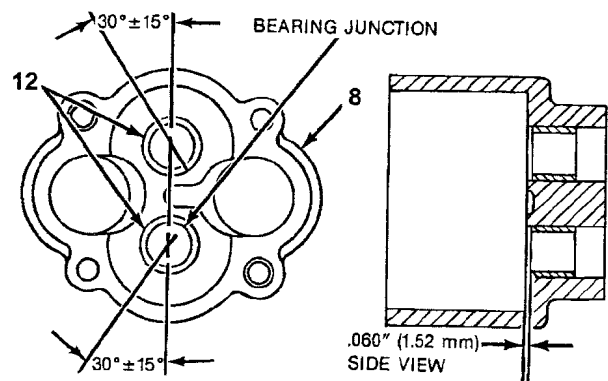


Illustration 309 g01033809

2. Use Tooling (B) to install bearings (12) in spacer (8). Install bearings (12) until bearings are  $1.52 \pm 0.025$  mm ( $0.060 \pm 0.010$  inch) from the inside edge of the bearing bores. The bearing joint on the bearings should be oriented in the spacer at a specific angle. Refer to Illustration 309. Install the bearings so that the oil holes are aligned with the oil holes in spacer (8).

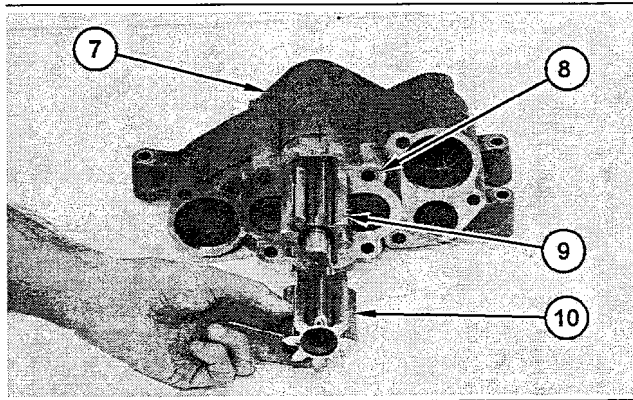


Illustration 310 g01033769

3. Before final assembly, check the condition and specifications of all of the parts of the oil pump. Refer to Specification, "BrakeSaver Engine Oil Pump".
4. Lubricate gears and bearings with clean engine oil before gears and bearings are assembled in the oil pump. Install idler gear (9) and drive gear (10) in main oil pump body (7).
5. Install spacer (8) on the gear shaft. Align the holes in the spacer toward the pump outlet passage.

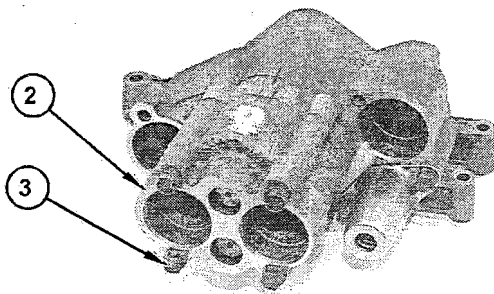


Illustration 311 g01033766

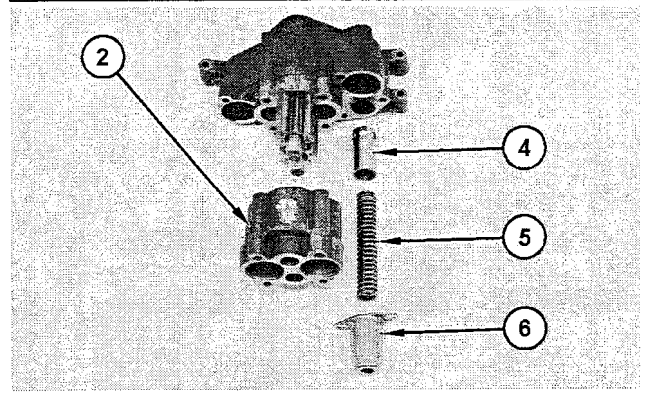


Illustration 312 g01033768

**⚠ 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.

6. Install pump body (2) and bolts (3). Install bypass valve (4), spring (5), and retainer (6).
7. Install the key on the shaft.

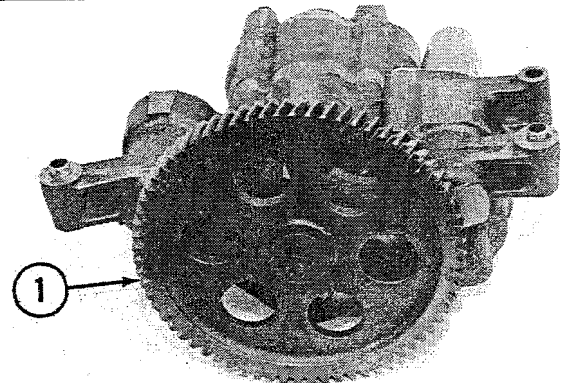


Illustration 313 g00523414

**NOTICE**  
The oil pump must turn freely after it is assembled.

8. Install gear (1) on the shaft. Install the washer and the bolt that secures the gear on the shaft. Tighten the bolt to a torque of  $55 \pm 10$  N·m ( $41 \pm 7$  lb ft).

**End By:**

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

i01995999

## BrakeSaver Engine Oil Pump - Install

SMCS Code: 1155-012

### Installation 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.

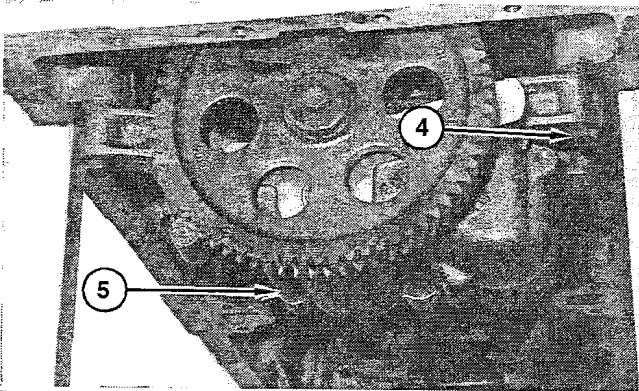


Illustration 314

g01040833

1. Install engine oil pump (5) on the engine.
2. Ensure that the oil pump gear is properly aligned with the crankshaft gear. Install bolts (4) in the engine oil pump.

**Note:** Check condition of the O-ring seals. If the O-ring seals are worn or damaged, use new parts for replacement.

3. Apply clean engine oil to the O-ring seals on the oil tube assemblies.

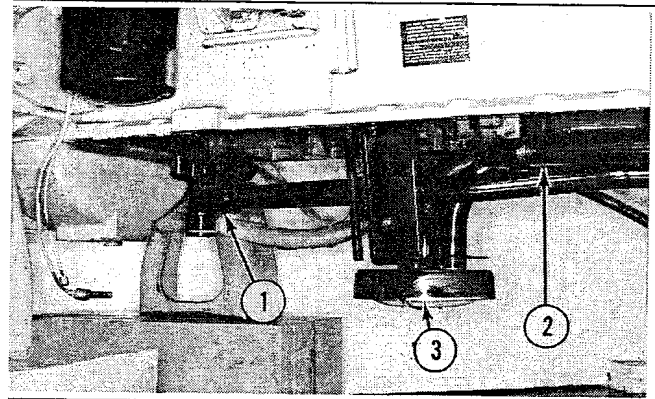


Illustration 315

g00523200

4. Install suction bell (3) and the tube assembly in the oil pump.
5. Install tube assembly (2) on the engine block. Install BrakeSaver tube assembly (1) on the engine block.

#### End By:

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

i01996122

## BrakeSaver Control Valve - Remove

SMCS Code: 1159-011

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.

**WARNING**

**Do not disconnect any air lines until the air pressure is zero.**

1. Release the air pressure in the air tanks.
2. Drain the oil from the oil pan.

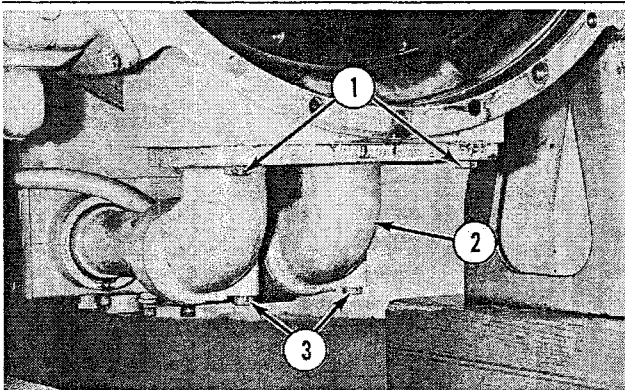


Illustration 316 g00524237

3. Remove short bolts (1) and longer bolts (3) from manifold (2) and the BrakeSaver housing. Remove manifold (2). Remove the O-ring seals from the manifold.

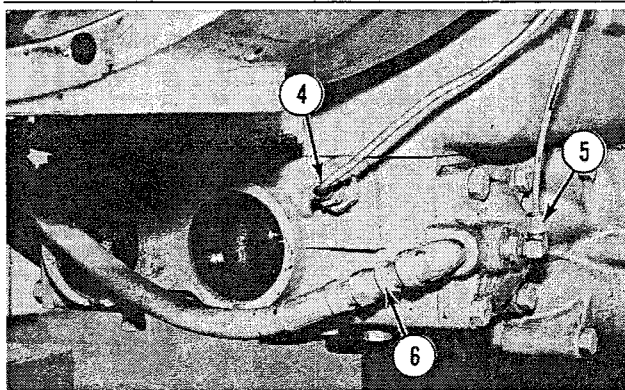


Illustration 317 g00524244

4. Remove oil temperature sensing unit (4) from the BrakeSaver control valve.
5. Disconnect air tube assembly (5) and hose assembly (6) from the BrakeSaver control valve.

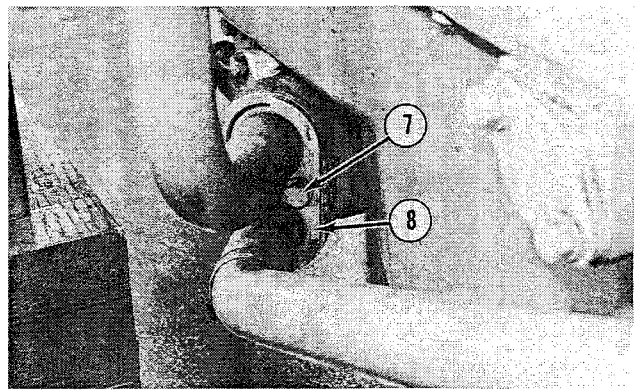


Illustration 318 g00524245

6. Remove bolt (7) and retainer (8) on tube assemblies in the BrakeSaver control valve.

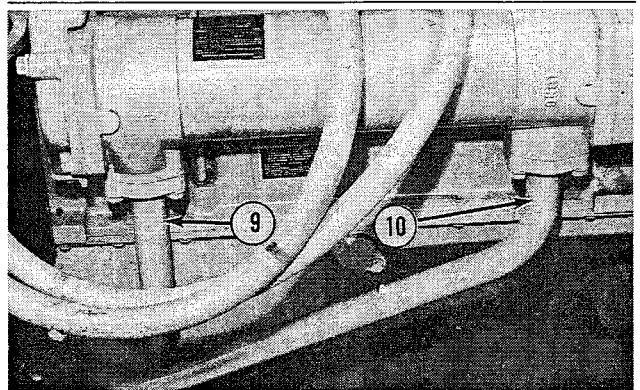


Illustration 319 g00524248

7. Disconnect tube assemblies (9) and (10) from the oil cooler. Remove tube assemblies (9) and (10) from the BrakeSaver control valve.

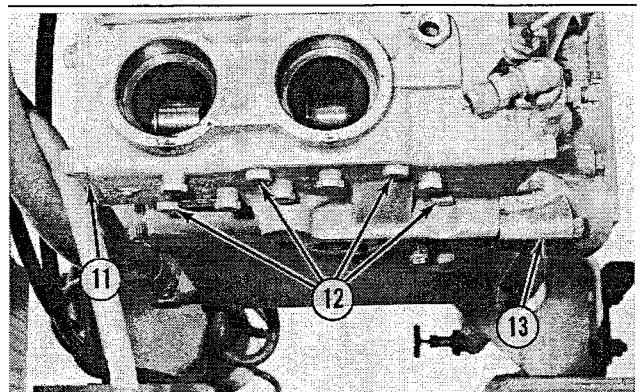


Illustration 320 g00524251

8. Remove bolts (12) and BrakeSaver control valve (11) from the oil pan. The weight of the BrakeSaver control valve is approximately 22 kg (50 lb).

9. Remove elbow assembly (13) from the BrakeSaver control valve. Remove the O-ring seals.

i01996154

## BrakeSaver Control Valve - Disassemble

SMCS Code: 1159-015

### Disassembly Procedure

#### Start By:

- a. Remove the BrakeSaver control valve. Refer to Disassembly and Assembly, "BrakeSaver Control Valve - 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.

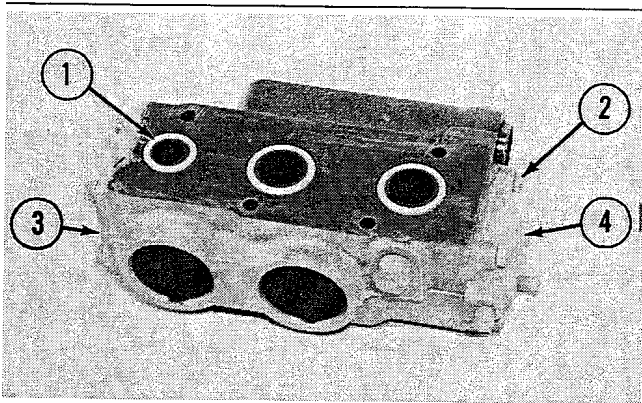


Illustration 321

g00524416

1. Remove O-ring seals (1) from the BrakeSaver control valve.

#### **! WARNING**

The covers hold springs under compression. To prevent possible injury from flying parts, hold covers when the bolts are removed.

2. Remove bolts (2) evenly from covers (3) and (4). Remove cover (4).
3. Remove cover (3) and the seal from the opposite end of the BrakeSaver control valve.

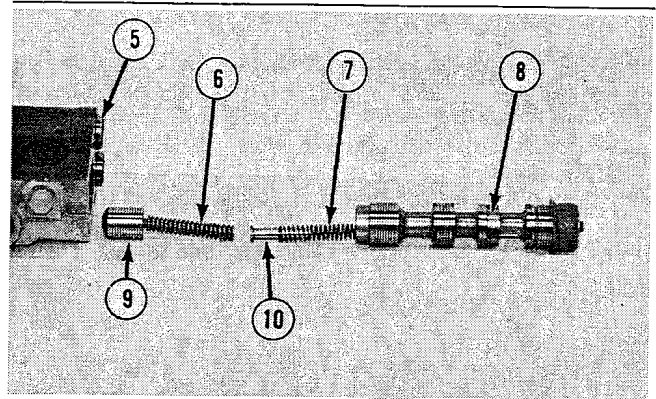


Illustration 322

g00524473

4. Remove spool (8) as an assembly.

#### **! 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.

5. Remove spring (7), stop (10), spring (6), and slug (9).
6. Remove the O-ring seals and sleeve (5).

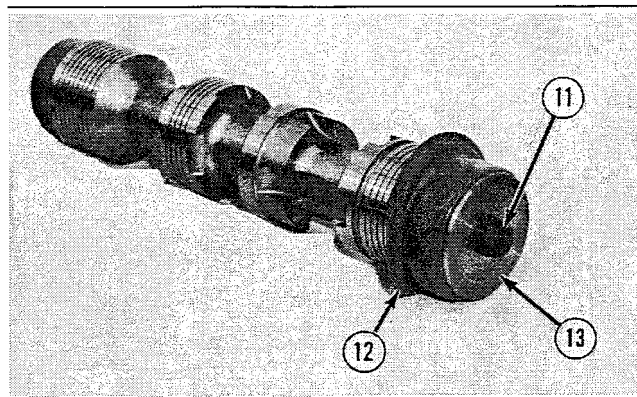


Illustration 323

g00524484

7. Remove bolt (11), plate (13), and diaphragm (12) from the spool. Inspect the pin on the spool and make a replacement of the pin if there is damage or wear.

i02111017

## BrakeSaver Control Valve - Assemble

SMCS Code: 1159-016

### Assembly Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

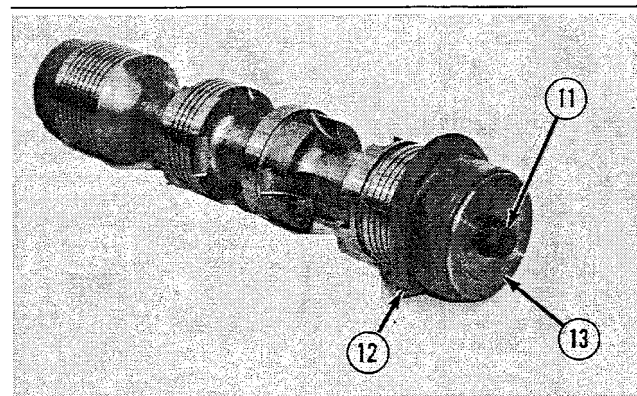


Illustration 324

g00524484

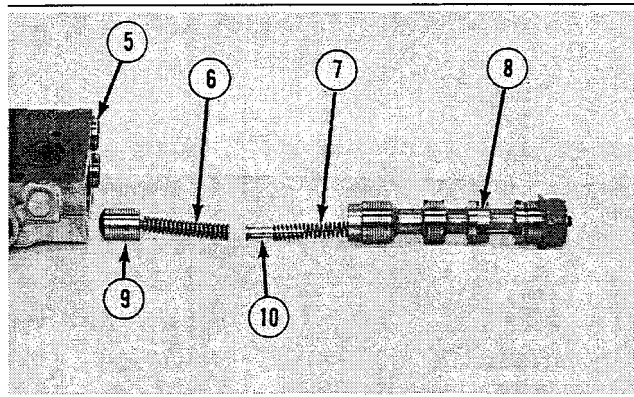


Illustration 325

g00524473

**Note:** When diaphragm (12) is installed on the valve spool, ensure that the fabric (side) is pulled down over the valve spool. The rubber (side) will be installed next to the valve body.

1. Position diaphragm (12) on valve spool (8).
2. Align the hole in plate (13) with the pin in valve spool (8). Install plate (13) with bolt (11).
3. Install sleeves (5) and the O-ring seals in the BrakeSaver control valve.
4. Position spring (7), stop (10), spring (6), and slug (9) in valve spool (8).
5. Install valve spool (8) into the valve body. As the valve spool (8) is installed, ensure that the edge of the diaphragm makes contact all the way around with the groove in the valve body. The valve spool (8) must extend 38.1 mm (1.50 inch) from the valve body. Push the valve spool approximately 6.4 to 12.7 mm (0.25 to 0.50 inch) farther into the valve body until a curved depression is caused between the valve spool and the valve body. Ensure that there are no wrinkles in the diaphragm.

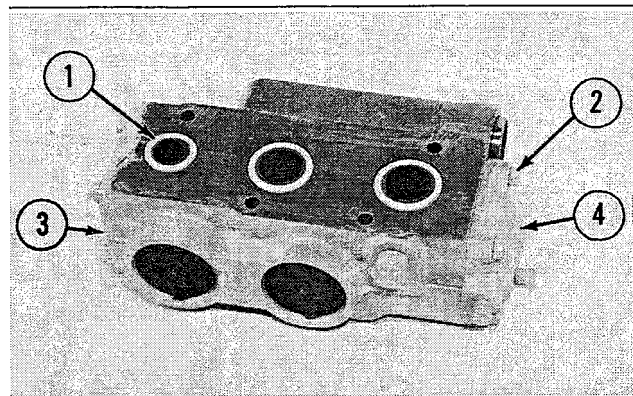


Illustration 326

g00524416

**⚠ 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.

6. Install covers (3) and (4) on the BrakeSaver control valve. Secure covers (3) and (4) with bolts (2).

7. Install O-ring seals (1).

**End By:**

a. Install the BrakeSaver control valve. Refer to Disassembly and Assembly, "BrakeSaver Control Valve - Install".

i01996159

## BrakeSaver Control Valve - Install

SMCS Code: 1159-012

### Installation Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
A	9S-3263	Thread Lock Compound	1

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the O-ring seals. If the O-ring seals are worn or damaged, use new parts for replacement. Apply clean engine oil to the O-ring seals.

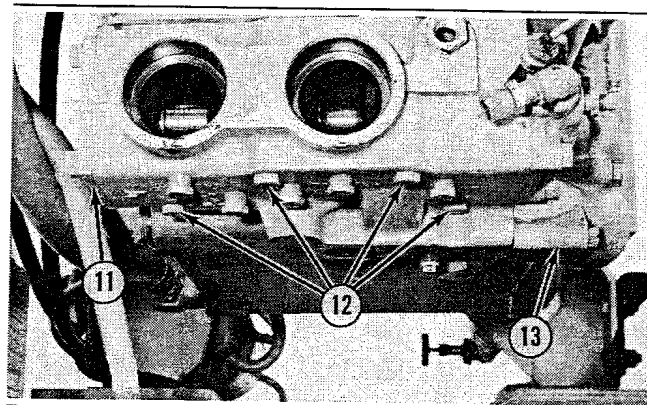


Illustration 327

g00524251

2. Install the O-ring seals and elbow assembly (13) on the BrakeSaver control valve.
3. Position BrakeSaver control valve (11) on the oil pan. The weight of the BrakeSaver control valve is approximately 22 kg (50 lb). Install bolts (12).

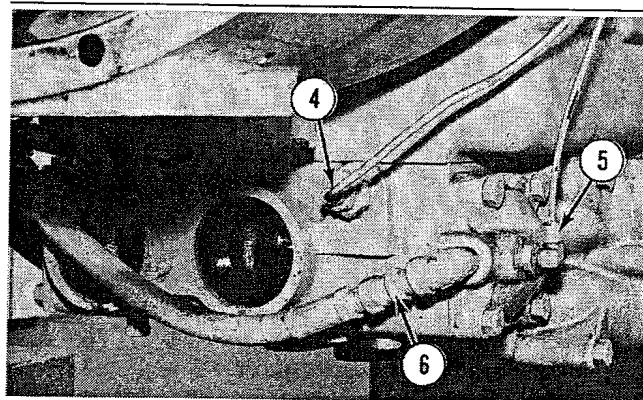


Illustration 328

g00524244

4. Install oil temperature sensing unit (4) in the BrakeSaver control valve.
5. Connect air tube assembly (5) and hose assembly (6) to the BrakeSaver control valve.

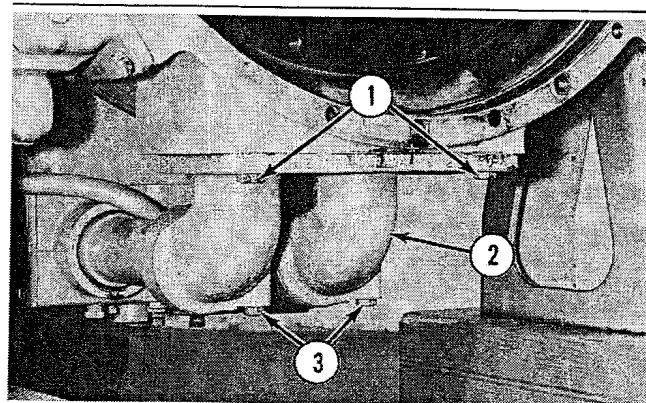


Illustration 329

g00524237



i01810472

6. Install the O-ring seals in manifold (2). Position manifold (2) on the BrakeSaver Control valve. Install bolts (1) and (3).

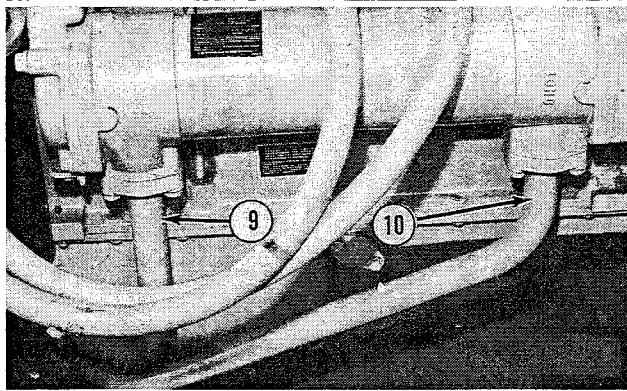


Illustration 330

g00524248

7. Inspect the O-ring seals and install tube assemblies (9) and (10).

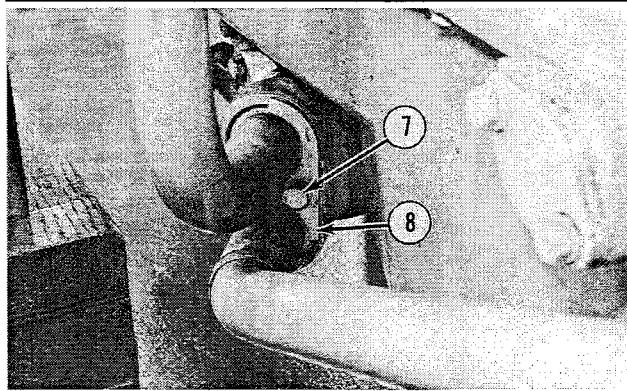


Illustration 331

g00524245

8. Position the tube assemblies in the BrakeSaver control valve. Install retainer (8) and bolt (7).

**Note:** If the bottom plug in the oil pan was removed, put the split (seam) of the gasket for the plug against the oil pan. If either plug on the side of the oil pan was removed, apply Tooling (A) to the threads and tighten to a torque of  $80 \pm 11$  N·m ( $59 \pm 8$  lb ft).

9. Fill the engine with oil to the correct level. Refer to Operation and Maintenance Manual, "Refill Capacities".

## Atmospheric Pressure Sensor - Remove and Install

SMCS Code: 1923-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

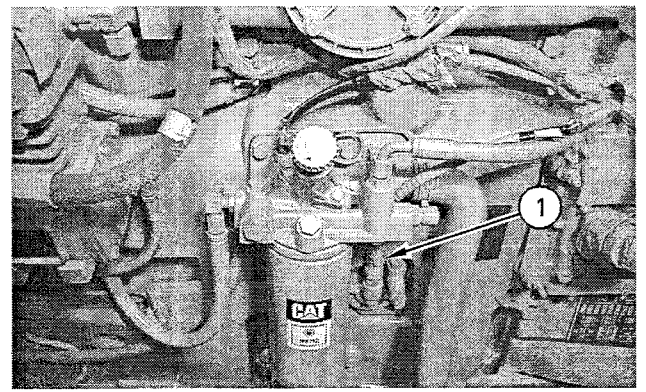


Illustration 332

g00621509

Typical example

1. Disconnect the harness assembly for atmospheric pressure sensor (1).
2. Remove atmospheric pressure sensor (1).

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

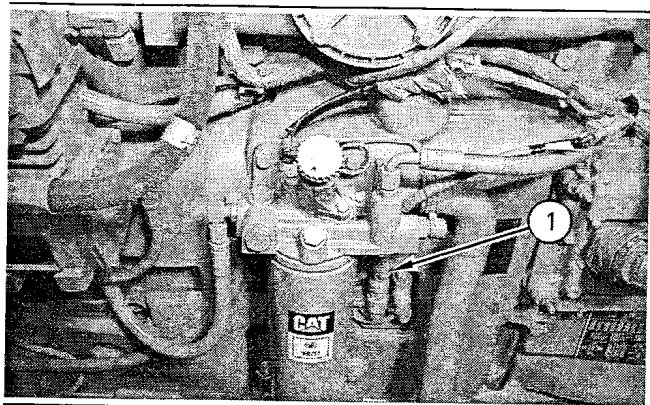


Illustration 333 g00621509

Typical example

1. Install atmospheric pressure sensor (1). Tighten the sensor to a torque of  $10 \pm 2 \text{ N}\cdot\text{m}$  ( $90 \pm 20 \text{ lb in}$ ).
2. Connect the harness assembly for atmospheric pressure sensor (1).

i01163761

## Camshaft Position Sensor - Remove and Install

SMCS Code: 1912-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

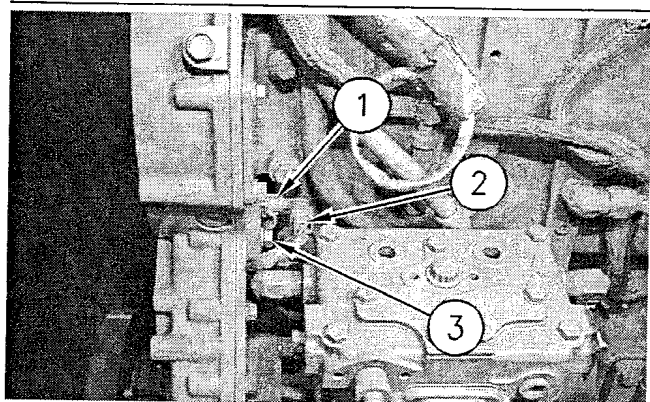


Illustration 334 g00517969

Typical example

1. Disconnect wiring harness (2) from camshaft position sensor (1).

2. Remove bolt (3) and the clip from camshaft position sensor (1). Remove camshaft position sensor (1).

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

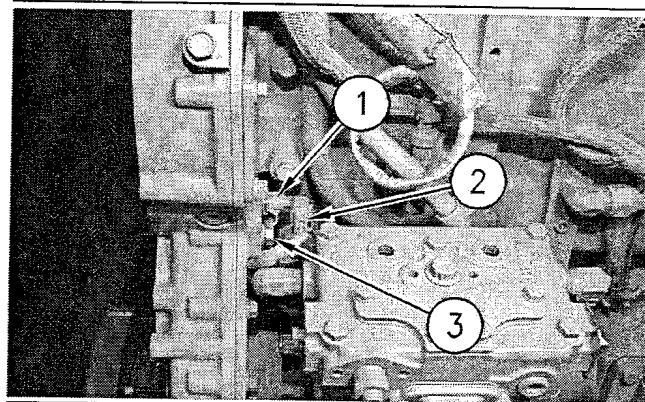


Illustration 335 g00517969

Typical example

1. Install camshaft position sensor (1). Put the clip in position and install bolt (3).
2. Connect wiring harness (2) to camshaft position sensor (1).

i01163834

## Crankshaft Position Sensor - Remove and Install

SMCS Code: 1912-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i01095557

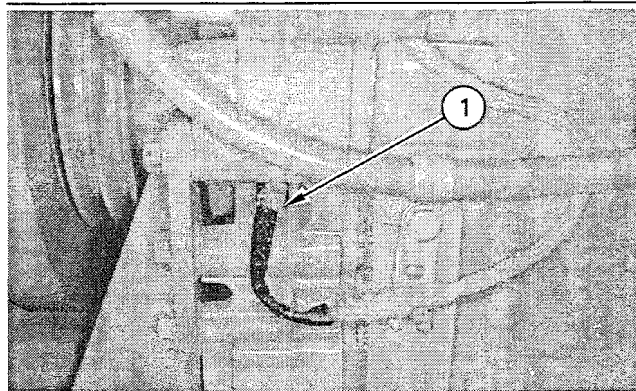


Illustration 336 g00518015

Typical example

1. Disconnect wiring harness (1) from the crankshaft position sensor.
2. Remove the bolt and the clip from the crankshaft position sensor. Remove the crankshaft position sensor.

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

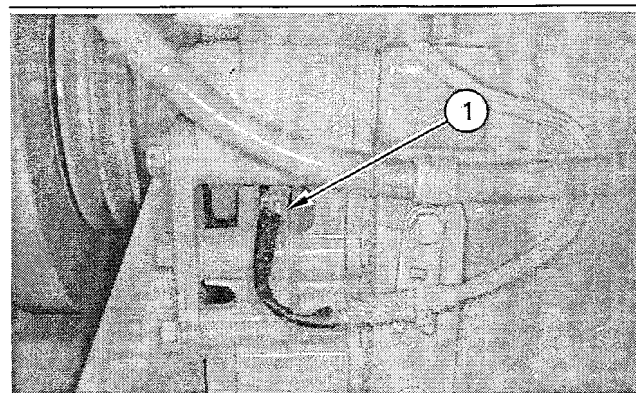


Illustration 337 g00518015

Typical example

1. Install the crankshaft position sensor. Put the clip in position and install the bolt that holds the crankshaft position sensor.
2. Connect wiring harness (1) to the crankshaft position sensor.

## Coolant Temperature Sensor - Remove and Install

SMCS Code: 1906-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.

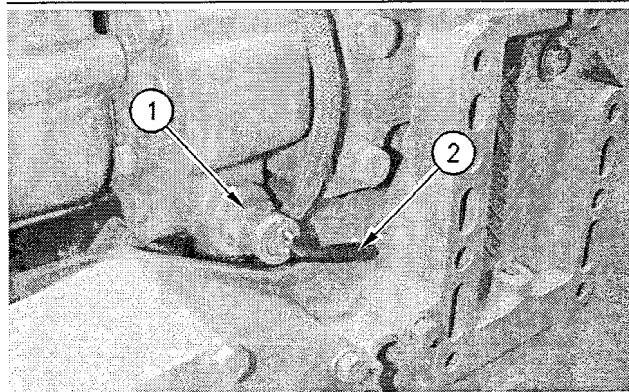


Illustration 338 g00518087

1. Drain the level of the coolant below the coolant temperature sensor. Drain the coolant into a suitable container for storage or disposal.
2. Disconnect the plug on wiring assembly (2) from the wiring harness.
3. Remove coolant temperature sensor (1).

## Installation Procedure

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

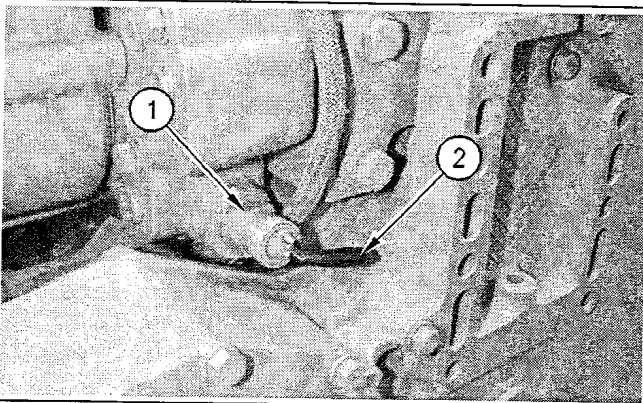


Illustration 339

g00518087

1. Install coolant temperature sensor (1). Tighten coolant temperature sensor (1) to a torque of  $20 \pm 3$  N·m ( $15 \pm 2$  lb ft).
2. Connect wire assembly (2) to the wiring harness.
3. Fill the cooling system with coolant to the correct level. Refer to the Operation and Maintenance Manual for the correct procedure.

i01810485

## Engine Oil Pressure Sensor - Remove and Install

SMCS Code: 1924-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

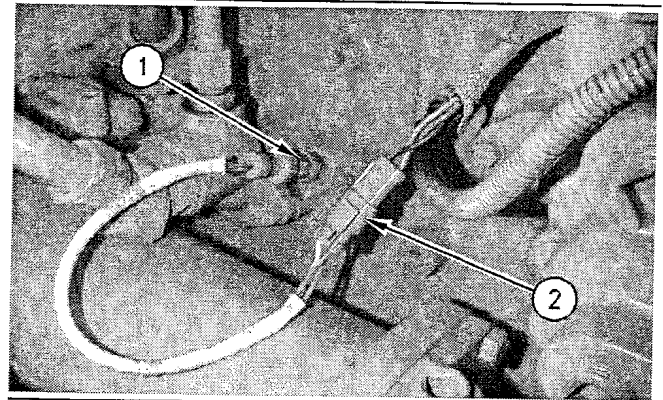


Illustration 340

g00518159

1. Disconnect harness assembly (2).
2. Remove engine oil pressure sensor (1) from the cylinder block.

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

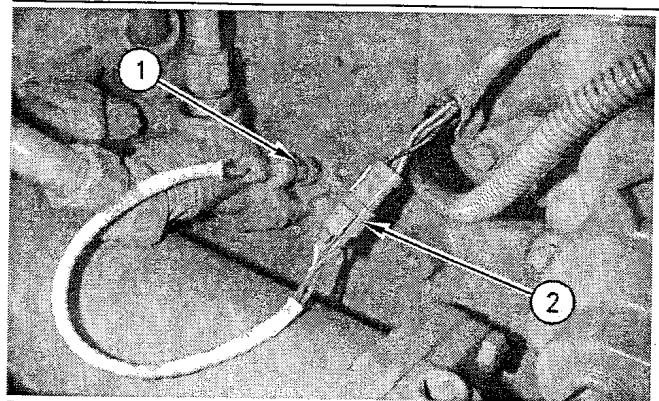


Illustration 341

g00518159

1. Install engine oil pressure sensor (1) and tighten to a torque of  $10 \pm 2$  N·m ( $88 \pm 18$  lb in).
2. Connect harness assembly (2).

i01165194

## Fuel Temperature Sensor - Remove and Install

SMCS Code: 1922-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

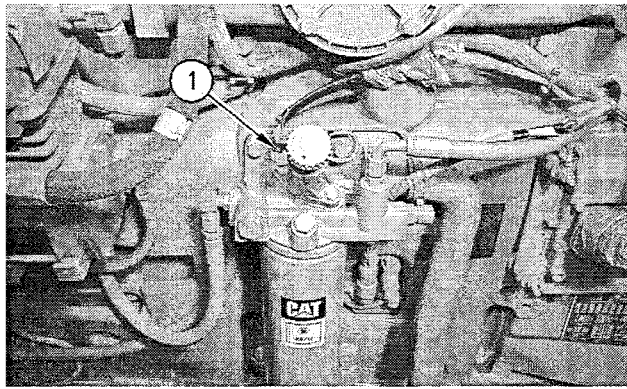


Illustration 342

g00621466

Typical example

1. Disconnect fuel temperature sensor (1) from the engine wiring harness.
2. Remove fuel temperature sensor (1).

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

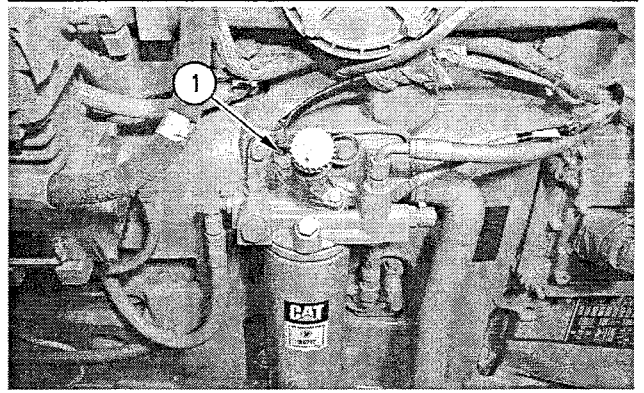


Illustration 343

g00621466

Typical example

1. Install fuel temperature sensor (1). Tighten the sensor to a torque of  $20 \pm 5$  N·m ( $15 \pm 4$  lb ft).
2. Connect fuel temperature sensor (1) to the engine wiring harness.

i01165265

## Boost Pressure Sensor - Remove and Install

SMCS Code: 1917-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

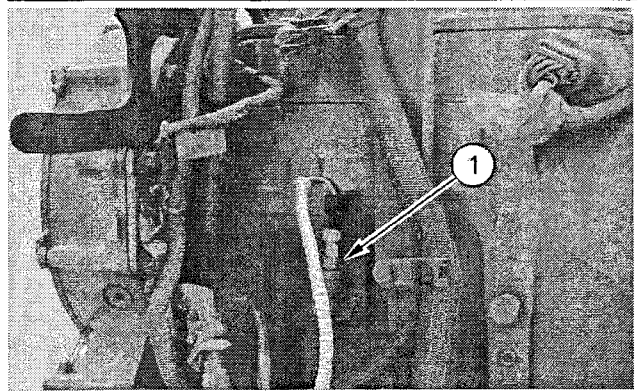


Illustration 344

g00621576

Typical example

1. Disconnect boost pressure sensor (1) from the engine wiring harness.
2. Remove boost pressure sensor (1).

## Installation Procedure

### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

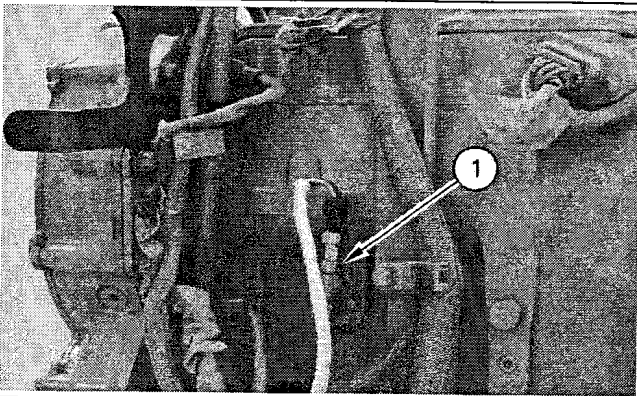


Illustration 345

g00621576

Typical example

1. Install boost pressure sensor (1). Tighten the sensor to a torque of  $10 \pm 2$  N·m ( $90 \pm 20$  lb in).
2. Connect boost pressure sensor (1) to the engine wiring harness.

i01165229

## Inlet Air Temperature Sensor - Remove and Install

SMCS Code: 1921-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

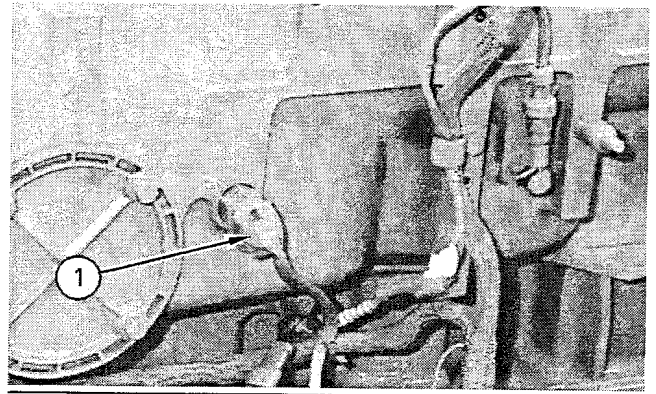


Illustration 346

g00621523

Typical example

1. Disconnect inlet air temperature sensor (1) from the engine wiring harness.
2. Remove inlet air temperature sensor(1).

### Installation Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

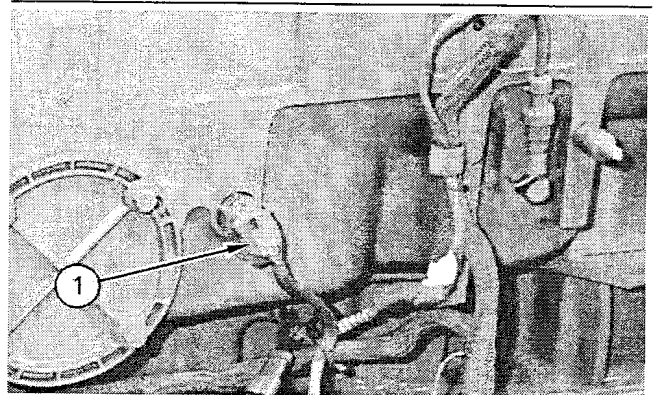


Illustration 347

g00621523

Typical example

1. Install inlet air temperature sensor (1). Tighten the sensor to a torque of  $15 \pm 3$  N·m ( $11 \pm 2$  lb ft).
2. Remove inlet air temperature sensor (1).

i01988415

## Fan Drive - Remove

SMCS Code: 1359-011

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

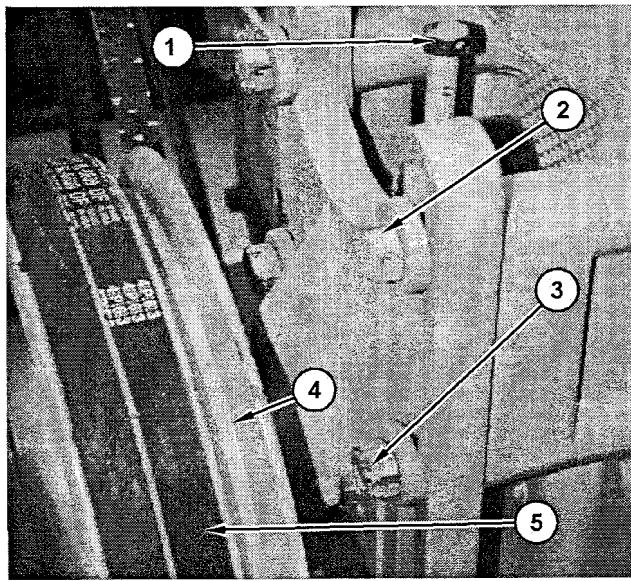


Illustration 348

g01029819

1. Loosen bolts (2) and nuts (3). Remove bolt (1), and remove fan drive belts (5).
2. Remove the nuts and the bolts that hold the fan drive. Remove fan drive (4).

i01988310

## Fan Drive - Disassemble

SMCS Code: 1359-015

### Disassembly Procedure

**Start By:**

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

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

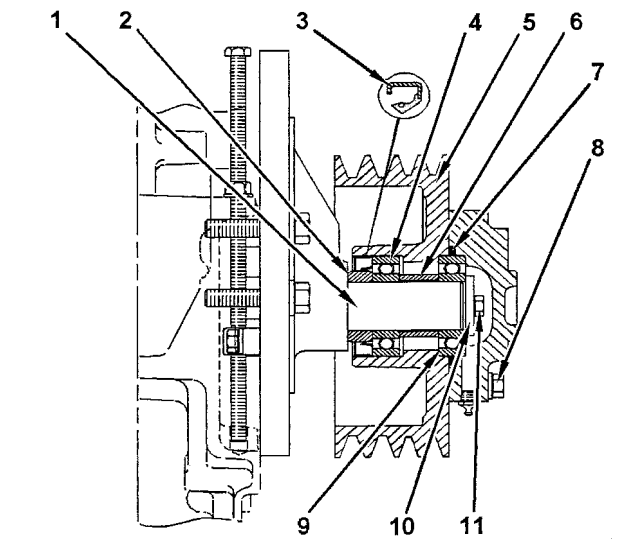


Illustration 349

g01029786

1. Remove bolts (8).
2. Remove the fan adapter from pulley (5).
3. Remove bolts (11) and retainer (10). Remove O-ring seal (7).
4. Remove pulley (5) from shaft assembly (1).
5. Remove bearing (9) and spacer (6) from pulley (5). Remove spacer (2), lip seal (3), and bearing (4) from pulley (5).

i02128458

## Fan Drive - Assemble

SMCS Code: 1359-016

### Assembly Procedure

Table 67

Required Tools			
Tool	Part Number	Part Description	Qty
A	1P-0510	Driver Group	1
B	1P-0808	Multipurpose Grease	-

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i01988436

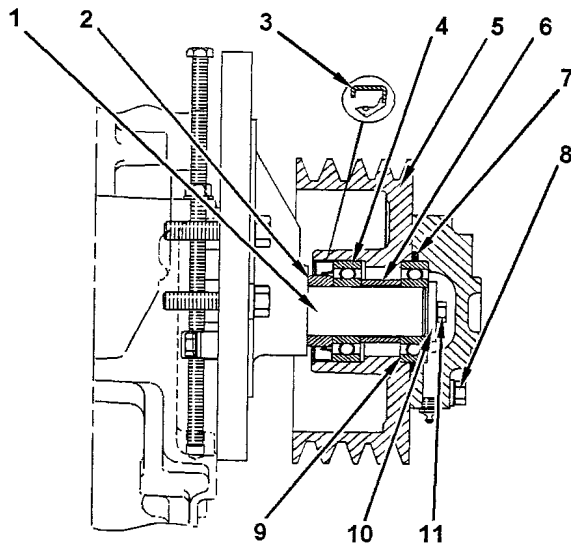


Illustration 350

g01029786

1. Install bearing (4) in pulley (5).
2. Install lip seal (3) with Tooling (A), as shown. Apply Tooling (B) to the lip of the seal.
3. Install spacer (2) so the end with the taper is toward the inside of pulley (5).
4. Install spacer (6) and bearing (9) in the front of pulley (5).
5. Position O-ring seal (7) on the front of pulley (5). Install the pulley on shaft assembly (1).
6. Install retainer (10) and bolts (11). Tighten bolts (11) to a torque of  $25 \pm 6$  N·m ( $18 \pm 4$  lb ft).
7. Install the fan adapter on pulley (5). Tighten bolts (8) to a torque of  $47 \pm 9$  N·m ( $35 \pm 7$  lb ft).
8. Fill the fan drive with Tooling (B).

**End By:**

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

## Fan Drive - Install

SMCS Code: 1359-012

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

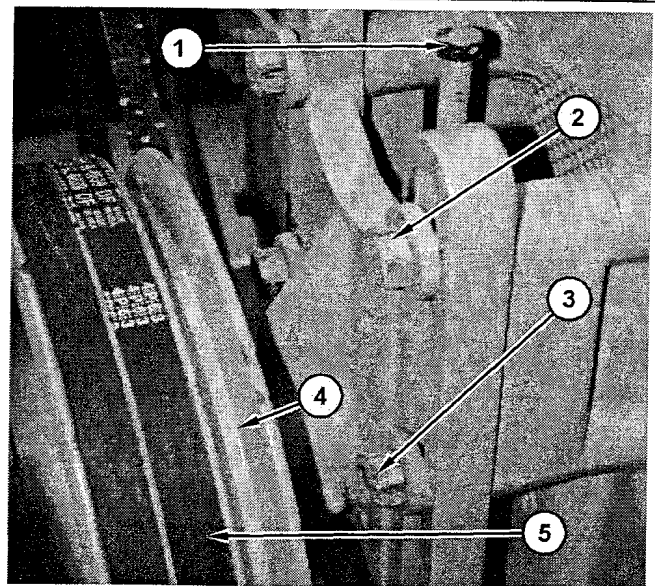


Illustration 351

g01029819

1. Position fan drive (4) on the front housing.
  2. Install bolts (2) and nuts (3) loosely.
  3. Install bolt (1).
- Note:** Install belts (5) as a set only.
4. Install the fan drive belts and adjust the belt tension. Refer to Specifications, "Belt Tension Chart".
  5. Tighten bolt (2) and nuts (3) that hold the fan drive in position.



i01934346

## Engine Control Module - Remove and Install

SMCS Code: 1901-010

### Removal Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

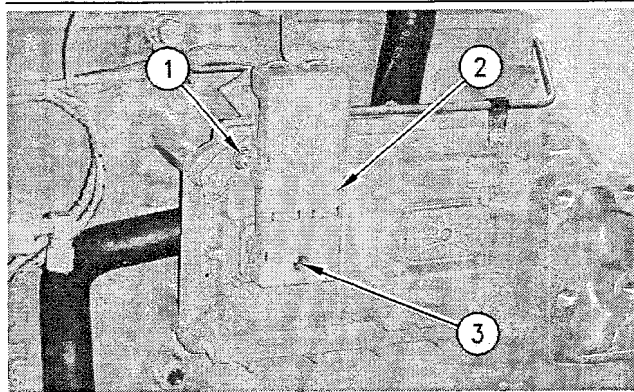


Illustration 352

g00625429

1. Remove nuts (1) and allen head screw (3).
2. Remove cover (2).

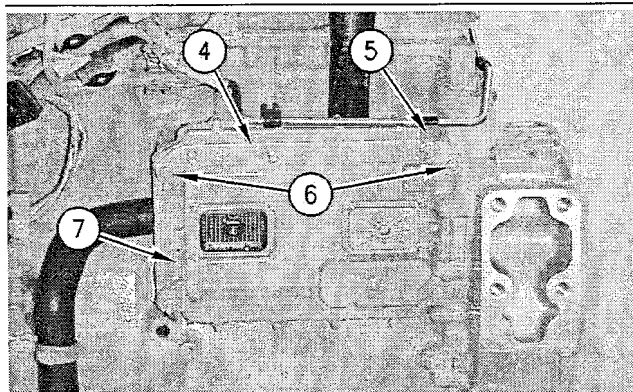


Illustration 353

g00625434

3. Remove the nut from clamp (5).
4. Remove two nuts (6). Remove bar (4).
5. Remove the bolts that fasten electronic control module (7) to the cylinder block. Remove electronic control module (7).

### Installation Procedure

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

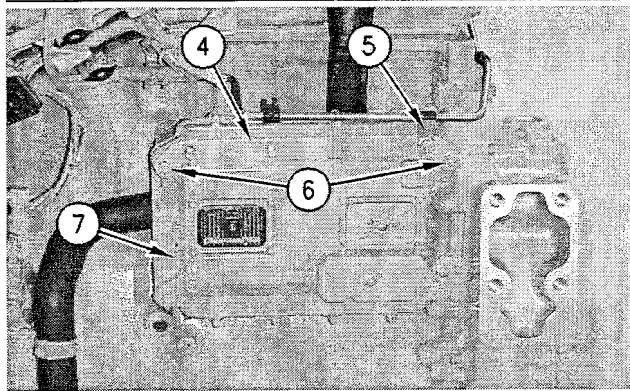


Illustration 354

g00625434

1. Install electronic control module (7) on the cylinder block.
2. Position bar (4) and install nuts (6).
3. Install clamp (5) in position.

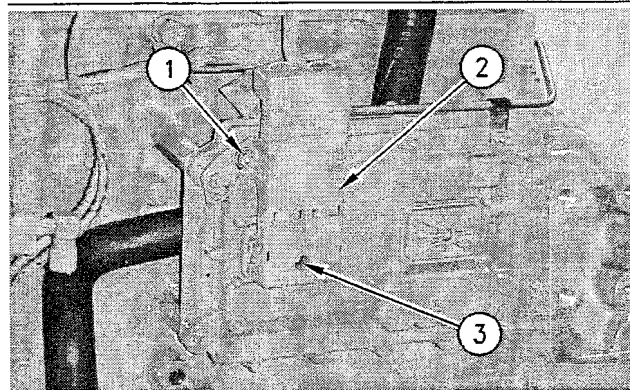


Illustration 355

g00625429

4. Position cover (2) and install nuts (1). Tighten allen head screw (3) to a torque of  $6 \pm 1$  N·m ( $53 \pm 9$  lb in).

i02017563

## Electric Starting Motor - Remove and Install

SMCS Code: 1453-010

### Removal Procedure

#### WARNING

Accidental engine starting can cause injury or death to personnel working on the equipment.

To avoid accidental engine starting, disconnect the battery cable from the negative (-) battery terminal. Completely tape all metal surfaces of the disconnected battery cable end in order to prevent contact with other metal surfaces which could activate the engine electrical system.

Place a Do Not Operate tag at the Start/Stop switch location to inform personnel that the equipment is being worked on.

1. Disconnect the batteries.
2. Disconnect the harness assemblies from the electric starting motor.

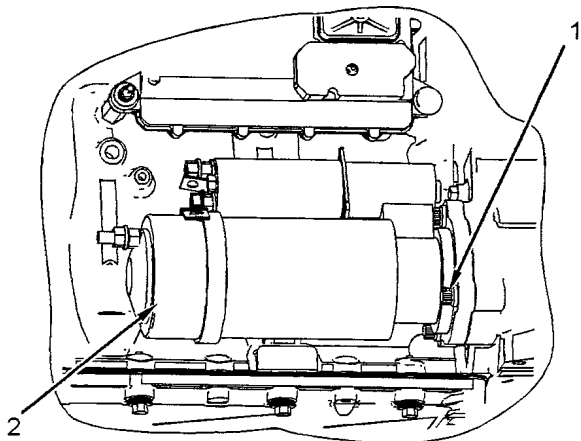


Illustration 356

g01042714

3. Fasten a suitable lifting device to the electric starting motor. Remove bolts (1) that hold the electric starting motor to the flywheel housing. Remove electric starting motor (2). The weight of the electric starting motor is approximately 36 kg (80 lb).

## Installation Procedure

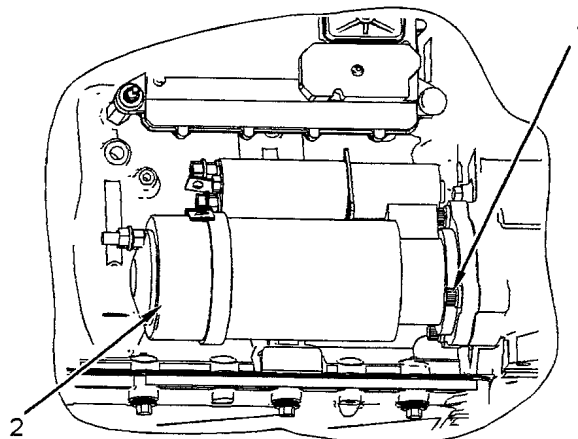


Illustration 357

g01042714

1. Fasten a suitable lifting device to the electric starting motor. Position electric starting motor (2) on the flywheel housing. The weight of the electric starting motor is approximately 36 kg (80 lb). Install bolts (1) that hold the electric starting motor to the flywheel housing.
2. Connect the harness assemblies to the electric starting motor.
3. Connect the batteries.

i01934391

## Air Compressor - Remove and Install

SMCS Code: 1803-010

### Removal Procedure

#### NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

**NOTICE**

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

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.

**WARNING**

**Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.**

1. Loosen the purge valves, and release the air pressure in the air tank.

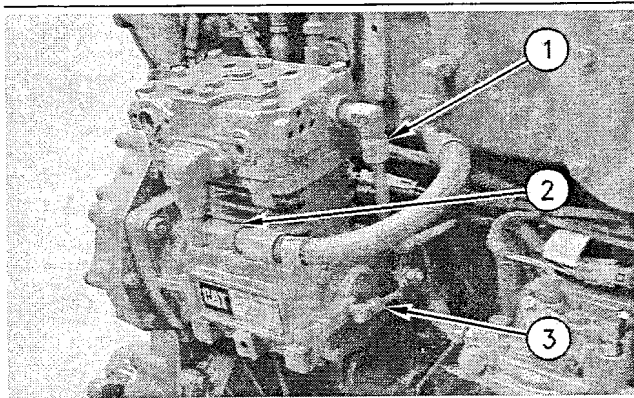


Illustration 358  
Typical example

g00620850

2. Disconnect coolant supply line (1) and air supply line (2) from the air compressor.
3. Disconnect oil supply line (3) from the air compressor.

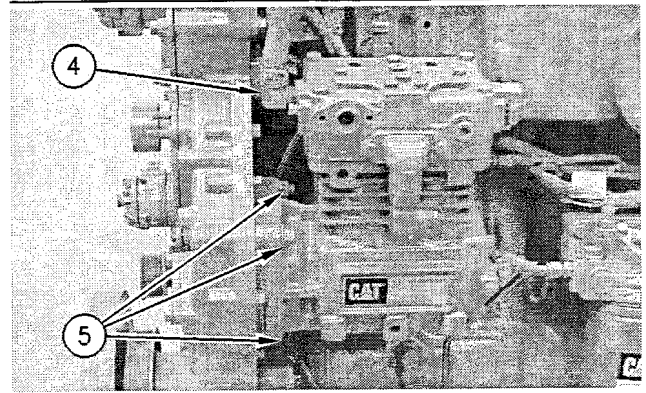


Illustration 359  
Typical example

g00620840

4. Remove coolant line (4) from the air compressor.
5. Remove nuts (5) that hold the air compressor to the accessory drive.
6. Remove the air compressor from the engine.

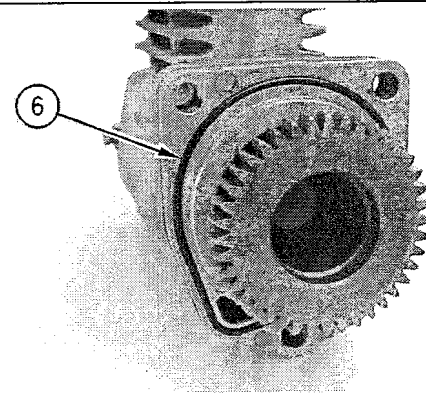


Illustration 360  
Typical example

g00620856

7. Remove seal (6) from the air compressor.

**Installation Procedure**

**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

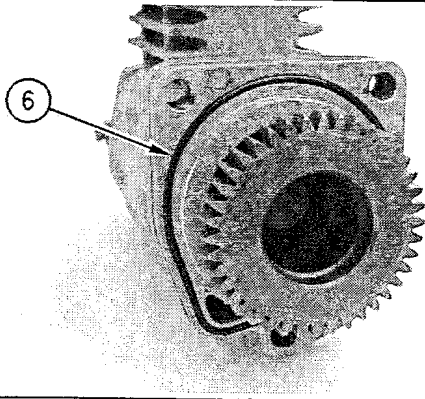


Illustration 361 g00620856

Typical example

1. Install new seal (6) on the air compressor.
2. Install the air compressor on the engine.

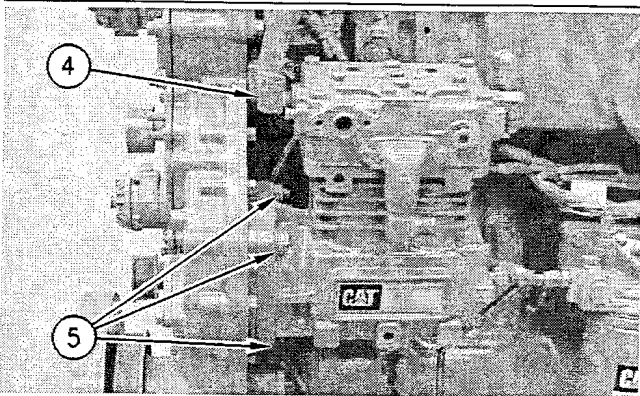


Illustration 362 g00620840

Typical example

3. Install nuts (5) in order to hold the air compressor on the engine.
4. Connect coolant line (4) to the air compressor.

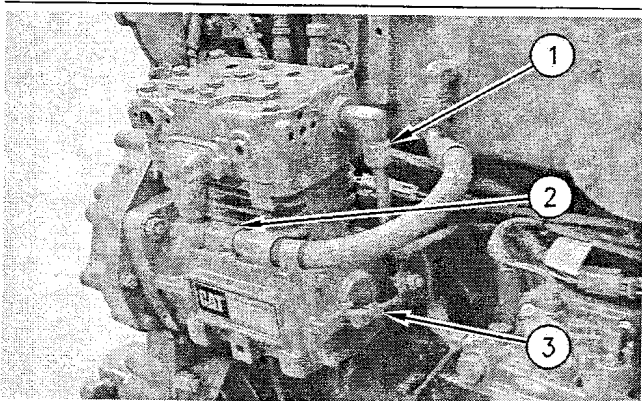


Illustration 363 g00620850

Typical example

5. Connect coolant supply line (1) to the air compressor.
6. Connect air supply line (2) to the air compressor.

**NOTICE**

To prevent water from collecting and freezing in the air compressor lines, ensure that the air compressor lines are sloping downward and away from the air compressor.

7. Connect oil line (3) to the air compressor.

i02237680

## Air Compressor Drive Gear - Remove

SMCS Code: 1803-011-GE

### Removal Procedure

Table 68

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

**Start By:**

- a. Remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".

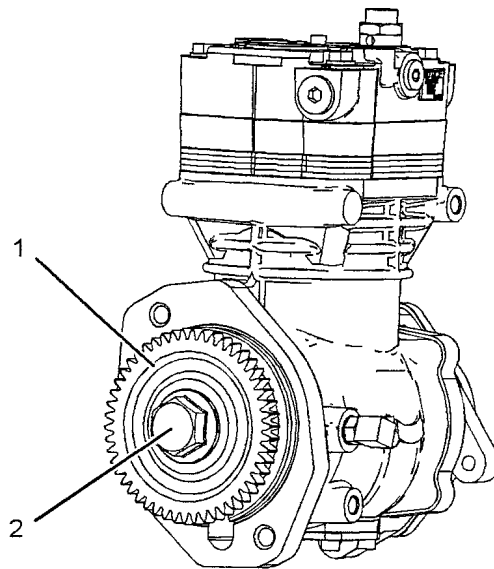


Illustration 364

g01128545

1. Install Tooling (A) on air compressor drive gear (1).

2. Remove nut (2).
3. Remove air compressor drive gear (1).

i02294313

## Air Compressor Drive Gear - Install (Two Cylinder)

SMCS Code: 1803-012-GE

### Installation Procedure

Table 69

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

**Note:** Caterpillar may use air compressors that have a tapered shaft or a straight shaft. The torque for the nut on the air compressor crankshaft is different for each type of crankshaft.

**Note:** Identify the manufacturer of the air compressor for your particular application.

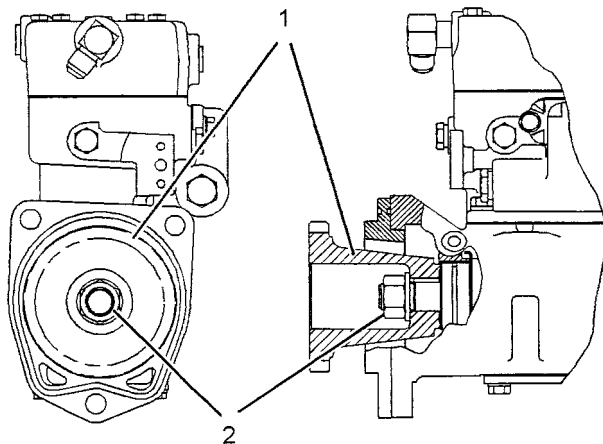


Illustration 365

g01148907

1. Install air compressor drive gear (1) on the air compressor.
2. Install Tooling (A) on air compressor drive gear (1).
3. Install nut (2).

## Tapered Shaft on Bendix Air Compressor

1. Tighten nut (2) to a torque of  $160 \pm 15$  N·m ( $118 \pm 11$  lb ft).
2. Tap the gear axially with a soft faced hammer in order to seat the gear onto the tapered crankshaft.
3. Tighten the nut again to a torque of  $160 \pm 15$  N·m ( $118 \pm 11$  lb ft).

## Straight Shaft on Bendix Air Compressor

1. Tighten nut (2) to a torque of  $460 \pm 60$  N·m ( $340 \pm 44$  lb ft).

## Wabco 250 Air Compressor

1. Tighten nut (2) to a torque of  $150 \pm 5$  N·m ( $111 \pm 4$  lb ft).
2. Place an index mark on the nut and rotate nut (2) for an additional turn of  $60 \pm 5$  degrees.

### End By:

- a. Install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".

i02237686

## Air Compressor Drive Gear - Install

SMCS Code: 1803-012-GE

### Installation Procedure

Table 70

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

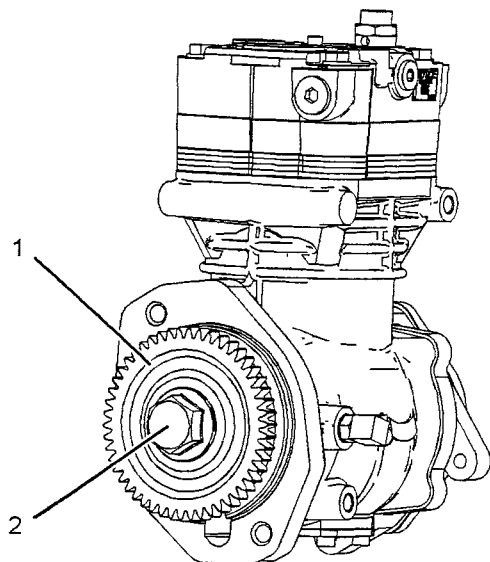


Illustration 366

g01128545

1. Install air compressor drive gear (1) on the air compressor.
2. Install Tooling (A) on air compressor drive gear (1).
3. Install nut (2).
4. Tighten nut (2) to a torque of  $170 \pm 15$  N·m ( $125 \pm 11$  lb ft).
5. Place a driver which is slightly larger than the nut over the nut and tap the driver with a hammer.
6. Tighten the nut again to a torque of  $170 \pm 15$  N·m ( $125 \pm 11$  lb ft).

**End By:**

- a. Install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".

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