

Disassembly and Assembly

1104D (Mech) Industrial Engine

NK (Engine)
NL (Engine)
NM (Engine)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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



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

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

Table of Contents

Disassembly and Assembly Section

Fuel Priming Pump and Fuel Filter Base - Remove and Install	4
Fuel Injection Lines - Remove and Install	5
Fuel Injector Cover - Remove and Install	7
Fuel Injection Pump - Remove	8
Fuel Injection Pump - Install	9
Fuel Injection Pump Gear - Remove	11
Fuel Injection Pump Gear - Install	13
Fuel Injector - Remove	14
Fuel Injector - Install	15
Turbocharger - Remove	15
Turbocharger - Install	17
Exhaust Manifold - Remove and Install	18
Exhaust Elbow - Remove and Install	20
Inlet and Exhaust Valve Springs - Remove and Install	21
Inlet and Exhaust Valves - Remove and Install	23
Engine Oil Filter Base - Remove and Install	26
Engine Oil Cooler - Remove	27
Engine Oil Cooler - Install	28
Engine Oil Relief Valve - Remove and Install (Engines Without a Balancer Unit)	29
Engine Oil Relief Valve - Remove and Install (Engines with a Balancer Unit)	30
Engine Oil Pump - Remove and Install (Engines Without a Balancer Unit)	32
Water Pump - Remove	34
Water Pump - Install	35
Water Temperature Regulator - Remove and Install	36
Flywheel - Remove	38
Flywheel - Install	39
Crankshaft Rear Seal - Remove	40
Crankshaft Rear Seal - Install	41
Flywheel Housing - Remove and Install	42
Crankshaft Pulley - Remove and Install (Engines With an Automatic Belt Tensioner)	44
Crankshaft Pulley - Remove and Install (Engines Without an Automatic Belt Tensioner)	45
Crankshaft Front Seal - Remove and Install	46
Crankshaft Wear Sleeve (Front) - Remove and Install	47
Front Cover - Remove and Install	49
Gear Group (Front) - Remove and Install	50
Idler Gear - Remove	53
Idler Gear - Install	56
Housing (Front) - Remove	59
Housing (Front) - Install	61
Accessory Drive - Remove and Install	63
Crankcase Breather - Remove and Install (Turbocharged Engines with Unfiltered Breather)	65
Crankcase Breather - Remove and Install (Turbocharged Engines with Filtered Breather) ..	67
Crankcase Breather - Remove and Install (Naturally Aspirated Engines)	69
Valve Mechanism Cover - Remove and Install	71

Rocker Shaft and Pushrod - Remove	72
Rocker Shaft - Disassemble	73
Rocker Shaft - Assemble	74
Rocker Shaft and Pushrod - Install	75
Cylinder Head - Remove	76
Cylinder Head - Install	78
Lifter Group - Remove and Install	81
Camshaft - Remove and Install	82
Camshaft Gear - Remove and Install	84
Camshaft Bearings - Remove and Install	86
Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)	87
Engine Oil Pan - Remove and Install (Cast Iron Oil Pan)	90
Balancer - Remove	93
Balancer - Install	95
Piston Cooling Jets - Remove and Install	97
Pistons and Connecting Rods - Remove	99
Pistons and Connecting Rods - Disassemble	100
Pistons and Connecting Rods - Assemble	101
Pistons and Connecting Rods - Install	103
Connecting Rod Bearings - Remove (Connecting rods in position)	105
Connecting Rod Bearings - Install (Connecting rods in position)	106
Crankshaft Main Bearings - Remove and Install (Crankshaft in position)	108
Crankshaft - Remove	112
Crankshaft - Install	114
Crankshaft Gear - Remove and Install	117
Bearing Clearance - Check	118
Glow Plugs - Remove and Install	119
V-Belts - Remove and Install (Engines Without an Automatic Belt Tensioner)	121
Alternator Belt - Remove and Install (Engines With an Automatic Belt Tensioner)	122
Fan - Remove and Install	123
Fan Drive - Remove and Install	124
Alternator - Remove (Engines With an Automatic Belt Tensioner)	125
Alternator - Remove (Engines Without an Automatic Belt Tensioner)	125
Alternator - Install (Engines With an Automatic Belt Tensioner)	126
Alternator - Install (Engines Without an Automatic Belt Tensioner)	127
Electric Starting Motor - Remove and Install	127
Air Compressor - Remove and Install	128
Vacuum Pump - Remove and Install	133

Index Section

Index	135
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Disassembly and Assembly Section

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Fuel Priming Pump and Fuel Filter Base - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

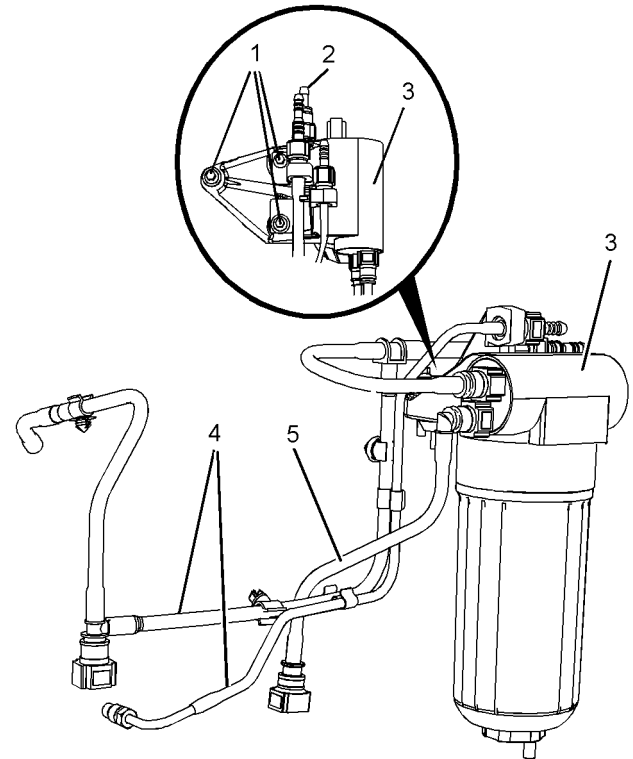


Illustration 1

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Typical example

1. Isolate the fuel supply.
2. Isolate the electrical supply.
3. Disconnect plastic tube assemblies (4) and (5) from fuel priming pump (3).
4. Disconnect plastic tube assembly (2) from fuel priming pump (3).
5. Plug all the connections on fuel priming pump (3) and plastic tube assemblies (4) and (5).
6. Disconnect the harness assembly from fuel priming pump(3).
7. Support the fuel priming pump. Remove bolts and washers (1) and remove fuel priming pump (3).

Note: Note the location and the orientation of the brackets for the tube assemblies.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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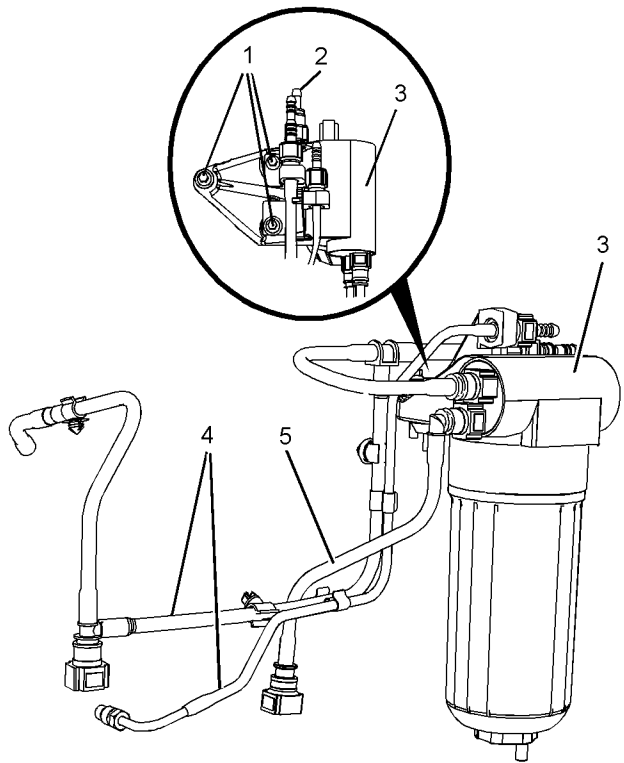


Illustration 2

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Typical example

1. Ensure that the fuel priming pump is clean and free from wear or damage. If necessary, replace the fuel priming pump as a complete assembly.
2. Position the fuel priming pump (3) onto the cylinder head. Install bolts and washers (1). Ensure that any brackets that are retained by the bolts are installed in the correct position. Tighten the bolts to a torque on 9 N·m (80 lb in).
3. Remove all plugs from the fuel priming pump and from the plastic tube assemblies. Connect plastic tube assemblies (4) and (5) to fuel priming pump (3).
4. Connect plastic tube assembly (2) to fuel priming pump (3).
5. Install the harness assembly to fuel priming pump (3).
6. Restore the fuel supply.
7. Restore the electrical supply.
8. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, "Fuel System - Prime".

Fuel Injection Lines - Remove and Install

Removal Procedure

NOTICE

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NOTICE

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Dispose of all fluids according to local regulations and mandates.

1. Isolate the fuel supply.
2. Isolate the electrical supply.
3. If the engine is equipped with a cover over the fuel injectors remove the cover. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
4. Remove the breather tube from the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".

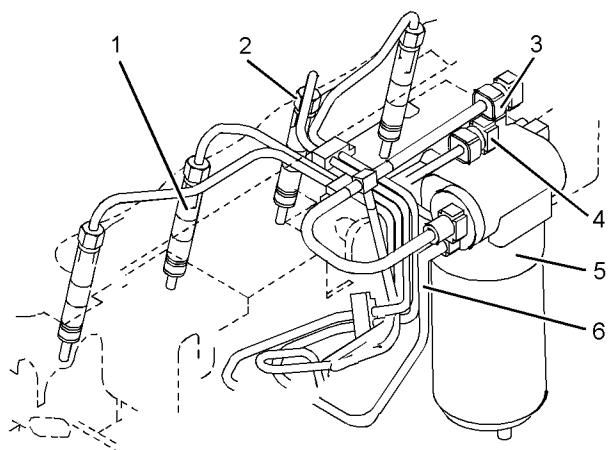


Illustration 3

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5. Loosen the clip and disconnect plastic tube assembly (3) from fuel priming pump (5).
6. Loosen the clip and disconnect plastic tube assembly (4) from the fuel return.
7. Remove plastic tube assembly (6).
8. Disconnect fuel injection lines (2) at fuel injectors (1).

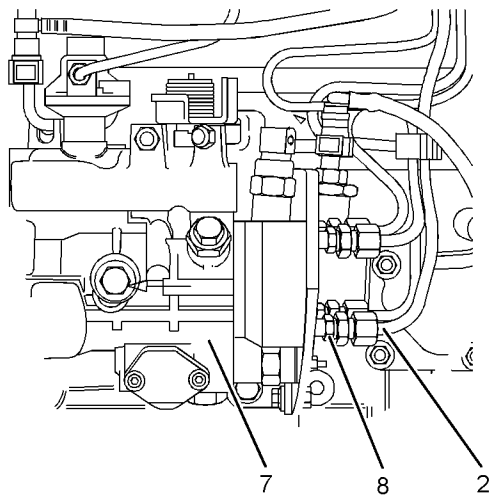


Illustration 4

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Typical example

9. Disconnect fuel injection lines (2) at fuel injection pump (7). Ensure that connections (8) do not turn.

10. Plug and cap all open ports, fuel injection lines and all tube assemblies.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the fuel injection lines for damage. Replace any components that are damaged.

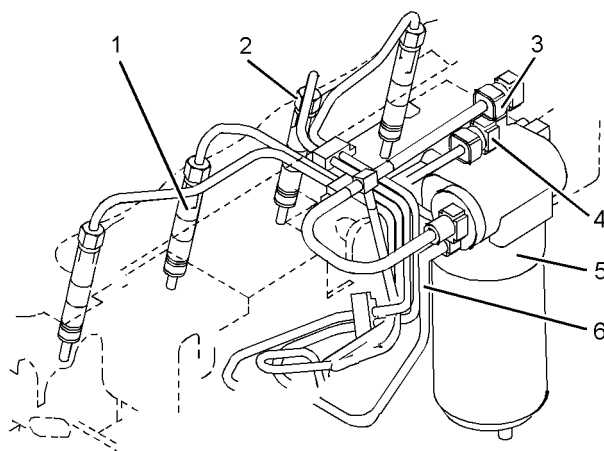


Illustration 5

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Typical example

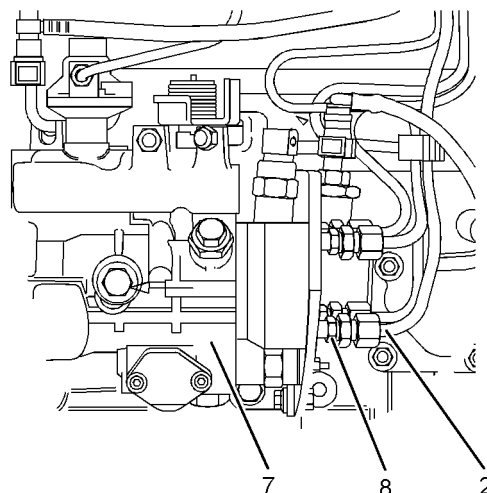


Illustration 6

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2. Remove the caps from fuel injection pump (7) and from fuel injectors (1). Remove the caps from fuel injection lines (2).
3. Install fuel injection lines(2). Loosely connect the nuts at both ends of the fuel injection lines.
4. Tighten fuel injection lines (2) at fuel injector (1) to a torque of 30 N·m (22 lb ft).
5. Tighten fuel injection lines (2) at fuel injection pump (7) to 30 N·m (22 lb ft). Ensure that the connection (8) does not turn.

Note: Ensure that each fuel injection line does not contact any other fuel injection line or any other engine component.

6. Remove the caps from fuel priming pump (5) and from the plastic tube assemblies.
7. Connect plastic tube assembly (4) to the fuel return. Secure the plastic tube assembly with the clip.
8. Connect plastic tube assembly (3) to the fuel priming pump. Secure the plastic tube assembly with the clip.
9. Install plastic tube assembly (6).
10. Install the breather tube to the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".
11. If the engine is equipped with a cover over the fuel injectors install the cover. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
12. Restore the fuel supply.
13. Restore the electrical supply.
14. Remove the air from the fuel system. Refer to the Operations and Maintenance Manual, "Fuel System - Prime".

Fuel Injector Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

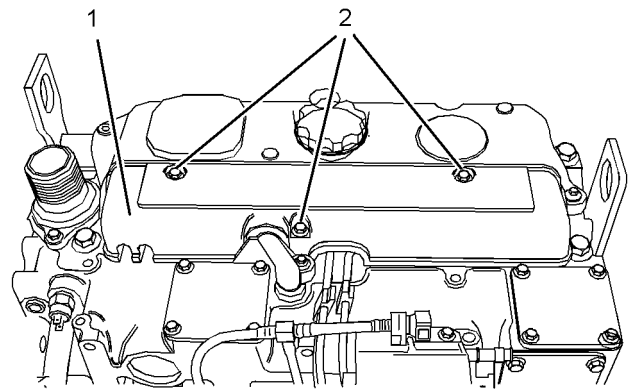


Illustration 7

g01319811

Typical example

1. Thoroughly clean all of the outer surfaces of cover (1).
2. Remove bolts (2) from the cover (1).
3. Remove cover (1).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

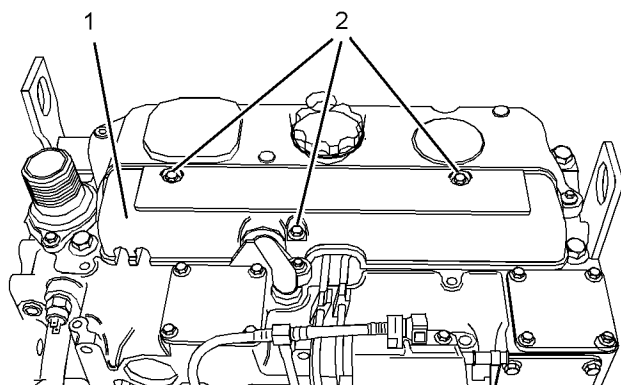


Illustration 8 g01319811

Typical example

1. Thoroughly clean all of the inner surfaces of cover (1).
2. Install cover (1).
3. Install bolts (2). Tighten bolts (2) to a torque of 9 N·m (7 lb ft).

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Fuel Injection Pump - Remove

Removal Procedure

Table 1

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1

Start By:

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

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

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Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

1. Isolate the fuel supply.
2. Isolate the electrical supply.

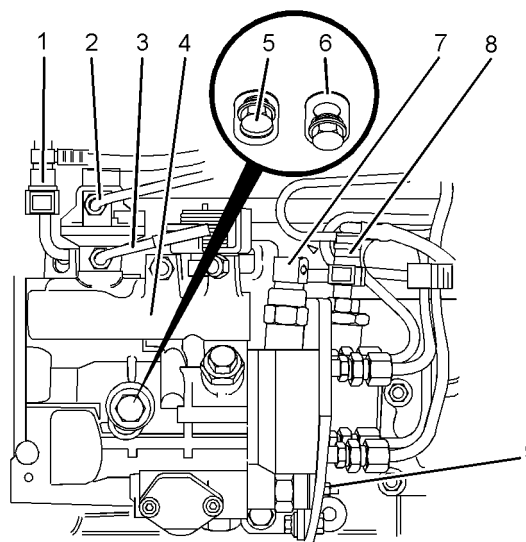


Illustration 9 g01349817

Typical example

3. Disconnect plastic tube assemblies (1) and (8) from the fuel injection pump (4).
4. Disconnect tube assembly (3) from the fuel injection pump (4).

5. Remove the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove".
6. Remove tube assembly (2).
7. Disconnect the harness assembly from solenoid (7).
8. Disconnect the harness assembly from solenoid (9).
9. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".
10. Use Tooling (B) in order to lock the camshaft in the correct position. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove" for the correct procedure.
11. Remove the backlash from the fuel pump gear. Lock the fuel injection pump in the correct position and remove the fuel pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove and Install" for the correct procedure.
12. Loosen locking screw (5). Rotate spacer (6) in order to allow locking screw (5) to tighten against the shaft of the fuel injection pump. Rotate the fuel injection pump gear in a counterclockwise direction in order to remove the backlash. Tighten locking screw (5) to a torque of 17 N·m (13 lb ft).

Note: Locking screw (5) must be tightened in order to prevent the shaft of the fuel injection pump from rotating. The shaft of the fuel injection pump must not be rotated after the fuel injection pump has been removed from the engine.

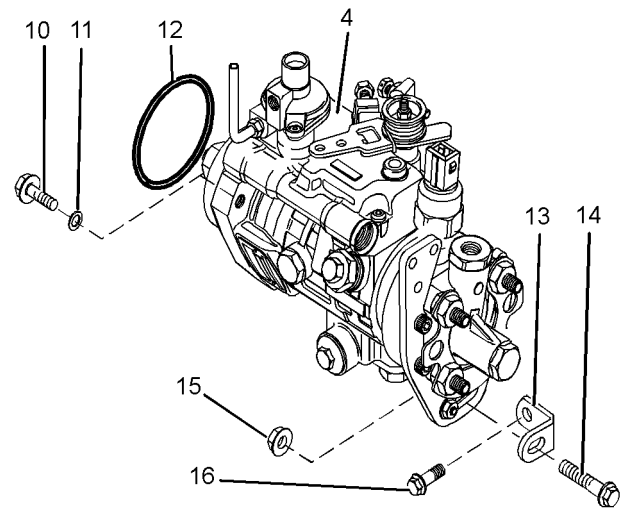


Illustration 10

g01349818

13. Remove nut (15). Remove bolt (14).
 14. Remove bolt (16) and bracket (13) from the cylinder block.
 15. Remove bolts (10) and washers (11) in order to remove the fuel injection pump (4).
- Note:** The fuel injection pump should be supported by hand as the bolts are removed.
16. Remove the fuel injection pump from the front housing. Remove O-ring seal (12).

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Fuel Injection Pump - Install

Installation Procedure

Table 2

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1
D	21820221	POWERPART Rubber Grease	1

NOTICE

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NOTICE

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Dispose of all fluids according to local regulations and mandates.

1. Inspect the bore in the front housing for damage. If the bore is damaged, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install".
-

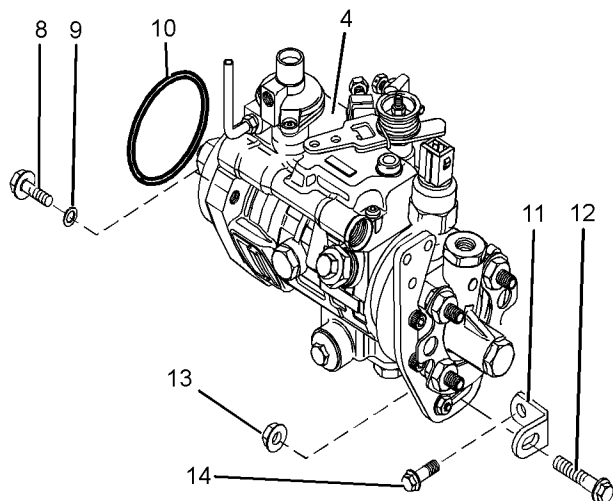


Illustration 11

g01350306

Typical example

2. Use Tooling (D) in order to lubricate O-ring seal (10). Install a new O-ring seal (10) onto the fuel injection pump (4).
3. Install the new washers (9) to bolts (8).
4. Align the holes in the fuel injection pump with the holes in the front housing. Install the fuel injection pump (4) to the housing.

Note: The fuel injection pump should be supported by hand until the bolts are installed.

5. Install bolts (8). Tighten bolts (8) to a torque of 25 N·m (18 lb ft).
6. Position support bracket (11) onto the cylinder block. Install bolt (14) finger tight.
7. Install bolt (12) and nut (13) finger tight.
8. Tighten bolt (14) to a torque of 44 N·m (32 lb ft). Tighten bolt (12) and nut (13) to a torque of 22 N·m (16 lb ft).

Note: Ensure that the fuel injection pump is not stressed as the bolts for the bracket are tightened.

9. Ensure that the No. 1 cylinder is at top dead center on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check". If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

10. Use Tooling (B) in order to lock the camshaft in the correct position. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove" for the correct procedure.
11. Install the fuel injection pump gear to fuel injection pump (4). Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" and refer to Disassembly and Assembly, "Gear Group (Front) - Install".

Note: Ensure that the fuel injection pump is in the unlocked position after the installation of the fuel injection pump gear is completed.

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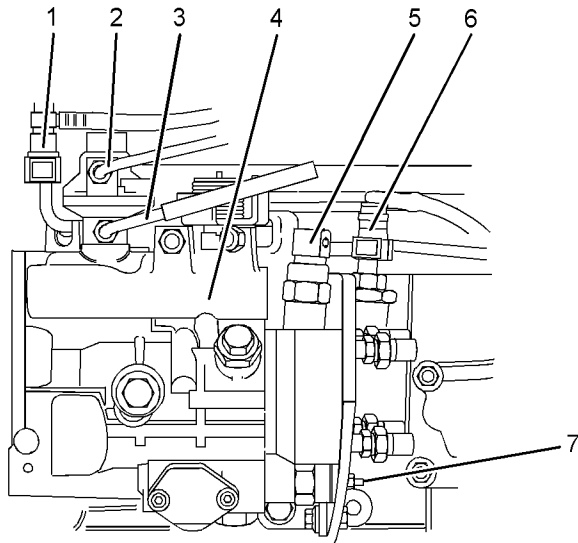


Illustration 12

g01350305

Typical example

12. Remove the plugs and caps from ports and tube assemblies.
13. Install the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
14. Connect plastic tube assemblies (1) and (6) to fuel injection pump(4).
15. Connect tube assembly (3) to fuel injection pump (4).
16. Install tube assembly (2).
17. Connect the harness assembly to solenoid (7). Tighten nut (7) to a torque of 4 N·m (35 lb in).
18. Connect the harness assembly to solenoid (5).
19. Restore the fuel supply.
20. Restore the electrical supply.

End By:

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

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 3

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1
D	-	Puller (Three Leg)	1

Start By:

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

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

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NOTICE

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Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

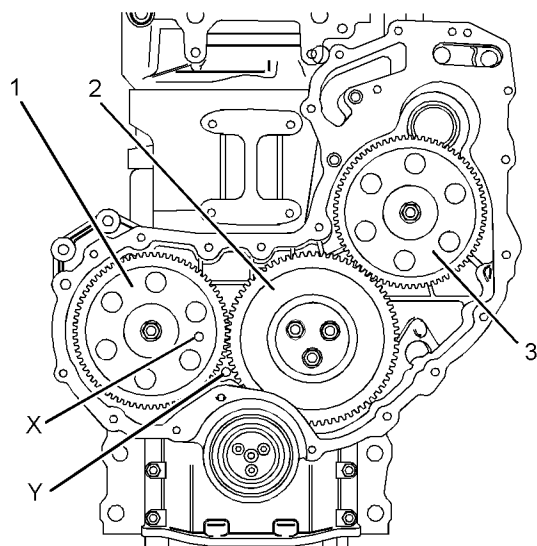


Illustration 13 g01343056

2. Install Tooling (B) through hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position.
3. Install Tooling (C) into hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

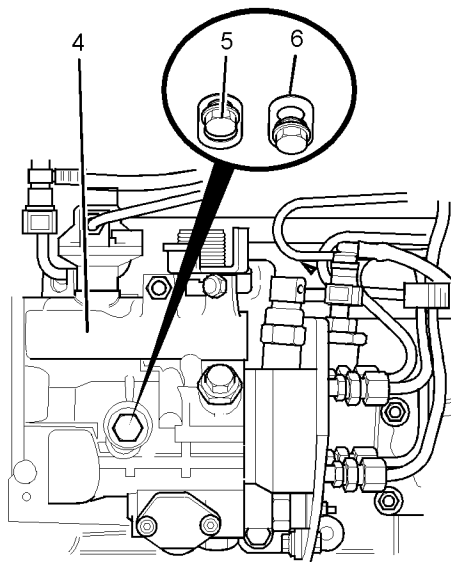


Illustration 14 g01320304

4. Apply sufficient pressure to fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Lock fuel injection pump (4) in this position. Loosen locking screw (5). Rotate spacer (6) in order to allow locking screw (5) to tighten against the shaft of the fuel injection pump. Tighten locking screw (5) to a torque of 17 N·m (13 lb ft).

Note: Locking screw (5) must be tightened in order to prevent the shaft of the fuel injection pump from rotating. The shaft of the fuel injection pump must not be rotated after the fuel injection pump has been removed from the engine.

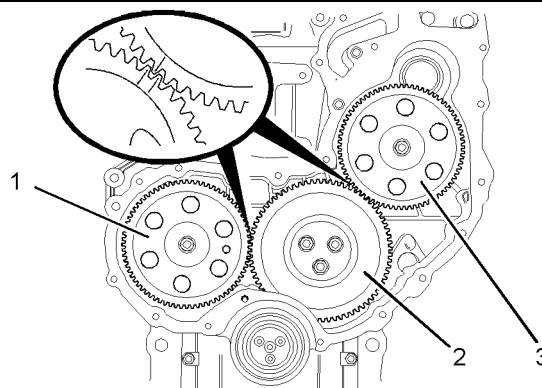


Illustration 15 g01335384
Alignment of timing marks

5. Mark gears (1), (2) and (3) in order to show alignment. Refer to Illustration 15.

Note: Identification will ensure that the gears can be installed in the original alignment.

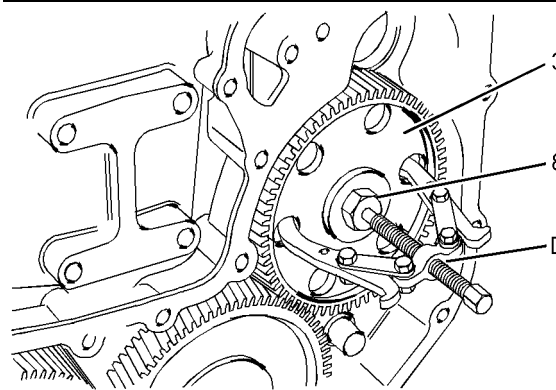


Illustration 16 g01335385

6. Loosen nut (8) on fuel pump gear (3).
7. Install Tooling (D) through two opposite holes in fuel pump gear (3). Tighten Tooling (D) until the fuel pump gear is released.
8. Remove Tooling (D) from fuel pump gear (3).

9. Remove nut (8) and the washer from fuel pump gear (3). Remove the fuel pump gear.

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Fuel Injection Pump Gear - Install

Installation Procedure

Table 4

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1
D	21825617	Dial Indicator Group	1
	-	Finger Clock	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.

Dispose of all fluids according to local regulations and mandates.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

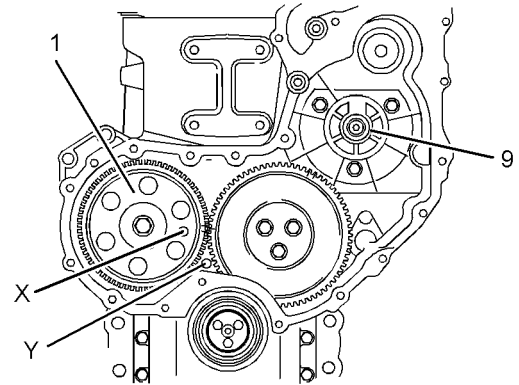


Illustration 17

g01343058

Typical example

2. Ensure that Tooling (C) is installed in hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

3. Ensure that Tooling (B) is installed into hole (X) in camshaft gear (1).
4. Ensure that shaft (9) on the fuel injection pump is clean, dry and free from damage.
5. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".
6. Ensure that the fuel pump gear is clean, dry and free from wear or damage. If necessary, replace the fuel pump gear.

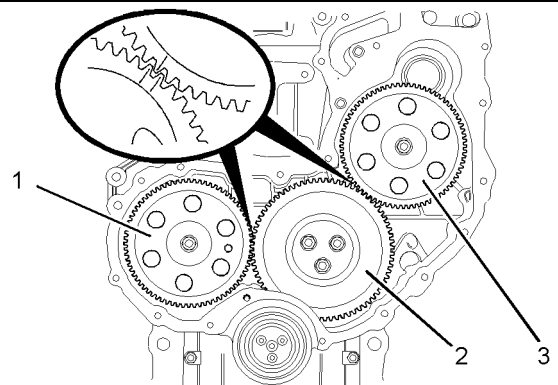


Illustration 18

g01335384

Alignment of timing marks

7. Install fuel pump gear (3) to shaft (9) of the fuel injection pump. Ensure that the timing marks on gears (2) and (3) are in alignment and that the mesh of the gears is correct.

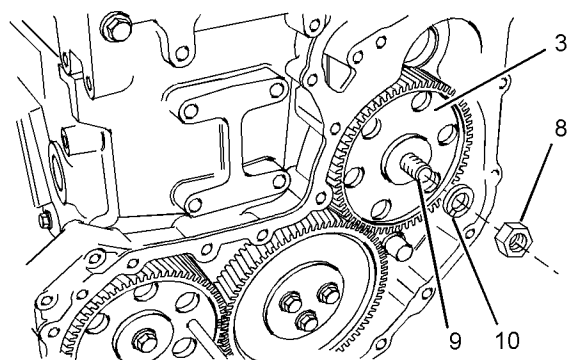


Illustration 19

g01343060

Typical example

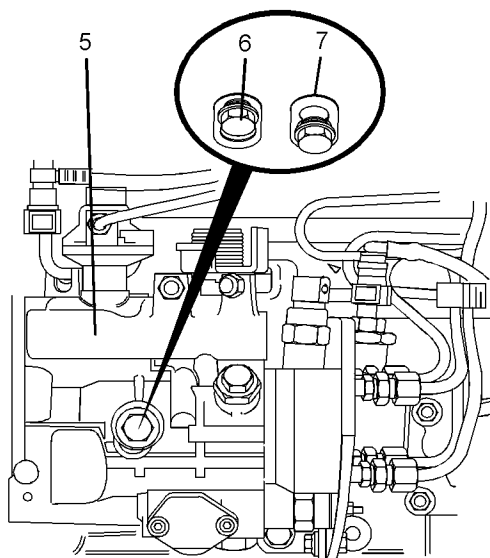


Illustration 20

g01320629

Typical example

8. Install a new spring washer (10) and install nut (8) to shaft (9) of the fuel injection pump. Apply sufficient pressure to the fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Tighten nut (8) to a torque of 24 N·m (17 lb ft). Unlock the fuel injection pump (5).

In order to unlock the fuel injection pump, loosen locking screw (6) on the fuel injection pump. Rotate spacer (7) in order to allow locking screw (6) to tighten against the spacer. Tighten the locking screw against the spacer to a torque of 17 N·m (13 lb ft). This will prevent the locking screw from tightening against the shaft of the fuel injection pump.

9. Remove Tooling (B) and (C).

10. Tighten nut (8) to a torque of 88 N·m (65 lb ft).

11. Use Tooling (D) to measure the backlash of gears (2) and (3). Ensure that the backlash for the gears is within specified values. Refer to Specifications, "Gear Group (Front)" for further information.

12. Lubricate the teeth of the gears with clean engine oil.

End By:

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

i02628874

Fuel Injector - Remove

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

1. Isolate the fuel supply.

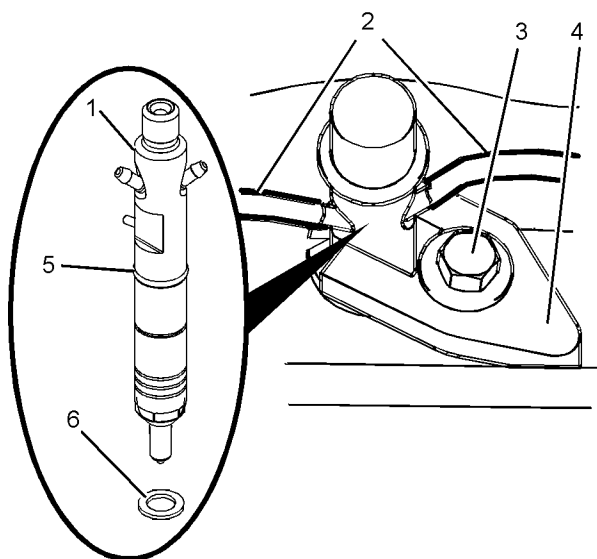


Illustration 21

g01320676

Typical example

2. Remove fuel return lines (2) from fuel injector (1).
3. Remove bolt (3). Remove clamp (4) from fuel injector (1).
4. Remove fuel injector (1) from the cylinder head. Remove O-ring seal (5) from fuel injector (1).
5. Remove seat washer (6).

i02628873

Fuel Injector - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

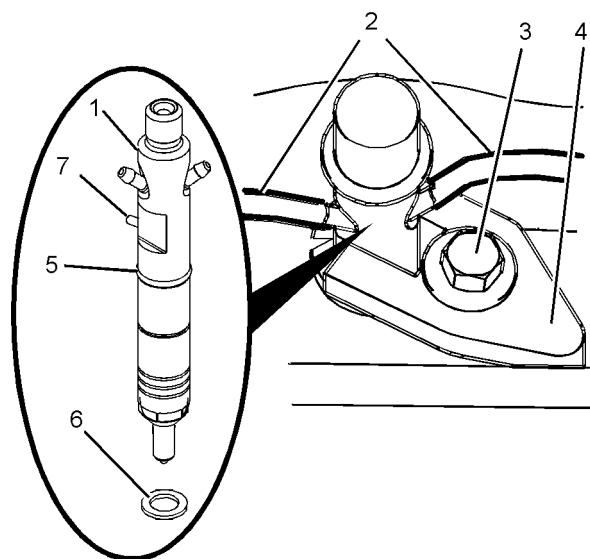


Illustration 22

g01320782

1. Ensure that the seat for the fuel injector in the cylinder head is clean and free from damage. Position a new sealing washer (6) on the seat for the fuel injector in the cylinder head.
 2. Install a new O-ring seal (5) on fuel injector (1).
 3. Install fuel injector (1) into the cylinder head.
- Note:** Alignment Pin (7) must be located opposite clamp (4).
4. Position clamp (4) on fuel injector (1). Install bolt (3). Tighten the bolt to a torque of 27 N·m (20 lb ft).
 5. Install fuel return lines (2) to fuel injector (1).

End By:

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

i02628909

Turbocharger - Remove

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: Plug and cap all open ports and tube assemblies.

1. If the turbocharger is equipped with an exhaust elbow, remove the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".
2. Loosen the hose clamp and disconnect the air inlet hose from the turbocharger.
3. Loosen the hose clamp and disconnect the air outlet hose from the turbocharger. If the engine is equipped with an air pipe, remove the air pipe and remove the gasket from the cylinder head.
4. If the valve mechanism cover is equipped with a heat shield, remove the heat shield.

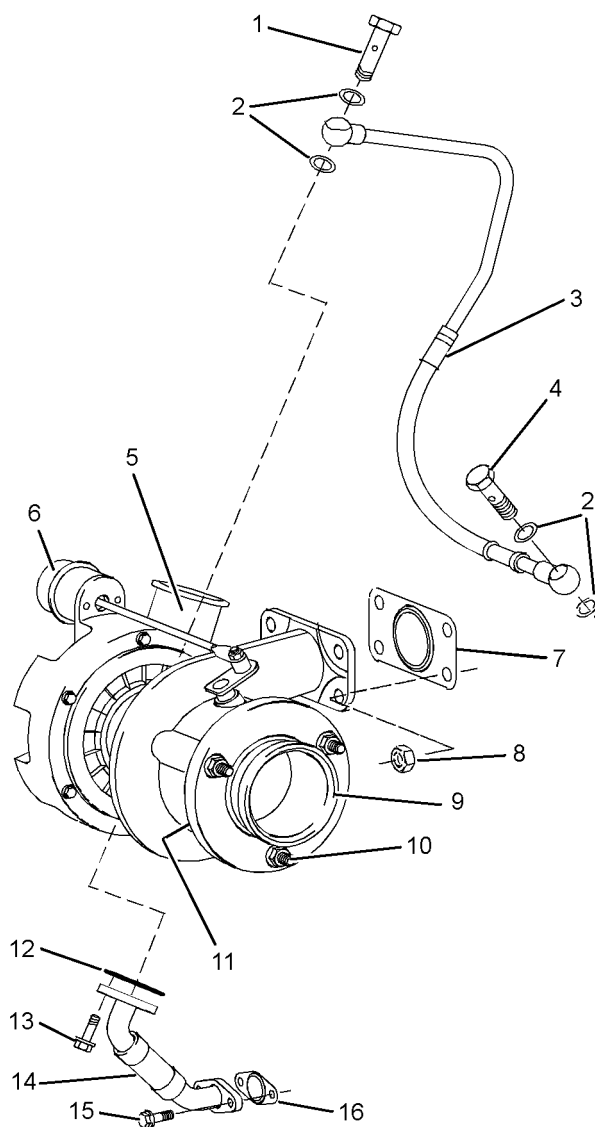


Illustration 23

g01343533

Typical example

5. If the turbocharger is equipped with an adapter (9), Remove nuts (10) and remove adapter (9) from turbocharger (5). Remove gasket (11) (not shown).
6. Remove banjo bolt (1) and disconnect tube assembly (3) from turbocharger (5). Remove sealing washers (2) from tube assembly (3).
7. Remove banjo bolt (4) and disconnect tube assembly (3) from the cylinder block. Remove sealing washers (2) from tube assembly (3). Remove tube assembly (3).
8. Remove bolts (13). Disconnect tube assembly (14) from turbocharger (5). Remove joint (12).

If necessary, remove bolts (15) and remove tube assembly (14) from the cylinder block. Remove joint (16).

If tube assembly (14) is secured with tube clips, loosen the fasteners for the tube clips. If the engine has a top mounted turbocharger, the exhaust manifold must be removed in order to remove tube assembly (13). Refer to Disassembly and Assembly , “Exhaust Manifold - Remove and Install”.

9. Remove nuts (8) and remove turbocharger (5).

Note: Do not use the actuator rod to lift the turbocharger.

10. Remove gasket (7).

11. If necessary, remove the studs from the exhaust manifold.

i02628908

Turbocharger - Install

Installation Procedure

Table 5

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the turbocharger is clean and free from damage. Inspect the turbocharger for wear. Refer to Systems Operation, Testing and Adjusting, “Turbocharger - Inspect” for more information. If the turbocharger is worn, the complete turbocharger must be replaced.

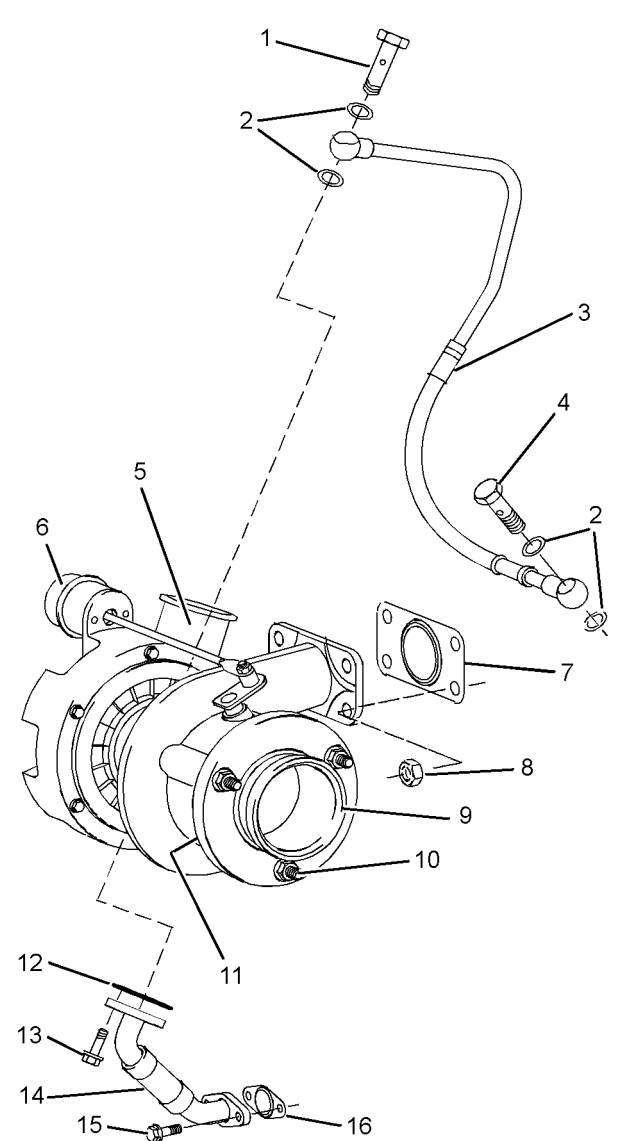


Illustration 24
Typical example

g01343533

2. Test actuator (6) for correct operation. Refer to Systems Operation, Testing and Adjusting, “Turbocharger - Inspect”. If the actuator is damaged or the actuator does not operate within the specified limits, the complete turbocharger must be replaced.
3. Clean the mating surfaces of the exhaust manifold. If necessary, install the studs to the exhaust manifold. Tighten the studs to a torque of 18 N·m (13 lb ft).
4. Install a new gasket (7) to the exhaust manifold.
5. Position turbocharger (5) onto the exhaust manifold and install nuts (8). Tighten the nuts to a torque of 44 N·m (32 lb ft).

Note: Do not use the actuator rod to lift the turbocharger.

6. Position a new joint (12) and tube assembly (14) onto turbocharger (5). Install bolts (13) finger tight.

7. The turbocharger has different sized bolts (13).
Tighten M6 bolts to a torque of 9 N·m (80 lb in).

Tighten M8 bolts to a torque of 22 N·m (16 lb ft).

8. Position a new joint (16) onto the cylinder block. Install bolts (15) finger tight.

9. Tighten bolts (15) to a torque of 22 N·m (16 lb ft).

If tube assembly (14) is secured with tube clips, tighten the fasteners for the tube clips to a torque of 22 N·m (16 lb ft).

10. Lubricate the bearings of turbocharger (5) with clean engine oil through the oil inlet port. Rotate the shaft of the turbocharger in order to distribute the lubricant.

11. Position tube assembly (3) onto turbocharger (5). Install new washers (2) and banjo bolt (1) to tube assembly (3). Tighten the banjo bolt finger tight.

12. Install new washers (2) and banjo bolt (4) onto tube assembly (3). Connect the tube assembly to the cylinder block. Tighten the banjo bolt finger tight.

13. Tighten banjo bolts (1) and (4) to a torque of 20 N·m (15 lb ft).

Note: Ensure that the tube assembly does not come into contact with any other engine components.

14. The turbocharger is equipped with an adapter (9). Install a new gasket (11) (not shown) and position the adapter (9) onto the turbocharger. Install nuts (10). Tighten the nuts to a torque of 44 N·m (33 lb ft).

15. If the turbocharger is equipped with an exhaust elbow, install the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

16. Connect the air outlet hose to turbocharger (5).

If the engine is equipped with an air pipe, install the air pipe and install the gasket to the cylinder head. Apply Tooling (A) to the fasteners for the air pipe. Tighten the fasteners to a torque of 22 N·m (16 lb ft).

Tighten the hose clamps to a torque of 5 N·m (44 lb in).

Note: If the air outlet hose has a reflective heat shield, ensure that the reflective heat shield is installed toward the engine.

17. Connect the air inlet hose to turbocharger (5).

18. If the valve mechanism cover is equipped with a heat shield, install the heat shield. Tighten the fasteners for the heat shield to a torque of 9 N·m (80 lb in).

i02628843

Exhaust Manifold - Remove and Install

Removal Procedure

Start By:

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

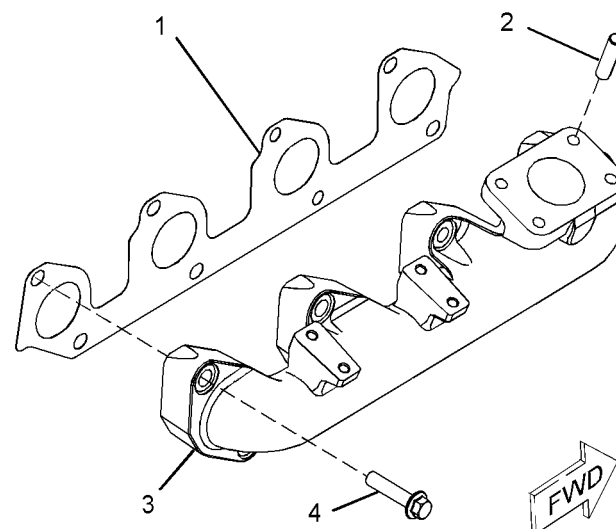


Illustration 25
Typical example

g01343539

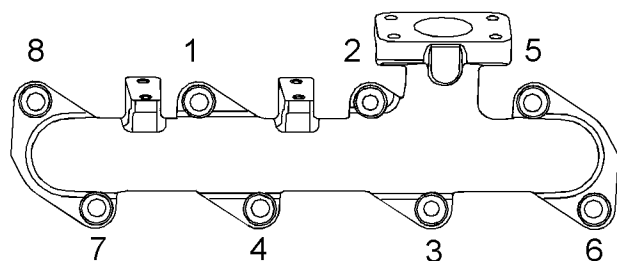


Illustration 26

g01363916

Sequence for loosening the exhaust manifold

1. Loosen bolts (4) in reverse numerical order to the sequence that is shown in Illustration 26.

Note: This will help prevent distortion of the exhaust manifold.

2. Remove bolts (4) from exhaust manifold (3).

Note: Bolts (4) may be equipped with spacers. Record the position of the spacers. Support the manifold as the bolts are removed.

3. Remove exhaust manifold (3).

4. Remove exhaust manifold gasket (1).

5. If necessary, remove studs (2) from exhaust manifold (3).

Installation Procedure

Table 6

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M10 by 100 mm)	2

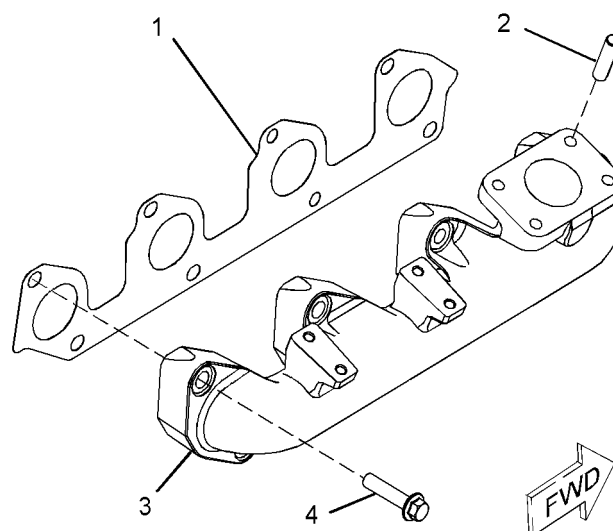


Illustration 27

g01343539

Typical example

1. Ensure that the exhaust manifold is clean and free from damage. Clean the joint face of the cylinder head.
2. If necessary, install studs (2) to exhaust manifold (3). Tighten the studs to a torque of 18 N·m (13 lb ft).

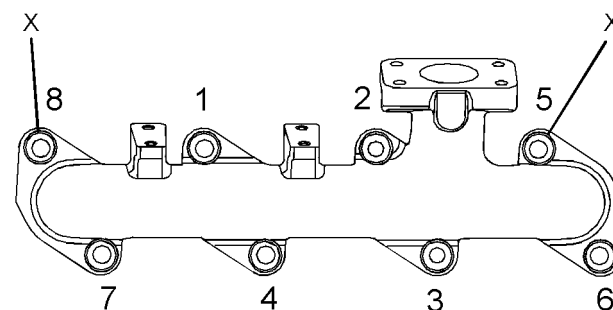


Illustration 28

g01363918

Tightening sequence for the exhaust manifold

3. Install Tooling (A) to the cylinder head in positions (X). Refer to Illustration 28.
4. Position a new exhaust manifold gasket (1) onto Tooling (A).

Note: Ensure that the exhaust manifold gasket is correctly oriented.

5. Align exhaust manifold (3) with Tooling (A). Install the exhaust manifold to the cylinder head.

Note: If the engine has a top mounted turbocharger, the tube assembly for the oil drain must be connected to the cylinder block before the exhaust manifold is installed.

6. Install new bolts (4) finger tight.

Note: Bolts (4) that were equipped with spacers. Install the spacer in the original position.

7. Remove Tooling (A). Install the remaining bolts (4) finger tight.

8. Tighten bolts (4) to a torque of 40 N·m (30 lb ft) in the sequence that is shown in Illustration 28.

End By:

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

Exhaust Elbow - Remove and Install

i02628842

Removal Procedure

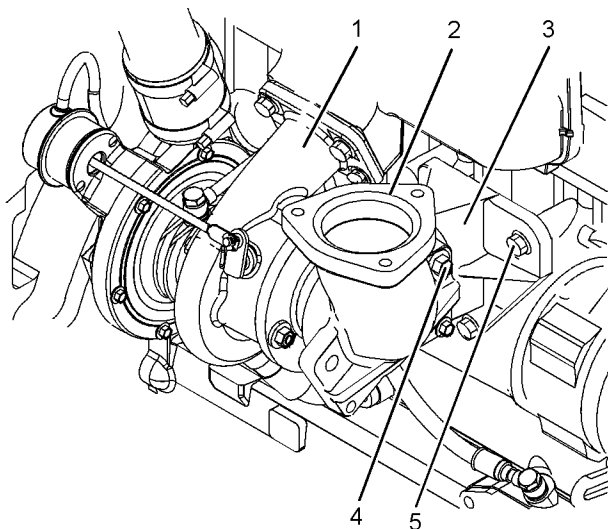


Illustration 29

g01343547

Typical example

1. Remove bolts (4) and remove exhaust elbow (2). Note the orientation of the exhaust elbow.
2. Remove bolts (5) and remove support bracket (3) from the cylinder block.

Installation Procedure

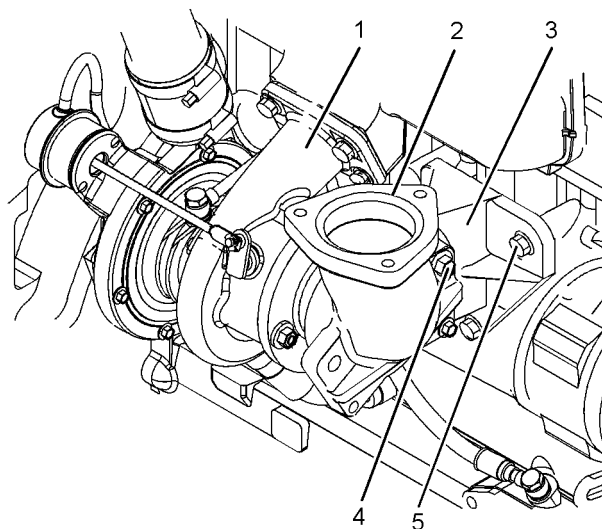


Illustration 30

g01343547

Typical example

1. Ensure that the exhaust elbow is clean and free from wear or damage.
 2. Position support bracket (3) to the cylinder block and install bolts (5). Tighten bolts (5) to a torque of 44 N·m (33 lb ft).
 3. Position exhaust elbow (2).
- Note:** Ensure the correct orientation of the exhaust elbow.
4. Install bolts (4) to support bracket (3). Tighten bolts (4) to a torque of 44 N·m (33 lb ft).

i02628893

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 7

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1

Start By:

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

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The following procedure should be adopted in order to remove the valve springs when the cylinder head is installed to the engine. Refer to Disassembly and Assembly, "Inlet and Exhaust Valves - Remove and Install" for the procedure to remove the valve springs from a cylinder head that has been removed from the engine.

Note: Ensure that the appropriate piston is at the top center position before the valve spring is removed. Failure to ensure that the piston is at the top center position may allow the valve to drop into the cylinder bore.

NOTICE

Plug the apertures for the push rods in the cylinder head in order to prevent the entry of loose parts into the engine.

WARNING

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

Make sure to wear all necessary protective equipment.

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

NOTICE

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

1. Follow Steps 1.a through 1.d in order to position the appropriate piston at top center.
 - a. Install Tooling (B) in position on the cylinder head in order to compress a valve spring for the appropriate piston.
 - b. Use Tooling (B) in order to compress valve spring (3) and open the valve slightly.
- Note:** Do not compress the spring so that the valve spring retainer (2) touches the valve stem seal.
- c. Use Tooling (A) in order to rotate the crankshaft carefully, until the piston touches the valve.
- Note:** Do not use excessive force to turn the crankshaft. The use of force can result in bent valve stems.
- d. Continue to rotate the crankshaft and gradually release the pressure on Tooling (B) until the piston is at the top center position. The valve is now held in a position that allows the valve spring to be safely removed.

NOTICE

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

Note: Valve springs must be replaced in pairs for the inlet valve or the exhaust valve of each cylinder. If all valve springs require replacement the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. Ensure that all of the valve springs are installed before changing from one pair of cylinders to another pair of cylinders.

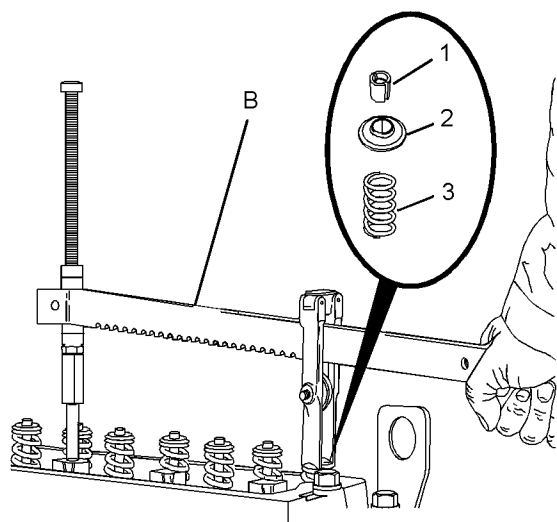


Illustration 31 g01343550

Typical example

2. Apply sufficient pressure to Tooling (B) in order to allow removal of the valve keepers (1). Remove valve keepers (1).

Note: Do not compress the spring so that the valve spring retainer (2) touches the valve stem seal.

3. Slowly release the pressure on Tooling (B).
4. Remove valve spring retainer (2) and remove valve spring (3).
5. If necessary, remove the valve stem seals.
6. Repeat Steps 2 through 5 in order to remove the remaining valve spring from the appropriate cylinder.
7. Remove Tooling (B).

Installation Procedure

Table 8

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

1. Inspect the valve springs for the correct length. Refer to Specifications, "Cylinder Head Valves" for more information.
2. If necessary, install a new valve stem seal onto the valve guide.

Note: The outer face of the valve guide must be clean and dry before installing the valve stem seal.

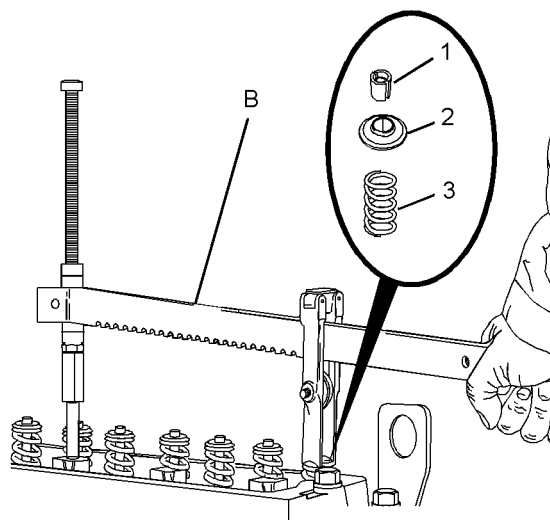


Illustration 32 g01343550

Typical example

3. Install valve spring (3) onto the cylinder head. Position valve spring retainer (2) onto valve spring (3).

WARNING

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

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

4. Install Tooling (B) in the appropriate position on the cylinder head in order to compress the valve spring.

NOTICE

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

5. Apply sufficient pressure to Tooling (B) in order to install valve keepers (1). Install the valve spring keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches the valve stem seal .

6. Carefully release the pressure on Tooling (B).

Note: Ensure that the valve keepers are correctly seated.

7. Repeat Steps 2 to 6 for the remaining valves.

⚠ 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.

8. Remove Tooling (B).

End By:

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

i02628894

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 9

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	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.

1. Clean the bottom face of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, "Cylinder Head Valves" for the correct dimensions.
2. Place a temporary identification mark on the heads of the valves in order to identify the correct position. Inlet valves have a recess in the center of the head.

Note: Do not stamp the heads of the valve. Stamping or punching the heads of the valves could cause the valves to fracture.

3. Use a suitable lifting device to position the cylinder head with the valve springs upward. The weight of the cylinder head is approximately 56 kg (125 lb).

Note: Ensure that the cylinder head is kept on a clean, soft surface in order to prevent damage to the machined face.

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

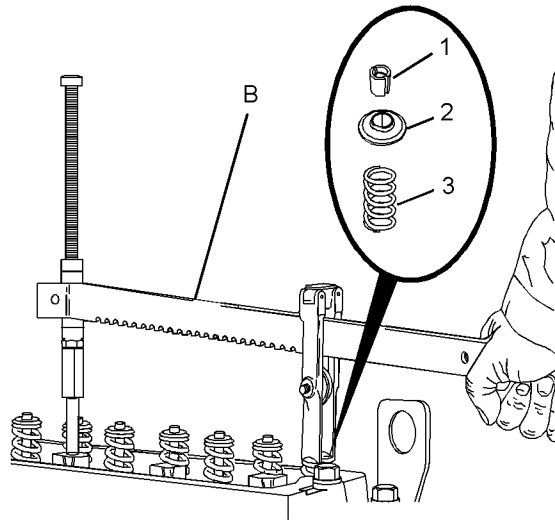


Illustration 33
Typical example

4. Install Tooling (A) in position on the cylinder head in order to compress the appropriate valve spring.

NOTICE

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

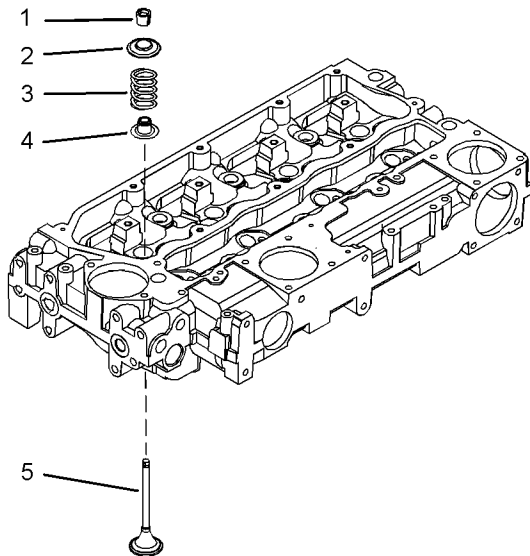


Illustration 34
Typical example

5. Apply sufficient pressure to Tooling (A) in order to remove valve keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches valve stem seal (4).

6. Slowly release the pressure on Tooling (A).
7. Remove valve spring retainer (2). Remove valve spring (3).
8. Repeat Steps 4 to 7 for the remaining valves.
9. Remove Tooling (A).
10. Remove valve stem seals (4).
11. Use a suitable lifting device to carefully turn over the cylinder head.
12. Remove valves (5).

Installation Procedure

Table 10

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean all components of the cylinder head assembly. Ensure that all ports, all coolant passages and all lubrication passages in the cylinder head are free from debris. Follow Steps 1.a through 1.e in order to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.
 - a. Inspect the cylinder head for wear and for damage. Refer to Systems Operation, Testing and Adjusting, "Cylinder Head Inspect".
 - b. Inspect the valve seats for wear and for damage. Refer to Specifications, "Cylinder Head Valves" for further information.
 - c. Inspect the valve guides for wear and for damage. Refer to Specifications, "Cylinder Head Valves" and Systems Operation, Testing and Adjusting, "Valve Guide - Inspect" for further information.
 - d. Inspect the valves for wear and for damage. Refer to Specifications, "Cylinder Head Valves".

- e. Inspect the valve springs for the correct length. Refer to Specifications, "Cylinder Head Valves".

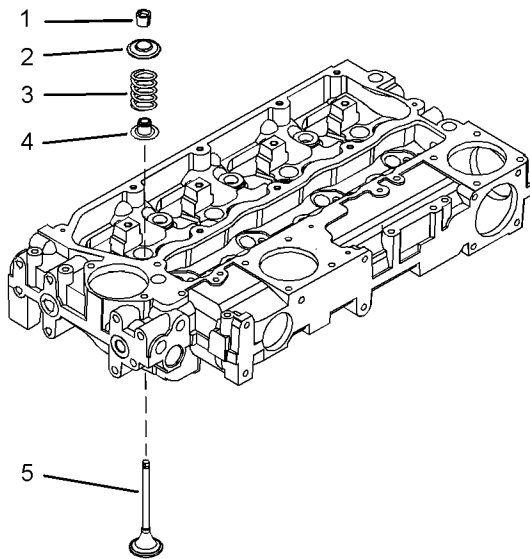


Illustration 35

g01352229

2. Lubricate the stems of valves (5) with clean engine oil. Install valves (5) in the appropriate positions in the cylinder head. Check the depth of the valves below the face of the cylinder head. Refer to Systems Operation, Testing and Adjusting, "Valve Depth - Inspect" for more information.
3. Use a suitable lifting device to carefully turn over the cylinder head. The weight of the cylinder head is approximately 56 kg (125 lb).

Note: Ensure that all of the valves remain in place.

4. Install new valve stem seals (4) onto each of the valve guides.

Note: The outer face of the valve guides must be clean and dry before installing the valve stem seals.

5. Install valve spring (3) onto the cylinder head. Position valve spring retainer (2) onto valve spring (3).

WARNING

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

Make sure to wear all necessary protective equipment.

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

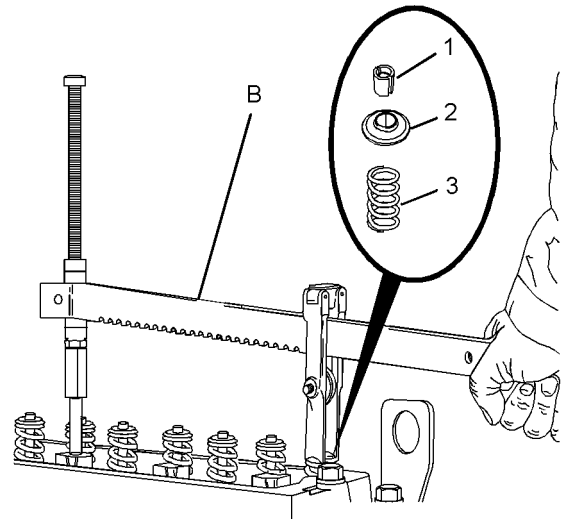


Illustration 36

g01343550

Typical example

6. Install Tooling (A) in the appropriate position on the cylinder head in order to compress valve spring (3).

NOTICE

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

7. Apply sufficient pressure to Tooling (A) in order to install valve keepers (1).

Note: Do not compress the spring so that valve spring retainer (2) touches valve stem seal (4).

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.

8. Carefully release the pressure on Tooling (A).
9. Repeat Steps 5 to 8 for the remaining valves.
10. Remove Tooling (A) from the cylinder head.
11. Use a suitable lifting device to position the cylinder head on a support. Ensure that the heads of the valves are not obstructed. Lightly strike the top of the valves with a soft hammer in order to ensure that valve keepers (1) are properly installed.

End By:

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

i02628834

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 11

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

Note: The oil filter may be installed vertically or the oil filter may be installed horizontally.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

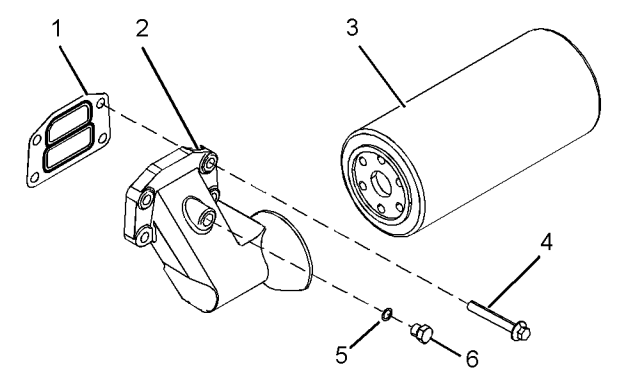


Illustration 37
Typical example

g01343554

1. Use Tooling (A) to remove engine oil filter (3). Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change".
2. If the engine oil pressure sensor is located in the engine oil filter base, remove the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install".
3. Remove bolts (4) and remove engine oil filter base (2).
4. Remove joint (1).
5. If the engine oil filter base has a spacer plate, remove the spacer plate and remove the joint.
6. If necessary, remove plug (6) from engine oil filter base (2). Remove O-ring seal (5) from the plug.

Installation Procedure

Table 12

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

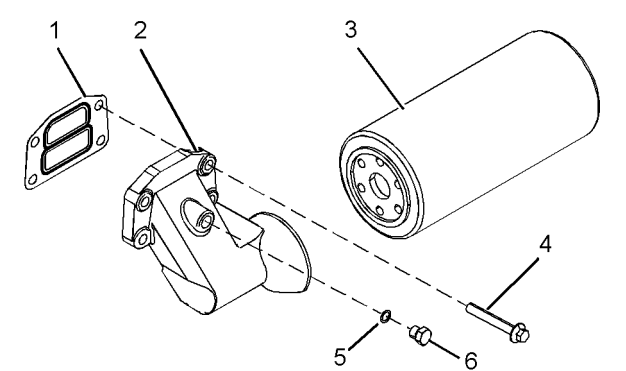


Illustration 38
Typical example

g01343554

1. Ensure that the engine oil filter base is clean. Clean the mating surfaces of the cylinder block.
2. If necessary, install a new O-ring seal (5) to plug (6). Install plug (6) to engine oil filter base (2). Tighten the plug to a torque of 12 N·m (106 lb in).

3. Install bolts (4) to engine oil filter base (2).
4. Install a new joint (1) onto bolts (4). If the engine oil filter base has a spacer plate, install the spacer plate and a new joint onto the bolts.
5. Apply Tooling (B) to the threads of the bolts. Install the assembly of the engine oil filter base to the cylinder block.
6. Tighten bolts (4) to a torque of 22 N·m (16 lb ft).
7. If the engine oil pressure sensor is located in the engine oil filter base, install the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install".
8. Install a new engine oil filter (3). If necessary, fill the engine oil pan to the correct level that is indicated on the oil level gauge. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".

3. If necessary, remove the electric starting motor. Refer to Disassembly and Assembly, "Electric Starting Motor - Remove and Install".

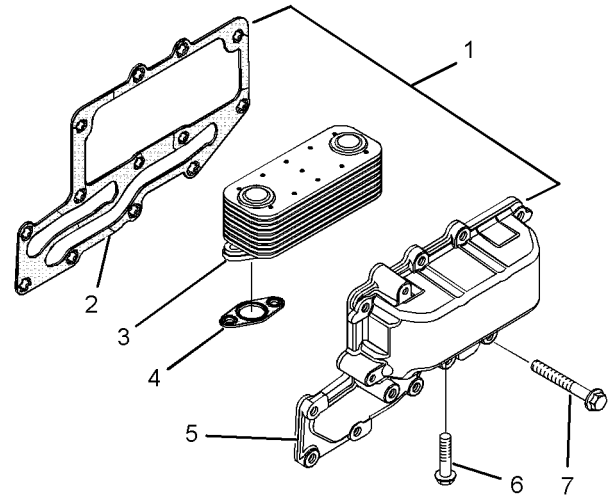


Illustration 39
Typical example

g01343557

Engine Oil Cooler - Remove

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Drain the engine lubricating oil into a suitable container. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

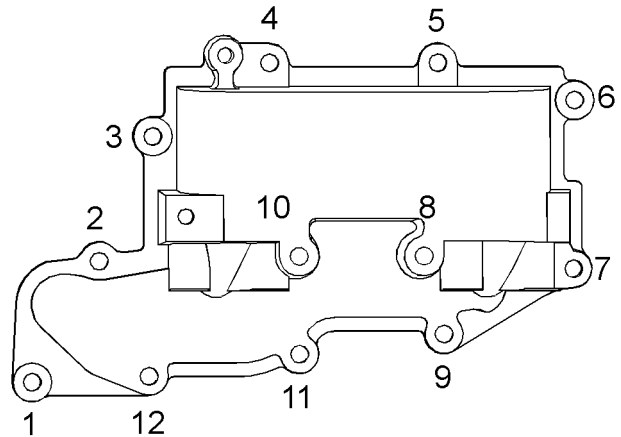


Illustration 40

Tightening sequence for the engine oil cooler

g01343558

4. Loosen fasteners (7) in reverse numerical order to the sequence that is shown in Illustration 40. Remove fasteners (7). Support the assembly of the engine oil cooler (1) as the fasteners are removed.

Note: fasteners (7) are different lengths. Note the correct position of the fasteners. Note the position of any brackets that are secured by the fasteners. Do not remove fasteners (6) at this time.

5. Remove the assembly of oil cooler (1) from the cylinder block.
6. Remove joint (2).
7. Follow Steps 7.a through 7.c in order to disassemble the engine oil cooler.
 - a. Remove bolts (6).
 - b. Remove cooler matrix (3) from housing (5).
 - c. Remove joints (4).

- b. Position new joints (4) onto housing (5). Install cooler matrix (3).
- c. Apply Tooling (A) to the threads of bolts (6).
- d. Install bolts (6). Tighten the bolts to a torque of 22 N·m (16 lb ft).

2. Clean the mating surface of the cylinder block.

i02628832

Engine Oil Cooler - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

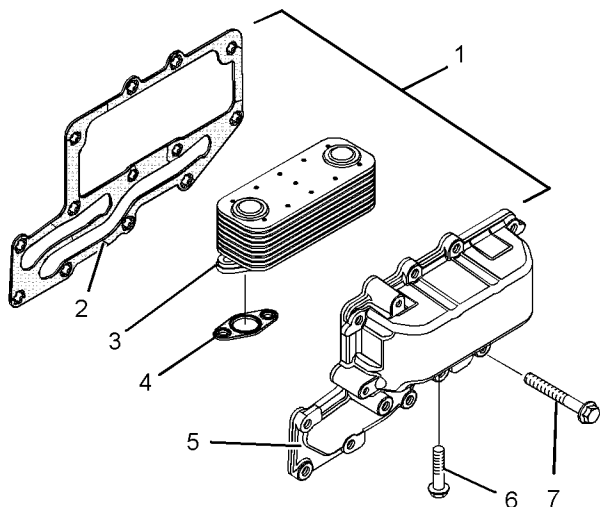


Illustration 41

g01347869

Typical example

1. Follow Steps 1.a through 1.d in order to assemble the engine oil cooler.
 - a. Ensure that cooler matrix (3) is clean and free from damage. Ensure that housing (5) is clean and free from damage.

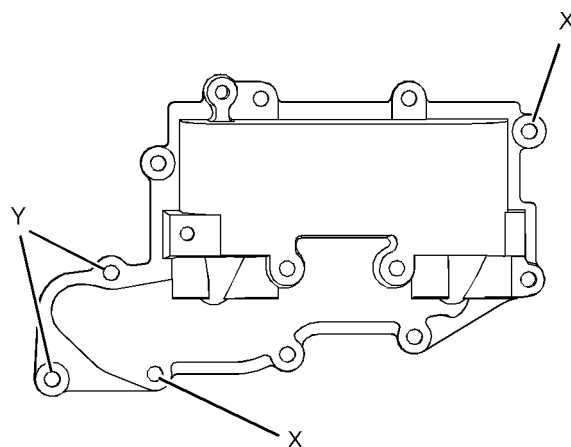


Illustration 42

g01347870

Typical example

3. Position a new joint (2) on the assembly of engine oil cooler (1). Install fasteners (7) to positions (X) on the assembly of engine oil cooler (1).

Note: The holes in the joint have serrations that hold the fasteners captive.

4. Install the assembly of engine oil cooler (1) to the cylinder block. Tighten bolts (7) finger tight.

Note: The fasteners are different lengths. Ensure that the different fasteners are installed in the correct location. Ensure that any brackets that are secured by the fasteners are installed in the correct location.

5. Apply Tooling (B) to the fasteners (7) at positions (Y).

Note: The fasteners in this position are allen head screws.

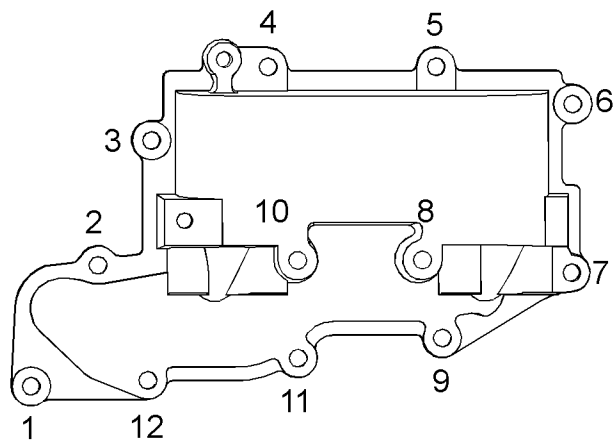


Illustration 43
Tightening sequence for the engine oil cooler

- 6. Install the remaining fasteners (7) into the engine oil cooler (1). Tighten the fasteners to a torque of 22 N·m (16 lb ft). Tighten the bolts in the sequence that is shown in Illustration 43.
- 7. If necessary, Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install”.
- 8. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.
- 9. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil Filter and Change” for the correct procedure.

i02628841

Engine Oil Relief Valve - Remove and Install (Engines Without a Balancer Unit)

Removal Procedure

Table 13

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Telescopic Magnet	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

WARNING

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

Make sure to wear all necessary protective equipment.

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

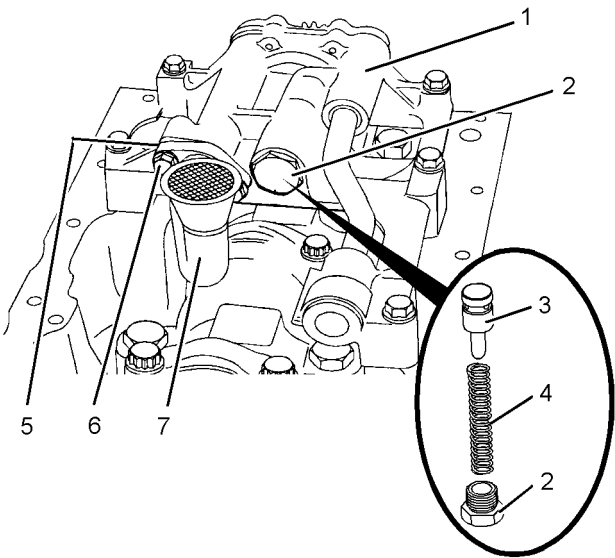


Illustration 44
Typical example

- 1. Remove bolts (6) and suction pipe (7).
 - 2. Remove the joint from suction pipe (5) (not shown).
 - 3. Loosen cap (2). Carefully remove cap (2) from the housing of engine oil pump (1).
- Note:** The spring force will be released when the cap is removed.
- 4. Remove spring (4) from the bore for the relief valve in the housing of engine oil pump (1).

5. Use Tooling (A) to remove plunger (3) from the bore for the relief valve in the housing of engine oil pump (1).

Installation Procedure

Table 14

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Loctite 577	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

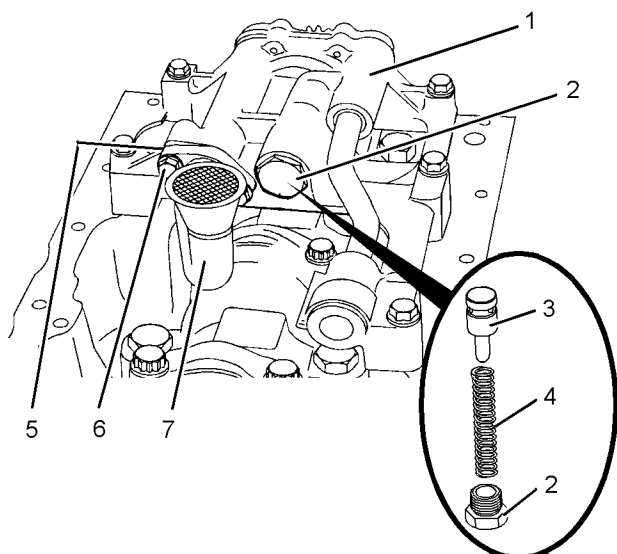


Illustration 45

g01343561

Typical example

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged. If the bore for the relief valve in the housing of engine oil pump (1) is worn or damaged, the complete assembly of the engine oil pump must be replaced.

WARNING

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

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

2. Lubricate plunger (3) with clean engine oil. Use long nose pliers to install plunger (3) and spring (4) into the bore for the relief valve in the housing of engine oil pump (1).

Note: The plunger must slide freely in the bore for the relief valve.

3. Apply Tooling (A) to the threads of cap (2). Install cap (2) to engine oil pump (1). Tighten the cap to a torque of 35 N·m (26 lb ft).

Note: Ensure that the spring is properly located inside the plunger and the cap. Ensure that Tooling (A) does not contaminate the bore for the relief valve in the housing of engine oil pump.

4. Install suction pipe (7) and a new joint (5) to the assembly of the engine oil pump.

5. Install bolts (6). Tighten the bolts to a torque to 22 N·m (16 lb ft).

End By:

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

i02628840

Engine Oil Relief Valve - Remove and Install (Engines with a Balancer Unit)

Removal Procedure

Table 15

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Telescopic Magnet	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

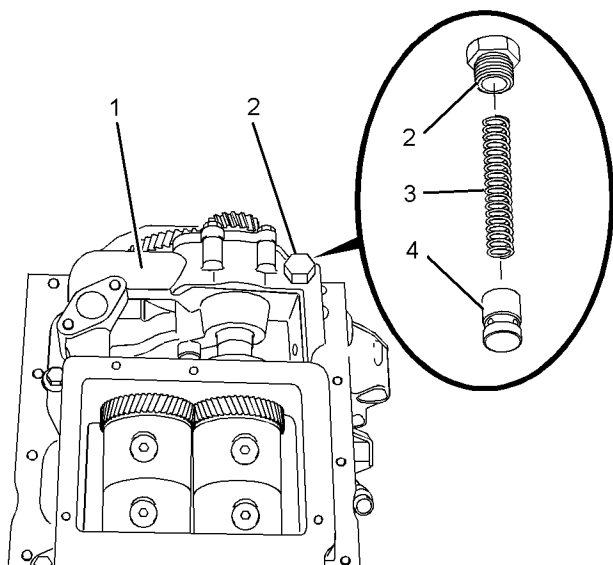


Illustration 46

g01343600

Typical example

1. Loosen cap (2). Carefully remove the cap from balancer (1).

Note: The spring force will be released when the cap is removed.

2. Remove spring (3) from the bore for the relief valve in balancer (1).
3. Use Tooling (A) in order to remove plunger (4) from the bore for the relief valve in balancer (1).

Installation Procedure

Table 16

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Loctite 577	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

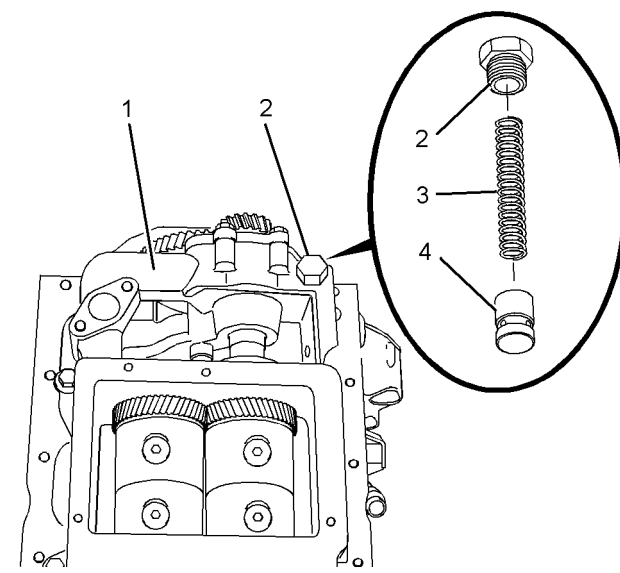


Illustration 47

g01343600

Typical example

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged. If the bore for the relief valve in balancer (1) is worn or damaged, the complete assembly of the balancer must be replaced.

⚠ WARNING

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

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

2. Lubricate plunger (4) with clean engine oil. Install plunger (4) and spring (3) into the bore for the relief valve in balancer (1).

Note: The plunger must slide freely in the bore for the relief valve.

3. Apply Tooling (B) to the threads of cap (2). Install cap (2) to balancer (1). Tighten the cap to a torque of 21 N·m (15.5 lb ft).

Note: Ensure that the spring is properly located inside the plunger and the cap. Ensure that Tooling (B) does not contaminate the bore for the relief valve in balancer (1).

End By:

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

i02628837

Engine Oil Pump - Remove and Install (Engines Without a Balancer Unit)

Removal Procedure

Start By:

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

Note: This procedure is for the removal of the engine oil pump on engines that are not equipped with a balancer. Refer to Disassembly and Assembly, "Balancer Group - Remove" for information on the removal of the engine oil pump for engines that are equipped with a balancer.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

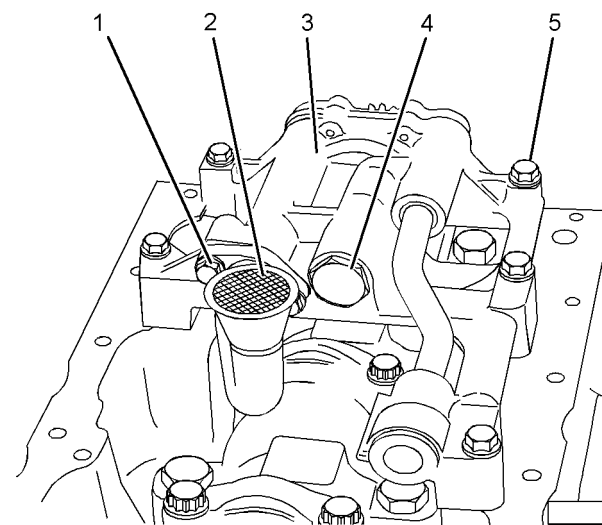


Illustration 48

g01343631

Typical example

1. Remove bolts (1) and suction pipe (2).
2. Remove the joint from suction pipe (2).
3. Remove bolts (5). Remove the assembly of engine oil pump (3) from the cylinder block.
4. If necessary, remove pressure relief valve (4) from the housing of engine oil pump (3). Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install".

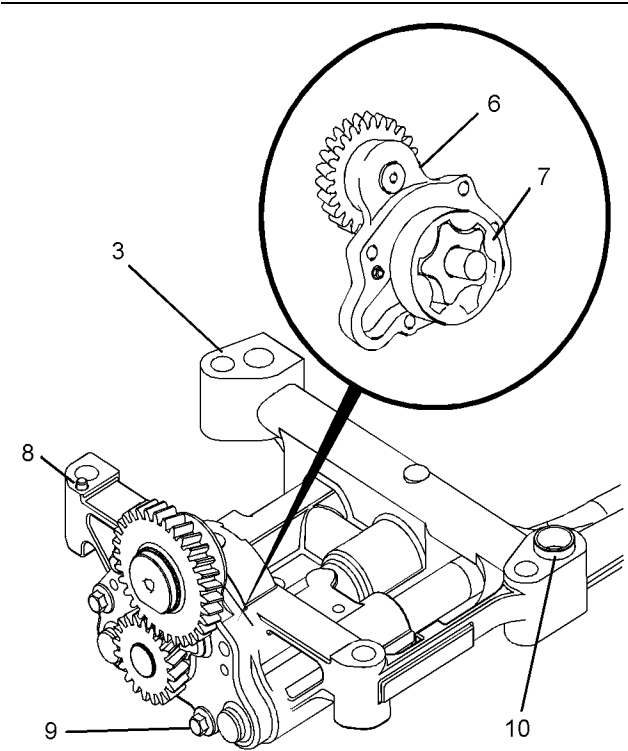


Illustration 49
Typical example

5. If necessary, remove bolts (9) and front cover assembly (6). Remove outer rotor (7) from the housing of engine oil pump (3).
- Note:** Do not remove dowels (8) and (10) from the housing of the engine oil pump unless the dowels are damaged.

Installation Procedure

Table 17

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825617	Dial Indicator Group	1
	-	Finger Clock	1

Note: This procedure is for the installation of the engine oil pump on engines that are not equipped with a balancer. Refer to Disassembly and Assembly, “Balancer Group - Install” for information on the installation of the engine oil pump for engines that are equipped with a balancer.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

1. Ensure that all components of the engine oil pump are clean and free from wear or damage. Check the clearance between the outer rotor of the oil pump and the oil pump body. Check the clearance between the outer rotor and the inner rotor. Check the end play of the rotor. Refer to the Systems Operation, Testing and Adjusting, “Engine Oil Pump - Inspect”. Replace the complete assembly of the engine oil pump if any of the components are worn or damaged.

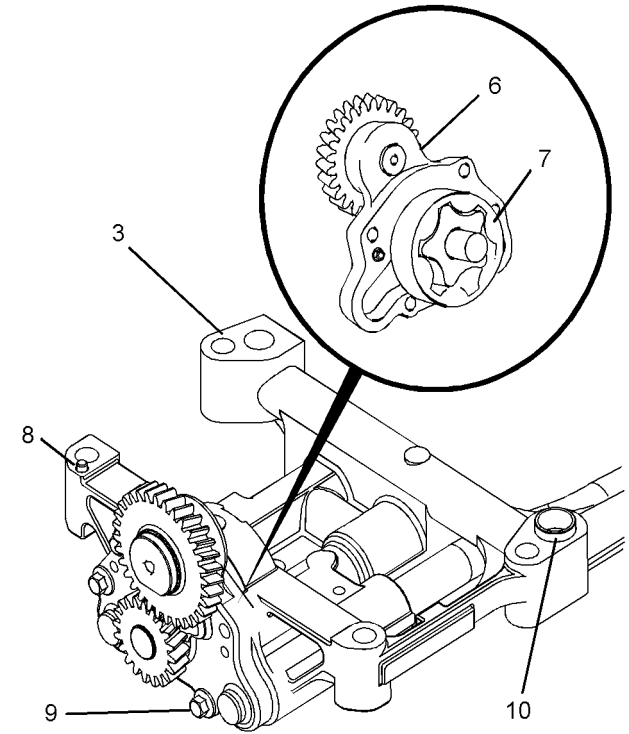


Illustration 50

2. If necessary, lubricate the internal components of the assembly of the engine oil pump with clean engine oil. Install outer rotor (7) and front cover (6) to the housing of engine oil pump (3). Install bolts (9). Tighten the bolts to a torque of 9.5 N·m (84 lb in).

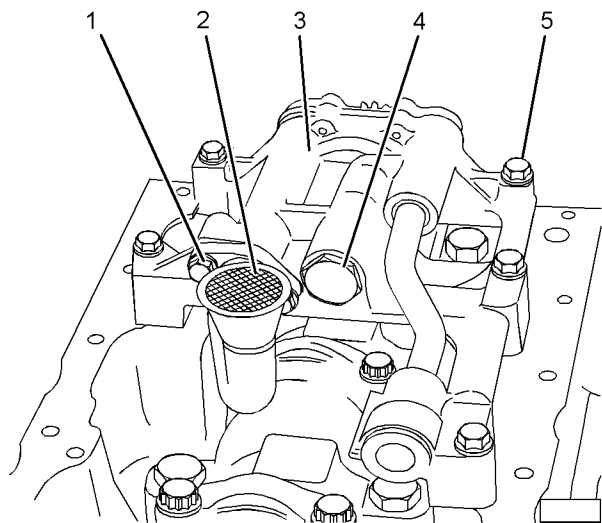


Illustration 51

g01343631

3. If necessary, install pressure relief valve (4). Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install" for further information.
 4. Ensure that dowels (8) and (10) are correctly located in the housing of the engine oil pump (3). Position the assembly of the engine oil pump onto the cylinder block.
- Note:** Ensure that the dowels in the housing of the engine oil pump are aligned with the holes in the cylinder block.
5. Install bolts (5). Tighten the bolts to a torque of 44 N·m (32 lb ft).
 6. Install suction pipe (2) and a new joint to the assembly of the engine oil pump.
 7. Install bolts (1). Tighten the bolts to a torque to 22 N·m (16 lb ft).
 8. Use Tooling (A) in order to check the backlash between the idler gear of the oil pump and the crankshaft gear. Refer to Specifications, "Gear Group - Front" for further information.

End By:

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

Water Pump - Remove

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Loosen the hose clamps and remove the hose from the water pump inlet.

i02628916

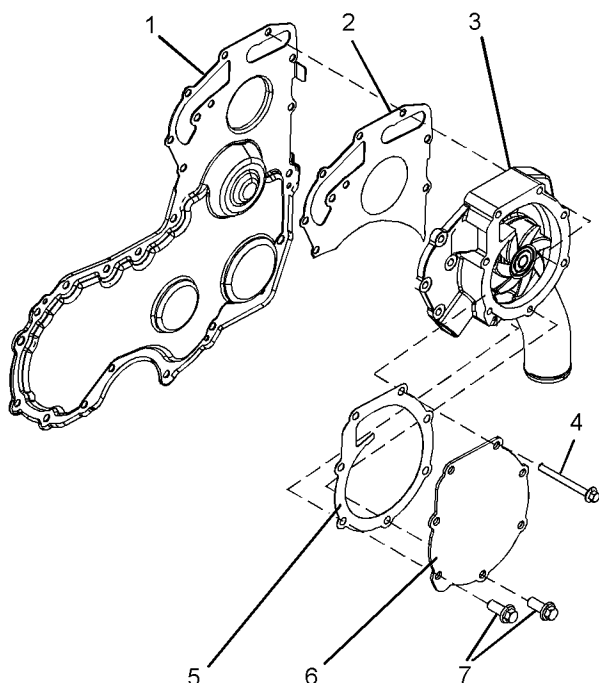


Illustration 52

g01263054

Typical example

3. Remove bolts (4). The bolts are different lengths. Note the positions of the different bolts.

Note: Do not remove bolts (7) at this time.

4. Remove water pump (3) from front cover (1).

Note: If necessary, tap the water pump with a soft hammer in order to loosen the water pump.

5. Remove joint (2).

6. If necessary, remove the cover (6) from the water pump. Follow Steps 6.a through 6.c in order to remove the cover.

- a. Remove bolts (7).
- b. Remove cover (6).
- c. Remove joint (5).

Water Pump - Install

Installation Procedure

Table 18

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M8 by 80 mm)	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the water pump is clean and free from wear or damage. If necessary, replace the water pump.

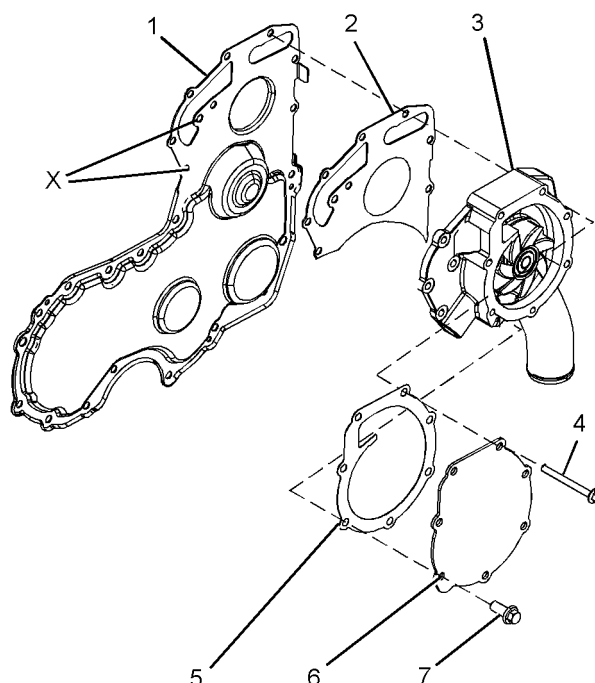


Illustration 53

g01269391

Typical example

2. If necessary, install cover (6) to water pump (3). Follow Steps 2.a through 2.d in order to install the cover.

- a. Clean the mating surface of cover (6).

- b. Position a new joint (5) onto water pump (3).
- c. Install cover (6) to water pump (3).
- d. Install bolts (7) to cover (6). Tighten the bolts finger tight.

3. Clean the mating surface of front cover (1).

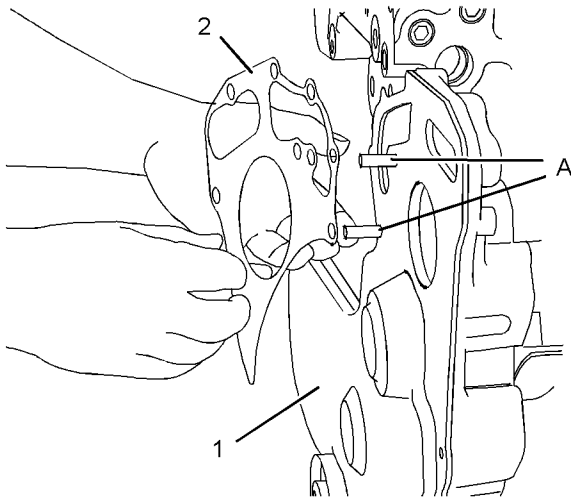


Illustration 54

g01269392

4. Install Tooling (A) in position (X).
 5. Use Tooling (A) in order to align a new joint (2) to front cover (1). Install the joint to the front cover.
 6. Align water pump (3) with Tooling (A). Install the water pump to front cover (1).
- Note:** Ensure that the gear of the water pump and the gear of the fuel injection pump mesh.
7. Install bolts (4). Refer to Illustration 53. Tighten the bolts finger tight.
- Note:** Ensure that bolts of different lengths are installed in the correct positions.
8. Remove Tooling (A) and install remaining bolts (4) finger tight.

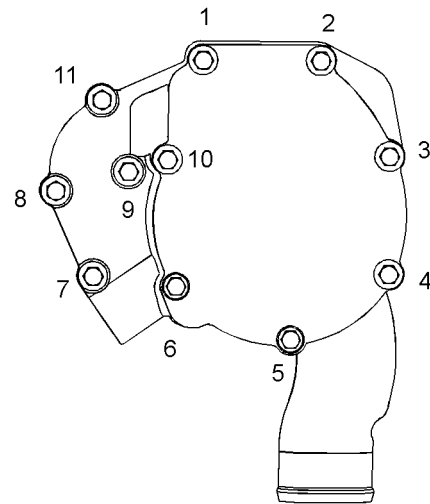


Illustration 55

g01269393

Tightening sequence for the water pump

9. Tighten bolts (4) and bolts (7) to a torque of 22 N·m (16 lb ft). Refer to Illustration 53. Tighten the bolts in the sequence that is shown in Illustration 55.
10. Install the hose to the water pump inlet. Tighten the hose clamps.
11. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

End By:

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

i02628918

Water Temperature Regulator - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

- 1. Drain the coolant from the cooling system to a level below the water temperature regulator, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
- 2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from water temperature regulator housing (2).

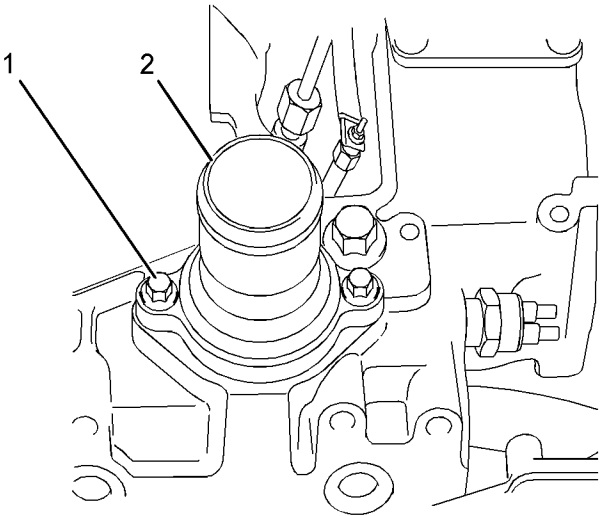


Illustration 56
Typical example

- 3. Remove bolts (1) from water temperature regulator housing (2).
- 4. Remove water temperature regulator housing (2) from the cylinder head.

Note: Note the orientation of the water temperature regulator housing.

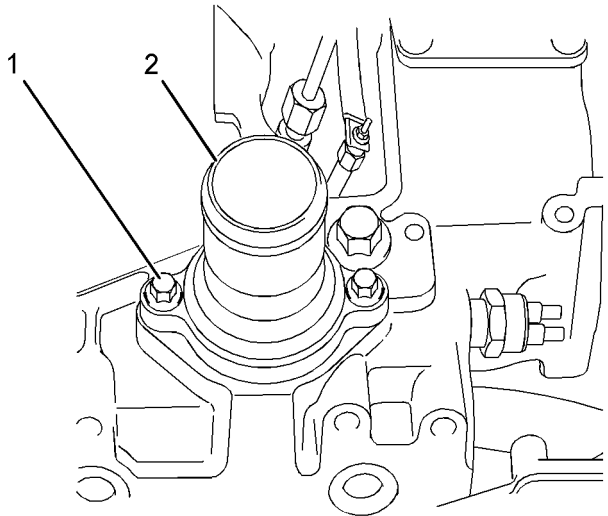


Illustration 57
Typical example

- 5. Remove O-ring seal (3) from water temperature regulator housing (2).

Installation Procedure

Table 19

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- 1. Ensure that all components of water temperature regulator are clean and free of wear or damage. Check the water temperature regulator for correct operation. Refer to Systems Operation, Testing and Adjusting, "Water Temperature Regulator - Test" for the procedure to test the water temperature regulator. If any components of the water temperature regulator are worn or damaged, the complete assembly must be replaced.

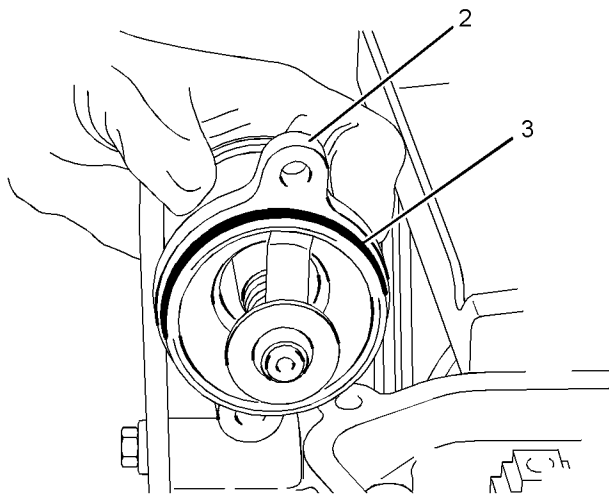


Illustration 58

g01343960

Typical example

2. If the original water temperature regulator housing is installed, position a new O-ring seal (3) into the groove in water temperature regulator housing (2).

A new water temperature regulator housing is supplied with a new O-ring seal.

3. Use Tooling (A) to lubricate the new O-ring seal.
4. Install water temperature regulator housing (2) to the cylinder head.

Note: Ensure the correct orientation of the water temperature regulator housing.

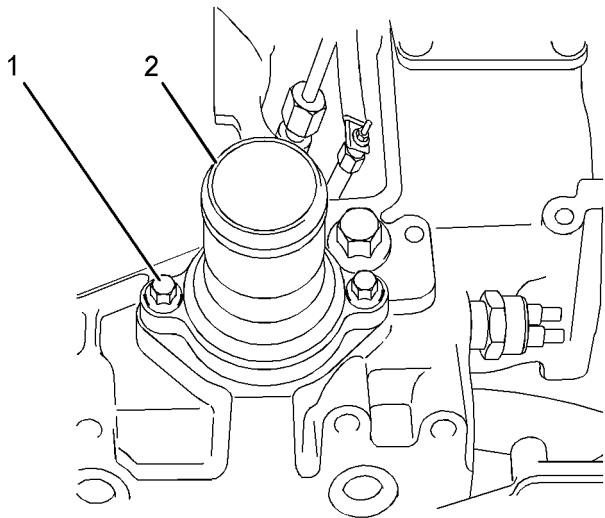


Illustration 59

g01343959

Typical example

5. Install bolts (1). Tighten the bolts to a torque of 22 N·m (16 lb ft).
6. Connect the upper radiator hose and tighten the hose clamps.
7. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

i02628847

Flywheel - Remove

Removal Procedure

Table 20

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (1/2 inch - UNF by 4 inch)	2

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

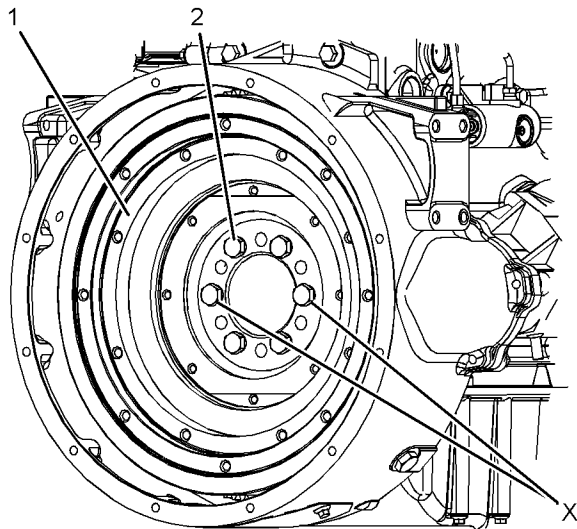


Illustration 60
Typical example

1. Remove two bolts from positions (X) on flywheel (1).
2. Install Tooling (A) to positions (X) on flywheel (1).
3. Attach a suitable lifting device to flywheel (1). Support the weight of the flywheel. The weight of the flywheel is approximately 71 kg (155 lb).
4. Remove remaining bolts (2).
5. Use the lifting device in order to remove the flywheel from the engine.

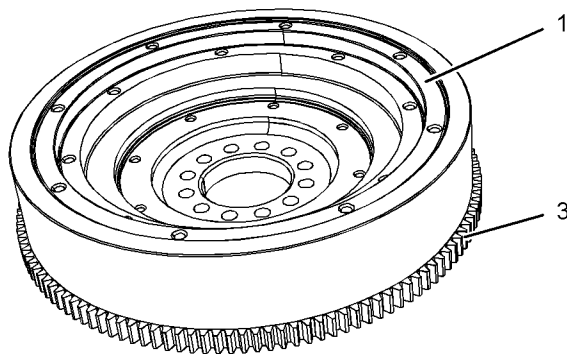


Illustration 61
Typical example

6. Inspect flywheel (1) and ring gear (3) for wear or damage. Replace any components that are worn or damaged.
7. To remove the flywheel ring gear, follow Steps 7.a and 7.b.
 - a. Place the flywheel assembly on a suitable support.

Note: Identify the orientation of the teeth on the flywheel ring gear.

- b. Use a hammer and a punch in order to remove ring gear (3) from flywheel (1).

i02628846

Flywheel - Install

Installation Procedure

Table 21

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (1/2 inch - 20 UNF by 4 inch)	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

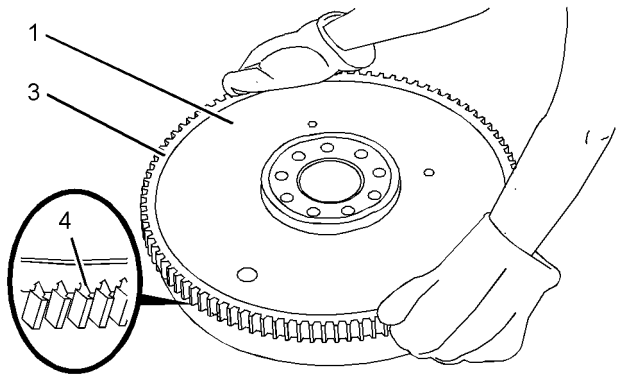


Illustration 62
Typical example



WARNING

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

1. If the flywheel ring gear was removed, follow Steps 1.a through 1.c in order to install a new ring gear to the flywheel.

- a. Identify the orientation of teeth (4) on the new ring gear (4).

Note: The chamfered side of the ring gear teeth must face toward the starting motor when the flywheel is installed. This will ensure the correct engagement of the starting motor.

- b. Heat flywheel ring gear (3) in an oven to a maximum temperature of 250 °C (482 °F) prior to installation.

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

- c. Ensure that the orientation of ring gear (3) is correct and quickly install the ring gear onto flywheel (1).

2. Inspect the crankshaft rear seal for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".

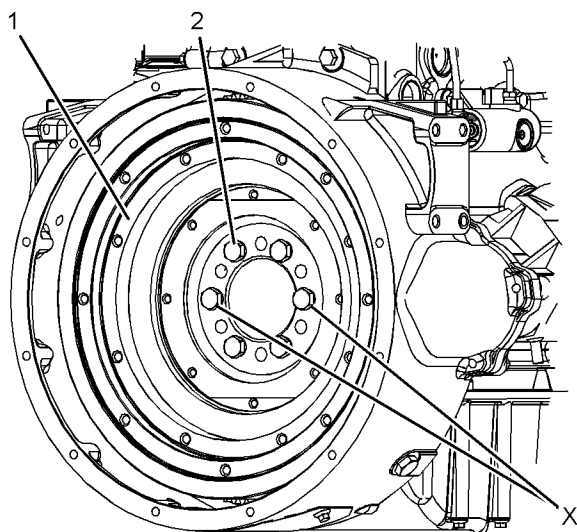


Illustration 63

g01245126

Typical example

3. Install a suitable lifting device to flywheel (1). The flywheel weighs approximately 71 kg (155 lb).
4. Install Tooling (A) to positions (X) on the crankshaft.
5. Use the lifting device in order to position flywheel (1) onto Tooling (A).
6. Install bolts (2) to flywheel (1) finger tight.

7. Remove Tooling (A) and install remaining bolts (2) to the flywheel (1).
8. Remove the lifting device from flywheel (1).
9. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) to a torque of 115 N·m (85 lb ft).
10. Check the run out of the flywheel. Refer to System Operation, Test and Adjusting, "Flywheel - Inspect" for further information.

End By:

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

i02628827

Crankshaft Rear Seal - Remove

Removal Procedure

Table 22

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E12 Torx Socket	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.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: The crankshaft rear seal and the housing are manufactured as a one-piece assembly. The assembly is not serviceable. If the crankshaft rear seal is removed, the assembly must be replaced.

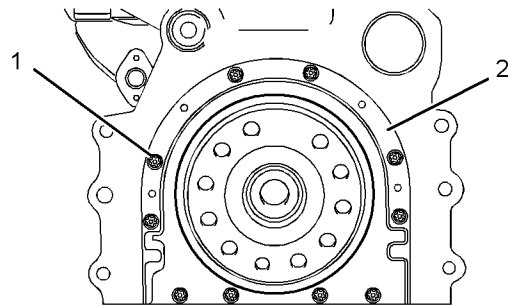


Illustration 64
Typical example

- 1. Use Tooling (A) in order to remove torx screws (1) from crankshaft rear seal (2).
- 2. Remove crankshaft rear seal (2) from the cylinder block. Discard the crankshaft rear seal.

i02628824

Crankshaft Rear Seal - Install

Installation Procedure

Table 23

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E12 Torx Socket	1
B	27610306	Alignment Tool	1

Note: The crankshaft rear seal and the housing are manufactured as a one-piece assembly.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

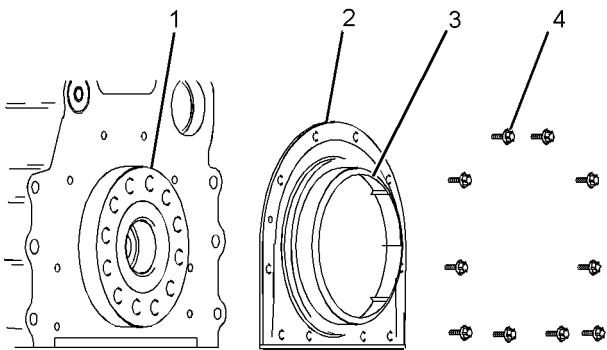


Illustration 65
g01258105

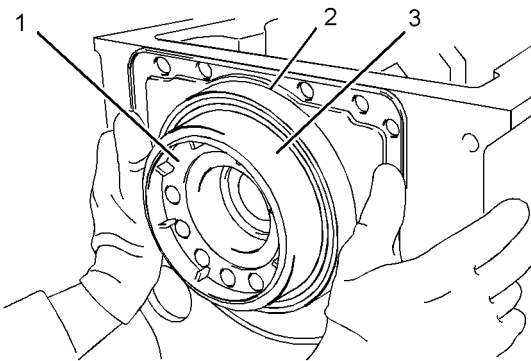


Illustration 66
Typical example

- 1. Ensure that crankshaft flange (1) is clean, dry and free from damage. It is possible to reclaim a crankshaft flange that has a worn seal surface, or a damaged seal surface by installing a wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Wear Sleeve (Rear) - Remove and Install" for more information.
- 2. Ensure that the face of the cylinder block and the bridge piece are clean and dry.
- 3. A new crankshaft rear seal is supplied with a plastic sleeve (3). Ensure that the plastic sleeve is squarely installed within crankshaft rear seal (2).

Note: The plastic sleeve is included in order to protect the lip of the seal as the seal is pushed over the crankshaft flange.

Note: Do not lubricate the crankshaft rear seal or the crankshaft flange. The crankshaft rear seal must be installed dry.

- 4. Align plastic sleeve (3) with crankshaft flange (1). Ensure that the plastic sleeve is engaged onto the crankshaft flange. Push new crankshaft rear seal (2) squarely onto the crankshaft flange.

During this process, the plastic sleeve will be forced out of the crankshaft rear seal. Discard the plastic sleeve.

i02628848

5. Align the two molded locators on crankshaft rear seal (2) with the holes in the cylinder block. Ensure that the crankshaft rear seal is seated against the cylinder block.

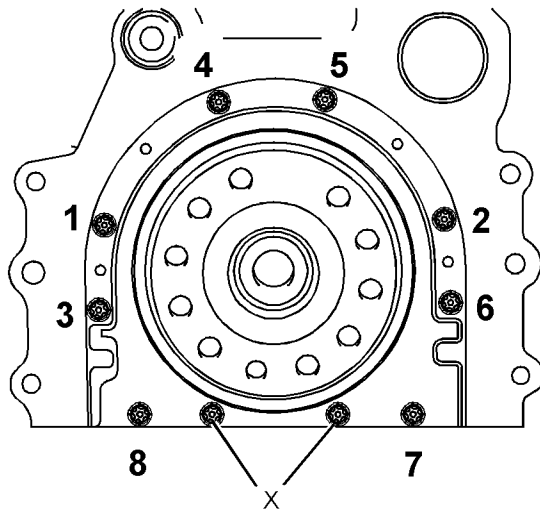


Illustration 67
Tightening sequence for the crankshaft rear seal

6. Install torx screws (4) finger tight.

Note: Do not install torx screws to positions (X) at this stage.

7. Install Tooling (B) to crankshaft rear seal (2) and to crankshaft flange (1).
8. Use Tooling (A) in order to tighten torx screws (4) to a torque of 22 N·m (16 lb ft). Tighten torx screws (4) in the sequence that is shown in Illustration 67.
9. Remove Tooling (B).
10. Install remaining torx screws (4) to positions (X). Use Tooling (A) in order to tighten the torx screws to a torque of 22 N·m (16 lb ft). Refer to Illustration 67.

End By:

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

Flywheel Housing - Remove and Install

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Install a suitable lifting device to the flywheel housing in order to support the flywheel housing. The flywheel housing weighs approximately 30 kg (66 lb).

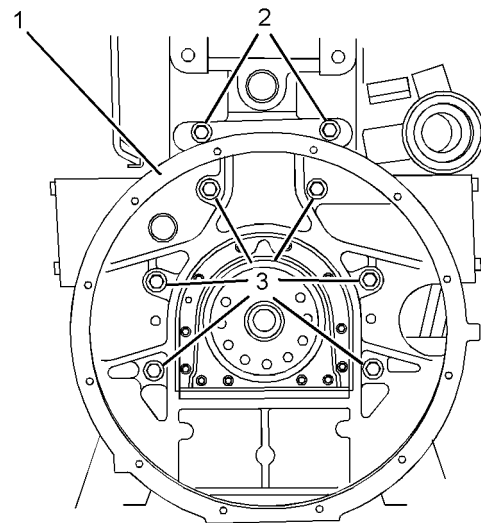


Illustration 68
Typical example

2. Remove bolts (2) and bolts (3) from flywheel housing (1).
3. Use the lifting device in order to remove flywheel housing (1) from the cylinder block.

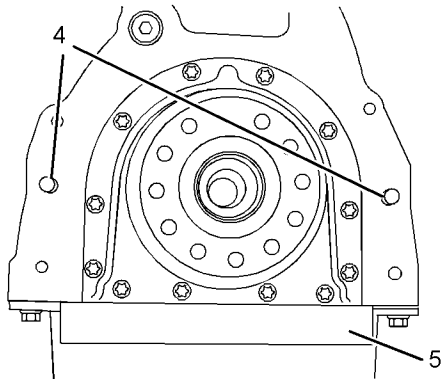


Illustration 69
Typical example

4. If the engine has an aluminum oil pan, remove dust seal (5).
5. If necessary, remove dowels (4) from the cylinder block.

Installation Procedure

Table 24

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M10 by 100 mm)	2
B	21825617	Dial Indicator Group	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the flywheel housing is clean and free from damage. If necessary, replace the flywheel housing.

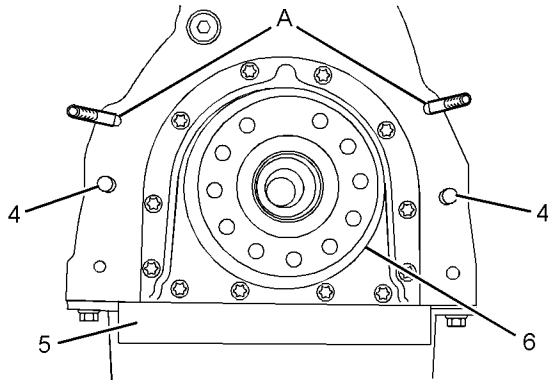


Illustration 70
Typical example

2. Inspect crankshaft rear seal (6) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".
3. Clean the rear face of the cylinder block. If necessary, install dowels (4) to the cylinder block.
4. Install Tooling (A) to the cylinder block.
5. Install dust seal (5).

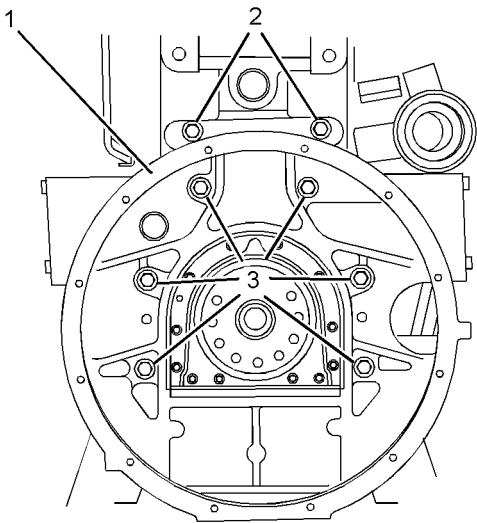


Illustration 71
Typical example

6. Install a suitable lifting device to the flywheel housing. The flywheel housing weighs approximately 30 kg (66 lb).
7. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
8. Install the bolts (2) and bolts (3) finger tight.
9. Remove Tooling (A). Install the remaining bolts (3).
10. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).
11. Tighten bolts (2) to a torque of 75 N·m (55 lb ft).
12. Use Tooling (B) to check the alignment of the flywheel housing with the crankshaft. Refer to Systems Operation, Testing and Adjusting, "Flywheel Housing - Inspect".

End By:

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

i02674882

Crankshaft Pulley - Remove and Install (Engines With an Automatic Belt Tensioner)

Removal Procedure

Start By:

- a. Remove the Alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

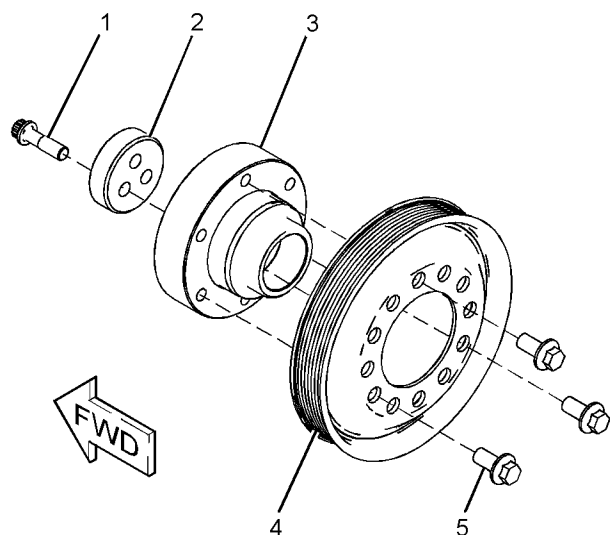


Illustration 72

g01249049

1. Use a suitable tool in order to prevent the crankshaft from rotating. Remove bolts (1).
2. Remove thrust block (2).
3. Carefully remove the assembly of the crankshaft pulley from the crankshaft.
4. Follow Steps 4.a through 4.b in order to disassemble the crankshaft pulley.
 - a. Remove bolts (5).

- b. Remove crankshaft pulley (4) from crankshaft adapter (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft adapter, the pulley and the thrust block are clean and free from damage. Replace any components that are damaged. It is possible to reclaim a crankshaft adapter with a worn seal surface by installing a wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Wear Sleeve (Front) - Remove and Install".

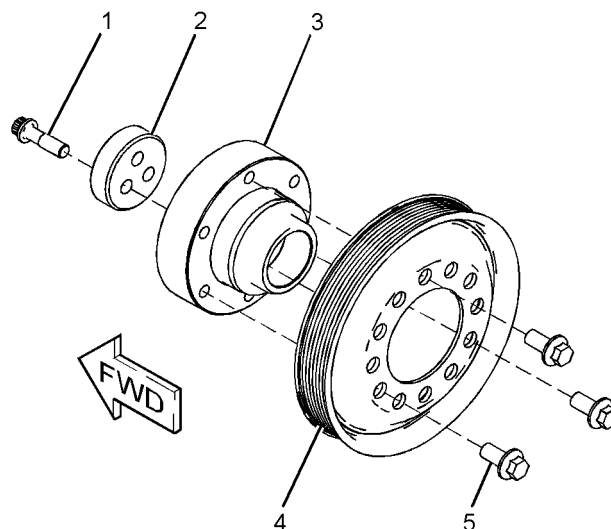


Illustration 73

g01367385

2. If necessary, follow Steps 2.a through 2.b in order to assemble the crankshaft pulley.
 - a. Install crankshaft pulley (4) to crankshaft adapter (3).
 - b. Install bolts (5) to the assembly of the crankshaft pulley, and the crankshaft adapter. The bolts should be evenly spaced.
 - c. Tighten the bolts to a torque of 78 N·m (58 lb ft).
3. Ensure that the front of the crankshaft is clean and free from damage. Install the assembly of the crankshaft pulley to the crankshaft.

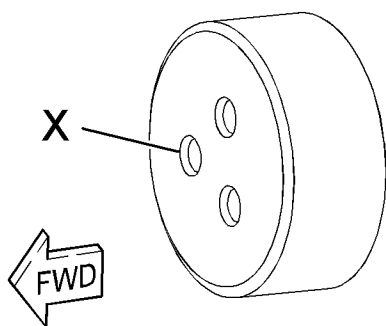


Illustration 74

g01367392

4. Align the holes in thrust block (2) with the holes in the crankshaft.

Note: Ensure chamfered holes (X) in thrust block (2). Face toward the front of the engine.

5. Install thrust block (2) to the assembly of the crankshaft pulley.
6. Install bolts (1) to thrust block (2).
7. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the bolts evenly to a torque of 115 N·m (85 lb ft).
8. Repeat Step 7 one more times in order to ensure correct torque.

End By:

- a. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".

i02628822

Crankshaft Pulley - Remove and Install (Engines Without an Automatic Belt Tensioner)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

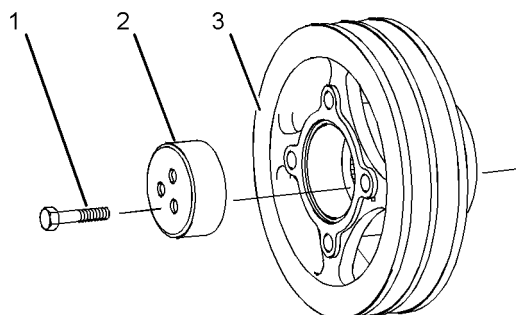


Illustration 75

g01255707

1. Use a suitable tool in order to prevent the crankshaft from rotating. Remove bolts (1).
2. Remove thrust block (2).
3. Carefully remove crankshaft pulley (3) from the crankshaft.

Installation Procedure

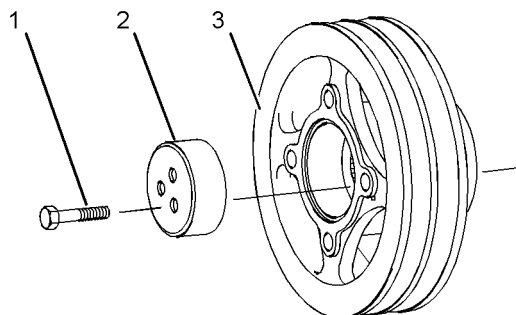


Illustration 76

g01255707

1. Ensure that the crankshaft pulley and the thrust block are clean and free from damage. Replace any components that are damaged. It is possible to reclaim a crankshaft pulley with a worn seal surface by installing a wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Wear Sleeve (Front) - Remove and Install".
2. Ensure that the front of the crankshaft is clean and free from damage. Install crankshaft pulley (3) to the crankshaft.

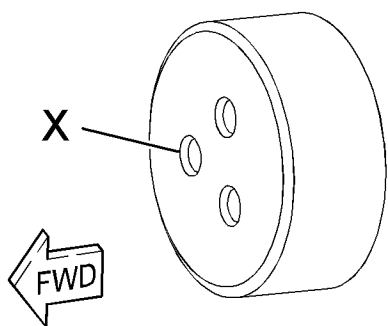


Illustration 77

g01367392

3. Align the holes in thrust block (2) with the holes in the crankshaft.

Note: Ensure chamfered holes (X) in thrust block (2). Face toward the front of the engine.

4. Install thrust block (2) to the assembly of the crankshaft pulley.
5. Install bolts (1) to thrust block (2).
6. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the bolts evenly to a torque of 115 N·m (85 lb ft).
7. Repeat Step 6 one more times in order to ensure correct torque.

End By:

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

Crankshaft Front Seal - Remove and Install

i02628819

Removal Procedure

Table 25

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610230	Puller	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

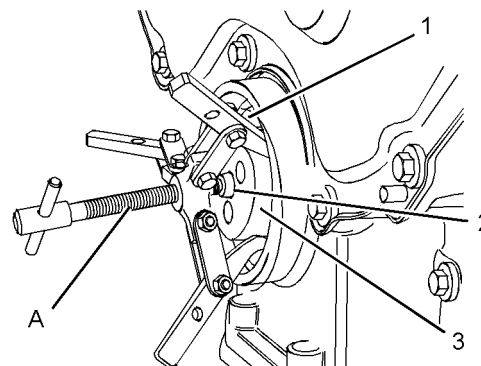


Illustration 78

g01266942

1. Install the legs of Tooling (A) behind crankshaft front seal (1). Install a suitable spacer (2) between Tooling (A) and crankshaft (3). Use Tooling (A) in order to pull the crankshaft front seal out of the front housing.

Note: Do not damage the bore for the crankshaft front seal in the front housing.

Installation Procedure

Table 26

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825577	Threaded Bar	1
	21825580	Anchor Plate	1
	21825579	Sleeve	1
	21825578	Pressure Plate	1
	27610217	Adapter	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the bore for the crankshaft front seal in the front housing is clean and free from damage.

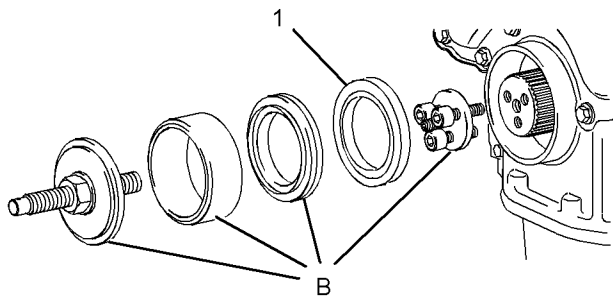


Illustration 79
Typical example

2. Assemble Tooling (B).
3. Align a new crankshaft front seal (1) to the front housing.
4. Use Tooling (B) to install crankshaft front seal (1). Ensure that the front face of the seal is installed to a depth of 9 ± 0.2 mm (0.354 ± 0.008 inch) into the front housing.
5. Remove Tooling (B) from the crankshaft.

End By:

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

i02628828

Crankshaft Wear Sleeve (Front) - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".
- b. Remove the crankshaft front seal . Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Wear sleeves are used to reclaim worn seal surfaces. Wear sleeves are not original equipment. A new crankshaft front seal must be installed when a new wear sleeve is installed.

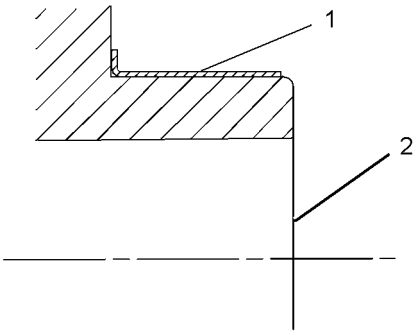


Illustration 80
Sectional view of the crankshaft pulley and the wear sleeve

1. Use a sharp tool to score a deep line across wear sleeve (1).

Note: Take care to avoid damaging to the crankshaft pulley.

2. Insert a thin blade between wear sleeve (1) and crankshaft pulley (2) below the scored line. The wear sleeve will separate along the line.
3. Remove wear sleeve (1) from crankshaft pulley (2).

Installation Procedure

Table 27

Required Tools		
Tool	Part Number	Part Description
A	21820518	POWERPART Liquid Gasket

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft pulley is thoroughly clean and dry. Remove any areas of raised damage.

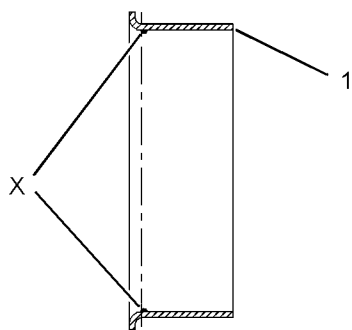


Illustration 81

g01269521

Sectional view of the wear sleeve

2. Apply a small continuous bead of Tooling (A) to the inner surface of wear sleeve (1) at position X. Apply the bead of Tooling (A) 5.00 mm (0.2 inch) from the flange end of the wear sleeve.

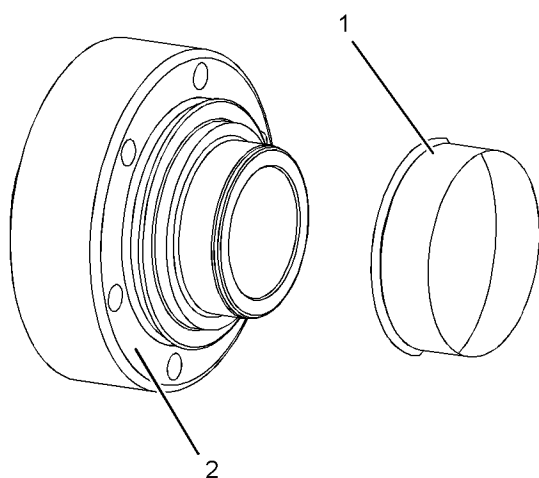


Illustration 82

g01258423

Typical example

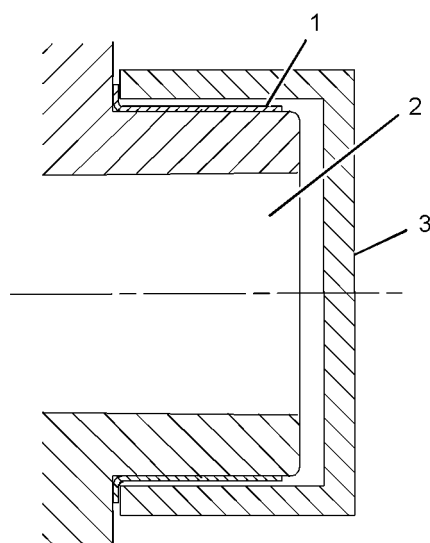


Illustration 83

g01258430

Sectional view of the crankshaft pulley, the wear sleeve and the installation tool

3. Align wear sleeve (1) with crankshaft pulley (2). Use installation tool (3) that is provided with the wear sleeve and use a suitable press in order to install wear sleeve (1) onto crankshaft pulley (2).

Note: Ensure that the wear sleeve is installed squarely against the shoulder of the crankshaft pulley.

4. Remove installation tool (3) from wear sleeve (1).
5. Ensure that wear sleeve (1) has no rough edges.

End By:

- a. Install a new crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".
- b. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".

i02628849

Front Cover - Remove and Install

Removal Procedure

Start By:

- a. If the engine is equipped with a fan, remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".
- b. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove".

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: In order to remove the front cover, it is not necessary to remove the crankshaft pulley or the alternator.

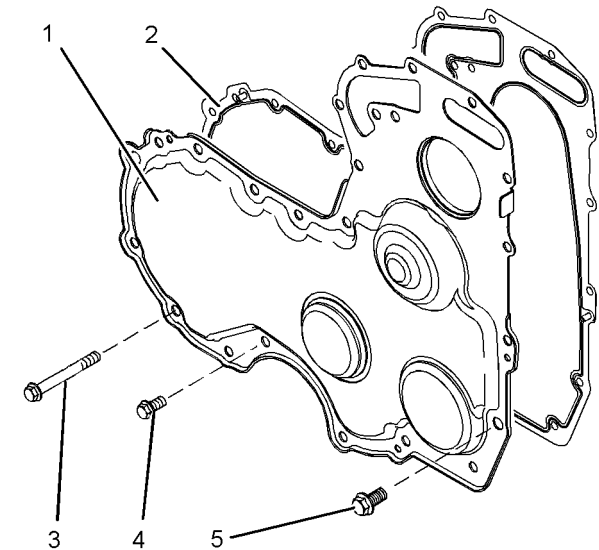


Illustration 84

g01258462

Typical example

1. Remove bolts (3), (4) and (5). Identify the positions of the different bolts.
2. Remove front cover (1) from the front housing.
3. Remove joint (2) from front cover (1).

Installation Procedure

Table 28

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Guide Bolt (M8 by 80 mm)	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

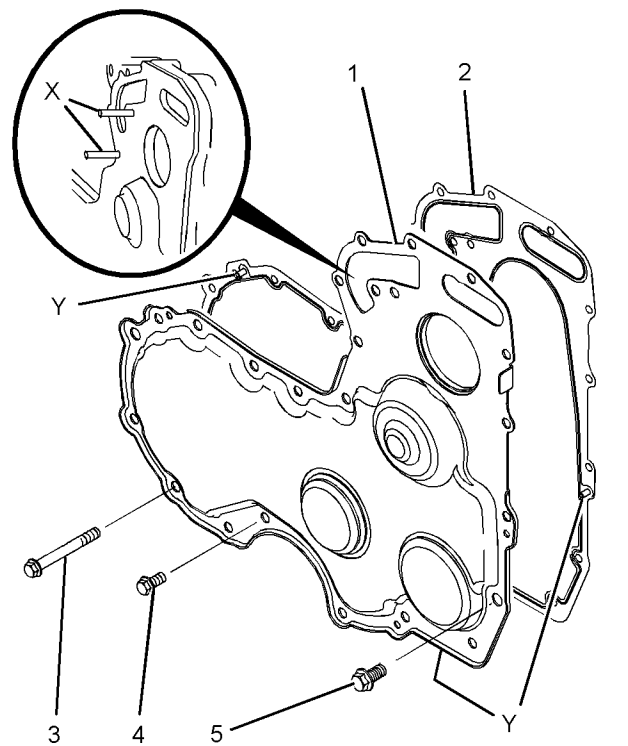


Illustration 85

g01343967

Typical example

1. Thoroughly clean the mating surface of the front housing.
2. If the original front cover is installed, follow Steps 2.a and 2.b in order to install the joint.
 - a. Thoroughly clean the front cover.
 - b. Install a new joint (2) to front cover (1). Engage locators (Y) into the holes in the front cover.
3. Install Tooling (A) into holes (X) in the front housing.
4. Use Tooling (A) in order to position the front cover assembly onto the front housing.
5. Install bolts (3), (4) and (5) finger tight. Ensure that the different bolts are installed in the correct positions.
6. Loosely install the water pump assembly and remove Tooling (A). Refer to Disassembly and Assembly, "Water Pump - Install" for the correct procedure.
7. Tighten bolts (3), (4) and (5) to a torque of 22 N·m (16 lb ft).

8. Tighten the bolts for the water pump to a torque of 22 N·m (16 lb ft).

End By:

- a. If the engine is equipped with a fan, install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02628883

Gear Group (Front) - Remove and Install

Removal Procedure

Table 29

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
	27610291	Barring Device Housing	1
A ²	27610289	Gear	1
	27610212	Camshaft Timing Pin	1
B	27610211	Crankshaft Timing Pin	1

Start By:

- a. If the engine is equipped with an air compressor, remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- b. If the engine is equipped with a vacuum pump, remove the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- c. If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".
- d. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
- e. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the front gear group. Carefully follow the procedure in order to remove the gear group.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

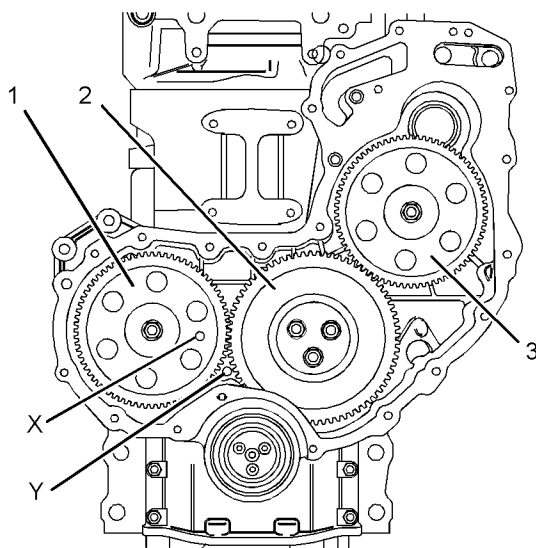


Illustration 86

g01247433

Typical example

2. Install Tooling (B) through hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Install Tooling (C) into hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

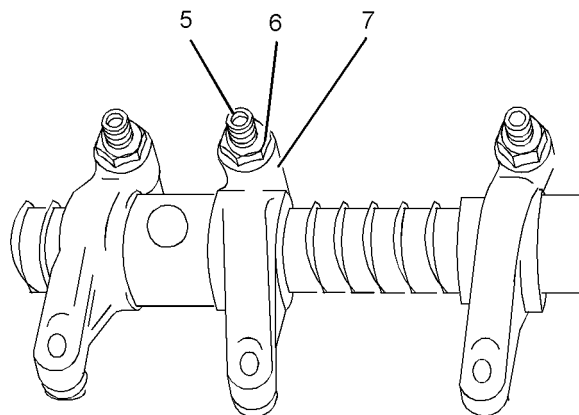


Illustration 87

g01322693

Typical example

3. Loosen nuts (6) on all rocker arms (7). Unscrew adjusters (5) on all rocker arms (7) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

4. Apply sufficient pressure to fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Lock the fuel injection pump in this position. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove" for the correct procedure.

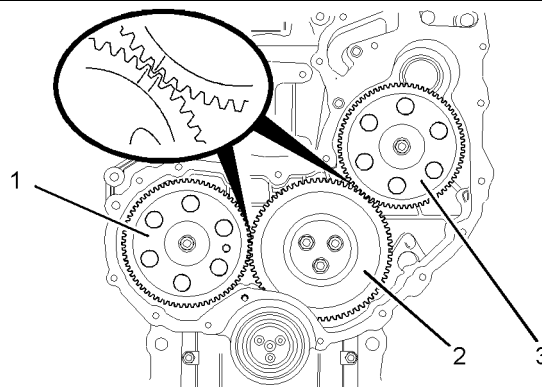


Illustration 88

g01335384

Typical example

5. Mark gears (1), (2) and (3) in order to show alignment. Refer to Illustration 88.

Note: Identification will ensure that the gears can be installed in the original alignment.

6. Remove fuel pump gear (3). Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove" for the correct procedure.
7. Remove camshaft gear (1). Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install".
8. Remove idler gear (2). Refer to Disassembly and Assembly, "Idler Gear - Remove and Install".

Installation Procedure

Table 30

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
D	21825617	Dial Indicator Group	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

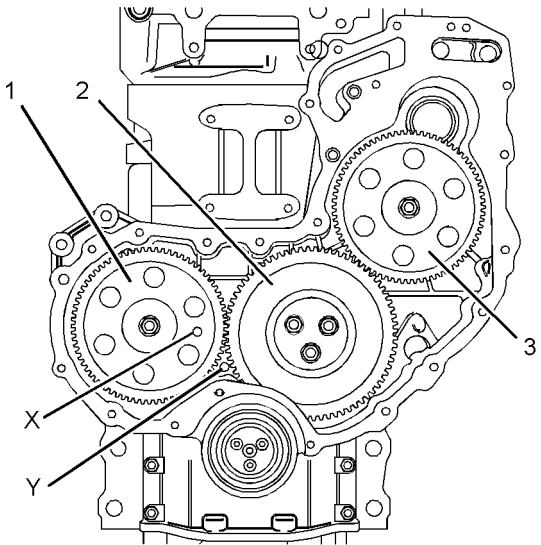


Illustration 89

g01247433

Typical example

2. If necessary, install Tooling (C) into hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

3. Ensure that all of the components of the front gear group are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

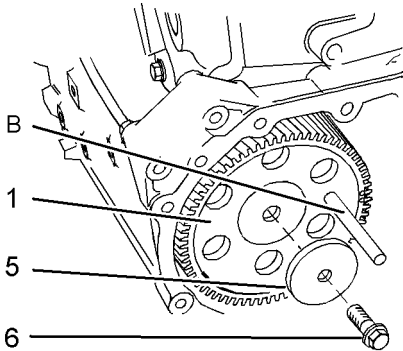


Illustration 90

g01269928

Typical example

4. Install camshaft gear (1). Loosely install bolt (6) and washer (5). Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install" for more information.

5. Install Tooling (B) through hole (X) in camshaft gear (1) into the front housing.

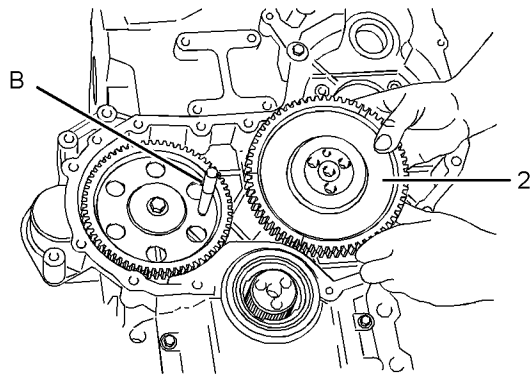


Illustration 91
Typical example

g01269927

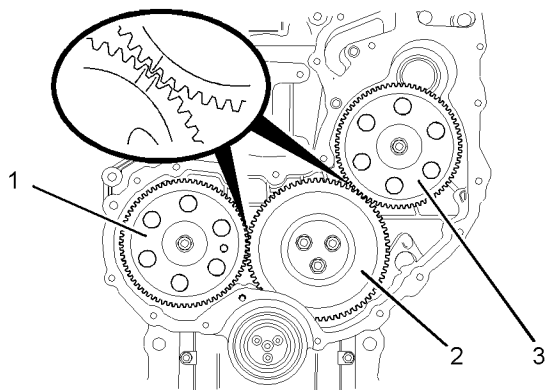


Illustration 92
Alignment of timing marks

g01335384

6. Install idler gear (2). Ensure that the timing marks on gears (1) and (2) are in alignment and that the mesh of the gears is correct. Refer to Disassembly and Assembly, "Idle Gear - Remove and Install". Check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" and refer to Disassembly and Assembly, "Idle Gear - Remove and Install" for further information.

7. Remove Tooling (B) and (C). Tighten the bolt (6) for the camshaft gear to a torque of 95 N·m (70 lb ft). Check the end play of the camshaft gear. Refer to Specifications, "Camshaft" for more information.

Install Tooling (B) through hole (X) in camshaft gear (1) into the front housing and install Tooling (C) into hole (Y) in the front housing.

8. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install".

9. Install fuel injection pump gear (3). Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" for the correct procedure. Ensure that timing marks on gears (2) and (3) are in alignment. See Illustration 92. Ensure that the mesh of the gears is correct.

10. Remove Tooling (B) and (C).

11. Use Tooling (D) in order to measure the backlash for the gears (1), (2) and (3). Ensure that the backlash for the gears is within specified values. Refer to Specifications, "Gear Group (Front)" for further information.

12. Lubricate each gear with clean engine oil.

13. Adjust the engine valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".

End By:

- Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
- Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
- If the engine is equipped with an air compressor, install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- If the engine is equipped with a vacuum pump, install the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".

i02628889

Idle Gear - Remove

Removal Procedure (Standard Idle Gear)

Table 31

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610211	Crankshaft Timing Pin	1

Start By:

- a. If the engine is equipped with an air compressor, remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- b. If the engine is equipped with a vacuum pump, remove the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- c. If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".
- d. Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove".
- e. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

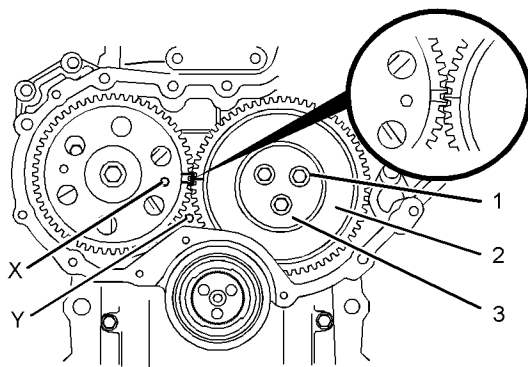


Illustration 93

g01343975

Alignment of timing marks

1. Ensure that Tooling (A) is installed into hole (X) in the camshaft gear. Use Tooling (A) in order to lock the camshaft in the correct position.

Note: Ensure that the gears are marked in order to show alignment. Refer to Illustration 93.

2. Ensure that Tooling (B) is installed in hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

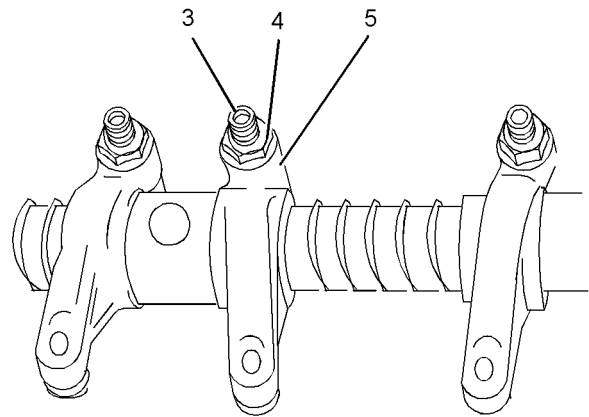


Illustration 94

g01348926

Typical example

3. Loosen nuts (4) on all rocker arms (5). Unscrew adjusters (3) on all rocker arms (5) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

4. Mark plate (3) in order to show orientation. Refer to Illustration 93.

Note: Identification will ensure that the plate can be installed in the original orientation.

5. Remove bolts (1). Refer to Illustration 93.

6. Remove plate (3).

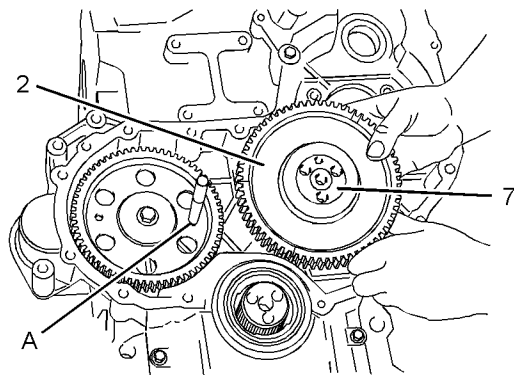


Illustration 95

g01269930

Typical example

7. Remove the assembly of idler gear (2) and hub (7) from the recess in the front housing.

Note: The idler gear must be tilted during removal.

8. Remove hub (7) from idler gear (2).

Removal Procedure (Heavy-Duty Idler Gear)

Table 32

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610211	Crankshaft Timing Pin	1
C	-	Bolt (M8x80mm)	1

Start By:

- a. If the engine is equipped with an air compressor, remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- b. If the engine is equipped with a vacuum pump, remove the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- c. If the engine is equipped with an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".
- d. Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove".
- e. Remove the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The assembly of heavy-duty idler gear is not serviceable. Do not disassemble the heavy-duty idler gear.

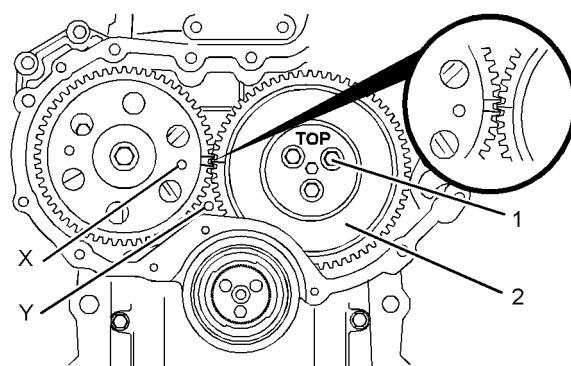


Illustration 96

g01343977

Alignment of timing marks

1. Ensure that Tooling (A) is installed into hole (X) in the camshaft gear. Use Tooling (A) in order to lock the camshaft in the correct position.

Note: Ensure that the gears are marked in order to show alignment. Refer to Illustration 96.

2. Ensure that Tooling (B) is installed in hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

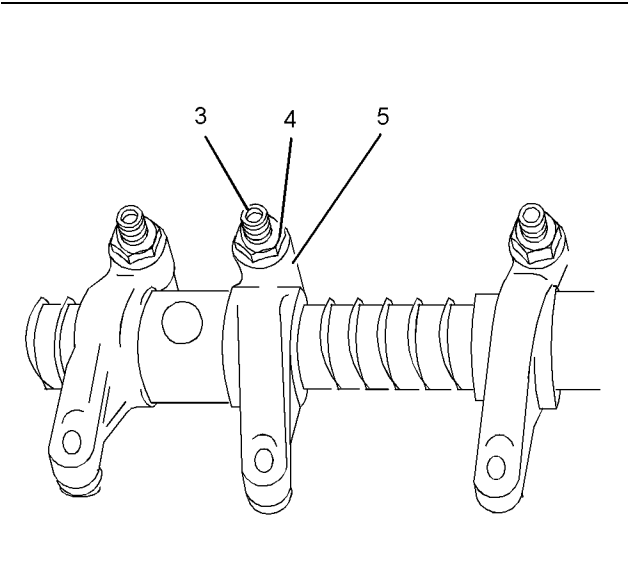


Illustration 97
Typical example

3. Loosen nuts (4) on all rocker arms (5). Unscrew adjusters (3) on all rocker arms (5) until all valves are fully closed.

Note: Failure to ensure that ALL adjusters are fully unscrewed can result in contact between the valves and pistons.

4. Remove bolts (1) from the assembly of heavy-duty idler gear (2). Refer to Illustration 96.

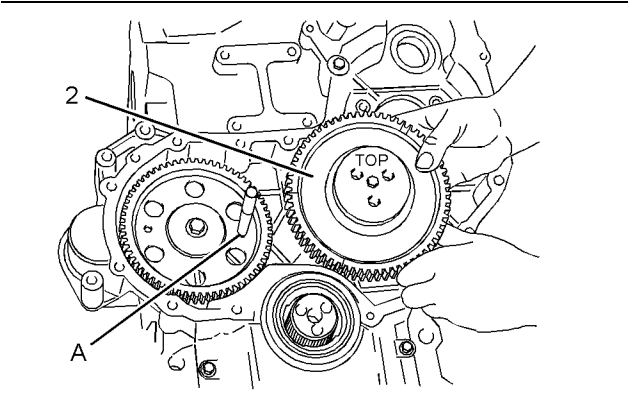


Illustration 98
Typical example

5. Remove the assembly of idler gear (2) from the recess in the front housing.

Note: The idler gear must be tilted during removal.

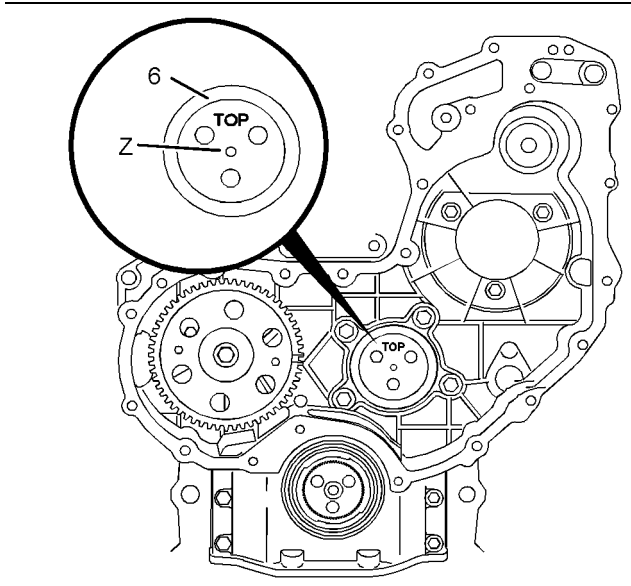


Illustration 99
Typical example

6. If necessary, remove plate (6). Install Tooling (C) into threaded hole (Z) in order to remove plate (6).

i0262887

Idler Gear - Install

Installation Procedure (Standard Idler Gear)

Table 33

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610211	Crankshaft Timing Pin	1
C	21825617	Dial Indicator Group	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

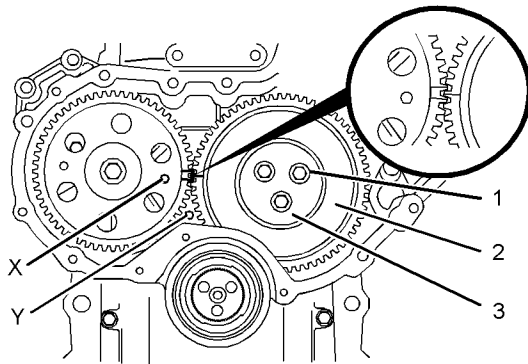


Illustration 100

g01343975

Alignment of timing marks

2. Ensure that Tooling (A) is installed into hole (X) in camshaft gear (1).
3. Ensure that Tooling (B) is installed in hole (Y) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

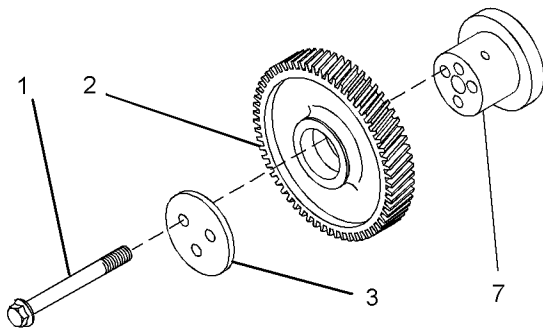


Illustration 101

g01269934

4. Clean idler gear (2) and inspect the idler gear for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the idler gear.
5. Clean hub (7) and inspect the hub for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the hub.
6. Lubricate hub (7) with clean engine oil. Slide the hub into idler gear (2). Ensure that the timing marks are toward the front of the idler gear.

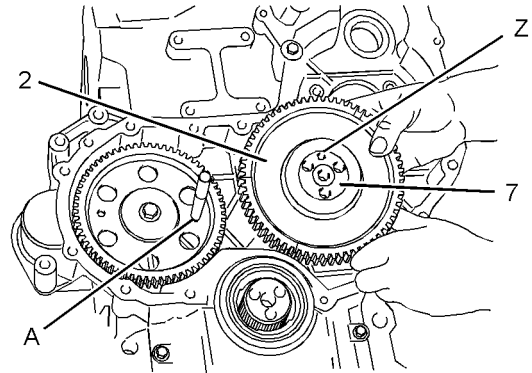


Illustration 102

g01269935

Typical example

7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to the Illustration 100. Install the assembly of idler gear (2) and hub (7) into the recess in the timing case. Ensure that oil hole (Z) is to the top of the hub.

Note: The idler gear must be tilted during installation. Ensure that the holes in the hub are aligned with the holes in the cylinder block.

8. Clean plate (3) and inspect the plate for wear or damage. If necessary, replace the plate.
9. Lubricate plate (3) with clean engine oil. A used plate should be installed in the original orientation. If a new plate is installed, ensure that the holes in plate (3) are aligned with the holes in hub (7). Install plate (3) to hub (7).
10. Install bolts (1). Tighten bolts (1) to a torque of 44 N·m (32 lb ft).

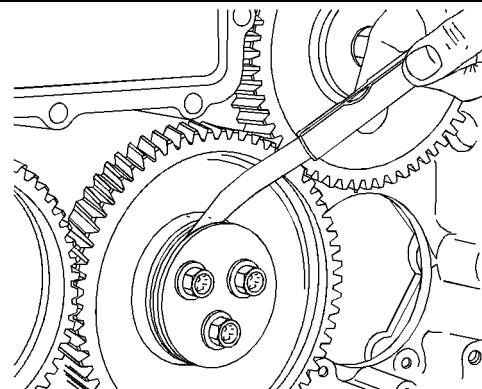


Illustration 103

g01269936

Checking end play by using a set of feeler gauge's

11. Use a set of feeler gauge's in order to check the end play for the idler gear. Refer to Specifications, "Gear Group (Front)" for more information.

12. Use Tooling (C) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
13. Use Tooling (C) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
14. Lightly lubricate all of the gears with clean engine oil.

End By:

- a. Install the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Install".
- b. If the engine is equipped with an air compressor, install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- c. If the engine is equipped with a vacuum pump, install the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- d. If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".

Installation Procedure (Heavy-Duty Idler Gear)

Table 34

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610211	Crankshaft Timing Pin	1
C	21825617	Dial Indicator Group	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

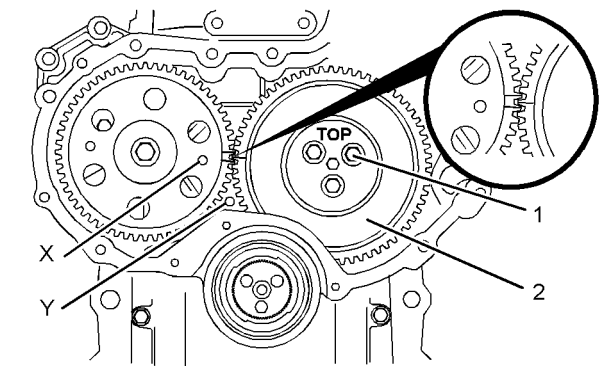


Illustration 104

g01343977

Alignment of timing marks

2. Ensure that Tooling (A) is installed into hole (X) in the camshaft gear.
3. Ensure that Tooling (B) is installed in hole (Y) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

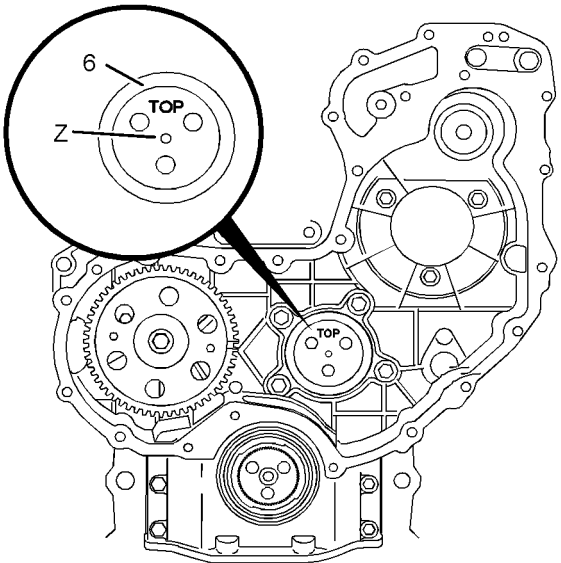


Illustration 105

g01348946

Typical example

4. Install plate (6) into the recess in the front housing.

Note: Ensure that the identification mark TOP is upward.

5. Clean the assembly of idler gear (2) and inspect the assembly of the idler gear for wear or damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the assembly of the idler gear.

6. Lubricate the bearings in the assembly of idler gear (2) with clean engine oil.

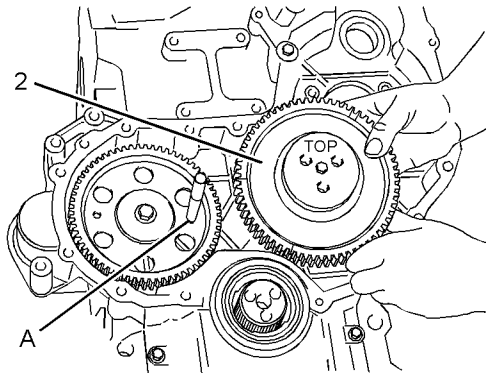


Illustration 106

g01269933

7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to Illustration 104. Install the assembly of idler gear (2) into the recess in the timing case. Ensure that the identification mark TOP is upward.

Note: The idler gear must be tilted during installation. Ensure that the holes in the assembly of the idler gear are aligned with the holes in the cylinder block.

8. Install bolts (1). Tighten bolts (1) to a torque of 44 N·m (32 lb ft).

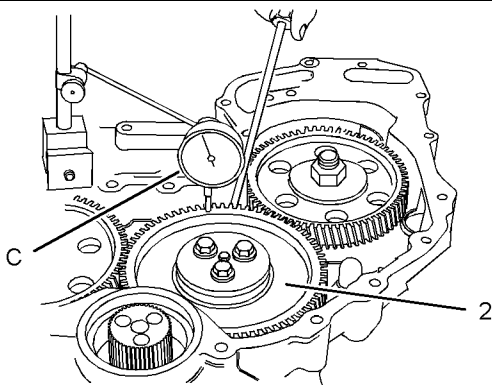


Illustration 107

g01269937

Checking end play by using a dial indicator group

9. Use Tooling (C) in order to check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" for more information.
10. Use Tooling (C) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
11. Use Tooling (C) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.

12. Lightly lubricate all of the gears with clean engine oil.

End By:

- Install the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Install".
- If the engine is equipped with an air compressor, install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove and Install".
- If the engine is equipped with a vacuum pump, install the vacuum pump. Refer to Disassembly and Assembly, "Vacuum Pump - Remove and Install".
- If the engine is equipped with an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".

i02628886

Housing (Front) - Remove

Removal Procedure

Start By:

- Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".
- Remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
- Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install".
- Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install".
- Remove the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install".
- Remove the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Ensure that the coolant is drained into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

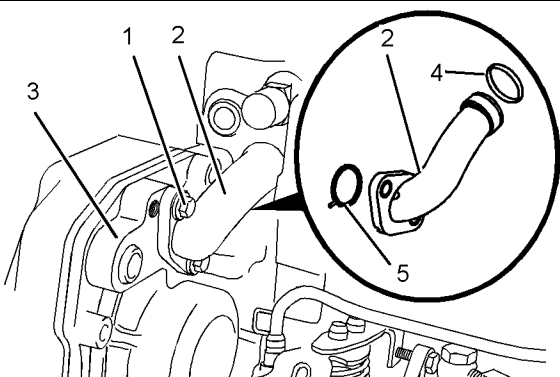


Illustration 108

g01337982

Typical example

2. Remove bolts (1) that secure bypass tube (2) to front housing (3). Note the position of any brackets that are secured by the bolts. Remove bypass tube (2). Remove O-ring seals (4) and (5) from bypass tube (2).

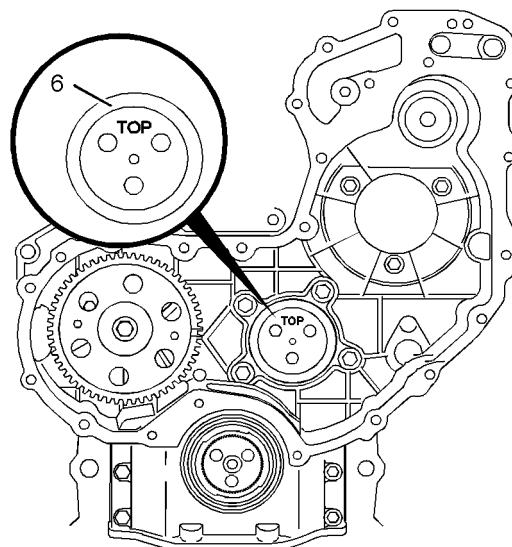


Illustration 109

g01350333

3. If the engine is equipped with a heavy duty idle gear. Remove plate (6). Refer to Disassembly and Assembly, "Idle Gear - Remove" for the correct procedure.

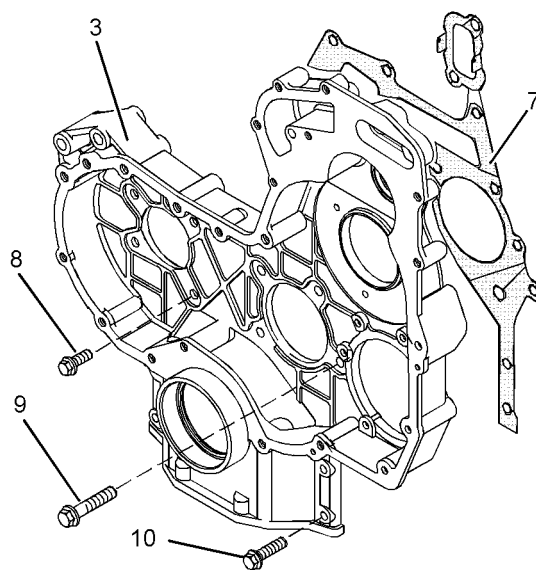


Illustration 110

g01350336

Typical example

4. Remove bolts (8), (9) and (10) from front housing (3).

Note: The bolts are three different lengths. Note the positions of the different bolts.

5. Remove front housing (3) from the cylinder block.

6. Remove joint (7).

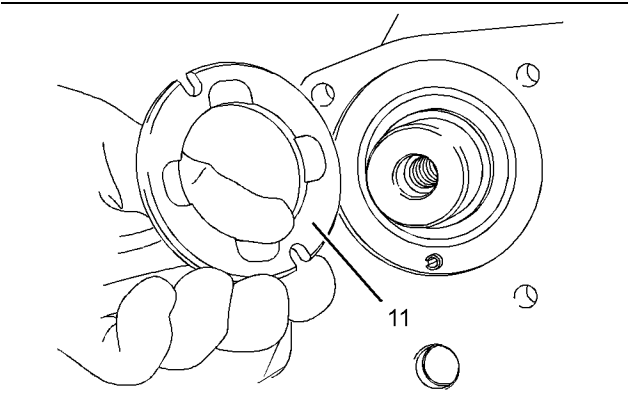


Illustration 111
Typical example

7. Remove thrust washer (11) from the cylinder block.

i02628885

Housing (Front) - Install

Installation Procedure

Table 35

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	POWERPART Threadlock and Nutlock	1
B	-	Guide Stud (M8 by 80 mm)	2
C	27610216	Alignment Tool	1
	-	Bolts (M10 by 50 mm)	3
D	-	Straight Edge	1
E	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the front housing is clean and free from damage. If necessary, replace the front housing.

If necessary, install blanking plugs to a new front housing. Use Tooling (A) to seal all D-plugs.

2. Check the condition of the crankshaft front seal. If the front seal is damaged, remove the front seal from the front housing.
3. Clean the mating surfaces of the cylinder block.

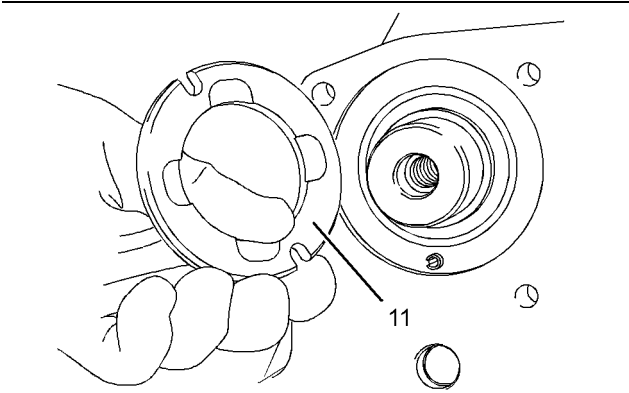


Illustration 112
Typical example

4. Install thrust washer (11) into the recess in the cylinder block. Refer to Disassembly and Assembly, "Camshaft - Install" for more information.

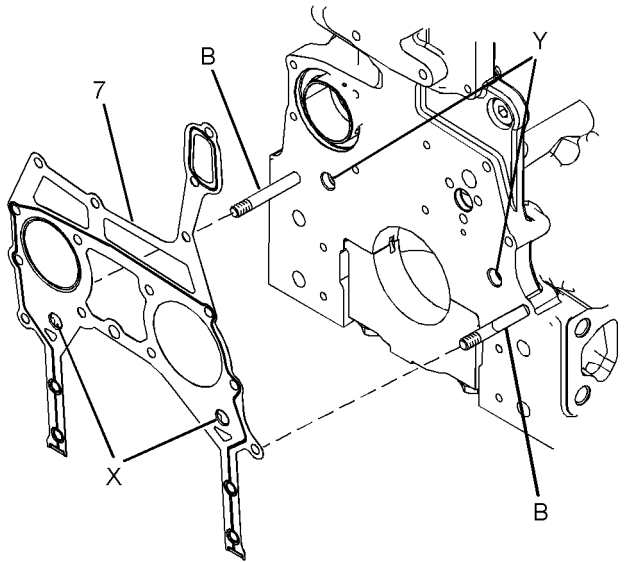


Illustration 113
Typical example

5. Install Tooling (B) to the cylinder block. Refer to Illustration 113.
6. Install Tooling (C) to the cylinder block.
7. Align a new joint (7) with Tooling (B). Install the joint to the cylinder block.

Note: Ensure that tabs (X) on the joint are engaged in the holes (Y) in the cylinder block.

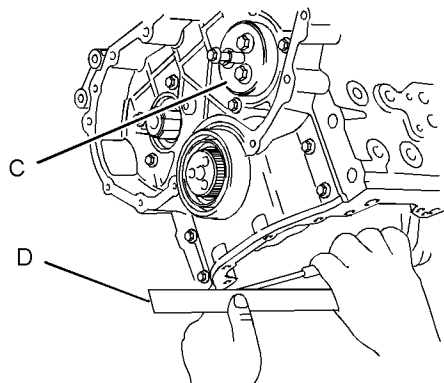


Illustration 114

g01269947

Typical example

8. Install the front housing over Tooling (B) and over Tooling (C) onto the cylinder block.

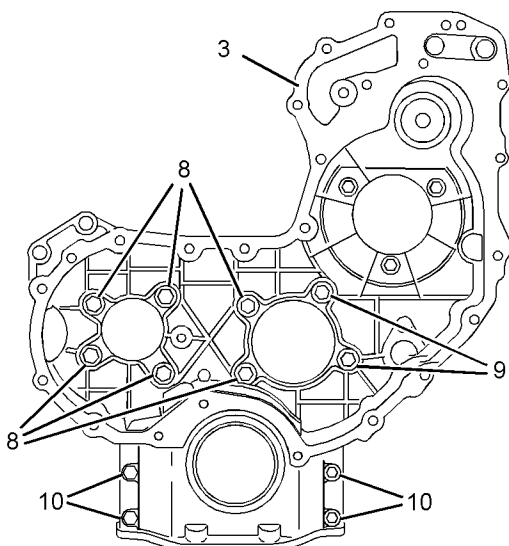


Illustration 115

g01350344

- (8) M8 by 20 mm
- (9) M8 by 35 mm
- (10) M8 by 25 mm

9. Install bolts (10) to front housing (3) finger tight.
10. Remove Tooling (B).
11. Loosely install bolts (8) and (9). Refer to Illustration 115 for the correct position of the bolts.
12. Align the bottom face of front housing (3) to the lower machined face of the cylinder block. Use a Tooling (D) and a feeler gauge in order to check the alignment between the front housing and the cylinder block. Refer to Illustration 114. Refer to Specifications, "Front Housing and Covers" for further information.

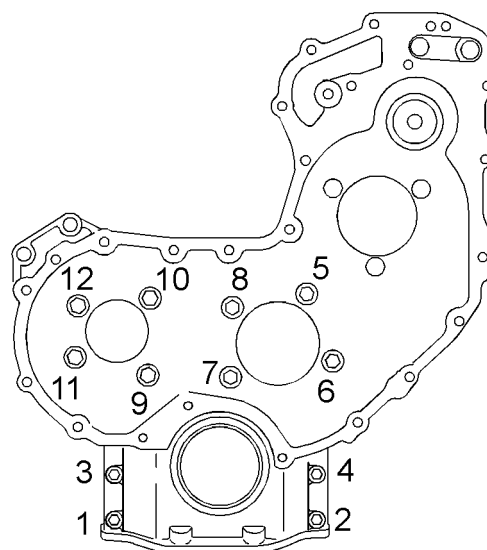


Illustration 116

g01269949

Tightening sequence for the front housing

13. Tighten bolts (8), (9) and (10) to a torque of 28 N·m (20 lb ft). Tighten the bolts in the sequence that is shown in Illustration 116.

Note: Ensure that the housing and the cylinder block are correctly aligned.

14. Remove Tooling (C) from the cylinder block.

15. If necessary, install a new crankshaft front seal. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install".

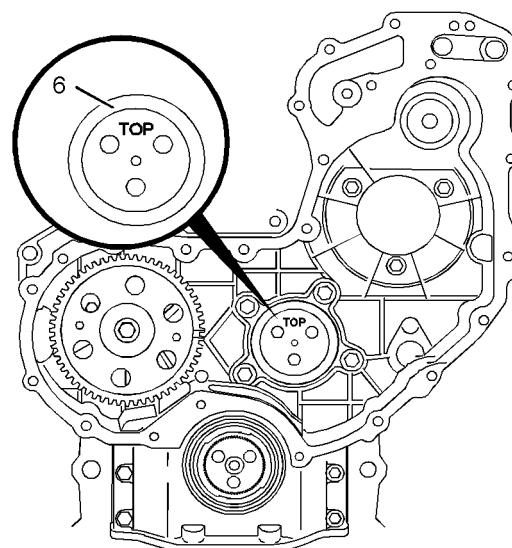


Illustration 117

g01350333

16. If the engine is equipped with a heavy duty idle gear. Install plate (6). Refer to Disassembly and Assembly, “Idle Gear - Install” for the correct procedure.

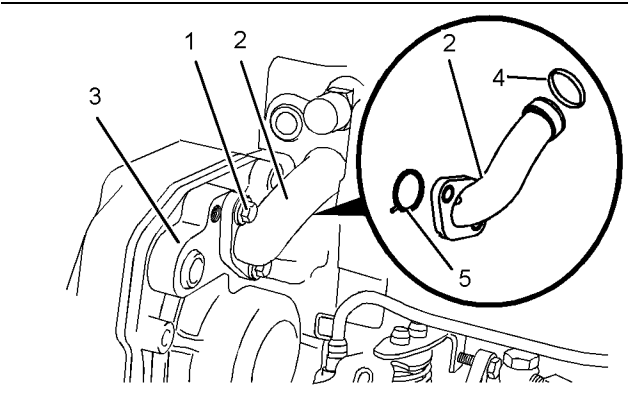


Illustration 118
Typical example

17. Install new O-ring seals (4) and (5) to bypass tube (2). Use Tooling (E) in order to lubricate O-ring seal (5). Install bypass tube (2) to the cylinder head. Install bolts (1). Ensure that any brackets that are secured by the bolts are installed in the correct location. Tighten the bolts to a torque of 22 N·m (16 lb ft).

End By:

- a. Install the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install”.
- b. Install the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Install”.
- c. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.
- d. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install”.
- e. Install the alternator. Refer to Disassembly and Assembly, “Alternator - Install”.
- f. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install”.

i02628800

Accessory Drive - Remove and Install

Removal Procedure

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

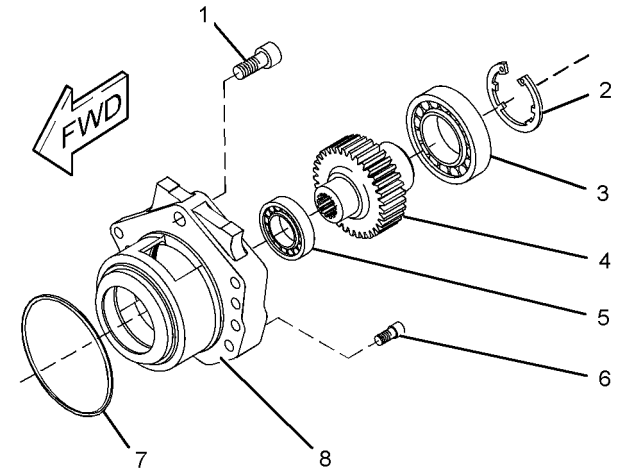


Illustration 119
Typical example

g01269954

1. Remove allen head screw (1) from accessory drive housing (8). Remove allen head screws (6) from accessory drive housing (8).
2. Remove accessory drive housing (8) from the front housing.
3. If necessary, follow Steps 3.a through 3.c in order to disassemble the accessory drive.
 - a. Remove circlip (2) from accessory drive housing (8).
 - b. Place accessory drive housing (8) onto a suitable support. Press the assembly of gear (4) and bearings (3) and (5) out of accessory drive housing (8). Use a Tooling (A) in order to remove bearings (3) and (5) from gear (4).
 - c. Remove O-ring seal (7) from accessory drive housing (8).

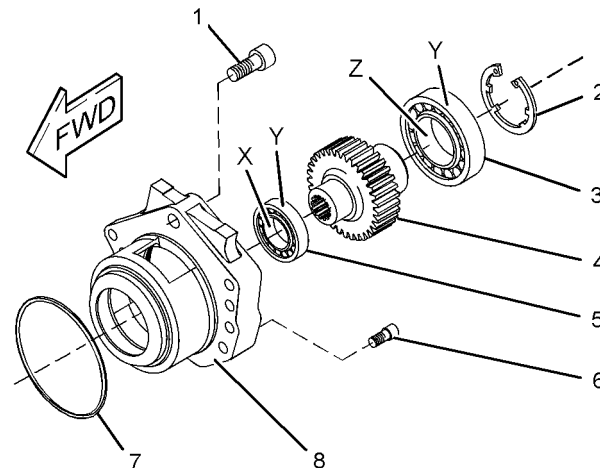


Illustration 120

g01264852

Typical example

Installation Procedure

Table 37

Required Tools			
Tool	Part Number	Part Description	Qty
B	21820603	POWERPART Retainer	-
C	21820221	POWERPART Rubber Grease	1
D	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If necessary, follow Steps 1.a through 1.e in order to assemble the accessory drive.
 - a. Inspect the condition of the teeth and the splines of gear (4) for wear or damage. Inspect bearings (3) and (5), circlip (2), and the front housing for wear or damage. Replace any components that are worn or damaged.
 - b. Apply a small continuous bead of Tooling (B) to inner surface (X) of bearing (5). Place the gear shaft on a suitable support. Press on the inner race of bearing (5) until the bearing (5) is against the shoulder of gear (4). Remove any excess sealant.
 - c. Apply a small continuous bead of Tooling (B) to inner surface (Z) of bearing (3). Place the inner race of bearing (3) onto a suitable support. Press the shaft of gear (4) into bearing (3) until the shoulder of the gear is against the bearing. Remove any excess sealant.
 - d. Apply a small continuous bead of Tooling (B) to the outer surface (Y) of bearings (3) and (5). Place accessory drive housing (8) on a suitable support. Press the assembly of the gear into the accessory drive housing. Ensure that bearing (5) is against the front face of the recess in accessory drive housing (8). Remove any excess sealant.
 - e. Install circlip (2) into the groove in accessory drive housing (8). Ensure that circlip (2) is correctly positioned in the groove.

2. Lightly lubricate a new O-ring seal (7) with Tooling (C). Install the O-ring seal into the groove in accessory drive housing (8).
3. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install".
4. Lightly lubricate bearing (3), bearing (5), and gear (4) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing. Ensure that the flange on the accessory drive housing is flush with the front housing.
5. Apply Tooling (D) to allen head screws (1) and (6). Install allen head screws (1) and (6) to accessory drive housing (8).
6. Tighten the allen head screws to a torque of 22 N·m (16 lb ft).
7. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

i02628816

Crankcase Breather - Remove and Install (Turbocharged Engines with Unfiltered Breather)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

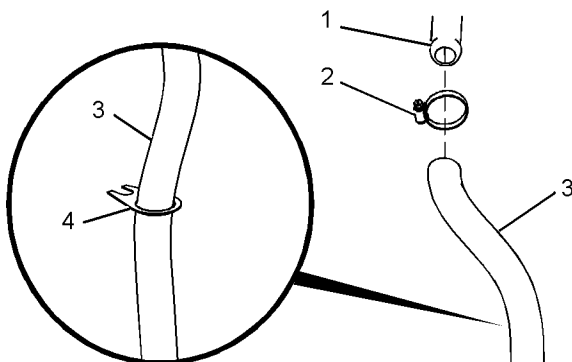


Illustration 121

Typical example

g01343996

1. Loosen clamp (2) and remove hose (3) from breather tube (1). Withdraw hose (3) from clip (4) and remove the hose.

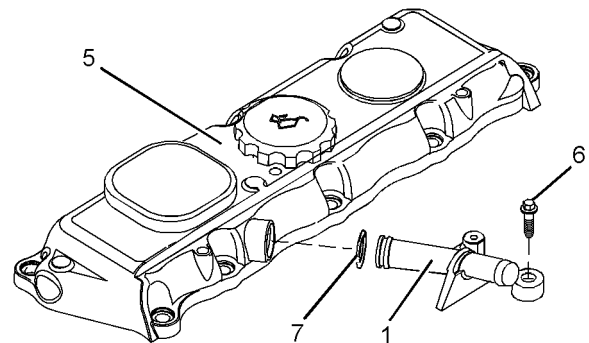


Illustration 122

g01346677

2. Remove bolt (6) and remove breather tube (1) from valve mechanism cover (5).
3. Remove O-ring seal (7) from breather tube(1).

Disassembly Procedure

⚠ 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.

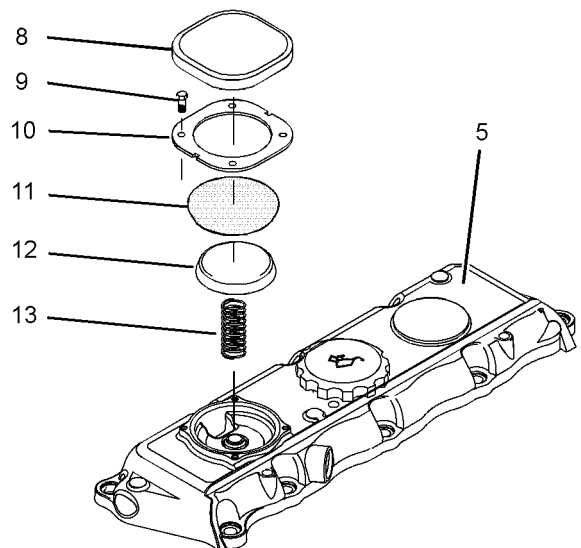


Illustration 123

g01347094

1. Remove plastic cover (8) from valve mechanism cover (5).
2. Remove screws (9). Remove plate (10).
3. Remove assembly of diaphragm (11) and the cap (12). Remove spring (13).

Assembly Procedure

Table 38

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610296	Torque Wrench	1

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.

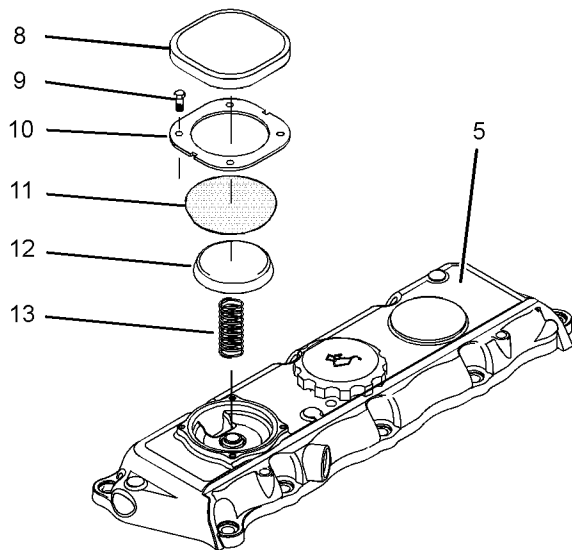


Illustration 124

g01347094

1. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
2. Install spring (13). Install assembly of diaphragm (11) and cap (12).
3. Position plate (10) on valve mechanism cover (5) and install screws (9).

4. Use Tooling (A) to tighten screws (9) to a torque of 1.3 N·m (12 lb in).
5. Install plastic cover (8) to valve mechanism cover (5).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

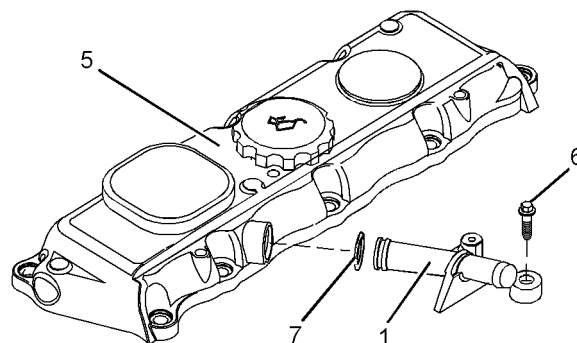


Illustration 125

g01346677

1. Install a new O-ring seal (7) to breather tube(1).
2. Install breather tube (1) to valve mechanism cover (5). Install bolt (6) and tighten the bolt to a torque of 9 N·m (80 lb in).

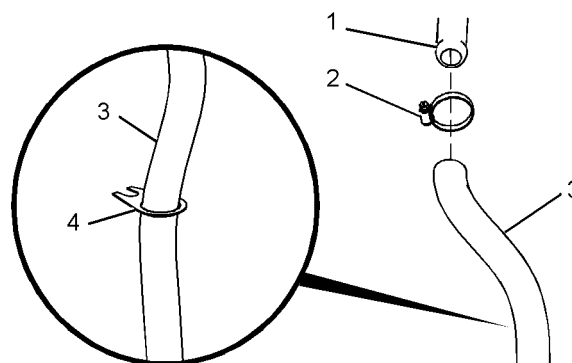


Illustration 126

g01343996

Typical example

3. Connect hose (3) to breather tube (1). Tighten clamp (2). Install hose (3) into clip (4).

i02628815

Crankcase Breather - Remove and Install (Turbocharged Engines with Filtered Breather)

Removal Procedure

NOTICE

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

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.

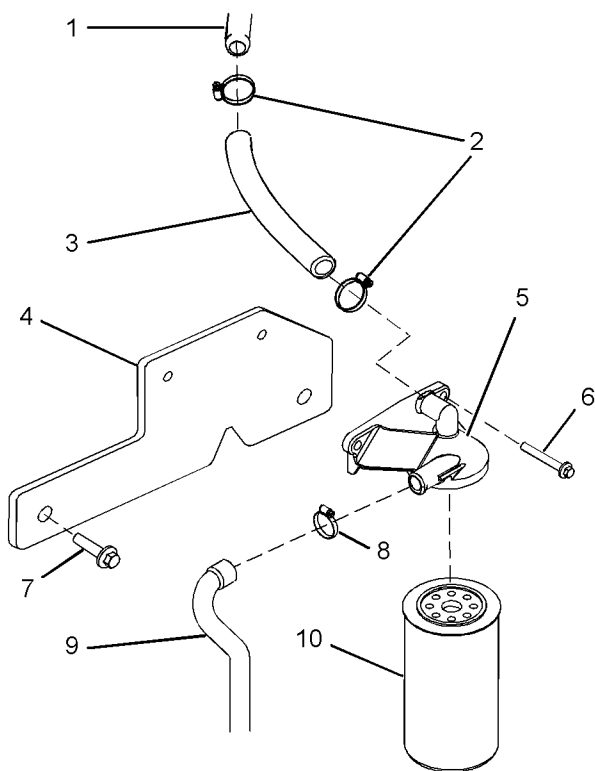


Illustration 127

g01368198

Typical example

1. Remove canister (10). Refer to Operation and Maintenance Manual, "Crankcase Breather (Canister) - Replace".
2. Release spring clamps (8) and remove hose (9).
3. Release spring clamps (2) in order to remove hose (3). Remove the hose from breather tube (1) and from filter base (5).
4. Remove bolts (6) and remove filter base (5).
5. If necessary, remove bolts (7) and remove bracket (4) from cylinder head.

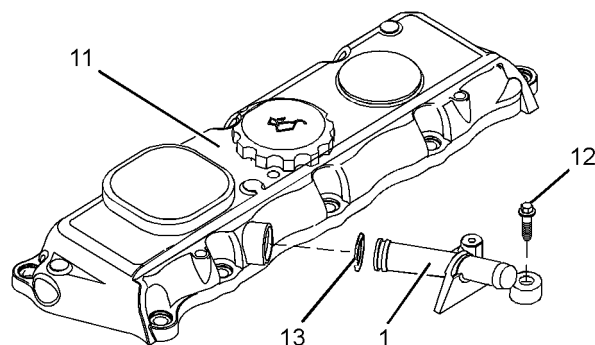


Illustration 128

g01368677

6. Remove bolt (12) and remove breather tube (1) from valve mechanism cover (11).
7. Remove O-ring seal (13) from breather tube (1).

Disassembly Procedure

⚠ 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.

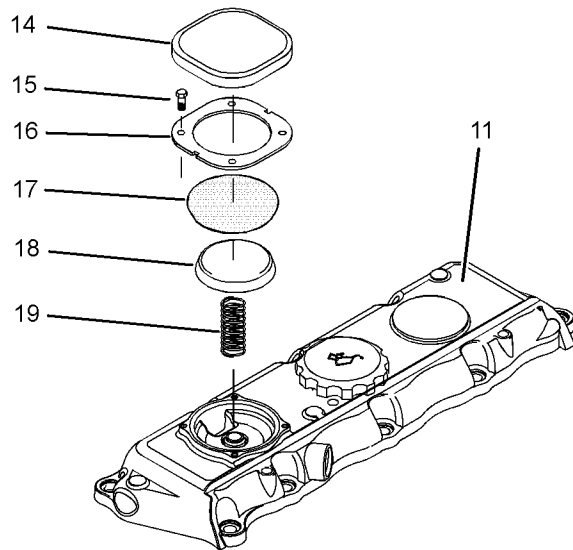


Illustration 129 g01368678

1. Remove plastic cover (14) from valve mechanism cover (11).
2. Remove screws (15). Remove plate (16).
3. Remove assembly of diaphragm (17) and the cap (18). Remove spring (19).

Assembly Procedure

Table 39

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610296	Torque Wrench	1

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.

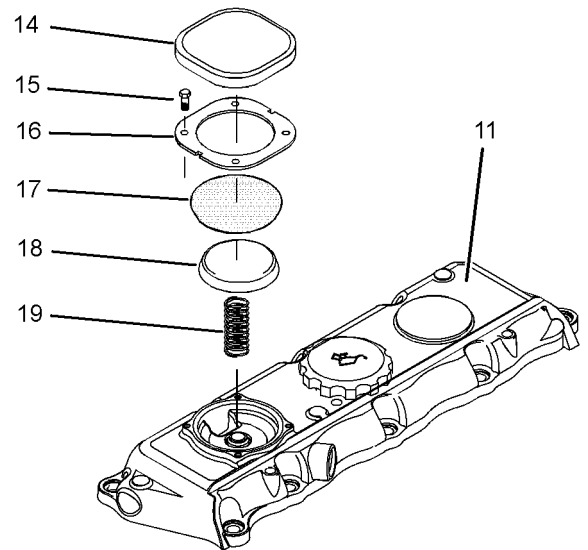


Illustration 130 g01368678

1. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
2. Install spring (19). Install assembly of diaphragm (17) and cap (18).
3. Position plate (16) on valve mechanism cover (11) and install screws (15).
4. Use Tooling (A) to tighten screws (15) to a torque of 1.3 N·m (12 lb in).
5. Install plastic cover (14) to valve mechanism cover (11).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

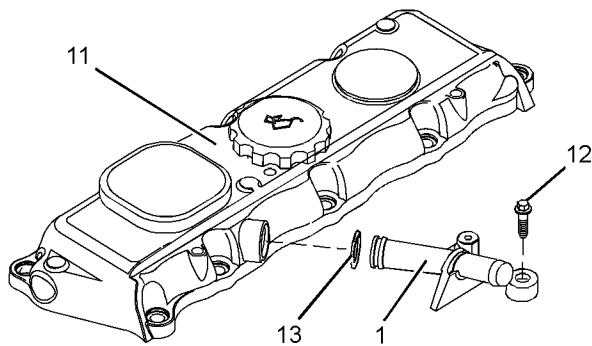


Illustration 131

g01368677

1. Install a new O-ring seal (13) to breather tube (1).
2. Install breather tube (1) to valve mechanism cover (11). Install bolt (12) and tighten the bolt to a torque of 9 N·m (80 lb in).

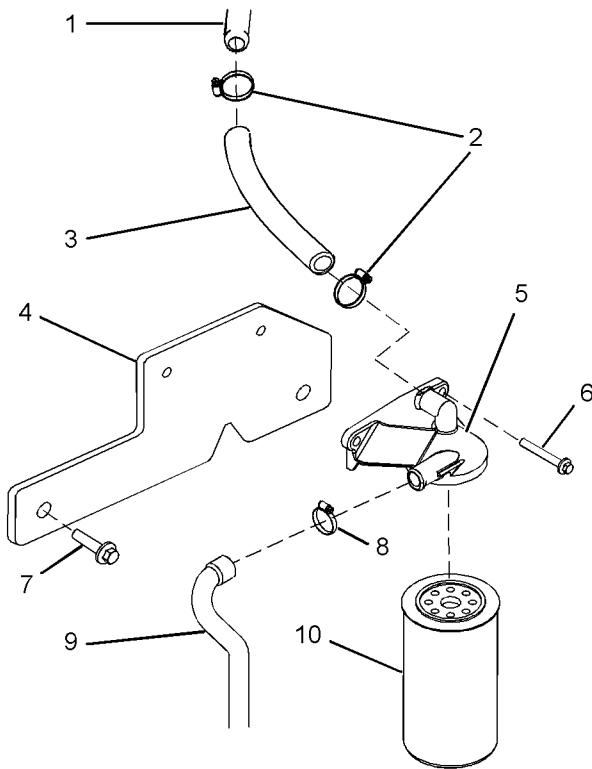


Illustration 132

g01368198

3. If necessary, install bracket (4). Position bracket (4) onto cylinder head and install bolts (7). Tighten the bolts to a torque of 22 N·m (16 lb ft).
4. Install bolts (6) to filter base (5).
5. Install the assembly of the filter base to the engine.
6. Tighten bolts (6) to a torque of 22 N·m (16 lb ft).

7. Install spring clamps (2) to hose (3). Install hose (3) to connection (1) on the valve mechanism cover and to filter base (4).

Note: Ensure that the spring clamps are correctly positioned in order to secure the hose.

8. Install spring clamp (8) to hose (9). Install hose (9) to filter base (5).
9. Install a new canister (10) to filter base (5). Refer to Operation and Maintenance Manual, "Crankcase Breather (Canister) - Replace".

i02681626

Crankcase Breather - Remove and Install (Naturally Aspirated Engines)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

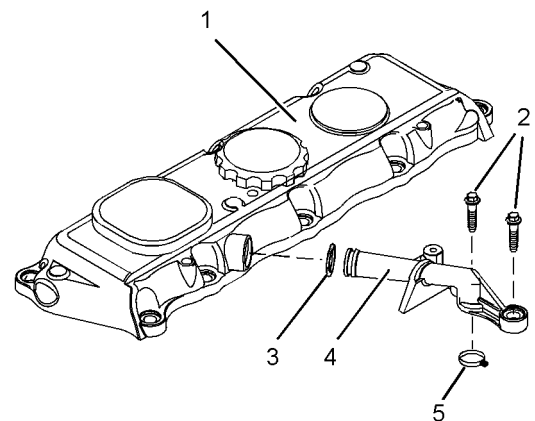


Illustration 133

g01368193

Typical example

1. Remove bolts (2) and remove breather tube (4) from valve mechanism cover (1).
2. Remove O-ring seal (3) and seal (5) from breather tube(4).

Disassembly Procedure

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.

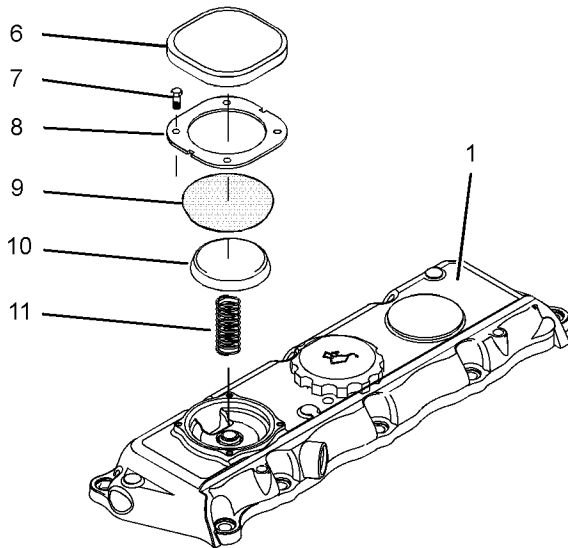


Illustration 134
Typical example

g01347463

1. Remove plastic cover (6) from valve mechanism cover (1).
2. Remove screws (7). Remove plate (8).
3. Remove assembly of diaphragm (9) and the cap (10). Remove spring (11).

Assembly Procedure

Table 40

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610296	Torque Wrench	1

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.

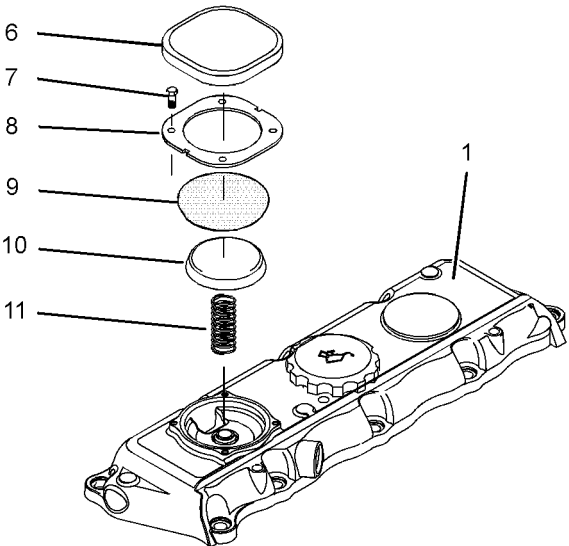


Illustration 135

g01347463

Typical example

1. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
2. Install spring (11). Install assembly of diaphragm (10) and cap (9).
3. Position plate (8) on valve mechanism cover (1) and install screws (7).
4. Use Tooling (A) to tighten screws (7) to a torque of 1.3 N·m (12 lb in).
5. Install plastic cover (6) to valve mechanism cover (1).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

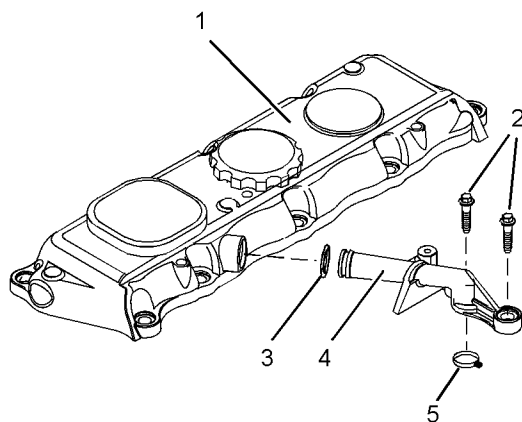


Illustration 136

g01368193

Typical example

1. Install new O-ring seals (3) and (5) to breather tube(4).
2. Install breather tube (4) to valve mechanism cover (1). Install bolts (2) and tighten the bolt to a torque of 9 N·m (80 lb in).

i02628915

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. If the engine is equipped with a cover for the fuel injectors, remove the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
2. If the engine is equipped with a heat shield, remove the heat shield.

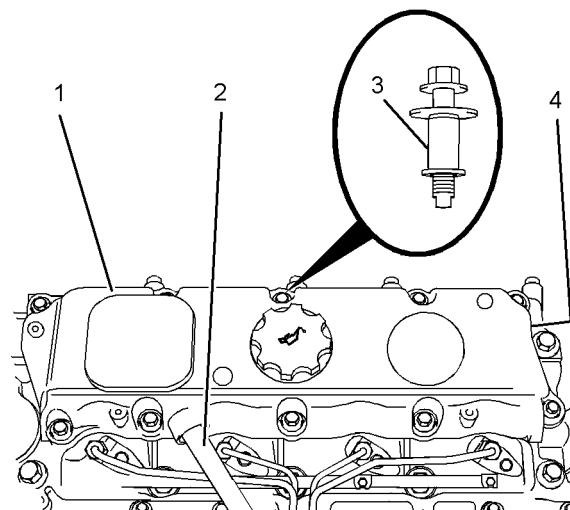


Illustration 137

g01368184

Typical example

3. Remove breather tube (2) from valve mechanism cover (1). Refer to Disassembly and Assembly, "Crankcase Breather - Remove and Install".
4. Loosen captive bolts (3). Remove valve mechanism cover (1).
5. Remove captive bolts (3) and remove joint (4) (not shown) from valve mechanism cover (1).

Installation Procedure

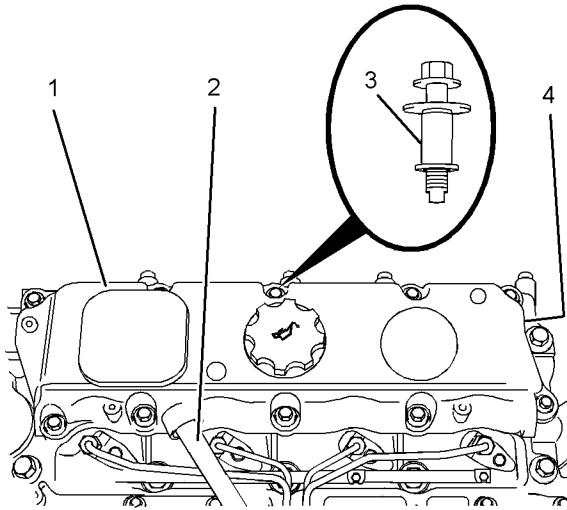


Illustration 138

g01368184

Typical example

1. Thoroughly clean valve mechanism cover (1). Ensure that the groove for the joint in the valve mechanism cover is clean and dry. Ensure that the mating surface on the cylinder head is clean and dry.
2. Check the condition of captive bolts (3). If necessary, replace the captive bolts.
3. Install a new joint (4) to valve mechanism cover (1). Ensure that the joint is seated correctly in the groove in the valve mechanism cover.
4. Install captive bolts (3) to valve mechanism cover (1).
5. Position valve mechanism cover (1) onto the cylinder head.

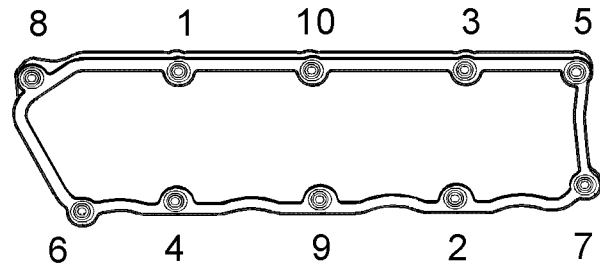


Illustration 139

g01344009

Sequence for tightening the isolating bolts

6. Tighten the captive bolts for the valve mechanism cover in the sequence that is shown in Illustration 139. Tighten the captive bolts to a torque of 9 N·m (80 lb in).
7. Install breather tube (3) to valve mechanism cover (1). Refer to Disassembly and Assembly, "Crankcase Breather - Remove and Install".
8. If the engine is equipped with a heat shield, install the heat shield.
9. If the engine is equipped with a cover for the fuel injectors, install the cover for the fuel injectors. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".

i02628906

Rocker Shaft and Pushrod - Remove

Removal Procedure

Table 41

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610227	Rocker Assembly Tool	4

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

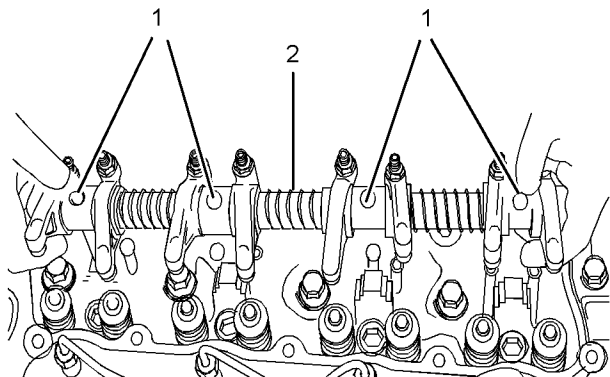


Illustration 140
Typical example

g01323013

1. Use Tooling (A) to progressively loosen torx screws (1). Begin at the ends of the rocker shaft assembly and work toward the center.
- Note:** To avoid distortion of the rocker shaft assembly, each torx screw should be loosened by a quarter of a turn at one time. Repeat the procedure until all torx screws are loosened.
2. Remove torx screws (1) from rocker shaft assembly (2).
 3. If the rocker shaft will not be disassembled, install Tooling (B) between each pair of rocker arms.
 4. Remove rocker shaft assembly (2) from the cylinder head.

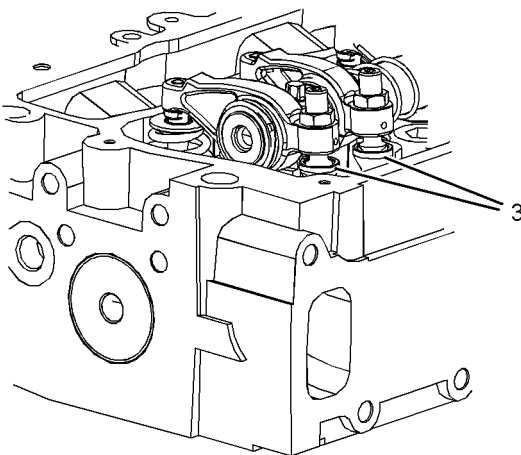


Illustration 141
Typical example

g01359104

5. Place an identification mark on pushrods (3) in order to show the location. Remove the pushrods from the cylinder head.

Note: Identification will ensure that the pushrods can be reinstalled in the original positions. Do not interchange the positions of used pushrods.

i02628903

Rocker Shaft - Disassemble

Disassembly Procedure

Table 42

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ 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. Make an identification mark on each rocker arm assembly in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

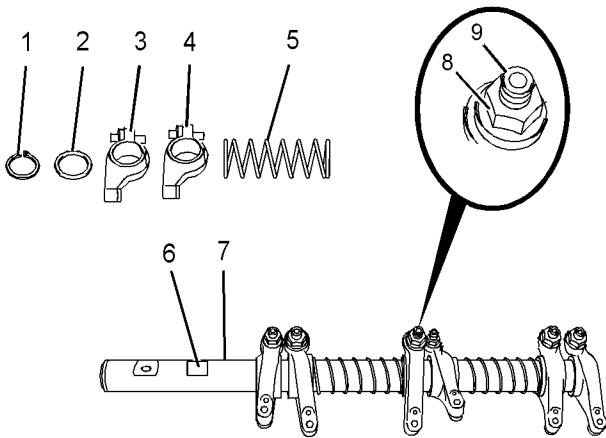


Illustration 142

g01350909

Typical example

2. Use Tooling (A) to remove circlip (1) and remove washer (2) from both ends of the rocker shaft assembly.

Note: The rocker shaft (7) is not symmetrical as there is a machined flat (6) toward one end of the shaft.

3. Remove rocker arm assembly (3) for the inlet valve from rocker shaft (7). Remove rocker arm assembly (4) for the exhaust valve from rocker shaft (7).
4. Remove spring (5) from rocker shaft (7).
5. Repeat Step3 and Step4 in order to completely disassemble the rocker shaft assembly.

6. If necessary, remove nuts (8) and adjusters (9) from the rocker arms. Make a temporary identification mark on each adjuster in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

i02628901

Rocker Shaft - Assemble

Assembly Procedure

Table 43

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. Refer to Specifications, "Rocker Shaft" for more information. If necessary, replace any components that are worn or damaged.

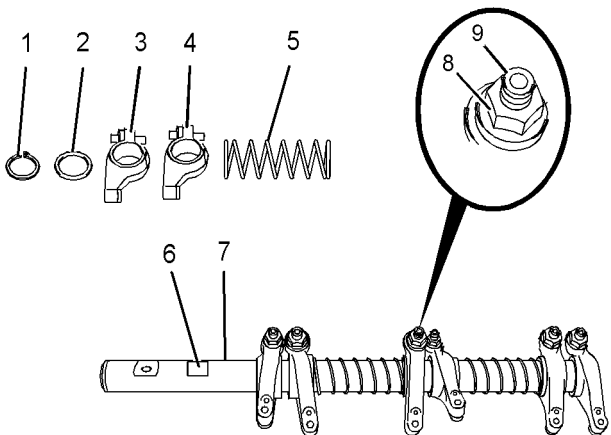


Illustration 143

g01350909

Typical example

2. If necessary, install adjusters (9) and nuts (8) to rocker arm assemblies (3) and (4). If the original adjusters are reused, ensure that the adjusters are installed in the original positions.
3. Use Tooling (A) to install circlip (1) and washer (2) to the front end of rocker shaft (7).
4. Lubricate the bores of rocker arm assemblies (3) and (4) and rocker shaft (7) with clean engine oil.
5. Install rocker arm assembly (3) for number 1 cylinder inlet valves to the rocker shaft. Install rocker arm assembly (4) for number 1 cylinder exhaust valves to rocker shaft (7).

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 spring (5) to rocker shaft (7).
7. Repeat Steps 5 to 6 in order to assemble the remaining components to rocker shaft (7).
8. Install washer (2) to rocker shaft (7). Use Tooling (A) to install circlip (1).

End By:

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

i02628904

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 44

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610227	Rocker Assembly Tool	4

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the pushrods. Inspect the pushrods for wear or damage. Replace any pushrods that are worn or damaged.

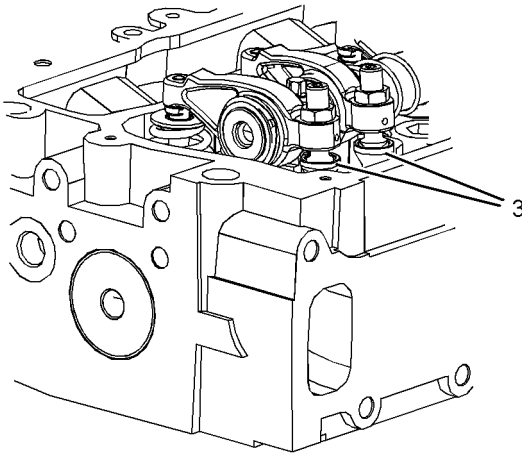


Illustration 144

g01359104

Typical example

2. Apply clean engine lubricating oil to both ends of pushrods (3). Install the pushrods to the engine with the cup upward.

Note: Ensure that the pushrods are installed in the original location and that the ball end of each pushrod is correctly seated in the valve lifters.

3. Ensure that the rocker shaft assembly is clean and free from wear or damage.
4. If the rocker shaft assembly was disassembled, install Tooling (B) between each pair of rocker arms.

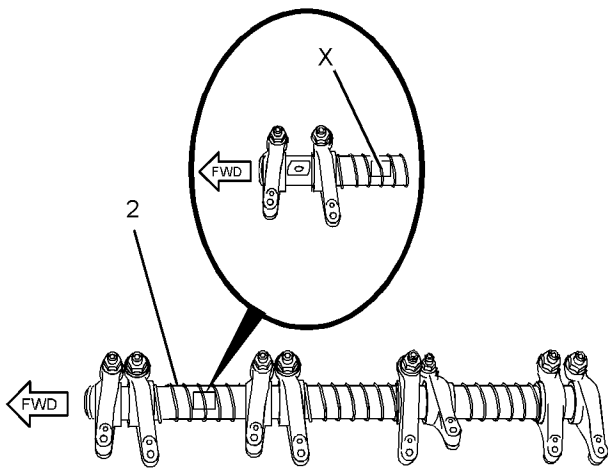


Illustration 145
Typical example

g01323445

5. Ensure that the machined flat (X) is facing upward, and facing the front end of the engine.

6. Position rocker shaft assembly (2) onto the cylinder head.

Note: Ensure that adjustment screws are properly seated in the ends of pushrods (3).

7. Install torx screws (1) to the rocker shaft assembly finger tight.

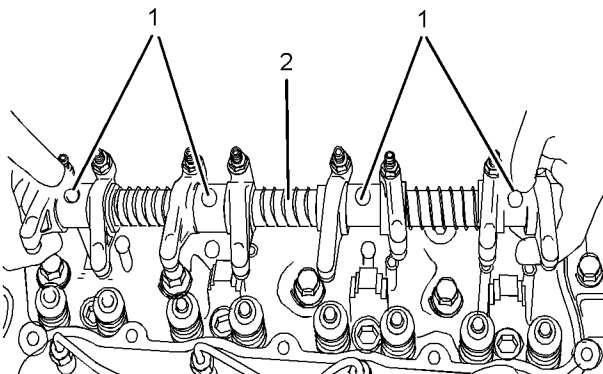


Illustration 146
Typical example

g01323447

8. Use Tooling (A) to progressively tighten torx screws (1). Begin at the center of the rocker shaft assembly and work toward the ends.

Note: To avoid distortion of the rocker shaft assembly, each torx screw should be tightened by a quarter of a turn at one time. Repeat the procedure until all torx screws are tightened.

Tighten torx screws (1) to a torque of 35 N·m (26 lb ft).

9. Check the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust". If necessary, adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust" for the correct procedure.

End By:

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

i02628830

Cylinder Head - Remove

Removal Procedure

Start By:

- Remove the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- Remove the injectors. Refer to Disassembly and Assembly, "Injector - Remove".
- Remove the rocker shaft assembly and the pushrods. Refer to this Disassembly and Assembly Manual, "Rocker Shaft and Pushrod - Remove".
- Remove the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

1. If the alternator bracket is mounted on the cylinder head, remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
2. If the fuel priming pump and the fuel filter base are mounted on the cylinder head, remove the fuel priming pump and the fuel filter base. Refer to Disassembly and Assembly, "Fuel Priming Pump and Fuel Filter Base - Remove and Install".
3. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
4. Disconnect the upper radiator hose from the water temperature regulator housing.
5. If necessary, remove the air hose from the inlet connection.

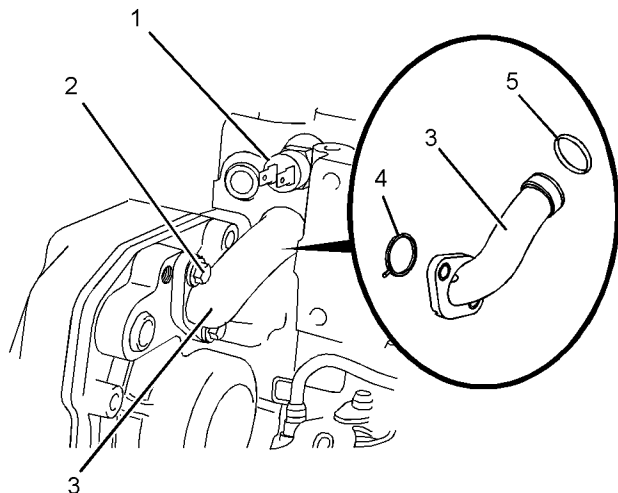


Illustration 147

g01344073

6. Disconnect the harness assembly from sensor (1).
7. Remove the bolts (2). Remove the bypass tube (3) from the cylinder head. Remove O-ring seals (4) and (5).

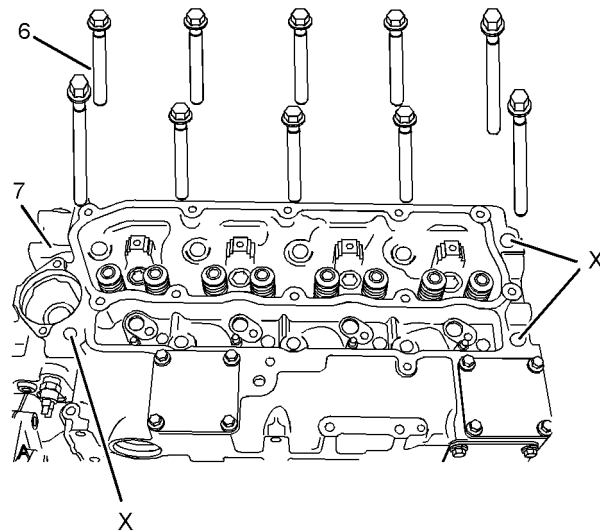


Illustration 148

g01323622

Typical example

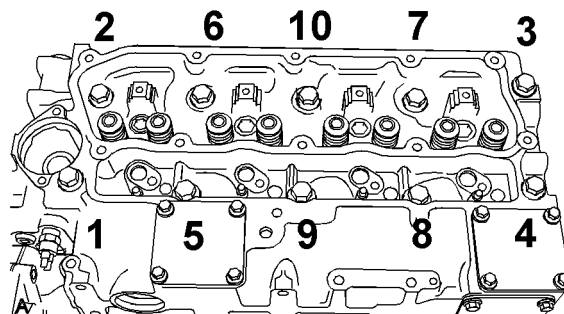


Illustration 149

g01352264

Sequence for tightening the bolts for the cylinder head

8. Gradually loosen bolts (6) in the reverse numerical order to the sequence that is shown in Illustration 149.

Note: Follow the correct sequence in order to help prevent distortion of the cylinder head.

9. Remove bolts (6) from cylinder head (7).

Note: The bolts are two different lengths. Note the positions of the different bolts.

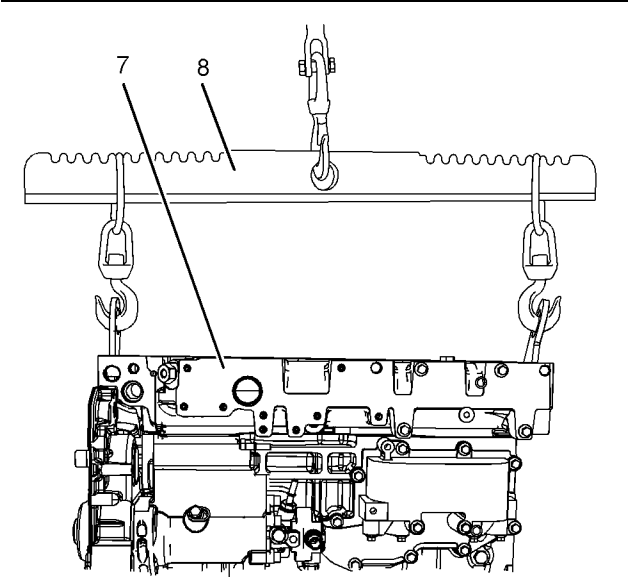


Illustration 150
Typical example

10. Attach a suitable lifting device (8) to cylinder head (7). Support the weight of the cylinder head. The weight of the cylinder head is approximately 56 kg (124 lb).

Note: It is advisable to use a spreader bar during the lifting operation in order to distribute the weight of the cylinder head .

11. Use lifting device (8) to carefully lift cylinder head (7) off the cylinder block.

Note: Do not use a lever to separate the cylinder head from the cylinder block. Take care not to damage the machined surfaces of the cylinder head during the removal procedure.

NOTICE

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

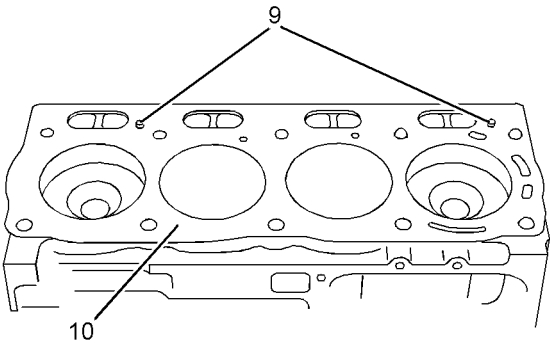


Illustration 151
Typical example

12. Remove cylinder head gasket (10).

13. Note the position of dowels (9) in the cylinder block. Do not remove the dowels unless the dowels are damaged.

14. If necessary, remove the sensor from cylinder head.

15. If necessary, remove the water temperature regulator from the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".

i02628829

Cylinder Head - Install

Installation Procedure

Table 45

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M16 by 115mm)	2
B	-	Straight Edge	1
C	21825607	Degree Wheel	1
D	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean the mating surfaces of the cylinder head and the cylinder block. Do not damage the mating surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.
2. Inspect the mating surface of the cylinder head for distortion. Refer to Specifications, "Cylinder Head" for more information.

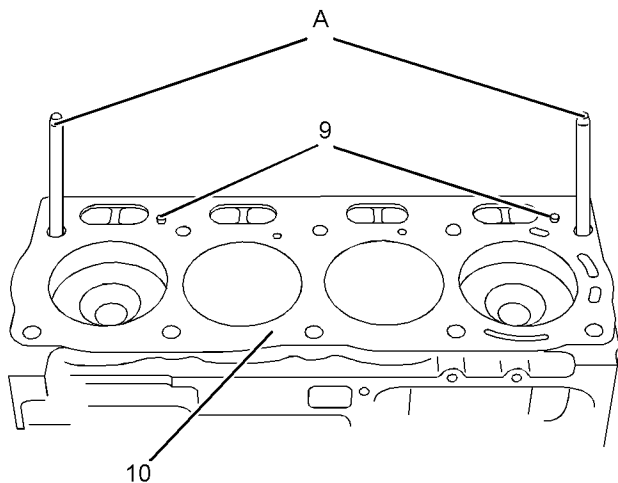


Illustration 152

g01324063

Typical example

3. Inspect dowels (9) for damage. If necessary, replace the dowels in the cylinder block.
4. Install Tooling (A) to the cylinder block. Refer to Illustration 152.
5. Align cylinder head gasket (10) with Tooling (A) and with dowels (9). Install the cylinder head gasket onto the cylinder block.

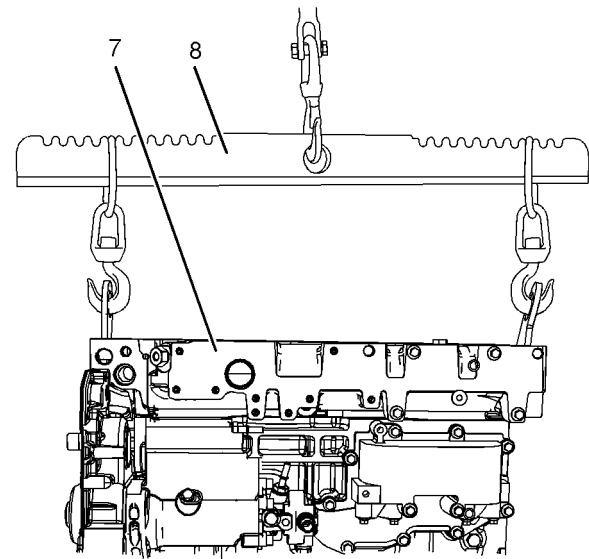


Illustration 153

g01323631

Typical example

6. Use a suitable lifting device (8) to lift the cylinder head. The weight of the cylinder head is approximately 56 kg (124 lb).

Note: It is advisable to use a spreader bar during the lifting operation in order to distribute the weight of the cylinder head.

7. Use Tooling (A) to align cylinder head (7) with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned onto dowels (9).

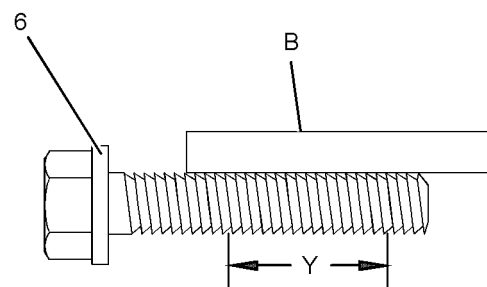


Illustration 154

g01324064

8. Clean bolts (6). Follow Steps 8.a and 8.b for the procedure to inspect the bolts.

- a. Check the length of the bolts.

- b. Use Tooling (B) in order to check the threads of the bolts. Refer to Illustration 154. Replace any bolts that show visual reduction in the diameter of the thread over length (Y).

9. Lubricate the threads and the shoulder of bolts (6) with clean engine oil.

10. Remove Tooling (A).

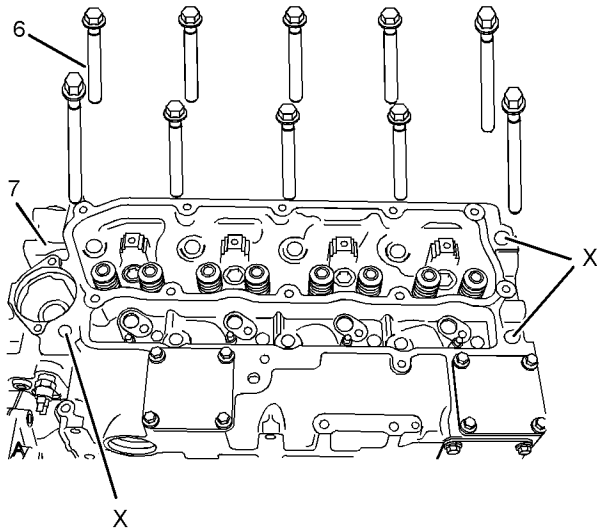


Illustration 155

g01323622

11. Install bolts (6) to cylinder head (7).

Note: There are two different lengths of bolts (6) for cylinder head (7). Install longer bolts in position (X) in the cylinder head.

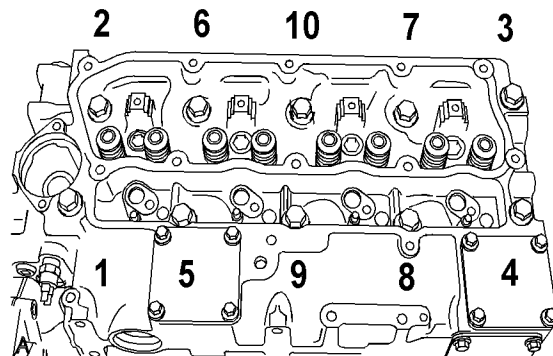


Illustration 156

g01352300

Sequence for tightening the bolts for cylinder head

12. Tighten bolts (6) to a torque of 50 N·m (37 lb ft) in the sequence that is shown in Illustration 156.

13. Tighten bolts (6) to a torque of 100 N·m (74 lb ft) in the sequence that is shown in Illustration 156.

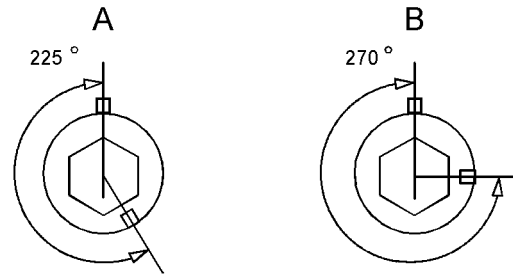


Illustration 157

g01352369

(A) Short bolts

(B) Long bolts

14. Use Tooling (C) to turn bolts (6) through an additional angle in the sequence that is shown in Illustration 156.

Turn the long bolts through 270 degrees.

Turn the short bolts through 225 degrees.

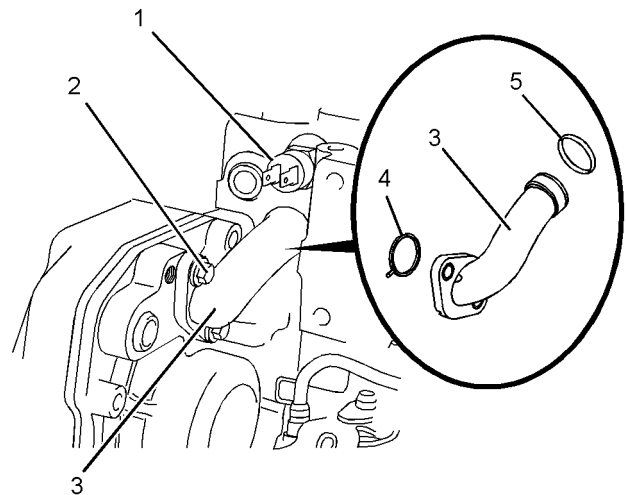


Illustration 158

g01344073

15. Install new O-ring seals (4) and (5) to bypass tube (3). Use Tooling (D) in order to lubricate the O-ring seal (5). Install the bypass tube to the cylinder head. Install bolts (2). Ensure that any brackets that are secured by the bolts are installed in the correct position. Tighten the bolts to a torque of 22 N·m (16 lb ft).

16. Connect the harness assembly to sensor (1).

17. If the alternator bracket is mounted on the cylinder head, install the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
18. Install the injectors. Refer to Disassembly and Assembly, "Injector - Install".
19. Install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".
20. If the fuel priming pump and the fuel filter base are mounted on the cylinder head, install the fuel priming pump and the fuel filter base. Refer to Disassembly and Assembly, "Fuel Priming Pump and Fuel Filter Base - Remove and Install".
21. Install the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
22. If necessary, install the air hose to the inlet connection.
23. If necessary, install the water temperature regulator housing to the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator Housing - Remove and Install".
24. Connect the upper radiator hose to the water temperature regulator housing .
25. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.
26. If necessary, fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".

i02628895

Lifter Group - Remove and Install

Removal Procedure

Table 46

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
B	-	Telescopic Magnet	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- b. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to lifters (1).

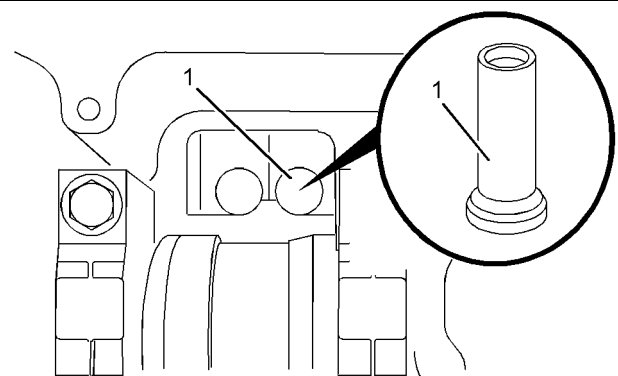


Illustration 159

g01340518

Typical example

2. Use Tooling (B) in order to remove lifters (1).

Note: Make a temporary identification mark on each lifter in order to identify the correct location.

3. Repeat Steps 1 and 2 in order to remove the remaining lifters.

Installation Procedure

Table 47

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
B	-	Telescopic Magnet	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

It is strongly recommended that all lifters should be replaced when a new camshaft is installed.

1. Clean the lifters. Follow Steps 1.a through 1.c in order to inspect the lifters. Replace lifters that are worn or damaged.
 - a. Inspect the seat of the pushrod in the lifter for visual wear or damage.
 - b. Inspect the shank of the lifter for wear or damage. Refer to Specifications, "Lifter Group" for more information.
 - c. Inspect the face of the lifter that runs on the camshaft for visual wear or damage.
2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft. Rotate the crankshaft to access to the cylinder block in order to install lifters (1).
3. Lubricate lifters (1) with clean engine oil.

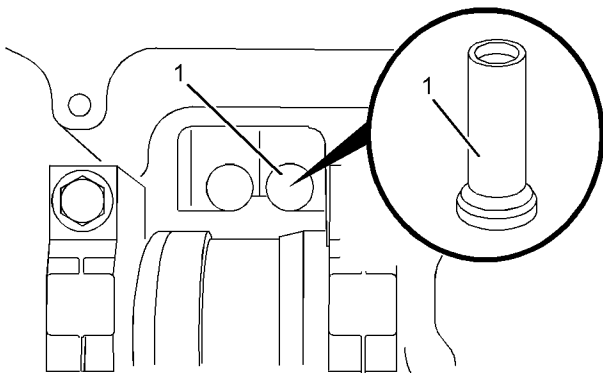


Illustration 160

g01340518

Typical example

4. Use Tooling (B) to install lifters (1) to the cylinder block. Ensure that used lifters are installed in the correct location.

Note: The lifters should be free to rotate.

5. Repeat Steps 1 and 4 in order to install the remaining lifters.

End By:

- a. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02628809

Camshaft - Remove and Install

Removal Procedure

Start By:

- a. Remove the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rocker shaft and Pushrod - Remove".
- b. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. The engine should be mounted on a suitable stand and placed in the inverted position.
-

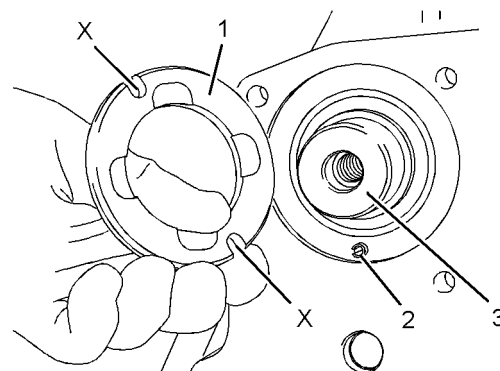


Illustration 161

g01266056

Typical example

2. Remove thrust washer (1) from the cylinder block. Do not remove dowel (2) from the cylinder block unless the dowel is damaged.

Note: The thrust washer can have one or two slots (X).

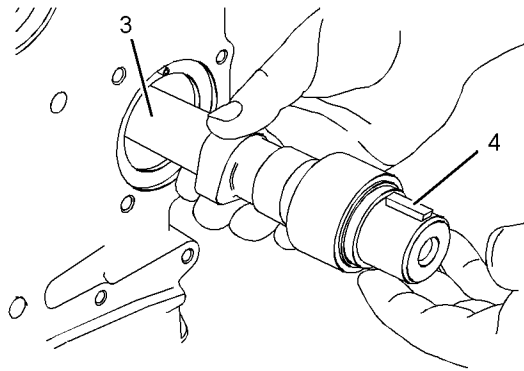


Illustration 162

g01266057

NOTICE

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

3. Carefully remove camshaft (3) from the cylinder block.
4. Do not remove key (4) from camshaft (3) unless the key is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the camshaft and the thrust washer. Inspect the camshaft and the thrust washer for wear and for damage. Refer to Specifications, "Camshaft" for more information. Replace any components that are worn or damaged.
2. Clean the camshaft bearing in the cylinder block. Inspect the camshaft bearing for wear and for damage. Refer to Specifications, "Camshaft Bearings" for more information. If necessary, replace the camshaft bearing. Refer to Disassembly and Assembly, "Camshaft Bearing - Remove and Install".

NOTICE

It is strongly recommended that all lifters should be replaced when a new camshaft is installed.

3. Inspect the lifters for wear and for damage. Refer to Specifications, "Lifter Group" for more information. Replace any worn lifters or any damaged lifters. Refer to Disassembly and Assembly, "Lifter Group - Remove and install".

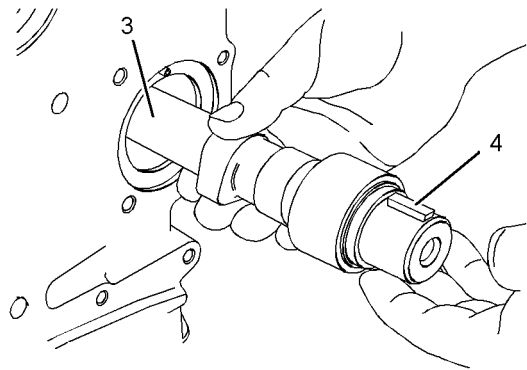


Illustration 163

g01266057

4. If necessary, install a new key (4) to camshaft (3).
5. Lubricate the bearing surfaces of camshaft (3) and lubricate the lobes of the camshaft with clean engine oil.

NOTICE

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

6. Carefully install camshaft (3) into the cylinder block.

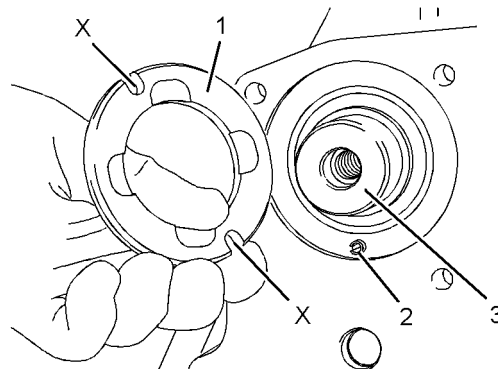


Illustration 164

g01266056

Typical example

7. Lubricate the thrust washer with clean engine oil. Align slot (X) in thrust washer (1) with dowel (2) in the cylinder block. Install thrust washer (1) into the recess in the cylinder block.

Note: The thrust washer can have one or two slots.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- b. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rocker shaft and Pushrod - Install".

i02628811

Camshaft Gear - Remove and Install

Removal Procedure

Table 48

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1

Start By:

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

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

- Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

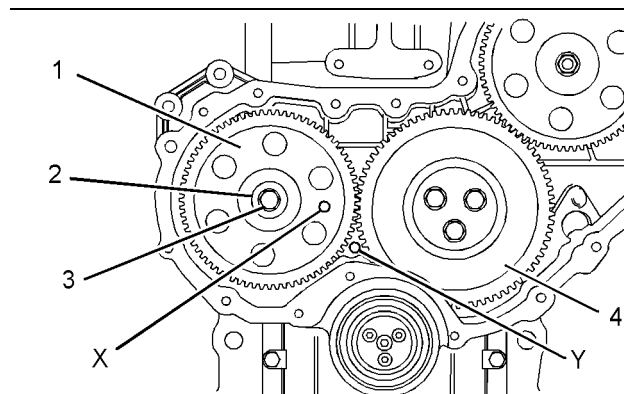


Illustration 165

g01255712

Typical example

- Install Tooling (B) through hole (X) in camshaft gear (1) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position.
- Install Tooling (C) into hole (Y) in the front housing. Use Tooling (C) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (C). Do not use Tooling (C) to hold the crankshaft during repairs.

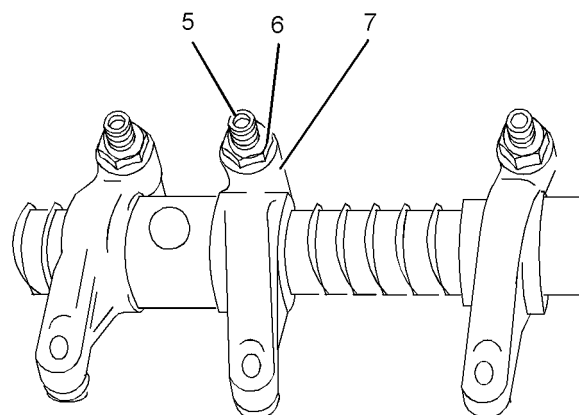


Illustration 166

g01350327

Typical example

- Loosen nuts (6) on ALL rocker arms (7). Unscrew adjusters (5) on all rocker arms (7) until all valves are fully closed.

Note: Failure to ensure that all adjusters are fully unscrewed can result in contact between the valves and pistons.

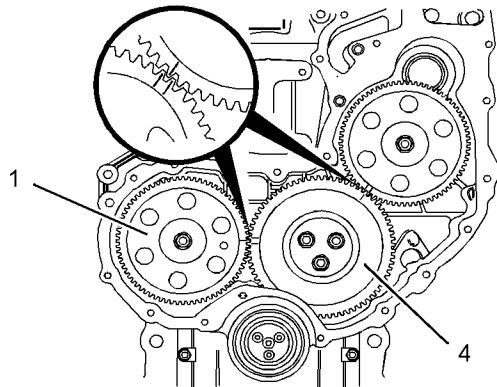


Illustration 167
Alignment of timing marks
g01344527

5. Mark gears (1) and (4) in order to show alignment. Refer to Illustration 167.

Note: Identification will ensure that the gears can be installed in the original alignment.

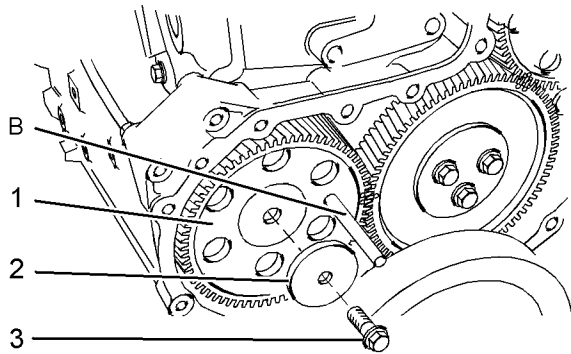


Illustration 168
Typical example
g01340554

6. Remove Tooling (B) and Tooling (C). Remove bolt (3) and washer (2) from camshaft gear (1).
7. Remove camshaft gear (1) from the camshaft.

Note: If the camshaft gear is a tight fit on the nose of the camshaft, use a prybar in order to remove the camshaft gear.

8. If necessary, remove the key from the nose of the camshaft.

Installation Procedure

Table 49

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610211	Crankshaft Timing Pin	1
D	21825617	Dial Indicator Group	1
	-	Finger Clock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

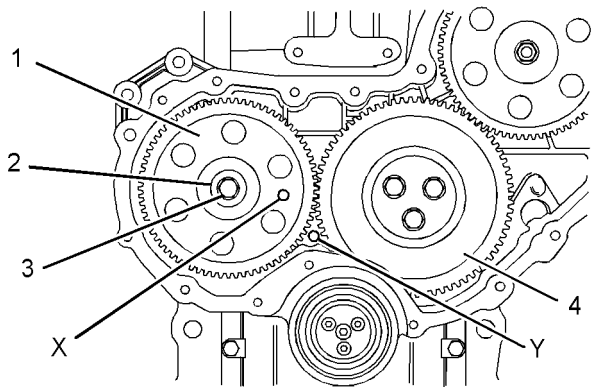


Illustration 169
Typical example
g01255712

2. Install Tooling (C) into hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".
3. Ensure that the camshaft gear and the key are clean and free from wear or damage.
4. If necessary, install the key into the nose of the camshaft.

Note: Ensure that the key is squarely seated.

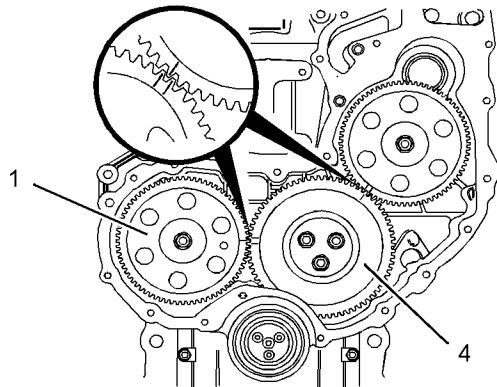


Illustration 170

g01344527

Alignment of timing marks

5. Align the keyway in camshaft gear (1) with the key in the camshaft. Install the camshaft gear onto the camshaft. Ensure that the timing marks on gears (1) and (8) are in alignment and that the mesh of the gears is correct. Refer to Illustration 170.

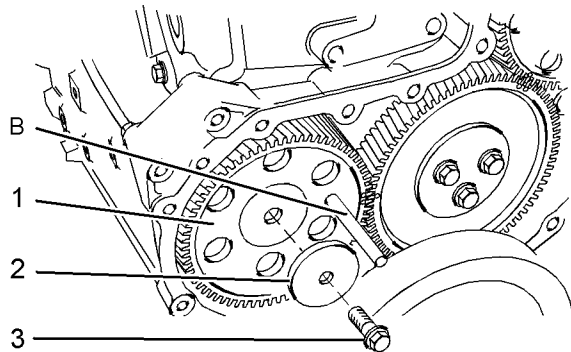


Illustration 171

g01340554

Typical example

6. Install Tooling (B) through hole (X) in the camshaft gear into the front housing. Install washer (2) and bolt (3) to camshaft gear (1).
7. Remove Tooling (B) and (C).
8. Tighten bolt (3) to a torque of 95 N·m (70 lb ft).
9. Use Tooling (D) to check the backlash for gears (1) and (8). Ensure that the backlash for the gears is within specified values. Refer to the Specifications, "Gear Group (Front)" for further information.
10. Use Tooling (D) to check the end play for camshaft gear (1). Ensure that the end play is within specified values. Refer to the Specifications, "Camshaft" for further information.
11. Lubricate the teeth of the gears with clean engine oil.

12. Adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".

End By:

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

i02628810

Camshaft Bearings - Remove and Install

Removal Procedure

Table 50

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610275	Bearing Puller Group	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- b. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

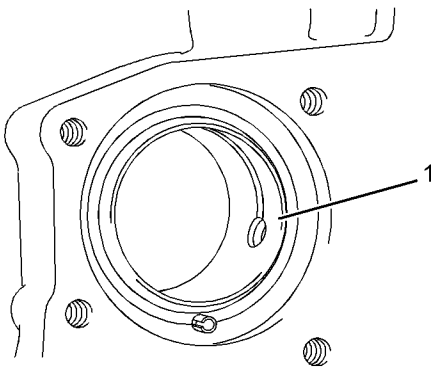


Illustration 172

g01270437

1. Inspect camshaft bearing (1). Refer to Specifications, “Camshaft Bearings” for more information.
2. If camshaft bearing (1) is worn or damaged use Tooling (A) in order to remove the camshaft bearing from the cylinder block.

Note: Remove the camshaft bearing from the front of the cylinder block.

Installation Procedure

Table 51

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610271	Bearing Puller Group	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bearing housing in the cylinder block. Ensure that the oil holes in the bearing housing are free from debris.

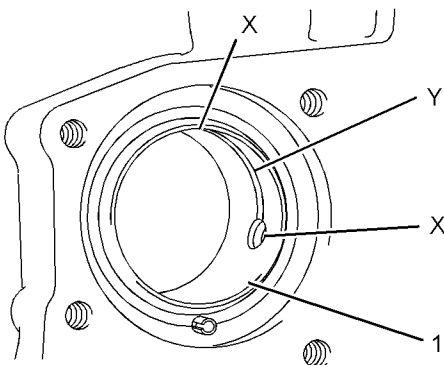


Illustration 173

g01266512

2. Lubricate the bearing housing in the cylinder block with clean engine oil.
3. Accurately align the two oil holes (X) in camshaft bearing (1) with the two oil holes in the cylinder block.

Note: The groove (Y) in the camshaft bearing must be to the top of the cylinder block.

4. Use Tooling (A) in order to install camshaft bearing (1) into the cylinder block. Install the camshaft bearing so that the front edge of the bearing is flush with the face of the recess in the cylinder block.

Note: Ensure that all oil holes are correctly aligned. If the oils are not correctly aligned, the camshaft bearing should be removed.

End By:

- a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install”.
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install”. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install”.

i02628836

Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

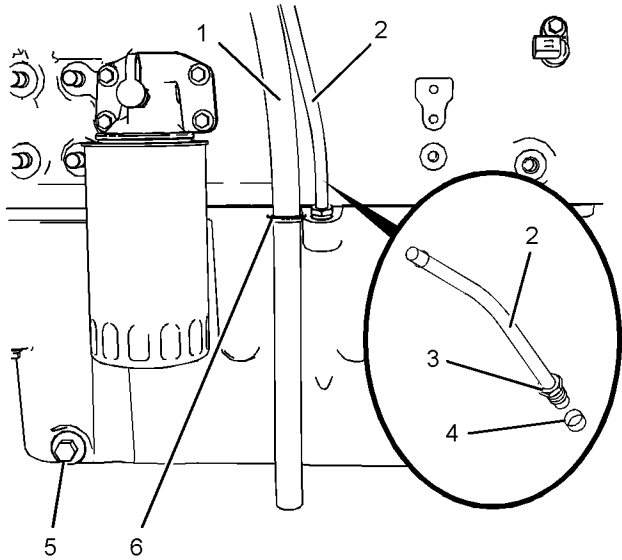


Illustration 174
Typical example

1. Place a suitable container below the engine oil pan. Remove drain plug (5) and drain the engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

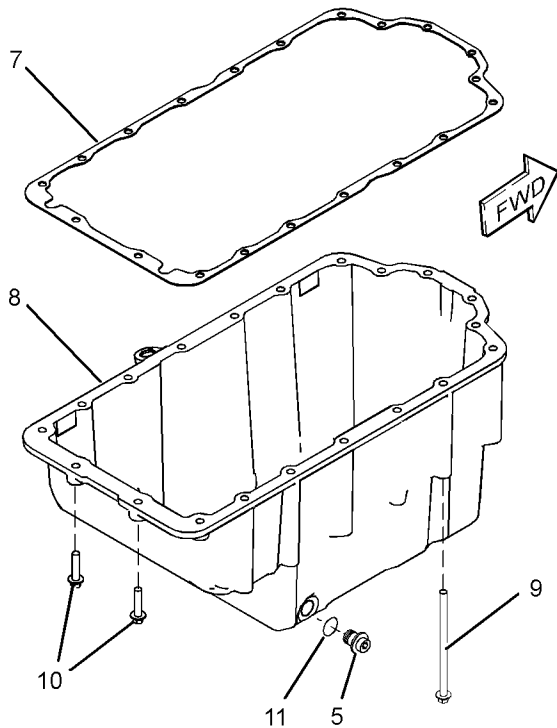


Illustration 175
Typical example

2. Remove O-ring seal (11) from drain plug (5).
 3. Disconnect breather hose (1) from clip (6). Position the breather hose away from the engine oil pan.
 4. If necessary, remove the assembly of dipstick tube. Loosen nut (3) and remove tube assembly (2). Remove seal (4) from the tube assembly.
- Note:** Identify the position and orientation of the tube assembly.
5. Support the assembly of the engine oil pan. Mark the position of clip (6). Loosen the bolt that secures the clip and remove the clip.
 6. Remove bolts (9) and (10).
 7. Remove engine oil pan (8) and remove joint (7) from the cylinder block.

Installation Procedure

Table 52

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M8 by 100 mm)	4
B	21826038	POWERPART Silicon Rubber Sealant	-
C	21820117	POWERPART Threadlock and Nutlock	-

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the mating surface of the cylinder block is clean and free from damage.

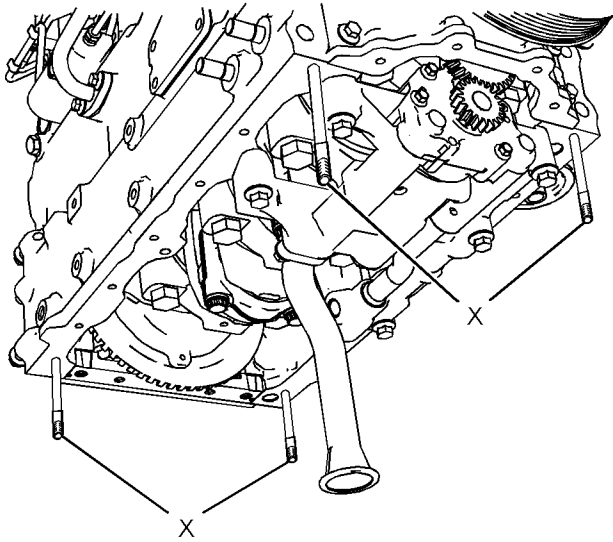


Illustration 176

g01251768

Typical example

2. Install Tooling (A) to positions (X) in the cylinder block.
3. Ensure that the engine oil pan is clean and free from damage.

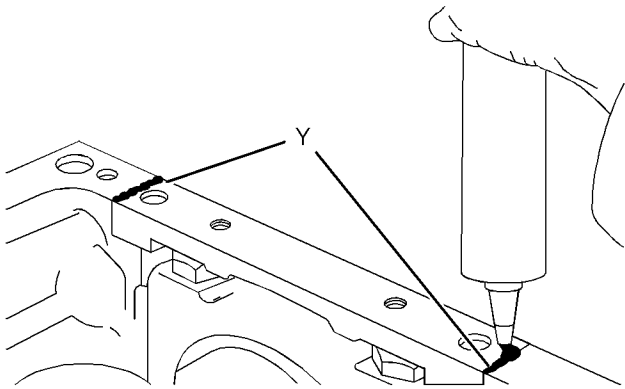


Illustration 177

g01251763

Typical example

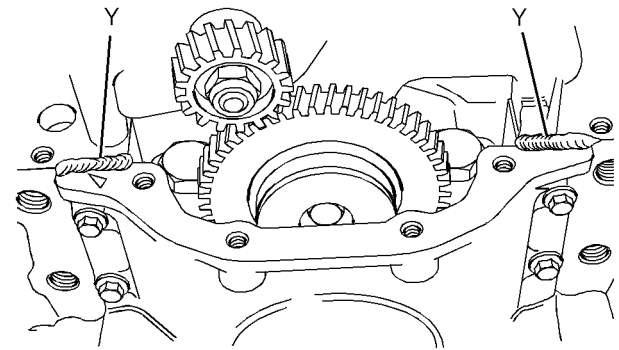


Illustration 178

g01251766

Typical example

4. Apply a bead of Tooling (B) to positions (Y) on the cylinder block.

Note: If the bridge piece for the cylinder block has just been installed, the engine oil pan must be installed before Tooling (B) has cured.

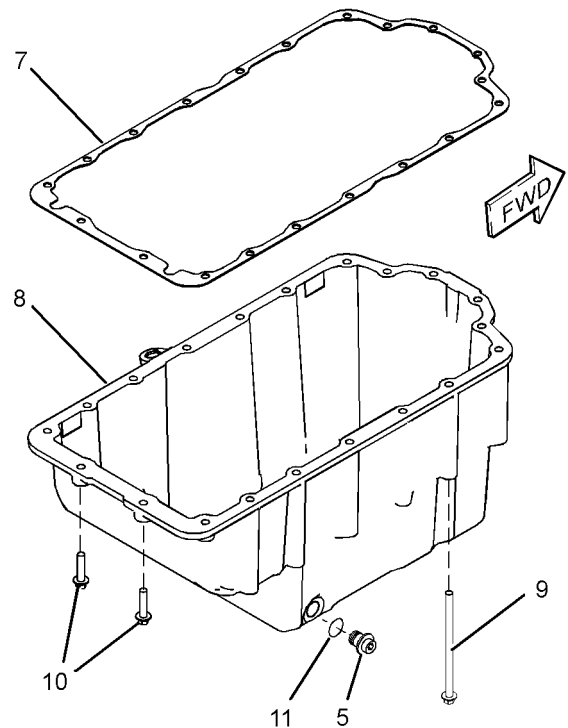


Illustration 179

g01251767

Typical example

5. Position a new joint (7) onto engine oil pan (8).

i02628835

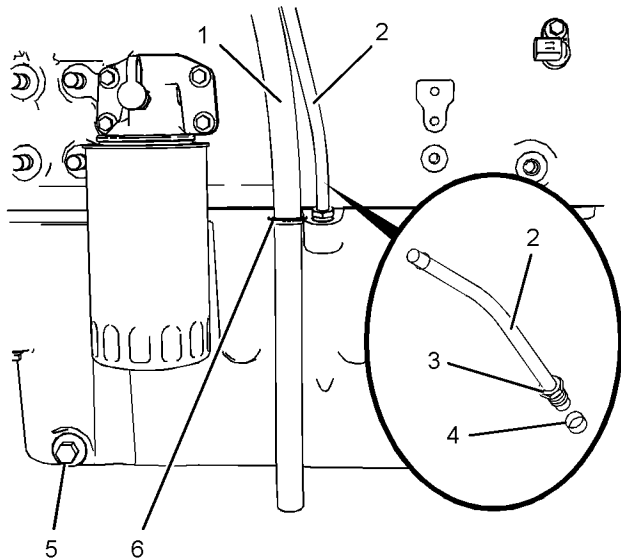


Illustration 180
Typical example g01344541

6. Align the assembly of the engine oil pan with Tooling (A). Install the assembly of the engine oil pan to the cylinder block.
7. Install bolts (9) finger tight. Install clip (6) in the correct position.
8. Remove Tooling (A).
9. Apply Tooling (C) to bolts (10). Install bolts (10) and the remaining bolts (9).
10. Tighten bolts (9) and (10) to a torque of 22 N·m (16 lb ft).
11. Install a new O-ring seal (11) to drain plug (5). Install the drain plug to engine oil pan (8). Tighten the oil drain plug to a torque of 34 N·m (25 lb ft).
12. If necessary, follow Steps 12.a through 12.c in order to install the assembly of the dipstick tube.
 - a. Install a new seal (4) to tube assembly (2).
 - b. Apply Tooling (C) to nut (3). Install the tube assembly to the engine oil pan.

Note: Ensure that the orientation of the tube assembly is correct.

- c. Tighten nut (3) to a torque of 18 N·m (13 lb ft). Install the dipstick.
13. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the procedure.

Engine Oil Pan - Remove and Install (Cast Iron Oil Pan)

Removal Procedure

Note: In order to remove a cast iron oil pan, the engine must be removed from the machine. Ensure that the engine lubricating oil is drained. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. The engine should be mounted in a suitable stand and placed in the inverted position.

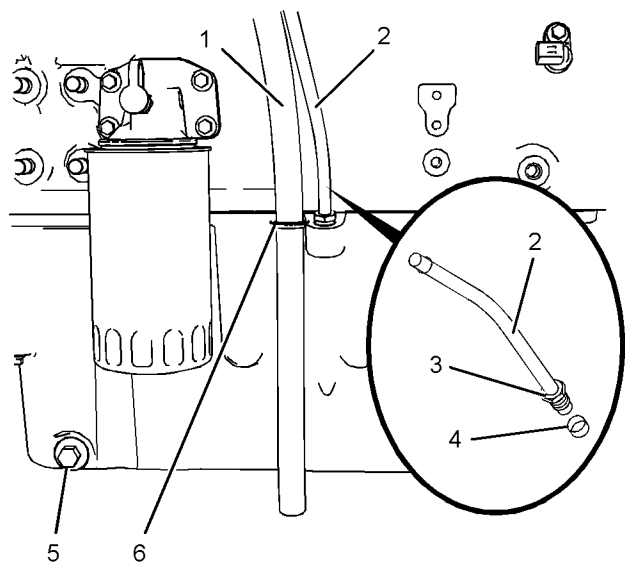


Illustration 181

g01344541

Typical example

2. Disconnect breather hose (1) from clip (6). Position the breather hose away from the engine oil pan.

Note: Identify the position and orientation of the tube assembly before removal.

3. Remove the assembly of the dipstick tube. Loosen nut (3) and remove tube assembly (2). Remove seal (4) from the tube assembly.

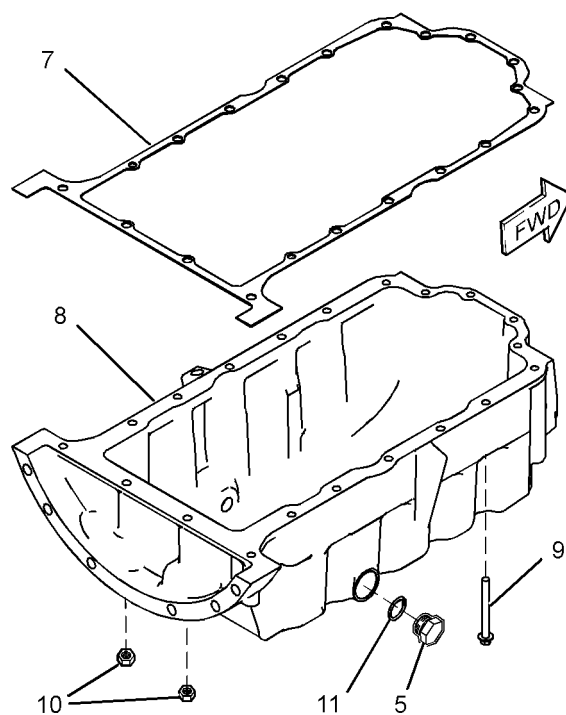


Illustration 182

g01251978

Typical example

4. Mark the position of clip (6). Refer to Illustration 181. Loosen the bolt that secures the clip and remove the clip.
 5. Remove nuts (10) and bolts (9).
- Note:** The bolts are different lengths. Note the position of the different bolts.
6. Attach a suitable lifting device to engine oil pan (8). Support the weight of the engine oil pan. The engine oil pan weighs approximately 41 kg (90 lb).
 7. Use the lifting device to remove engine oil pan (8) from the cylinder block.
 8. Remove joint (7) from the cylinder block.
 9. If necessary, remove drain plug (5). Remove O-ring seal (11) from oil drain plug (5).

Installation Procedure

Table 53

Required Tools			
Tool	Part Number	Part Description	Qty
A	21826038	POWERPART Silicon Rubber Sealant	-
B	21820117	POWERPART Threadlock and Nutlock	-
C	-	Straight Edge	1

Note: In order to install a cast iron oil pan, the engine must be removed from the machine.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the mating surface of the cylinder block is clean and free from damage. Inspect the studs in the cylinder block for damage. If necessary, replace the studs.
2. Ensure that the engine oil pan is clean and free from damage.

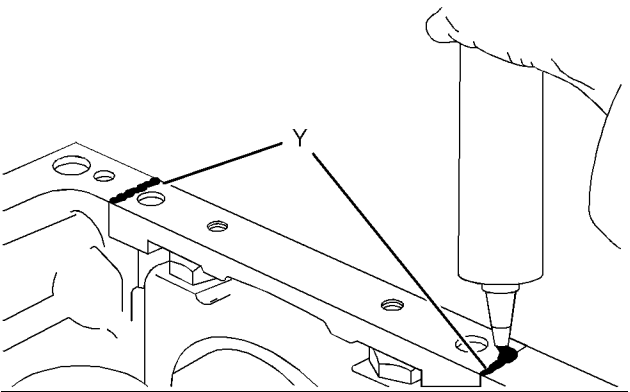


Illustration 183

Typical example

g01251763

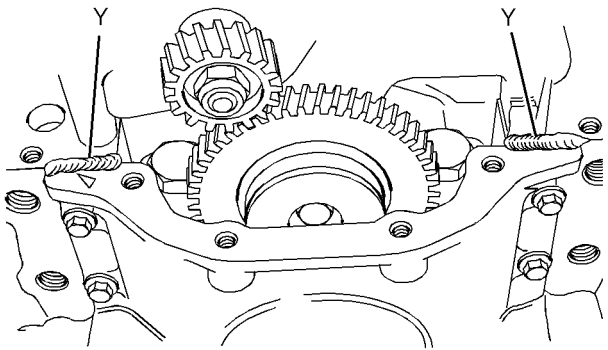


Illustration 184

Typical example

g01251766

3. Apply a bead of Tooling (A) to positions (Y) on the cylinder block.

Note: If the bridge piece for the cylinder block has just been installed, the engine oil pan must be installed before Tooling (A) has cured.

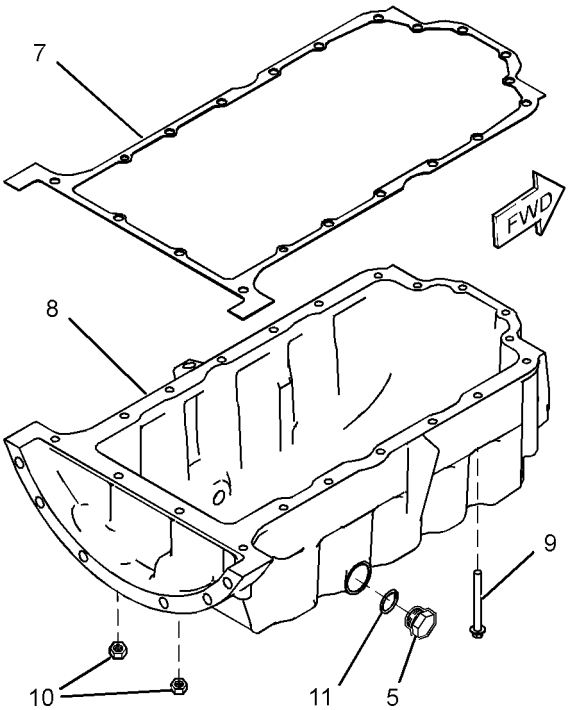


Illustration 185

Typical example

g01251978

4. Align a new joint (7) with the studs in the cylinder block. Install the joint to the cylinder block.
5. Attach a suitable lifting device to engine oil pan (8). The engine oil pan weighs approximately 41 kg (90 lb).

6. Use the lifting device to align engine oil pan (8) with the studs in the cylinder block. Install the engine oil pan to the cylinder block. Remove the lifting device from the engine oil pan.
7. Install bolts (9) and nuts (10) finger tight. Install the clip (6).

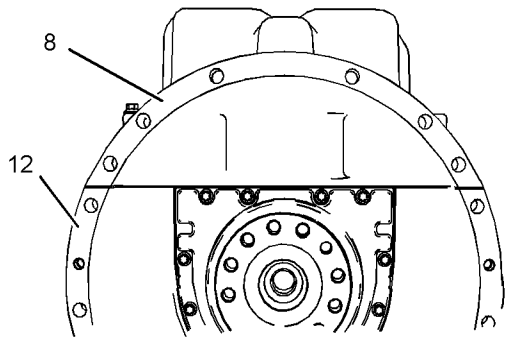


Illustration 186
Typical example

8. Align the rear face of engine oil pan (8) to the rear face of cylinder block (12). Use Tooling (C) and a feeler gauge in order to check the alignment between the engine oil pan and the cylinder block.
9. Tighten bolts (9) and nuts (10) to a torque of 22 N·m (16 lb ft).
10. If necessary, install a new O-ring seal (11) to drain plug (5). Install drain plug (5) to engine oil pan (8). Tighten the drain plug to a torque of 34 N·m (25 lb ft).

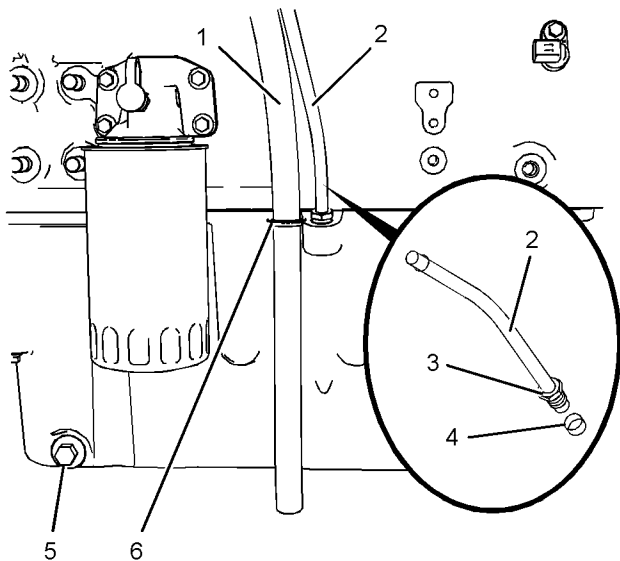


Illustration 187
Typical example

11. Follow Steps 11.a through 11.c in order to install the assembly of the dipstick tube.
- a. Install a new seal (4) to tube assembly (2).
- b. Apply Tooling (B) to nut (3). Install the tube assembly to the engine oil pan.

Note: Ensure that the orientation of the tube assembly is correct.

- c. Tighten the nut to a torque of 18 N·m (13 lb ft). Install the dipstick .

12. Install breather hose (1) to clip (6).

Note: After the engine has been installed, ensure that the engine oil pan is filled with lubricating oil to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for the correct procedure.

i02628808

Balancer - Remove

Removal Procedure

Table 54

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825576	Crankshaft Turning Tool	1
B	27610211	Crankshaft Timing Pin	1
C	27610225	Timing Pin (Balancer)	1
D	-	Puller (Two Leg)	1

Start By:

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

Note: In order to remove the balancer, the engine must be removed from the machine. The engine should be mounted in a suitable stand and placed in the inverted position.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position.

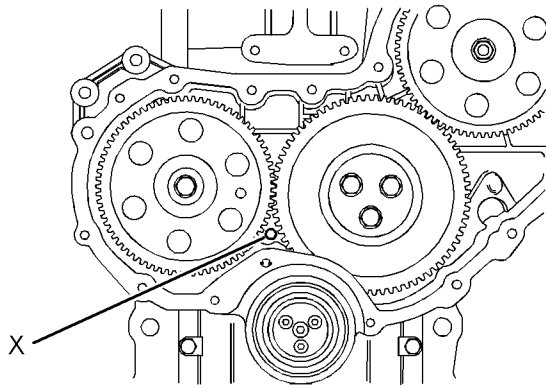


Illustration 188

g01259627

Typical example

2. Install Tooling (B) through hole (X) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

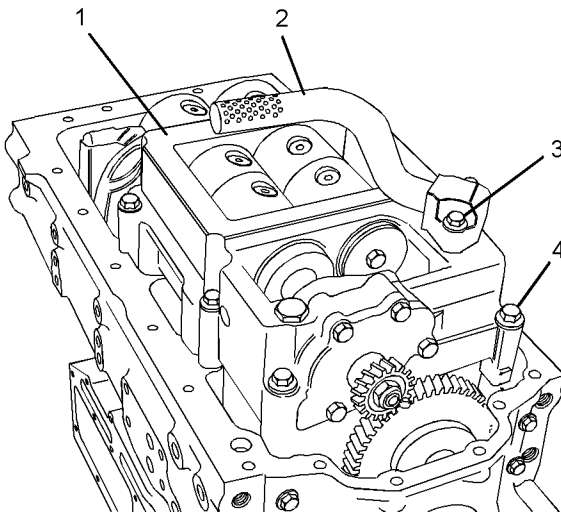


Illustration 189

g01259635

Typical example

3. Remove bolts (3) and suction pipe (2).
4. Remove the joint from the suction pipe.

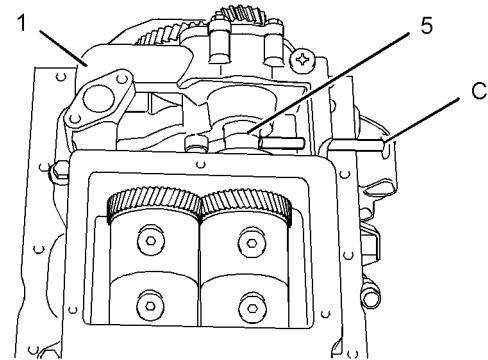


Illustration 190

g01252310

Typical example

5. Install Tooling (C) into balancer (1). Ensure that Tooling (C) is engaged into the hole in drive shaft (5).
6. Attach a suitable lifting device to balancer (1). Support the weight of the balancer. The balancer weighs approximately 23 kg (51 lb).
7. Remove bolts (4). Use the lifting device to remove the balancer.

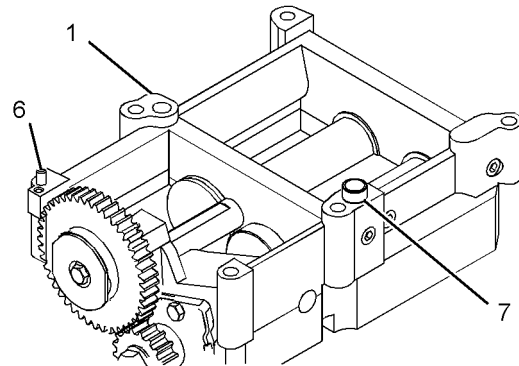


Illustration 191

g01259636

8. Do not remove dowels (6) and (7) unless the dowels are damaged.

Note: The balancer unit is not a serviceable item. The engine oil pump and the engine oil relief valve are the only serviceable parts of the balancer.

Disassembly Procedure

1. Remove the engine oil relief valve. Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install".

i02628805

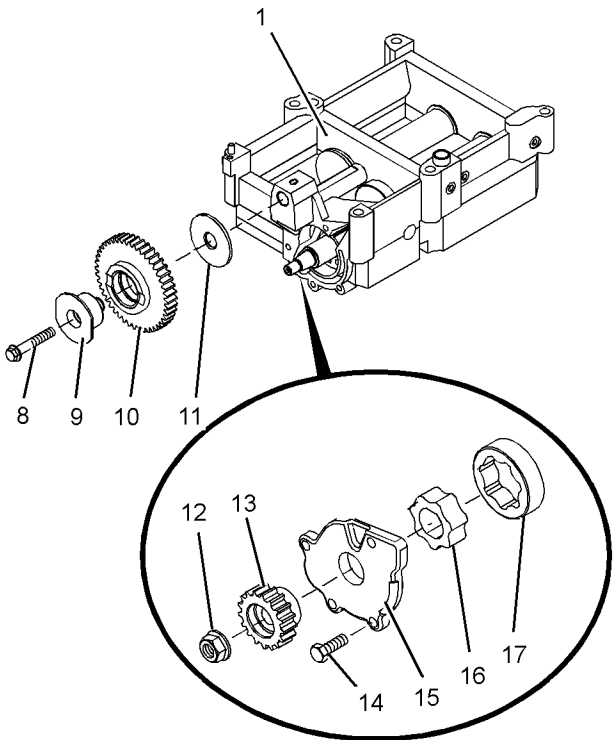


Illustration 192 g01344542

2. Remove bolt (8) and hub (9). Remove idler gear (10) and thrust washer (11).

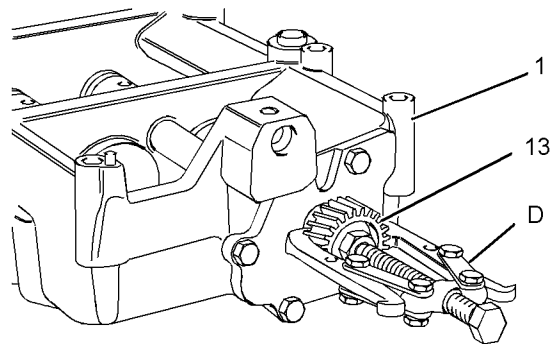


Illustration 193 g01259631

3. Remove nut (12). Use Tooling (D) in order to remove gear (13) from the shaft of the oil pump.

Note: Do not use a timing pin to lock the balancer in order to loosen nut (12).

4. Remove bolts (14) and remove front cover (15).

5. Remove outer rotor (17) and remove inner rotor (16).

Note: Mark the direction of rotation of the rotors.

Balancer - Install

Assembly Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
E	21820117	POWERPART Threadlock and Nutlock	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of the engine oil pump are clean and free from wear or damage.

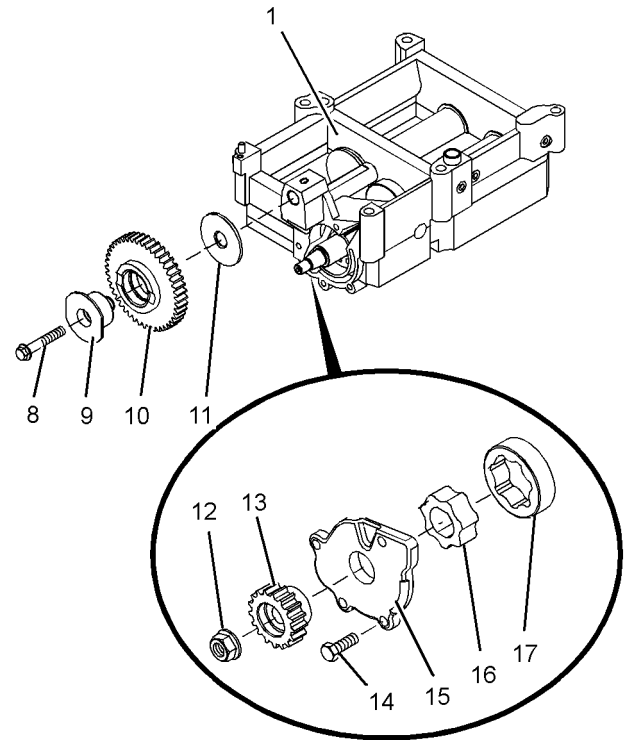


Illustration 194
Typical example

g01344542

2. Install inner rotor (16) and outer rotor (17). Used rotors should be installed in the original direction of rotation. Check the clearance between the outer rotor and the body of the oil pump. Check the clearance between the inner rotor and the outer rotor. Check the end play of the rotor assembly. Refer to Specifications, "Engine Oil Pump" for more information.
3. Lubricate the assembly of the oil pump with clean engine oil. Install front cover (15). Install bolts (14). Tighten the bolts to a torque of 26 N·m (19 lb ft).
4. Ensure that the shaft of the oil pump is clean and dry. Position gear (13) onto the shaft. Install nut (12). Tighten the nut to a torque of 95 N·m (70 lb ft).

Note: Do not use a timing pin to lock the balancer in order to tighten nut (12).

5. Lubricate hub (9), thrust washer (11) and the bush of idler gear (10) with clean engine oil. Install hub (9) and thrust washer (11) to idler gear (10).

Note: Ensure the correct orientation of the idler gear.

6. Install the assembly of the idler gear to balancer (1).
7. Ensure that the threads of bolt (8) are clean and dry. Apply Tooling (E) to the threads of the bolt. Install bolt (8). Tighten the bolt to a torque of 26 N·m (19 lb ft).
8. Check the end play of idler gear (10). Refer to Specifications, "Engine Oil Pump".
9. Install the engine oil relief valve . Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install" for further information.

Installation Procedure

Table 56

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610211	Crankshaft Timing Pin	1
C	27610225	Timing Pin (Balancer)	1
F	21825617	Dial Indicator Group	1
	-	Finger Clock	1
G	-	Guide Studs (M10 by 75 mm)	1

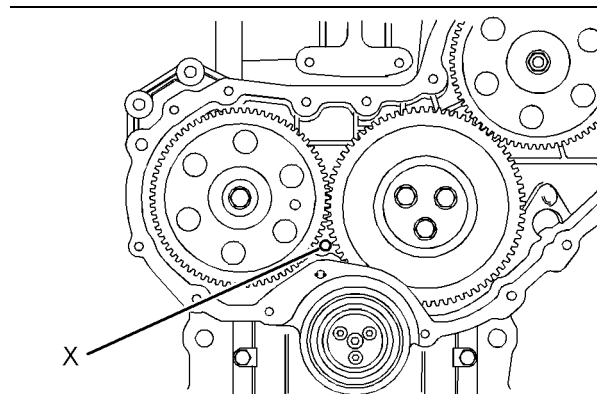


Illustration 195

g01259627

1. Ensure that No. 1 piston is at the top center position and that Tooling (B) is installed to position (X) in the front housing.

2. Clean the mating surfaces of the cylinder block.

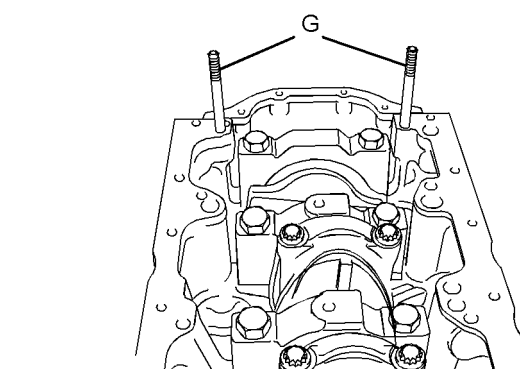


Illustration 196

g01252312

3. Install Tooling (G) to the cylinder block.

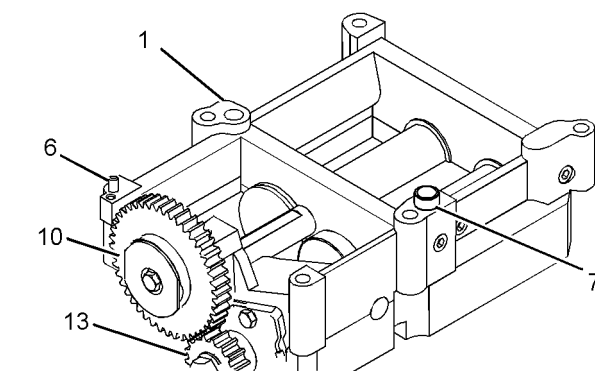


Illustration 197

g01260306

4. Ensure that dowels (6) and (7) are seated in the housing of balancer (1).

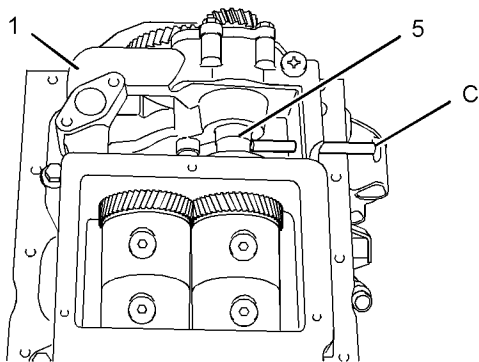


Illustration 198

g01252310

5. Install Tooling (C) to balancer (1). Ensure that Tooling (C) is engaged into shaft (5).
6. Attach a suitable lifting device to the balancer. The balancer weighs approximately 23 kg (51 lb).
7. Use the lifting device to align balancer (1) with Tooling (G). Install the balancer to the cylinder block. Ensure that dowels (6) and (7) are aligned with the holes in the cylinder block. Ensure that gear (10) and the crankshaft gear mesh. Remove the lifting device.

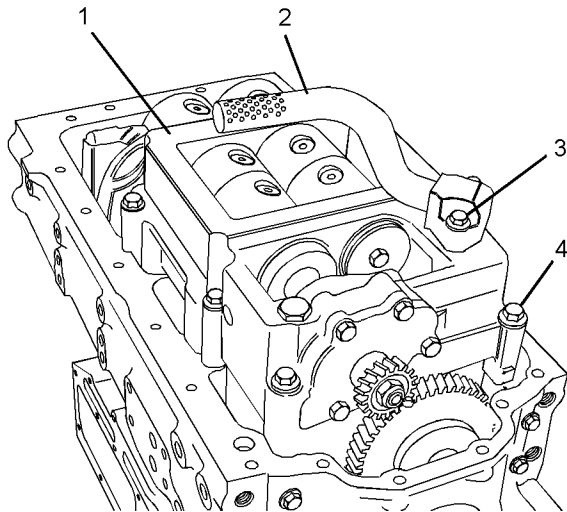


Illustration 199

g01259635

8. Install bolts (4) to balancer (1) finger tight.
9. Remove the Tooling (G) and install the remaining bolts (4). Tighten the bolts to a torque of 54 N·m (40 lb ft).
10. Remove the Tooling (B) and (C).
11. Install suction pipe (2) and a new joint to balancer (1).

12. Install bolts (3). Tighten the bolts to a torque to 22 N·m (16 lb ft).
13. Use Tooling (F) in order to check the backlash between gears (10) and (13). Refer to Illustration 197. Refer to Specifications, "Engine Oil Pump".
14. Use Tooling (F) in order to check the backlash between gear (10) and the crankshaft gear. Refer to Specifications, "Gear Group - Front" for further information.

End By:

- a. Install the engine oil pan. Refer to Disassembly and Assembly , "Engine Oil Pan - Remove and Install".
- b. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

i02628896

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 57

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to the piston cooling jet.

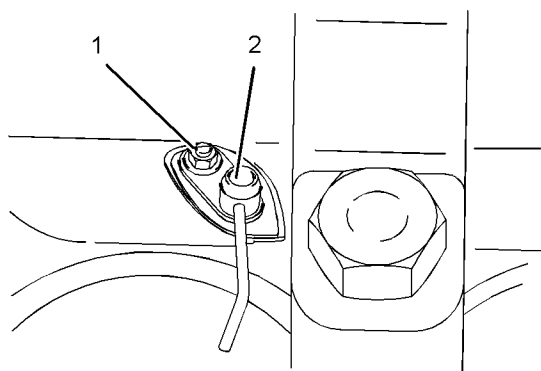


Illustration 200

g01265615

Typical example

2. Remove bolt (1) and piston cooling jet (2) from the cylinder block.
3. Repeat Steps 1 and 2 for the remaining piston cooling jets.

Installation Procedure

Table 58

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

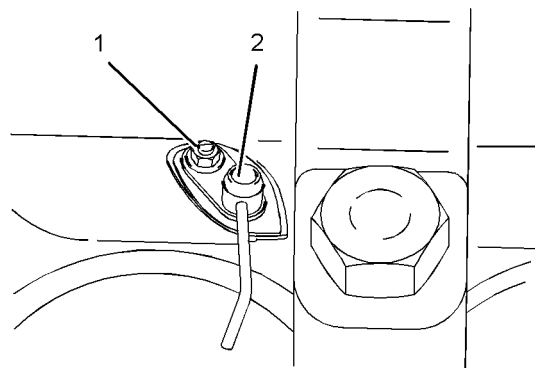


Illustration 201

g01265615

1. Clean the piston cooling jets and inspect the piston cooling jets for damage. Ensure that the valve is free to move within each piston cooling jet. Replace any damaged piston cooling jets.
2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to access the mounting flange for the piston cooling jet.
3. Position piston cooling jet (2) in the cylinder block. Install bolt (1). Tighten the bolt to a torque of 9 N·m (80 lb in).
4. Repeat Steps 2 through 3 for the remaining piston cooling jets.
5. If the cylinder head has been removed, It is possible to check the alignment of the piston cooling jets. Refer to Specifications, "Piston Cooling Jet Alignment" for more information.

Note: It is not possible to check the alignment of the piston cooling jets with the cylinder head in position.

End By:

- a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02628900

Pistons and Connecting Rods - Remove

Removal Procedure

Table 59

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610274	Ridge Reamer	1

Start By:

- Remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".
- If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- Remove the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- Use Tooling (A) to rotate the crankshaft until the crank pin is at the bottom center position.
- Use Tooling (B) to remove the carbon ridge from the top inside surface of the cylinder bore.

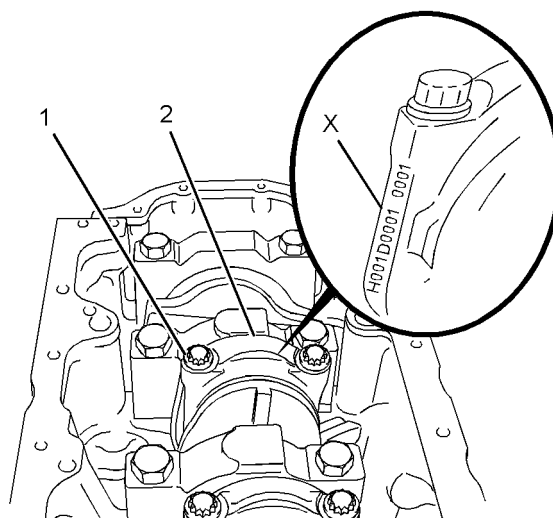


Illustration 202

g01344569

- The connecting rod and the connecting rod cap should have an etched number (X) on the side. The number on the connecting rod and the connecting rod cap must match. Ensure that the connecting rod and connecting rod cap (2) are marked for the correct location. If necessary, make a temporary mark on the connecting rod and the connecting rod cap in order to identify the cylinder number.

Note: Do not stamp the connecting rod assembly. Stamping or punching the connecting rod assembly could cause the connecting rod to fracture.

- Remove bolts (1) and remove connecting rod cap (2) from the connecting rod.

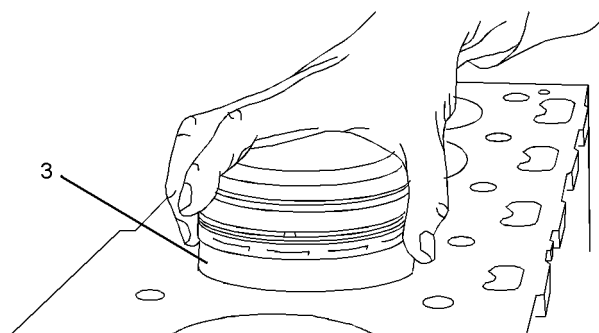


Illustration 203

g01244066

Typical example

- Carefully push piston (3) and the connecting rod assembly out of the cylinder bore. Lift the piston out of the top of the cylinder block.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result.

6. Temporarily install connecting rod cap (2) and bolts (1) to the connecting rod when the assembly is out of the engine. Tighten bolts (1) to a torque of 20 N·m (14 lb ft).

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. Ensure that the etched number on connecting rod cap matches the etched number on connecting rod. Ensure the correct orientation of the connecting rod cap.

7. Repeat Steps 1 through 5 for the remaining pistons and connecting rods.

i02628898

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 60

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	-	Piston Ring Expander	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Make a temporary mark on the components of the piston and connecting rod assembly. This will ensure that the components of each piston and connecting rod assembly can be reinstalled in the original cylinder. Mark the underside of the piston on the front pin boss. Do not interchange components.

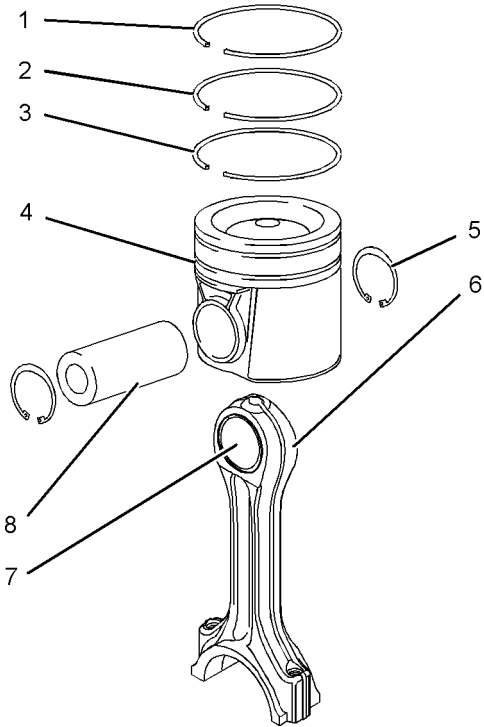


Illustration 204

g01244067

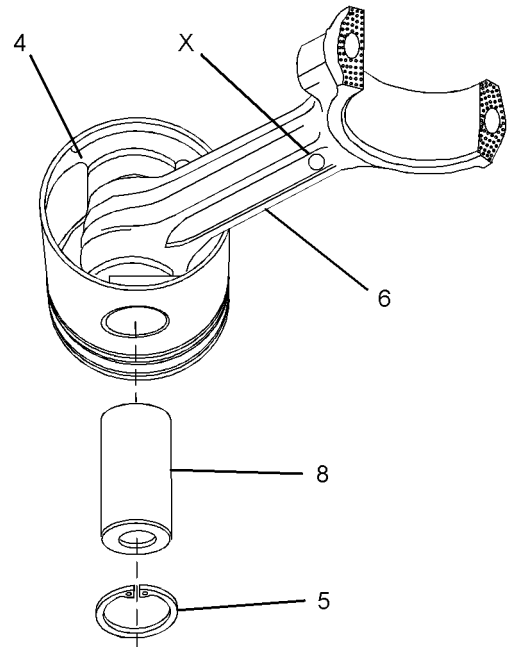


Illustration 205

g01253091

Typical example

2. Place the piston and connecting rod assembly on a suitable surface with the connecting rod upward. Use Tooling (A) in order to remove retaining rings(5).

Note: The forged marks (X) identify the front of the connecting rod assembly. The forged marks should be used for the purposes of orientation.

3. Remove piston pin (8) and connecting rod (6) from piston (4).

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of $45 \pm 5^\circ\text{C}$ ($113 \pm 9^\circ\text{F}$). Do not use a torch to heat the piston. Note the orientation of the connecting rod and the piston.

4. Place the piston on a suitable surface with the crown upward. Use Tooling (B) in order to remove compression rings (1) and (2), and oil control ring (3) from piston (4).

Note: Identify the position and orientation of compression rings (1) and (2), and oil control ring (3).

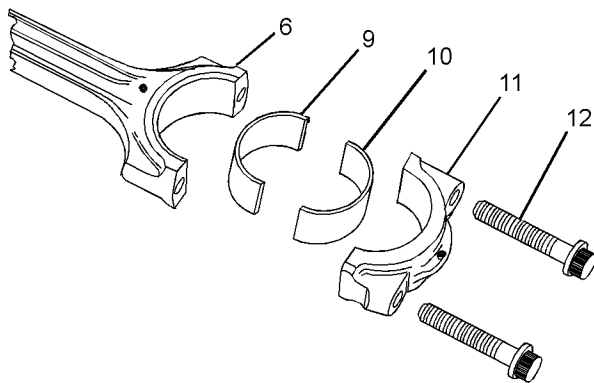


Illustration 206

g01244068

5. Remove bolts (12) and connecting rod cap (11) from connecting rod (6). Discard the bolts.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the disassembly procedure for the piston and connecting rod is completed, carry out the assembly procedure and the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Assemble" and Disassembly and Assembly, "Piston and Connecting Rods - Install".

6. Remove the lower half of connecting rod bearing (10) from connecting rod cap (11). Remove the upper half of connecting rod bearing (9) from connecting rod (6). Keep the bearing shells together.

NOTICE

Removal of the piston pin bushing in the connecting rod must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins distributor.

7. Inspect the connecting rod for wear or damage. If necessary, replace connecting rod (6) or replace bush (7) for the piston pin.

Note: If the connecting rod or the bush for the piston pin are replaced, first identify the height grade of the connecting rod. Refer to Specifications, "Connecting Rod".

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

i02628897

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 61

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	-	Piston Ring Expander	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.
2. If the original piston is assembled, follow Steps 2.a through 2.e in order to install the piston rings.
 - a. Position the spring for oil control ring (3) into the oil ring groove in piston (4). The central wire must be located inside the end of the spring.

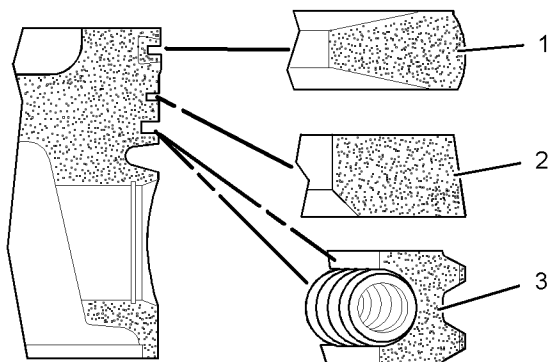


Illustration 207

g01155119

- b. Use Tooling (B) to install oil control ring (3) over the spring.

Note: Ensure that the central wire is 180 degrees from the ring gap.

- c. Use Tooling (B) to install intermediate compression ring (2) into the second groove in piston (4). The word "TOP" must be upward. The chamfer on the inner face must be downward.

- d. Use Tooling (B) to install top compression ring (1) into the top groove in piston (4). The word "TOP" must be upward.

- e. Position the piston ring gaps at 120 degrees away from each other.

Note: A new piston assembly is supplied with new piston rings.

NOTICE

Removal of the piston pin bushing in the connecting rod must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins distributor.

3. If the connecting rod assembly or the bush for the piston pin have been replaced, ensure that the height grade of the connecting rod is correct. Refer to Specifications, "Connecting Rod" for further information.

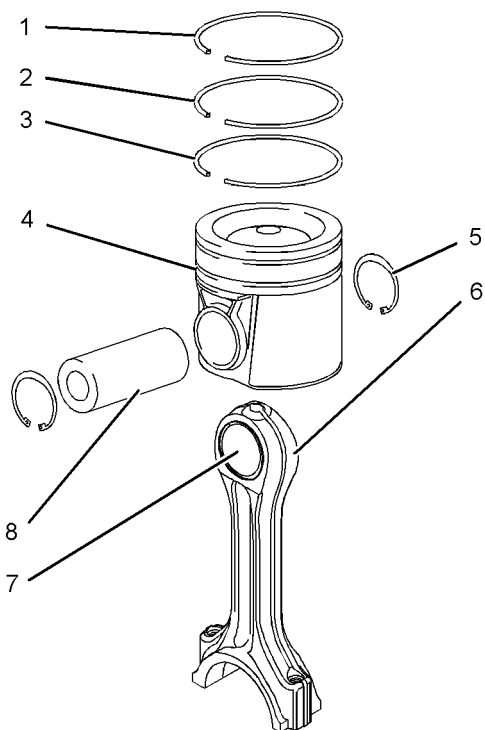


Illustration 208

g01244067

4. Lubricate bush (7) and lubricate the bore for the piston pin in piston (4) with clean engine oil.

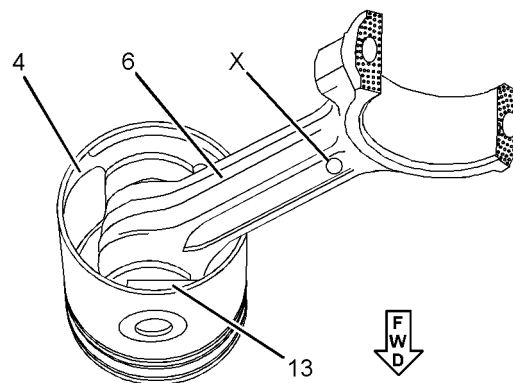


Illustration 209

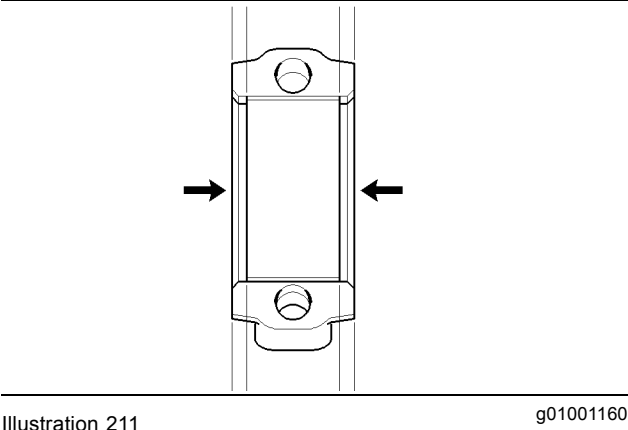
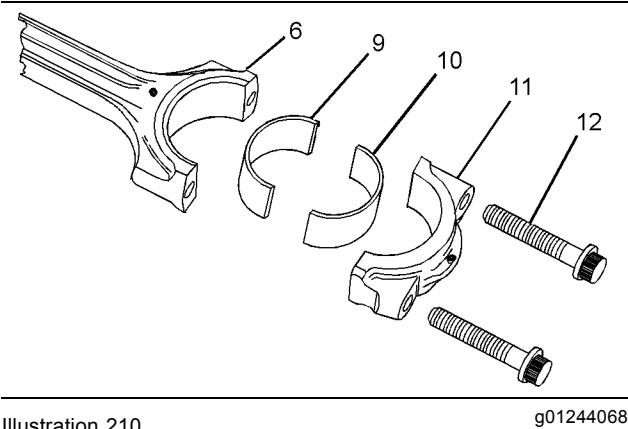
g01244172

5. Place the piston on a suitable surface with the crown downward. Install connecting rod (6) and piston pin (8) to piston (4). Ensure that square boss (13) on the piston, and forged mark (X) on the connecting rod are in the correct position. See illustration 209.

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of $45^{\circ} \pm 5^{\circ}\text{C}$ ($113^{\circ} \pm 9^{\circ}\text{F}$).

6. Use Tooling (A) in order to install retaining rings (5) to the piston pin bore in piston (4).

Note: Ensure that the retaining rings are seated in the grooves in the piston.



Aligning the connecting rod bearing in the center of the connecting rod

Note: New connecting rod bearings are supplied with an alignment tool. If new connecting rod bearings are installed, use the tool to align the bearing in the connecting rod.

7. Install the upper half of connecting rod bearing (9) to connecting rod (6). Ensure that the bearing is centralized in the connecting rod. Refer to Illustration 211.
8. Install the lower half of connecting rod bearing (10) to connecting rod cap (11). Ensure that the bearing is centralized in the connecting rod cap. Refer to Illustration 211.
9. Repeat Steps 2 through 8 for the remaining piston and connecting rod assemblies.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the assembly procedure for the piston and connecting rod is completed, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

End By:

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

i02628899

Pistons and Connecting Rods - Install

Installation Procedure

Table 62

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	21825491	Piston Ring Compressor	1
C	21825607	Angle gauge	1

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

1. If the connecting rod caps were temporarily installed, remove the connecting rod caps. If necessary, thoroughly clean all of the components.
2. Apply clean engine oil to the cylinder bore, to the piston rings, to the outer surface of the piston and to the connecting rod bearings.

Note: Install the connecting rod bearings dry when clearance checks are performed. Refer to Disassembly and Assembly, "Bearing Clearance - Check". Apply clean engine oil to the connecting rod bearings during final assembly.

3. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom center position. Lubricate the crankshaft pin with clean engine oil.

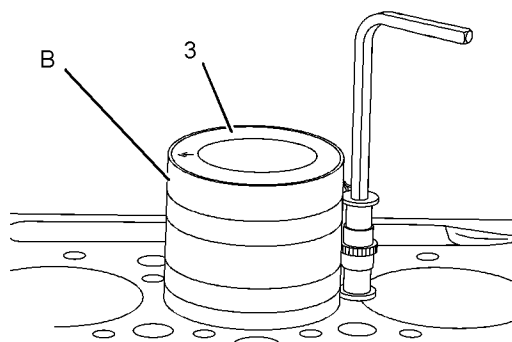


Illustration 212

g01253096

Typical example

4. Ensure that the gaps for the piston rings are at 120 degrees away from each other. Install Tooling (B) onto piston (3).

Note: Ensure that Tooling (B) is installed correctly and that the piston can easily slide from the tool. Ensure that the piston and the connecting rod assembly are installed in the correct cylinder. The arrow on the top of the piston must be toward the front of the engine.

5. Carefully push the piston and the connecting rod assembly into the cylinder bore and onto the crankshaft pin.

Note: Do not damage the finished surface of the crankshaft pin.

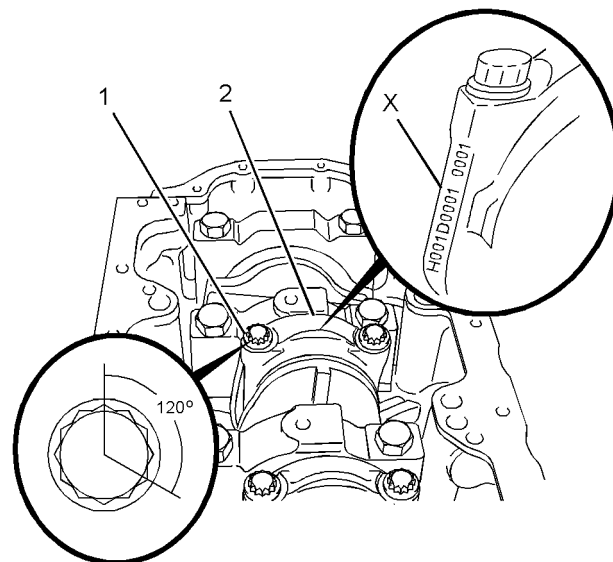


Illustration 213

g01344572

Typical example

6. Install connecting rod cap (2) onto the connecting rod.

Note: Ensure that etched number (X) on the connecting rod cap matches the etched number on the connecting rod. Ensure the correct orientation of connecting rod cap (2).

7. Install new bolts (1) to the connecting rod. Tighten the bolts evenly to a torque of 18 N·m (13 lb ft).
8. Tighten the bolts evenly to a torque of 70 N·m (52 lb ft).
9. Use Tooling (B) to turn the bolts through an additional 120 degrees.
10. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft in order to ensure that there is no binding.
11. Repeat Steps 2 through 10 in order to install the remaining pistons and connecting rods.

Note: If all pistons and connecting rods require replacement the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the pistons and connecting rods are installed before changing from one pair of cylinders to another pair of cylinders..**

12. Check the height of the pistons above the top face of the cylinder block. Refer to Systems Operation, Testing and Adjusting, "Piston Height - Inspect" for the correct procedure.

End By:

- a. Install the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- c. Install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".

i02628814

Connecting Rod Bearings - Remove (Connecting rods in position)

Removal Procedure

Table 63

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

Note: If all connecting rod bearings require replacement the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders.** Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

- 1. Use Tooling (A) to rotate the crankshaft until the crank pin is at the bottom center position.

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

Note: Removal of the glow plugs aids removal of the connecting rod bearings. It is not essential.

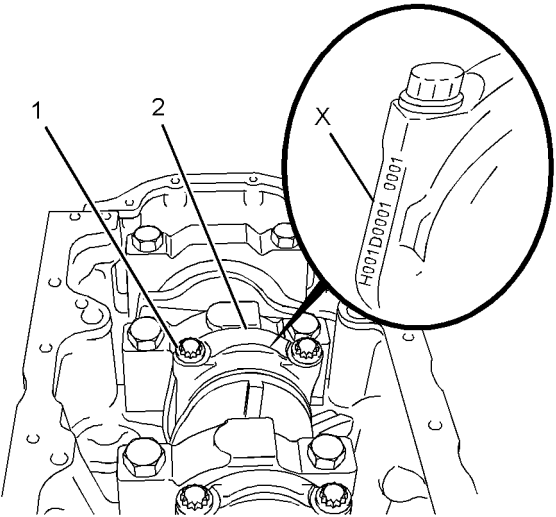


Illustration 214

g01344569

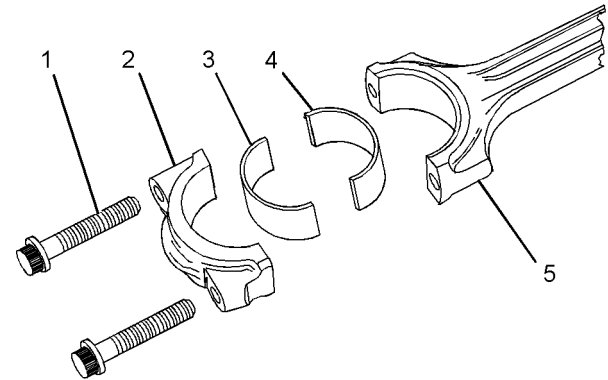


Illustration 215

g01253101

2. The connecting rod and the connecting rod cap should have an etched number (X) on the side. The number on the connecting rod and the connecting rod cap must match. If necessary, make a temporary mark on connecting rod (5) and connecting rod cap (2) in order to identify the cylinder number.

Note: Do not punch identification marks onto fracture split connecting rods. Do not stamp identification marks onto fracture split connecting rods.

3. Remove bolts (1) and connecting rod cap (2) from connecting rod (5). Discard the bolts.
4. Remove the lower half of connecting rod bearing (3) from connecting rod cap (2). Keep the connecting rod bearing and the connecting rod cap together.
5. Carefully push the piston and connecting rod assembly into the cylinder bore until connecting rod (5) is clear of the crankshaft. Remove the upper half of connecting rod bearing (4) from connecting rod (5). Keep the bearings together.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result. Do not allow the connecting rod to contact the piston cooling jet.

Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the connecting rod bearings is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

i02744541

Connecting Rod Bearings - Install (Connecting rods in position)

Installation Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1
B	21825607	Angle Gauge	1

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used connecting rod bolts.

1. Inspect the pins of the crankshaft for damage. If the crankshaft is damaged, replace the crankshaft or recondition the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove" and Disassembly and Assembly, "Crankshaft - Install". Ensure that the connecting rod bearings are clean and free from wear or damage. If necessary, replace the connecting rod bearings.

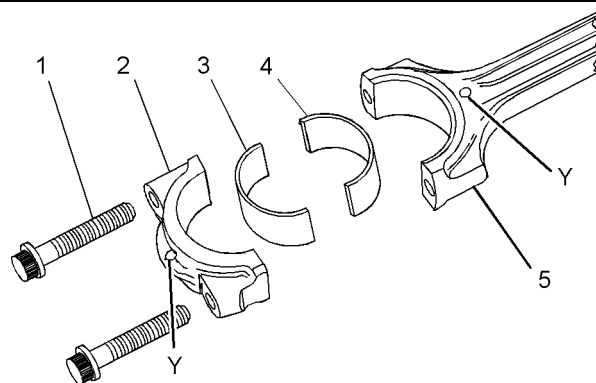


Illustration 216

g01260354

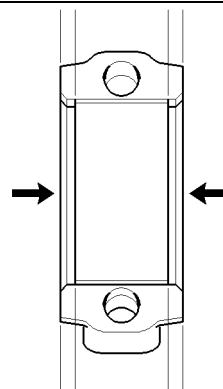


Illustration 217

g01001160

Aligning the bearing in the center of the connecting rod

Note: New connecting rod bearings are supplied with an alignment tool. If new bearings are installed, use the tool to align the bearing in the connecting rod.

2. Install the upper half of connecting rod bearing (4) to connecting rod (5). Ensure that the bearing is centralized in the connecting rod. Refer to Illustration 217.

The ends of the bearing must be centered in the connecting rod. The ends of the bearing must be equally positioned in relation to the mating faces of the connecting rod.

3. Clean the connecting rod cap. Install lower connecting rod bearing (3) to connecting rod cap (2). Ensure that the connecting rod bearing is centralized in the connecting rod cap. Refer to Illustration 217.

The ends of the lower connecting rod bearing must be centered in the connecting rod cap. The ends of the lower connecting rod bearing must be equally positioned in relation to the mating faces of the connecting rod cap.

4. Lubricate upper connecting rod bearing (4) with clean engine oil.
5. If necessary, use Tooling (A) in order to rotate the crankshaft until the crankshaft pin is at the bottom dead center position.
6. Carefully pull connecting rod (5) against the crankshaft pin.

Note: Do not allow the connecting rod to contact the piston cooling jet.

7. Lubricate the pin of the crankshaft and lubricate lower connecting rod bearing (3) with clean engine oil.

Note: Ensure that etched number (X) on connecting rod cap (2) matches etched number (X) on connecting rod (5). Ensure the correct orientation of the connecting rod cap. The forged marks (Y) on the connecting rod and the connecting rod cap should be on the same side. Refer to Illustration 216.

9. Install new bolts (1). Tighten the bolts evenly to a torque of 18 N·m (13 lb ft).

Note: Do not reuse the old bolts in order to secure the connecting rod cap.

10. Tighten the bolts evenly to a torque of 70 N·m (52 lb ft).

11. Use Tooling (B) to turn the bolts through an additional 120 degrees.

12. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft in order to ensure that there is no binding.

13. Repeat Steps 2 through 12 for the remaining connecting rod bearings.

Note: If all connecting rod bearings require replacement the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders..**

14. If the glow plugs were removed, install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".

End By:

- a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

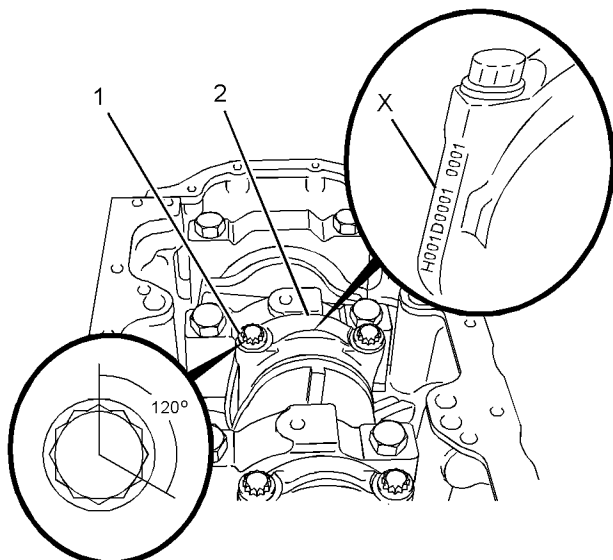


Illustration 218

g01344572

8. Install connecting rod cap (2) to connecting rod (5).

i02628821

Crankshaft Main Bearings - Remove and Install (Crankshaft in position)

Removal Procedure

Table 65

Required Tools			
Tool	Part Number	Part Description	Qty
A ¹	21825576	Crankshaft Turning Tool	1
A ²	27610291	Barring Device Housing	1
	27610289	Gear	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- b. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

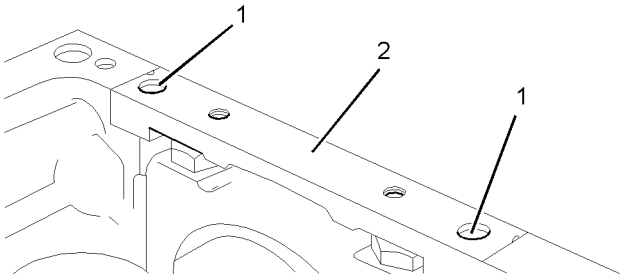


Illustration 219

g01253717

Typical example

1. Remove allen head screws (1). Remove bridge piece (2).
2. Ensure that the main bearing cap is marked for the correct location and orientation.

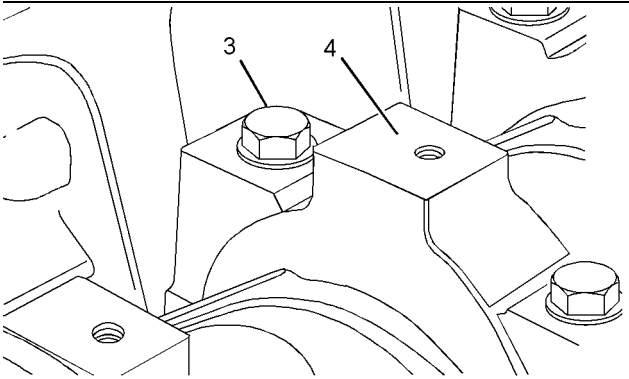


Illustration 220

g01253719

Typical example

3. Remove bolts (3). Remove main bearing cap (4) from the cylinder block.

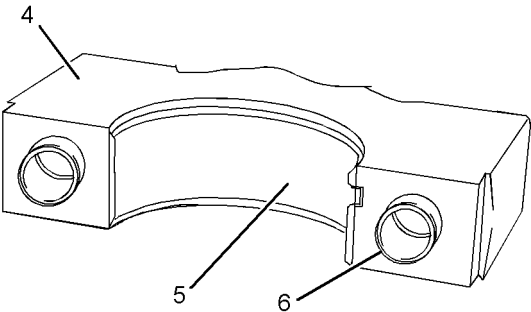


Illustration 221

g01253146

Typical example

4. Remove lower main bearing (5) from main bearing cap (4). Keep the main bearing and the main bearing cap together. Take care not to displace dowels (6).

Note: The lower main bearing is a plain bearing that has no oil holes. The dowels may remain in the main bearing cap or in the cylinder block.

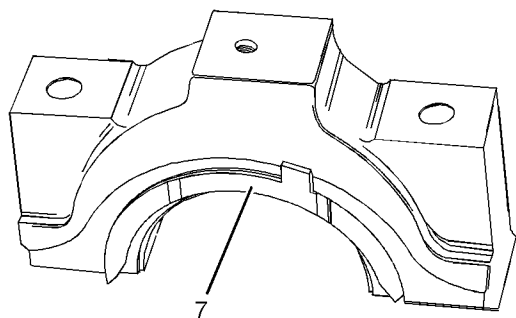


Illustration 222

g01253137

Typical example

5. For number three main bearing cap, remove thrust washers (7).

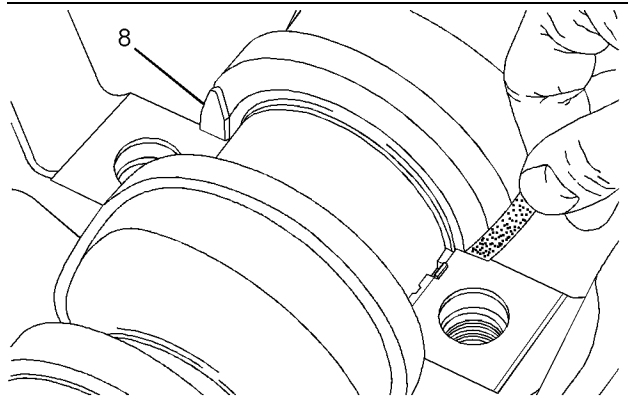


Illustration 223

g01253142

Typical example

6. For number three main bearing, remove thrust washers (8) from the cylinder block. In order to remove the thrust washers, push the crankshaft toward the front of the engine or push the crankshaft toward the rear of the engine. Use Tooling (A) in order to rotate the crankshaft. If necessary, use a suitable tool to free the thrust washers.

Note: Do not damage the machined surfaces of the crankshaft during removal of the thrust washers.

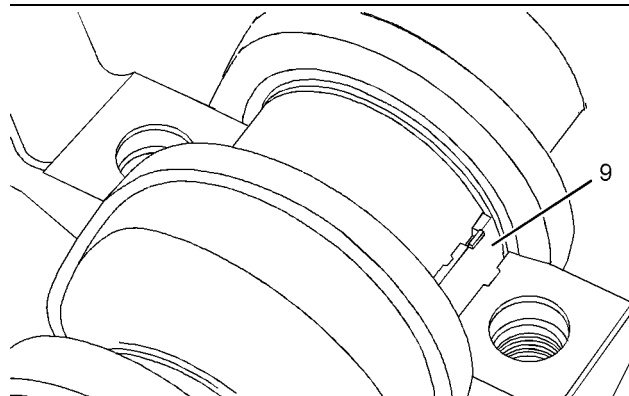


Illustration 224

g01253145

7. Push out upper main bearing (9) with a suitable tool from the side opposite the locating tab. Carefully rotate the crankshaft while you push on the bearing. Remove upper main bearing (9) from the cylinder block. Keep the bearings together.

Note: Do not damage the machined surfaces of the crankshaft during removal of the upper main bearing. The upper main bearing has a groove and two oil holes.

Installation Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825617	Dial Indicator Group	1
C	-	Straight Edge	1
D	-	5 mm Allen Socket	1
E	21826038	POWERPART Silicon Rubber Sealant	-

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the main bearings are clean and free from wear or damage. If necessary, replace the main bearings.
2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

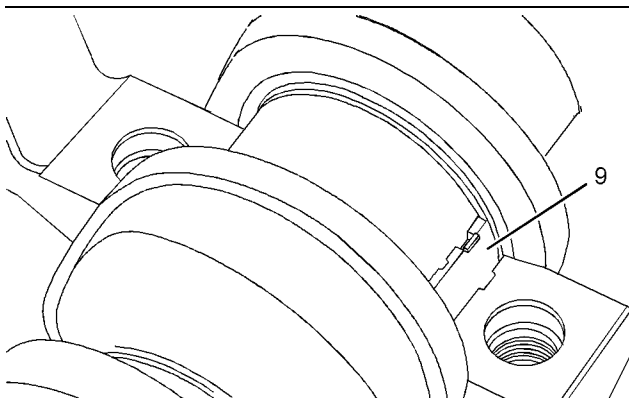


Illustration 225

g01253145

Typical example

3. Lubricate the crankshaft journal and the upper main bearing (9) with clean engine oil. Slide the upper main bearing (9) into position between the crankshaft journal and the cylinder block. Ensure that the locating tab for the upper main bearing is correctly seated in the slot in the cylinder block.

Note: The upper main bearing has a groove and two oil holes.

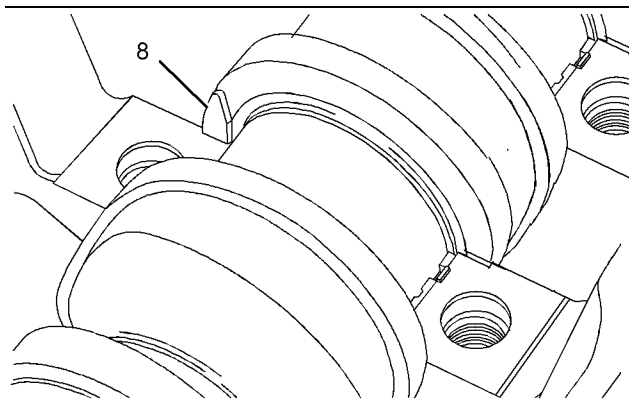


Illustration 226

g01261200

Typical example

4. For number three main bearing, ensure that thrust washers (8) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (8) with clean engine oil. Slide the thrust washers into position between the crankshaft and the cylinder block. The grooves in the thrust washers must be located against the crankshaft.

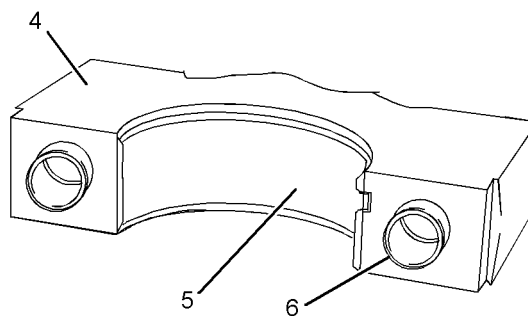


Illustration 227

g01253146

Typical example

5. Install lower main bearing (5) into main bearing cap (4). Ensure that the locating tab for the lower main bearing is correctly seated into the slot in the bearing cap.

Note: The lower main bearing is a plain bearing that has no oil holes.

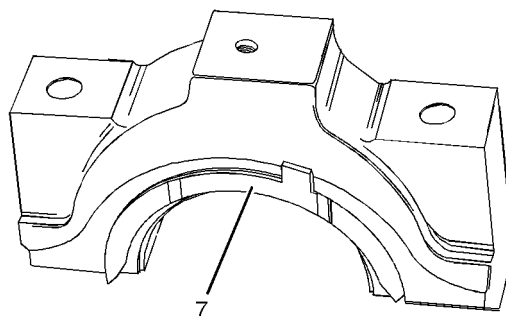


Illustration 228

g01253137

Typical example

6. For number three main bearing cap, ensure that thrust washers (7) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (7) with clean engine oil. Place the thrust washers into position on the main bearing cap. Ensure that the locating tab is correctly seated in the main bearing cap.

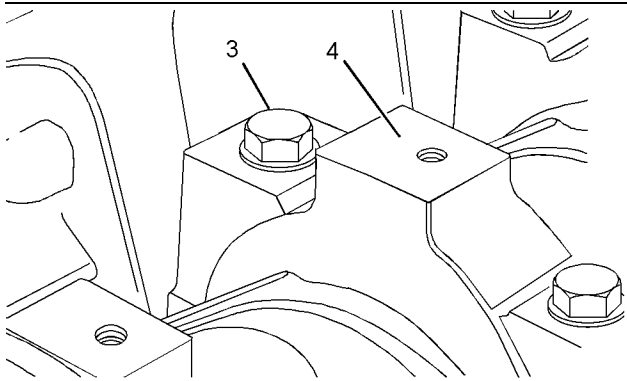


Illustration 229

g01253719

Typical example

7. Lubricate the crankshaft journal and the lower main bearing with clean engine oil. Install main bearing cap (4) to the cylinder block.

Note: Ensure the correct orientation of the main bearing cap. The locating tab for the upper and the lower bearing should be on the same side of the engine.

8. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of the bolts with clean engine oil.

9. Install bolts (3) to main bearing cap (4). Evenly tighten the bolts in order to pull cap (5) into position. Ensure that the cap is correctly seated.

Note: Do not tap the main bearing cap into position as the bearing may be dislodged.

10. Tighten bolts (3) to a torque of 245 N·m (180 lb ft).

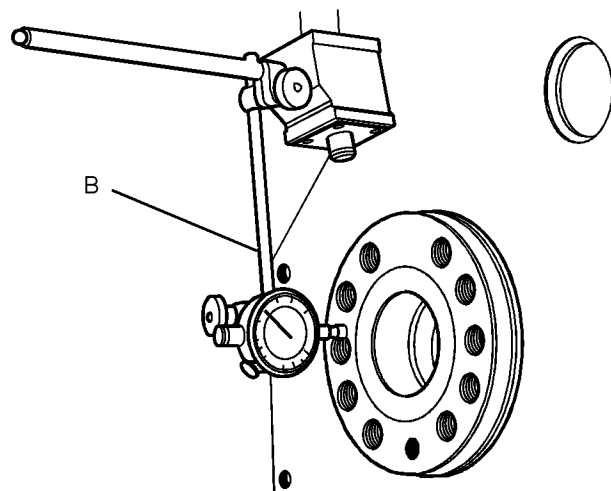


Illustration 230

g01253186

Typical example

11. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (B) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (B) to measure the crankshaft end play. The permissible crankshaft end play is 0.17 mm (0.007 inch) to 0.41 mm (0.016 inch).

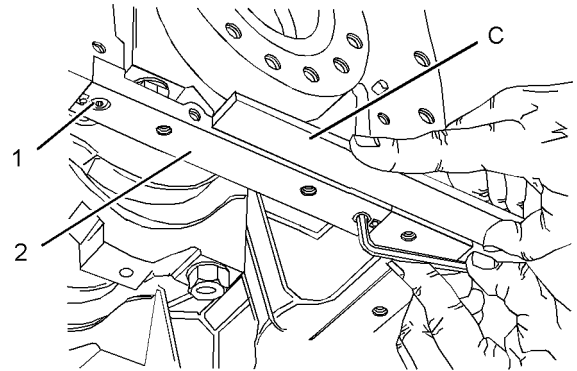


Illustration 231

g01253836

Typical example

12. Follow Steps 12.a through 12.d in order to install the bridge piece.

- a. Ensure that the recess in the cylinder block and the bridge piece are clean, dry and free from old sealant.
- b. Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.
- c. Use Tooling (C) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
- d. Use Tooling (D) to tighten allen head screws (1) to a torque of 16 N·m (12 lb ft).

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

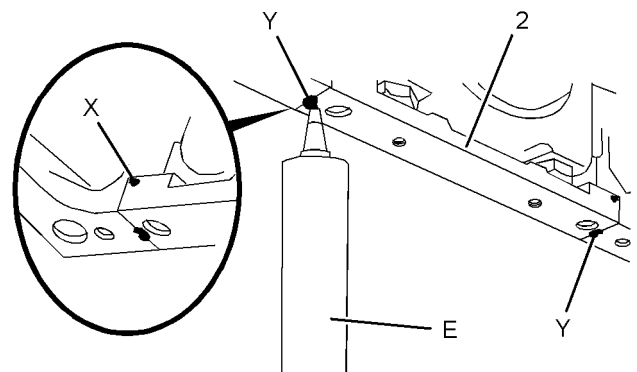


Illustration 232

g01344584

Typical example

14. Apply Tooling (E) to cavities (Y) in bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece. and the cylinder block are left free of sealant.

End By:

- a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02628818

Crankshaft - Remove

Removal Procedure

Table 67

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Strap	1

Start By:

- Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".
- Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".
- Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".
- If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".

NOTICE

If the crankshaft has been reground or if the crankshaft has been replaced, the height of the piston above the cylinder block must be inspected. It is necessary to remove the cylinder head in order to inspect the height of the piston above the cylinder block.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- The engine should be mounted on a suitable stand and placed in the inverted position.
- If necessary, remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove". Remove the pistons and connecting rods. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - Remove".

If the cylinder head, the pistons and the connecting rods have not been removed, remove the connecting rod caps. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Remove".

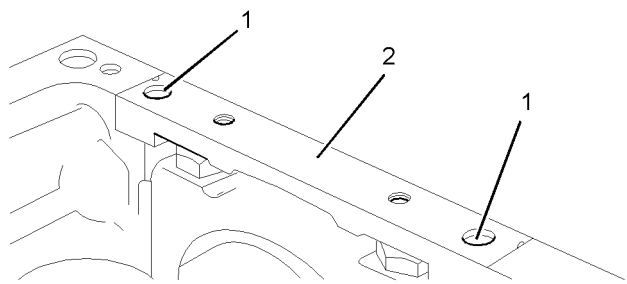


Illustration 233

Typical example

g01253717

- Remove allen head screws (1). Remove bridge piece (2).
- Ensure that the bearing caps are marked for the location and orientation.

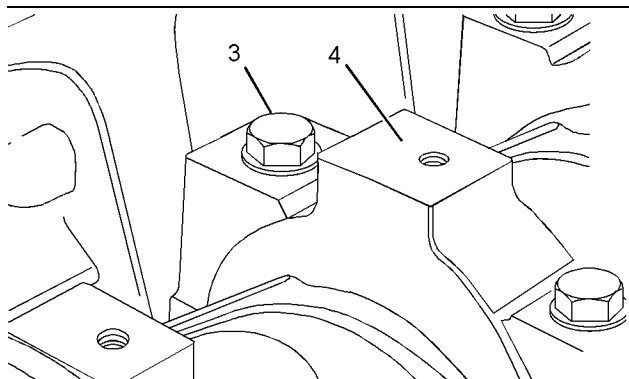


Illustration 234

g01253719

Typical example

5. Remove bolts (3) and bearing caps (4) from the cylinder block.

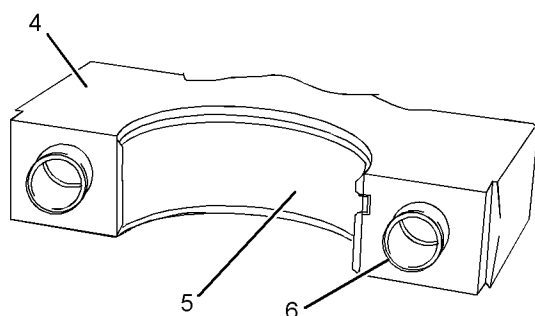


Illustration 235

g01253146

Typical example

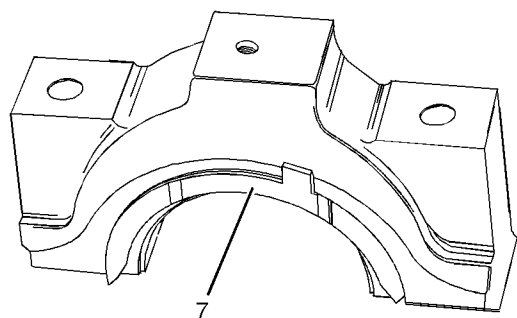


Illustration 236

g01253137

Typical example

6. Remove lower bearings (5) from bearing caps (4). Take care not to displace dowels (6). For number three bearing cap, remove thrust washers (7). Keep the lower bearing and the thrust washers with the respective bearing caps.

Note: The lower bearings are plain bearings that have no oil holes. The dowels may remain in the bearing cap or in the cylinder block.

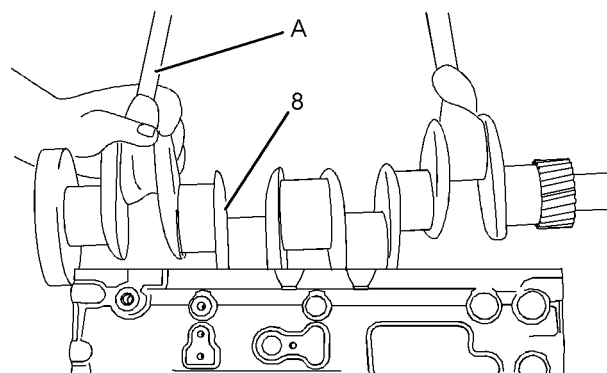


Illustration 237

g01254099

Typical example

7. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Carefully lift the crankshaft out of the cylinder block. The weight of the crankshaft is approximately 30 kg (66 lb).

Note: Do not damage any of the finished surfaces on the crankshaft, when the crankshaft is removed from the engine.

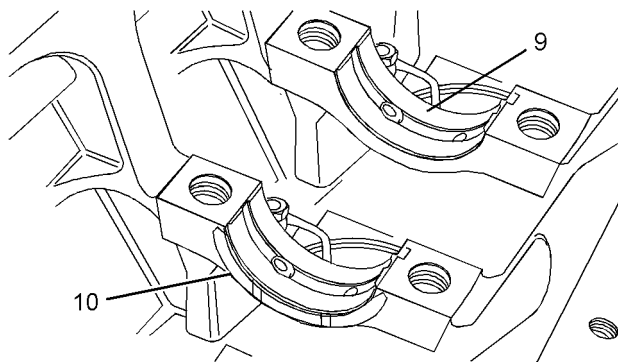


Illustration 238

g01254104

Typical example

8. Remove upper bearings (9) from the cylinder block. Keep the upper bearings with the respective bearing caps.

Note: The upper bearings have a groove and two oil holes.

9. Remove thrust washers (10) from number three bearing in the cylinder block.

10. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install".

i02628817

Crankshaft - Install

Installation Procedure

Table 68

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Strap	1
B	21825617	Dial Indicator Group	1
C	-	Straight Edge	1
D	-	5 mm Allen Socket	1
E	21826038	POWERPART Silicon Rubber Sealant	-

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

If the crankshaft has been reground or if the crankshaft has been replaced, the height of the piston above the cylinder block must be inspected. It is necessary to remove the cylinder head in order to inspect the height of the piston above the cylinder block.

1. Clean the crankshaft and inspect the crankshaft for wear or damage. Refer to Specifications, "Crankshaft" for more information. If necessary, replace the crankshaft or recondition the crankshaft.
2. If necessary, install the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install".

Note: The engine should be mounted on a suitable stand and placed in the inverted position.

3. Ensure that the parent bores for the crankshaft bearings in the cylinder block are clean. Ensure that the threads for the bearing bolts in the cylinder block are clean and free from damage.
4. Clean the crankshaft bearings and the thrust washers. Inspect the bearings and the thrust washers for wear or damage. If necessary, replace the bearings and the thrust washers.

Note: If the crankshaft bearings are replaced, check whether oversize bearings were previously installed. If the thrust washers are replaced, check whether oversize thrust washers were previously installed.

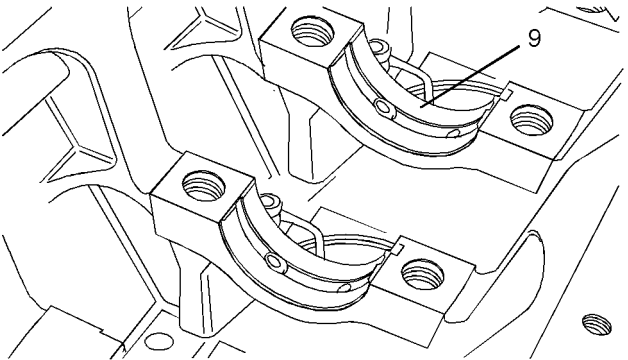


Illustration 239

g01253240

Typical example

5. Install upper bearings (9) to the cylinder block. Ensure that the locating tabs for the upper bearings are seated in the slots in the cylinder block.

Note: The upper bearings have a groove and two oil holes.

6. Lubricate upper bearings (9) with clean engine oil.

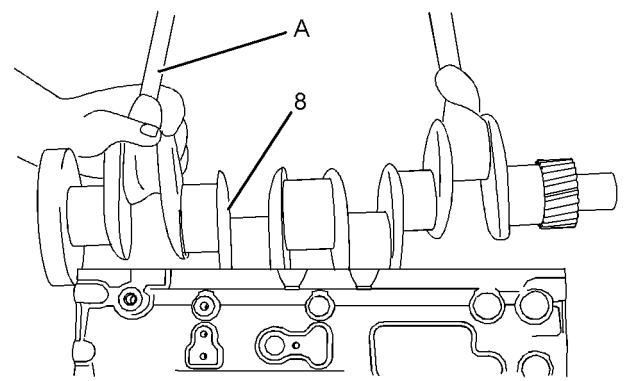


Illustration 240

g01254099

Typical example

7. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Carefully lift the crankshaft into the cylinder block. The weight of the crankshaft is approximately 30 kg (66 lb). Remove Tooling (A).

Note: Do not damage any of the finished surfaces on the crankshaft. Do not damage the bearing.

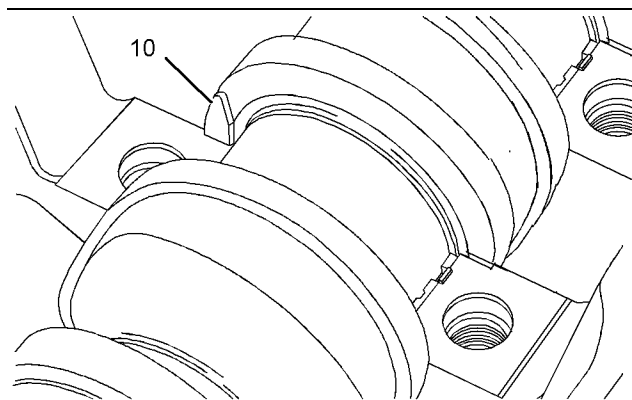


Illustration 241

g01254100

Typical example

8. For number three bearing, ensure that thrust washers (10) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (10) with clean engine oil. Slide the thrust washers into position between the crankshaft and the cylinder block.

Note: The grooves in the thrust washers must be located against the crankshaft.

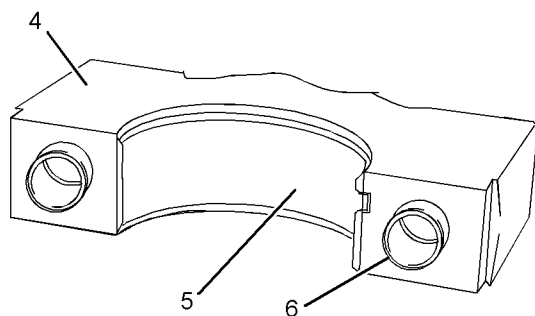


Illustration 242

g01253146

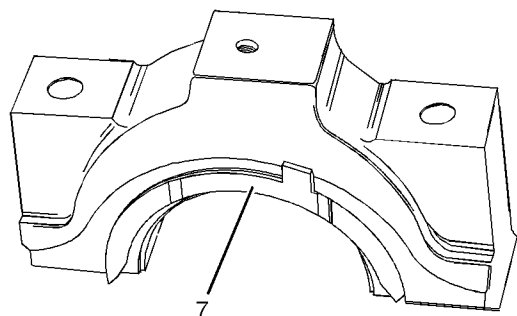


Illustration 243

g01253137

9. Install lower bearings (5) into bearing caps (4). Ensure that the locating tabs for the lower bearings are correctly seated into the slots in the bearing caps. For number three bearing cap, ensure that thrust washers (7) are clean and free from wear or damage. If necessary, replace both the thrust washers. Lubricate thrust washers (7) with clean engine oil. Place the thrust washers into position on the bearing cap. Ensure that the locating tab is correctly seated in the bearing cap.

Note: The lower bearing is a plain bearing that has no oil holes.

10. Lubricate lower bearings (5) and lubricate the journals of crankshaft (8) with clean engine oil. Install bearing caps (4) to the cylinder block.

Note: Ensure the correct location and orientation of the bearing caps. The locating tabs for the upper and the lower bearings should be on the same side of the engine.

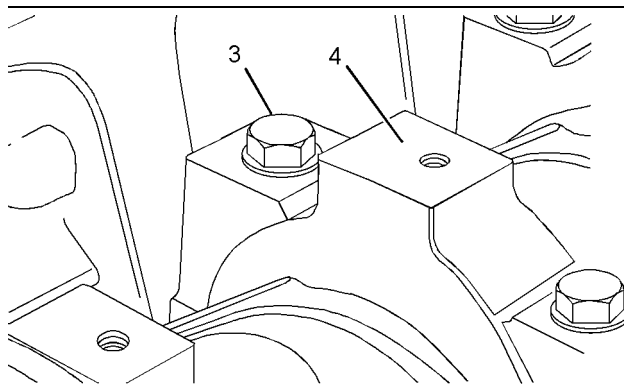


Illustration 244

g01253719

11. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of the bolts with clean engine oil.
12. Install bolts (3) to bearing caps (4). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.
- Note:** Do not tap the bearing caps into position as the bearing may be dislodged.
13. Tighten bolts (3) to a torque of 245 N·m (180 lb ft).
14. Rotate the crankshaft in order to ensure that there is no binding.

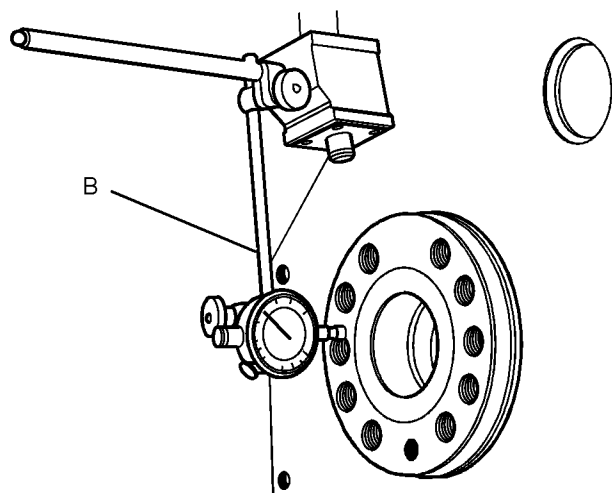


Illustration 245
Typical example

15. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (B) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (B) to measure the crankshaft end play. The permissible crankshaft end play is 0.17 mm (0.007 inch) to 0.41 mm (0.016 inch).

16. If the piston and connecting rods have been removed, install the piston and connecting rods. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install".

If the piston and connecting rods have not been removed, install the connecting rod caps. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

17. If the crankshaft has been replaced or the crankshaft has been reconditioned, inspect the height of the piston above the cylinder block. Refer to Systems Operation, Testing and Adjusting, "Piston Height - Inspect" for more information.

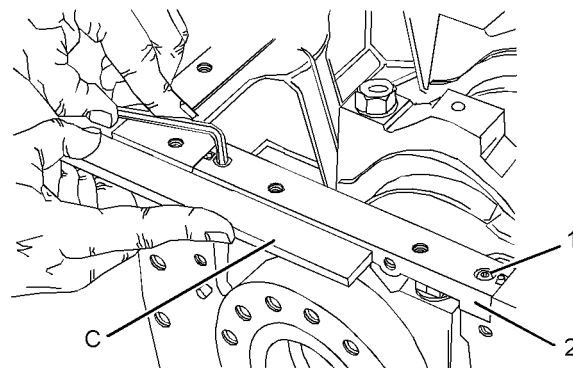


Illustration 246
Typical example

18. Follow Steps 18.a through 18.d in order to install the bridge piece.

- a. Ensure that the cylinder block and the bridge piece are clean, dry and free from old sealant.
- b. Install bridge piece. (2) and allen head screws (1). Tighten the allen head screws finger tight.
- c. Use Tooling (C) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
- d. Use Tooling (D) in order to tighten the allen head screws to a torque of 16 N·m (12 lb ft).

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

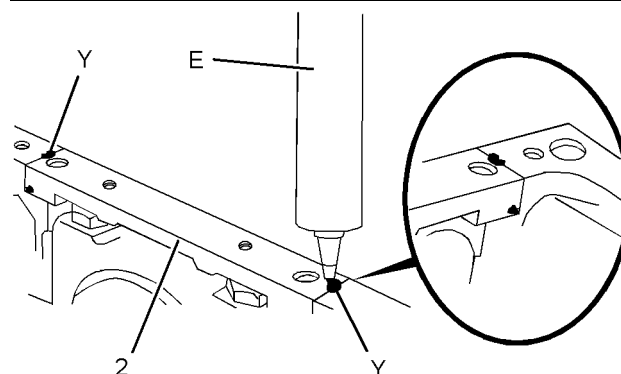


Illustration 247
Typical example

20. Apply Tooling (E) to cavities (Y) in the bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

- a. If the engine has a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine does not have a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".
- b. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- c. If necessary, install the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Install".
- d. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rockershaft and Push Rods - Install".

i02628820

Crankshaft Gear - Remove and Install

Removal Procedure

Table 69

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

Start By:

- a. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".
- b. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove". If the engine is not equipped with a balancer, 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.

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

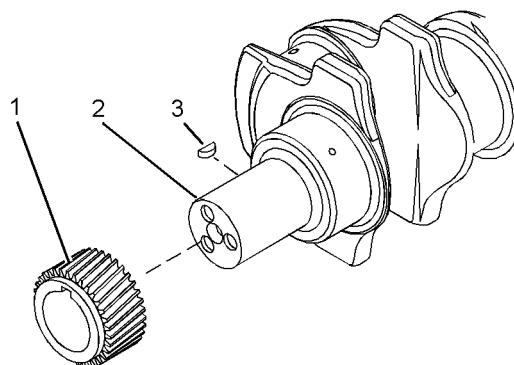


Illustration 248
Typical example

g01367358

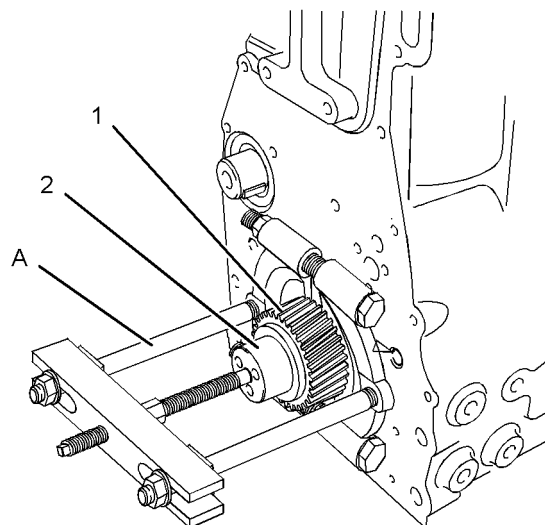


Illustration 249
Typical example

g01270549

1. If the crankshaft gear is a sliding fit on the crankshaft, remove crankshaft gear (1) from crankshaft (2).

If the crankshaft gear is an interference fit on the crankshaft, use Tooling (A) in order to remove crankshaft gear (1) from crankshaft (2).

2. If necessary, remove key (3) from crankshaft (2).

Note: Do not remove the key from the crankshaft unless the key is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

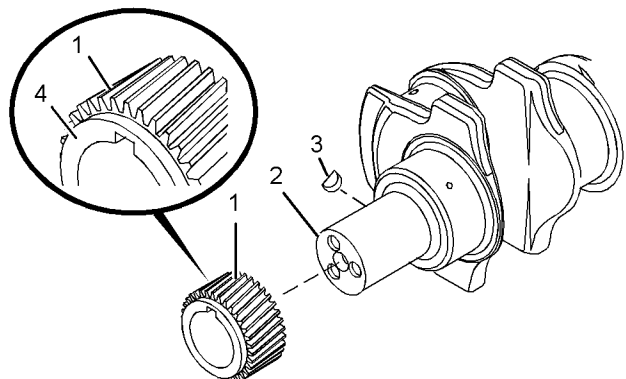


Illustration 250

g01367359

Typical example

2. If necessary, install a new key (3) to crankshaft (2).

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

3. If the crankshaft gear is a sliding fit on the crankshaft, align the keyway in crankshaft gear (1) with key (3) in the crankshaft. Install crankshaft gear (1) to crankshaft (2).

If the crankshaft gear is an interference fit on the crankshaft, heat crankshaft gear (1) in an oven to $150^{\circ} \pm 50^{\circ}\text{C}$ ($302^{\circ} \pm 90^{\circ}\text{F}$). Align the keyway in crankshaft gear (1) with key (3) in the crankshaft. Install crankshaft gear (1) to crankshaft (2).

Ensure that shoulder (4) on crankshaft gear (1) is toward the front of the engine.

End By:

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

- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install". If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02748526

Bearing Clearance - Check

Measurement Procedure

Table 70

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Perkins does not recommend the checking of the actual clearances of the bearing shells particularly on small engines. This is because of the possibility of obtaining inaccurate results and of damaging the bearing shell or the journal surfaces. Each Perkins bearing shell 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 251.

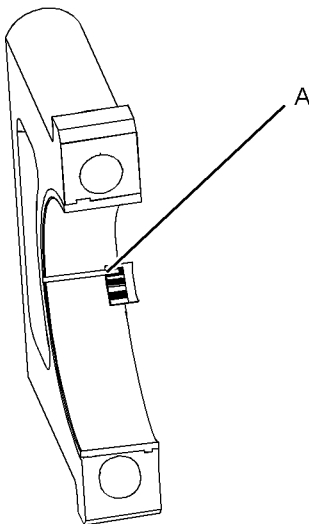


Illustration 251

g01152855

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.

i02628884

Glow Plugs - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Isolate the electrical supply.
2. If the engine is equipped with a cover over the fuel injectors remove the cover. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
3. Remove the breather tube from the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".

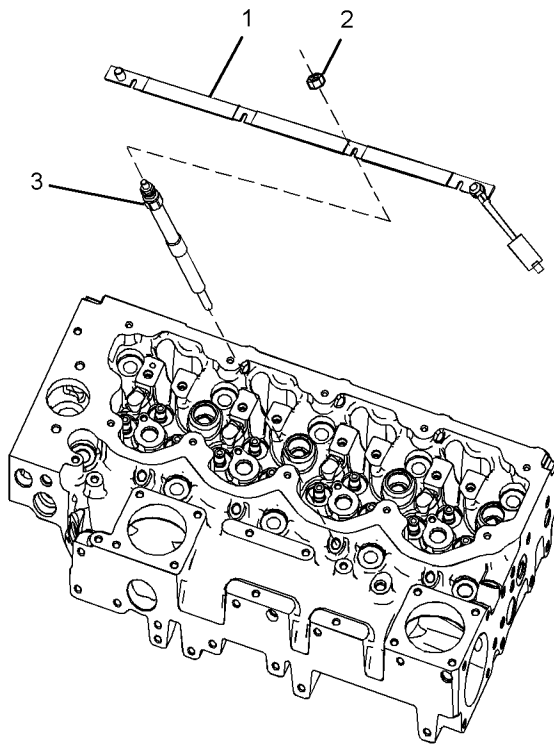


Illustration 252

g01346250

Typical example

4. Disconnect harness assembly from bus bar (1).
5. Remove nuts (2) that secure bus bar (1) to glow plugs (3).
6. Remove bus bar (1) from glow plugs (3).
7. Remove glow plugs (3) from the cylinder head.

Installation Procedure

Table 71

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610296	Torque Wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.

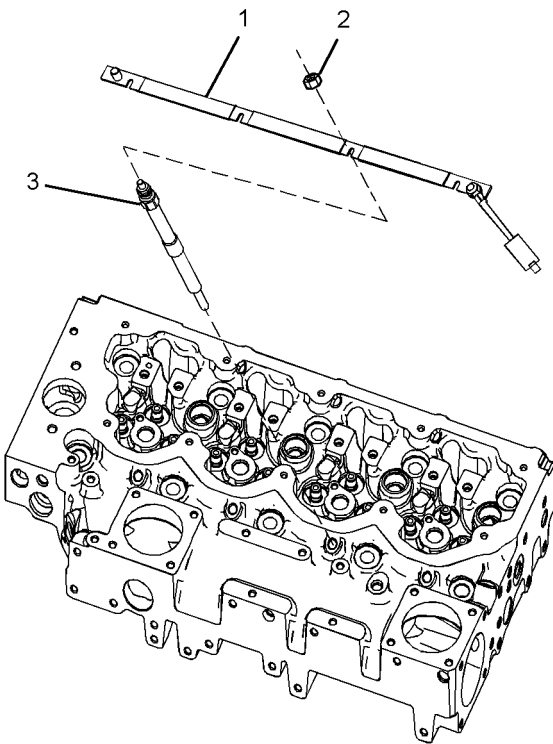


Illustration 253

g01346250

Typical example

2. Install glow plugs (3) into the cylinder head. Tighten the glow plugs to a torque of 15 N·m (132 lb in).
3. Position bus bar (1) onto glow plugs (3). Install nuts (2) onto the glow plugs. Use Tooling (A) in order to tighten the nuts to a torque of 2 N·m (17 lb in).
4. Connect harness assembly to bus bar (1).
5. Install the breather tube to the valve mechanism cover. Refer to Disassembly and Assembly, "Crankcase Breather- Remove and Install".
6. If the engine is equipped with a cover over the fuel injectors install the cover. Refer to Disassembly and Assembly, "Fuel Injector Cover - Remove and Install".
7. Restore the electrical supply to the engine.

i02628912

V-Belts - Remove and Install (Engines Without an Automatic Belt Tensioner)

Removal Procedure

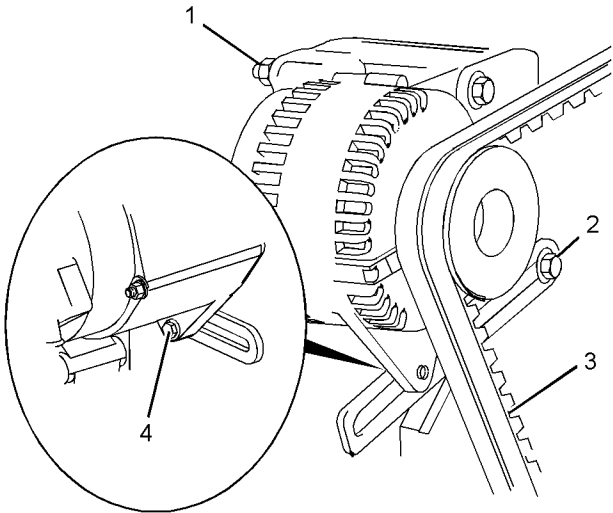


Illustration 254
Typical example

1. If the engine is equipped with fan guards, remove the fan guards.
2. Loosen nut (1), bolt (2) and bolt (4). Slide the alternator toward the engine.
3. Remove V-belts (3).

Note: Mark the position and direction of rotation if the V-belts will be reused. Never replace single V-belts. Always replace V-belts as a pair.

Installation Procedure

Table 72

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Belt Tension Gauge	1

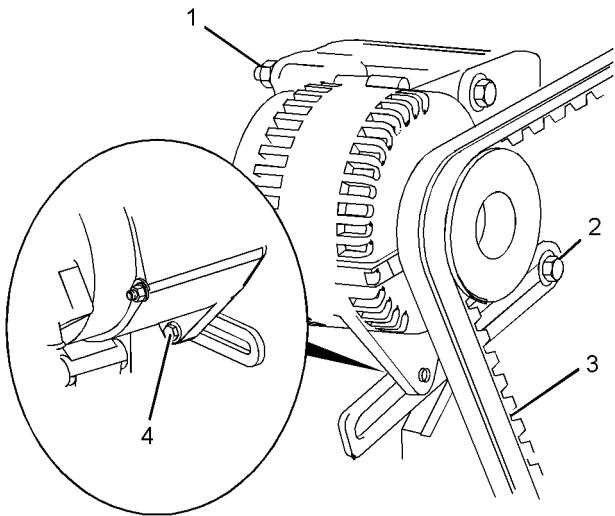


Illustration 255
Typical example

1. Install V-belts (3) onto the correct pulleys.
- Note:** Used V-belts should be installed in the original position and direction of rotation.
2. Adjust the tension on the V-belts by moving the alternator away from the engine. Use Tooling (A) in order to achieve the correct belt tension. Refer to System Operation, Testing and Adjusting, "V-Belt -Test" for more information. Tighten bolt (4) to a torque of 22 N·m (16 lb ft).
 3. Tighten bolt (2) to a torque of 44 N·m (32 lb ft).
 4. Tighten nut (1) to a torque of 22 N·m (16 lb ft).
 5. If the engine is equipped with fan guards, install the fan guards.

i02589352

Alternator Belt - Remove and Install (Engines With an Automatic Belt Tensioner)

Removal Procedure

Table 73

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Locking Pin (Ø 8mm by 85 mm)	1

1. If the engine has fan guards, remove the fan guards.

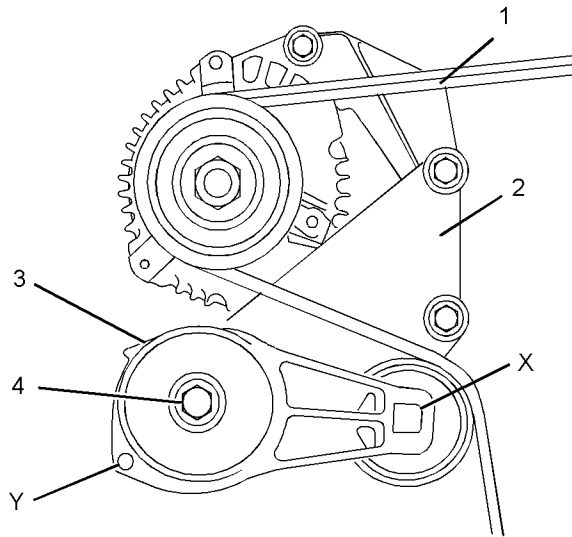


Illustration 256

g01260739

Typical example

2. Install a suitable square drive tool into hole (X) in tensioner (3). From the front of the engine, turn the tool in a clockwise direction.
3. Insert Tooling (A) into hole (Y). Release the pressure on the square drive tool.
4. Remove alternator belt (1).

Note: Mark the direction of rotation if the belt will be reused.

5. From the front of the engine, turn the square drive tool in a clockwise direction. Release the pressure on Tooling (A). Remove Tooling (A) from hole (Y).
6. Release the pressure on the square drive tool and remove the tool from hole (X).
7. If necessary, follow Steps 7.a and 7.b in order to remove tensioner (3) from mounting bracket (2).
 - a. Remove bolt (4) that secures tensioner (3) to mounting bracket (2).
 - b. Remove tensioner (3) from mounting bracket (2).

Installation Procedure

Table 74

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Locking Pin (Ø 8mm by 85 mm)	1

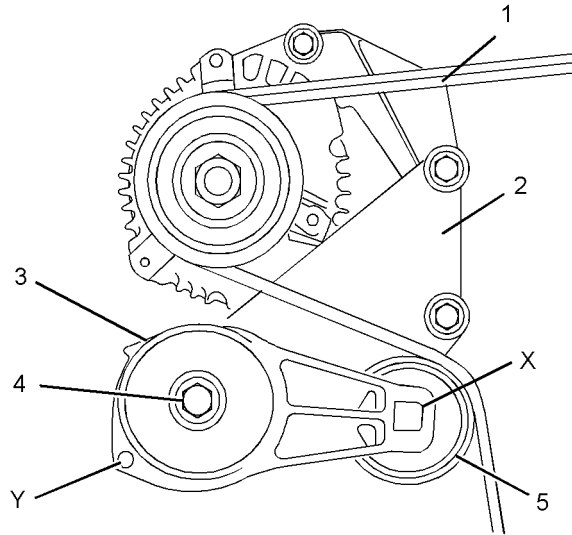


Illustration 257

g01270907

Typical example

1. If the tensioner was previously removed, follow Steps 1.a through 1.c in order to install the tensioner.
 - a. Align the dowel in the back of tensioner (3) with the hole in mounting bracket (2).
 - b. Install tensioner (3) to mounting bracket (2).

- c. Install bolt (4). Tighten the bolt to a torque of $45 \pm 5 \text{ N}\cdot\text{m}$ ($33 \pm 3 \text{ lb ft}$).
2. Install a suitable square drive tool into hole (X) in tensioner (1). From the front of the engine, turn the tool in a clockwise direction.
3. Insert Tooling (A) into hole (Y). Release the pressure on the square drive tool.
4. Install alternator belt (1). Ensure that the alternator belt is centered on pulley (5). A used alternator belt should be installed in the original direction of rotation.

Note: The ribs on the alternator belt must be located into the ribs of all pulleys.

5. From the front of the engine, turn the square drive tool in a clockwise direction. Release the pressure on Tooling (A). Remove Tooling (A) from hole (Y).
6. Release the pressure on the square drive tool until the alternator belt is tensioned. Remove the tool from hole (X).

Note: The tensioner should be at the nominal position.

7. If the engine has fan guards, install the fan guards.

i02628844

Fan - Remove and Install

Removal Procedure

Start By:

- a. If the engine is equipped with an automatic belt tensioner, remove the Alternator Belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install". If the engine is not equipped with an automatic belt tensioner, remove the V-Belts. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

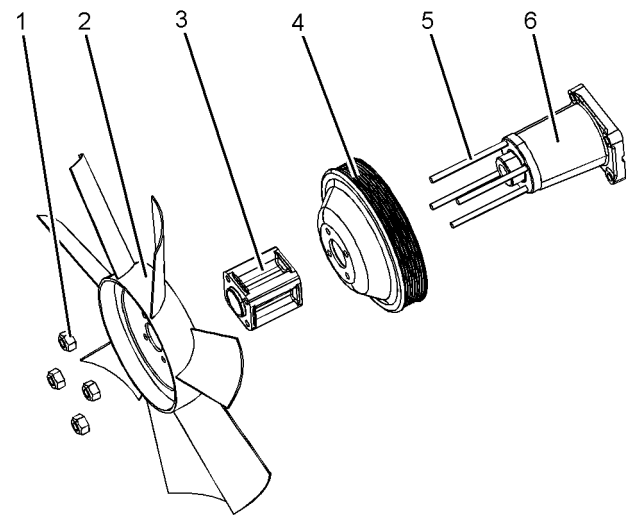


Illustration 258

g01270917

Typical example

1. Remove locking nuts (1).

2. Remove fan (2).

Note: Note the orientation of the fan.

3. Remove fan adapter (3).

4. Remove fan pulley (4).

5. If necessary, remove studs (5) from fan drive (6).

Installation Procedure

1. Ensure that all the components are free from wear or damage. If necessary, replace any components that are worn or damaged.

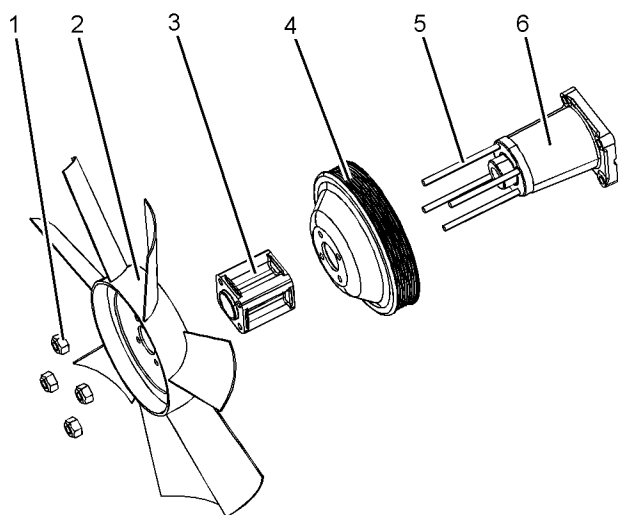


Illustration 259

g01270917

Typical example

2. If necessary, install studs (5) to fan drive (6).
3. Install fan pulley (4).
4. Install fan adapter (3).
5. Install fan (2).

Note: Ensure that the fan is correctly oriented.

6. Inspect the condition of locking nuts (1). If necessary, replace the locking nuts. Install locking nuts (1) and tighten to a torque of 22 N·m (16 lb ft).

End By:

- a. If the engine is equipped with an automatic belt tensioner, install the Alternator Belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install". If the engine is not equipped with an automatic belt tensioner, install the V-Belts. Refer to Disassembly and Assembly, "V-Belts - Remove and Install".

i02628845

Fan Drive - Remove and Install

Removal Procedure

Start By:

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

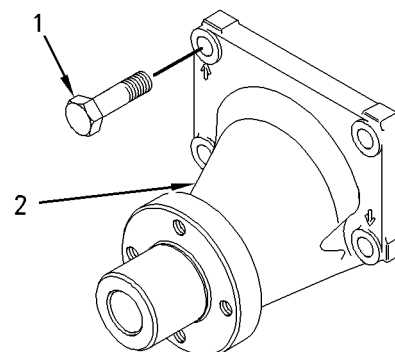


Illustration 260

g00944500

Typical example

1. Remove bolts (1) from fan drive (2).

Note: Identify the orientation and the position of the fan drive.

2. Remove fan drive (2).

Installation Procedure

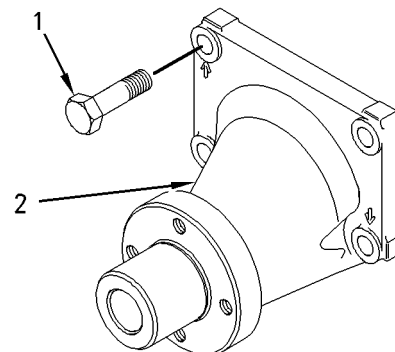


Illustration 261

g00944500

Typical example

1. Check the fan drive for wear or damage. The fan drive is not a serviceable item. If the fan drive is worn or damaged, replace the fan drive.

2. Install fan drive (2).

Note: Ensure the correct orientation of the fan drive.

3. Install bolts (1). Tighten the bolts to a torque of 44 N·m (32 lb ft).

End By:

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

i02725803

Alternator - Remove (Engines With an Automatic Belt Tensioner)

Removal Procedure

Start By:

- a. Remove the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Isolate the electrical supply to the engine.
2. Make temporary identification marks on the connections of the harness assembly.

Note: The incorrect connection of the harness assembly can result in damage to the alternator or failure.

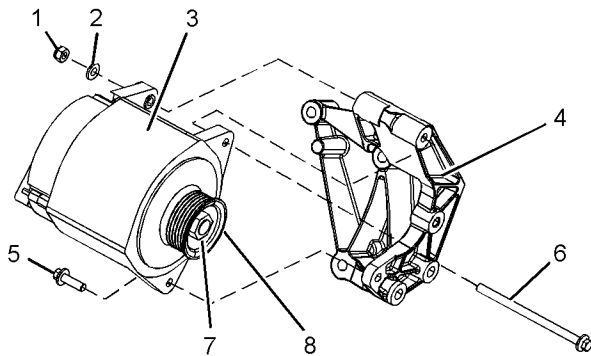


Illustration 262

g01271317

Typical example

3. Disconnect the harness assembly from alternator (3).
4. Remove bolt (5) from alternator (3).
5. Remove nut (1) and washer (2). Remove bolt (6) from alternator (3). Remove the alternator from alternator bracket (4).
6. If necessary, follow Steps 6.a and 6 in order to remove pulley (8) from alternator (1).

- a. Hold the shaft of alternator (3) with an allen wrench. Use a cranked ring spanner (box wrench) in order to loosen nut (7).
- b. Remove nut (7) and pulley (8) from alternator (1).

i02628804

Alternator - Remove (Engines Without an Automatic Belt Tensioner)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Isolate the electrical supply to the engine.
2. Make temporary identification marks on the connections of the harness assembly.

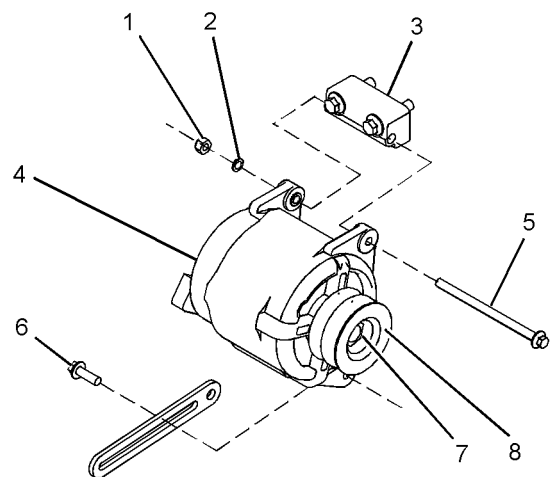


Illustration 263

g01255718

Typical Example

3. Disconnect the harness assembly from alternator (1).

4. Remove bolt (6) from alternator (4).
5. Remove nut (1) and washer (2). Remove bolt (5) from alternator (4). Remove alternator (4) from alternator bracket (3).
6. If necessary, remove pulley (8) from alternator (4). Follow Steps 6.a and 6.b for the method in order to remove the pulley from the alternator.

Note: This method may not be suitable for some configurations of pulley.

- a. Hold the shaft of alternator (4) with an allen wrench. Use a cranked ring spanner (box wrench) in order to loosen nut (7).
- b. Remove nut (7) and pulley (8) from alternator (4).

i02725802

Alternator - Install (Engines With an Automatic Belt Tensioner)

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

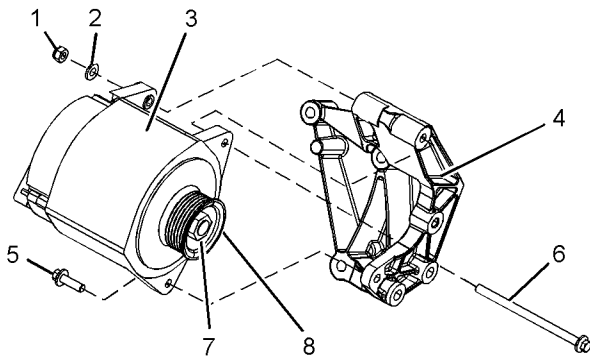


Illustration 264

g01271317

Typical example

1. If necessary, install pulley (8) and nut (7) to alternator (3). Hold the shaft of the alternator with an allen wrench. Use a cranked ring spanner (box wrench) in order to tighten nut (7).

Note: Different types of alternator have different sizes of nut. Ensure that the correct torque value is used for the nut.

Tighten M16 and M17 nuts to a torque of 80 N·m (59 lb ft). Tighten 5/8 inch - 18 UNF nuts to a torque of 102 N·m (75 lb ft).

2. Position alternator (3) on alternator mounting bracket (4).
3. Install bolt (6) to alternator (3). Install washer (2) and nut (1) to bolt (6).
4. Install bolt (5) to alternator (3).
5. Tighten nut (1) and bolt (5) to a torque of 22 N·m (16 lb ft).
6. Connect the wiring harness assembly to alternator (3).

Note: The incorrect connection of the harness assembly can result in damage to the alternator or failure.

7. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".
8. Restore the electrical supply.

i02628802

Alternator - Install (Engines Without an Automatic Belt Tensioner)

Installation Procedure

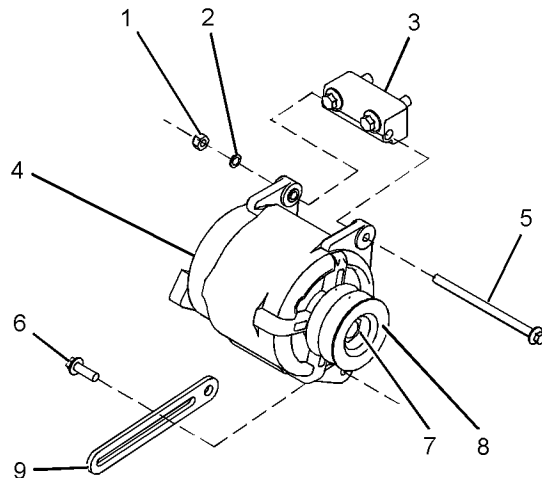


Illustration 265

g01263045

Typical example

1. If necessary, install the pulley to the alternator. Follow Steps 1.a and 1.b for the method in order to install the pulley to the alternator.

Note: This method may not be suitable for some configurations of pulley.

 - a. Install pulley (8) and nut (7) to the shaft of alternator (4).
 - b. Hold the shaft of the alternator with an allen wrench. Use a cranked ring spanner (box wrench) in order to tighten nut (7). Tighten the nut to a torque of 80 N·m (59 lb ft).
2. Install alternator (4) to bracket (3) and install bolt (5) to alternator (4).
3. Install washer (2) and nut (1) to bolt (5) finger tight.
4. Install bolt (6) through adjusting link (9) to alternator (4) finger tight.
5. Install the V-belts. Refer to the Disassembly and assembly, "V-belts - Remove and Install" for the correct procedure.

6. Tighten nut (1) and bolt (6) to a torque of 22 N·m (16 lb ft).
7. Connect the harness assembly to alternator (4).
8. Restore the electrical supply.

i02628831

Electric Starting Motor - Remove and Install

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 battery.
2. If necessary, remove the hose for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".
3. Make temporary identification marks on the harness assemblies that are connected to the electric starting motor and to the solenoid.

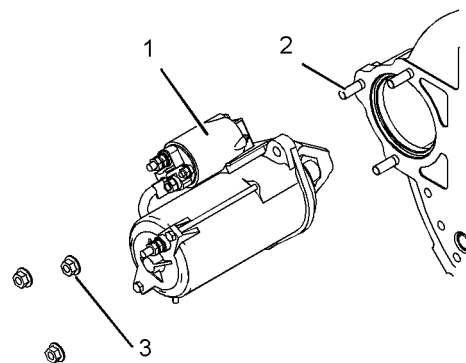


Illustration 266

g01261155

Typical example

4. Disconnect the harness assemblies from the electric starting motor and from the solenoid.

5. Remove nuts (3) from electric starting motor (1).

Note: Support the weight of the electric starting motor as the nuts are removed.

6. Remove electric starting motor (1).
7. If necessary, remove studs (2).

Installation Procedure

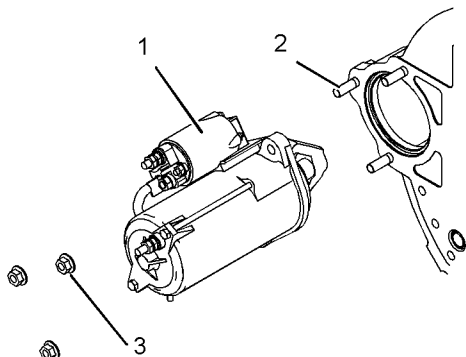


Illustration 267

g01261155

Typical example

1. If necessary, install studs (2).
2. Align electric starting motor (1) to studs (2). Install the electric starting motor.
3. Install nuts (3). Different types of starting motor have different sized nuts.

Tighten M10 nuts to a torque of 44 ± 11 N·m (32 ± 8 lb ft).

Tighten M12 nuts to a torque of 78 ± 19.5 N·m (57 ± 14 lb ft).

4. Connect the harness assemblies to the electric starting motor and the solenoid.
5. If necessary, install the hose for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Install".
6. Connect the battery.

i02628801

Air Compressor - Remove and Install

Removal Procedure

Table 75

Required Tools			
Tool	Part Number	Part Name	Qty
A ¹	21825576	Crankshaft Turning Tool	1
	27610291	Barring Device Housing	1
A ²	27610289	Gear	1
	27610211	Crankshaft Timing Pin	1
B	-	Puller (Three Leg)	1
C	-	Puller (Three Leg)	1

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system.

2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
3. Remove the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
4. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump.
5. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

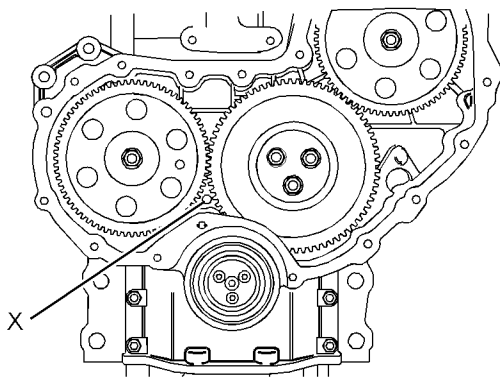


Illustration 268
Typical example

6. Install Tooling (B) through hole (X) in the front housing. Use Tooling (B) in order to lock the crankshaft.

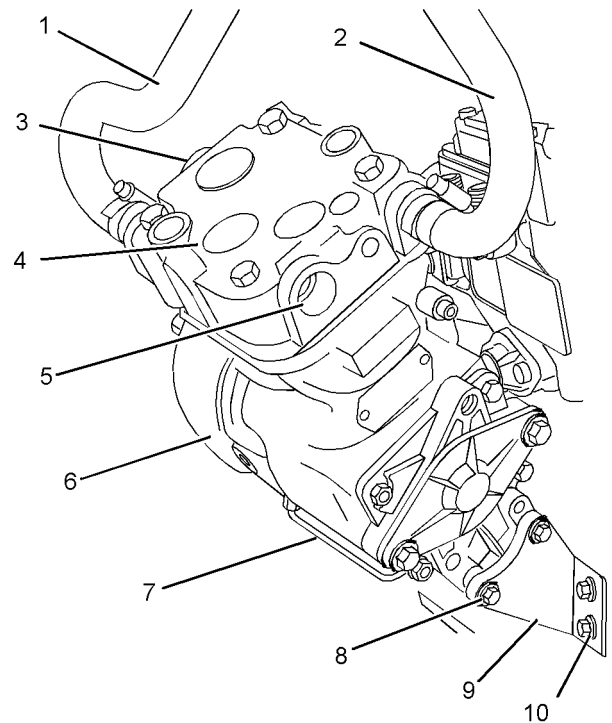


Illustration 269

g01250794

Typical example

7. Disconnect coolant hoses (1) and (2) from air compressor (4).
8. Disconnect the air lines from ports (3) and (5).
9. Remove tube assembly (7) from air compressor (4) and from the cylinder block.
10. Remove bolts (8) and (10) from support bracket (9) and remove the support bracket.



This diagram shows the rear of the engine with a gear assembly. A hand is shown holding the gear assembly, which consists of a gear (16) mounted on a shaft (17) and a housing (18). The gear assembly is being positioned to be attached to the rear of the engine. The gear (16) is shown meshing with a gear on the engine. The shaft (17) is shown passing through the housing (18). The housing (18) is shown with a flange and a mounting bracket. The gear assembly is shown in a cross-sectional view.

Illustration 271

Typical example

g01250889

14. If necessary, remove nut (17) and remove the spring washer. Use Tooling (C) in order to remove gear (16) from the crankshaft of the air compressor.

Installation Procedure

Table 76

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610211	Crankshaft Timing Pin	1
D	21826051	POWERPART High Strength Retainer	-
E	21820221	POWERPART Rubber Grease	-

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

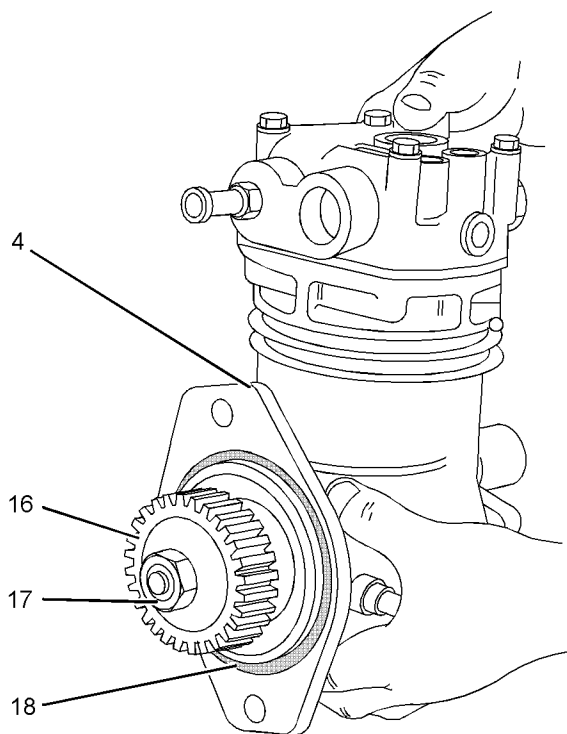


Illustration 272

g01250889

Typical example

1. If necessary, follow Steps 1.a through 1.b in order to install the gear to the air compressor.
 - a. Ensure that the shaft of air compressor (4) is clean and dry. Ensure that gear (16) is clean and free from damage.
 - b. Install gear (16) and a new spring washer to the shaft of the air compressor.

- c. Apply Tooling (D) to the threads of the shaft. Install nut (17) to the shaft of air compressor (4). Tighten the nut to a torque of 120 N·m (89 lb ft).

2. Install the O-ring seal to air compressor (4). Use Tooling (E) in order to lubricate the O-ring seal.

3. Ensure that number one piston is at the top center position on the compression stroke. Refer to the Systems Operation, Testing and Adjusting, "Finding Top Center Position for No. 1 Piston".

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

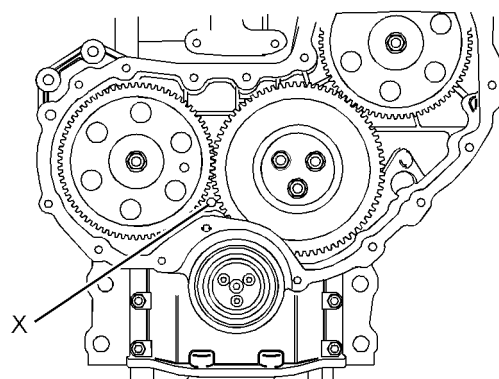


Illustration 273

g01272266

Typical example

4. Ensure that Tooling (B) is installed in hole (X) in the front housing. Use Tooling (B) in order to lock the crankshaft in the correct position.

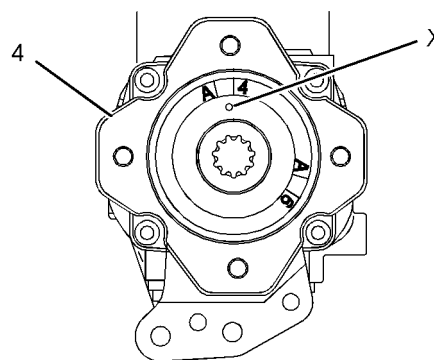


Illustration 274

g01250968

Typical air compressor with a SAE drive

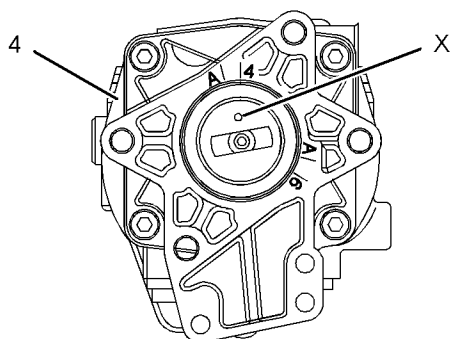


Illustration 275

g01251223

Typical air compressor with a DIN drive

5. Rotate the crankshaft of the air compressor until the timing mark (X) is aligned with the timing mark A4 on the rear face of air compressor (4). Refer to Illustration 274 for air compressors with a SAE drive. Refer to Illustration 275 for air compressors with a DIN drive.

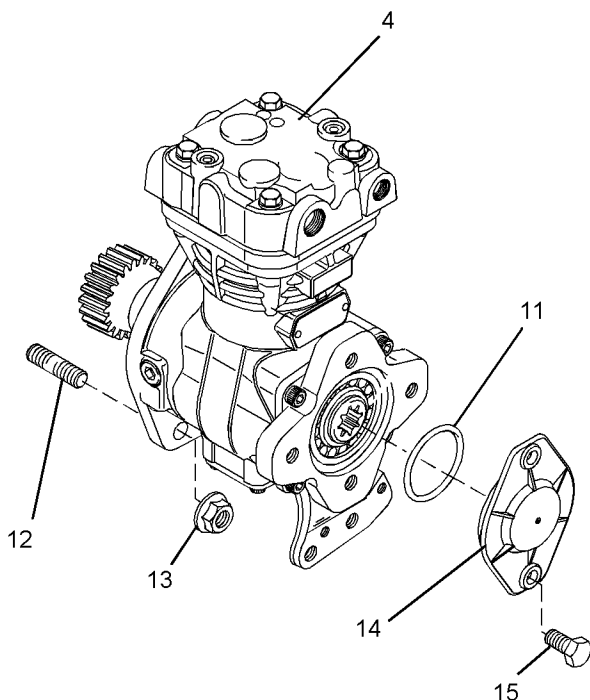


Illustration 276

g01250816

Typical example

6. Align the air compressor (4) with studs (12). Install the air compressor to the front housing. If necessary, rotate the crankshaft of the air compressor in a clockwise direction in order to align the gears.

Note: Ensure that timing mark (X) is aligned with the timing mark A4. Refer to Illustration 274 for air compressors with a SAE drive. Refer to Illustration 275 for air compressors with a DIN drive.

7. Install nuts (13). Tighten the nuts to a torque of 78 N·m (58 lb ft).
8. If necessary, follow Steps 8.a through 8.c in order to install cover (14).
 - a. Install a new O-ring seal (11) to cover (14). Use Tooling (E) in order to lubricate the O-ring seal.
 - b. Install cover (14) to air compressor (4).
 - c. Install bolts (15). Tighten the bolts to a torque of 13 N·m (9.5 lb ft).

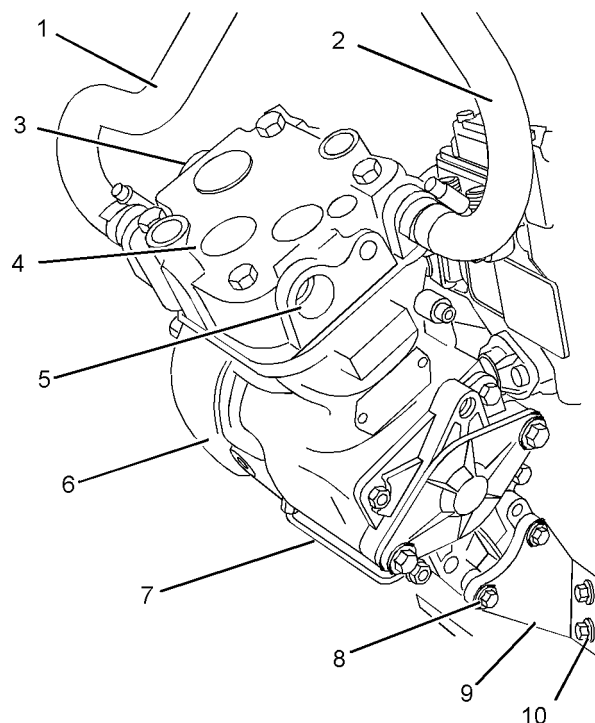


Illustration 277

g01250794

Typical example

9. Position support bracket (9) onto air compressor (4). Install bolts (8) finger tight.
10. Install bolts (10) finger tight.
11. Tighten the bolts (8) to a torque of 22 N·m (16 lb ft). Tighten the bolts (10) to a torque 22 N·m (16 lb ft).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

12. Install tube assembly (7) to air compressor (4) and to the cylinder block. Tighten the nuts to a torque of 9 N·m (80 lb in).
13. Remove Tooling (B) from hole (X) in the front housing.
14. Install the front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".
15. If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump.
16. Connect the air lines to ports (3) and (5) in the air compressor.
17. Connect coolant hoses (1) and (2) to air compressor (4).
18. Fill the cooling system with coolant to the correct level. Refer to the Operation and Maintenance Manual.

i02628914

Vacuum Pump - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

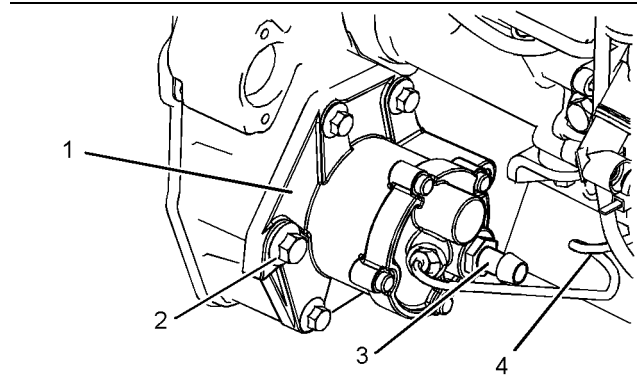


Illustration 278

g01254510

Typical example

1. Remove tube assembly (4) from vacuum pump (1) and from the cylinder block.
2. Disconnect the vacuum line from connector (3) on the vacuum pump.
3. Remove bolts (2). Remove vacuum pump (1) from the front housing.
4. Remove the joint.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

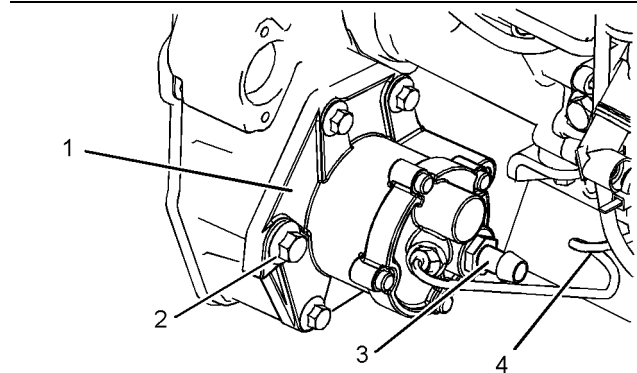


Illustration 279

g01254510

Typical example

1. Ensure that the vacuum pump is clean and free from damage. If necessary, replace the vacuum pump.
2. Clean the mating surfaces on the front housing.
3. Install a new joint to vacuum pump (1).

4. Install vacuum pump (1) to the front housing. If necessary, rotate the shaft of the vacuum pump in order to align the gears.

5. Install bolts (2).

Tighten M8 bolts to a torque of 22 N·m (16 lb ft).

Tighten M10 bolts to a torque of 44 N·m (32 lb ft).

6. Connect the vacuum line to connector (3).

7. Install tube assembly (4) to vacuum pump (1) and to the cylinder block. Tighten the nuts on the tube assembly to a torque of 9 N·m (80 lb in).

Index

A

Accessory Drive - Remove and Install.....	63
Installation Procedure	64
Removal Procedure	63
Air Compressor - Remove and Install.....	128
Installation Procedure	130
Removal Procedure	128
Alternator - Install (Engines With an Automatic Belt Tensioner).....	126
Installation Procedure	126
Alternator - Install (Engines Without an Automatic Belt Tensioner).....	127
Installation Procedure	127
Alternator - Remove (Engines With an Automatic Belt Tensioner).....	125
Removal Procedure	125
Alternator - Remove (Engines Without an Automatic Belt Tensioner).....	125
Removal Procedure	125
Alternator Belt - Remove and Install (Engines With an Automatic Belt Tensioner).....	122
Installation Procedure	122
Removal Procedure	122

B

Balancer - Install.....	95
Assembly Procedure.....	95
Installation Procedure	96
Balancer - Remove.....	93
Disassembly Procedure	94
Removal Procedure	93
Bearing Clearance - Check	118
Measurement Procedure	118

C

Camshaft - Remove and Install	82
Installation Procedure	83
Removal Procedure	82
Camshaft Bearings - Remove and Install.....	86
Installation Procedure	87
Removal Procedure	86
Camshaft Gear - Remove and Install	84
Installation Procedure	85
Removal Procedure	84
Connecting Rod Bearings - Install (Connecting rods in position)	106
Installation Procedure	106
Connecting Rod Bearings - Remove (Connecting rods in position)	105
Removal Procedure	105

Crankcase Breather - Remove and Install (Naturally Aspirated Engines)	69
Assembly Procedure.....	70
Disassembly Procedure.....	70
Installation Procedure	70
Removal Procedure	69
Crankcase Breather - Remove and Install (Turbocharged Engines with Filtered Breather)...	67
Assembly Procedure.....	68
Disassembly Procedure.....	67
Installation Procedure	68
Removal Procedure	67
Crankcase Breather - Remove and Install (Turbocharged Engines with Unfiltered Breather).....	65
Assembly Procedure.....	66
Disassembly Procedure.....	65
Installation Procedure	66
Removal Procedure	65
Crankshaft - Install.....	114
Installation Procedure	114
Crankshaft - Remove.....	112
Removal Procedure	112
Crankshaft Front Seal - Remove and Install.....	46
Installation Procedure	46
Removal Procedure	46
Crankshaft Gear - Remove and Install	117
Installation Procedure	118
Removal Procedure	117
Crankshaft Main Bearings - Remove and Install (Crankshaft in position).....	108
Installation Procedure	109
Removal Procedure	108
Crankshaft Pulley - Remove and Install (Engines With an Automatic Belt Tensioner).....	44
Installation Procedure	44
Removal Procedure	44
Crankshaft Pulley - Remove and Install (Engines Without an Automatic Belt Tensioner).....	45
Installation Procedure	45
Removal Procedure	45
Crankshaft Rear Seal - Install.....	41
Installation Procedure	41
Crankshaft Rear Seal - Remove.....	40
Removal Procedure	40
Crankshaft Wear Sleeve (Front) - Remove and Install	47
Installation Procedure	47
Removal Procedure	47
Cylinder Head - Install	78
Installation Procedure	78
Cylinder Head - Remove	76
Removal Procedure	76

D

Disassembly and Assembly Section.....	4
---------------------------------------	---

E

Electric Starting Motor - Remove and Install	127
Installation Procedure	128
Removal Procedure	127
Engine Oil Cooler - Install	28
Installation Procedure	28
Engine Oil Cooler - Remove	27
Removal Procedure	27
Engine Oil Filter Base - Remove and Install	26
Installation Procedure	26
Removal Procedure	26
Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)	87
Installation Procedure	88
Removal Procedure	87
Engine Oil Pan - Remove and Install (Cast Iron Oil Pan)	90
Installation Procedure	92
Removal Procedure	90
Engine Oil Pump - Remove and Install (Engines Without a Balancer Unit)	32
Installation Procedure	33
Removal Procedure	32
Engine Oil Relief Valve - Remove and Install (Engines with a Balancer Unit)	30
Installation Procedure	31
Removal Procedure	30
Engine Oil Relief Valve - Remove and Install (Engines Without a Balancer Unit)	29
Installation Procedure	30
Removal Procedure	29
Exhaust Elbow - Remove and Install	20
Installation Procedure	20
Removal Procedure	20
Exhaust Manifold - Remove and Install	18
Installation Procedure	19
Removal Procedure	18

F

Fan - Remove and Install	123
Installation Procedure	123
Removal Procedure	123
Fan Drive - Remove and Install	124
Installation Procedure	124
Removal Procedure	124
Flywheel - Install	39
Installation Procedure	39
Flywheel - Remove	38
Removal Procedure	38
Flywheel Housing - Remove and Install	42
Installation Procedure	43
Removal Procedure	42
Front Cover - Remove and Install	49
Installation Procedure	49
Removal Procedure	49
Fuel Injection Lines - Remove and Install	5
Installation Procedure	6
Removal Procedure	5

Fuel Injection Pump - Install	9
Installation Procedure	9
Fuel Injection Pump - Remove	8
Removal Procedure	8
Fuel Injection Pump Gear - Install	13
Installation Procedure	13
Fuel Injection Pump Gear - Remove	11
Removal Procedure	11
Fuel Injector - Install	15
Installation Procedure	15
Fuel Injector - Remove	14
Removal Procedure	14
Fuel Injector Cover - Remove and Install	7
Installation Procedure	7
Removal Procedure	7
Fuel Priming Pump and Fuel Filter Base - Remove and Install	4
Installation Procedure	4
Removal Procedure	4

G

Gear Group (Front) - Remove and Install	50
Installation Procedure	52
Removal Procedure	50
Glow Plugs - Remove and Install	119
Installation Procedure	120
Removal Procedure	119

H

Housing (Front) - Install	61
Installation Procedure	61
Housing (Front) - Remove	59
Removal Procedure	59

I

Idle Gear - Install	56
Installation Procedure (Heavy-Duty Idle Gear) ..	58
Installation Procedure (Standard Idle Gear)	56
Idle Gear - Remove	53
Removal Procedure (Heavy-Duty Idle Gear)	55
Removal Procedure (Standard Idle Gear)	53
Important Safety Information	2
Inlet and Exhaust Valve Springs - Remove and Install	21
Installation Procedure	22
Removal Procedure	21
Inlet and Exhaust Valves - Remove and Install	23
Installation Procedure	24
Removal Procedure	23

L

Lifter Group - Remove and Install.....	81
Installation Procedure	81
Removal Procedure	81

P

Piston Cooling Jets - Remove and Install.....	97
Installation Procedure	98
Removal Procedure	97
Pistons and Connecting Rods - Assemble	101
Assembly Procedure.....	101
Pistons and Connecting Rods - Disassemble	100
Disassembly Procedure	100
Pistons and Connecting Rods - Install.....	103
Installation Procedure	103
Pistons and Connecting Rods - Remove.....	99
Removal Procedure	99

R

Rocker Shaft - Assemble.....	74
Assembly Procedure.....	74
Rocker Shaft - Disassemble	73
Disassembly Procedure	73
Rocker Shaft and Pushrod - Install.....	75
Installation Procedure	75
Rocker Shaft and Pushrod - Remove.....	72
Removal Procedure	72

T

Table of Contents.....	3
Turbocharger - Install	17
Installation Procedure	17
Turbocharger - Remove	15
Removal Procedure	15

V

V-Belts - Remove and Install (Engines Without an Automatic Belt Tensioner).....	121
Installation Procedure	121
Removal Procedure	121
Vacuum Pump - Remove and Install	133
Installation Procedure	133
Removal Procedure	133
Valve Mechanism Cover - Remove and Install.....	71
Installation Procedure	72
Removal Procedure	71

W

Water Pump - Install	35
Installation Procedure	35
Water Pump - Remove	34
Removal Procedure	34

Water Temperature Regulator - Remove and Install	36
Installation Procedure	37
Removal Procedure	36

