

Disassembly and Assembly

1106D Industrial Engine

PJ (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.

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Disassembly and Assembly Section

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Fuel Priming Pump - Remove and Install (Mechanical Priming Pump)

Removal Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Isolate the fuel supply.
2. Make a temporary identification mark on plastic tube assemblies (1) in order to show the correct position of the tube assemblies.
3. Place a suitable container below the fuel priming pump in order to catch any fuel that might be spilled. Drain the primary filter (7). Refer to Operation and Maintenance Manual, "Fuel System Primary Filter (Water Separator) Element - Replace".

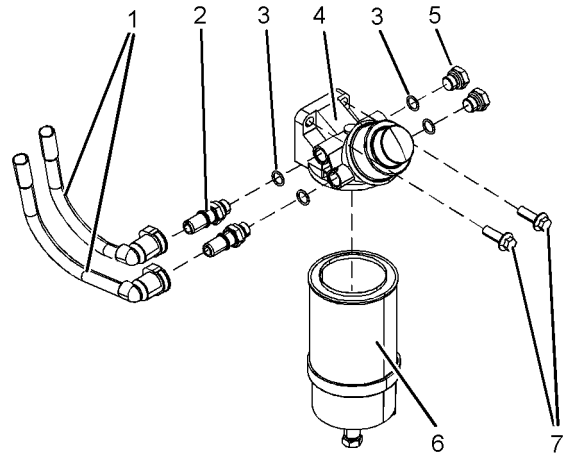


Illustration 1

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Typical example

4. Disconnect plastic tube assemblies (1). Plug the tube assemblies with new plugs. Cap open connectors (2) on the fuel priming pump with new caps.
5. Remove primary filter (6) from fuel priming pump (4). Refer to Operation and Maintenance, "Fuel System Primary Filter (Water Separator) Element - Replace".
6. Remove bolts (7) from fuel priming pump (4). Remove fuel priming pump (4) from the mounting bracket.
7. If necessary, follow Steps 7.a through 7.c in order to disassemble fuel priming pump (4).
 - a. Remove connectors (2) from fuel priming pump (4).
 - b. Remove plugs (5) from fuel priming pump (4).
 - c. Remove O-ring seals (3) from connectors (2) and plugs (5).

Installation Procedure (Manual Priming Pump)

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Ensure that fuel priming pump (4) is clean and free from wear or damage. If necessary, replace the fuel priming pump.

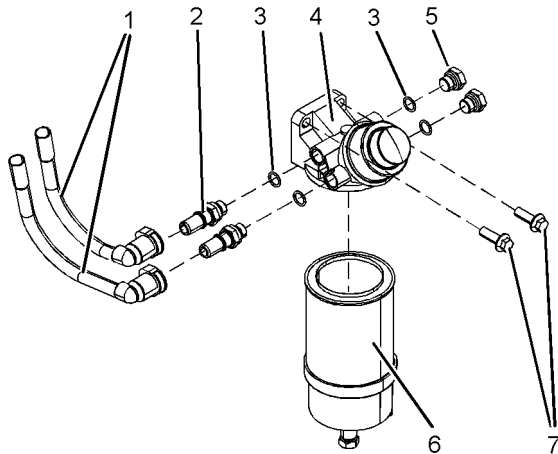


Illustration 2

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Typical example

2. If necessary, follow Steps 2.a through 2.d in order to assemble fuel priming pump (4).
 - a. Install new O-ring seals (3) to connectors (2) and to plugs (5).
 - b. Install connectors (2) to fuel priming pump (4).
 - c. Install plugs (5) to fuel priming pump (4).
 - d. Tighten the plugs and the connectors to a torque of 20 N·m (14 lb ft).

3. Position fuel priming pump (4) on the mounting bracket. Install bolts (7) to the fuel priming pump. Tighten the bolts to a torque of 44 N·m (32 lb ft).
 4. Remove the plugs from the plastic tube assemblies. Remove the caps from the connectors.
 5. Connect plastic tube assemblies (1) to connectors (2).
- Note:** Ensure that the plastic tube assemblies are installed in the original positions.
6. Install a new primary filter (6) to fuel priming pump (4). Refer to Operation and Maintenance Manual, "Fuel System Primary Filter (Water Separator) Element - Replace".
 7. Restore the fuel supply.
 8. Prime the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

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Fuel Priming Pump - Remove and Install (Electrical Priming Pump)

Removal Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Isolate the fuel supply.

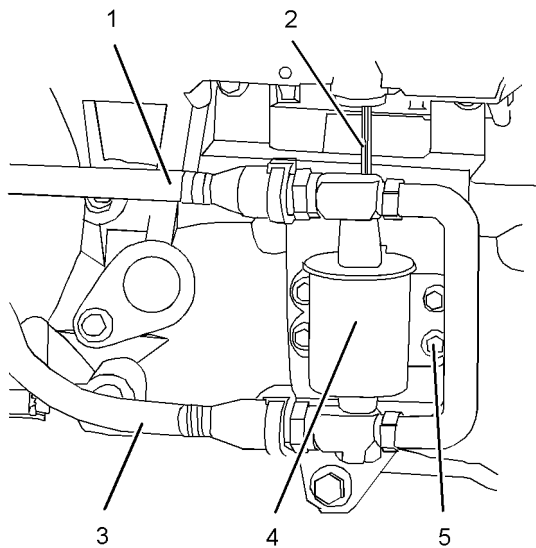


Illustration 3

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Typical example

2. Isolate the electrical supply.
3. Disconnect harness assembly (2) for electric priming pump (4).
4. Make a temporary identification mark on plastic tube assemblies (1) and (3) in order to show the correct position of the tube assemblies.
5. Disconnect plastic tube assemblies (1) and (3). Plug the tube assemblies with new plugs. Cap the ports in fuel priming pump (4) with new caps.
6. Remove bolts (5) from electric priming pump (4).
7. Remove electric priming pump (4) from the mounting bracket.

Installation Procedure (Electric Fuel Priming Pump)

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Ensure that electric priming pump (4) is clean and free from wear or damage. If necessary, replace the electric priming pump.

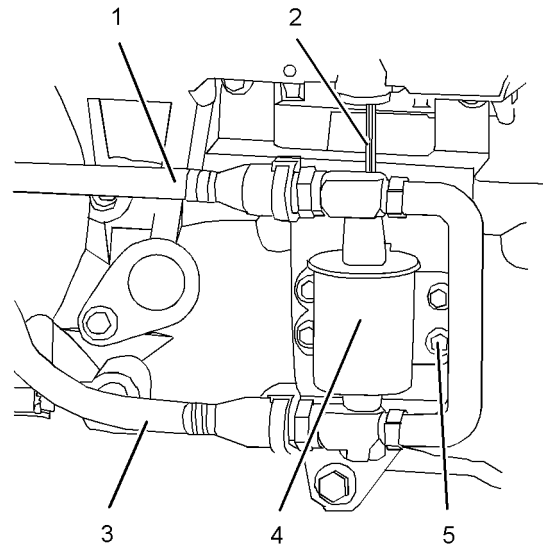


Illustration 4

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Typical example

2. Position electric priming pump (4) on the mounting bracket. Install bolts (5) to electric priming pump (4).
 3. Tighten bolts (5) to a torque of 9 N·m (79 lb in).
 4. Remove the plugs from the plastic tube assemblies. Remove the caps from the electric priming pump.
 5. Connect plastic tube assemblies (1) and (3) to electric priming pump (4).
- Note:** Ensure that the plastic tube assemblies are installed in the original positions.
6. Connect harness assembly (2) for electric priming pump (4).
 7. Restore the electrical supply.
 8. Restore the fuel supply.
 9. Prime the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i02654496

Fuel Filter Base - Remove and Install (Secondary Fuel Filter)

Removal Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Isolate the fuel supply.

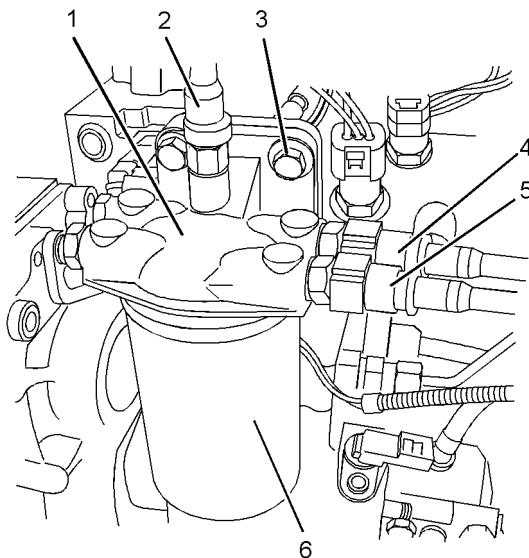


Illustration 5

g01334883

Typical example

2. Make temporary identification marks on plastic tube assemblies (2), (4) and (5) in order to show the correct position of the tube assemblies.
3. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.

4. Disconnect plastic tube assemblies (2), (4) and (5) from fuel filter base (1). Plug the plastic tube assemblies with new plugs. Cap the ports in the fuel filter base with new caps.

5. Remove fuel filter (6). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace".

6. Remove bolts (3) from fuel filter base (1). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

Installation Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Ensure that fuel filter base (1) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.

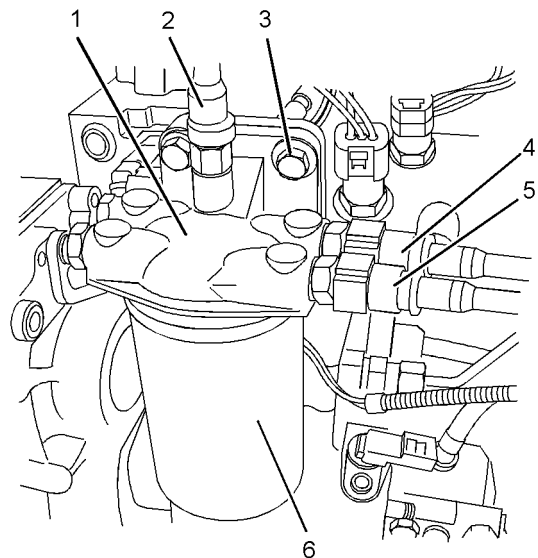


Illustration 6

g01334883

Typical example

2. Position fuel filter base (1) on the mounting bracket. Install bolts (3). Tighten the bolts to a torque of 44 N·m (32 lb ft).
3. Remove the plugs from the plastic tube assemblies. Remove the caps from the ports in the fuel filter base.

NOTICE

Ensure that the plastic tube assemblies are installed in the original positions. Failure to connect the plastic tube assemblies to the correct ports will allow contamination to enter the fuel system. Contaminated fuel will cause serious damage to the engine.

4. Connect plastic tube assemblies (2), (4) and (5) to fuel filter base (1).
5. If necessary, install a new fuel filter (6) to fuel filter base (1). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.
6. Restore the fuel supply.

End By:

- a. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i02654514

Fuel Transfer Pump - Remove

Removal Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Isolate the fuel supply.

2. Place a suitable container below fuel transfer pump (2) in order to catch any fuel that might be spilled.

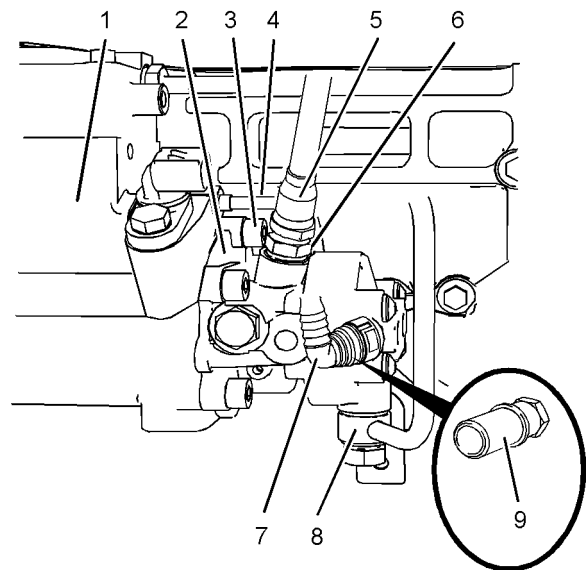


Illustration 7

g01334899

Typical example

3. Remove plastic tube assembly (7) from fuel transfer pump (2).

Note: If the tube assembly has quick fit connections, ensure that the connections are clean before the tube assembly is plugged.

4. Disconnect plastic tube assembly (5) from the outlet of fuel transfer pump (2).

Note: If the tube assembly has quick fit connections, ensure that the connections are clean before the tube assembly is plugged.

5. Remove connector (6) from fuel transfer pump (2). Remove the O-ring seal from connector (6).

If necessary, remove connector (9) from fuel transfer pump (2). Remove the O-ring seal from the connector (9).

6. Remove tube assembly (8) for the fuel return from the fuel transfer pump and the cylinder head.

Note: Disconnect the tube assembly at the fuel transfer pump first in order to drain the fuel from the cylinder head.

7. Remove tube assembly (4) for the engine oil supply from fuel injection pump (1).

8. Plug or cap all open ports and tube assemblies immediately with new plugs or caps.

9. Use an allen wrench with a ball end in order to remove allen head screws (3) that secure the fuel transfer pump to fuel injection pump (1).

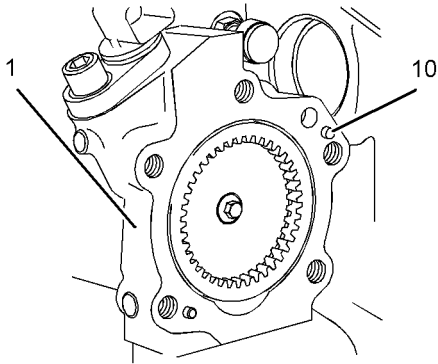


Illustration 8 g01335043

10. Remove fuel transfer pump (2) from fuel injection pump (1).

Note: Do not remove dowels (10) from the fuel injection pump.

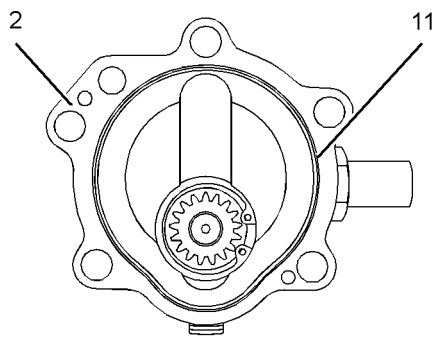


Illustration 9 g01335045

11. Remove O-ring seal (11) from fuel transfer pump (2).

i02654512

Fuel Transfer Pump - Install

Installation Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Ensure that the mating surfaces of fuel injection pump (1) and fuel transfer pump (2) are clean and free from damage.

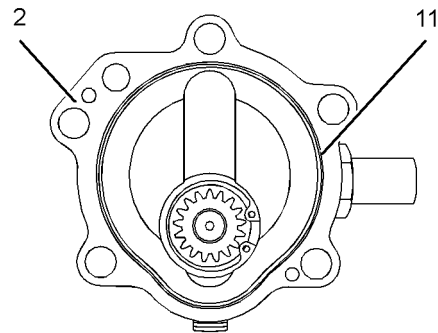


Illustration 10

g01335045

2. Install a new O-ring seal (11) to fuel transfer pump (2). Lubricate the O-ring seal with clean engine oil.

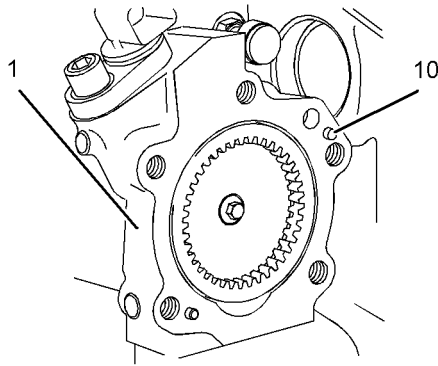


Illustration 11

g01335043

3. Align the holes in fuel transfer pump (2) with dowels (10) in fuel injection pump (1). Install the fuel transfer pump to the fuel injection pump.

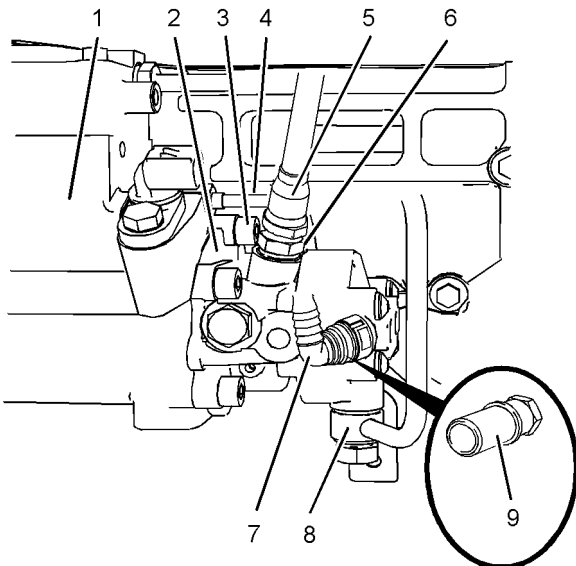


Illustration 12

g01334899

4. Use an allen wrench with a ball end to install the allen head screws (3). Tighten the allen head screws to a torque of 30 N·m (22 lb ft).
5. Remove the plugs and the caps from the ports and tube assemblies.
6. Install tube assembly (4) for the engine oil supply to fuel injection pump (1). Install new washers to the banjo bolt for oil supply tube assembly. Install the banjo bolt to the cylinder block. Tighten both connectors to a torque of 15 N·m (11 lb ft).
7. Install tube assembly (8) for the fuel return to fuel transfer pump (2) and to the cylinder head. Tighten both banjo bolts to a torque of 21 N·m (15 lb ft).
8. Install a new O-ring seal to connector (6). Install connector (6) to fuel transfer pump (2). Tighten the connector to torque of 15 N·m (11 lb ft).

9. If necessary, install a new O-ring seal to connector (9) and install connector (9) to fuel transfer pump (2). Tighten the connector to torque of 15 N·m (11 lb ft).
10. Connect plastic tube assembly (5) to the outlet of fuel transfer pump (2).
11. Install plastic tube assembly (7) to fuel transfer pump (2).
12. Restore the fuel supply.
13. Remove the air from the fuel system. Refer to System Operation, Testing and Adjusting, "Fuel System - Prime".

i02654510

Fuel Manifold (Rail) - Remove and Install

Removal Procedure

Start By:

- a. Remove the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove".
- b. If necessary, remove the fuel pressure sensor. Refer to Disassembly and Assembly, "Fuel Pressure Sensor - Remove and Install".

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. If the engine is equipped with a cover over the fuel system this will need to be removed.

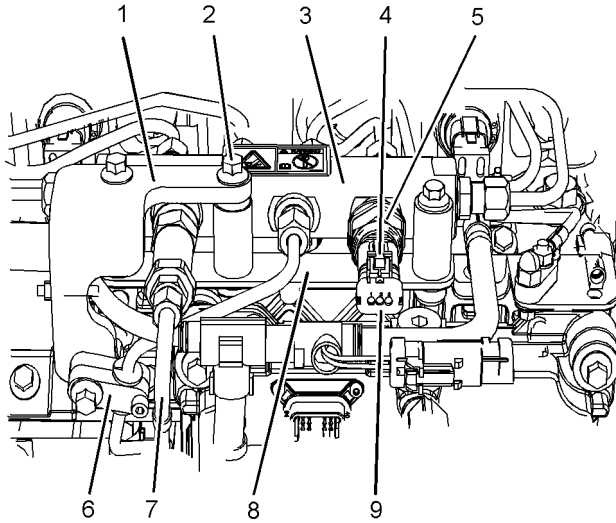


Illustration 13

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The fuel manifold is shown with fuel injection lines in position.

2. If fuel sensor (5) has not been removed from fuel manifold (3), slide locking tab (4) into the unlocked position. Disconnect the plug on harness assembly (9) from fuel pressure sensor (5).
3. Disconnect tube assembly (7) from the fuel pressure relief valve on fuel manifold (3). Immediately cap the open port in fuel manifold (3) with a new cap. Immediately plug the open end of tube assembly (7) with a new plug.
4. Remove bolts (2) from fuel manifold (3).
5. Remove the bolt from fuel injection line clamp (6). Remove clamp assembly from the bracket.
6. Remove bracket (1) from fuel manifold (3).
7. Remove fuel manifold (3) from mounting bracket (8).

Installation Procedure

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. Ensure that all ports on the fuel manifold are capped. Ensure that the fuel manifold is externally clean and free from damage.

Note: Do not install a fuel manifold that has not been capped. All caps must be left in place until the fuel injection lines or the fuel pressure sensor are installed.

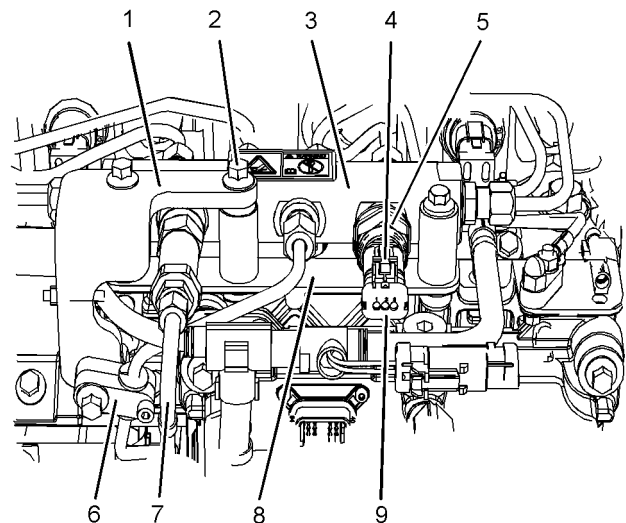


Illustration 14

g01335251

The fuel manifold is shown with fuel injection lines in position.

2. Position fuel manifold (3) on mounting bracket (8).
3. Install bracket (1) from fuel manifold (3).
4. Install bolts (2) to fuel manifold (3) finger tight.

5. Install the bolt to fuel injection line clamp (6). Tighten bolts (6) to a torque of 22 N·m (16 lb ft). Ensure that fuel injection line does not contact any other engine component.
6. Install a new set of fuel injection lines and seals. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for more information.
7. Tighten bolts (2) to a torque of 22 N·m (16 lb ft).
8. Remove the plug from tube assembly (7). Remove the cap from the appropriate port in fuel manifold (3). Connect tube assembly (7) to the fuel pressure relief valve on fuel manifold (3). Tighten the connection to a torque of 30 N·m (22 lb ft).
9. If fuel pressure sensor (5) was not removed from fuel manifold (3), connect the plug on harness assembly (9) to fuel pressure sensor (5). slide locking tab (4) into the locked position.

If fuel pressure sensor (5) was removed from fuel manifold (3), install fuel pressure sensor (5) and a new sealing washer. Refer to Disassembly and Assembly, "Fuel Pressure Sensor - Remove and Install" for more information.
10. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.
11. If the engine was equipped with a cover over the fuel system this will need to be installed.

i02654498

Fuel Injection Lines - Remove

Removal Procedure

Table 1

Required Tools			
Tool	Part Number	Part Name	Qty
A	U5MK1124	Cap Kit	1

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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 and on wires and all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. This will help to prevent fluid loss and this helps to keep contaminants from entering the system.

1. Isolate the fuel supply.
2. Isolate the electrical supply.
3. If the engine is equipped with a cover over the fuel system this will need to be removed.

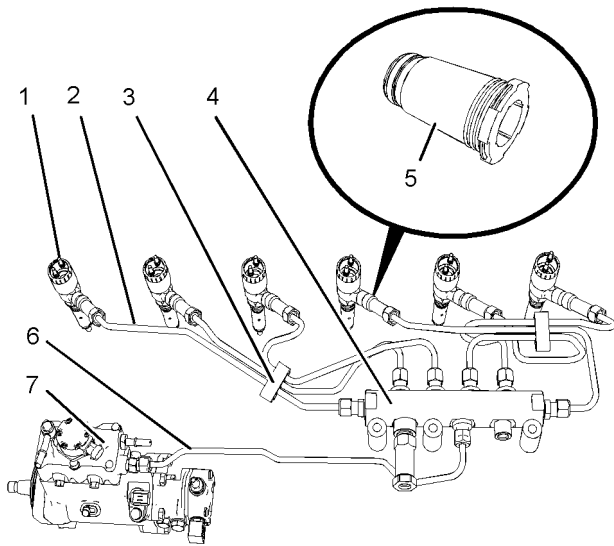


Illustration 15 g01335193

4. Remove plastic clamps (3) from the fuel injection lines (2).
5. Slide the dust seal from the nut on the fuel injection.
6. Disconnect fuel injection line (2) from electronic unit injector (1).
7. Disconnect fuel injection line (2) from fuel manifold (4).
8. Remove fuel injection line (2). Discard the fuel injection line.
9. Plug the open port in fuel manifold (4) immediately. Use Tooling (A) in order to plug the open port in the fuel manifold.
10. Remove seal (5) from electronic unit injector (1) and the base of the valve mechanism cover.
11. Plug the open port in electronic unit injector (1) immediately. Use Tooling (A) in order to plug the open port in the electronic unit injector.
12. Repeat Steps 5 through 12 in order to remove the remaining fuel injection lines from the fuel manifold to the electronic unit injectors.

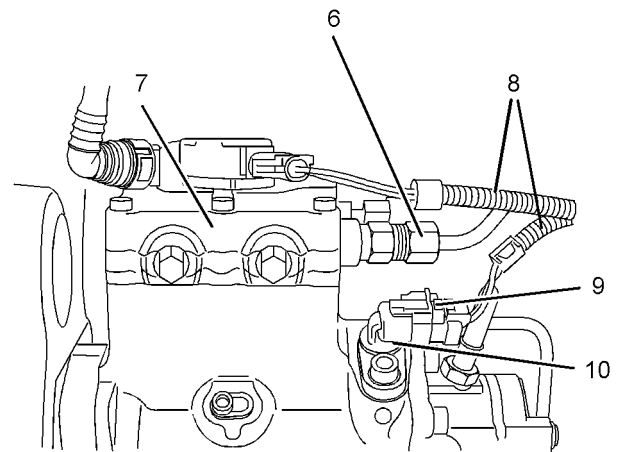


Illustration 16 g01335194

Typical Example

13. If necessary, disconnect harness assembly (8) from fuel injection pump (7). Slide locking tab (9) into the unlocked position. Disconnect harness assembly (8) from position sensor (10). Position harness assembly (8) so that the harness assembly is clear of fuel injection line (7).

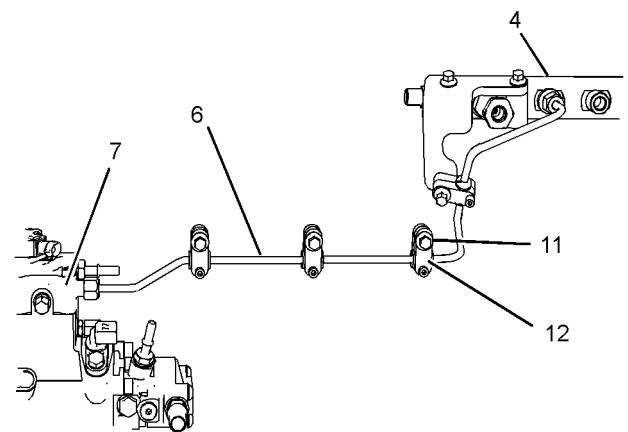


Illustration 17 g01335195

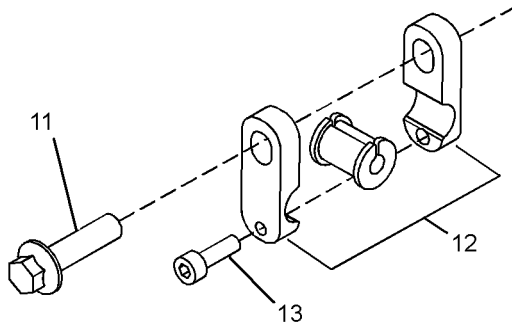


Illustration 18

g01335197

14. Remove bolts (11) from tube clips (12) that secure fuel injection line (6). Loosen allen head screws (13). Position the tube clips in order to allow removal of the fuel injection line.
15. Disconnect fuel injection line (6) at fuel injection pump (7).
16. Disconnect fuel injection line (6) at fuel manifold (4).
17. Plug all open ports immediately. Use Tooling (A) in order to plug the open ports in fuel manifold (4) and in fuel injection pump (7).
18. Remove fuel injection line (6).
19. Remove allen head screws (13) and tube clips (12) from fuel injection line (6). Discard the fuel injection line.

i02654497

Fuel Injection Lines - Install

Installation Procedure

Table 2

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610294	Injector Pipe Nut Tool	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

Note: The following procedure should be adopted in order to install the fuel injection lines when the electronic unit injectors or the fuel manifold have not been removed. If the electronic unit injectors or the fuel manifold have been removed, refer to Disassembly and Assembly, "Electronic Unit Injector - Install" and Disassembly and Assembly, "Fuel Manifold - Install" for more information.

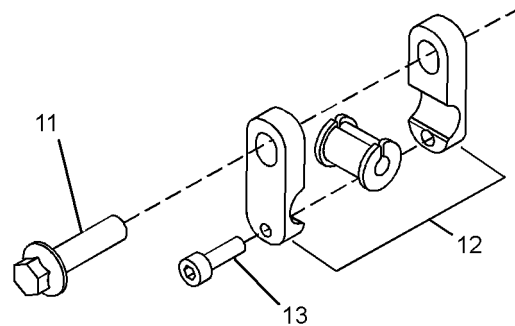


Illustration 19

Assembly of the tube clip

g01335197

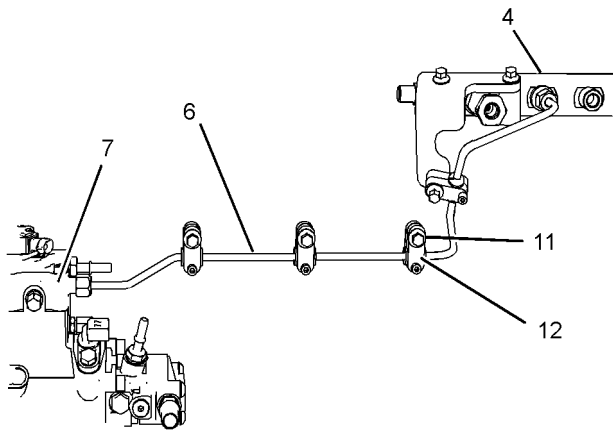


Illustration 20

g01335195

1. Loosely install tube clips (12) and the allen head screws (13) to the fuel injection line (6).
2. Place fuel injection line (6) in position.
3. Remove the caps from the port in fuel injection pump (7) and from the appropriate port in fuel manifold (4). Remove the caps from new fuel injection line (6).
4. Loosely connect the nuts at both ends of fuel injection line (6), to fuel manifold (4) and to fuel injection pump (7). Ensure that the ends of the fuel injection line are correctly seated in the fuel injection pump and in the fuel manifold.
5. Use Tooling (A) to tighten the nuts on fuel injection line (6) to a torque of 30 N·m (22 lb ft).
6. Install the bolts (11) for tube clips (12) that secure fuel injection line (6). Tighten bolts (11) to a torque of 22 N·m (16 lb ft). Tighten allen head screws (13) to a torque of 10 N·m (89 lb in). Ensure that fuel injection line does not contact any other engine component.

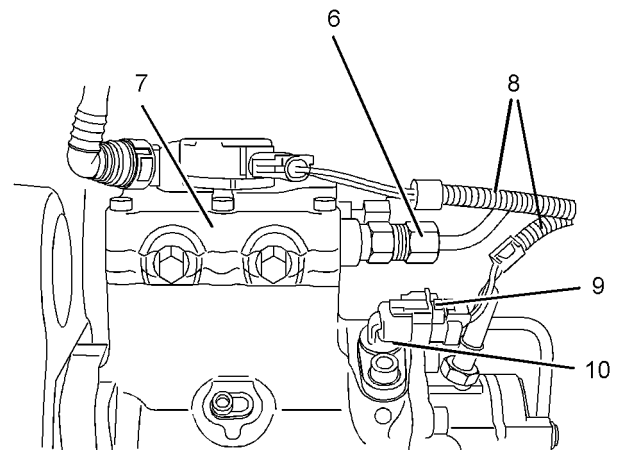


Illustration 21

g01335194

Typical example

7. Connect harness assembly (8) to position sensor (10). Slide locking tab (9) into the locked position. Connect harness assembly (8) to fuel injection pump (7).

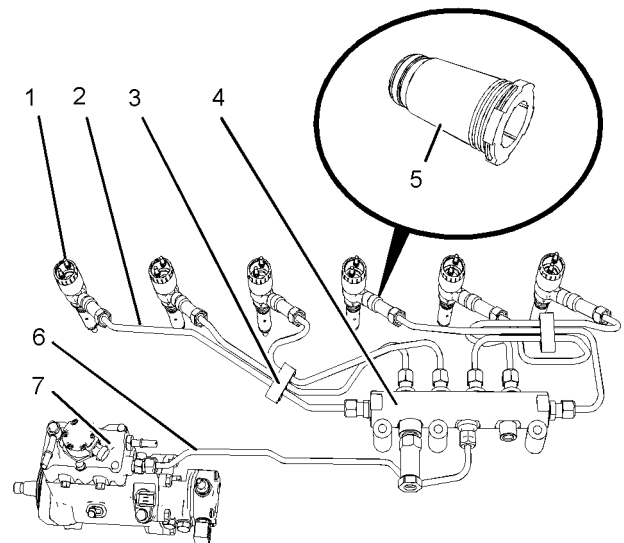


Illustration 22

g01335193

Typical example

8. Install a new seal (5) to electronic unit injector (1). Ensure that the flange on the seal is flush with the valve mechanism cover base.
9. Remove the caps from the port of electronic unit injector (1) and from the appropriate port in fuel manifold (4).

- 10. Loosely connect the nuts at both ends of fuel injection line (2), to electronic unit injector (1) and to the appropriate port in fuel manifold (4). Ensure that the ends of the fuel injection line are correctly seated in the electronic unit injector and in the fuel manifold.
 - 11. Use Tooling (A) to tighten the nuts on fuel injection line (2) to a torque of 30 N·m (22 lb ft). Ensure that the dust seal is seated correctly against seal (5).
 - 12. Follow Steps 8 through 11 in order to install the remaining fuel injection lines.
 - 13. Install new clamps (3) to the fuel injection lines. Ensure that the clamps are fully closed in order to retain the fuel injection lines.
- Note:** Ensure that fuel injection lines do not contact any other engine component.
- 14. Restore the fuel supply.
 - 15. Restore the electrical supply.
 - 16. If the engine was equipped with a cover over the fuel system this will need to be installed.
 - 17. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, "Fuel System - Prime".

i02654505

Fuel Injection Pump - Remove

Removal Procedure

Table 3

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1
D	-	Cap	2

Start By:

- a. If necessary, remove the fuel filter base. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".

- b. If necessary, remove the fuel priming pump. Refer to Disassembly and Assembly, "Fuel Priming Pump - Remove".
- c. 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.

⚠ WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

- 1. Isolate the fuel supply.
- 2. Isolate the electrical supply.
- 3. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".
- 4. 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.
- 5. 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.

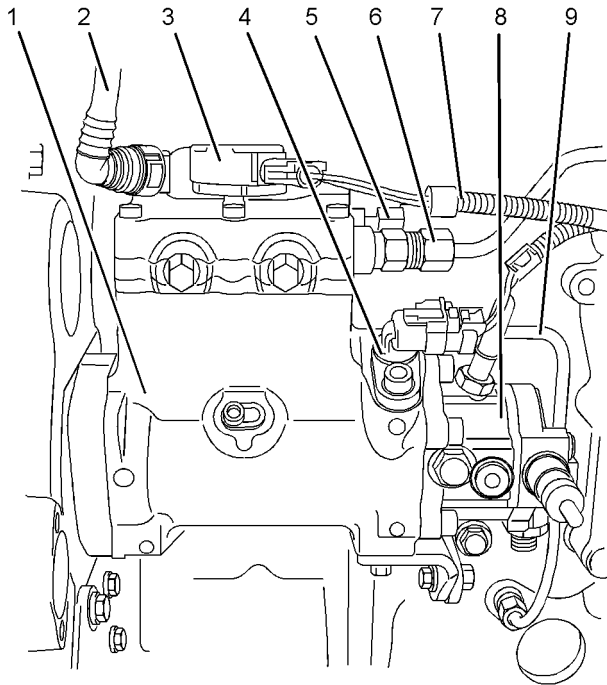


Illustration 23
Typical example

g01335253

6. Place a suitable container below fuel injection pump (1) in order to catch any fuel that might be spilled.
7. Disconnect plastic tube assembly (2) from fuel injection pump (1).
8. Disconnect harness assembly (7) from solenoid (3) of the fuel injection pump. Disconnect engine wiring harness (7) from position sensor (4) for the fuel injection pump.

Note: The harness assembly should be positioned in order to avoid an obstruction to the fuel injection pump.

9. Remove plastic tube assembly (11) from fuel transfer pump (8).
10. Disconnect plastic tube assembly (10) from the outlet of fuel transfer pump (8).
11. Disconnect plastic tube assembly (5) from fuel injection pump (1).
12. Remove tube assembly (12) for the fuel return from the fuel transfer pump and the cylinder head.

Note: Disconnect the tube assembly at the fuel transfer pump first in order to drain the fuel from the cylinder head.

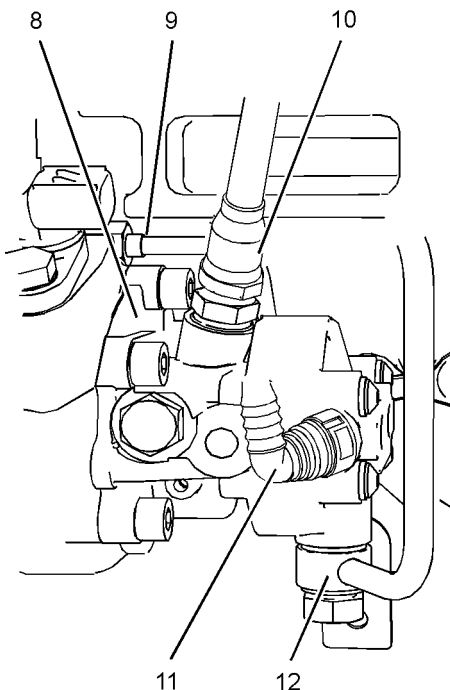


Illustration 24
Typical example

g01335254

13. Remove tube assembly (9) for the engine oil supply to fuel injection pump (1).
14. Plug or cap all open ports and tube assemblies immediately with new plugs or caps.
15. Remove fuel injection line (6) that connects the fuel injection pump to the fuel manifold. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove". Use Tooling (D) in order to plug the open ports in the fuel injection pump and in the fuel manifold. Discard the fuel injection line.

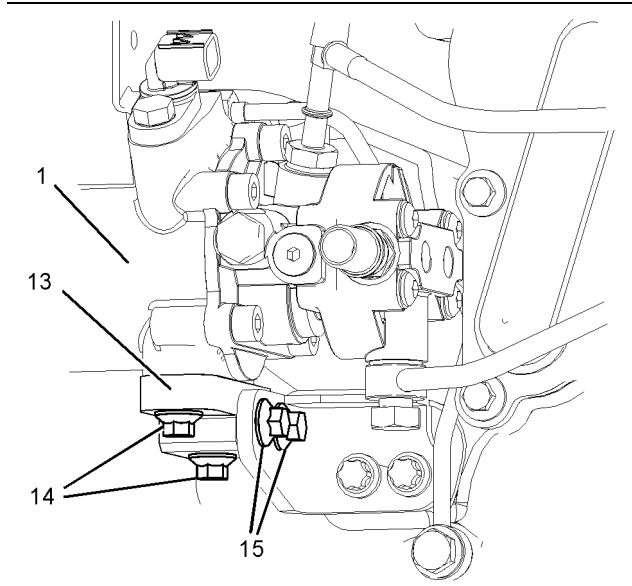


Illustration 25
Typical example
g01335275

16. Remove bolts (15). Remove bolts (14) and remove support bracket (13) from fuel injection pump (1).

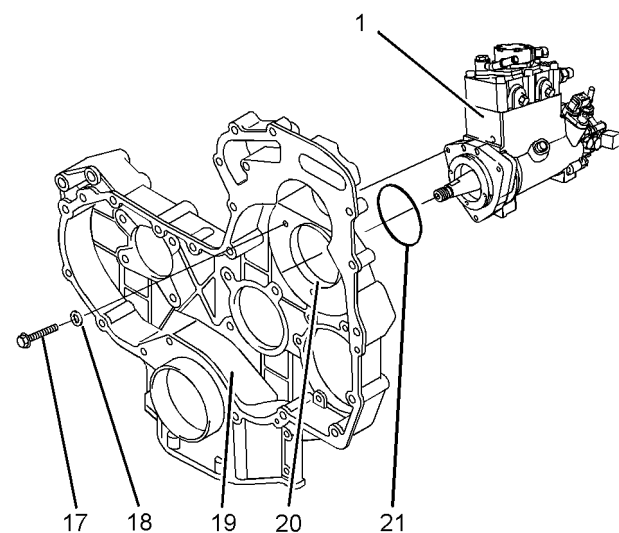


Illustration 26
Typical example
g01335277

17. Remove bolts (17) and sealing washers (18).

Note: The fuel injection pump should be supported by hand as the bolts are removed.

18. Carefully remove fuel injection pump (1) from front housing (19). Ensure that bore (20) in the front housing is not damaged as the fuel injection pump is removed.

19. Remove O-ring seal (21) from fuel injection pump (1).

20. If necessary, remove position sensor (4) from fuel injection pump (1). Refer to Disassembly and Assembly, "Position Sensor (Fuel Injection Pump) - Remove and Install".

21. If necessary, remove fuel transfer pump (8) from fuel injection pump (1). Refer to Disassembly and Assembly, "Fuel Transfer Pump - Remove".

i02654503

Fuel Injection Pump - Install

Installation Procedure

Table 4

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1
E	27610302	Fuel Injection Pump Timing Tool	1
F	21820221	POWERPART Rubber Grease	-

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

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

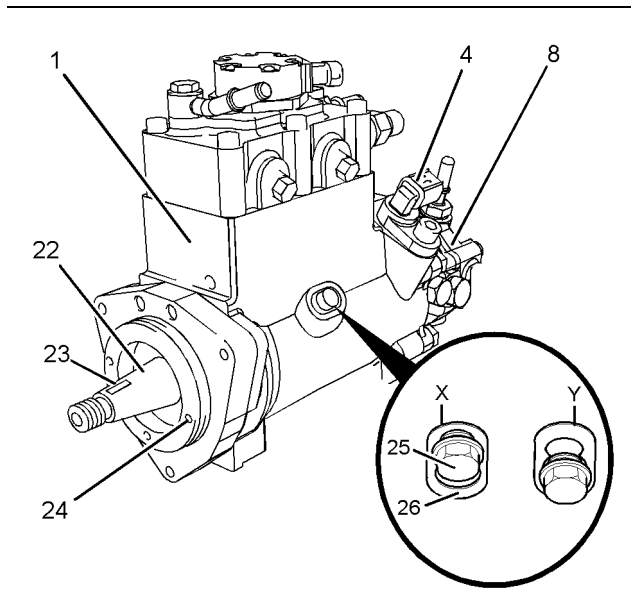


Illustration 27
Typical example

1. If the fuel injection pump was previously disassembled, follow Steps 1.a and 1.b in order to assemble the fuel injection pump.
 - a. Install fuel transfer pump (8) to fuel injection pump (1). Refer to Disassembly and Assembly, "Fuel Transfer Pump - Install".
 - b. Install position sensor (4) to fuel injection pump (1). Refer to Disassembly and Assembly, "Position Sensor (Fuel Injection Pump) - Remove and Install".

Note: A new fuel injection pump assembly includes the fuel transfer pump and the position sensor.

2. To check the fuel injection pump timing, follow Steps 2.a and 2.b.
 - a. Position Tooling (E) onto shaft (22) of the fuel injection pump. Align the lever of Tooling (E) with key slot (23). Engage the lever into the key slot.
 - b. Insert locking pin of Tooling (E) into hole (24) in fuel injection pump.

If the locking pin can be inserted into the hole, the fuel injection pump timing is correct.

If the locking pin cannot be inserted into the hole, the fuel injection pump timing is not correct.

Note: There should be no resistance when the locking pin is inserted.

3. If the fuel injection pump timing has been lost follow Steps 3.a through 3.e in order to reset the fuel injection pump timing.
 - a. If necessary, loosen locking screw (25) on the fuel injection pump. Slide spacer (26) into position (X). Tighten locking screw (25) to a torque of 9 N·m (80 lb in). This will prevent the locking screw from tightening against shaft (22).

The fuel injection pump is now unlocked.

 - b. Position Tooling (E) onto shaft (22) of the fuel injection pump. Align the lever of Tooling (E) with key slot (23) in the fuel injection pump. Engage the lever into the key slot.
 - c. Use the lever of Tooling (E) to rotate shaft (22) until pin of Tooling (E) can be engaged into hole (24). Engage pin of Tooling (E) into the hole.
 - d. Loosen locking screw (25) in the fuel injection pump. Slide spacer (26) into position (Y). Tighten locking screw (25) against the shaft of the fuel injection pump to a torque of 9 N·m (80 lb in).
- The fuel injection pump is now locked.
- e. Remove tooling (E).

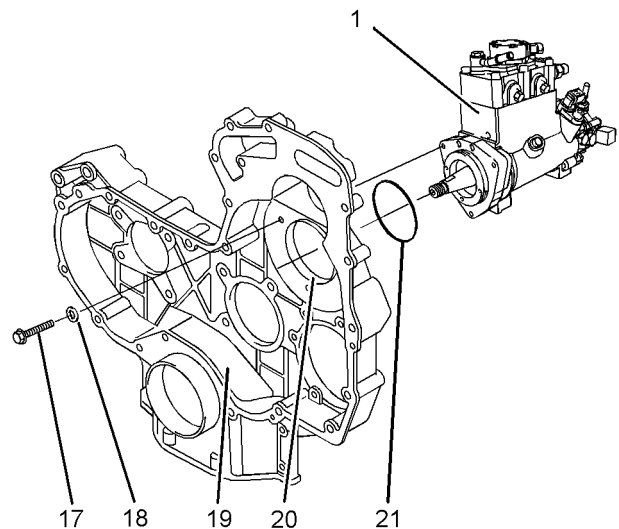


Illustration 28
Typical example

4. Inspect bore (20) in front housing (19) 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".

- 5. Use Tooling (F) to lubricate a new O-ring seal (21). Install the O-ring seal onto fuel injection pump (1).
- 6. Align the holes in fuel injection pump (1) with the holes in front housing (19). Carefully install the fuel injection pump to the front housing.

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

- 7. Install bolts (17) and two new sealing washers (18). Tighten the bolts to a torque of 25 N·m (18 lb ft).
- 8. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".
- 9. 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.
- 10. Install the fuel injection pump gear to the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" and refer to Disassembly and Assembly, "Gear Group (Front) - Install".

Note: Ensure that spacer (26) on the fuel injection pump is in unlocked position (X) after the installation of fuel injection pump gear is completed. Refer to Illustration 27.

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

- 12. Position support bracket (13) onto fuel injection pump (1). Install bolts (14) finger tight.
- 13. Install bolts (15) finger tight.
- 14. Tighten bolts (15) to a torque of 22 N·m (16 lb ft). bolts (14) to a torque of 22 N·m (16 lb ft).

Some engines have a single M10 nut and a bolt in place of bolts (15). Tighten the nut and bolt to a torque of 44 N·m (32.5 lb ft).

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

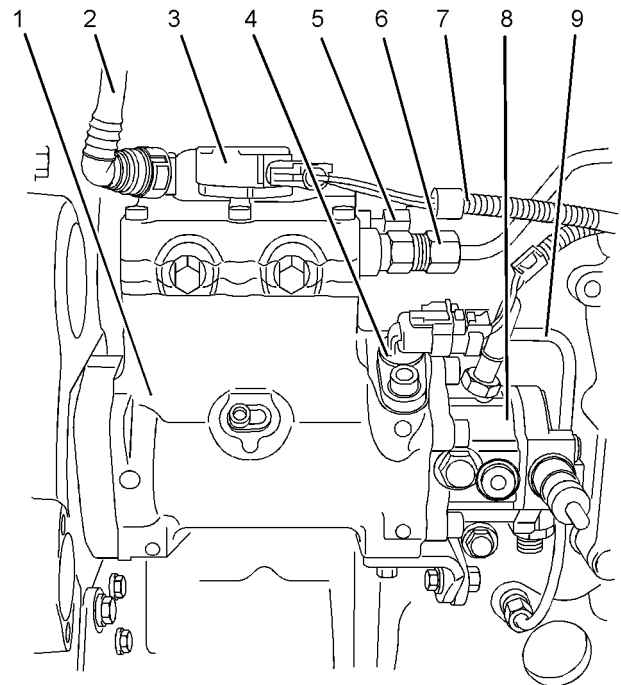


Illustration 30

g01335253

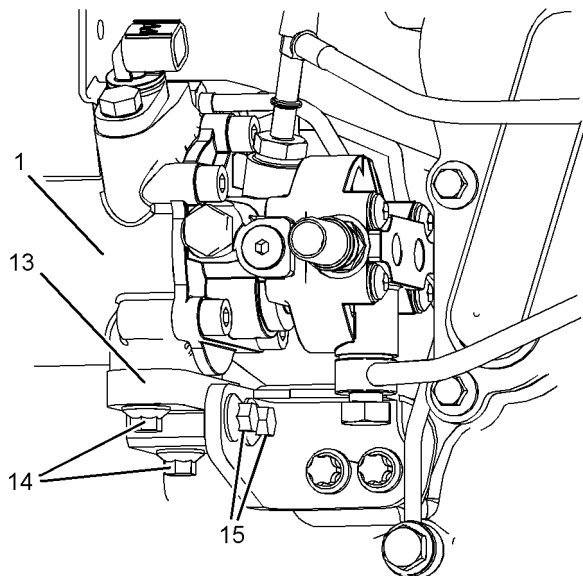


Illustration 29

g01335377

Typical example

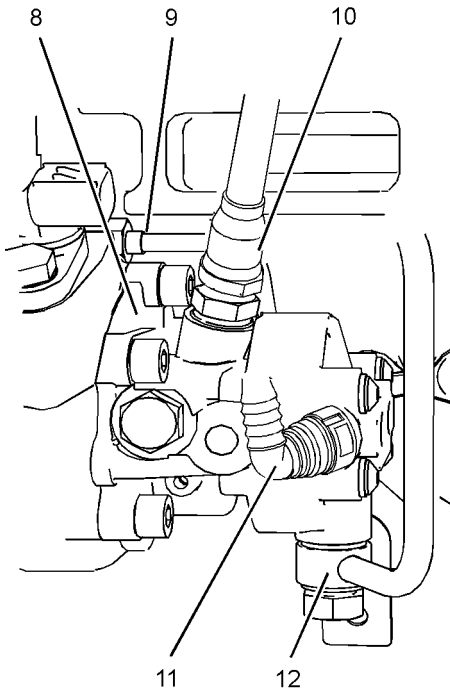


Illustration 31

g01335254

15. Remove the appropriate plugs and caps in order to install tube assembly (9) for the engine oil supply to the fuel injection pump. Install new washers to the banjo bolt for oil supply tube assembly. Install the banjo bolt to the cylinder block. Tighten both connectors to a torque of 15 N·m (11 lb ft).
16. Remove the appropriate caps in order to install fuel injection line (6). Install a new fuel injection line (6) to the fuel injection pump and to the fuel manifold. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
17. Remove the plugs and caps from the remaining ports and tube assemblies.
18. Install new washers to the banjo bolt for tube assembly (12) for the fuel return to the fuel transfer pump and to the cylinder head.
19. Position tube assembly (12) for the fuel return to the fuel transfer pump and to the cylinder head. Install both the banjo bolts to both ends of the tube assembly. Tighten banjo bolts at the cylinder head end to a torque of 26 N·m (19 lb ft). Tighten banjo bolts at the transfer pump end to a torque of 21 N·m (15 lb ft)
20. Install plastic tube assembly (5) to fuel injection pump (1).

21. Install plastic tube assembly (10) for the fuel outlet to fuel transfer pump (8).
22. Install plastic tube assembly (11) to fuel transfer pump (8).
23. Connect harness assembly (7) to solenoid (3) on the fuel injection pump. Connect harness assembly (7) to position sensor (4) on the fuel injection pump. Slide the locking tab into the locked position.
24. If necessary, install the fuel priming pump. Refer to Disassembly and Assembly, "Fuel Priming Pump - Remove and Install".
25. If necessary, install the fuel filter base. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".
26. Restore the fuel supply.
27. Restore the electrical supply.
28. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

i02654509

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 5

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housing	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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

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 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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

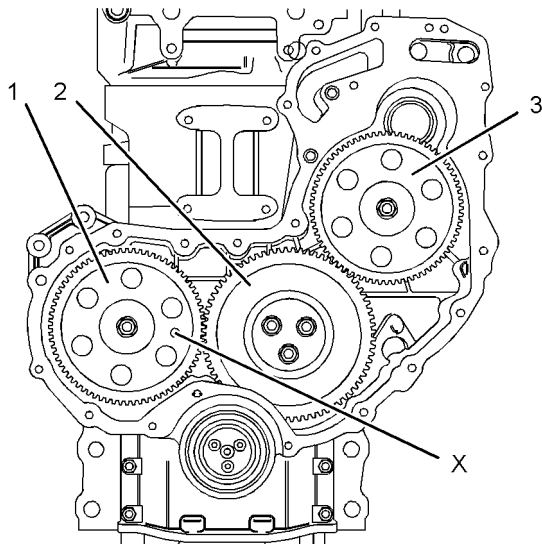


Illustration 32

g01335379

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.

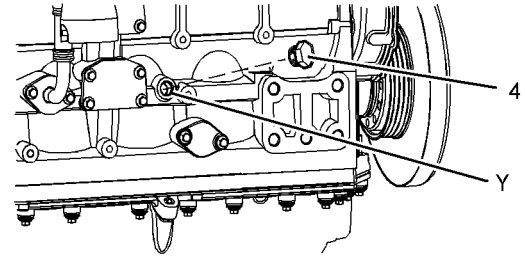


Illustration 33

g01335380

3. Remove plug (4) from the cylinder block. Install Tooling (C) into hole (Y) in the cylinder block. 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.

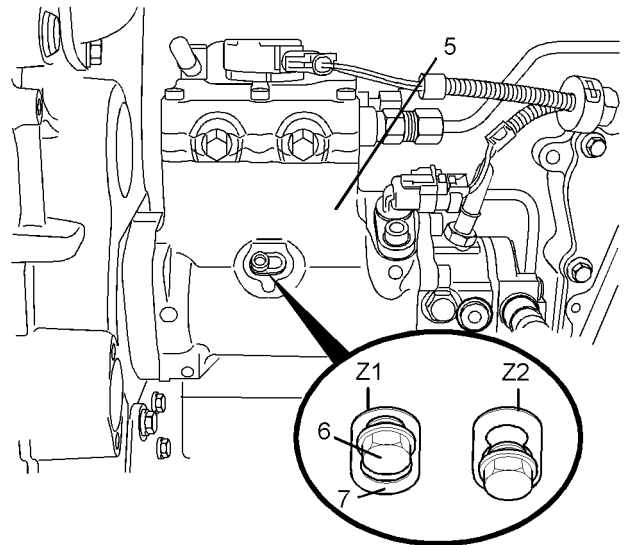


Illustration 34

g01335382

4. Apply sufficient pressure to fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Lock fuel injection pump (5) in this position.

In order to lock fuel injection pump (5), loosen locking screw (6) in the fuel injection pump. Slide spacer (7) into position (Z2). Tighten locking screw (6) against the shaft of the fuel injection pump to a torque of 9 N·m (80 lb in).

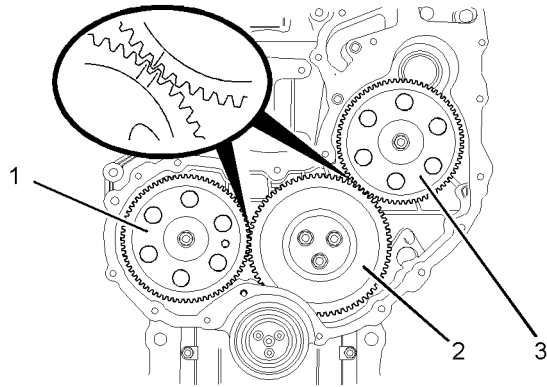


Illustration 35
Alignment of timing marks

5. Mark gears (1), (2) and (3) in order to show alignment. Refer to Illustration 35.

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

6. Loosen nut (8) for fuel pump gear (3).
7. Install Tooling (D) through three holes in fuel pump gear (3). Tighten Tooling (D) until fuel pump gear (3) 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.

i02654507

Fuel Injection Pump Gear - Install

Installation Procedure

Table 6

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center for No. 1 Piston".

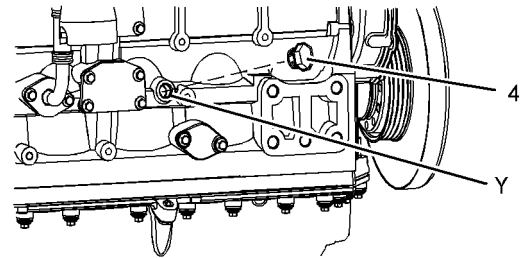


Illustration 36

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

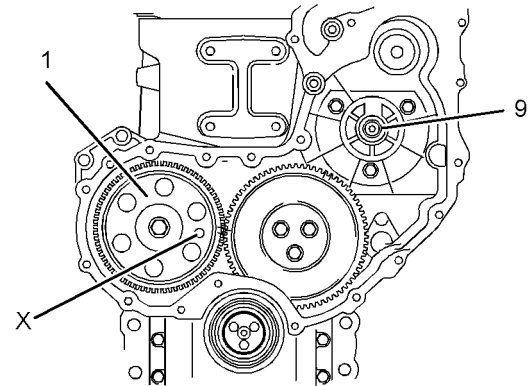


Illustration 37

3. Ensure that Tooling (B) is installed into hole (X) in camshaft gear (1).
4. Ensure that shaft (9) of the fuel injection pump is clean 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 and free from wear or damage. If necessary, replace the fuel pump gear.

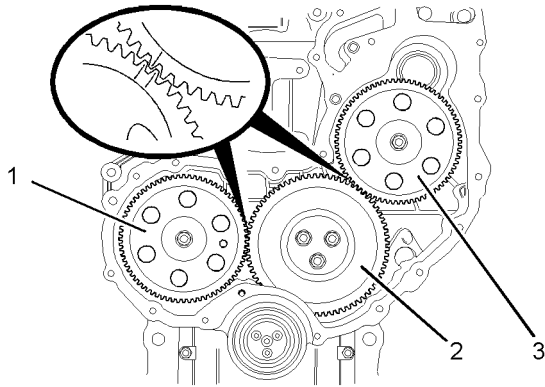


Illustration 38 g01335384
Alignment of timing marks

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.

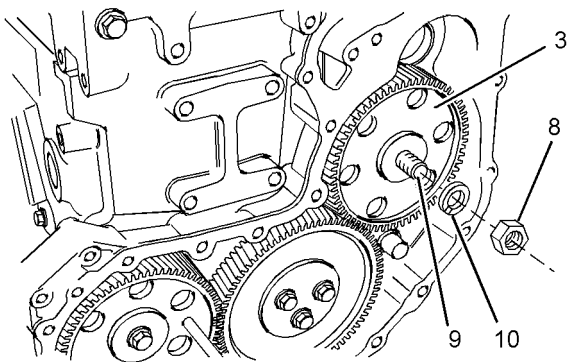


Illustration 39 g01335395
Typical example

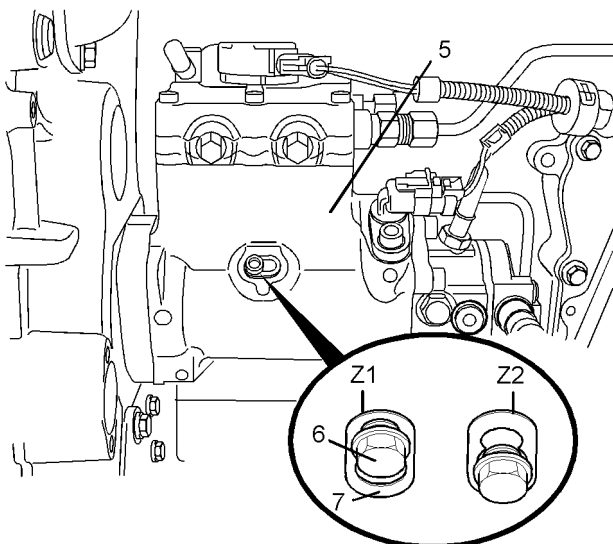


Illustration 40 g01335382
Typical example

8. Install a new spring washer (10) and install nut (8) to shaft (9) of the fuel injection pump. Apply sufficient pressure to fuel injection pump gear (3) in a counterclockwise direction in order to remove the backlash. Tighten nut (8) to a torque of 25 N-m (18 lb ft). Unlock the fuel injection pump (5).

In order to unlock fuel injection pump (5), loosen the locking bolt (5) in the fuel injection pump. Slide spacer (7) into position (Z1). Tighten locking bolt (6) against the spacer to a torque of 9 N-m (80 lb in). This will prevent the locking bolt from tightening against the shaft of the fuel injection pump.

9. Remove Tooling (B) and (C). Install plug (4) into hole (Y) in the cylinder block. Refer to Illustration 36.

10. Tighten nut (8) to a torque of 90 N-m (66.4 lb ft).

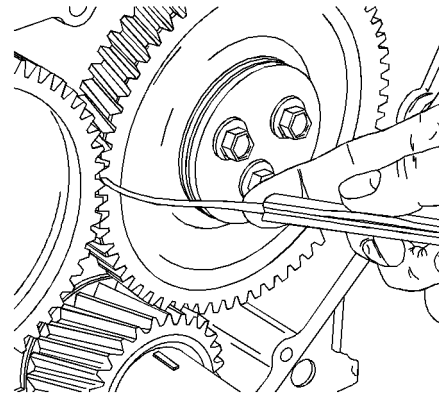


Illustration 41 g01335426
Typical example

11. Ensure that the backlash for gears (2) and (3) is within specified values. Refer to the 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".

i02654483

Electronic Unit Injector - Remove

Removal Procedure

Table 7

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	27610307	T40 Torx Socket	1
C	27610288	Pry Bar	1

Start By:

- a. 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.

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to Systems Operation, Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

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 to the engine.
2. Isolate the electrical supply to the engine.

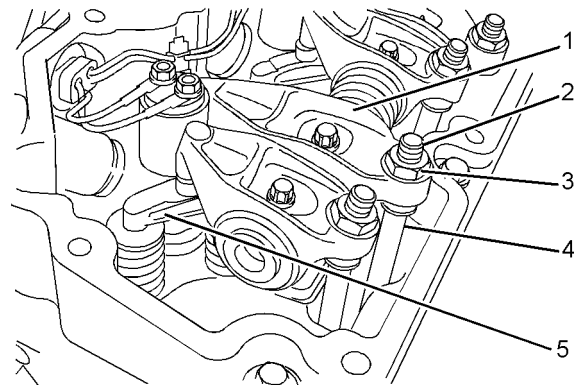


Illustration 42

g01374098

Typical example

3. Use Tooling (A) in order to rotate the crankshaft until rocker arms (1) for the appropriate cylinder are in the correct position in order to adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".
4. Follow Steps 4.b through 4.a in order to gain access to the electronic unit injector.
 - a. Make a temporary mark on valve bridges (5) in order to show the location and orientation.

Note: Identification will ensure that the valve bridges can be reinstalled in the original location and the original orientation.

- b. Loosen nuts (3) for the appropriate cylinder. Unscrew adjusters (2) for the appropriate cylinder until pushrods (4) can be withdrawn from the balls of the adjusters.
- c. Withdraw the cups of pushrods (4) from the balls of adjusters (2).
- d. Remove the valve bridges from the cylinder head.

Note: Do not interchange the location or the orientation of used valve bridges.

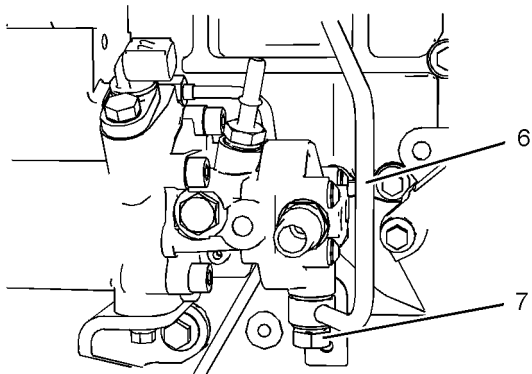


Illustration 43 g01247489
Typical example

- 5. Loosen banjo bolt (7) sufficiently in order to allow the fuel to drain from tube assembly (6).

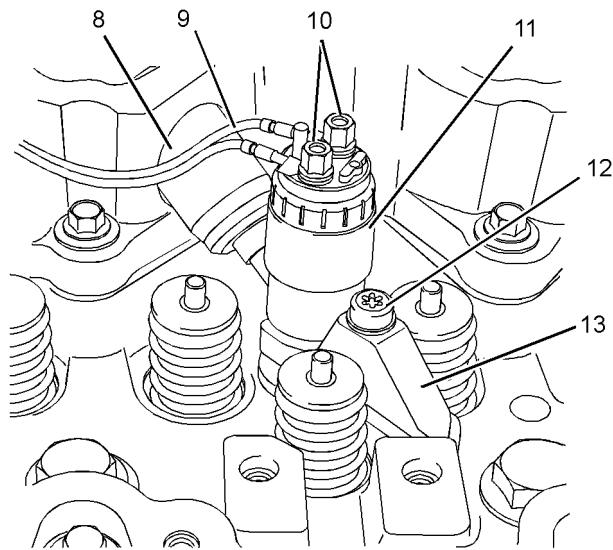


Illustration 44 g01255699
The rocker shaft is not shown for clarity.

- 6. Remove the fuel injection line and remove seal (8) from the appropriate electronic unit injector (11). Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove".

Note: Cap all open ports immediately with new caps.

- 7. Use a deep socket to remove connections (10) from electronic unit injector (11).
- 8. Slide rocker arms (1) to one side in order to gain access to torx screw (12). Use Tooling (B) in order to remove the torx screw from clamp (13). Discard the torx screw.

Note: Tooling (B) must be used to ensure no damage to the rocker arms.

- 9. Place a temporary identification mark on the original electronic unit injector. The electronic unit injector must be reinstalled in the original location in the cylinder head.

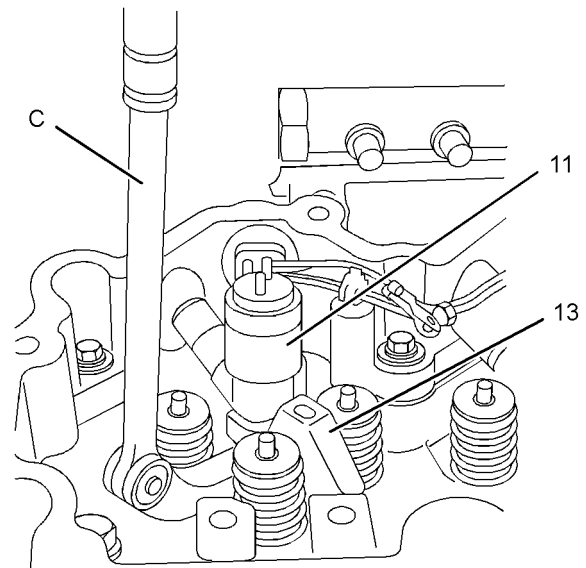


Illustration 45 g01255700
The rocker shaft is not shown for clarity.

- 10. Use Tooling (C) to pry beneath clamp (13) and free electronic unit injector (11) from the cylinder head.
- 11. Remove electronic unit injector (11) and clamp (13) from the cylinder head.

Note: Always handle electronic unit injectors with care.

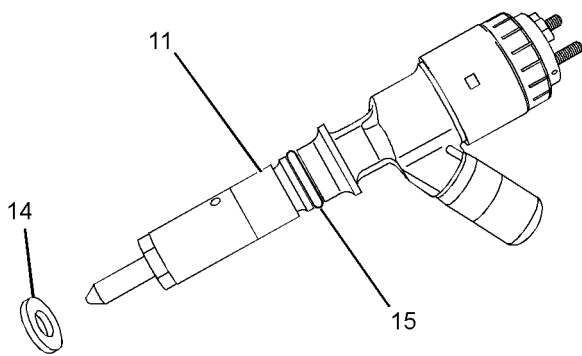


Illustration 46
Typical example

g01255701

12. Remove sealing washer (14) . Ensure that the sealing washer is removed from the cylinder head. Remove O-ring seal (15) from the electronic unit injector.

Alternative Removal Procedure

Table 8

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610307	T40 Torx Socket	1
B	27610288	Pry Bar	1

Start By:

- a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft - Remove".
- b. Remove the fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove".

Note: This is an optional procedure to remove the electronic unit injectors. The method should ONLY be used when all electronic unit injectors are removed and when the engine is removed from the application.

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to Systems Operation, Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

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 to the engine.
2. Isolate the electrical supply to the engine.

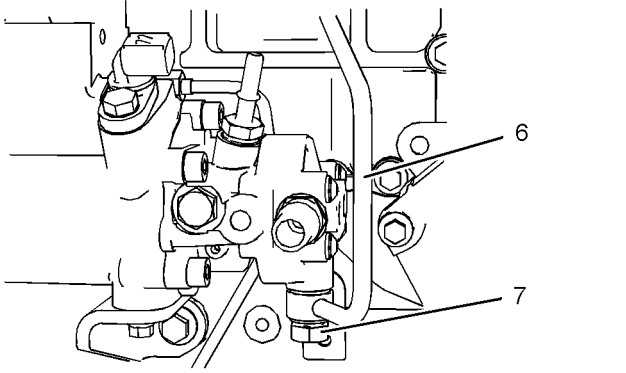


Illustration 47
Typical example
g01247489

- Loosen banjo bolt (7) sufficiently in order to allow the fuel to drain from tube assembly (6).

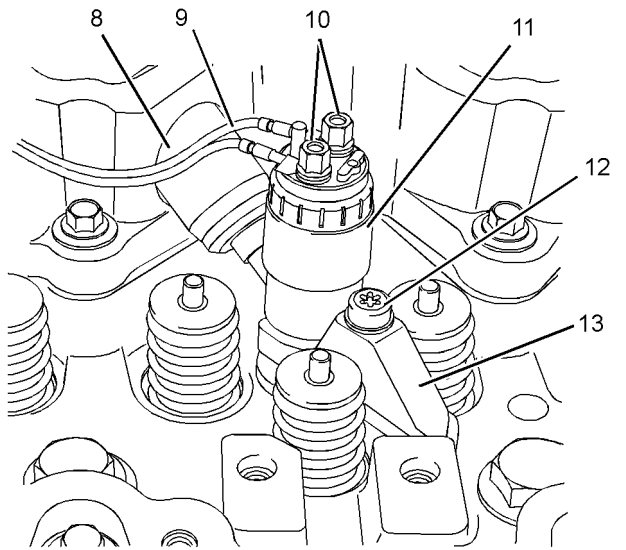


Illustration 48
g01255699

- Place a temporary identification mark on connections (10) for harness assembly (9).
- Use a deep socket to remove connections (10) from electronic unit injector (11).
- Use Tooling (B) in order to remove torx screw (12) from clamp (13). Discard the torx screw.
- Place a temporary identification mark on the original electronic unit injector. The electronic unit injector must be reinstalled in the original location in the cylinder head.

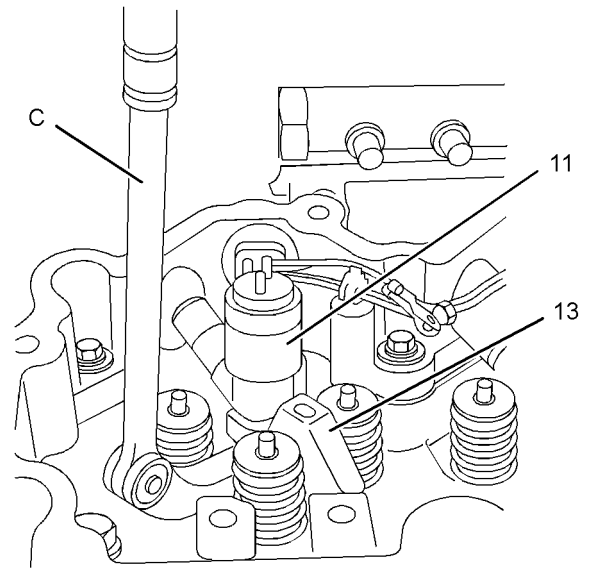


Illustration 49
g01255700

- Use Tooling (C) to pry beneath clamp (13) and free electronic unit injector (11) from the cylinder head.
- Remove electronic unit injector (11) and clamp (13) from the cylinder head.

Note: Always handle electronic unit injectors with care.

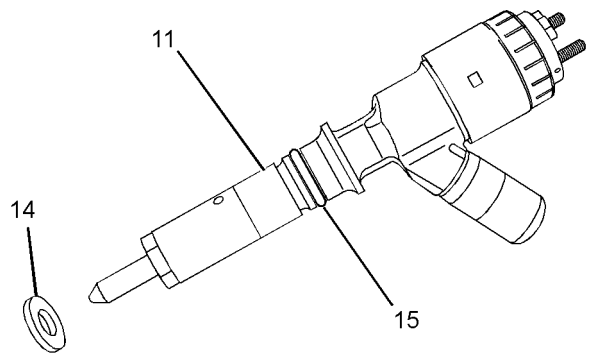


Illustration 50
Typical example
g01255701

- Remove sealing washer (14). Ensure that the sealing washer is removed from the cylinder head. Remove O-ring seal (15) from the electronic unit injector.
- Repeat Steps 4 through 11 in order to remove the remaining electronic unit injectors.

i02654481

Electronic Unit Injector - Install

Installation Procedure

Table 9

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610307	T40 Torx Socket	1
D	GE50028	Vacuum Pump	1
	GE50030	Tube 7.9 mm (0.31 inch) Outside Diameter	1
E	27610294	Injector Pipe Nut Tool	1
F	27610296	Torque Wrench	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to Systems Operation, Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

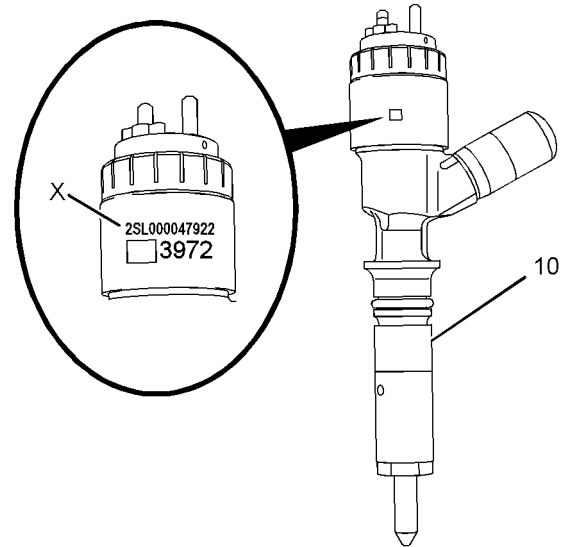


Illustration 51

g01341874

Typical calibration code

1. If a replacement electronic unit injector is installed, the correct injector trim file must be programmed into the electronic control module. Refer to Troubleshooting, "Injector Trim File" for more information. The code that is required to obtain the injector trim file is located at position (X).

Note: Record code (X) before the electronic unit injector is installed.

2. Use Tooling (D) in order to remove any fuel from the cylinder.

Note: Evacuate as much fuel as possible from the cylinder before installing the electronic unit injector.

3. Ensure that the fuel inlet port of the electronic unit injector is capped. Ensure that the electronic unit injector is clean.

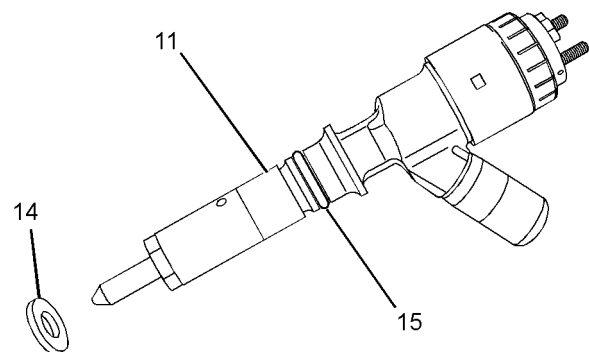


Illustration 52

g01255701

4. On installing an original electronic unit injector, install a new O-ring seal (15) and sealing washer (14) to electronic unit injector (11).

Ensure that the O-ring seal (15) and sealing washer (14) on a new electronic unit injector are not damaged and in place.

Note: Do not lubricate the O-ring seal.

5. Ensure that the seat for the electronic unit injector in the cylinder head is clean and free from damage. Ensure that the sealing washer has been removed from the cylinder head.

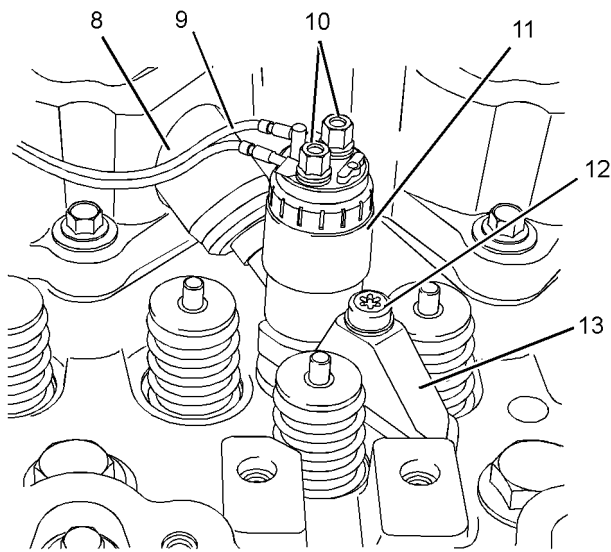


Illustration 53 g01255699

The rocker shaft is not shown for clarity.

6. Position clamp (13) between the rocker arm and the valve springs. Align electronic unit injector (11) to the bore for the electronic unit injector in the cylinder head. Install the clamp to the electronic unit injector. Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head.
7. Install a new torx screw (12) to clamp (13). Tighten the torx screw finger tight.
8. Remove the cap from electronic unit injector (11). Install a new seal (8) to electronic unit injector (11) and to the valve mechanism cover base. Ensure that the flange on the seal is flush with the valve mechanism cover base.
9. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".

Note: Ensure that the ends of the fuel injection line are seated in the electronic unit injector and the fuel manifold. Tighten the nuts finger tight.

10. Use Tooling (B) to tighten torx screw (12) to a torque of 27 N·m (20 lb ft).

Note: Tooling (B) must be used to ensure no damage to the rocker arms.

11. Use Tooling (E) to tighten the fuel injection line to a torque of 30 N·m (22 lb ft). Refer to Disassembly and Assembly, "Fuel Injector Lines - Install".

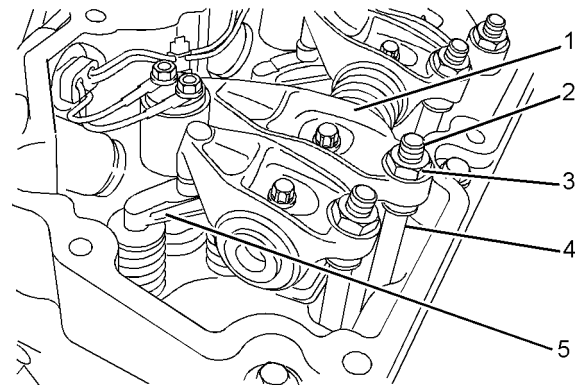


Illustration 54 g01374098

Typical example

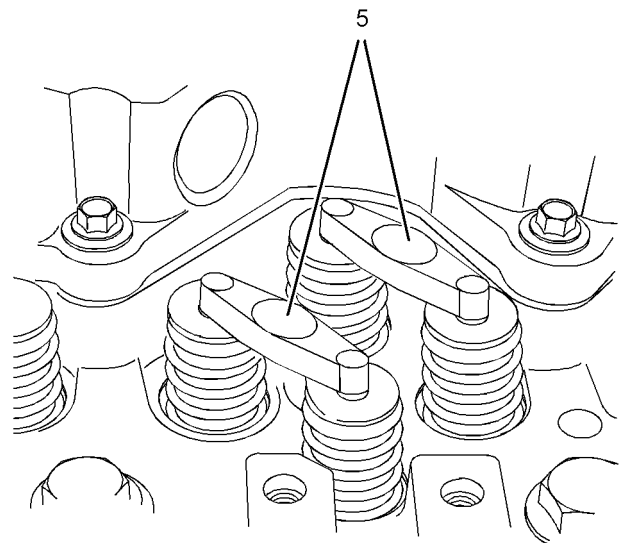


Illustration 55 g01355048

The electronic unit injector is not shown for clarity.

NOTICE

Failure to ensure that ALL valve bridges are correctly seated onto the valve stems will cause interference between the pistons and the valves, resulting in damage to the engine.

12. Install valve bridges (5) to the cylinder head.

Note: Ensure that used valve bridges are reinstalled in the original location and the original orientation. Do not interchange the location or the orientation of used valve bridges.

13. Ensure that the bottoms of the pushrods are seated in the cups of the valve lifters. Locate the balls of adjusters (2) into the cups of pushrods (4). Adjust the valve lash. Refer to Systems Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust".
14. Use a deep socket to install harness assembly (9) to electronic unit injector (11). Use Tooling (F) to tighten connections (10) to a torque of 2.4 N·m (21 lb in).

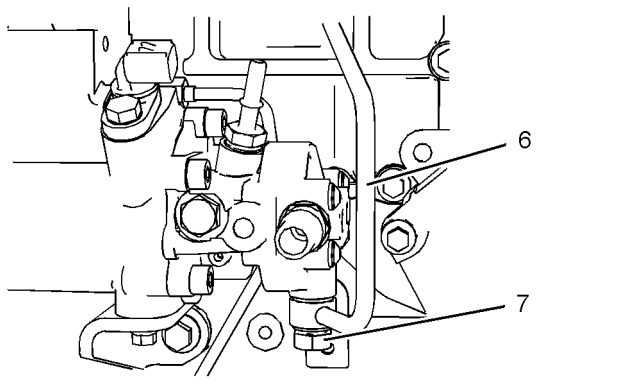


Illustration 56

g01247489

Typical example

15. Tighten banjo bolt (7) for tube assembly (6). Tighten the banjo bolt to a torque of 21 N·m (15 lb ft).
16. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".
17. Restore the fuel supply to the engine.
18. Restore the electrical supply to the engine.
19. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

Alternative Installation Procedure

Table 10

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610307	T40 Torx Socket	1
D	GE50028	Vacuum Pump	1
	GE50030	Tube 7.9 mm (0.31 inch) Outside Diameter	1
E	27610294	Injector Pipe Nut Tool	1
F	27610296	Torque Wrench	1

Note: This is an optional procedure to install the electronic unit injectors. The method should ONLY be used when all electronic unit injectors are installed and when the engine is removed from the application.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to Systems Operation, Testing and Adjusting Manual, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

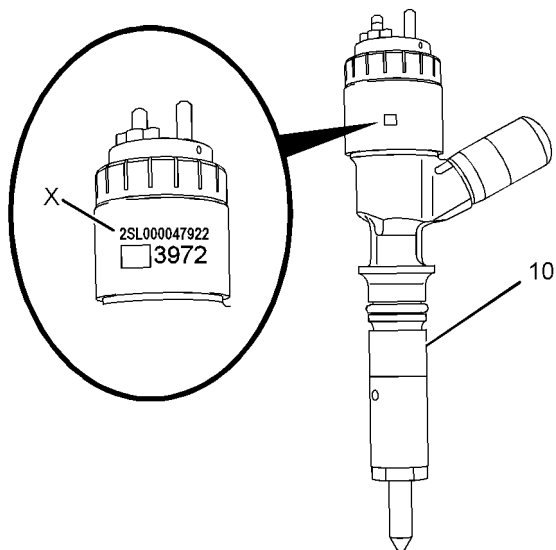


Illustration 57 g01341874

Typical calibration code

1. If a replacement electronic unit injector is installed, the correct injector trim file must be programmed into the electronic control module. Refer to Troubleshooting, "Injector Trim File" for more information. The code that is required to obtain the injector trim file is located at position (X).

Note: Record code (X) before the electronic unit injector is installed.

2. Use Tooling (D) to remove any fuel from the cylinder.

Note: Evacuate as much fuel as possible from the cylinder before installing the electronic unit injector.

3. Ensure that the fuel inlet port of the electronic unit injector is capped. Ensure that the electronic unit injector is clean.

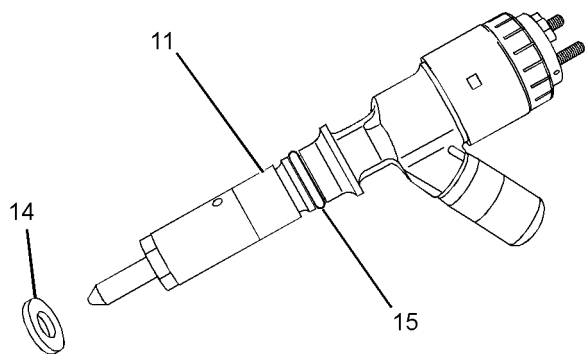


Illustration 58 g01255701

4. On installing an original electronic unit injector, install a new O-ring seal (15) and sealing washer (14) to electronic unit injector (11).

Ensure that the O-ring seal (15) and sealing washer (14) on a new electronic unit injector are not damaged and in place.

Note: Do not lubricate the O-ring seal.

5. Ensure that the seat for the electronic unit injector in the cylinder head is clean and free from damage. Ensure that the sealing washer has been removed from the cylinder head.

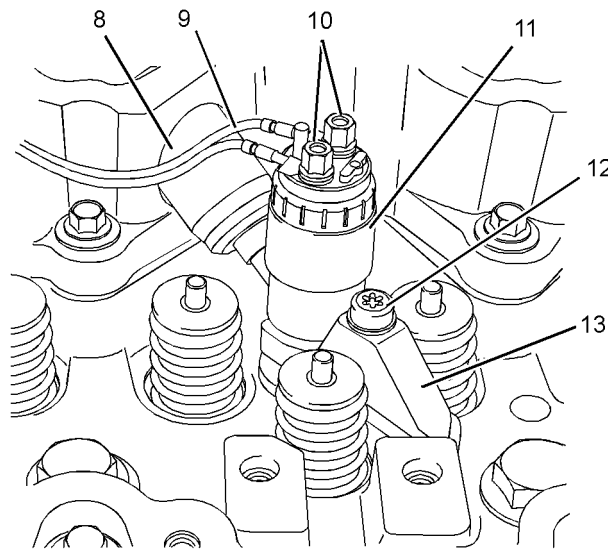


Illustration 59 g01255699

6. Install clamp (13) to electronic unit injector (11). Install the electronic unit injector assembly into the original location in the cylinder head.

Note: Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head. Install the electronic unit injector for number one cylinder first. Install the electronic unit injectors in numerical order.

7. Install a new torx screw (12) to clamp (13). Tighten the torx screw finger tight.

8. Remove the cap from electronic unit injector (11). Install a new seal (8) to electronic unit injector (11) and to the valve mechanism cover base. Ensure that the flange on the seal is flush with the valve mechanism cover base.

9. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".

Note: Ensure that the ends of the fuel injection line are seated in the electronic unit injector and the fuel manifold. Tighten the nuts finger tight.

10. Use Tooling (B) to tighten torx screw (12) to a torque of 27 N·m (20 lb ft).
11. Use Tooling (E) to tighten the fuel injection line to a torque of 30 N·m (22 lb ft). Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
12. Repeat Steps 2 through 11 in order to install the remaining electronic unit injectors.
13. Use a deep socket to install harness assemblies (9) to electronic unit injectors (11). Use Tooling (F) to tighten connections (10) to a torque of 2.4 N·m (21 lb in).

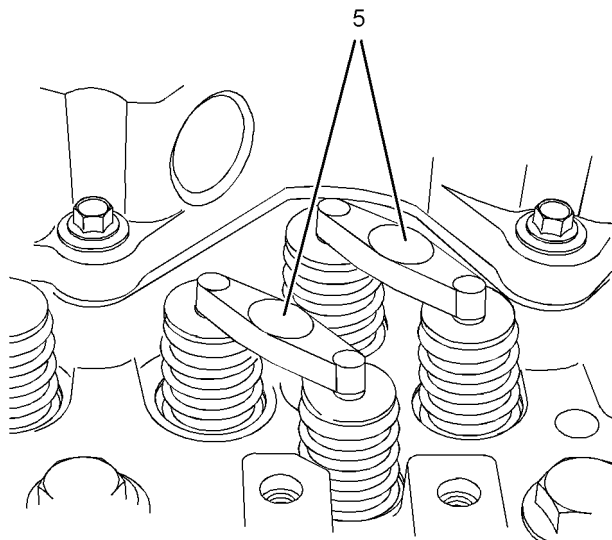


Illustration 60

g01355048

The electronic unit injector is not shown for clarity.

NOTICE

Failure to ensure that ALL valve bridges are correctly seated onto the valve stems will cause interference between the pistons and the valves, resulting in damage to the engine.

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

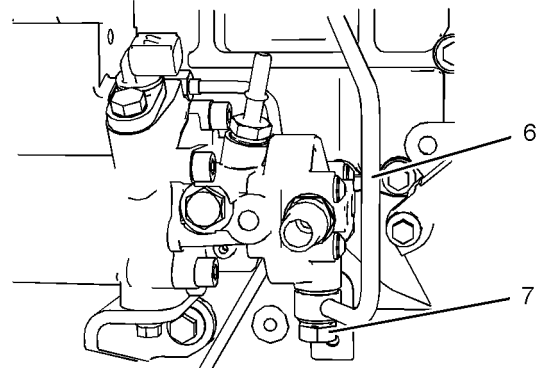


Illustration 61

g01247489

Typical example

15. Tighten banjo bolt (7) for tube assembly (6). Tighten the banjo bolt to a torque of 21 N·m (15 lb ft).
16. Restore the fuel supply to the engine.
17. Restore the electrical supply to the engine.
18. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

i02654357

Turbocharger - Remove (Turbocharger Top Mounted)

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. Disconnect the air hose for the turbocharger inlet and for the turbocharger outlet.
2. If the turbocharger has a remote wastegate solenoid, disconnect the hose to the solenoid from the turbocharger.
3. Disconnect the exhaust pipe.
4. If the turbocharger has an exhaust elbow, remove the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

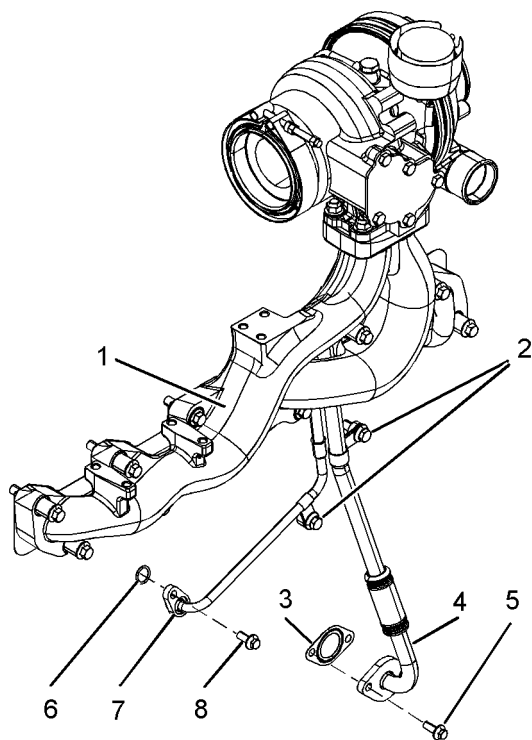


Illustration 62

g01335754

5. Remove bolts (5) in order to disconnect tube assembly (4) from the cylinder block. Remove joint (3).
6. Remove bolt (8) in order to disconnect tube assembly (7) from the cylinder block.
7. Remove the bolts for tube clips (2).
8. Loosen nuts (11). Refer to Illustration 63.
9. Remove exhaust manifold (1) and the assembly of the turbocharger from the cylinder head. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install" for the correct procedure.

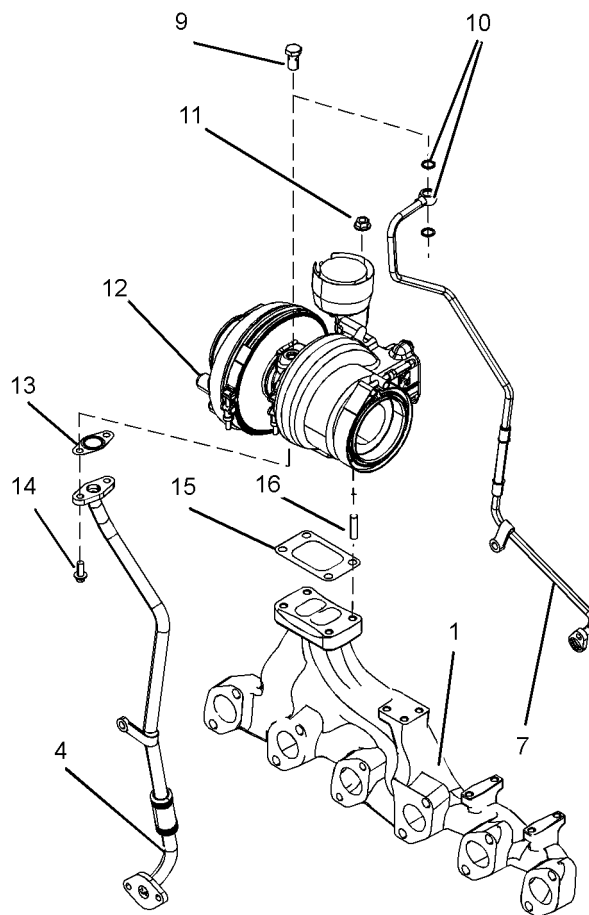


Illustration 63

g01335756

10. Remove banjo bolt (9) and remove tube assembly (7) for the oil feed from turbocharger (12). Remove sealing washers (10).
 11. Remove O-ring seal (6) from tube assembly (7). Refer to Illustration 62.
 12. Remove bolts (14) and remove tube assembly (4) for the oil drain from turbocharger (12).
 13. Remove joint (13).
 14. Remove nuts (11) and remove turbocharger (12) from exhaust manifold (1).
- Note:** Ensure that the exhaust manifold and the turbocharger are adequately supported during the removal of the turbocharger.
15. Remove joint (15) from the exhaust manifold (1).
 16. If necessary, remove studs (16) from exhaust manifold (1).

i02654359

Turbocharger - Remove (Side Mounted Turbocharger)

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. Disconnect the air hose for the turbocharger inlet and for the turbocharger outlet.
2. If the turbocharger has a remote wastegate solenoid, disconnect the hose to the solenoid from the turbocharger.
3. Disconnect the exhaust pipe.
4. If the turbocharger has an exhaust elbow, remove the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

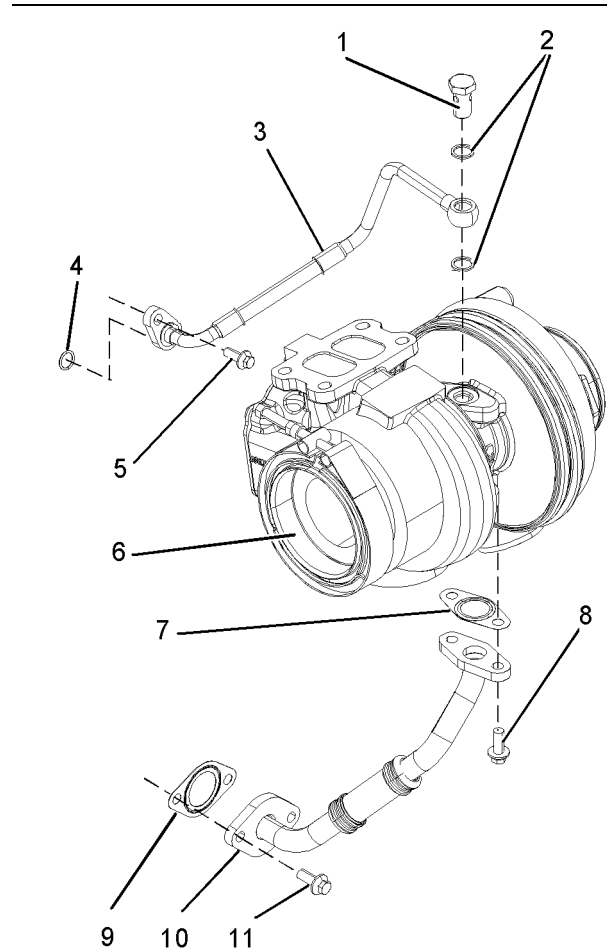


Illustration 64

g01335455

5. Follow Steps 5.a through 5.c in order to remove tube assembly (4) for the oil feed.
 - a. Remove bolt (5).
 - b. Remove banjo bolt (1) and remove sealing washers (2).
 - c. Remove tube assembly (3) from the cylinder block. Remove O-ring seal (4) from the tube assembly.

Note: Plug the port for the oil feed to the turbocharger with a suitable plug.

6. Follow Steps 6 through 6.c in order to remove tube assembly (10) for the oil drain.
 - a. Remove bolts (11).
 - b. Remove bolts (8) and remove tube assembly (10) from turbocharger (6).
 - c. Remove joint (7) and remove joint (9).

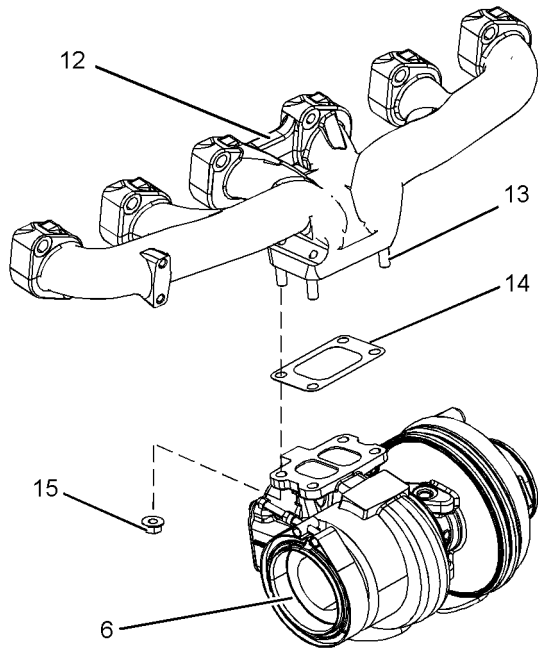


Illustration 65

g01335456

7. Remove nuts (15) from turbocharger (6) and remove turbocharger (6) from exhaust manifold (12).

Note: Ensure that the weight of the turbocharger is supported as the nuts are loosened.

8. Remove joint (14).
9. If necessary, remove studs (13) from exhaust manifold (12).

i02654544

Turbocharger - Disassemble

Disassembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

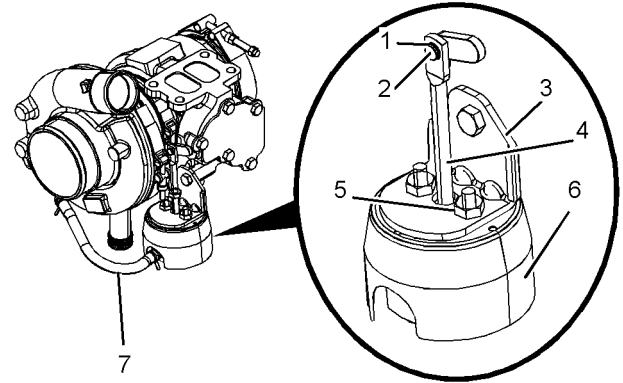


Illustration 66

g01335760

1. Disconnect the pipe for boost sensor (7) at actuator (6).
2. Remove circlip (1) that retains actuator rod (4).
3. Remove actuator rod (4) from pin (2).
4. Remove nuts (5) from bracket (3).
5. Remove actuator (6) from bracket (3).

NOTICE

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

i02654542

Turbocharger - Assemble

Assembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i02654360

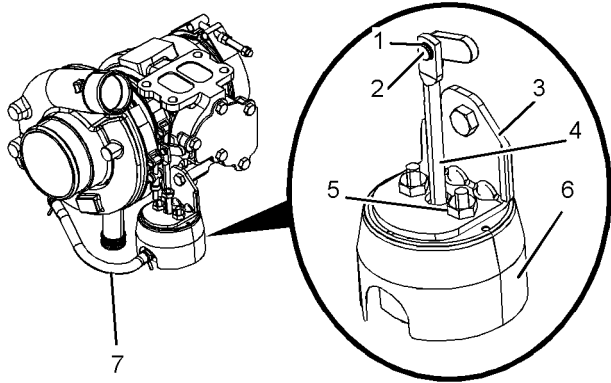


Illustration 67

g01335760

1. Install actuator (6) to bracket (3). Install nuts (5) to bracket (3).
2. Tighten the nuts to a torque of 5 N·m (44 lb in).
3. Connect the bottom of actuator (6) to a suitable air supply with an accurate gauge.
4. Operate the arm of the actuator by hand in order to check that the valve is free to move.
5. Push the arm of the wastegate valve toward actuator (6) and hold the arm in position. Slowly apply air pressure to actuator (6) until pin (2) will fit into actuator rod (4). Install circlip (1) into the groove in pin (2).

Note: Do not apply an air pressure of more than 205 kPa (29 psi) to the actuator. High pressures may damage the actuator.

6. Install the pipe for boost pressure (7) to actuator (6).

End By:

- a. To check the wastegate actuator for correct operation, refer to System Operation, Testing and Adjusting, "Turbocharger - Inspect".

Turbocharger - Install (Turbocharger Top Mounted)

Installation Procedure

Table 11

Required Tools			
Tool	Part Number	Part Description	Qty
A	218200221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

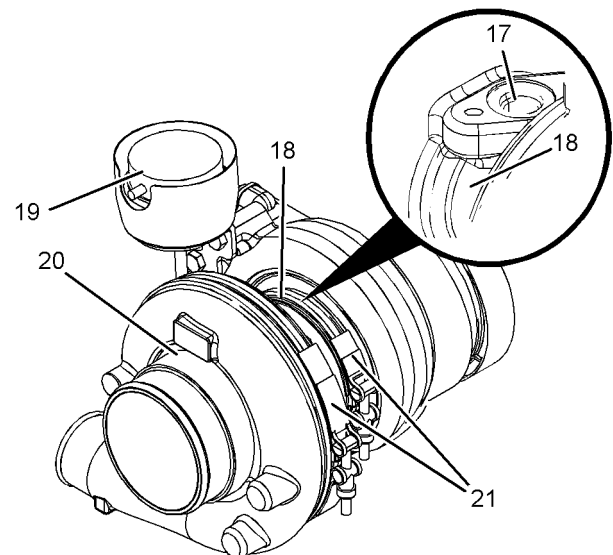


Illustration 68

g01335496

Typical example

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

2. Test the wastegate actuator (19) for correct operation. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect". If the wastegate actuator is damaged or the wastegate actuator does not operate within the specified limits, the wastegate actuator must be replaced. Refer to Disassembly and Assembly, "Turbocharger - Dissassemble" and refer to Disassembly and Assembly, "Turbocharger - Assemble" for more information.

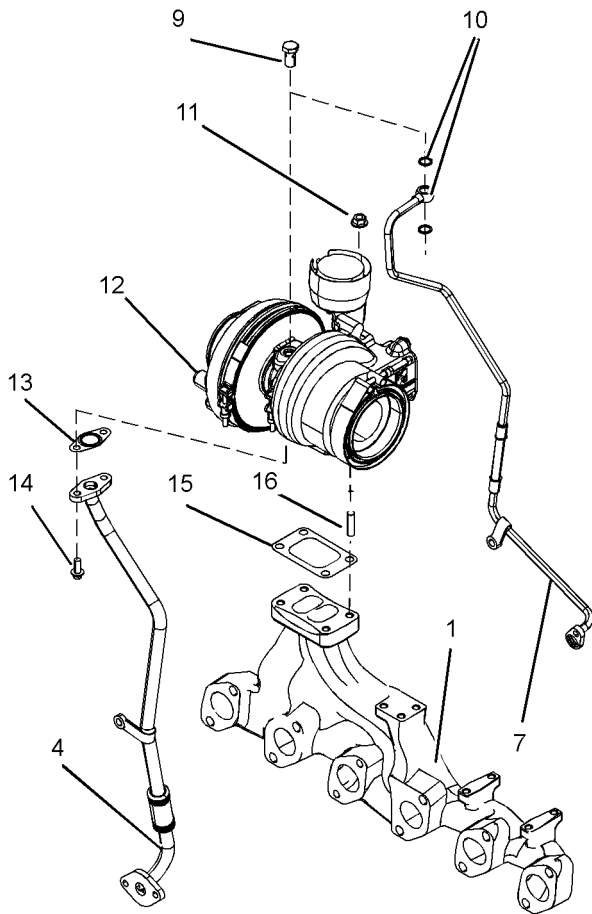


Illustration 69

g01335756

3. Clean the mating surfaces of the exhaust manifold (1). If necessary, install studs (16) to the exhaust manifold. Tighten the studs to a torque of 18 N·m (13 lb ft).

Note: Support the exhaust manifold during installation of the turbocharger.

4. Install a new joint (15) to exhaust manifold (1).
5. Position turbocharger (12) on exhaust manifold (1).

Note: Ensure that the turbocharger is correctly oriented.

6. Install nuts (11). Tighten the nuts to a torque of 44 N·m (32 lb ft).
7. If a new turbocharger is installed, bearing housing (18) and compressor housing (20) must be oriented to the correct positions. Refer to Illustration 68. Follow Steps 7.a through 7.d in order to orient the bearing housing and the compressor housing.
 - a. Loosen band clamps (21) sufficiently in order to allow the housings to rotate.

Note: If the band clamps are damaged, replace the band clamps.

- b. Carefully turn bearing housing (18) until the port for oil feed (17) is upward.
 - c. Rotate compressor housing (20) until the compressor outlet is in the correct position. Refer to the turbocharger that was originally installed for the correct orientation.
 - d. Ensure that band clamps (21) are correctly oriented. Refer to the turbocharger that was originally installed for the correct orientation. Tighten the band clamps finger tight.
8. Ensure that tube assemblies (4) and (7) are clean and free from damage. Replace any damaged components.
 9. Position a new joint (13) and bolts (14) onto tube assembly (4).
 10. Install tube assembly (4) to turbocharger (12). Tighten bolts (14) finger tight.
 11. Remove the plug from oil inlet port (17). Refer to Illustration 68. Lubricate the turbocharger bearings with clean engine oil through the oil inlet port. Rotate the wheel of the compressor several times in order to lubricate the bearings.

12. Install banjo bolt (9) and new sealing washers (10) to tube assembly (7).
13. Use Tooling (A) in order to lubricate a new O-ring seal (6). Install O-ring seal (6) to tube assembly (7). Refer to Illustration 70.
14. Install tube assembly (7) to turbocharger (12). Tighten banjo bolt (9) finger tight.

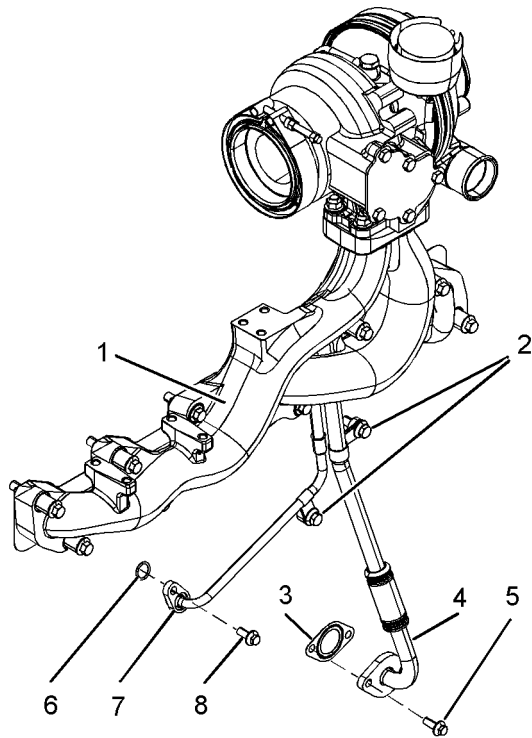


Illustration 70

g01335754

15. Install exhaust manifold (1) and the assembly of the turbocharger to the cylinder head. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install" for the correct procedure.
16. Install bolt (8) finger tight. Ensure that tube assembly (7) fits correctly.
17. Position a new joint (3) between the flange of tube assembly (4) and the cylinder block. Install bolts (5) finger tight.
18. If a new turbocharger has been installed, check that the orientation of bearing housing (18) is correct. If the orientation of the bearing housing is not correct, rotate the bearing housing until tube assemblies (4) and (7) fit correctly. Tighten band clamps (21) to a torque of 13 N·m (9.6 lb ft).
19. Tighten banjo bolt (9) to a torque of 20 N·m (14 lb ft). Tighten bolt (5) and (8) to a torque of 22 N·m (16 lb ft).
20. Install the bolts for tube clips (2) to the cylinder block. Tighten bolt (2) to a torque of 44 N·m (32 lb ft).
21. If the turbocharger has an exhaust elbow, install the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".

22. Connect the exhaust pipe.
23. If the turbocharger has a remote wastegate solenoid, connect the hose for the solenoid to the turbocharger.
24. Connect the air inlet hose and connect the air outlet hose to the turbocharger.

i02654361

Turbocharger - Install (Side Mounted Turbocharger)

Installation Procedure

Table 12

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.

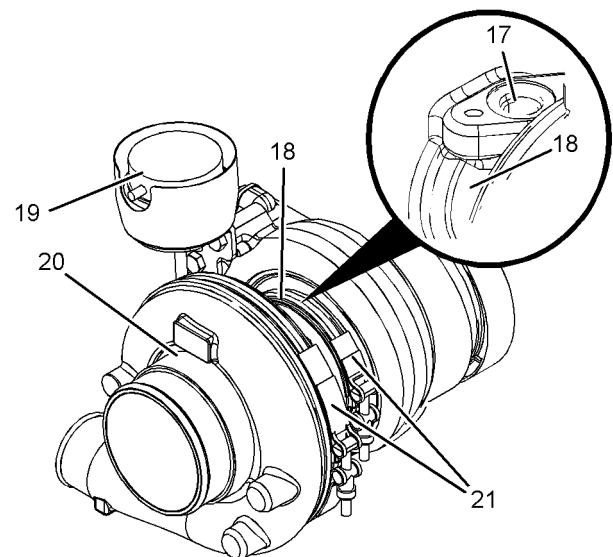


Illustration 71

g01335496

Typical example

1. Ensure that the turbocharger is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect" for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.
2. Test the wastegate actuator (19) for correct operation. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect". If the wastegate actuator is damaged or the wastegate actuator does not operate within the specified limits, the wastegate actuator must be replaced. Refer to Disassembly and Assembly, "Turbocharger - Dissassemble" and refer to Disassembly and Assembly, "Turbocharger - Assemble" for more information.

7. If a new turbocharger is installed, bearing housing (18) and compressor housing (20) must be oriented to the correct positions. Follow Steps 7.a through 7.d in order to orient the bearing housing and the compressor housing.
 - a. Loosen band clamps (21) sufficiently in order to allow the housings to rotate.

Note: If the band clamps are damaged, replace the band clamps.

- b. Carefully turn bearing housing (18) until the port for oil feed (17) is upward.
- c. Rotate compressor housing (20) until the compressor outlet is in the correct position. Refer to the turbocharger that was originally installed for the correct orientation.
- d. Ensure that band clamps (21) are correctly oriented. Refer to the turbocharger that was originally installed for the correct orientation. Tighten the band clamps finger tight.

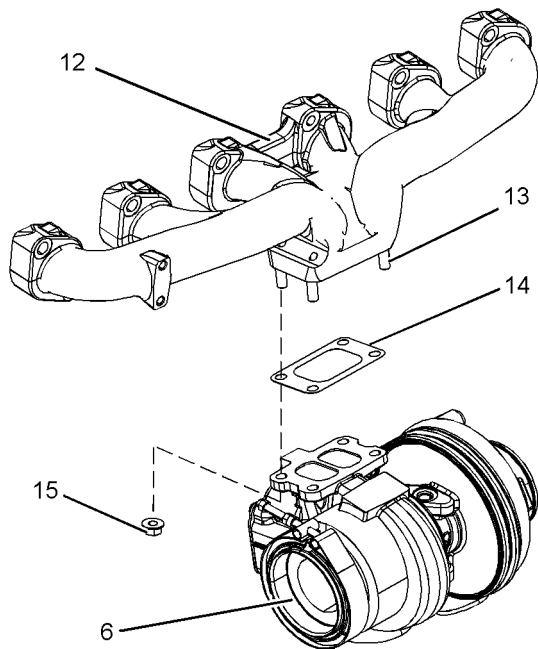


Illustration 72

g01335456

Typical example

3. Clean the mating surfaces of exhaust manifold (12). If necessary, install studs (13) to the exhaust manifold. Tighten the studs to a torque of 18 N·m (13 lb ft).
4. Install a new joint (14) to exhaust manifold (12).
5. Position turbocharger (6) on the exhaust manifold.

Note: Ensure that the turbocharger is correctly oriented.

6. Install nuts (15). Tighten the nuts to a torque of 44 N·m (32 lb ft).

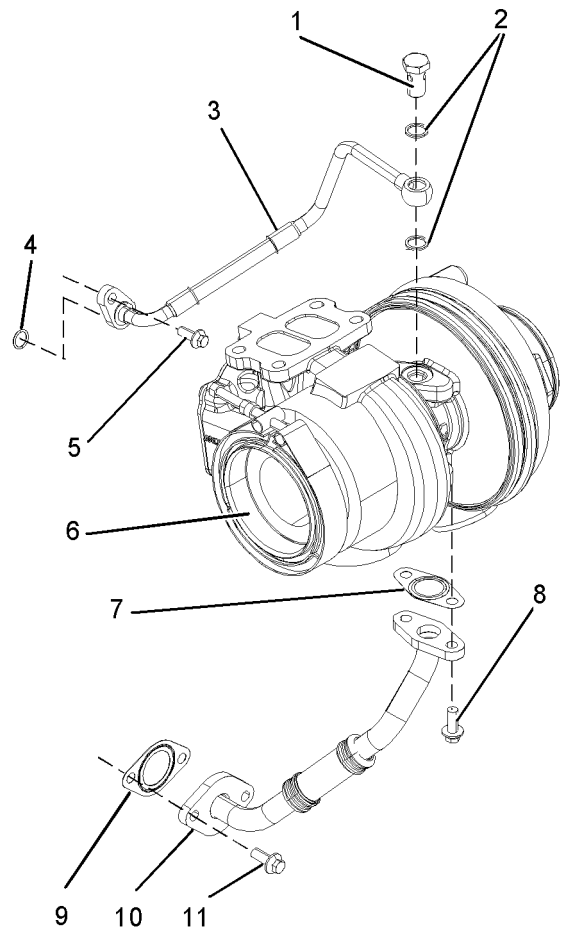


Illustration 73

g01335455

i02654550

8. Ensure that tube assemblies (3) and (10) are clean and free from damage. Replace any damaged components.
9. Position a new joint (7) and bolts (8) onto tube assembly (10).
10. Install tube assembly (10) to turbocharger (6). Tighten bolts (8) finger tight.
11. Position a new joint (9) between the flange of tube assembly (10) and the cylinder block. Install bolts (11) finger tight.
12. If a new turbocharger has been installed, check that the orientation of bearing housing (18) is correct. If the orientation of the bearing housing is not correct, rotate the bearing housing until tube assembly (10) fits correctly. Tighten band clamps (21) to a torque of 13 N·m (9.6 lb ft).
13. Tighten bolts (8) and (11) to a torque of 22 N·m (16 lb ft).
14. Remove the plug from oil inlet port (17). Lubricate the turbocharger bearings with clean engine oil through the oil inlet port. Rotate the wheel of the compressor several times in order to lubricate the bearings.
15. Use Tooling (A) in order to lubricate a new O-ring seal (4). Install O-ring seal (4) to tube assembly (3).
16. Install banjo bolt (1) and two new sealing washers (2) to tube assembly (3).
17. Install tube assembly (3) to the cylinder block and to turbocharger (6). Tighten banjo bolt (1) finger tight.
18. Install bolt (5) finger tight. Ensure that tube assembly (3) fits correctly.
19. Tighten banjo bolt (1) to a torque of 20 N·m (14 lb ft). Tighten bolt (5) and (11) to a torque of 22 N·m (16 lb ft).
20. If the turbocharger has an exhaust elbow, install the exhaust elbow. Refer to Disassembly and Assembly, "Exhaust Elbow - Remove and Install".
21. Connect the exhaust pipe.
22. If the turbocharger has a remote wastegate solenoid, connect the hose for the solenoid to the turbocharger.
23. Connect the air inlet hose and connect the air outlet hose to the turbocharger.

Wastegate Solenoid - Remove and Install

Removal Procedure

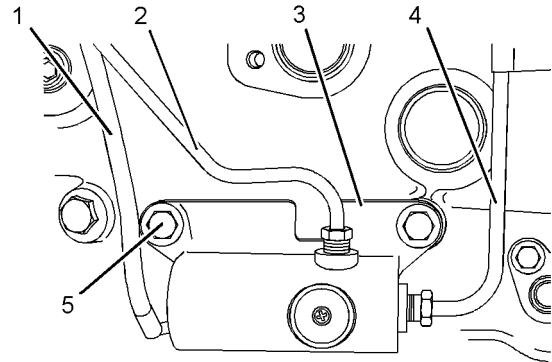


Illustration 74

g01335778

Typical example

1. Follow Steps 1.a through 1.c in order to disconnect wire lead (1).
 - a. Disconnect wire lead (1) from the harness assembly.
 - b. If harness assembly (1) is secured with a cable strap, remove the cable strap.
 - c. Remove wire lead (1) from tube assembly (2).
- Note:** The wire lead is secured to the tube assembly with clips.
2. Disconnect tube assembly (2) from wastegate solenoid (3).
3. Disconnect tube assembly (4) from wastegate solenoid (3). If tube assembly (4) is secured with tube clips, loosen the bolts for the tube clips.
- Note:** The tube clips must be loose in order to release the tube assembly from the wastegate solenoid.
4. Remove bolts (5) and remove wastegate solenoid (3) from the cylinder block.
5. Plug or cap all open ports and tube assemblies with new plugs or caps.

Installation Procedure

1. Remove the plugs or caps from all ports and tube assemblies.

i02654364

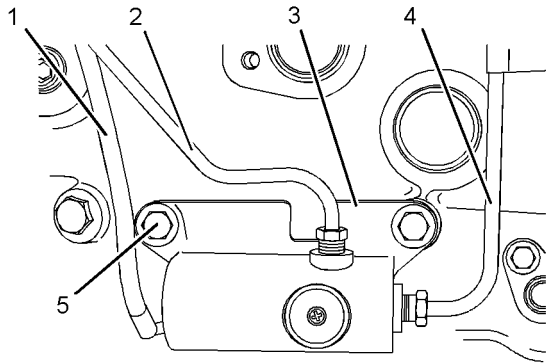


Illustration 75

g01335778

Typical example

2. Loosely install wastegate solenoid (3) to tube assembly (2).
3. Loosely install tube assembly (4) to wastegate solenoid (3).
4. Install bolts (5) to wastegate solenoid (3). Tighten bolts (5) to a torque of 44 N·m (32.5 lb ft).
5. Tighten tube assemblies (2) and (4) to a torque of 22 N·m (16 lb ft).
6. If tube assembly (4) is secured with tube clips, tighten the bolts for the tube clips.

Tighten M8 bolts to a torque of 22 N·m (16 lb ft).
Tighten bolts M10 to a torque of 44 N·m (32.5 lb ft).

7. Follow Steps 7 through 7.c in order to connect wire lead (1).
 - a. Install wire lead (1) to tube assembly (2).
 - b. Connect wire lead (1) to the harness assembly for the engine.
 - c. If wire lead (1) is secured with a cable strap, install a new cable strap.

Exhaust Manifold - Remove and Install (Side Mounted Exhaust Manifold)

Removal Procedure

Start By:

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

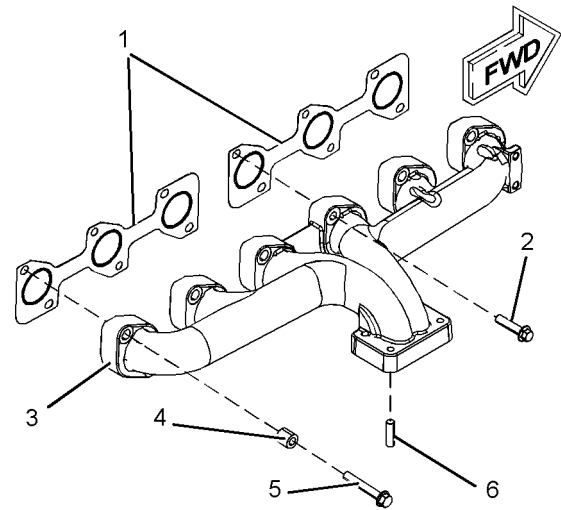


Illustration 76

g01335788

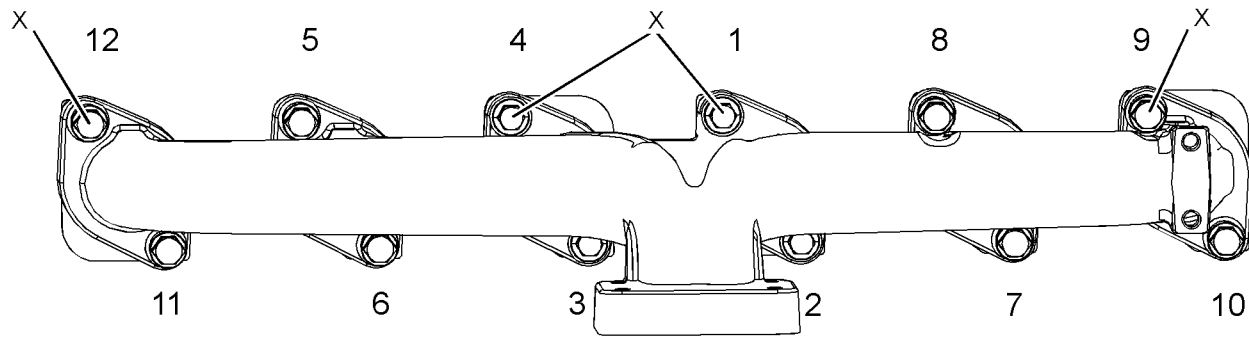


Illustration 77

g01335790

1. Loosen bolts (2) and (5) in reverse numerical order. Refer to Illustration 77.

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

2. Remove center bolts (2) from exhaust manifold (3). Remove outer bolts (5) and spacers (4) from exhaust manifold (3).

Note: Support the manifold as the bolts are removed.

3. Remove exhaust manifold (3).
4. Remove exhaust manifold gaskets (1).
5. If necessary, remove studs (6) from exhaust manifold (3).

Installation Procedure (Side Mounted Exhaust Manifold)

Table 13

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M10 by 100 mm)	4
B	-	Loctite 575	-

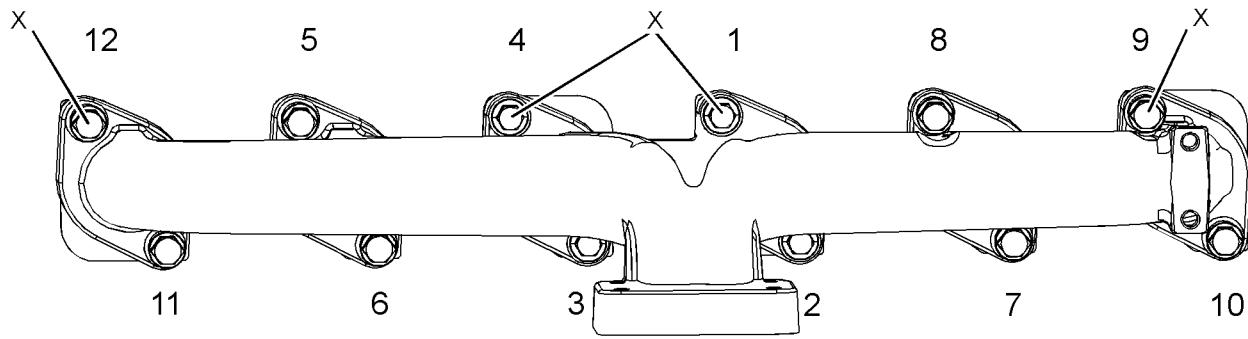


Illustration 78

g01335790

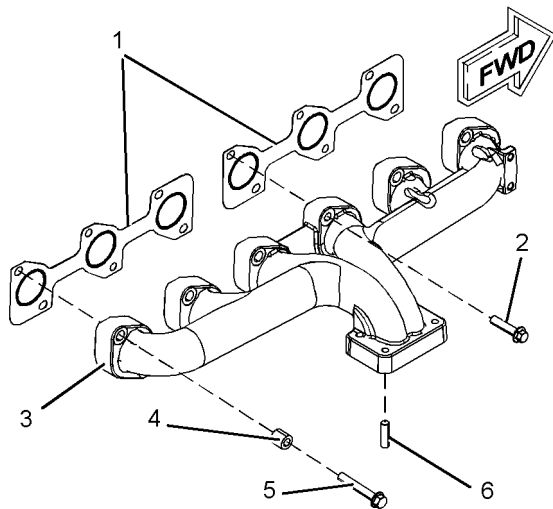


Illustration 79

g01335788

1. Ensure that the exhaust manifold is clean and free from damage. If necessary, replace the exhaust manifold. Clean the joint face of the cylinder head.
2. If necessary, install studs (6) to exhaust manifold (3). Tighten the studs to a torque of 18 N·m (13 lb ft).
3. Install Tooling (A) to the cylinder head in positions (X). Refer to Illustration 78.
4. Position two new exhaust manifold gaskets (1) onto Tooling (A).

Note: Ensure that the word TOP is outward and upward.

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

6. If bolts (2) and (5) have been previously used, the bolts should be thoroughly cleaned. Tooling (B) should be applied to the first two threads of the bolts.

Note: Do not apply Tooling (B) to new bolts.

7. Install bolts (2) finger tight. Install bolts (5) and spacers (4) finger tight.
8. Remove Tooling (A). Install remaining bolts (2) finger tight. Install remaining bolts (5) and spacers (4) finger tight.
9. Tighten bolts (2) and (5) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 78.

End By:

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

i02654362

Exhaust Manifold - Remove and Install (Top Mounted Exhaust Manifold)

Removal Procedure

1. Disconnect all hoses, tube assemblies and wire leads from the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove" Steps 1 through 7.

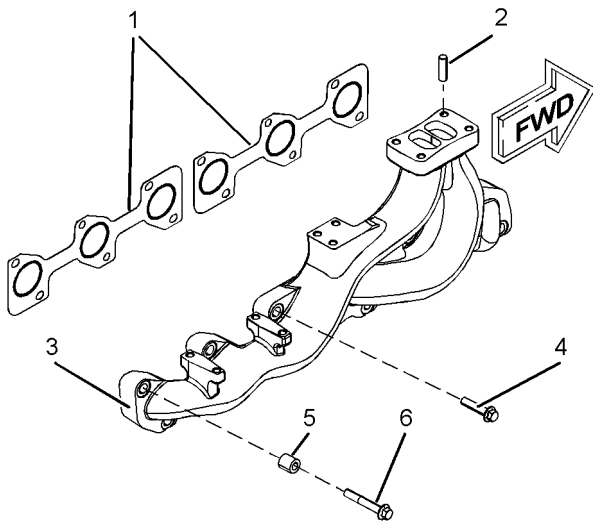


Illustration 80

g01335809

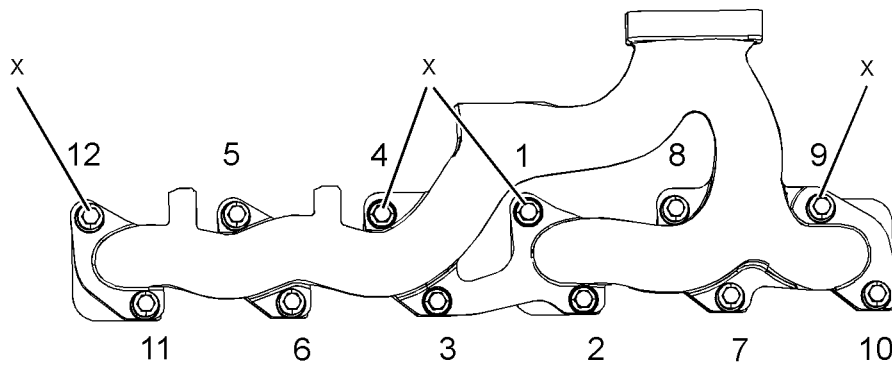


Illustration 81

g01335810

2. Loosen bolts (4) and (6) in reverse numerical order. Refer to Illustration 81.

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

3. Remove center bolts (4) from exhaust manifold (3). Remove outer bolts (6) and spacers (5) from exhaust manifold (3).

Note: Support the manifold as the bolts are removed.

4. Remove the assembly of exhaust manifold (3) and turbocharger.
5. Remove exhaust manifold gaskets (1).
6. Remove the turbocharger from exhaust manifold (3). Refer to Disassembly and Assembly, "Turbocharger - Remove" Steps 8 through 15.

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

Installation Procedure (Top Mounted Exhaust Manifold)

Table 14

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M10 by 100 mm)	4
B	21820117	Loctite 575	-

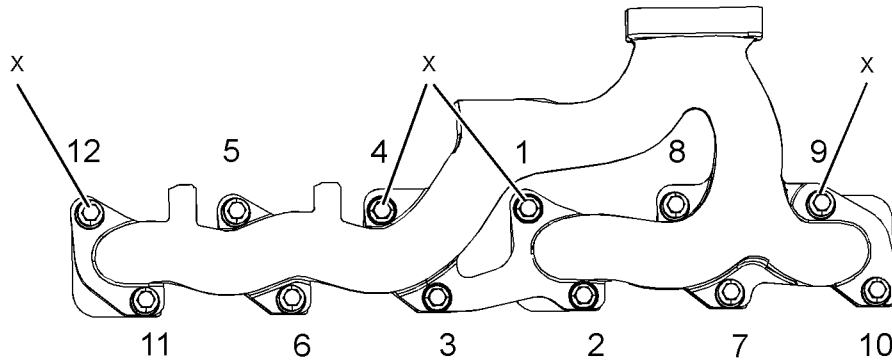


Illustration 82

g01335810

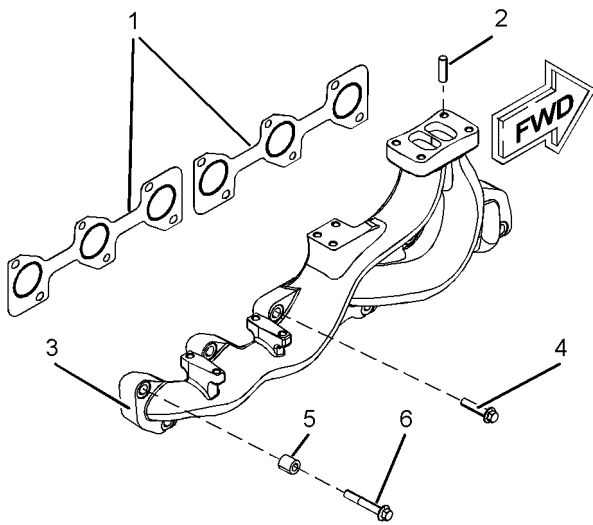


Illustration 83

g01335809

1. Ensure that the exhaust manifold is clean and free from damage. If necessary, replace the exhaust manifold. Clean the mating surface 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).
3. Install the turbocharger to the exhaust manifold. Refer to Disassembly and Assembly, "Turbocharger - Install" Steps 1 through 14.
4. Install Tooling (A) to the cylinder head in positions (X). Refer to Illustration 82.
5. Position two new exhaust manifold gaskets (1) onto Tooling (A).

Note: Ensure that the word TOP is outward and upward.

6. Align exhaust manifold (3) with Tooling (A). Install the exhaust manifold to the cylinder head.
 7. If bolts (4) and (6) have been previously used, the bolts should be thoroughly cleaned. Tooling (B) should be applied to the first two threads of the bolts.
- Note:** Do not apply Tooling (B) to new bolts.
8. Install bolts (4) finger tight. Install bolts (6) and spacers (5) finger tight.
 9. Remove Tooling (A). Install remaining bolts (4) finger tight. Install remaining bolts (6) and spacers (5) finger tight.
 10. Tighten bolts (4) and (6) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 82.

11. Connect all hoses, tube assemblies and wire leads from the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install" Steps 16 through 24.

i02654490

Exhaust Elbow - Remove and Install

Removal Procedure

Start By:

- a. Remove the exhaust pipe.

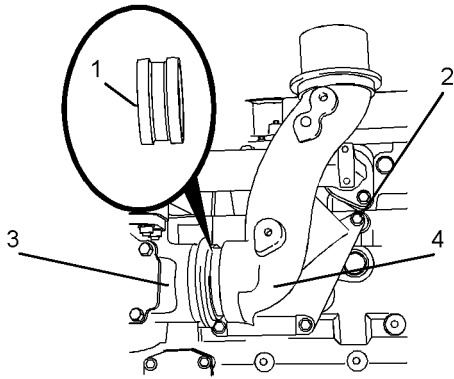


Illustration 84
Typical example

1. Remove bolts (2) that secure exhaust elbow (4) to the engine. Remove exhaust elbow (4) from the engine.
2. Remove coupling (1) that connects exhaust elbow (4) to turbocharger (3).
3. Some types of exhaust elbow have a separate support bracket. If necessary, remove the bolts that secure the bracket to the exhaust elbow. Remove the support bracket.

Installation Procedure

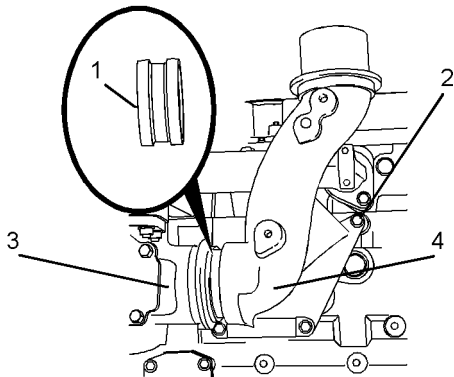


Illustration 85
Typical example

1. Thoroughly clean exhaust elbow (4), coupling (1) and outlet of turbocharger (3). Inspect the sealing faces of the components for wear or damage. Replace any components that are worn or damaged.
2. Install coupling (1) to exhaust elbow (4).
3. Align coupling (1) to the outlet of turbocharger (3). Install assembly of coupling (1) and exhaust elbow (4) to turbocharger (3).

4. Some types of exhaust elbow have a separate support bracket. If necessary, install the bracket and install the bolts that secure the bracket to the exhaust elbow finger tight.
5. Install bolts (2) finger tight.
6. Ensure that coupling (1) is fully engaged into the outlet of turbocharger (3) and into exhaust elbow (4). Ensure that the gap between the turbocharger and the exhaust elbow is evenly spaced.
7. Tighten bolts (2) to a torque of 44 N·m (33 lb ft).
8. If the exhaust elbow has a separate support bracket, tighten the bolts that secure the bracket to the exhaust elbow to a torque of 44 N·m (33 lb ft).

End By:

- a. Install the exhaust pipe.

i02654525

Inlet Manifold - Remove and Install

Removal Procedure

Start By:

- a. If necessary, remove the fuel filter base. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".
- b. Remove the fuel manifold. Refer to Disassembly and Assembly, "Fuel Manifold - Remove".
- c. Remove the ECM mounting bracket. Refer to Disassembly and Assembly, "ECM Mounting Bracket - Remove and Install".
- d. Remove the boost pressure sensor. Refer to Disassembly and Assembly, "Boost Pressure Sensor - Remove and Install".
- e. Remove the air inlet temperature sensor. Refer to Disassembly and Assembly, "Inlet Air Temperature Sensor - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the engine is equipped with a cover over the fuel system this will need to be removed.
2. Disconnect the breather hose from the separator for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".

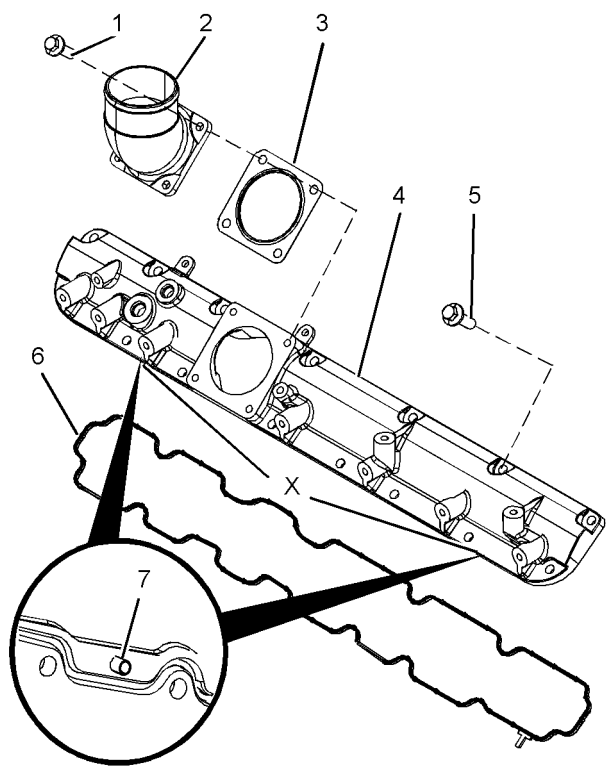


Illustration 86

g01335890

3. Cut the cable straps that secure the harness assembly to inlet manifold (4). Position the harness assembly away from the inlet manifold.
4. Remove bolts (1) from inlet connection (2).
5. Remove inlet connection (2) and gasket (3) from inlet manifold (4).
6. Remove bolts (5).
7. Remove inlet manifold (4) from the cylinder head. Use a suitable tool to pry the inlet manifold from the cylinder head. Use the recess at position (X) to pry the inlet manifold.
8. Remove inlet manifold seal (6) from the recess in inlet manifold (4).
9. Do not remove two dowel pins (7).

Installation Procedure

Table 15

Required Tools			
Tool	Part Number	Part Name	Qty
A	21820117	3 bond 1368D	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

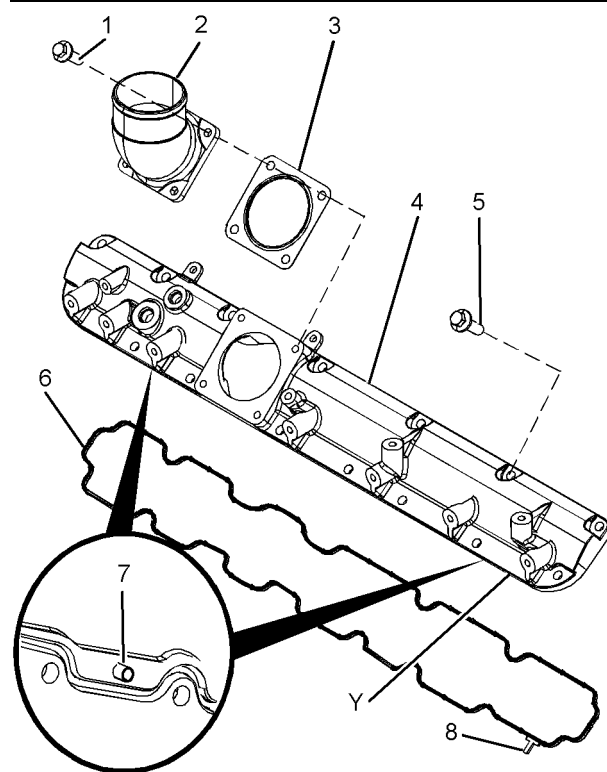


Illustration 87

g01335909

1. Ensure that the inlet manifold is clean and free from damage. If necessary, replace the inlet manifold. If a new inlet manifold is installed, install two new dowel pins (7) to inlet manifold (4).
- Note:** Do not install dowel pins to the cylinder head.
2. Clean the mating surface of the cylinder head.
 3. Align tag (8) to the slot at position (Y) on the inlet manifold. Install new seal (6) to the groove in inlet manifold (4). Ensure that the seal is correctly located.
 4. Align dowel pins (7) to the holes in the cylinder head. Install inlet manifold (4) to the cylinder head.

5. Apply Tooling (A) to bolts (5). Install the bolts to inlet manifold (4).

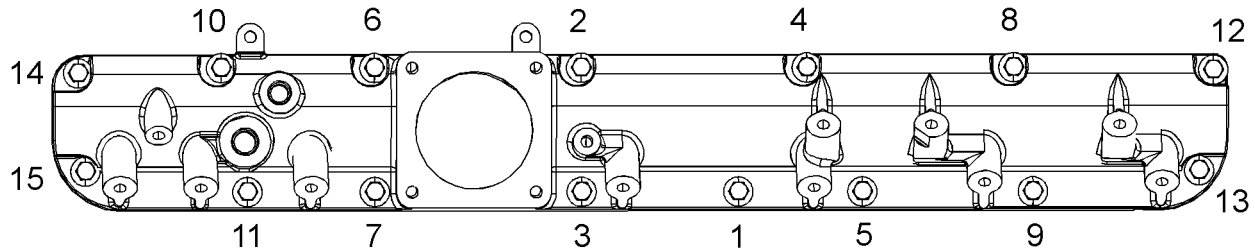


Illustration 88

g01335892

6. Tighten the bolts to a torque of 22 N·m (16 lb ft) in the sequence that is shown in Illustration 88.
7. Ensure that inlet connection (2) is clean and free from damage. If necessary, replace the inlet connection.
8. Position a new gasket (3) onto the inlet manifold. Install inlet connection (2) to inlet manifold (4).
9. Install bolts (1) to inlet connection (2). Tighten the bolts to a torque of 22 N·m (16 lb ft).
10. Install the air temperature sensor. Refer to Disassembly and Assembly, "Inlet Air Temperature Sensor - Remove and Install".
11. Install the boost pressure sensor. Refer to Disassembly and Assembly, "Boost Pressure Sensor - Remove and Install".
12. Position the harness assembly on the inlet manifold. Use new cable straps in order to secure the harness assembly.
13. Connect the breather hose to the separator for the crankcase breather (not shown). Refer to Disassembly and Assembly, "Crankcase Breather - Install".
14. If the engine is equipped with a cover over the fuel system this will need to be installed.

End By:

- a. Install the ECM mounting bracket. Refer to Disassembly and Assembly, "ECM Mounting Bracket - Remove and Install".
- b. Install the fuel manifold. Refer to Disassembly and Assembly, "Fuel Manifold - Install".

- c. If necessary, install the fuel filter base. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".

i02654522

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 16

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1
C	21825576	Crankshaft Turning Tool	1
C	27610291	Barring Device Housing	1
	27610289	Gear	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 top dead center before the valve spring is removed. Failure to ensure that the piston is at top dead center may allow the valve to drop into the cylinder bore.

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

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

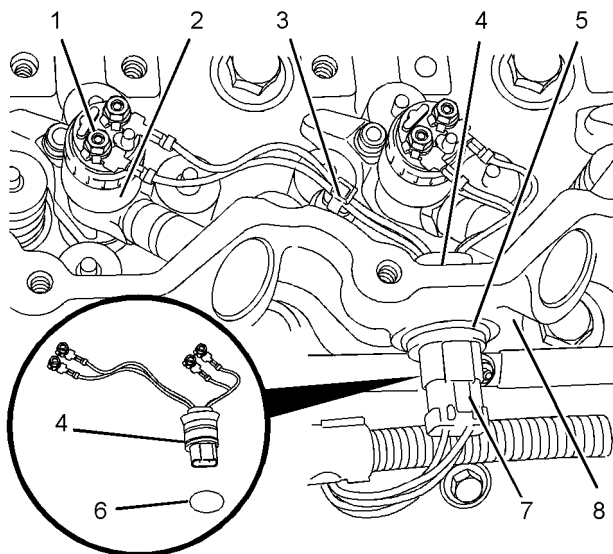


Illustration 89

g01335929

1. Follow Steps 1.a through 1.h in order to remove the harness assemblies for the electronic unit injectors.
 - a. Place a temporary identification mark on connections (1) for harness assembly (4) for electronic unit injectors (2).
 - b. Use a deep socket to remove connections (1) from electronic unit injectors (2).
 - c. Cut the cable straps (3).
 - d. Disconnect plug (7) from harness assembly (4).
 - e. Use Tooling (A) to remove circlip (5).
 - f. From the outside of valve mechanism cover base (8), push harness assembly (4) inward. Withdraw the harness assembly from the valve mechanism cover base.
 - g. Remove O-ring seal (6) from harness assembly (4).
 - h. Repeat Steps 1.a through 1.g in order to remove the remaining harness assemblies.

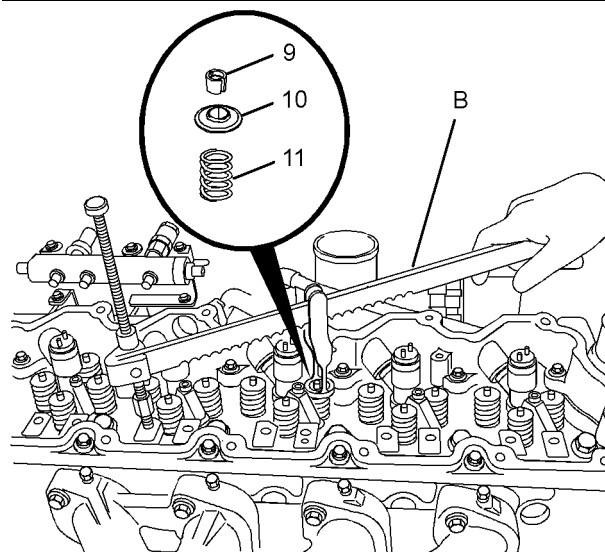


Illustration 90

g01335931

NOTICE

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

2. Follow Steps 2.a through 2.d in order to position the appropriate piston at top dead center.
 - a. Install Tooling (B) in position on the cylinder head in order to compress a valve spring (11) for the appropriate piston.

- b. Use Tooling (B) in order to compress valve spring (11) and open the valve slightly.

Note: Do not compress the spring so that the valve spring retainer (10) touches the valve stem seal.

- c. Use Tooling (C) in order to rotate the crankshaft carefully, until the piston touches the valve.

Note: 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 dead center position. The valve is now held in a position that allows the valve spring to be safely 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 6, 2 with 5, and 3 with 4. Ensure that all of the valve springs are installed before changing from one pair of cylinders to another pair of cylinders.

NOTICE

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

3. Apply sufficient pressure to Tooling (B) in order to allow removal of valve keepers (8).

Note: Do not compress the spring so that valve spring retainer (9) touches the valve stem seal.

Remove valve keepers (9).

4. Slowly release pressure on Tooling (B).
5. Remove valve spring retainer (10) and remove valve spring (11).
6. If necessary, remove the valve stem seals.
7. Repeat Steps 3 through 6 in order to remove the remaining valve springs from the appropriate cylinder.
8. Remove Tooling (B).

Installation Procedure

Table 17

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1
C	21825576	Crankshaft Turning Tool	1
C	27610291	Barring Device Housing	1
	27610289	Gear	1
D	21820221	POWERPART Rubber Grease	1
E	27610296	Torque Wrench	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.

NOTICE

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

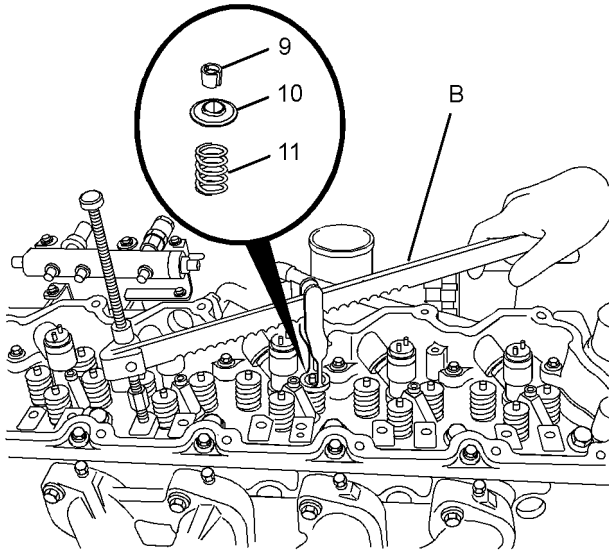


Illustration 91

g01335931

1. Inspect valve springs (11) for damage and for the correct length. Refer to Specifications, "Cylinder Head Valves".
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.

3. Install valve spring (11) onto the cylinder head. Position valve spring retainer (10) on valve spring (11).

WARNING

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

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

NOTICE

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

4. Install Tooling (B) in the appropriate position on the cylinder head in order to compress valve spring (11).
5. Apply sufficient pressure to Tooling (B) in order to install valve keepers (9).

Note: Do not compress the spring so that valve spring retainer (10) touches the valve stem seal.

Install the valve spring keepers.

6. Carefully release the pressure on Tooling (B).
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).
9. Use Tooling (C) to rotate the crankshaft through approximately 45 degrees. This will ensure that the appropriate valve is clear of the piston. Lightly strike the top of the valve with a soft hammer in order to ensure that valve keepers (9) are properly installed.

Note: 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 cylinders. 1 and 6, 2 and 5, and 3 and 4. Remember that the crankshaft must not be turned while the valve springs are removed. Ensure that all of the valve springs are installed before changing from one pair of cylinders to the other pair of cylinders. If all valve springs do not require replacement, the springs must be replaced in pairs.

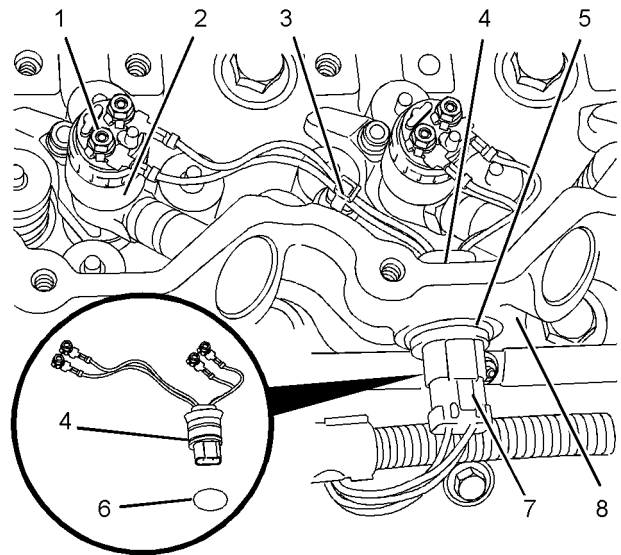


Illustration 92

g01335929

10. Follow Steps 10.a through 10.g in order to install the harness assemblies for the electronic unit injectors.

- a. Ensure that harness assembly (4) for the electronic unit injectors and the bore in valve mechanism cover base (8) are clean and free from damage. Replace any damaged components.
- b. Use Tooling (D) to lubricate a new O-ring seal. Install new O-ring seal (6) onto harness assembly (4) for the electronic unit injectors.
- c. From the inside of valve mechanism cover base (8), push harness assembly (4) into the valve mechanism cover base.
- d. Use Tooling (A) to install circlip (5).
- e. Connect plug (7) to harness assembly (4) for the electronic unit injectors.
- f. Use a deep socket to install connections (1) to electronic unit injectors (2). Use Tooling (E) to tighten the connections to a torque of 2.4 N·m (21 lb in).
- g. Install a new cable strap (3).

Note: Ensure that cable ties to OE specification are used.

- h. Repeat Steps 10.a through 10.g for the remaining harness assemblies.

End By:

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

i02654524

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 18

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825666	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 mating surface 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.

Note: Inlet valves have a recess in the center of the head.

3. Use a suitable lifting device to position the cylinder head with the valve springs upward. The weight of the cylinder head is approximately 65 kg (143 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.

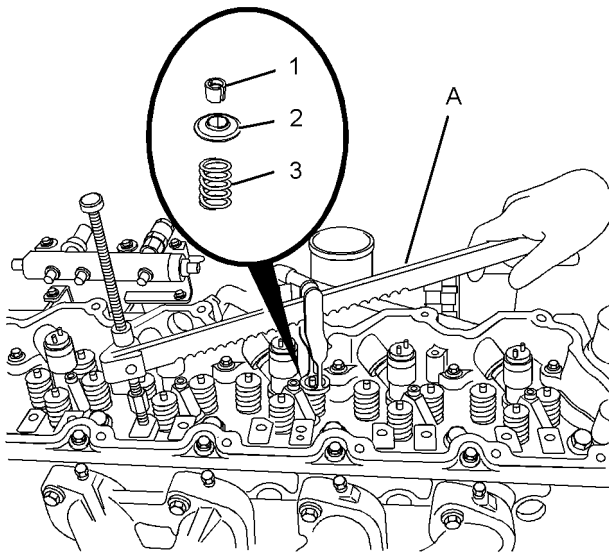


Illustration 93 g01335985
Typical example

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

NOTICE

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

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 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 19

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825666	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.

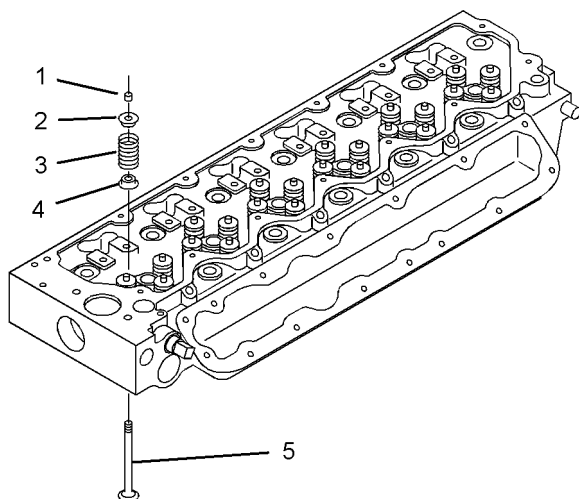


Illustration 94 g01335986

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.d 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 System 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 System 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 valve springs (3) for damage and for the correct length. Refer to Specifications, "Cylinder Head Valves".

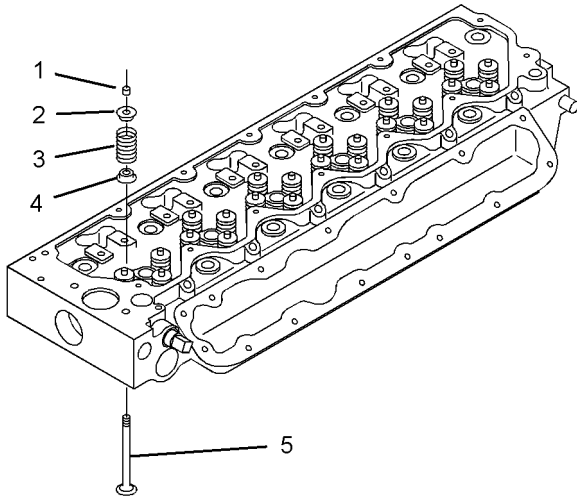


Illustration 95

g01335986

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 System 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 65 kg (143 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 valve stem seals (4).

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

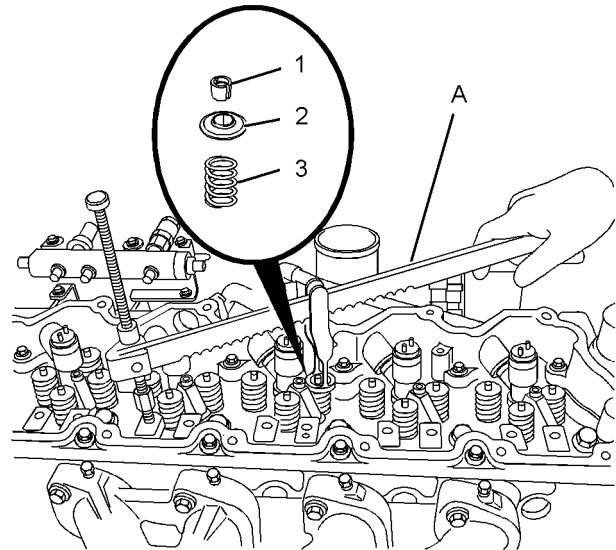


Illustration 96

g01335985

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. Gently 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".

i02654484

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 20

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

Note: The oil filter can be installed vertically or the oil filter can 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.

1. Place a suitable container below engine oil filter base (3) in order to catch any oil that might be spilled.

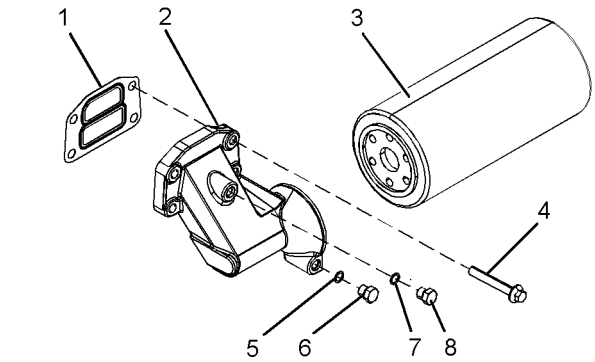


Illustration 97

g01336008

Typical example

2. If the engine oil filter base has a horizontal engine oil filter, follow Steps 2.a to 2.b in order to drain the engine oil filter.
 - a. Remove drain plug (6) from engine oil filter base (2).
 - b. Remove O-ring seal (5) from drain plug (6).
 3. Use Tooling (A) to remove engine oil filter (3). Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change".
 4. Remove bolts (4). If bolts of different lengths are installed, identify the correct position of the bolts.
- Note:** If necessary, remove the spacers and slide the bracket for the wiring loom to one side.
5. Remove engine oil filter base (2).
 6. Remove joint (1).
 7. If necessary, remove plug (8) from engine oil filter base (2). Remove O-ring seal (7) from plug (8).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i02654366

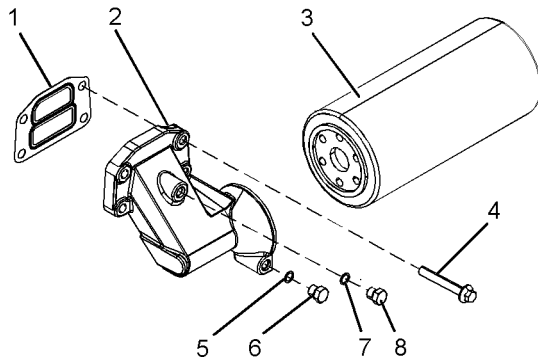


Illustration 98
Typical example

g01336008

1. Clean engine oil filter base (2). Clean the mating surfaces of the cylinder block or the engine oil cooler.
 2. If necessary, install new O-ring seals (5) and (7) to plugs (6) and (8). Install plugs (6) and (8) to engine oil filter base (2). Tighten the plugs to a torque of 12 N·m (106 lb in).
- Note:** Drain plug (6) is only installed to engines with a horizontal engine oil filter.
3. Install bolts (4) to engine oil filter base (2). Ensure that bolts of different lengths are installed in the correct positions.
- Note:** If necessary, install the spacers and the bracket for the wiring loom.
4. Install a new joint (1) onto bolts (4). Install the assembly of the engine oil filter base to the cylinder block or the engine oil cooler.
 5. Tighten bolts (4) to a torque of 22 N·m (16 lb ft).
 6. Install a new engine oil filter (3) and check the level of the engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check" for the correct procedure.

Engine Oil Cooler - Remove (Engine Oil Cooler with a Low Mounted Filter Base)

Removal Procedure

Start By:

- a. Remove the bracket for the Electronic Control Module. Refer to Disassembly and Assembly, "ECM Mounting Bracket - Remove and Install".

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Drain" for the correct procedure.

2. Place a suitable container below the engine oil cooler in order to catch any fluids that might be spilled.

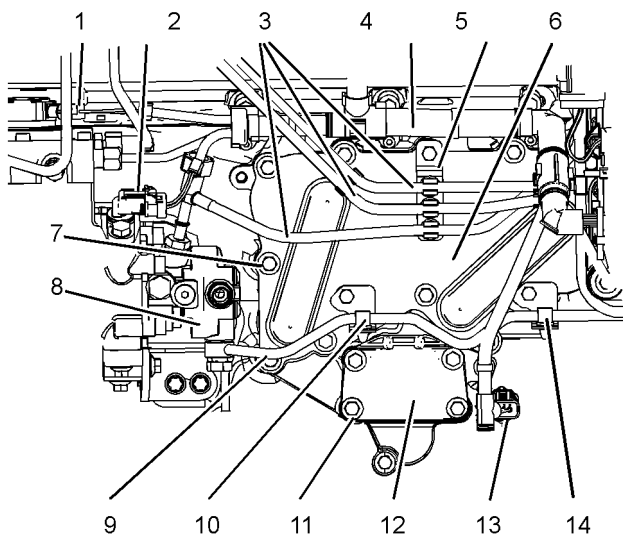


Illustration 99

g01336418

Typical example of an engine oil cooler with a blanking plate

3. If the engine has a left hand side oil filter, remove the oil filter base. Refer to Disassembly and Assembly, "Oil Filter Base - Remove and Install".

If the engine has a right hand side oil filter, follow Steps 3.a through 3.c in order to remove the blanking plate (12). Refer to Illustration 99.

- a. Remove bolts (11).
 - b. Remove blanking plate (12).
 - c. Remove the joint.
4. Make temporary identification marks on plastic tube assemblies (3) in order to show the correct position of the tube assemblies.
 5. Remove plastic tube assemblies (3). Plug all plastic tube assemblies with new plugs. Cap all open ports with new caps.
 6. Follow Steps 6.a through 6.d in order to disconnect the engine wiring harness (4).
 - a. Disconnect engine wiring harness (4) from position sensor (2) for the fuel injection pump.
 - b. Disconnect engine wiring harness (4) from solenoid (1) for the fuel injection pump.
 - c. Disconnect engine wiring harness (4) from oil pressure sensor (13).

- d. Cut the cable straps that secure engine wiring harness (4) to the assembly of oil cooler (6). Position the harness away from the assembly of the oil cooler.

7. Remove tube assembly (9) for the fuel return from cylinder head and from transfer pump (8). Plug the tube assembly with new plugs. Cap all open ports with new caps.

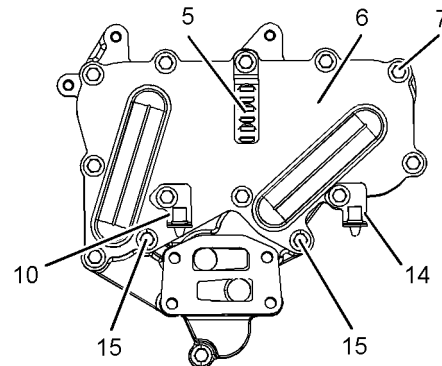


Illustration 100

g01336427

Typical example of engine oil cooler with a blanking plate or with a low mounted filter base

8. If necessary, loosen bolts (15). Remove bolts (7) and remove brackets (5), (14) and (10) for the tube assemblies. Remove the assembly of oil cooler (6) from the cylinder block.

Note: The bolts are different lengths. Note the position of the different bolts. Note the location and the orientation of the brackets for the tube assemblies.

9. Remove joint (16). Refer to Illustration 101.

Disassembly Procedure (Engine Oil Cooler with a Low Mounted Filter Base)

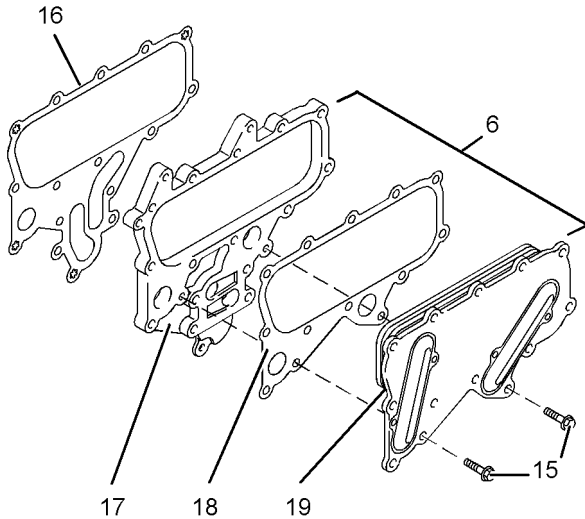


Illustration 101

g01336430

Typical example

1. Remove bolts (15).
2. Remove cooler matrix (19) from spacer plate (17).
3. Remove joint (18).

i02654365

Engine Oil Cooler - Remove (Engine Oil Cooler with a High Mounted Filter Base)

Removal Procedure

Start By:

- a. Remove the bracket for the Electronic Control Module. Refer to Disassembly and Assembly, "ECM Mounting Bracket - Remove and Install".

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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. Place a suitable container below the engine oil cooler in order to catch any fluids that might be spilled.

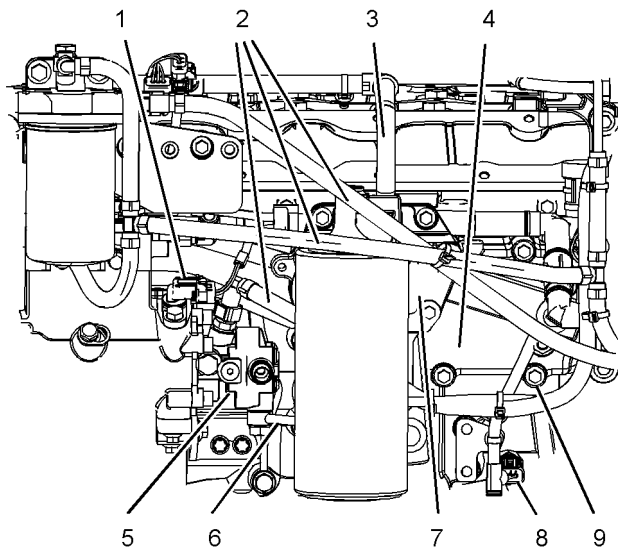


Illustration 102
Typical example
g01336192

3. If the engine has a left hand side oil filter, remove the oil filter base. Refer to Disassembly and Assembly, "Oil Filter Base - Remove and Install".
4. Make temporary identification marks on plastic tube assemblies (2) in order to show the correct position of the tube assemblies.
5. Remove plastic tube assemblies (2). Plug all plastic tube assemblies with new plugs. Cap all open ports with new caps.
6. Follow Steps 6.a through 6.d in order to disconnect the engine wiring harness (3).
 - a. Disconnect engine wiring harness (3) from position sensor (1) for the fuel injection pump.
 - b. Disconnect engine wiring harness (3) from the solenoid for the fuel injection pump.
 - c. Disconnect engine wiring harness (3) from oil pressure sensor (8).
 - d. Cut the cable straps that secure engine wiring harness (3) to the assembly of oil cooler (4). Position the harness away from the assembly of the oil cooler.
7. Remove tube assembly (6) for the fuel return from the cylinder head and from transfer pump (5). Plug the tube assembly with new plugs. Cap all open ports with new caps.

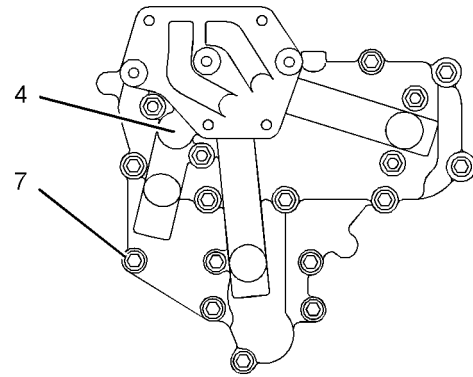


Illustration 103
Typical example
g01336193

8. If necessary, loosen bolts (7). Remove bolts (7) and remove brackets for the tube assemblies. Remove the assembly of oil cooler (4) from the cylinder block.

Note: The bolts are different lengths. Note the position of the different bolts. Note the location and the orientation of the brackets for the tube assemblies.

9. Remove joint (8). Refer to Illustration 104.

Disassembly Procedure (Engine Oil Cooler with a High Mounted Filter Base)

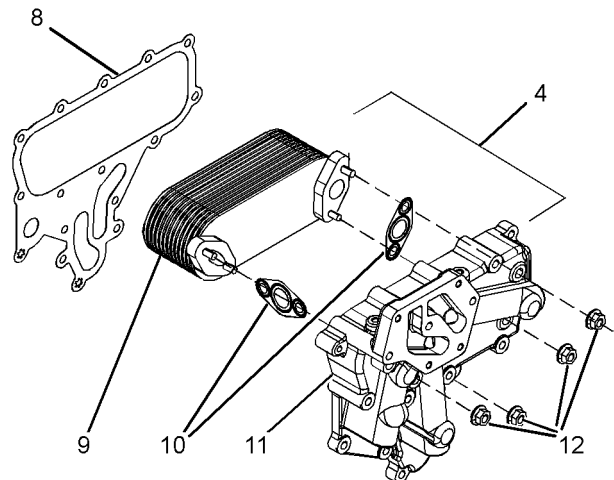


Illustration 104
g01336224

1. Remove nuts (12) from the assembly of oil cooler (6).
2. Remove cooler matrix (9) from housing (11).

3. Remove joints (10).

i02654368

Engine Oil Cooler - Install (Engine Oil Cooler with a Low Mounted Filter Base)

Assembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

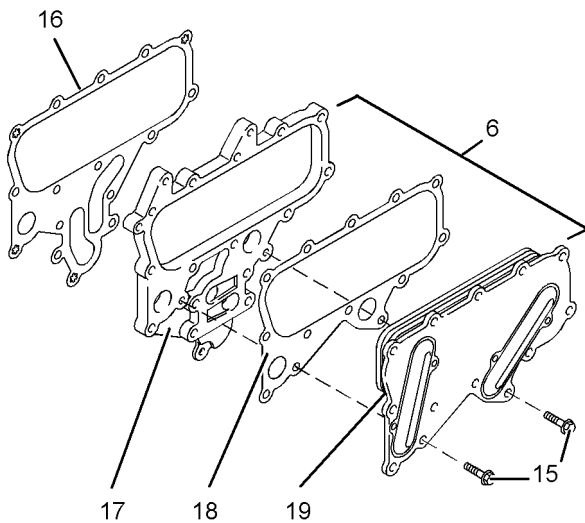


Illustration 105

g01336430

Typical example

1. Ensure that cooler matrix (19) is clean and free from damage. Ensure that spacer plate (17) is clean and free from damage. Replace any damaged components.
2. Position a new joint (18) onto spacer plate (17). Install cooler matrix (19) to the spacer plate.
3. Install bolts (15) finger tight.

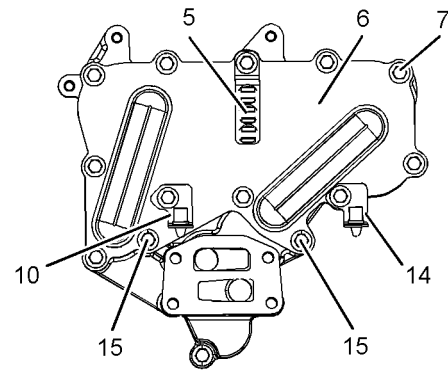


Illustration 106

g01336427

Typical example

4. Position brackets (5), (10) and (14) onto the assembly of oil cooler (6). Install bolts (7).

Note: Ensure that brackets for the tube assemblies are installed in the correct location and the correct orientation. The bolts are different lengths. Ensure that the different bolts are installed in the correct location.

5. Install new joint (16) to the assembly of oil cooler (6). Push bolts (7) through the holes in the joint.

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

Installation Procedure (Engine Oil Cooler with a Low Mounted Filter Base)

1. Clean the mating surfaces of the cylinder block.

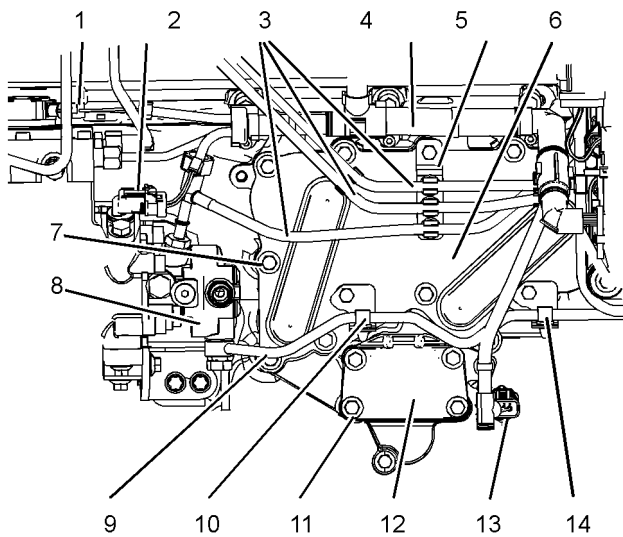


Illustration 107 g01336418

Typical example of an engine oil cooler with a blanking plate

2. Install the assembly of oil cooler (6) to the cylinder block. Tighten bolts (7) finger tight.

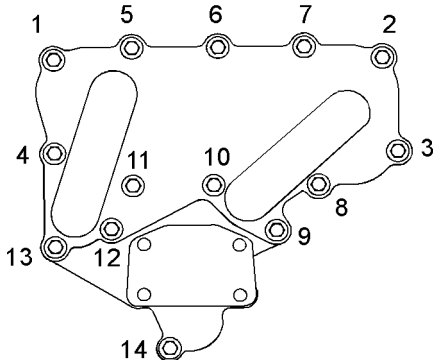


Illustration 108 g01336468

Tightening sequence for an engine oil cooler with a blanking plate or with a low mounted oil filter base

3. Tighten bolts (7) to a torque of 22 N·m (16 lb ft) in the sequence that is shown in Illustration 108.
4. If the engine has a low mounted oil filter on the left hand side, install the oil filter base. Refer to Disassembly and Assembly, "Oil Filter Base - Remove and Install".

If the engine has a right hand side oil filter, follow Steps 4.a through 4.d in order to install blanking plate (12).

- a. Install four bolts (11) to blanking plate (12).
- b. Position a new joint onto blanking plate (12).
- c. Install the assembly of the blanking plate to the assembly of oil cooler (6).

- d. Tighten bolts (11) to a torque of 22 N·m (16 lb ft).
5. Remove the plugs from tube assembly (9). Remove the caps for the fuel return from the cylinder head and from transfer pump (8). Install tube assembly (9) to the cylinder head and to transfer pump (8).
6. Follow Steps 6.a through 6.e in order to connect engine wiring harness (4).
 - a. Place the harness in position.
 - b. Connect engine wiring harness (4) to position sensor (2) for the fuel injection pump.
 - c. Connect engine wiring harness (4) to oil pressure sensor (13).
 - d. Connect engine wiring harness (4) to solenoid (1) for the fuel injection pump.
 - e. Install new cable straps in order to secure engine wiring harness (4) to the assembly of oil cooler (6).
7. Remove the plugs from all plastic tube assemblies (3). Remove the caps from the appropriate ports. Install plastic tube assemblies (3).
8. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
9. Check the level of the engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check" for the correct procedure.

End By:

- a. Install the bracket for the Electronic Control Module. Refer to Disassembly and Assembly, "ECM Bracket - Remove".

i02654367

Engine Oil Cooler - Install (Engine Oil Cooler with a High Mounted Filter Base)

Assembly Procedure

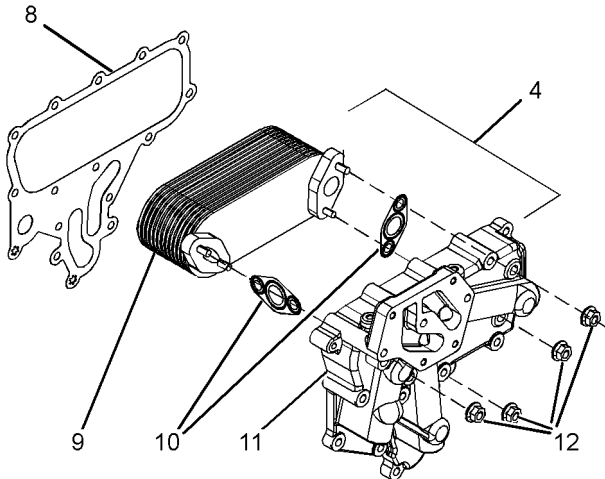


Illustration 109

g01336224

1. Ensure that cooler matrix (9) and housing (11) are clean and free from damage. Replace any damaged components.
2. Install new joints (10) to cooler matrix (9).
3. Install cooler matrix (9) to housing (11).
4. Install nuts (12) to the assembly of oil cooler (4). Tighten the nuts to a torque of 22 N·m (16 lb ft).

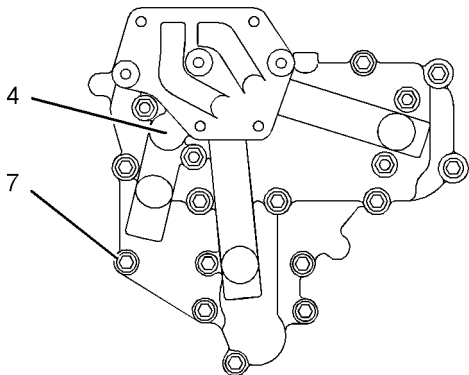


Illustration 110

g01336193

5. Install bolts (7) to the assembly of oil cooler (4).

Note: The bolts are different lengths. Ensure that the different bolts are installed in the correct location.

6. Install a new joint (8) to assembly of oil cooler (4). Push bolts (7) through holes in the joint.

Note: Holes in the joint have serrations that hold bolts captive.

Installation Procedure

1. Clean the mating surface of cylinder block.

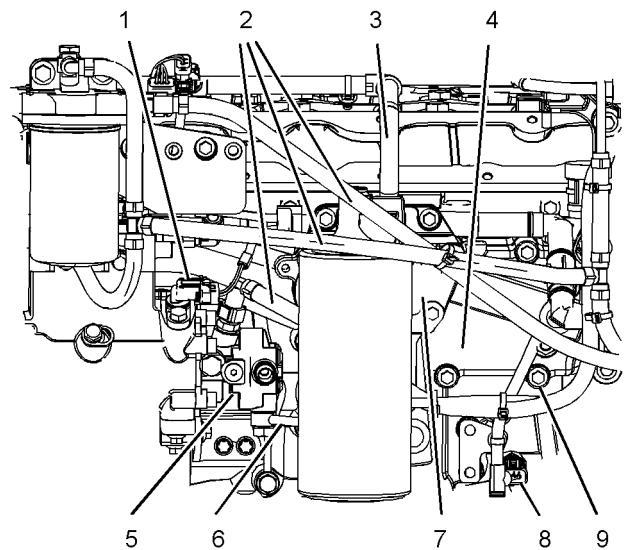


Illustration 111

g01336192

Typical example

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

Install oil filter base finger tight. Refer to Illustration 111 and refer to Disassembly and Assembly, "Engine Oil Filter Base - Remove and Install".

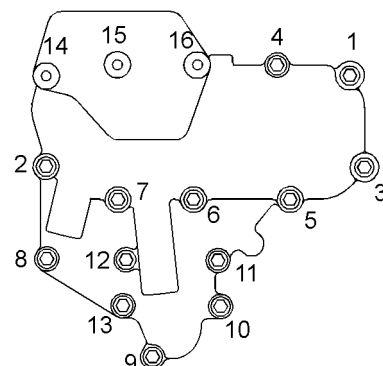


Illustration 112

g01336300

3. Tighten bolts (7) to a torque of 22 N·m (16 lb ft) in sequence that is shown in Illustration 112. Tighten remaining bolts that secure oil filter base to a torque of 22 N·m (16 lb ft).
4. Remove plugs from tube assembly (6). Remove caps for the fuel return from cylinder head and from transfer pump (5). Install tube assembly (6) to cylinder head and to transfer pump (5).
5. Follow Steps 5.a through 5.e in order to connect engine wiring harness (4).
 - a. Place the harness in position.
 - b. Connect engine wiring harness (3) to position sensor (1) for the fuel injection pump.
 - c. Connect engine wiring harness (3) to oil pressure sensor (8).
 - d. Reconnect wiring harness (3) to the solenoid for the fuel injection pump.
 - e. Install new cable straps in order to secure engine wiring harness (3) to assembly of oil cooler (4).
6. Remove plugs from all plastic tube assemblies (2). Remove caps from appropriate ports. Install plastic tube assemblies (2).
7. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
8. Check level of engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check" for the correct procedure.

End By:

- a. Install the bracket for the Electronic Control Module. Refer to Disassembly and Assembly, "ECM Bracket - Remove".

i02654488

Engine Oil Relief Valve - Remove and Install

Removal Procedure

Start By:

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

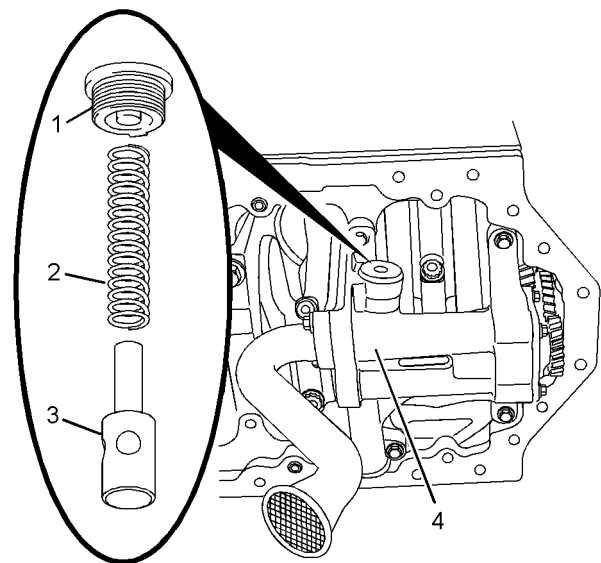


Illustration 113

g01336497

1. Use an allen wrench to loosen cap (1). Carefully remove cap (1) from the housing of engine oil pump (4).

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

2. Remove spring (2) from the bore for the relief valve in the housing of engine oil pump (4).
3. Use long nose pliers to remove plunger (3) from the bore for the relief valve in the housing of engine oil pump (4).

Installation Procedure

Table 21

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

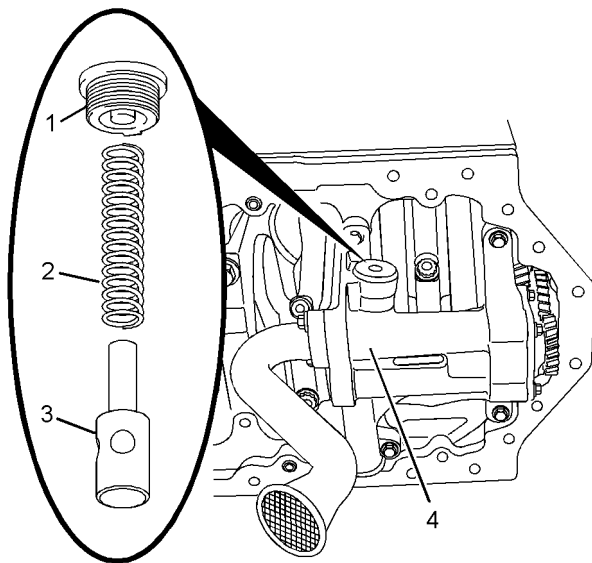


Illustration 114

g01336497

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 (4) 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 (2) into the bore for the relief valve in the housing of engine oil pump (4).

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

3. Apply Tooling (A) to the threads of cap (1). Use an allen wrench to install cap (1) to engine oil pump (4). 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 (A) does not contaminate the bore for the relief valve in the housing of the engine oil pump.

End By:

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

i02654487

Engine Oil Pump - Remove

Removal Procedure

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - 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. If the suction pipe has a support bracket, remove the support bracket.

Note: Note the position and orientation of the components for the support bracket.

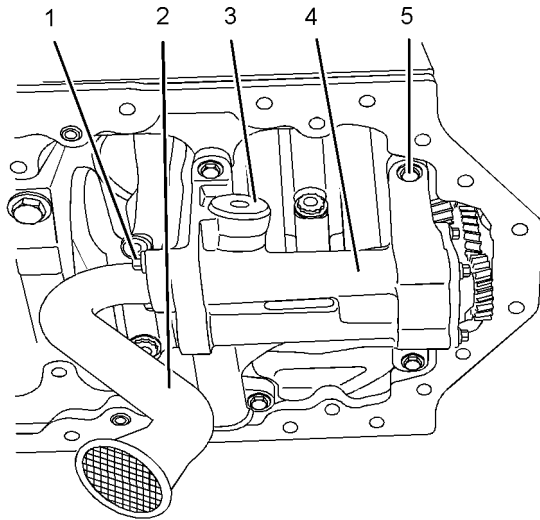


Illustration 115 g01336647
Typical example

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

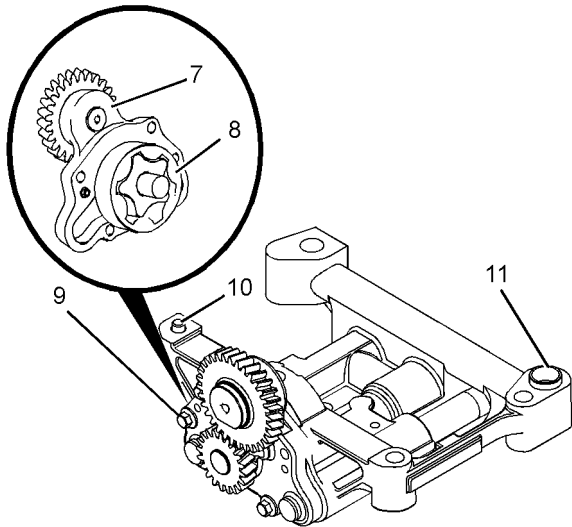


Illustration 116 g01336648
Typical example

6. If necessary, remove allen head screws (9) and front cover assembly (7). Remove outer rotor (8) from the housing of the engine oil pump.

Note: Do not remove dowels (9) or (11) from the housing of the engine oil pump unless the dowels are damaged.

i02654486

Engine Oil Pump - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

If any part of the engine oil pump is worn or damaged, the complete assembly of the engine oil pump must be replaced.

1. Ensure that all components of the engine oil pump are clean and free from wear or damage. Refer to System Operation, Testing and Adjusting, "Engine Oil Pump - Inspect" for more information. Replace the complete assembly of the engine oil pump if any of the components are worn or damaged.

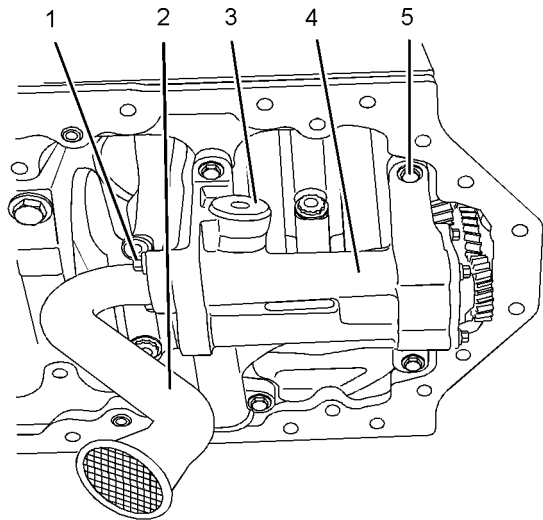


Illustration 117 g01336647
Typical example

2. If necessary, install the pressure relief valve (3). Refer to Disassembly and Assembly, "Engine Oil Relief Valve - Remove and Install" for further information.

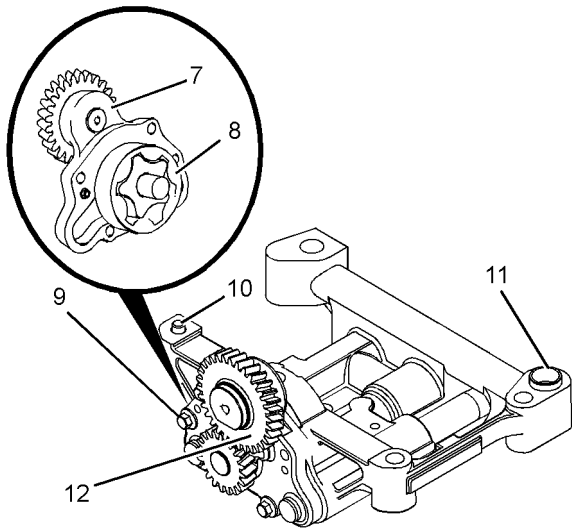


Illustration 118

g01336651

3. If necessary, lubricate the internal components for the assembly of the engine oil pump with clean engine oil. Install outer rotor (8) and front cover (7) to the housing of engine oil pump (4). Install the allen head screws (9). Tighten the allen head screws to a torque of 22 N·m (16 lb ft).
4. Ensure that two dowels (10) and (11) are correctly located in the housing of engine oil pump (4). 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. Check the backlash between idler gear (12) and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for further information.
7. Install suction pipe (2) and a new joint to the assembly of the engine oil pump.
8. Install bolts (1). Tighten the bolts to a torque to 22 N·m (16 lb ft).
9. If the suction pipe has a support bracket follow Steps 9.a through 9.c.
 - a. Install the components of the support bracket. Ensure the correct location and orientation of the bracket and the retaining clip.
 - b. Tighten the bolts finger tight in order to align the components of the support bracket.

- c. Tighten bolts (1) to a torque of 22 N·m (16 lb ft).

End By:

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

i02654553

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.

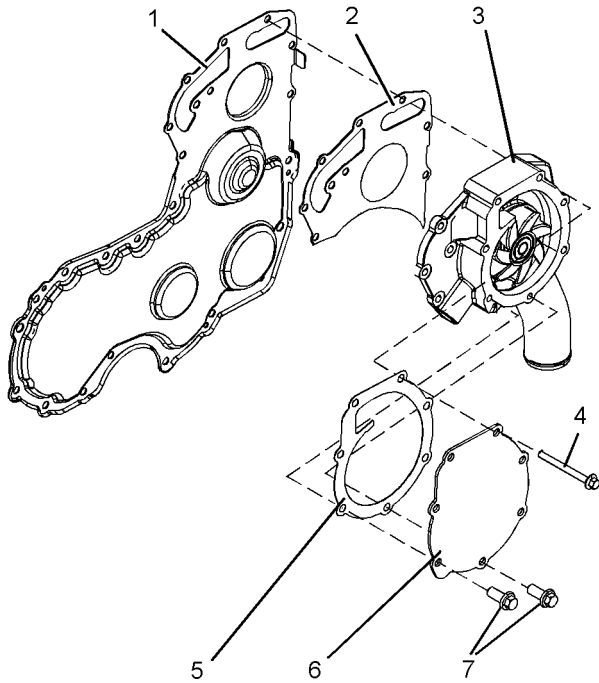


Illustration 119

g01336658

3. Remove bolts (4).

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

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 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 22

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M8 by 70 mm)	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.

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

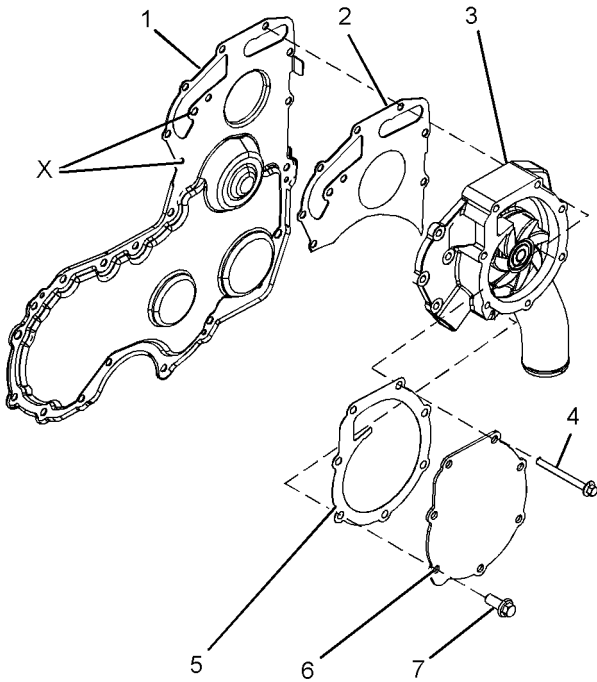


Illustration 120

g01336659

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) on water pump (3).
 - c. Install cover (6) to water pump (3).
 - d. Install bolts (7) to cover (6). Tighten bolts finger tight.
3. Clean the mating surface of front cover (1).

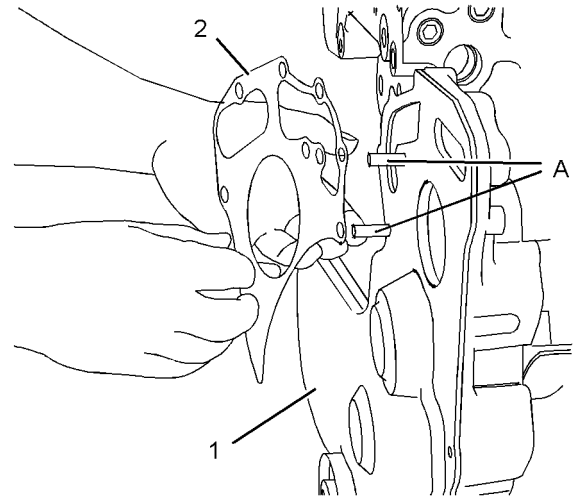


Illustration 121

g01336660

4. Install Tooling (A) in position (X).
 5. Use Tooling (A) in order to align new joint (2) to front cover (1). Install the joint to the front cover.
 6. Align water pump (3) to 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 120. Tighten the bolts finger tight.
- Note:** Ensure that all bolts of different lengths are installed in the correct positions.
8. Remove Tooling (A) and install remaining bolts (4).

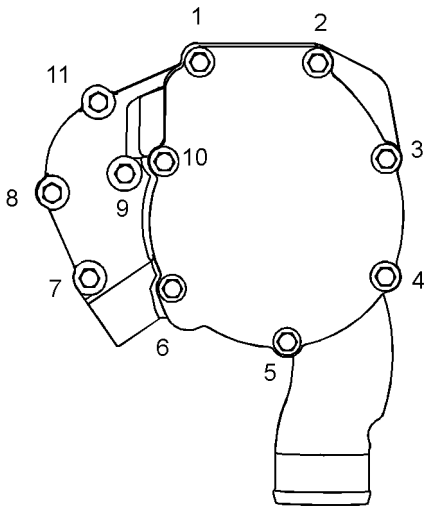


Illustration 122

g01336661

- 9. Tighten bolts (4) and (7) in the sequence that is shown in Illustration 122 to a torque of 22 N·m (16 lb ft).
- 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".

i02654555

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).

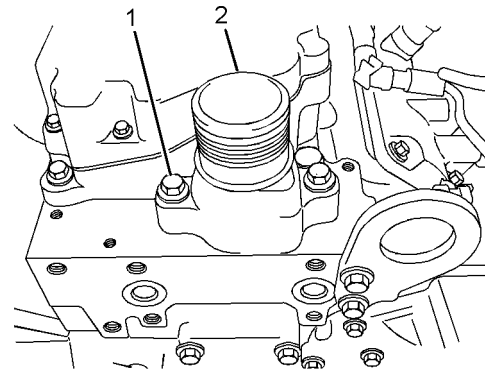


Illustration 123

g01336665

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.

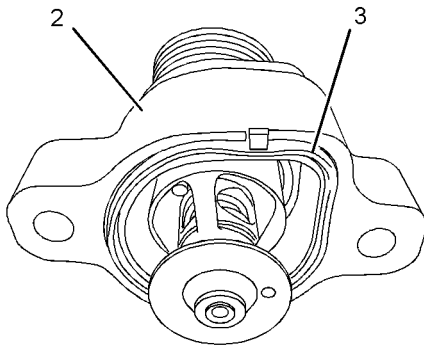


Illustration 124
Typical example

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

Installation Procedure

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 housing (2) are clean and free of wear or damage. Check the water temperature regulator for correct operation. Refer to System 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 housing are worn or damaged, the complete assembly must be replaced.

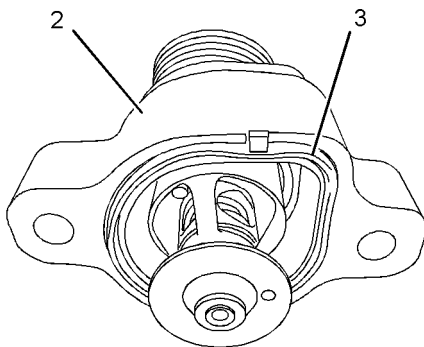


Illustration 125
Typical example

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. Install water temperature regulator housing (2) to the cylinder head.

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

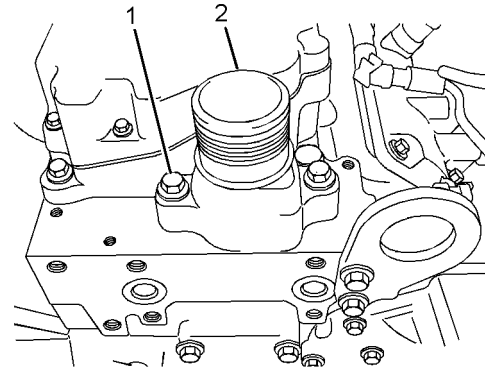


Illustration 126
Typical example

4. Install bolts (1). Tighten bolts (1) to a torque of 44 N·m (32.5 lb ft).
5. Connect the upper radiator hose and tighten the hose clamps.
6. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Check" and Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.

i02654493

Flywheel - Remove

Removal Procedure

Table 23

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (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.

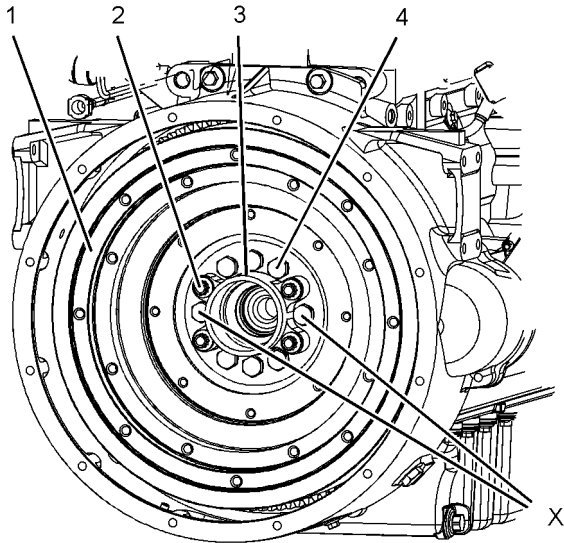


Illustration 127
Typical example g01336688

1. Remove bolts from position (X) on flywheel (1).
2. Install Tooling (A) in position (X) on flywheel (1).
3. Attach a suitable lifting device to flywheel (1). Support the weight of the flywheel. The flywheel can weigh 70.6 kg (155 lb).
4. If necessary, remove bolts (2) that secure the housing for pilot bearing (3) to flywheel (1). Remove the housing for pilot bearing (3).
5. Remove remaining bolts (4).
6. Use the lifting device to remove the flywheel from the engine.

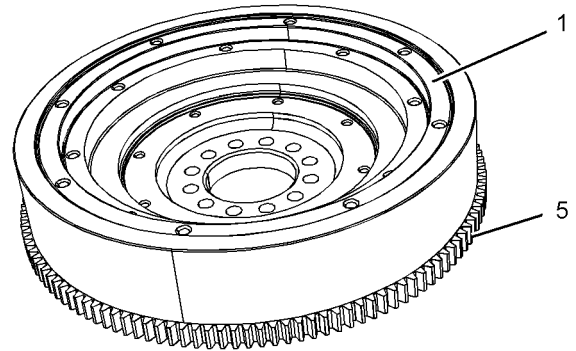


Illustration 128
Typical example g01336669

7. Inspect flywheel (1) and ring gear (5) for wear or damage. Replace any worn components or damaged components.
8. To remove flywheel ring gear (5), follow steps 8.a and 8.b.
 - a. Place the flywheel assembly on a suitable support.
 - b. Use a hammer and a punch in order to remove ring gear (5) from flywheel (1).

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

i02654492

Flywheel - Install

Installation Procedure

Table 24

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (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.

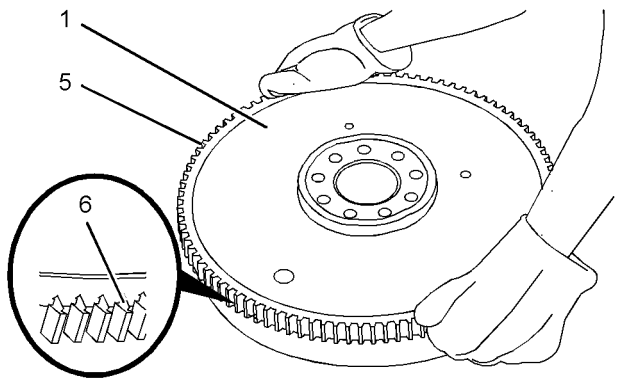


Illustration 129

g01336671

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 ring gear (5) to flywheel (1).
 - a. Identify the orientation of teeth (6) on new ring gear (5).

Note: The chamfered side of ring gear teeth (6) 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 (5) 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 (5) 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".

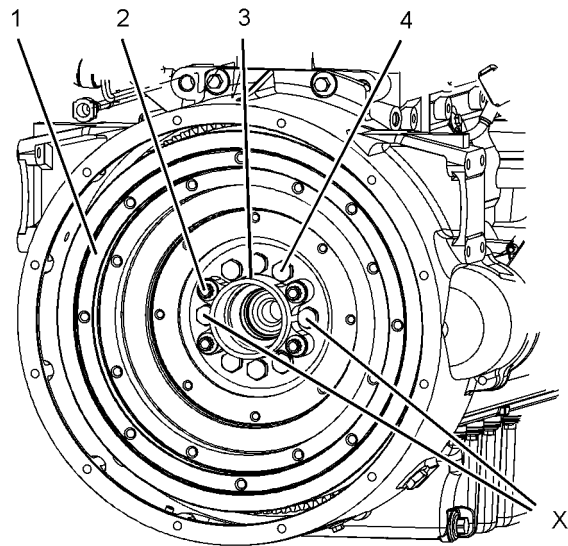


Illustration 130

g01336668

Typical example

3. Install a suitable lifting device to flywheel (1). The flywheel can weigh 70.6 kg (155.6 lb).
4. Install Tooling (A) in position (X) on the crankshaft.
5. Use the lifting device to position flywheel (1) onto Tooling (A).
6. If necessary, install pilot bearing (3) and bolts (2) to flywheel (1).
7. Install bolts (4) to flywheel (1).
8. Remove Tooling (A) and install remaining bolts (4) to flywheel (1).
9. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) and (4) to a torque of 120 N·m (88 lb ft).
10. Remove the lifting device from flywheel (1).
11. Check the run out of the flywheel. Refer to Specifications, "Flywheel" for further information.

End By:

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

i02654469

Crankshaft Rear Seal - Remove

Removal Procedure

Table 25

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1
B	-	E12 Torx Socket	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

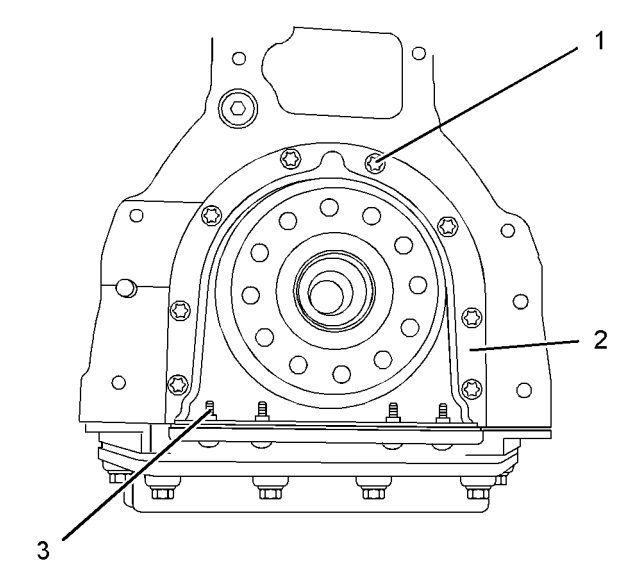


Illustration 131

g01337506

Typical example

Note: The assembly of the crankshaft rear seal is nonserviceable. If the assembly of the crankshaft rear seal is removed, the assembly must be replaced.

1. Use Tooling (B) in order to remove torx screws (1) from the assembly of crankshaft rear seal (2).
2. Use Tooling (A) in order to remove torx screws (3) from the assembly of the crankshaft rear seal.
3. Remove the assembly of crankshaft rear seal (2) from the cylinder block. Discard the assembly of crankshaft rear seal (2).

Note: It is not necessary to remove the adapter for the engine oil pan in order to remove the crankshaft rear seal.

i02662126

Crankshaft Rear Seal - Install

Installation Procedure With Oil Pan in Position

Table 26

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1
B	-	E12 Torx Socket	1

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

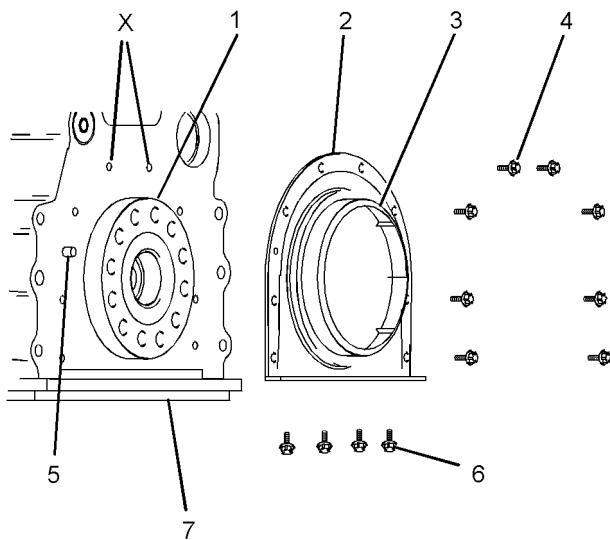


Illustration 132
Typical example

1. Ensure that crankshaft flange (1) is clean, dry and free from damage.
2. Ensure that the mating surface of the cylinder block is clean and dry. Ensure that the mating surface of isolating frame (7) is clean and dry.
3. Ensure that plastic sleeve (3) is squarely installed within new crankshaft rear seal (2).

Note: The plastic sleeve is included in order to protect the lip of the seal as the crankshaft rear seal is pushed over crankshaft flange (1). Do not attempt to install a crankshaft rear seal without the plastic sleeve.

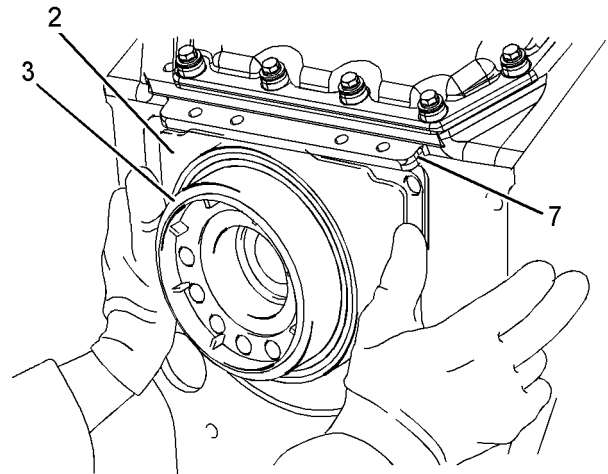


Illustration 133
Typical example

4. Place the assembly of the crankshaft rear seal over crankshaft flange (1). Align dowel (5) with the slot in crankshaft rear seal (2).
5. Ensure that plastic sleeve (3) is engaged on crankshaft flange (1). Push crankshaft rear seal (2) squarely onto the crankshaft. Ensure that the crankshaft rear seal is seated against the cylinder block. During this process, plastic sleeve (3) will be forced out of the crankshaft rear seal. Discard the plastic sleeve.

Note: Ensure that dowel (5) is engaged in the slot in the crankshaft rear seal.

6. Use Tooling (A) in order to install two outer Torx bolts (6) at the base of crankshaft rear seal (2). Tighten Torx bolts (6) to a torque of 15 N·m (11 lb ft).
7. Use Tooling (B) in order to install two Torx bolts (4) to crankshaft rear seal (2) at position (X). Tighten Torx bolts (4) to a torque of 22 N·m (16 lb ft).
8. Use Tooling (A) in order to unscrew Torx bolts (6) by one complete turn.
9. Use Tooling (B) in order to install remaining Torx bolts (4). Tighten Torx bolts (4) to a torque of 22 N·m (16 lb ft).
10. Use Tooling (A) in order to install remaining Torx bolts (6). Tighten all Torx bolts (6) to a torque of 22 N·m (16 lb ft).

End By:

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

Installation Procedure Without Isolating Frame for the Oil Pan

Table 27

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1
B	-	Alignment Tool	1
	-	Bolts (M8 by 20 mm)	4

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

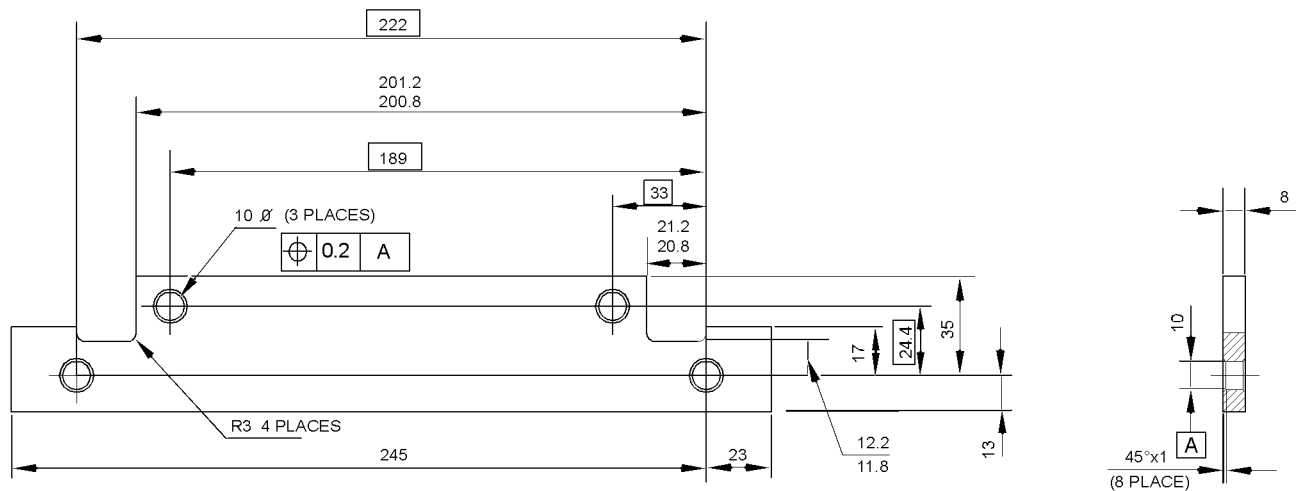


Illustration 134

Alignment tool

g01279001

1. To install the crankshaft rear seal without the isolating frame for the oil pan in position, Tooling (C) must be used. The tool should be fabricated from 8 mm (5/16 inch) steel stock. The dimensions for the tool are given in Illustration 134. All dimensions are shown in millimeters.

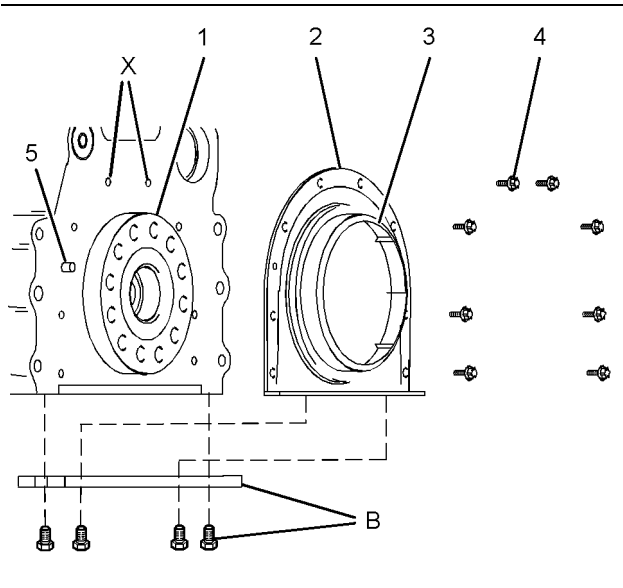


Illustration 135 g01374593

Typical example

2. Ensure that crankshaft flange (1) is clean, dry and free from damage.
3. Ensure that the mating surface of the cylinder block is clean and dry.
4. Ensure that plastic sleeve (3) is squarely installed within new crankshaft rear seal (2).

Note: The plastic sleeve is included in order to protect the lip of the seal as the crankshaft rear seal is pushed over crankshaft flange (1). Do not attempt to install a crankshaft rear seal without the plastic sleeve.

6. Ensure that plastic sleeve (3) is engaged on crankshaft flange (1). Push crankshaft rear seal (2) squarely onto the crankshaft. Ensure that the crankshaft rear seal is seated against the cylinder block. During this process, plastic sleeve (3) will be forced out of the crankshaft rear seal. Discard the plastic sleeve.

Note: Ensure that dowel (5) is engaged in the hole in the crankshaft rear seal.

7. Install Tooling (C) to the cylinder block and to crankshaft rear seal (2). Tighten the bolts to a torque of 15 N·m (11 lb ft).
8. Use Tooling (B) in order to install two Torx bolts (4) to crankshaft rear seal (3) in position (X). Tighten two Torx bolts (4) to a torque of 22 N·m (16 lb ft).
9. Use Tooling (B) in order to install remaining Torx bolts (4). Tighten all Torx bolts (4) to a torque of 22 N·m (16 lb ft).

10. Remove Tooling (C).

End By:

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

i02654494

Flywheel Housing - Remove and Install (Standard Housing)

Removal Procedure

Table 28

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

Start By:

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

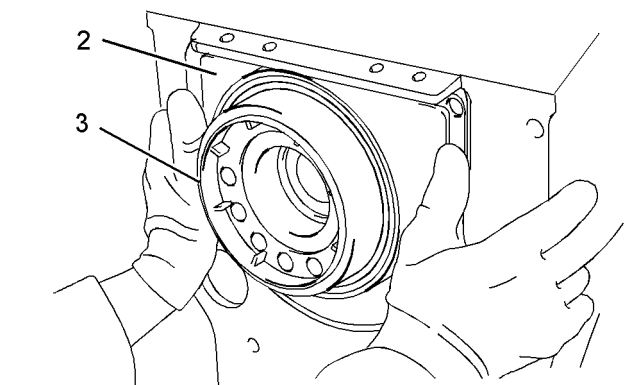


Illustration 136 g01337517

Typical example

5. Place the assembly of the crankshaft rear seal over crankshaft flange (1). Align dowel (5) with the slot in the crankshaft rear seal.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

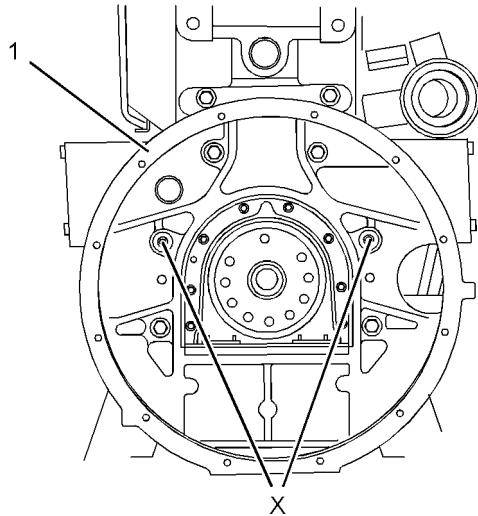


Illustration 137

g01374648

Typical example

1. Remove bolts (3) from position (X) from flywheel housing (1).
2. Install Tooling (A) into position (X) on flywheel housing (1).
3. Install a suitable lifting device to the flywheel housing in order to support the flywheel housing. The flywheel housing can weigh 32 kg (70.5 lb).

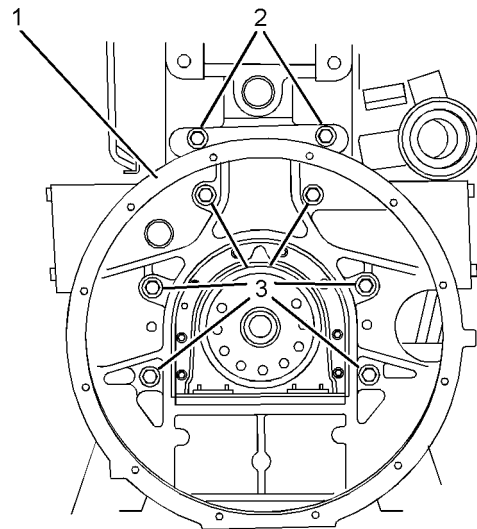


Illustration 138

g01337563

Typical example

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

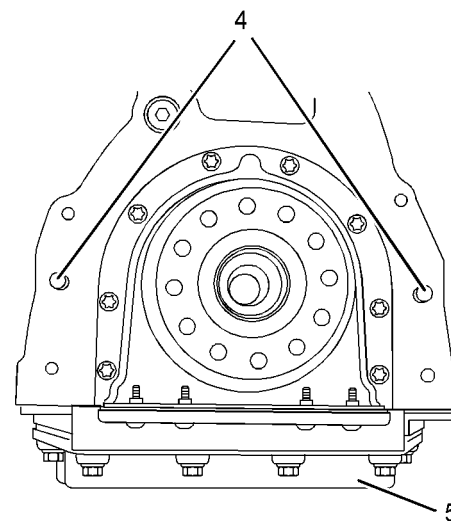


Illustration 139

g01337565

Typical example

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

Installation Procedure (Standard Housing)

Table 29

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M10 by 100 mm)	2
B	1861117	POWERPART Universal Jointing Compound	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.

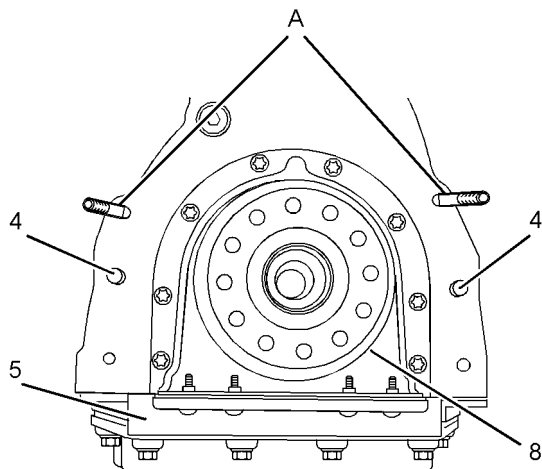


Illustration 140

g01337569

Engine with an aluminum oil pan

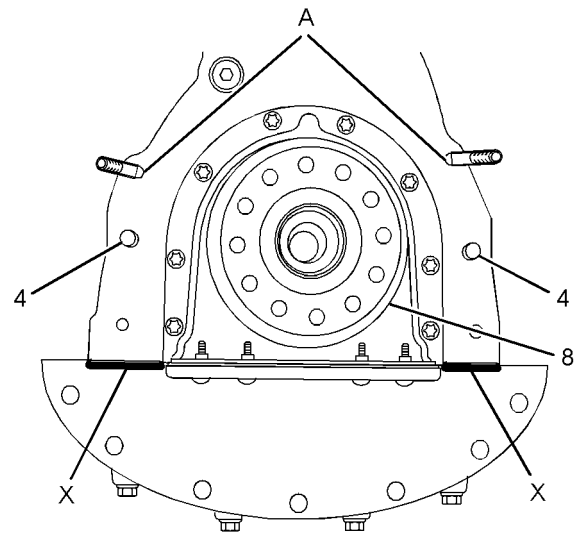


Illustration 141

g01337572

Engine with a cast iron oil pan

2. Inspect crankshaft rear seal (8) 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. If the engine has an aluminum oil pan, install dust seal (5).

If the engine has a cast iron oil pan, apply a bead of Tooling (B) to positions (X).

i02654369

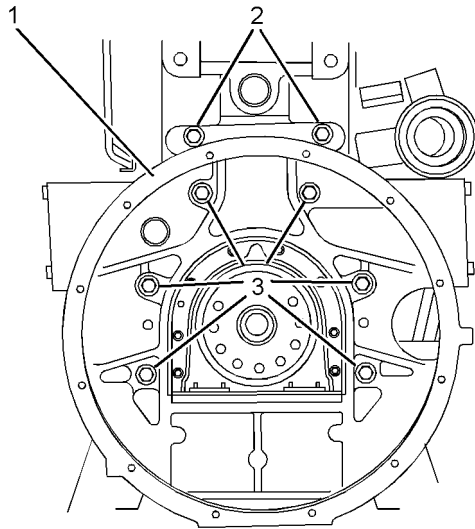


Illustration 142
Typical example g01337563

6. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 32 kg (70.5 lb).
7. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
8. Install bolts (2) and bolts (3).
9. Remove Tooling (A). Install 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 78 N·m (57.5 lb ft).
12. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, "Flywheel Housing - Inspect".

End By:

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

Flywheel Housing - Remove and Install (Wet Back End Housing)

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 can weigh 32 kg (70.5 lb).

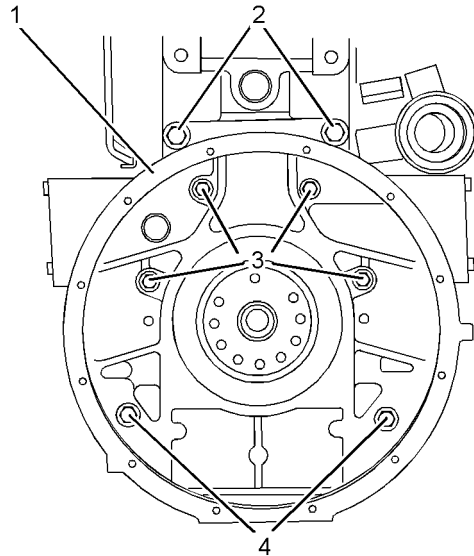


Illustration 143
Typical example g01337602

2. Remove bolts (2). Remove bolts (4). Remove bolts (3) from flywheel housing (1).
3. Use the lifting device in order to remove flywheel housing (1) from the cylinder block.

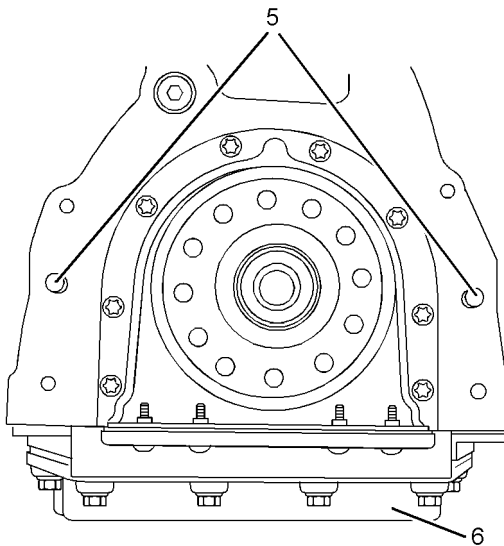


Illustration 144
Typical example
g01337603

4. If the engine has an aluminum oil pan, remove dust seal (6).

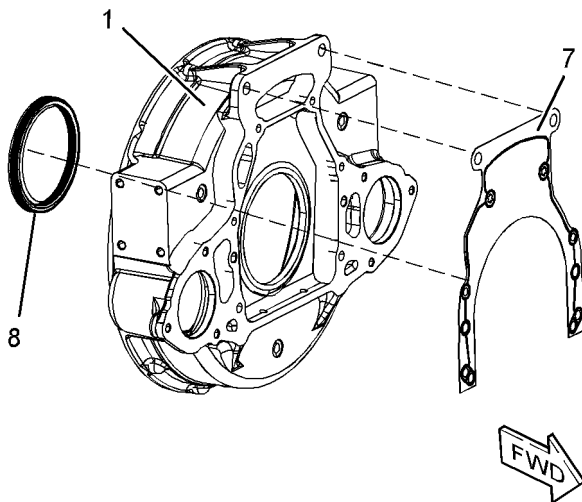


Illustration 145
Typical example
g01337605

5. Remove joint (7).
6. If necessary, remove dowels (5) from the cylinder block.
7. Remove oil seal (8) from flywheel housing (1).

Installation Procedure (Wet Back End Housing)

Table 30

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M10 by 100 mm)	2
B	1861117	POWERPART Universal Jointing Compound	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.

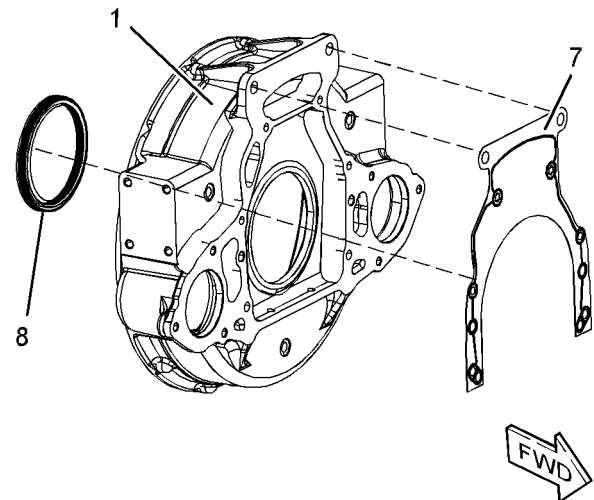


Illustration 146
Typical example
g01337605

2. Install a new oil seal (8) to flywheel housing (1).

Note: Press the oil seal into the flywheel housing from the rear. Ensure that the front edge of the oil seal is flush with the joint face of the flywheel housing .

3. Inspect crankshaft rear seal (9) 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".

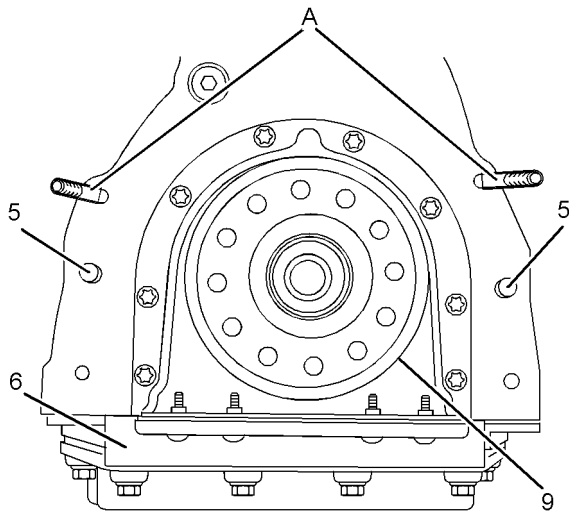


Illustration 147 g01337609
Engine with an aluminum oil pan

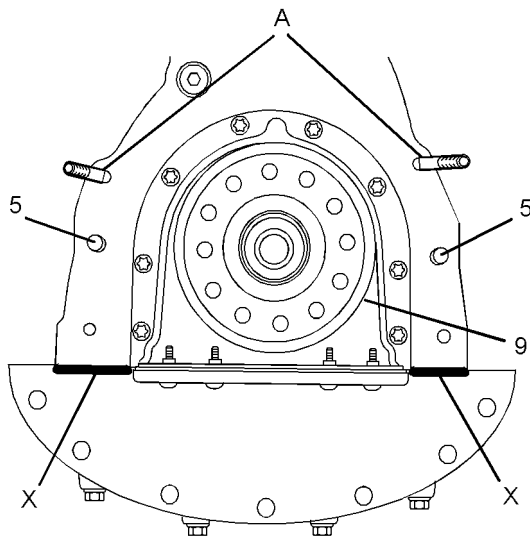


Illustration 148 g01337610
Engine with cast iron oil pan

4. Clean the rear face of the cylinder block. If necessary, install dowels (5) to the cylinder block.
5. Install Tooling (A) to the cylinder block.
6. Align a new joint (7) with Tooling (A). Install the joint to the cylinder block.
7. If the engine has an aluminum oil pan, install dust seal (6).

If the engine has a cast iron oil pan, apply a bead of Tooling (B) to positions (X).

8. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 32 kg (70.5 lb).

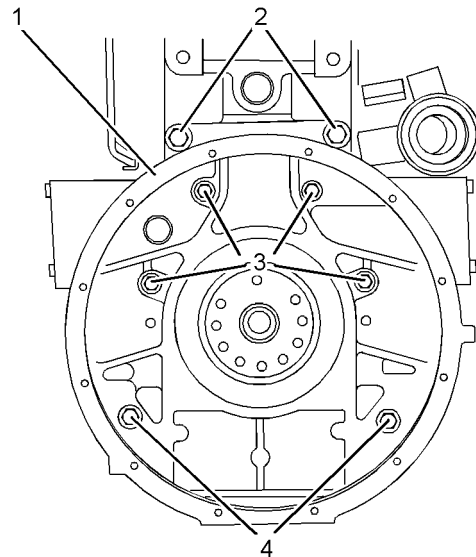


Illustration 149 g01337602
Typical example

9. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
10. Install bolts (2), bolts (4) and bolts (3).
11. Remove Tooling (A). Install remaining bolts (3).
12. Tighten bolts (2) to a torque of 190 N·m (140 lb ft).
Tighten bolts (4) to a torque of 115 N·m (85 lb ft).
Tighten bolts (3) to a torque of 63 N·m (46 lb ft).
13. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, "Flywheel Housing - Inspect".

End By:

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

i02654373

Vibration Damper and Pulley - Remove (Pulleys without Split Lock Rings)

Removal Procedure

Table 31

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M12 by 70 mm)	1
B	27610299	E18 Torx socket	1

Start By:

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

Note: The weight of the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter is approximately 22 kg (48 lb). Remove the vibration damper and the crankshaft pulley before the crankshaft adapter is removed from the engine.

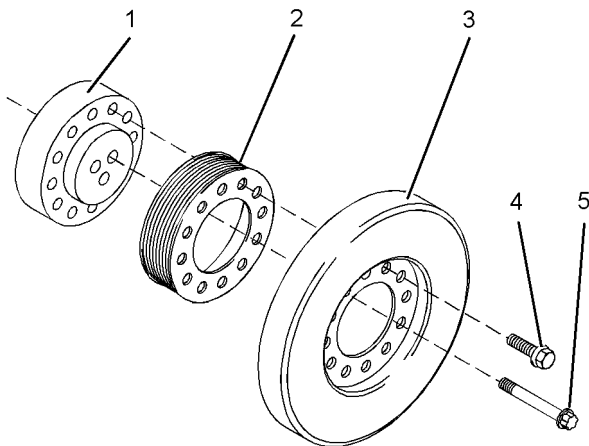


Illustration 150

g01337793

1. Remove one of bolts (4). Install Tooling (A) into the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter.

2. Remove remaining bolts (4).
3. Remove vibration damper (3) and crankshaft pulley (2) from crankshaft adapter (1). Remove Tooling (A) from crankshaft adapter (1).
4. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to remove torx screws (5).
5. Remove the crankshaft adapter (1) from the crankshaft.

i02654372

Vibration Damper and Pulley - Remove (Pulley with Split Lock Rings)

Removal Procedure

Table 32

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M12 by 70 mm)	1
B	27610299	E18 Torx socket	1

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.

Note: The weight of the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter is approximately 22 kg (48 lb). Remove the vibration damper and the crankshaft pulley before the crankshaft adapter is removed from the engine.

i02654371

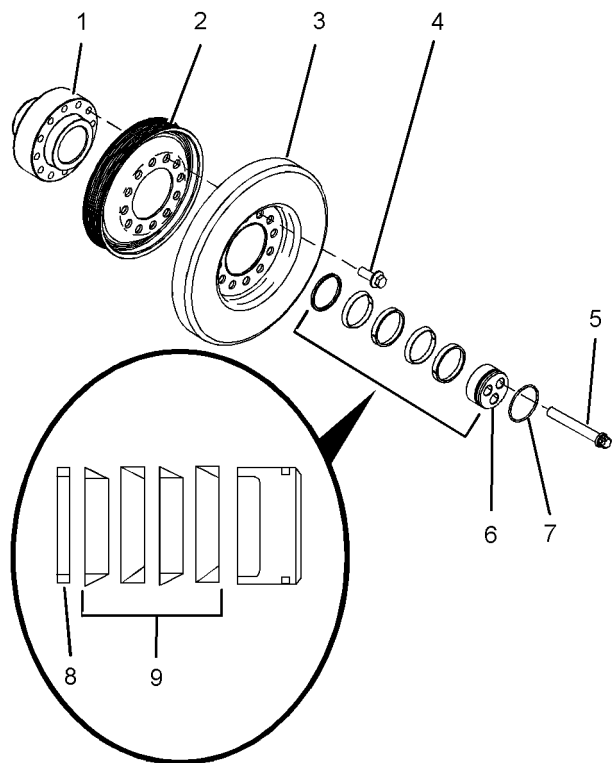


Illustration 151

g01337777

1. Install Tooling (A) into one of the unused threads in the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter.
2. Remove bolts (4).
3. Remove vibration damper (3) and crankshaft pulley (2) from crankshaft adapter (1). Remove Tooling (A) from crankshaft adapter (1).
4. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to remove torx screws (5).
5. Hold a wood block against crankshaft adapter (1). Strike the wood block with a hammer in order to loosen split lock rings (9).
6. Carefully remove crankshaft adapter (1) from the crankshaft. Remove thrust block (6) from crankshaft adapter (1). Remove O-ring seal (7) from thrust block (6). Remove split lock rings (9) and spacer (8) from crankshaft adapter (1). Note the position and orientation of the split lock rings and the spacer.

Vibration Damper and Pulley - Install (Pulleys without Split Lock Rings)

Installation Procedure

Table 33

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M12 by 70 mm)	1
B	27610299	E18 Torx socket	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

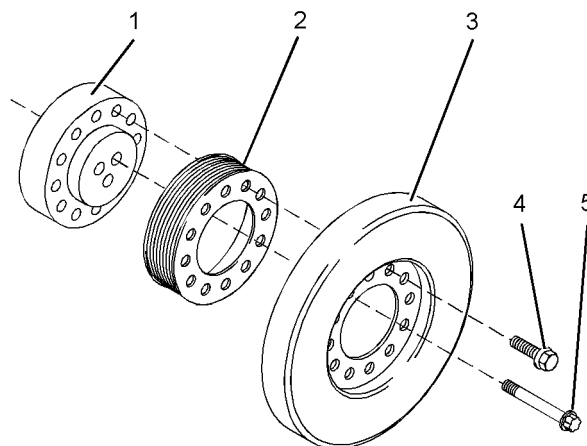


Illustration 152

g01337793

1. Ensure that the crankshaft adapter and the front of the crankshaft are clean and free from damage. Install crankshaft adapter (1) to the crankshaft.
2. Install torx screws (3) to crankshaft adapter (1).
3. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to tighten the torx screws to a torque of 200 N·m (147 lb ft).

4. Repeat Step 3 two more times in order to ensure correct torque.
5. Install Tooling (A) to crankshaft adapter (1).
6. Align crankshaft pulley (2) with Tooling (A). Install the crankshaft pulley to crankshaft adapter (1).
7. Inspect the vibration damper for damage. If necessary, replace the vibration damper.
8. Align vibration damper (3) with Tooling (A). Install the vibration damper to crankshaft adapter (1).
9. Install bolts (4) to the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter. Remove Tooling (A). Install remaining bolts (4).

Note: The bolts should be evenly spaced.

10. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten bolts (4) to a torque of 115 N·m (85 lb ft).

End By:

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

i02654370

Vibration Damper and Pulley - Install (Pulley with Split Lock Rings)

Installation Procedure

Table 34

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M12 by 70 mm)	1
B	27610299	E18 Torx socket	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

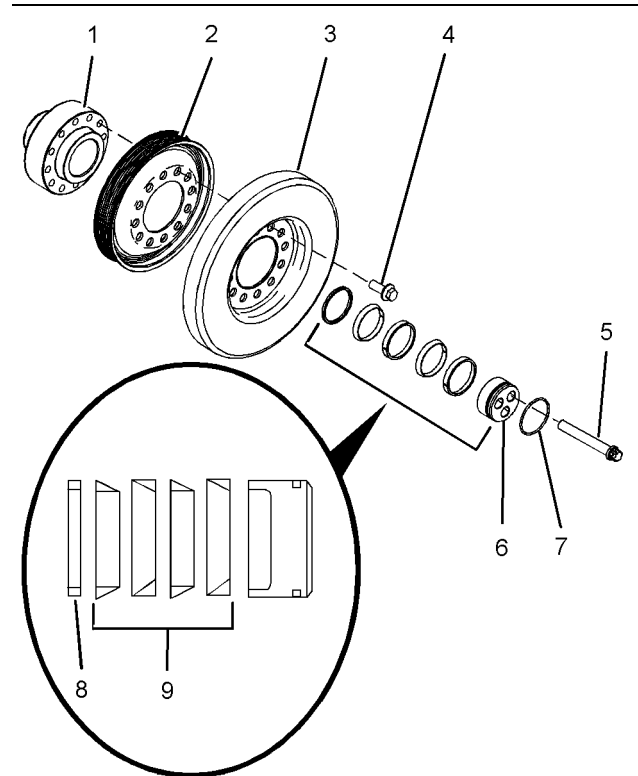


Illustration 153

g01337777

1. Ensure that the crankshaft adapter, the split lock rings, the spacer and the thrust block are clean and free from damage. Replace any components that are damaged.
2. Install a new O-ring seal (7) to thrust block (6).
3. Install spacer (8) to crankshaft adapter (1).
4. Install both pairs of split lock rings (9) to crankshaft adapter (1). There is an internal split lock ring and an external lock ring. Ensure that the split lock rings are installed in the correct position. Refer to Illustration 153.

Note: Position the gap in the split lock rings at 180 degrees away from each other.

5. Ensure that the front of the crankshaft is clean and free from damage. Install crankshaft adapter (1) onto the crankshaft.
6. Align the holes in the thrust block with the holes in the crankshaft. Install thrust block (6) into crankshaft adapter (1).
7. Install torx screws (5) to thrust block (6).
8. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to tighten the torx screws to a torque of 200 N·m (147 lb ft).

9. Repeat Step 8 two more times in order to ensure correct torque.
10. Install Tooling (A) to crankshaft adapter (1).
11. Align crankshaft pulley (2) with Tooling (A). Install the crankshaft pulley to crankshaft adapter (1).
12. Inspect the vibration damper for damage. If necessary, replace the vibration damper.
13. Align vibration damper (3) with Tooling (A). Install the vibration damper to crankshaft adapter (1).
14. Install bolts (4) to the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter. The bolts should be evenly spaced. Remove Tooling (A).
15. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten bolts (4) to a torque of 115 N·m (85 lb ft).

End By:

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

i02654463

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 35

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610301	Front Oil Seal Removal Tool	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.

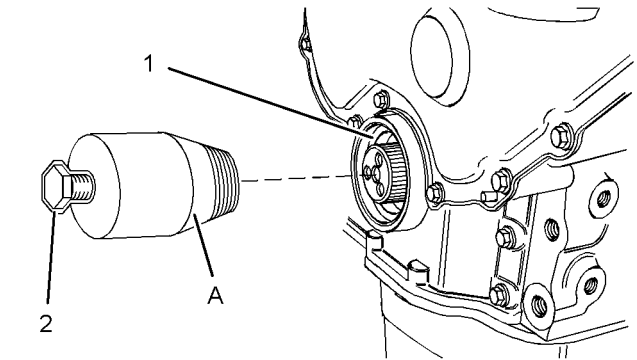


Illustration 154

g01337798

1. Position Tooling (A) on the nose of the crankshaft. Screw Tooling (A) into crankshaft front seal (1).

Note: Do not damage the edge of the housing for the crankshaft front seal.

2. Screw bolt (2) into Tooling (A) in order to remove crankshaft front seal (1).

Installation Procedure

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610284	Front Oil Installer	1
	21825577	Stud	1
	21825578	Plate	1
	27610292	Anchor Plate	1
	-	Setscrews	3
	218255761	Sleeve	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.

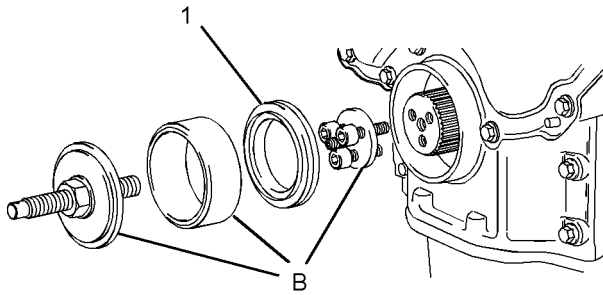


Illustration 155
Typical example
g01337799

2. Assemble Tooling (B).

3. Align new crankshaft front seal (1) to the front housing.

Note: If the crankshaft front seal is supplied with a sleeve, remove the sleeve from the crankshaft front seal before installation.

4. Use Tooling (B) to install crankshaft front seal (1). Ensure that the front face of the seal is installed to a depth of 6.5 ± 0.2 mm (0.256 ± 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".

i02654495

Front Cover - Remove and Install

Removal Procedure

Start By:

- a. If the engine has 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".

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

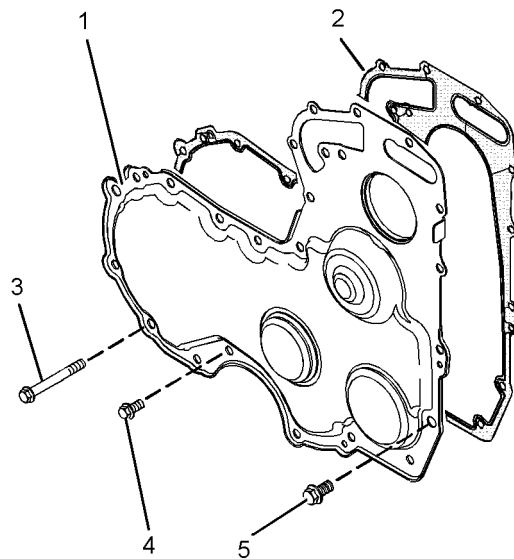


Illustration 156
Typical example
g01337873

1. Remove bolts (3) and (4). Remove bolt (5). Identify the positions of the different bolts .

Note: The bolt (5) may not be installed to some engines.

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

3. Remove joint (2) from front cover (1).

Installation Procedure

Table 37

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Guide Stud (M8 by 70 mm)	2

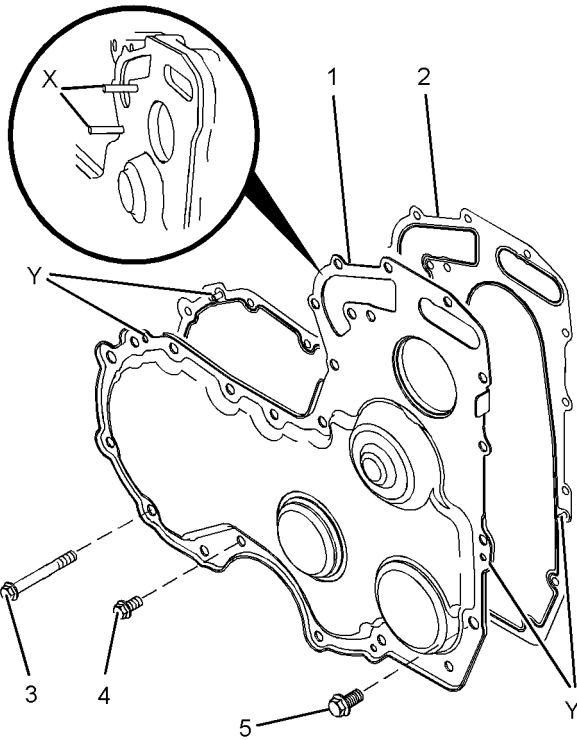


Illustration 157

g01337874

Typical example

1. Thoroughly clean the mating surface of the front housing.
 2. If the original front cover is installed, follow Steps 2.a through 2.b.
 - a. Thoroughly clean front cover (1).
 - b. Install a new joint (2) to front cover (1). Engage three 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) and (4). Install bolt (5) finger tight. Ensure that the different bolts are installed in the correct positions.
- Note:** The bolt (5) may not be installed to some engines.
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 has a fan, install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

i02654515

Gear Group (Front) - Remove and Install

Removal Procedure

Table 38

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housingl	1
	27610289	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1

Start By:

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: Either Tooling (A) can be used. Use the Tooling that is most suitable. 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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

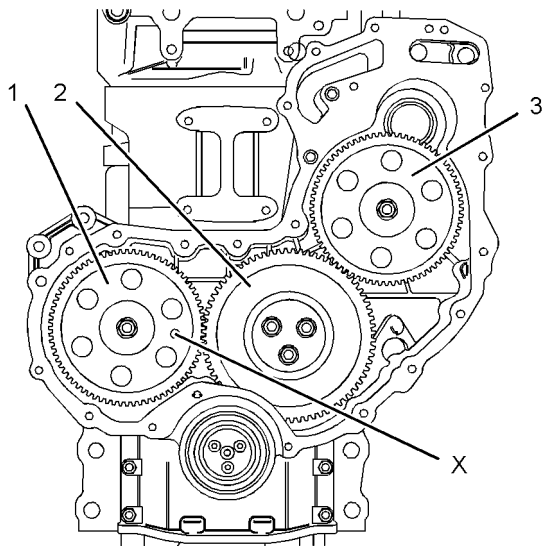


Illustration 158

g01335379

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. Refer to System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

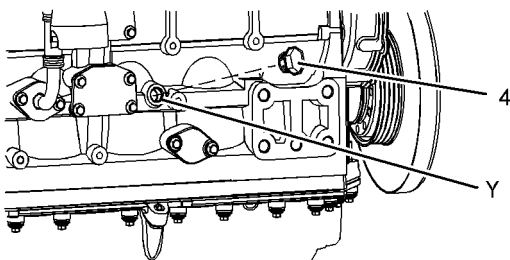


Illustration 159

g01335380

3. Remove plug (4) from the cylinder block. 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 System 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.

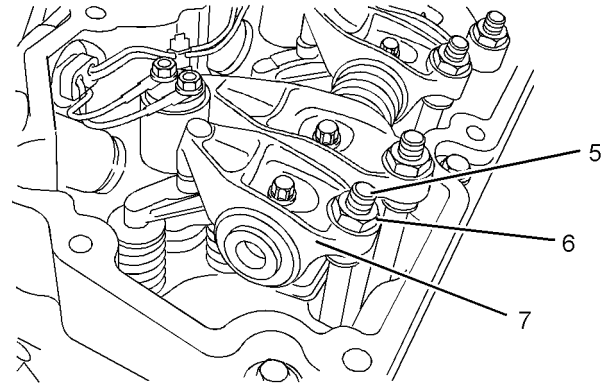


Illustration 160

g01337898

4. 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.

5. 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.

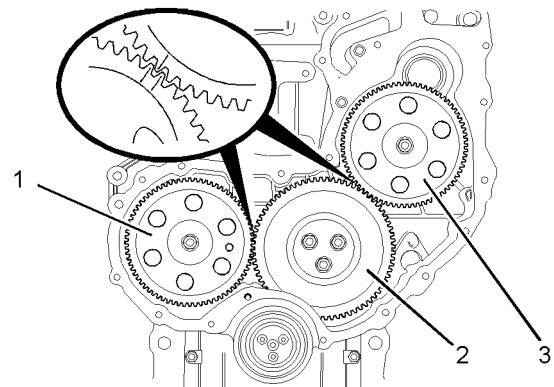


Illustration 161

g01335384

Typical example

6. Mark gears (1), (2) and (3) in order to show alignment. Refer to Illustration 161.

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

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

2. If necessary, 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 System 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.

Installation Procedure

Table 39

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610286	Adapter	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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center for No. 1 Piston".

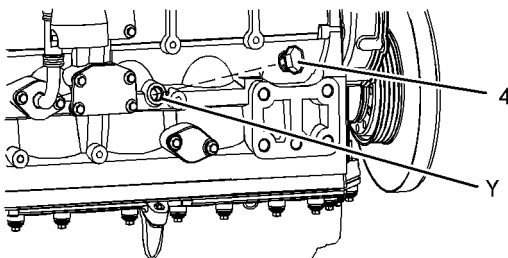


Illustration 162

g01335380

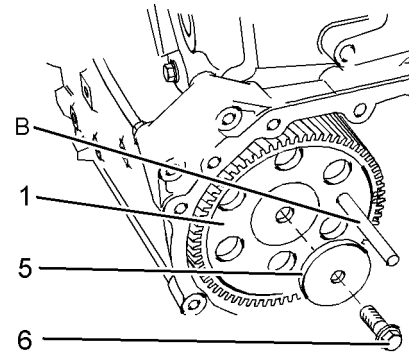


Illustration 163

g01337904

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

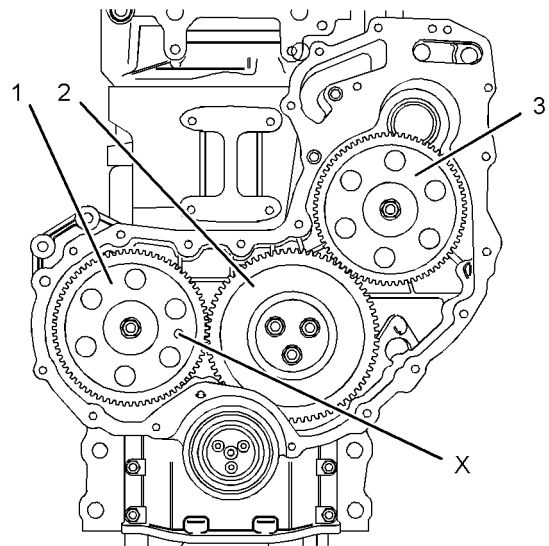


Illustration 164

g01335379

Typical example

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

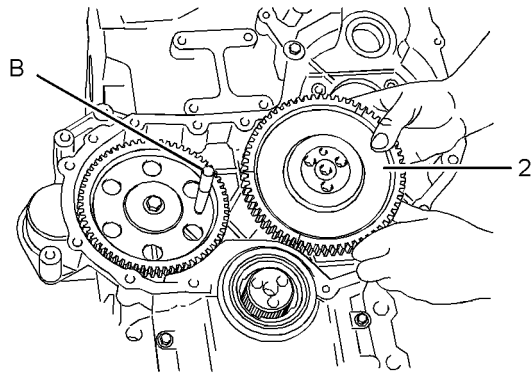


Illustration 165
Typical example
g01337905

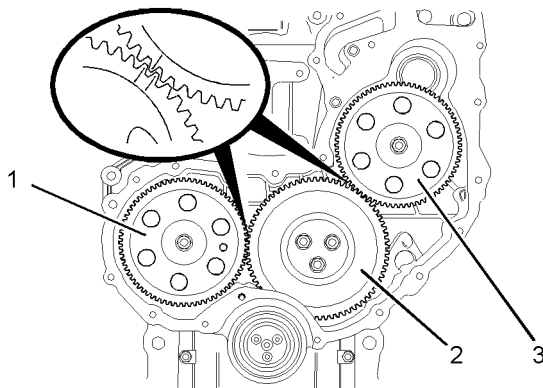


Illustration 166
Alignment of timing marks
g01335384

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, "Idler Gear - Remove and Install". Check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" and refer to Disassembly and Assembly, "Idler Gear - Remove and Install" for further information.
7. Tighten 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.
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). Ensure that the timing marks on gears (2) and (3) are in alignment. See Illustration 166. Ensure that the mesh of the gears is correct. Refer to Disassembly and Assembly, "Fuel Injection Pump Gear - Install" for more information.

10. Remove Tooling (B) and (C). Install plug (4) into hole (Y) in the cylinder block. Refer to Illustration 162.

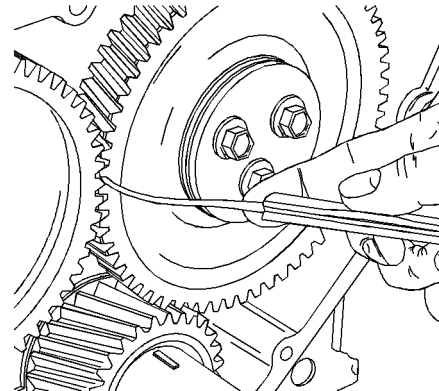


Illustration 167
Checking backlash
g01335426

11. Ensure that the backlash for gears (1), (2) and (3) 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 System 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 front cover. Refer to Disassembly and Assembly, "Front Cover - Remove and Install".

i02773140

Idler Gear - Remove

Removal Procedure (Standard Idler Gear)

Table 40

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1

Start By:

- a. Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove".
- b. 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.

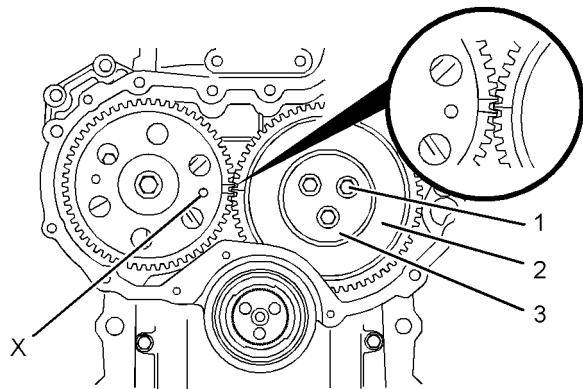


Illustration 168 g01337918

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 168.

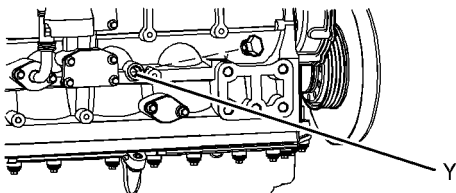


Illustration 169 g01337919

- 2. 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.

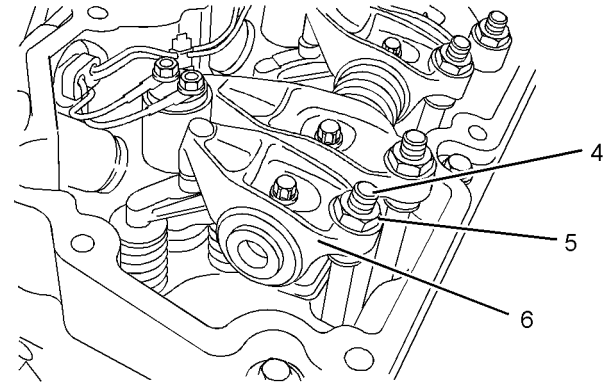


Illustration 170 g01337921

- 3. Loosen nuts (5) on all rocker arms (6). Unscrew adjusters (4) on all rocker arms (6) 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.

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

- 5. Remove bolts (1).
- 6. Remove plate (3).

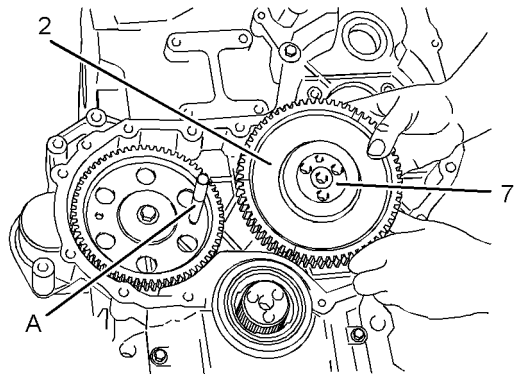


Illustration 171 g01337922

- 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 (Early Heavy-Duty Idler Gear)

Table 41

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1

Start By:

- a. Remove the fuel injection pump gear. Refer to Disassembly and Assembly, "Fuel Pump Gear - Removal".
- b. 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.

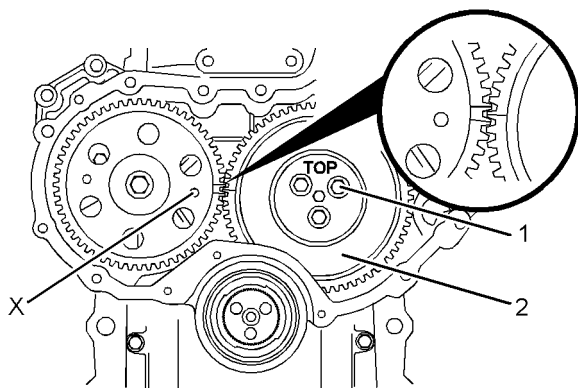


Illustration 172

g01337924

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 172.

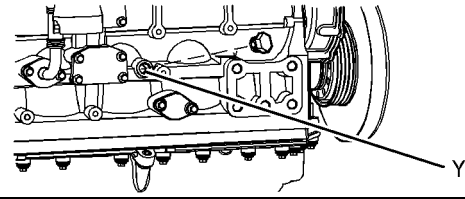


Illustration 173

g01337919

2. 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.

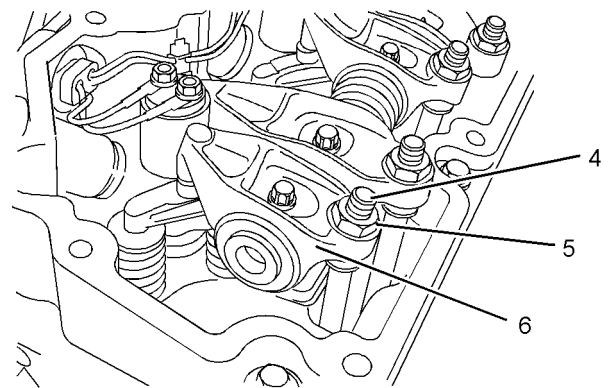


Illustration 174

g01337921

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).

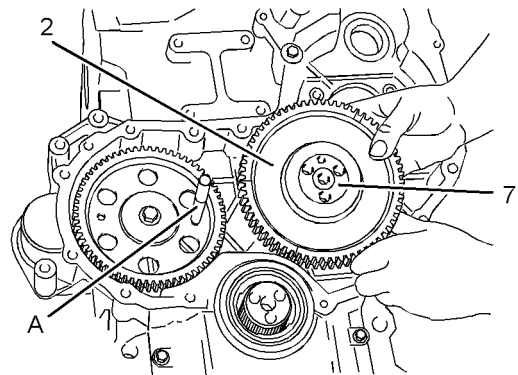


Illustration 175

g01337922

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

Note: The idler gear must be tilted during removal.

Removal Procedure (Latest Heavy-Duty Idler Gear)

Table 42

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:

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

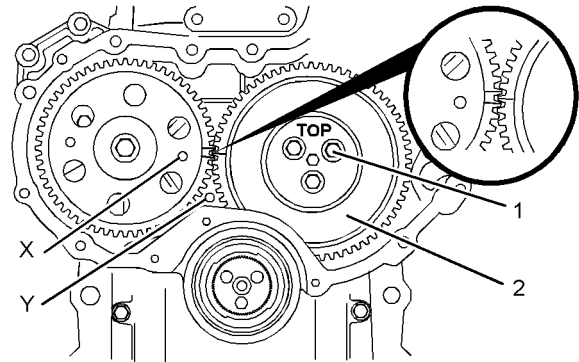


Illustration 176

g01343977

Alignment of timing marks

- 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 176.

- 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.

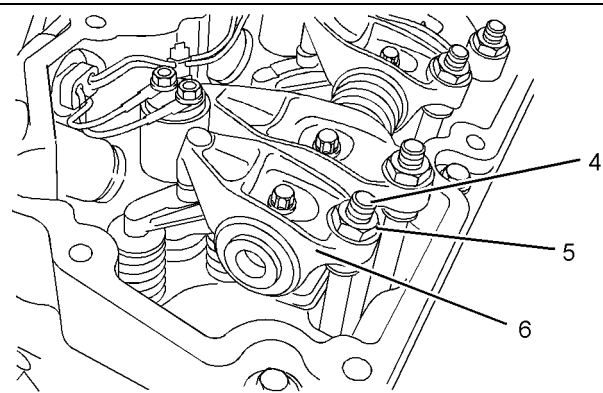


Illustration 177

g01337921

Typical example

- Loosen nuts (5) on all rocker arms (6). Unscrew adjusters (4) 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.

- Remove bolts (1) from the assembly of heavy-duty idler gear (2). Refer to Illustration 176.

i02773141

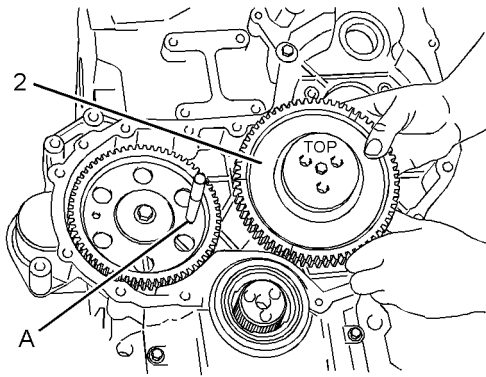


Illustration 178
Typical example
g01269933

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

Note: The idler gear must be tilted during removal.

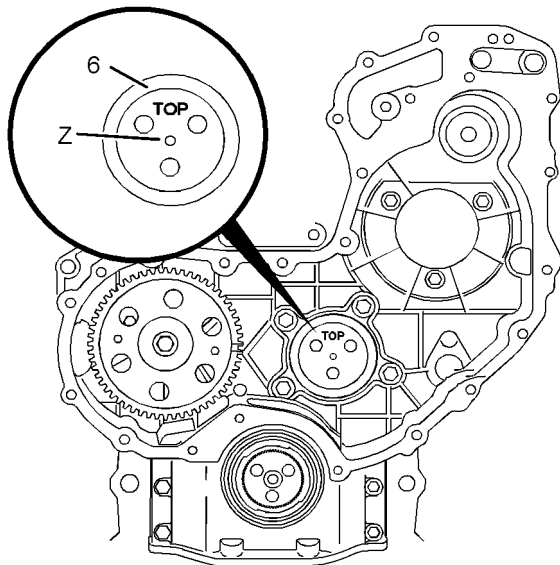


Illustration 179
Typical example
g01348835

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

Idler Gear - Install

Installation Procedure (Standard Idler Gear)

Table 43

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

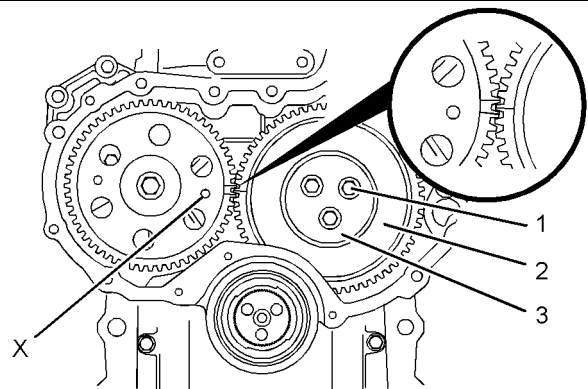


Illustration 180
Alignment of timing marks
g01337918

- Ensure that Tooling (A) is installed into hole (X) in camshaft gear (1).

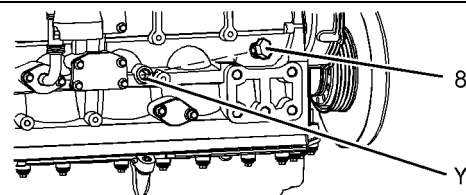


Illustration 181
g01337947

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 System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".

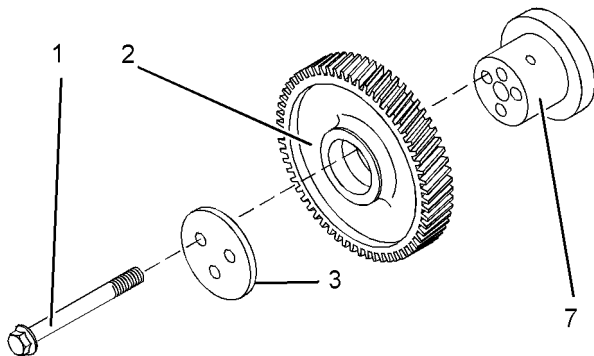


Illustration 182

g01337949

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 hub (7) into idler gear (2). Ensure that the timing marks are toward the front of the idler gear.

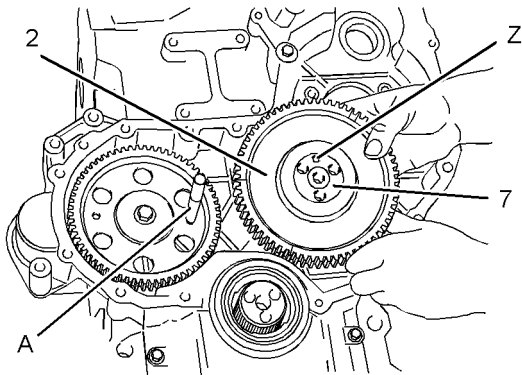


Illustration 183

g01337952

7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to the illustration 180. 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. Align the holes in plate (3) with the holes in hub (7). Install the plate in the original orientation.

10. Install bolts (1).

11. Remove Tooling (A) and (B).

Note: Ensure that timing marks are aligned, before removing the Tooling (A) and (B).

12. Install plug (8) to the cylinder block. Refer to Illustration 181.

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

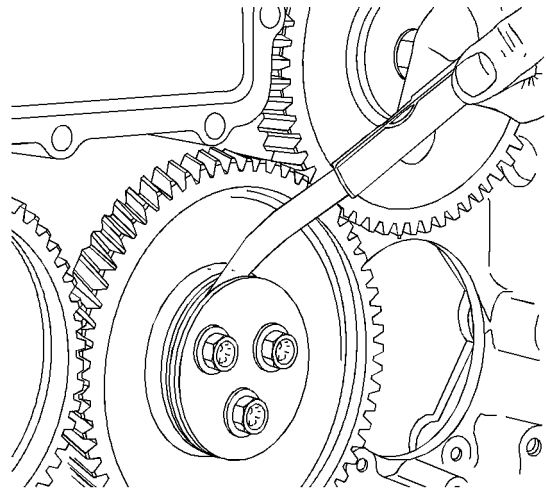


Illustration 184

g01337953

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

14. 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.

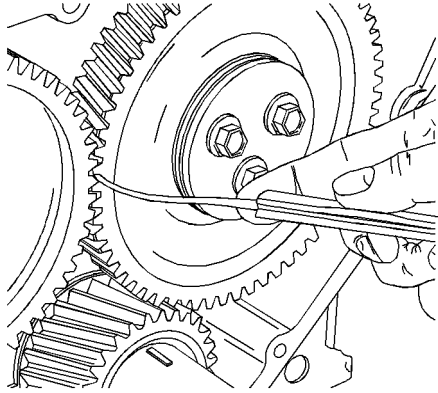


Illustration 185
Checking backlash g01335426

15. Check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
16. Check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
17. 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".

Installation Procedure (Early Heavy-Duty Idler Gear)

Table 44

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center for No. 1 Piston".

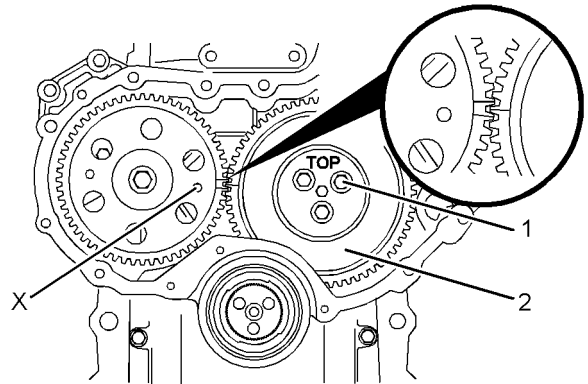


Illustration 186
Alignment of timing marks g01337924

2. Ensure that Tooling (A) is installed into hole (X) in the camshaft gear.

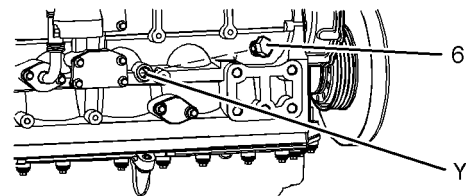


Illustration 187 g01337954

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 System Operation, Testing and Adjusting, "Finding Top Centre Position for No.1 Piston".
4. 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.
5. Lubricate the bearings in the assembly of idler gear (2) with clean engine oil.

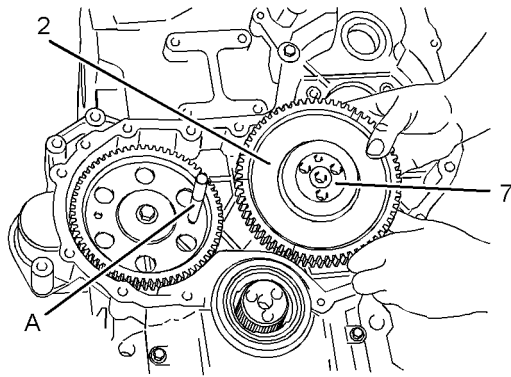


Illustration 188

g01337922

6. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to the illustration 186. 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 assembly of the idler gear are aligned with the holes in the cylinder block.

7. Install bolts (1).

8. Remove Tooling (A) and (B).

Note: Ensure that timing marks are aligned, before removing the Tooling (A) and (B).

9. Install plug (6) to the cylinder block. Refer to Illustration 187.

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

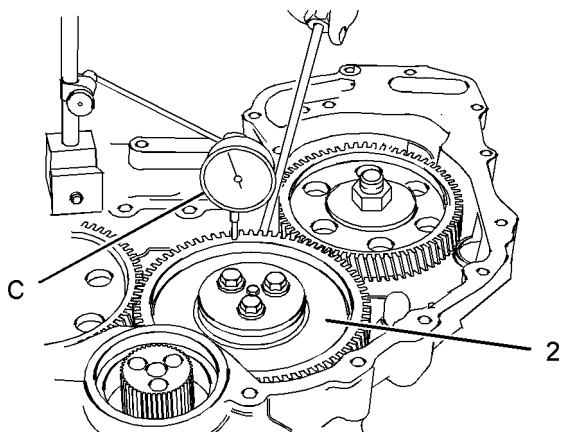


Illustration 189

g01337957

11. Use Tooling (C) in order to check the end play for the heavy-duty idler gear. Refer to Specifications, "Gear Group (Front)" for more information.

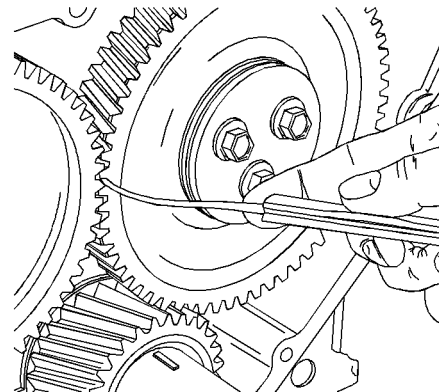


Illustration 190

g01335426

Checking backlash

12. Check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.

13. 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".

Installation Procedure (Latest Heavy-Duty Idler Gear)

Table 45

Required Tools			
Tool	Part Number	Part Name	Qty
A	27610212	Camshaft Timing Pin	1
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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".

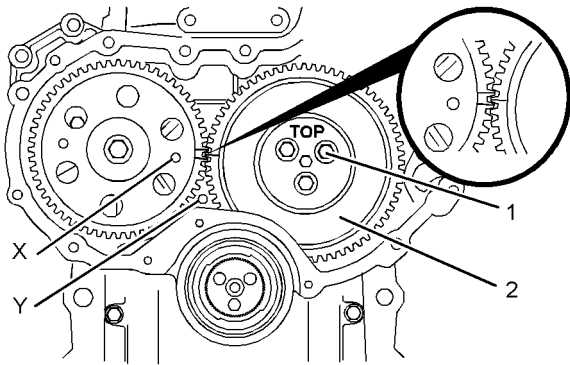


Illustration 191

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".

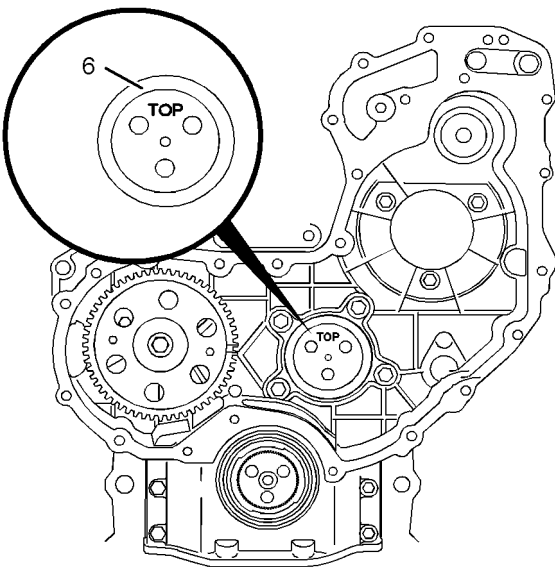


Illustration 192

g01387344

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.

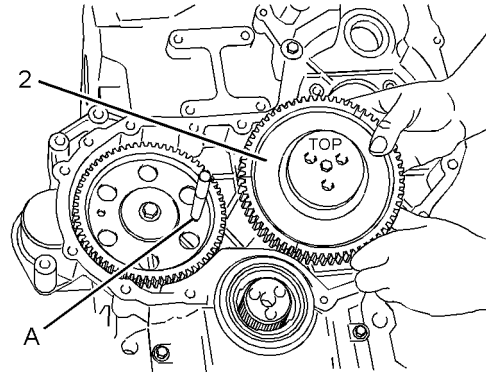


Illustration 193

g01269933

7. Align the timing mark on idler gear (2) with the timing mark on the camshaft gear. Refer to Illustration 191. 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).

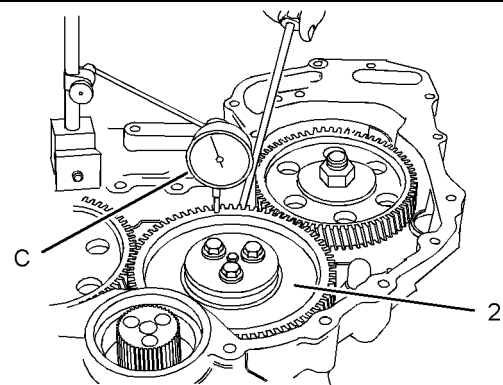


Illustration 194

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:

- 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".

- f. Drain the coolant into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Drain" for the correct procedure.
- g. Remove the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install".
- h. 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.

i02654518

Housing (Front) - Remove

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".
- b. If necessary, remove the alternator. Refer to Disassembly and Assembly, "Alternator - Remove".
- c. Remove the front pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Remove".
- d. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove".
- e. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".

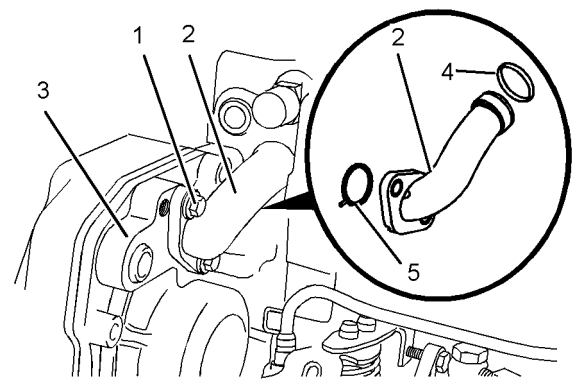


Illustration 195

g01337982

1. Remove bolts (1) that secure bypass tube (2) to front housing (3). Remove bypass tube (2) from the cylinder head. Remove O-rings (4) and (5) from bypass tube (2).

i02654517

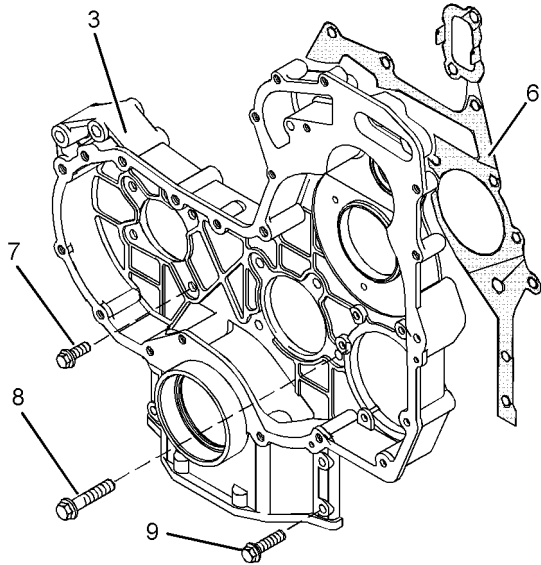


Illustration 196

g01337985

- Remove bolts (7), (8) and (9) from front housing (3).

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

- Remove front housing (3) from the cylinder block.
- Remove joint (6).

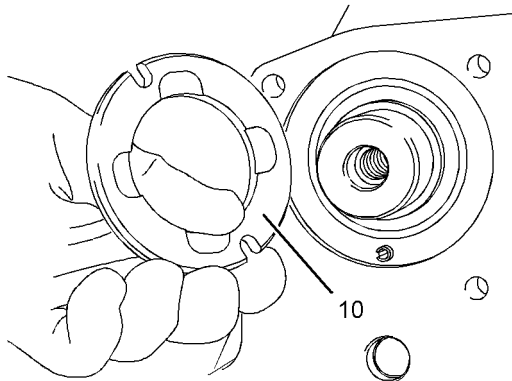


Illustration 197

g01337987

- Remove thrust washer (10) from the cylinder block.

Housing (Front) - Install

Installation Procedure

Table 46

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820117	3 Bond 1386D	1
B	-	Guide Stud (M8 by 70 mm)	2
C	27610216	Alignment Tool	1
	-	studs (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.

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

Install blanking plugs to a new front housing. Use Tooling (A) to seal all D-plugs.

- Check the condition of the crankshaft front seal. If the front seal is damaged, remove the front seal from the front housing.

- Clean all the mating surfaces of the cylinder block.

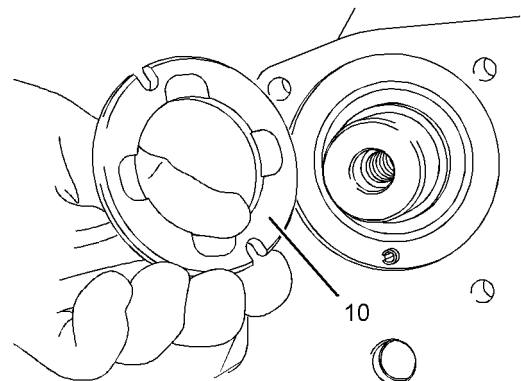


Illustration 198

g01337987

4. Install thrust washer (10) into the recess in the cylinder block. Refer to Disassembly and Assembly, "Camshaft - Install" for more information.

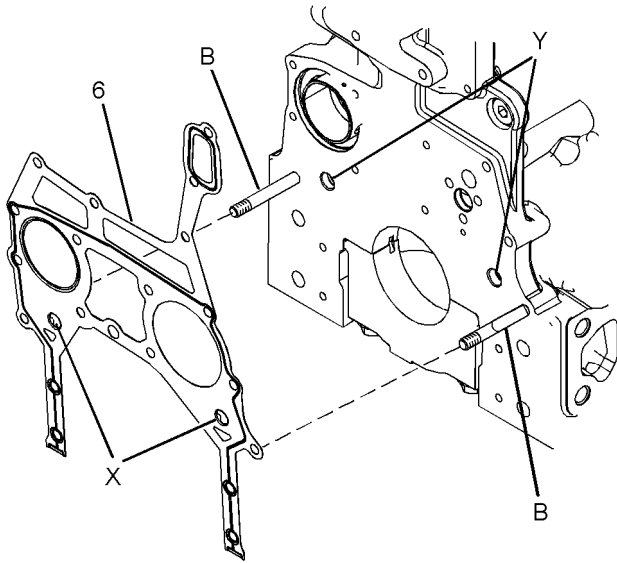


Illustration 199

g01338000

5. Install Tooling (B) to the cylinder block. Refer to Illustration 199.
6. Align a new joint (6) with Tooling (B). Install the joint to the cylinder block.

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

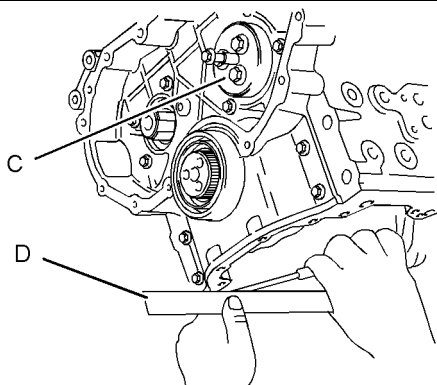


Illustration 200

g01338001

Typical example

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

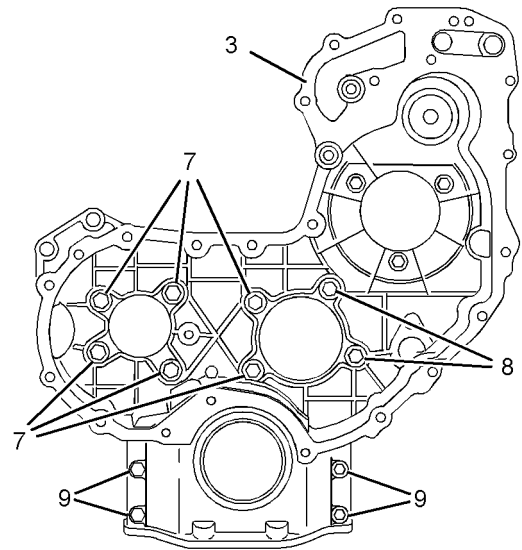


Illustration 201

g01338002

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

9. Install bolts (9) to front housing (3) finger tight.
10. Remove Tooling (B).
11. Loosely install bolts (7) and (8). Refer to Illustration 201 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 200. Refer to Specifications, "Front Housing and Covers" for further information.

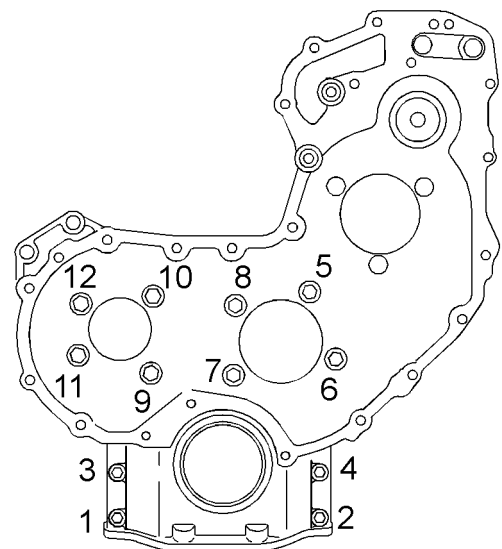


Illustration 202

g01338003

13. Tighten bolts (7), (8) and (9) in the sequence that is shown in illustration 202 to a torque of 28 N·m (20 lb ft).

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".

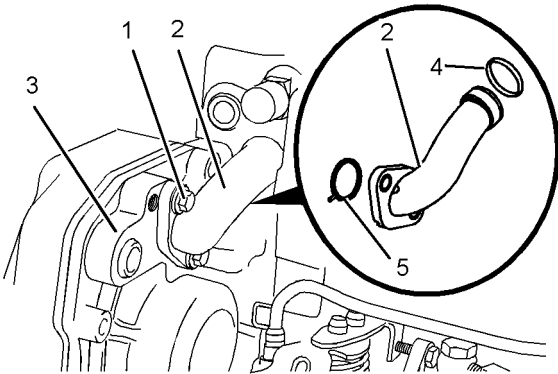


Illustration 203

g01337982

Typical example

16. Install new O-ring seals (4) and (5) to bypass tube (1). Use Tooling (E) in order to lubricate the O-ring seals. Install bypass tube (2) to the cylinder head. Install bolts (1). 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. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install".
- d. Install the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Install".
- e. Install the front pulley. Refer to Disassembly and Assembly, "Vibration Damper and Pulley - Install".
- f. If necessary, install the alternator. Refer to Disassembly and Assembly, "Alternator - Install".
- g. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install".

- h. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Fill" for the correct procedure.

i02654444

Accessory Drive - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

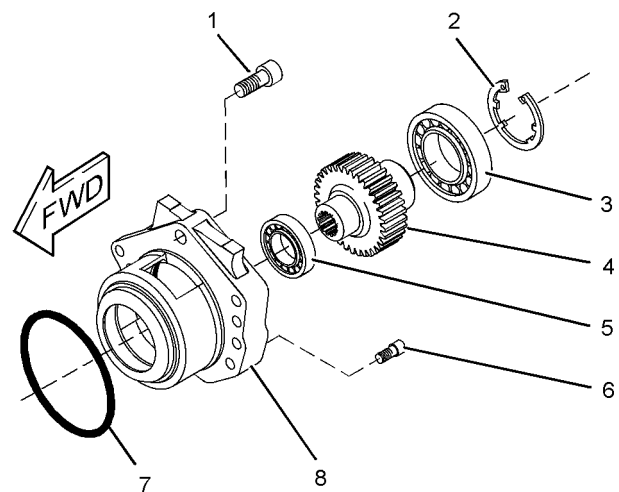


Illustration 204

g01339557

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 suitable puller in order to remove bearings (3) and (5) from gear (4).
- c. Remove O-ring seal (7) from accessory drive housing (8).

Installation Procedure

Table 47

Required Tools			
Tool	Part Number	Part Description	Qty
A	21820603	POWERPART Retainer	-
B	21820221	POWERPART Rubber Grease	1
C	21820117	3 Bond 1386D	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

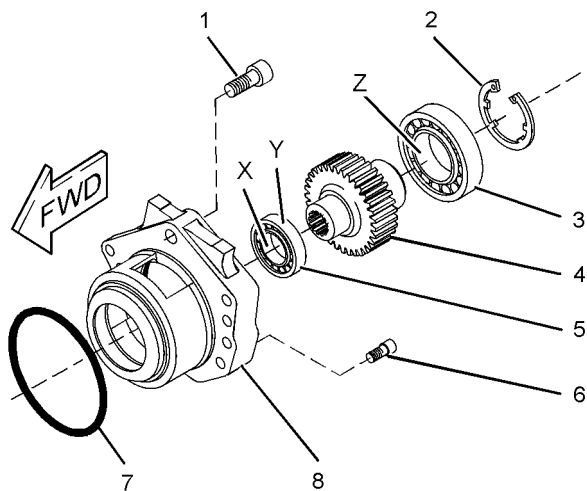


Illustration 205

g01339559

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 (A) to inner surface (X) of bearing (5). Place the gear shaft on a suitable support. Press on the inner race of bearing (5) until bearing (5) is against the shoulder of gear (4). Remove any excess sealant.
 - c. Apply a small continuous bead of Tooling (A) to inner surface (Z) of bearing (3). Place the front face of 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 (A) to outer surface (Y) of bearing (5). Place accessory drive housing (8) on a suitable support. Press the assembly of gear (4) and bearings (3) and (5) 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 (B) and 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.
 5. Apply Tooling (C) to Allen head screws (1) and (6). Install Allen head screws (6) to accessory drive housing (8). Install Allen head screw (1) 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.

i02654404

Crankcase Breather - Remove (Unfiltered Breather)

1. To remove the breather body, Tooling (A) must be used. The tool should be fabricated from 3.1 mm (1/8 inch) steel stock. The dimensions for the tool are given in Illustration 206. All dimensions are shown in millimeters.

Removal Procedure

Table 48

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Breather Tool	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

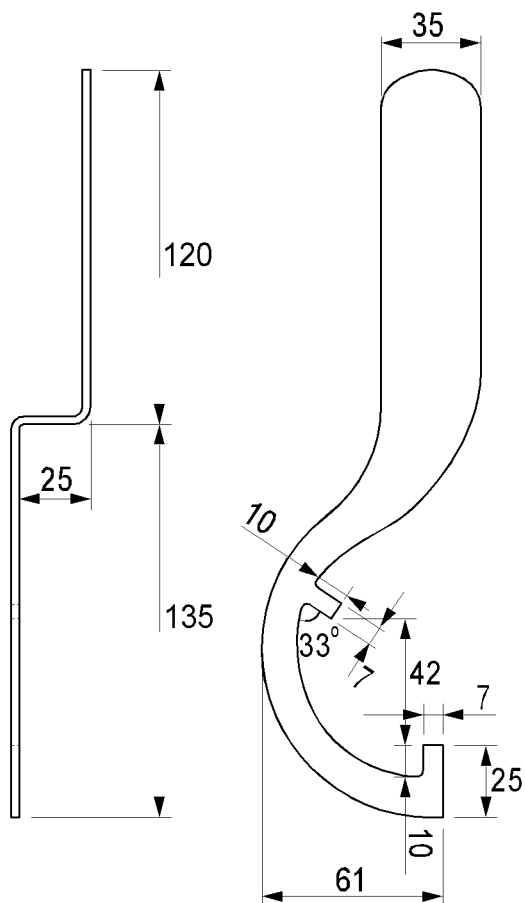


Illustration 206
Breather tool

g01339595

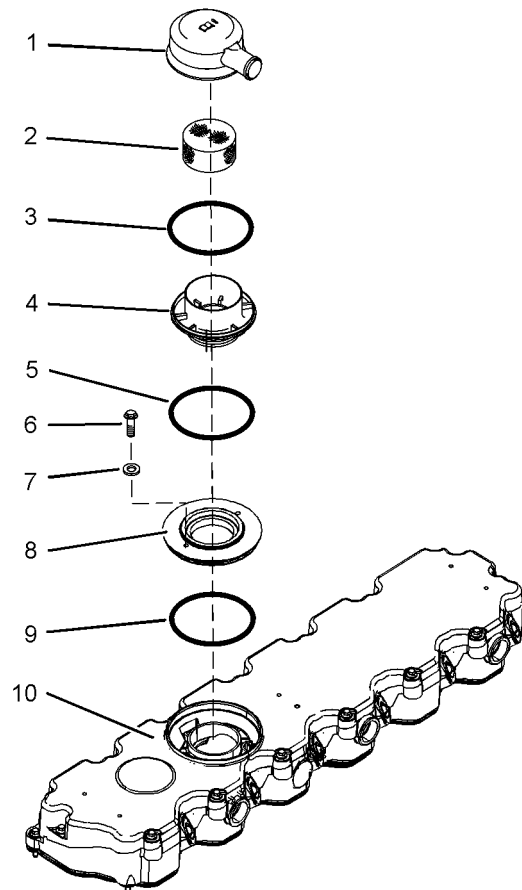


Illustration 207

g01339597

i02654402

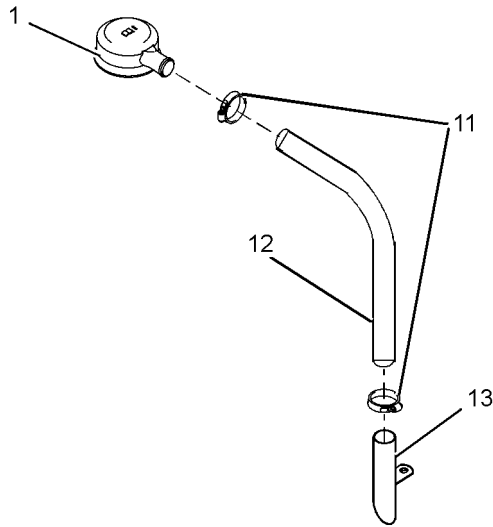


Illustration 208

g01339688

2. Loosen clamps (11) and remove hose (12) from cover (1) and from tube (13).

3. Carefully pry cover (1) from breather body (4).

Note: Note the orientation of the outlet.

4. Remove gauze (2) from breather body (4).

5. Remove O-ring seal (3) from breather body (4).

6. Use Tooling (A) in order to unscrew breather body (4) from adapter plate (8).

7. Remove O-ring seal (5) from breather body (4).

8. Remove bolts (6) and washers (7) from adapter plate (8).

9. Remove adapter plate (8) from valve mechanism cover (10).

10. Remove O-ring seal (9) from adapter plate (8).

Crankcase Breather - Remove (Filtered Breather)

Removal Procedure

Table 49

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Breather Tool	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

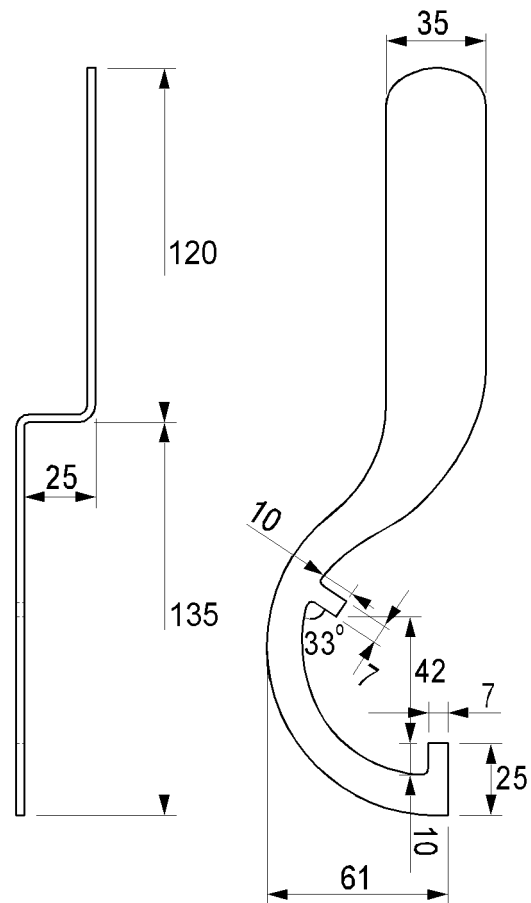


Illustration 209

g01339595

Breather tool

1. To remove the breather body, Tooling (A) must be used. The tool should be fabricated from 3.1 mm (1/8 inch) steel stock. The dimensions for the tool are given in Illustration 209. All dimensions are shown in millimeters.

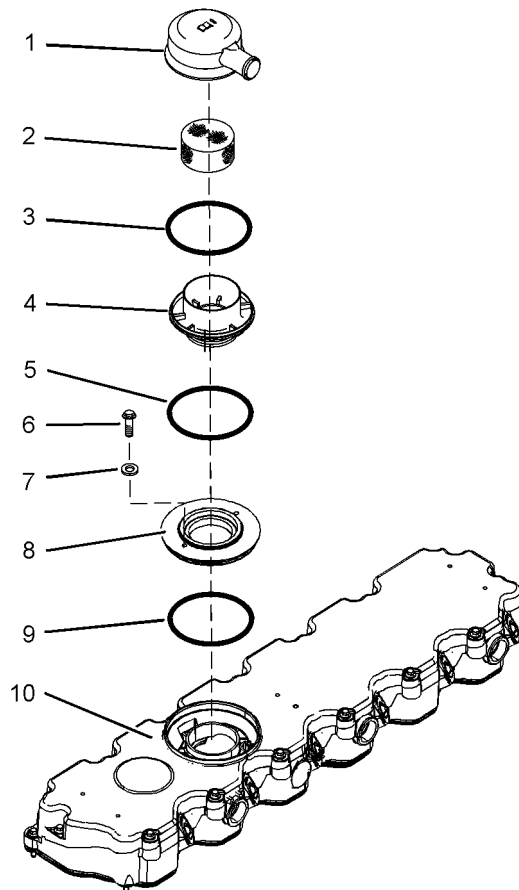


Illustration 210

g01339597

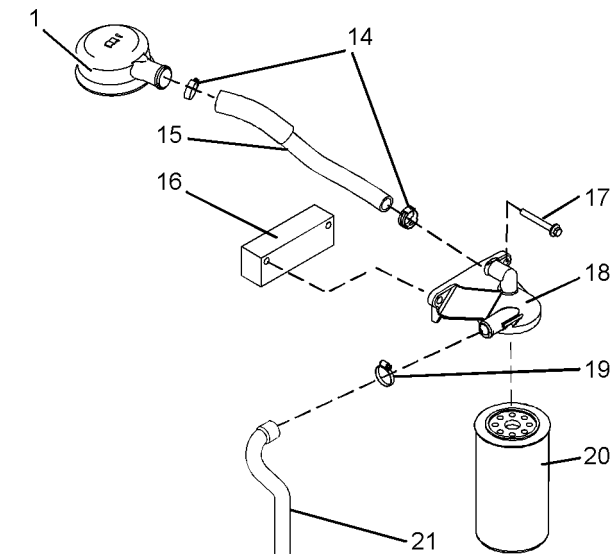


Illustration 211

g01339655

2. Remove canister (20) for the breather. Refer to Operation and maintenance Manual, "Crankcase Breather (Canister) - Replace".
 3. Loosen clamp (19) and remove hose (21).
 4. Release two spring clamps (14) in order to remove hose (15). Remove the hose.
 5. Remove bolts (17). Remove base (18) from the inlet manifold.

If a spacer is installed between the base and the inlet manifold, remove spacer (16).
 6. Carefully pry cover (1) from breather body (4).
- Note:** Note the orientation of the outlet.
7. Remove gauze (2) from breather body (4).
 8. Remove O-ring seal (3) from breather body (4).
 9. Use Tooling (A) in order to unscrew breather body (4) from adapter plate (8).
 10. Remove O-ring seal (5) from breather body (4).
 11. Remove bolts (6) and washers (7) from adapter plate (8).
 12. Remove adapter plate (8) from valve mechanism cover (10).
 13. Remove O-ring seal (9) from adapter plate (8).

i02654407

Crankcase Breather - Install (Unfiltered Breather)

Installation Procedure

Table 50

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Breather Tool	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

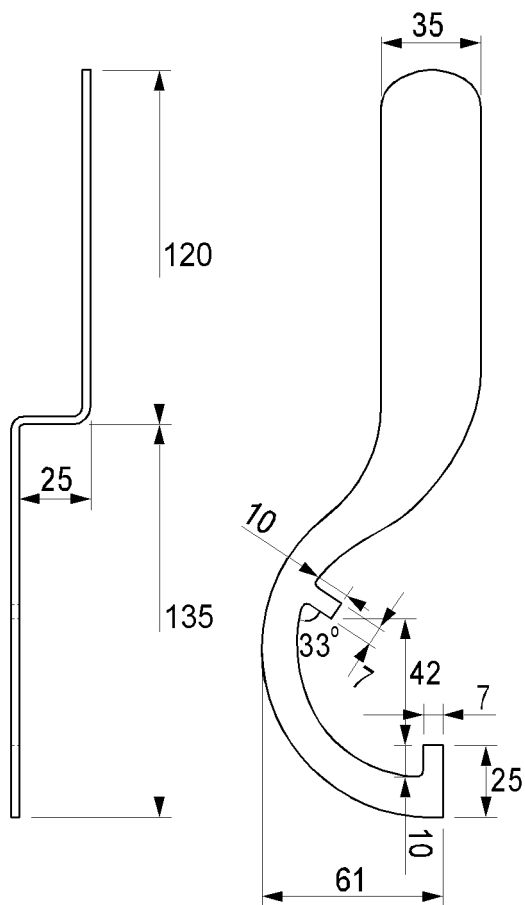


Illustration 212
Breather tool

g01339595

- To install the breather body, Tooling (A) must be used. The tool should be fabricated from 3.1 mm (1/8 inch) steel stock. The dimensions for the tool are given in Illustration 212. All dimensions are shown in millimeters.

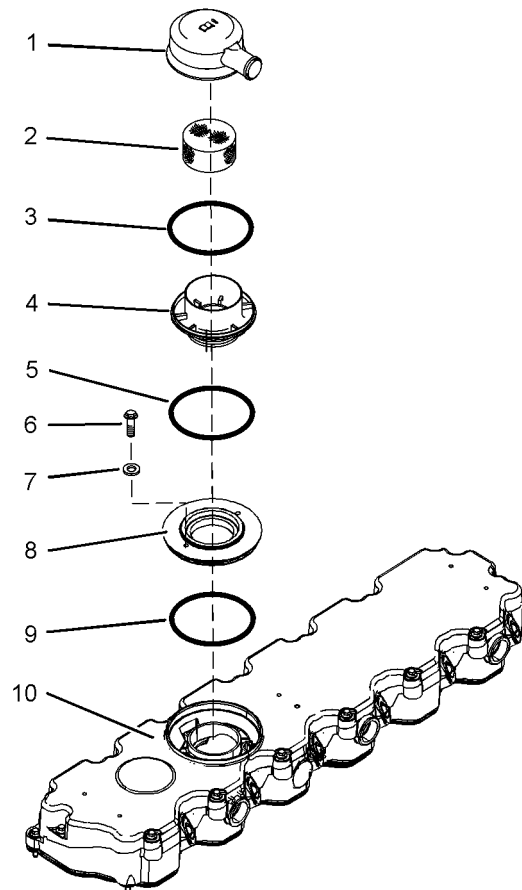


Illustration 213

g01339597

- Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
- Lubricate a new O-ring seal (9) with clean engine oil. Install the O-ring seal to the adapter plate (8).
- Install adapter plate (8) to valve mechanism cover (10).
- Install washers (7) and bolts (6) to adapter plate (8). Tighten the bolts to a torque of 4.4 N·m (38 lb in).

i02654406

6. Lubricate a new O-ring seal (5) with clean engine oil. Install the O-ring seal to the bottom of breather body (4).
7. Use Tooling (A) in order to screw breather body (4) into adapter plate (8). Tighten the breather body to a torque of 8 N·m (71 lb in).
8. Install gauze (2) into breather body (4).
9. Lubricate a new O-ring seal (3) with clean engine oil. Install the O-ring seal to the top of breather body (4).
10. Install cover (1) to breather body (4).

Note: Ensure that the outlet of the cover is in the correct position in order to align with hose (12) for the breather.

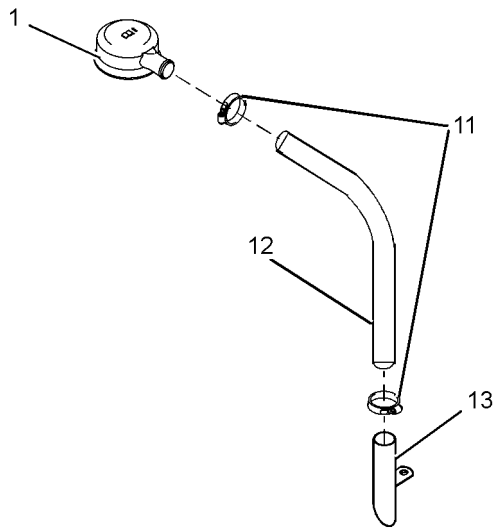


Illustration 214

g01339688

11. Install clamps (11) to hose (12).
12. Connect hose (12) to cover (1) and to tube (13). Tighten the clamps.

Crankcase Breather - Install (Filtered Breather)

Installation Procedure

Table 51

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Breather Tool	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

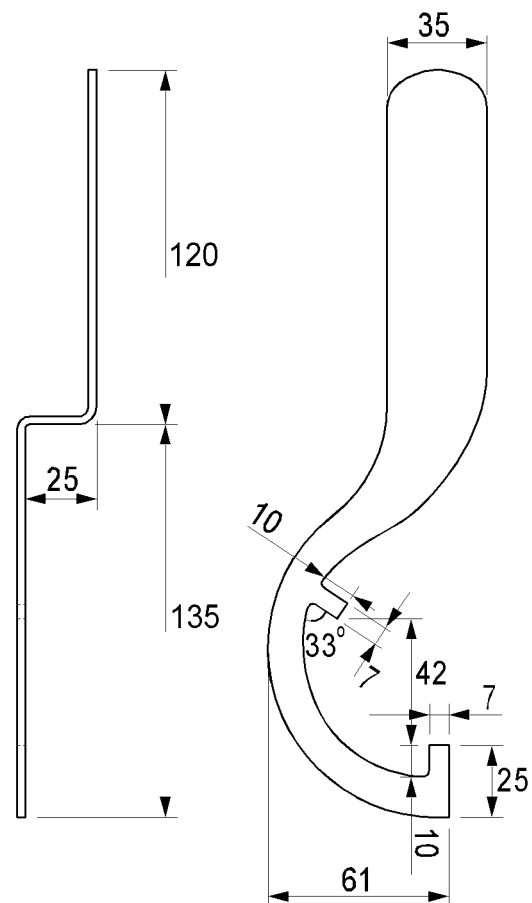


Illustration 215
Breather tool

g01339595

1. To install the breather body, Tooling (A) must be used. The tool should be fabricated from 3.1 mm (1/8 inch) steel stock. The dimensions for the tool are given in Illustration 215. All dimensions are shown in millimeters.

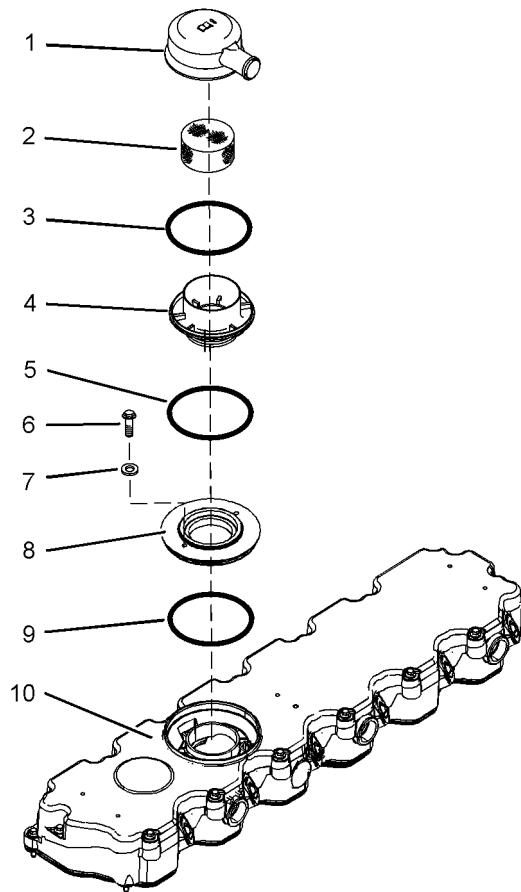


Illustration 216

g01339597

2. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.
3. Lubricate a new O-ring seal (9) with clean engine oil. Install the O-ring seal to adapter plate (8).
4. Install adapter plate (8) to valve mechanism cover (10).
5. Install washers (7) and bolts (6) to adapter plate (8). Tighten the setscrews to a torque of 4.4 N·m (38 lb in).

6. Lubricate a new O-ring seal (5) with clean engine oil. Install the O-ring seal to the bottom of breather body (4).
7. Use Tooling (A) in order to screw breather body (4) into adapter plate (8). Tighten the breather body to a torque of 8 N·m (71 lb in).
8. Install gauze (2) into breather body (4).
9. Lubricate a new O-ring seal (3) with clean engine oil. Install the O-ring seal to the top of breather body (4).
10. Install cover (1) to breather body (4).

Note: Ensure that the outlet of the cover is in the correct position in order to align with hose (15) for the breather.

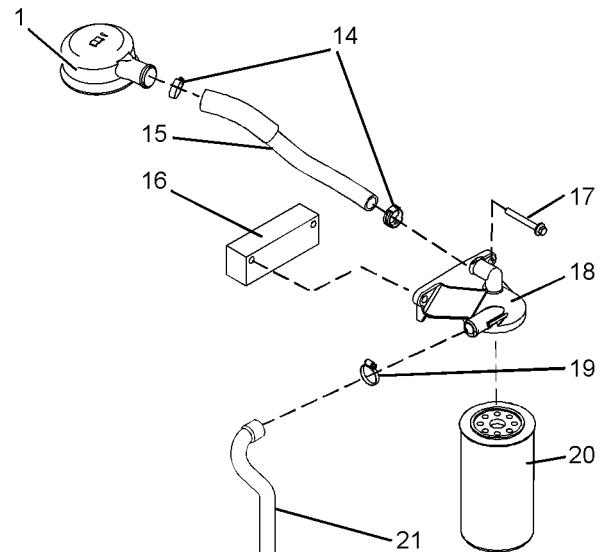


Illustration 217

g01339655

11. Install bolts (17) to base (18).
If a spacer is installed, position the spacer (16) to the bolts.
12. Install the assembly of the base to the inlet manifold.
13. Tighten bolts (17) to a torque of 22 N·m (16 lb ft).
14. Install a new canister (20) to base (18). Refer to Operation and maintenance Manual, "Crankcase Breather (Canister) - Replace".
15. Install spring clamps (14) to hose (15). Install hose (15) to cover (1) and to base (18).

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

16. Install clamp (19) to hose (21). Install hose (21) to base (18). Tighten the clamp.

i02697660

Valve Mechanism Cover - Remove and Install (Composite Valve Mechanism Cover)

Removal Procedure

Start By:

- a. Disconnect the crankcase breather or remove the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the valve mechanism cover is equipped with a heat shield, remove the heat shield.

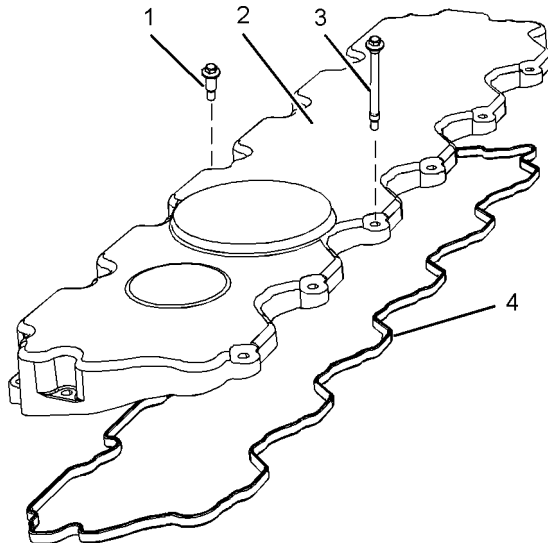


Illustration 218
Typical example

g01353908

2. Remove bolts (1) and (3) from valve mechanism cover (2).
3. Remove valve mechanism cover (2) from the valve mechanism cover base.

4. Remove joint (4) from valve mechanism cover (2).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean the valve mechanism cover. Clean the mating surfaces of the valve mechanism cover base.

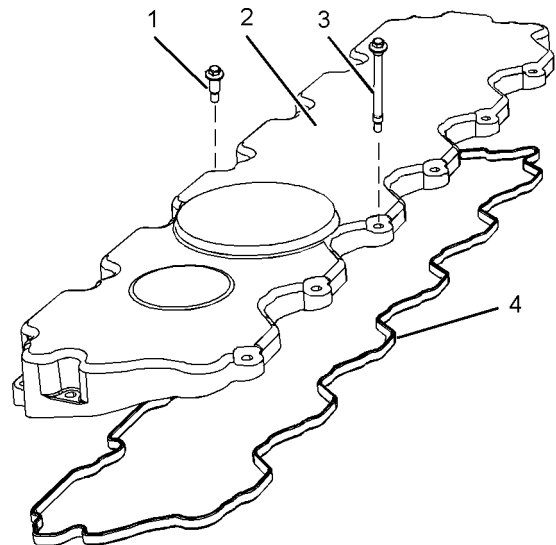


Illustration 219
Typical example

g01353908

2. Install a new joint (4) to valve mechanism cover (2).

Note: Ensure that the joint is fully seated into the groove of the valve mechanism cover.

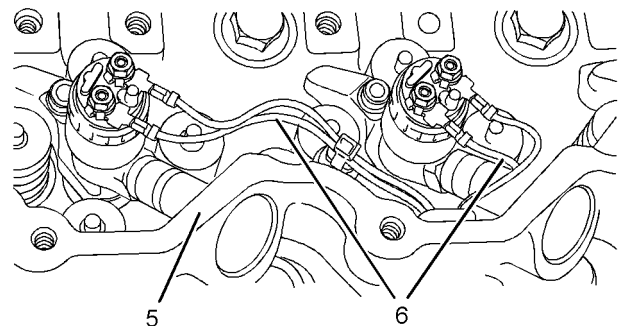


Illustration 220
Typical example

g01269961

3. Ensure that harness assemblies (6) are not in contact with the rocker arms or in contact with the valve mechanism cover base. Position valve mechanism cover (2) onto valve mechanism cover base (5). Ensure that harness assemblies (6) are not trapped during the assembly procedure. Install bolts (1) and (3).

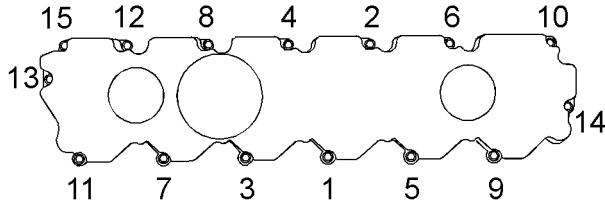


Illustration 221

g01353909

Tightening sequence for the valve mechanism cover

4. Tighten bolts (1) and (3) in the numerical sequence that is shown in Illustration 221. Tighten the bolts to a torque of 6 N·m (53 lb in).
5. If the valve mechanism cover is equipped with a heat shield, install the heat shield. Tighten the bolts to a torque of 9 N·m (79 lb in).

End By:

- a. Connect the crankcase breather or install the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Install".

i02654547

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

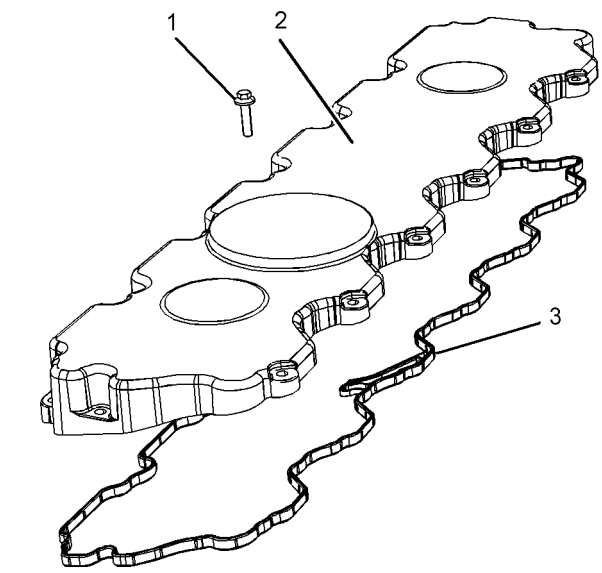


Illustration 222

g01342429

Typical example

1. Disconnect the breather hose from the separator for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".
2. If the engine is equipped with a cover over the fuel system this will need to be removed.
3. Remove bolts (1) from valve mechanism cover (2).
4. Remove valve mechanism cover (2) from the valve mechanism cover base.
5. Remove joint (3) from valve mechanism cover (2).
6. If necessary, remove the separator for the crankcase breather from the valve mechanism cover base. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Thoroughly clean all mating surfaces of the valve mechanism cover. Clean the mating surfaces of the valve mechanism cover base.
2. If necessary, install the separator for the crankcase breather to valve mechanism cover (2). Refer to Disassembly and Assembly, "Crankcase Breather - Install".

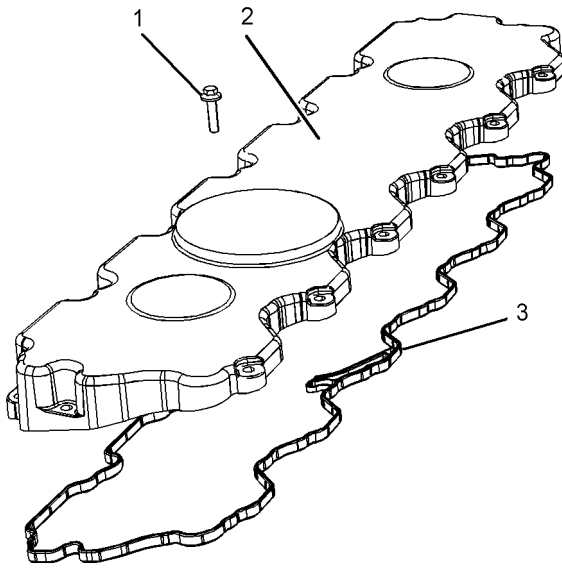


Illustration 223
Typical example g01342429

3. Install a new joint (3) to valve mechanism cover (2).

Note: Ensure that the joint is fully seated into the groove of the valve mechanism cover.

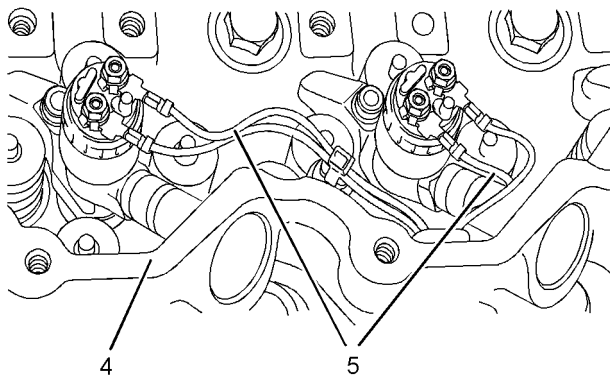


Illustration 224 g01342430

4. Ensure that harness assemblies (5) are not in contact with the rocker arms of the valve mechanism cover base. Position valve mechanism cover (2) onto valve mechanism cover base (4). Ensure that harness assemblies (5) are not trapped during the assembly procedure. Install bolts (1).

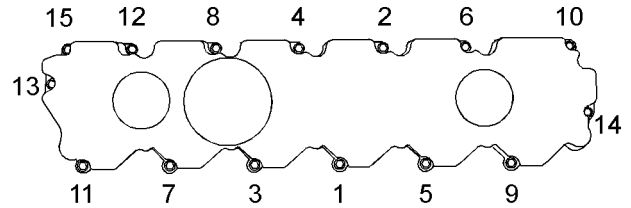


Illustration 225 g01342431

5. Tighten the bolts in the numerical sequence that is shown in Illustration 225. Tighten the bolts to a torque of 9 N·m (79 lb in).
6. Connect the breather hose to the separator for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Install".
7. If the engine is equipped with a cover over the fuel system this will need to be installed.

i02697661

Valve Mechanism Cover Base - Remove and Install (Composite Valve Mechanism Cover Base)

Removal Procedure

Table 52

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

Start By:

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

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

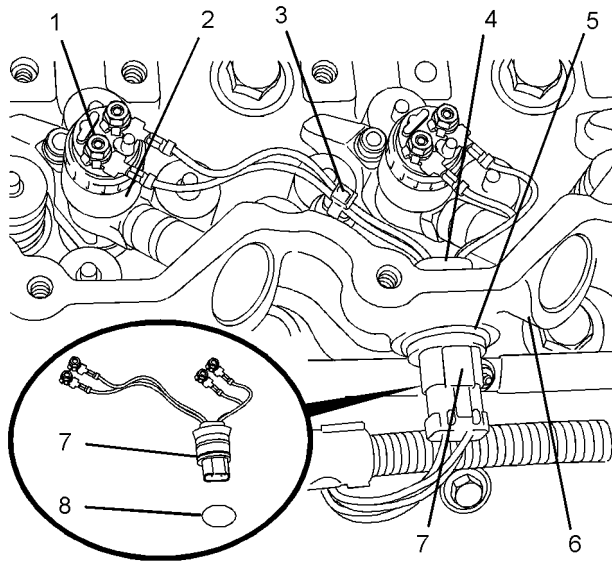


Illustration 226
Typical example
g01355167

1. Make a temporary identification mark on connections (1).
2. Use a deep socket to remove connections (1) from electronic unit injectors (2).
3. Disconnect plugs (7) from harness assemblies (4).
4. If necessary, follow Steps 4.a through 4.e in order to remove harness assemblies (4) from valve mechanism cover base (6).
 - a. Cut cable strap (3).
 - b. Use Tooling (A) to remove circlip (5).
 - c. From the outside of valve mechanism cover base (6), push harness assembly (4) inward. Withdraw the harness assembly from valve mechanism cover base (6).
 - d. Remove O-ring seal (8) from harness assembly (4).

- e. Repeat Steps 4.a through 4.d in order to remove the remaining harness assembly.

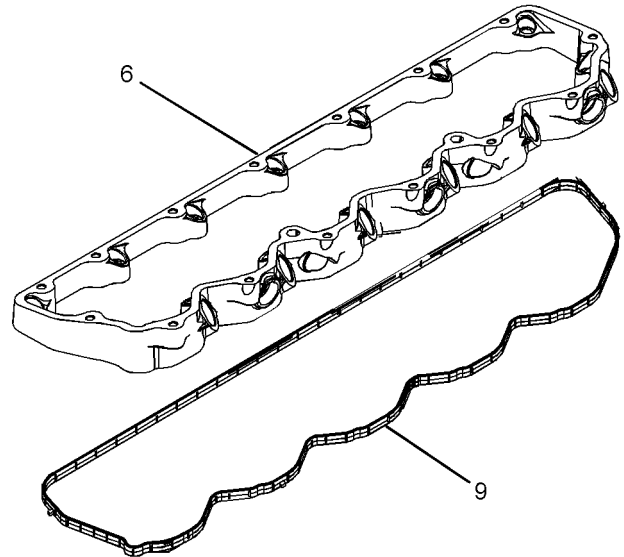


Illustration 227
Typical example
g01354234

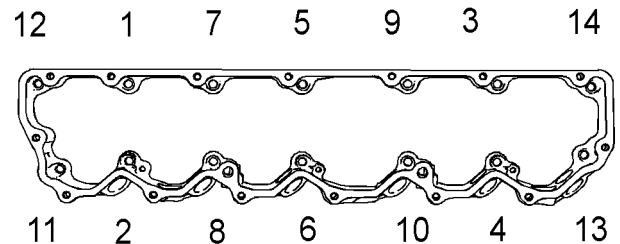


Illustration 228
Sequence for loosening the valve mechanism cover base
g01354235

5. Gradually loosen the captive bolts that secure the valve mechanism cover base in reverse numerical order. Refer to Illustration 228. This will help prevent distortion of the valve mechanism cover base.
- Note:** The captive bolts cannot be removed from the valve mechanism cover base.
6. Remove valve mechanism cover base (6) from the cylinder head.
 7. Remove seal (9) from valve mechanism cover base (6).

Installation Procedure

Table 53

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	21820221	POWERPART Rubber Grease	1
C	27610296	Torque wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Use a deep socket in order to remove the electrical connections from the electronic unit injectors. Use of incorrect tooling will result in damage to the electronic unit injectors.

1. Clean the valve mechanism cover base. Ensure that the mating surfaces are free from damage.

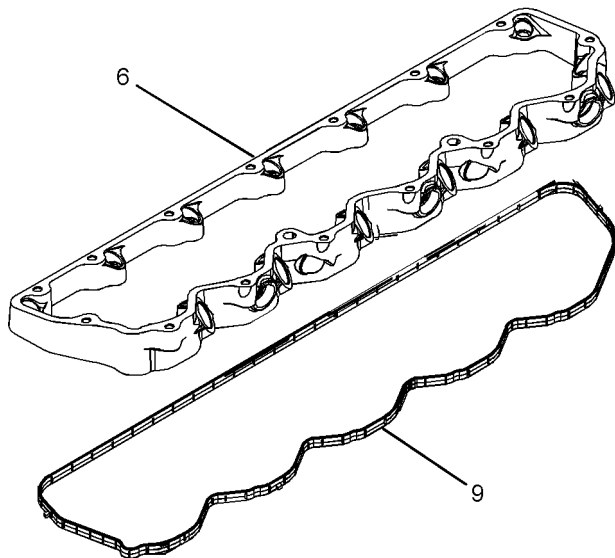


Illustration 229

g01354234

Typical example

2. Install seal (9) to valve mechanism cover base (6). Ensure that the seal is seated correctly in the groove in the valve mechanism cover base.

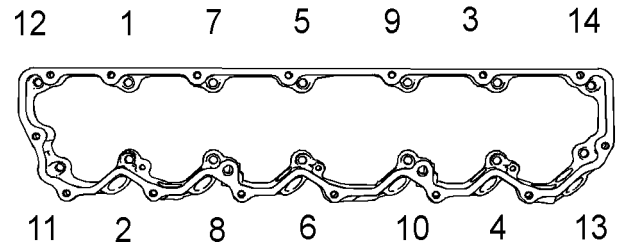


Illustration 230

g01354235

Tightening sequence for the valve mechanism cover base

3. Position valve mechanism cover base (6) on the cylinder head. Temporarily install two long bolts from the valve mechanism cover in positions (X).

Note: The long bolts must be installed in order to align the valve mechanism cover base.

4. Gradually tighten the captive bolts that secure the valve mechanism cover base to a torque of 9 N·m (79 lb in) in the sequence that is shown in Illustration 230.

5. Remove the bolts from positions (X).

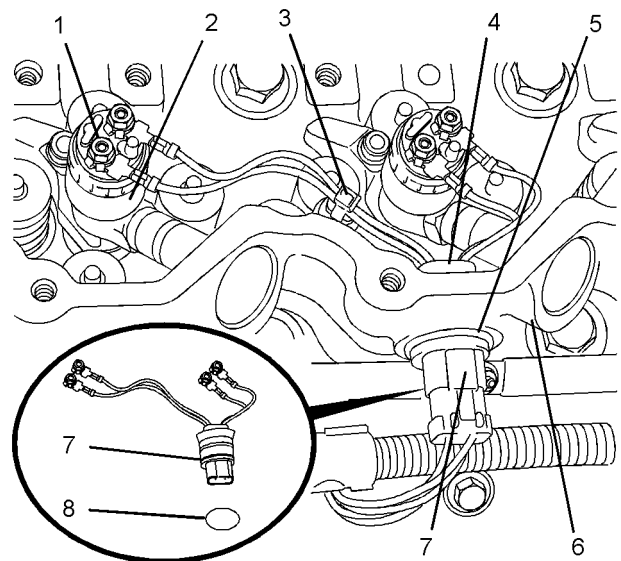


Illustration 231

g01355167

Typical example

6. If necessary, install the harness assemblies for the electronic unit injectors. Follow Steps 6.a through 6.e in order to install the harness assemblies to the electronic unit injectors.

- a. Ensure that harness assembly (4) and the bore in valve mechanism cover base (6) are clean and free from damage. Replace any damaged components.
 - b. Use Tooling (B) to lubricate a new O-ring seal (8). Install O-ring seal (8) onto harness assembly (4).
 - c. From the inside of valve mechanism cover base (6), push harness assembly (4) into the valve mechanism cover base.
 - d. Use Tooling (A) to install circlip (5).
 - e. Repeat Steps 6.a through 8 for the remaining harness assembly.
7. Use a deep socket to connect harness (4) to electronic unit injectors (2). Use Tooling (C) to tighten connectors (1) to a torque of 2.4 N·m (21 lb in).
8. If necessary, install new cable straps (3) to harness assemblies (4).

Note: Ensure that cable straps are to OE specification.

- 9. Connect plugs (7) to harness assemblies (4).

End By:

- a. Install new fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

i02654548

Valve Mechanism Cover Base - Remove and Install

Removal Procedure

Table 54

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

Start By:

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

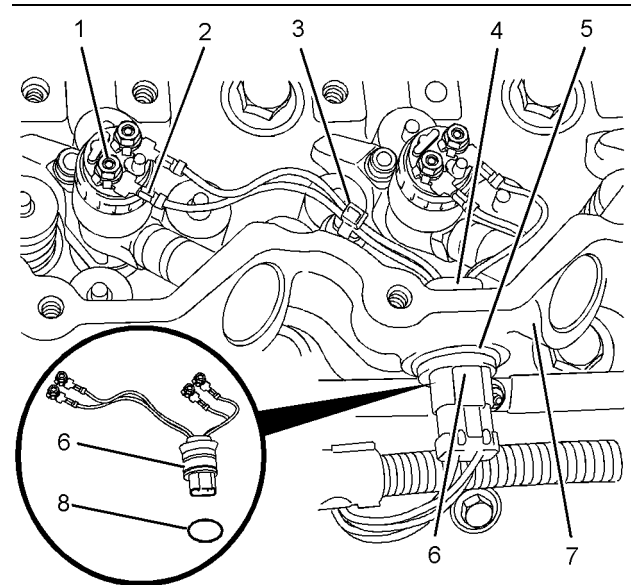


Illustration 232

g01342484

- 1. Place a temporary identification mark on connections (1) for harness assembly (4).
- 2. Use a deep socket to remove connections (1) from electronic unit injectors (2).
- 3. If necessary, follow steps 3.a through 3.f in order to remove harness assemblies (4) from valve mechanism cover base (7).
 - a. Cut cable strap (3).
 - b. Disconnect plug (6) from harness assembly (4).
 - c. Use Tooling (A) to remove circlip (5).
 - d. From the outside of valve mechanism cover base (7), push harness assembly (4) inward. Withdraw the harness assembly from valve mechanism cover base (7).
 - e. Remove O-ring seal (8) from harness assembly (4).

- f. Repeat steps 3.b through 3.e in order to remove the remaining harness assemblies.

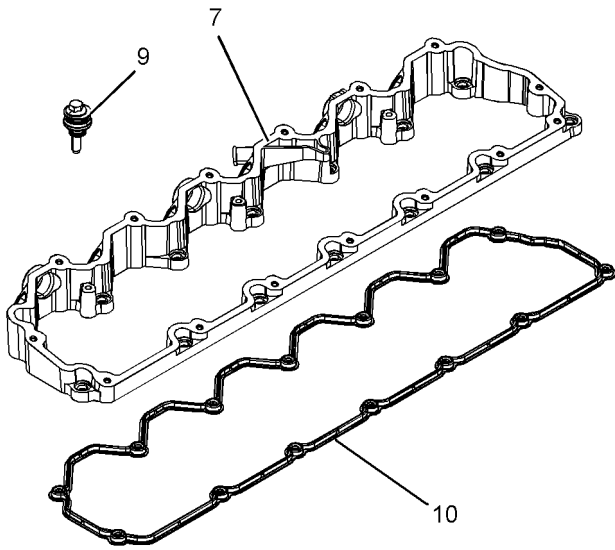


Illustration 233

g01342485

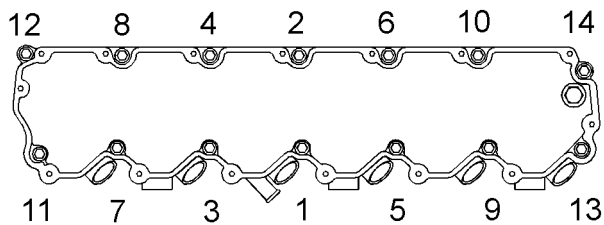


Illustration 234

g01342487

4. Loosen isolated screws (9) in reverse numerical order. Refer to illustration 234. This will help prevent distortion of valve mechanism cover base (6).
5. Remove valve mechanism cover base (7) from the cylinder head.
6. Remove isolated screws (9) from valve mechanism cover base (7).
7. Remove seal (10) from valve mechanism cover base (7).

Installation Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	21820221	POWERPART Rubber Grease	1
C	27610296	Torque wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the valve mechanism cover base. Ensure that the mating surfaces are free from damage.

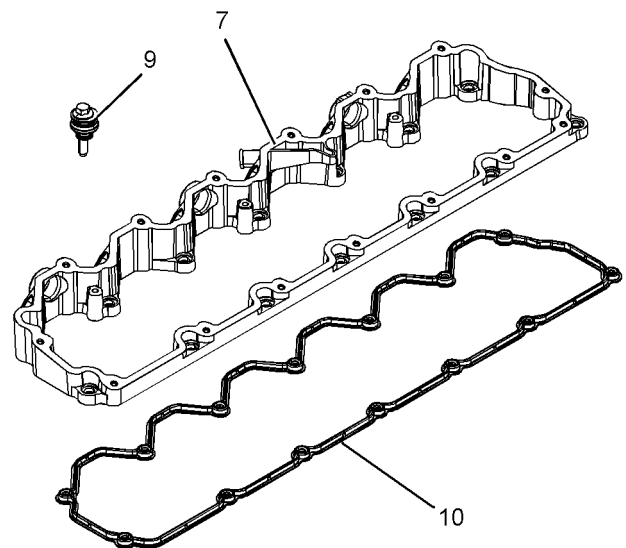


Illustration 235

g01342485

2. Install seal (10) to valve mechanism cover base (7). Ensure that seal (10) is seated correctly in the groove in the machined face of valve mechanism cover base (7).
3. Install isolated screws (9) to valve mechanism cover base (6).

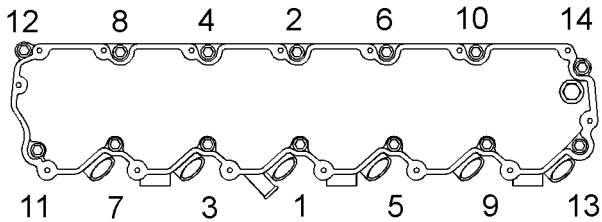


Illustration 236

g01342487

4. Position valve mechanism cover base (7) on the cylinder head. Tighten isolated screws (9) to a torque of 9 N·m (79 lb in) in the sequence that is shown in illustration 236.

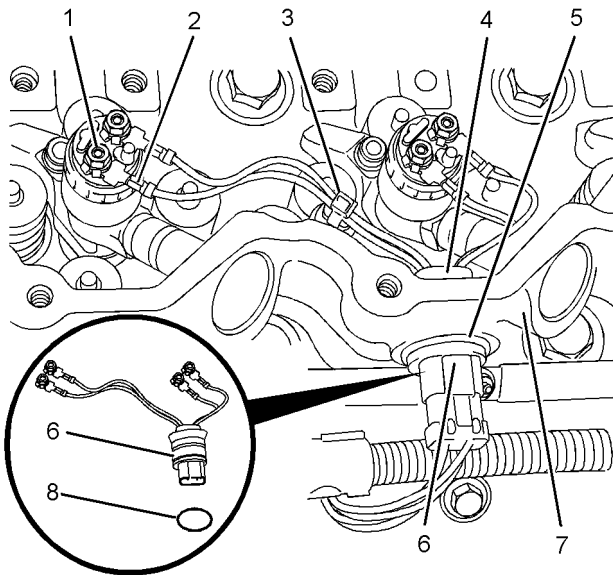


Illustration 237

g01342484

5. If necessary, install the harness assemblies for the electronic unit injectors. Follow steps 5.a through 5.h in order to install the harness assemblies for the electronic unit injectors.

- a. Ensure that harness assembly (4) and the bore in valve mechanism cover base (7) are clean and free from damage. Replace any damaged components.
- b. Use Tooling (B) to lubricate a new O-ring seal (8). Install the new O-ring seal (8) onto harness assembly (4).
- c. From the inside of valve mechanism cover base (7), push harness assembly (4) into valve mechanism cover base (7).
- d. Use Tooling (A) to install circlip (5).

- e. Connect plug (6) to harness assembly (4).
- f. Use a deep socket to connect harness (4) to electronic unit injectors (2). Use Tooling (C) to tighten connectors (1) to a torque of 2.4 N·m (21 lb in).
- g. Install a new cable strap (3) to harness assembly (4).

Note: Ensure that cable strap to OE specification.

- h. Repeat steps 5.a through 5.g for remaining harness assemblies (4).

End By:

- a. Install new fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install".
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install".

i02654541

Rocker Shaft and Pushrod - Remove

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

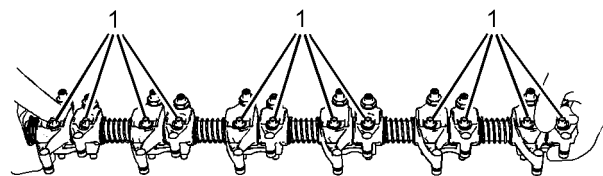


Illustration 238

g01340040

i02654539

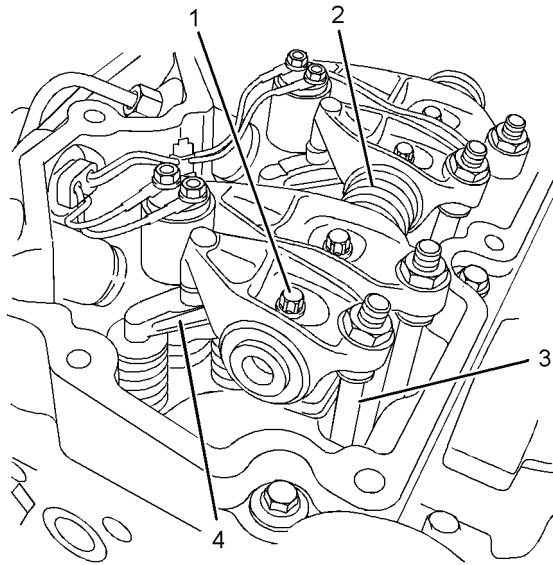


Illustration 239

g01340041

1. Progressively loosen torx screws (1). Begin at the ends of the rocker shaft assembly and work toward the center.

Note: To avoid distortion of rocker shaft assembly (2), each torx screw should be loosened by half 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. Remove rocker shaft assembly (2) from the cylinder head.
4. 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.

5. Make a temporary mark on valve bridges (4) in order to show the location and the orientation. Remove the valve bridges from the cylinder head.

Note: Identification will ensure that the valve bridges can be reinstalled in the original location and the original orientation. Do not interchange the location or the orientation of used valve bridges.

Rocker Shaft - Disassemble

Disassembly Procedure

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.

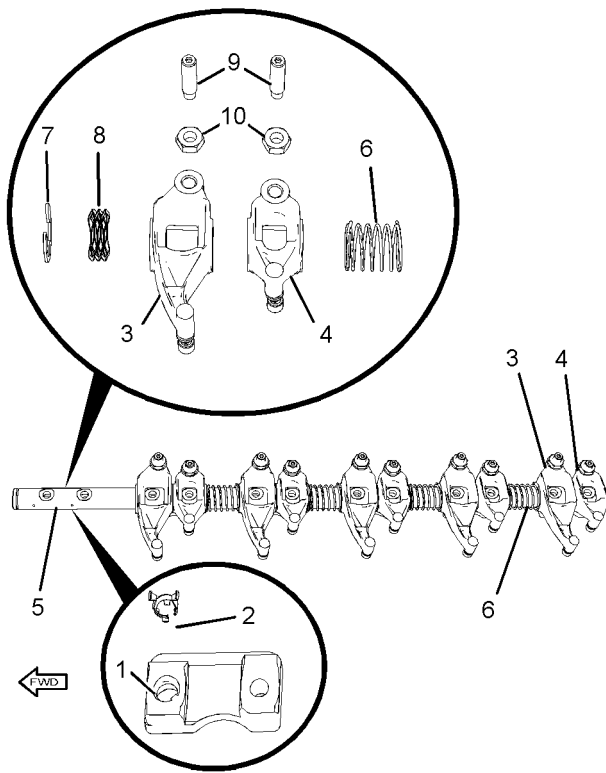


Illustration 240

g01340047

2. Remove pedestals (1) from rocker shaft (5). It is not necessary to remove locators (2) from the pedestals.
3. Remove rocker arm assembly (4) for the exhaust valve from rocker shaft (5). Remove rocker arm assembly (3) for the inlet valve from rocker shaft (5). Begin at the rear of the rocker shaft assembly.

Note: The rocker arm assembly for the inlet valve is longer than the rocker arm assembly for the exhaust valve.

4. Remove spring (6) from rocker shaft (5).
5. Repeat Steps 3 and 4 in order to remove the remaining rocker arms from rocker shaft (5).

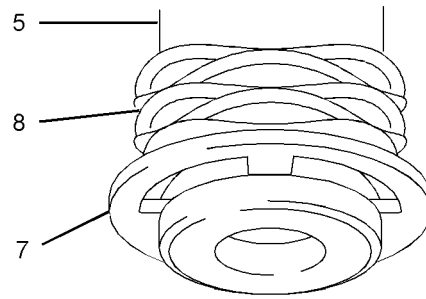


Illustration 241

g01340048

6. If necessary, remove retaining clip (7) and remove spring (8) from the front end of rocker shaft (5).
7. If necessary, remove nuts (10) 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.

i02654537

Rocker Shaft - Assemble

Assembly 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. Refer to Specifications, "Rocker Shaft" for more information. If necessary, replace any components that are worn or damaged.

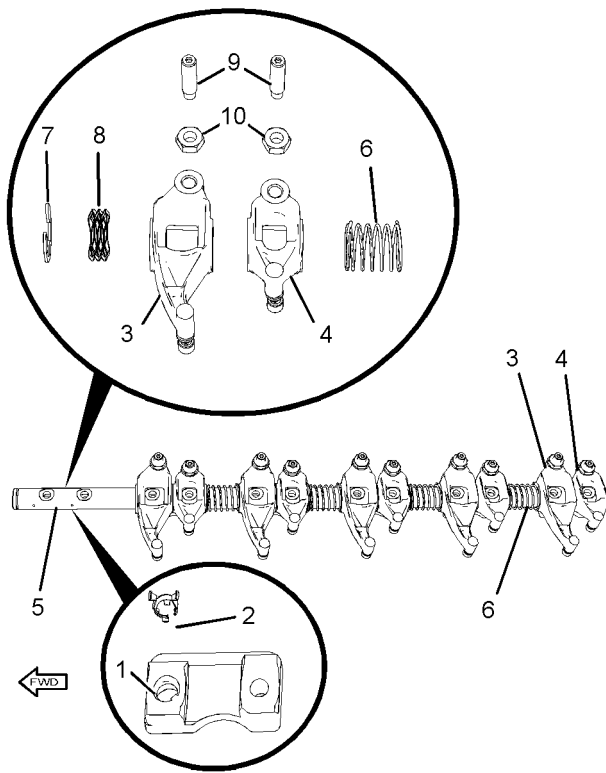


Illustration 242

g01340047

2. If necessary, install nuts (10) and adjusters (9) to rocker arm assemblies (3) and (4). If the original adjusters are reused, ensure that the adjusters are installed in the original positions.

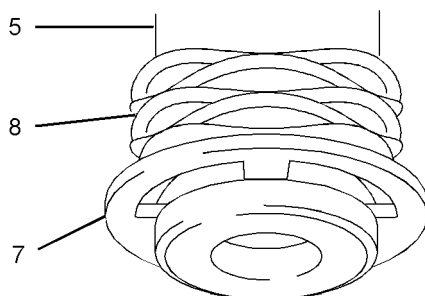


Illustration 243

g01340048

3. Install retaining clip (7) and spring (8) to the front end of rocker shaft (5).

4. Lubricate the bores of rocker arm assemblies (3) and (4) and rocker shaft (5) with clean engine oil.
5. Install rocker arm assembly (3) for number 1 inlet valve to the rocker shaft. Install rocker arm assembly (4) for number 1 exhaust valve to rocker shaft (5).

Note: The rocker arm assembly for the inlet valve is longer than the rocker arm assembly for the exhaust valve. Used components should be installed in the original location.

6. If necessary, ensure that locator (2) is correctly seated in pedestal (1). Ensure that the counterbores for the holes in rocker shaft (5) are upward. Align locator (2) with the hole to the front of rocker shaft (5). Install the pedestal to the rocker shaft.

WARNING

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

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

7. Install spring (6) to rocker shaft (5).
8. Repeat Steps 5 to 7 in order to assemble the remaining components to rocker shaft (5).

End By:

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

i02654540

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 56

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610298	Angled Feeler Gauges	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

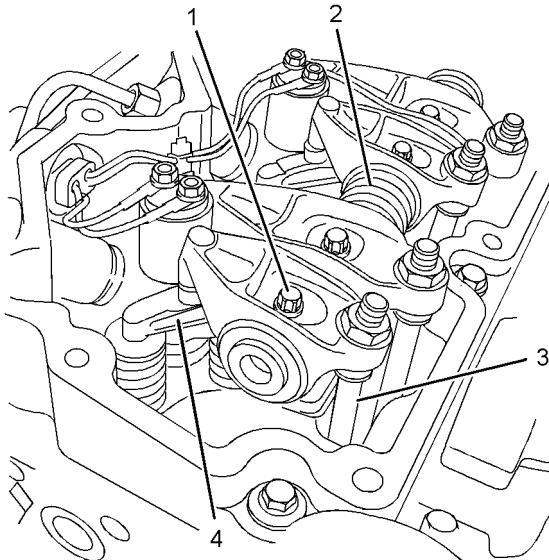


Illustration 244

g01340041

2. Lubricate valve bridges (4) with clean engine oil.

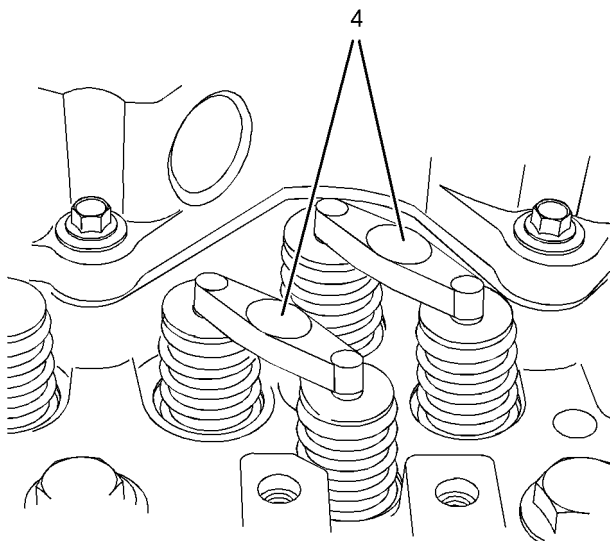


Illustration 245

g01355120

The electronic unit injector is not shown for clarity.

NOTICE

Failure to ensure that ALL valve bridges are correctly seated onto the valve stems will cause interference between the pistons and the valves, resulting in damage to the engine.

3. Install valve bridges (4) to the cylinder head.

Note: Install used valve bridges in the original location and in the original orientation. Ensure that the valve bridges are correctly seated on the valves. New valve bridges may be installed in either orientation.

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

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

Note: Ensure that pushrods (3) are installed in the original location and that the ball end of each pushrod is correctly seated in the valve lifters.

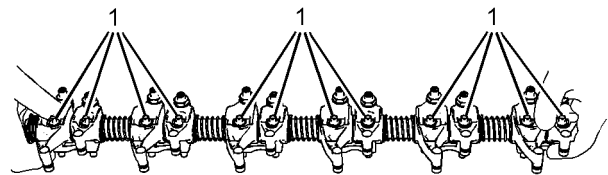


Illustration 246

g01340040

6. Ensure that the rocker shaft assembly is clean and free from wear or damage. Install torx screws (1) in the rocker shaft.

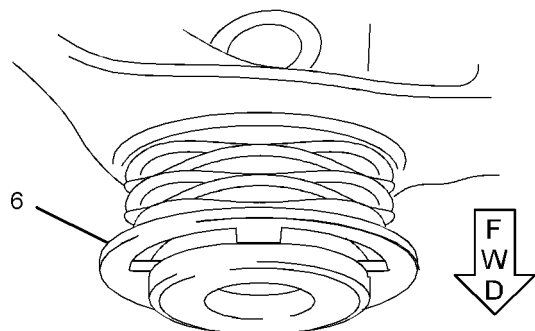


Illustration 247

g01340044

7. Position rocker shaft assembly (2) onto the cylinder head. The retaining clip (6) should face the front of the engine.

Note: Ensure that adjustment screws (5) are properly seated in ends of pushrods (3).

8. Gradually tighten torx screws (1).

Note: To avoid distortion of rocker shaft assembly (2), tighten the torx screws in the center first. Work toward the outside of the rocker shaft assembly.

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

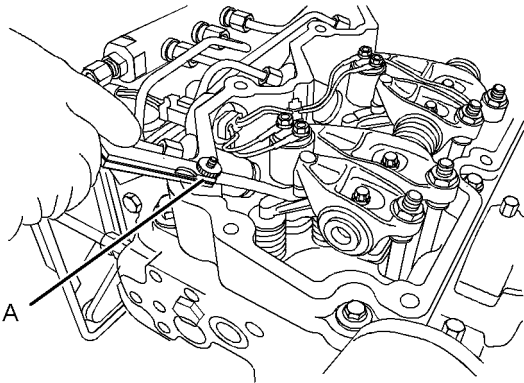


Illustration 248

g01340045

9. Use Tooling (A) in order to check the valve lash. Refer to System Operation, Testing and Adjusting, "Engine Valve Lash - Inspect/Adjust". If necessary, adjust the valve lash. Refer to System 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".

i02654475

Cylinder Head - Remove

Removal Procedure

Start By:

- a. If necessary, remove the secondary fuel filter and the fuel filter base. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".
- b. If necessary, remove the fuel priming pump and the primary fuel filter. Refer to Disassembly and Assembly, "Fuel Priming Pump - Remove and Install".
- c. Remove the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".

- d. Remove the fuel manifold. Refer to Disassembly and Assembly, "Fuel Manifold - Remove and Install".
- e. Remove the electronic control module and the mounting bracket. Refer to Disassembly and Assembly, "Electronic Control Module - Remove and Install".
- f. Remove the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Remove".
- g. Remove the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Remove".
- h. 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.

- 1. 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.

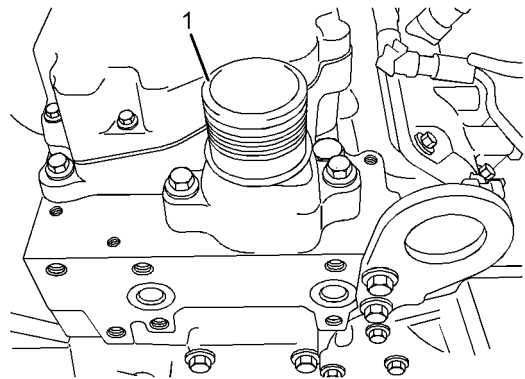


Illustration 249

g01340072

Typical example

2. Disconnect the upper radiator hose from water temperature regulator housing (1) on the cylinder head.

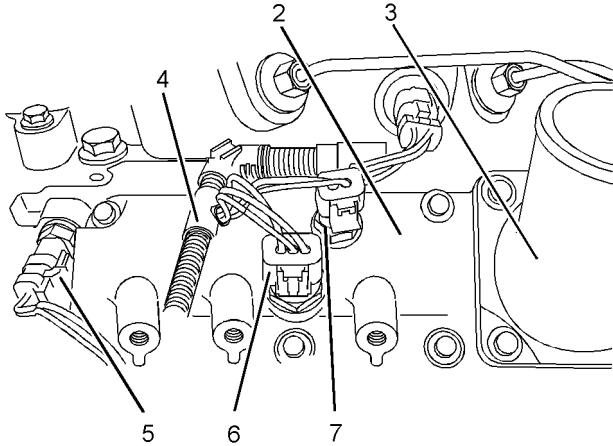


Illustration 250

g01340075

Typical example

3. Remove the air inlet hose from inlet connection (3) on inlet manifold (2).
4. Follow Steps 4.a and 4.b in order to disconnect harness assembly (4) from coolant temperature sensor (5).
 - a. Slide the locking tab into the unlocked position.
 - b. Disconnect harness assembly (4) from coolant temperature sensor (5).
5. Follow Steps 5.a and 5.b in order to disconnect harness assembly (4) from boost pressure sensor (6).
 - a. Slide the locking tab into the unlocked position.
 - b. Disconnect harness assembly (4) from boost pressure sensor (6).
6. Follow Steps 6.a and 6.b in order to disconnect harness assembly (4) from inlet air temperature sensor (7).
 - a. Slide the locking tab into the unlocked position.
 - b. Disconnect harness assembly (4) from inlet air temperature sensor (7).
7. Remove all cable straps that secure harness assembly (4) to the cylinder head or to the inlet manifold. The harness assembly should be positioned in order to avoid causing an obstruction during the removal of the cylinder head.

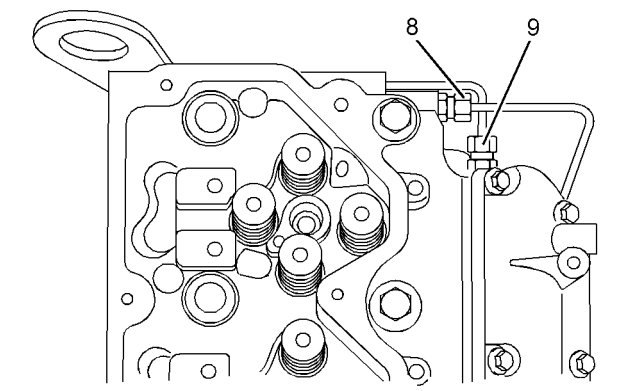


Illustration 251

g01340077

Typical example

8. Loosen the tube clips for tube assembly (8). Remove tube assembly (8) for the fuel return from the cylinder head and from the transfer pump. Plug the port in the transfer pump with a new plug. Cap the tube assembly with new caps.
9. If the engine has a wastegate solenoid, loosen the tube clips for tube assembly (9). Remove tube assembly (9) from the wastegate solenoid and from the cylinder head. Plug the port in the wastegate solenoid with a new plug. Cap the tube assembly with new caps.

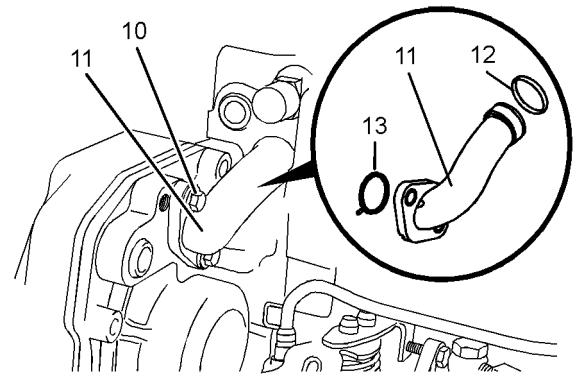


Illustration 252

g01340080

Typical example

10. Remove bolts (10). Remove bypass tube (11) from the cylinder head. Remove O-ring seals (12) and (13) from bypass tube (11).

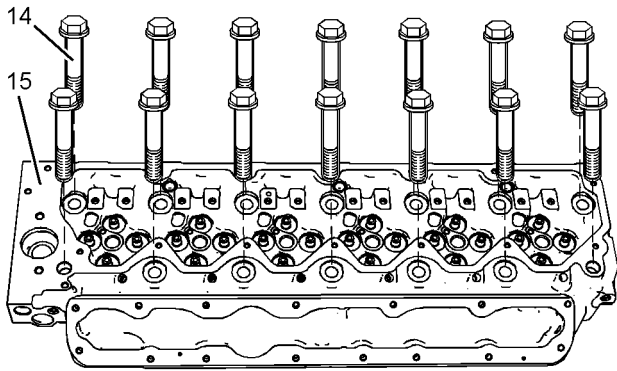


Illustration 253 g01340081

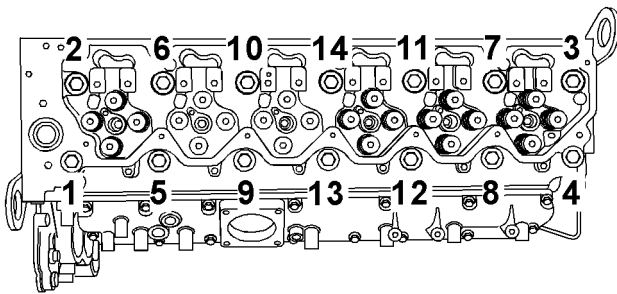


Illustration 254 g01340083
Sequence for tightening the bolts for the cylinder head

11. Gradually loosen bolts (14) in the reverse numerical order to the tightening sequence. Refer to the illustration 254.

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

12. Remove bolts (14) from cylinder head (15).

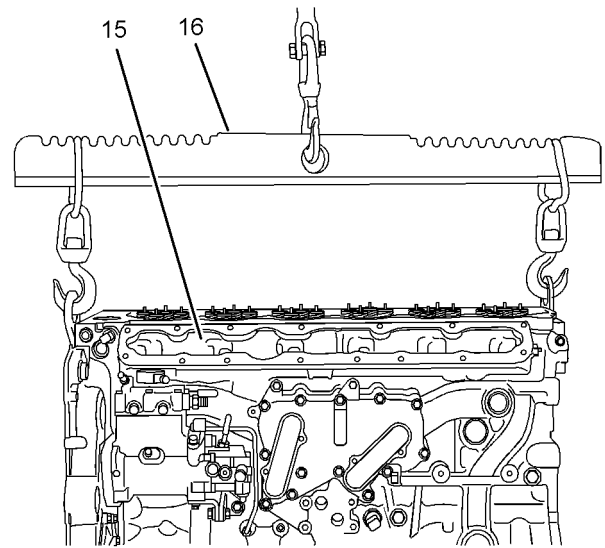


Illustration 255 g01340086
Typical example

13. Attach a suitable lifting device (16) to cylinder head (15). Support the weight of the cylinder head. The weight of the cylinder head is approximately 66 kg (145.5 lb).

Note: A spreader bar must be used in order to distribute the weight of the cylinder head during the lifting operation.

14. Use suitable lifting device (16) to carefully lift cylinder head (15) 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.

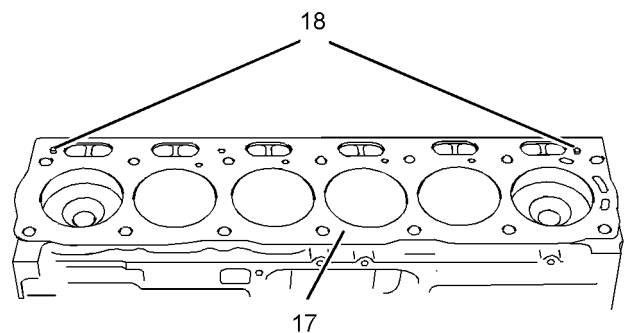


Illustration 256 g01340089

- 15. Remove cylinder head gasket (17).
- 16. Note the position of dowels (18) in the cylinder block.
- 17. If necessary, remove water temperature regulator (1) from cylinder head (15). Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install".
- 18. If necessary, remove inlet manifold (2) from cylinder head (15). Refer to Disassembly and Assembly, "Inlet manifold - Remove and Install".

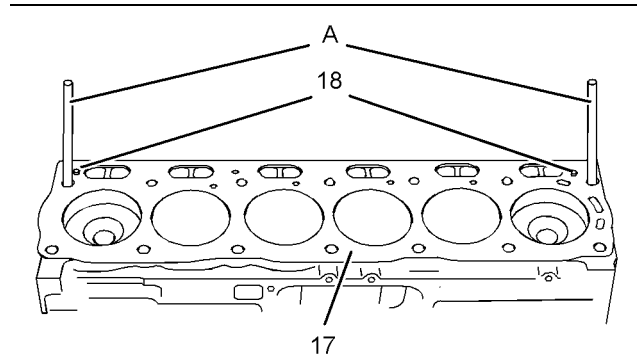


Illustration 257

g01340176

Cylinder Head - Install

Installation Procedure

Table 57

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Stud (M16 by 115mm)	2
B	21825607	Angle gauge	1
C	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 of 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. If the mating surface of the cylinder head is distorted beyond maximum permitted limits, replace the cylinder head.
- 3. If necessary, install the inlet manifold to the cylinder head. Refer to Disassembly and Assembly, "Inlet manifold - Remove and Install".

- 4. Inspect dowels (18) for damage. If necessary, replace the dowels in the cylinder block.
- 5. Install Tooling (A) to the cylinder block.
- 6. Align cylinder head gasket (17) with dowels (18). Install cylinder head gasket (17) onto the cylinder block.

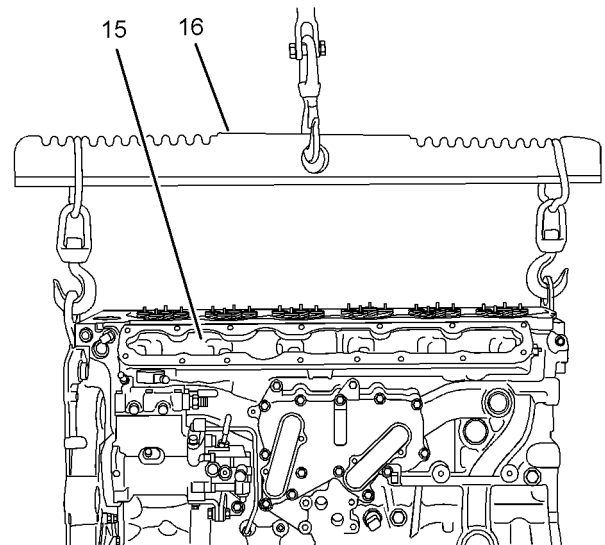


Illustration 258

g01340086

Typical example

- 7. Use a suitable lifting device (16) to lift cylinder head (15). The weight of the cylinder head is approximately 66 kg (145.5 lb).
- 8. Use Tooling (A) to align the cylinder head with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned on dowels (18).

9. Remove Tooling (A).

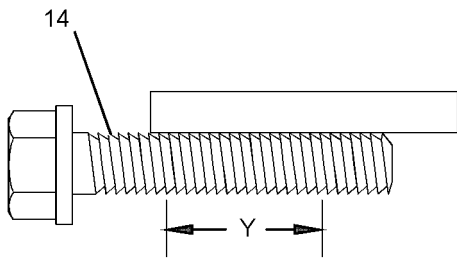


Illustration 259

g01340188

10. Clean bolts (14). Follow Steps 10.a for the procedure to inspect the bolts.

- a. Use a straight edge to check the threads of the bolts. Refer to Illustration 259. Replace any bolts that show visual reduction in the diameter of the thread over length (Y).

11. Lubricate the threads and the shoulder of bolts (14) with clean engine oil.

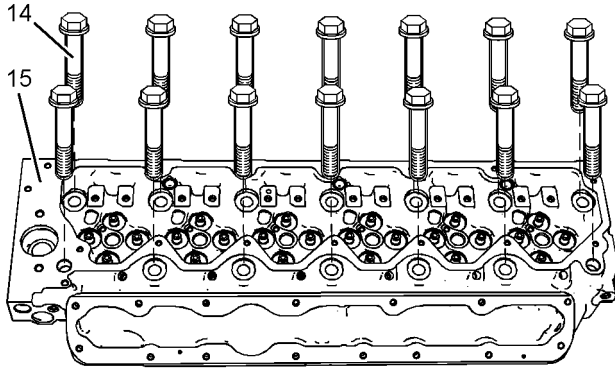


Illustration 260

g01340081

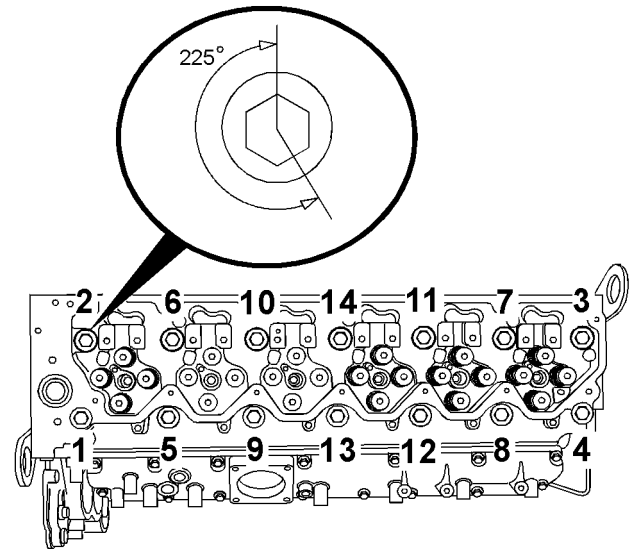


Illustration 261

g01340192

12. Install bolts (14) to cylinder head (16).

13. Tighten the bolts to a torque of 50 N·m (37 lb ft) in the numerical sequence. Refer to Illustration 261.

14. Tighten the bolts to a torque of 100 N·m (74 lb ft) in the numerical sequence. Refer to Illustration 261.

15. Turn the bolts through an additional 225 degrees in the numerical sequence. Refer to Illustration 261. Use Tooling (B) to achieve the correct final torque.

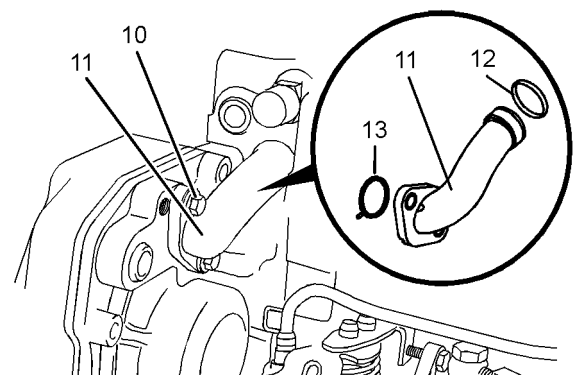


Illustration 262

g01340080

Typical example

16. Use Tooling (C) in order to lubricate the O-ring seals. Install new O-ring seals (12) and (13) to bypass tube (11). Install the bypass tube in the cylinder head. Install bolts (10). Tighten the bolts to a torque of 22 N·m (16 lb ft).

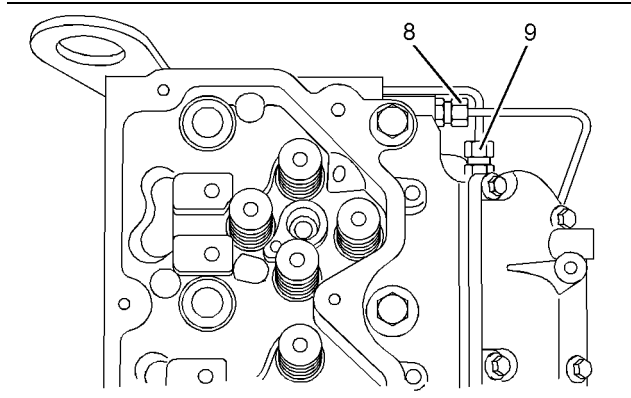


Illustration 263
Typical example
g01340077

- 17. Remove the plugs and caps from the ports and tube assemblies.
- 18. Install tube assembly (8) for the fuel return to the cylinder head and to the transfer pump. Secure the tube clips for tube assembly (8).
- 19. If the engine has a wastegate solenoid, install tube assembly (9) for the wastegate solenoid to the cylinder head. Secure the tube clips for tube assembly (9).

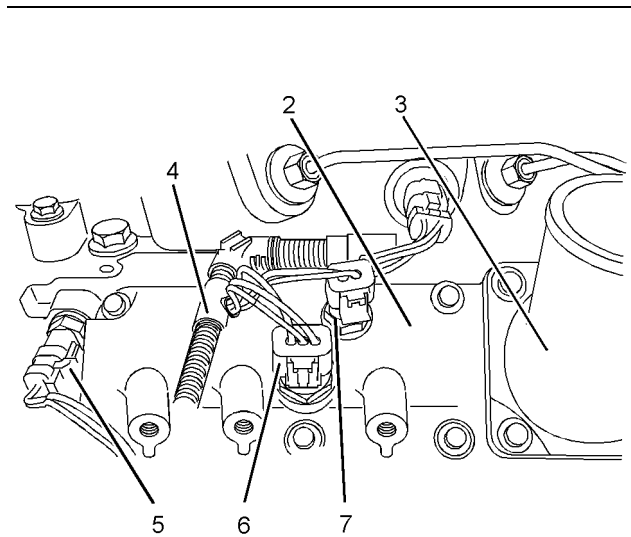


Illustration 264
Typical example
g01340075

- 20. Follow Steps 20.a and 20.b in order to connect harness assembly (4) to inlet air temperature sensor (7).
 - a. Connect harness assembly (4) to inlet air temperature sensor (7).
 - b. Slide the locking tab into the locked position.

- 21. Follow Steps 21.a and 21.b in order to connect harness assembly (4) to boost pressure sensor (6).
 - a. Connect harness assembly (4) to boost pressure sensor (6).
 - b. Slide the locking tab into the locked position.
- 22. Follow Steps 22.a and 22.b in order to connect harness assembly (4) to coolant temperature sensor (5).
 - a. Connect harness assembly (4) to coolant temperature sensor (5).
 - b. Slide the locking tab into the locked position.

- 23. Use new cable straps in order to secure the harness assembly to the cylinder head and to the inlet manifold. Ensure that the harness assembly is not strained.

Note: Ensure that the harness assembly is clear of other engine components.

- 24. Install the inlet hose to inlet connection (3) on inlet manifold (2).

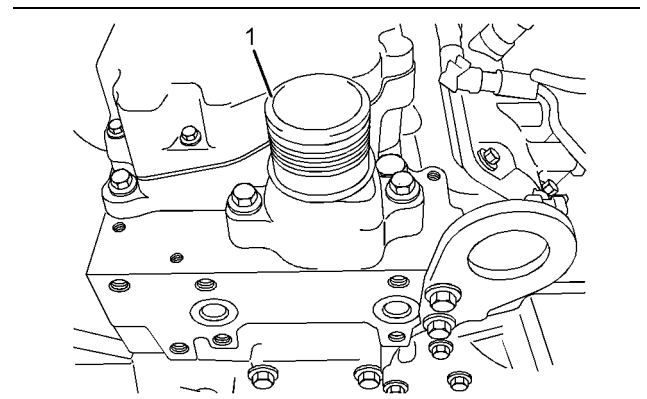


Illustration 265
Typical example
g01340072

- 25. If necessary, install water temperature regulator housing (1) to the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator Housing - Remove and Install".
- 26. Connect the upper radiator hose to water temperature regulator housing (1) on the cylinder head.
- 27. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.

28. If necessary, fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".

i02654526

End By:

- a. Install the electronic unit injectors. Refer to Disassembly and Assembly, "Electronic Unit Injector - Remove".
- b. Install the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrods - Install".
- c. Install the valve mechanism cover base. Refer to Disassembly and Assembly, "Valve Mechanism Cover Base - Install".
- d. Install the glow plugs. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install".
- e. Install the fuel manifold. Refer to Disassembly and Assembly, "Fuel Manifold - Remove and Install".
- f. Install the electronic control module and the mounting bracket. Refer to Disassembly and Assembly, "Electronic Control Module - Remove and Install".
- g. If necessary, install the fuel filter base and the secondary fuel filter. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install".
- h. If necessary, install the fuel priming pump and the primary fuel filter. Refer to Disassembly and Assembly, "Fuel Priming Pump - Remove and Install".
- i. Install the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".

Lifter Group - Remove and Install

Removal Procedure

Table 58

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housing	1
	27610289	Gear	1
B	-	Telescopic Magnet	1

Start By:

- a. 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".

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 appropriate lifters (1).

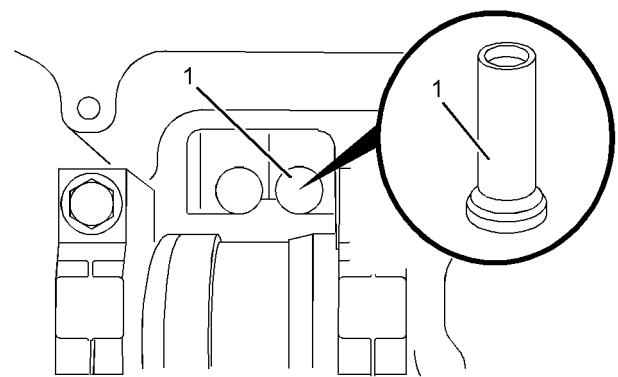


Illustration 266

g01340518

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

Note: Place 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 59

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610291	Barring Device Housing	1
	27610289	Gear	1
B	-	Telescopic Magnet	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

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 any worn lifters or damaged lifters.
 - 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 to access to the cylinder block in order to install appropriate lifters (1).
3. Lubricate lifters (1) with clean engine oil.

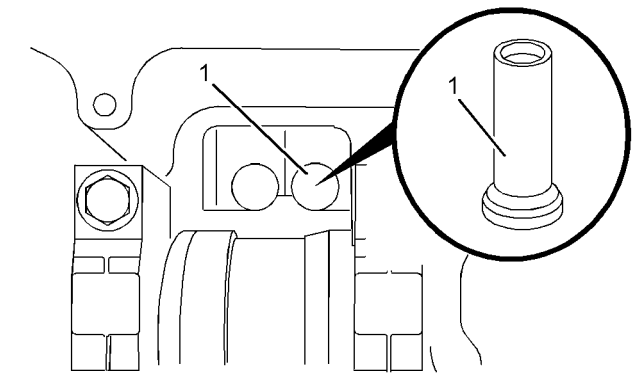


Illustration 267

g01340518

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

i02654455

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.

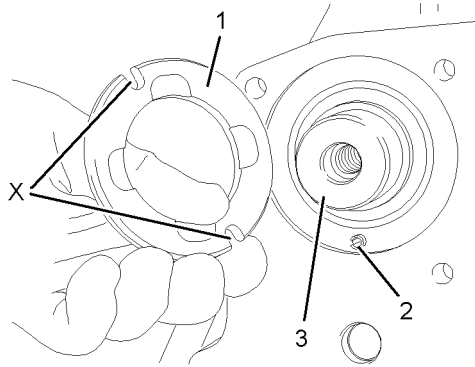


Illustration 268 g01340531
Typical example

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).

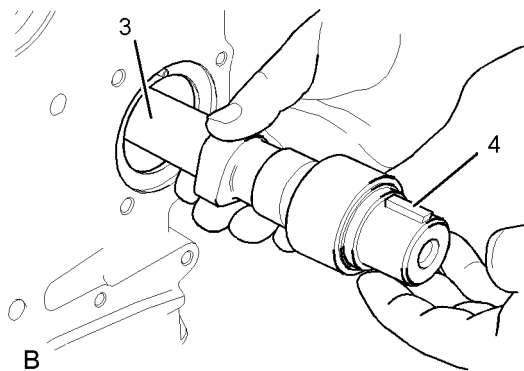


Illustration 269 g01340532

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. If necessary, remove key (4) from camshaft (3).

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 worn components or any damaged components.
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".

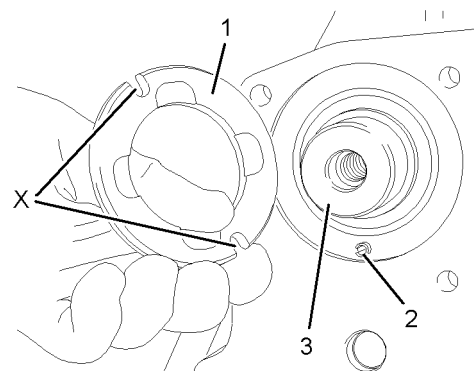


Illustration 270 g01340531
Typical example

4. If necessary, install a new key (4) into 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.

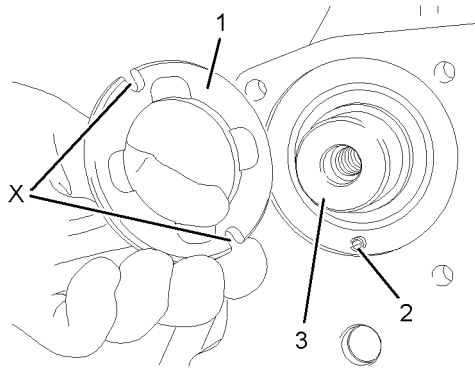


Illustration 271 g01167327
Typical example

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 (X).

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".

i02654457

Camshaft Gear - Remove and Install

Removal Procedure

Table 60

Required Tools			
Tool	Part Number	Part Name	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	1

Start By:

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

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

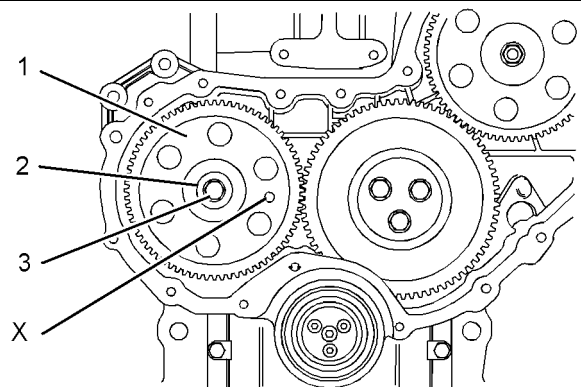


Illustration 272 g01340534

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.

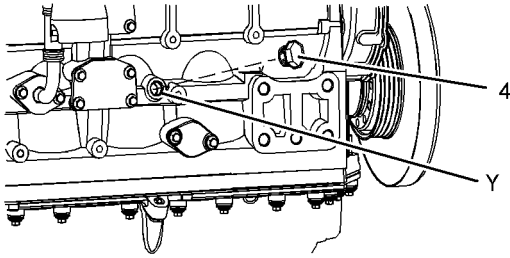


Illustration 273

g01335380

3. Remove plug (4) from the cylinder block. Install Tooling (C) into hole (Y) in the cylinder block. 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.

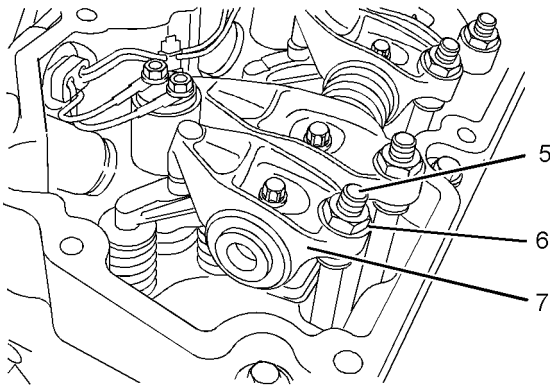


Illustration 274

g01340536

4. 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.

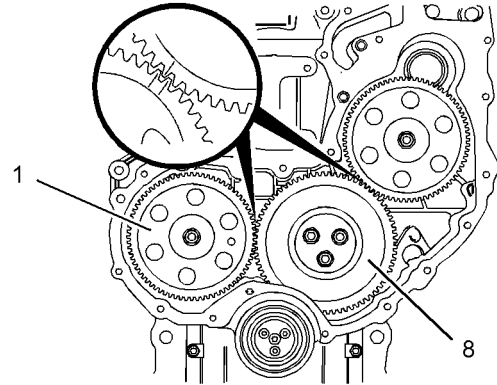


Illustration 275

g01340551

Alignment of timing marks

5. Mark gears (1) and (8) in order to show alignment. Refer to Illustration 275.

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

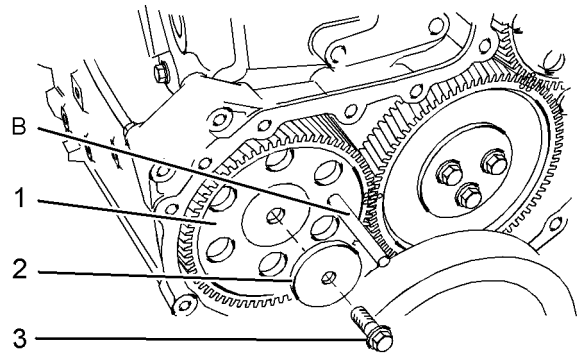


Illustration 276

g01340554

6. Remove Tooling (B). 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 61

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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 top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center for No. 1 Piston".

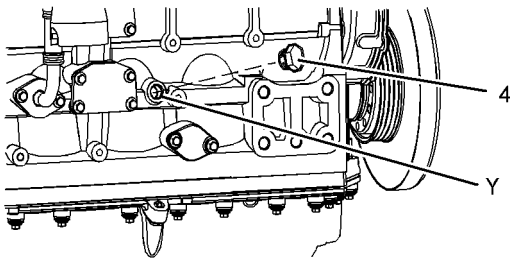


Illustration 277

g01335380

2. Ensure that Tooling (C) is installed in hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to System 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.

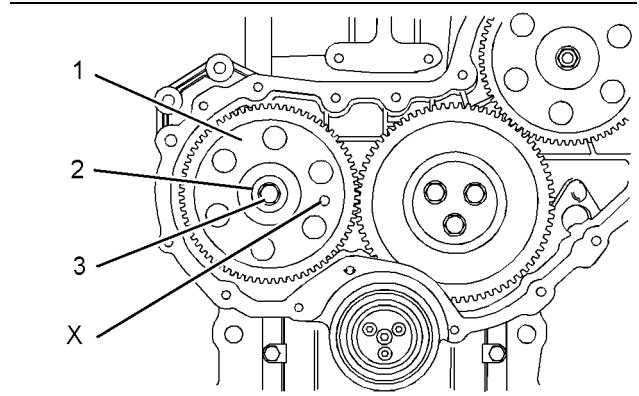


Illustration 278

g01340534

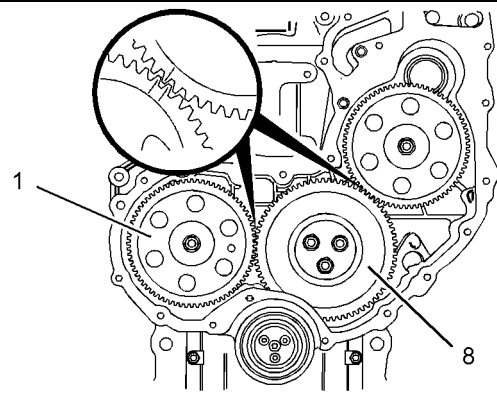


Illustration 279

g01340551

Alignment of timing marks

5. Align the keyway in camshaft gear (1) with the key in the camshaft. Install 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 279.

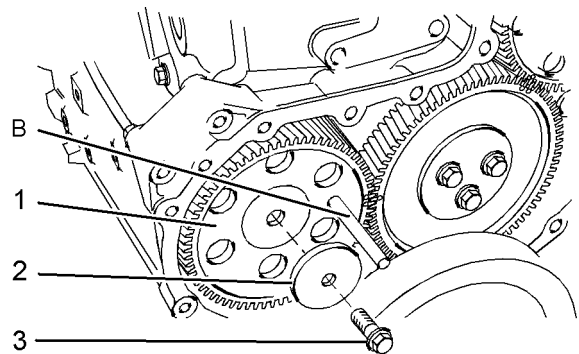


Illustration 280

g01340554

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). Install plug (4) into hole (Y) in the cylinder block. Refer to Illustration 277.

8. Tighten bolt (3) to a torque of 95 N·m (70 lb ft).

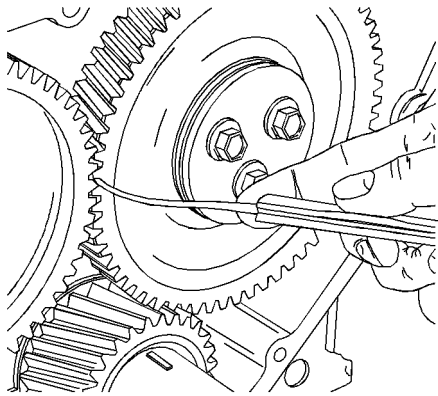


Illustration 281

g01335426

9. Ensure that the backlash for gears (1) and (8) is within specified values. Refer to Specifications, "Gear Group (Front)" for further information.
10. Ensure that the end play for camshaft gear (1) is within specified values. Refer to Specifications, "Camshaft" for further information.
11. Lubricate the teeth of the gears with clean engine oil.
12. Adjust the valve lash. Refer to System 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".

i02654456

Camshaft Bearings - Remove and Install

Removal Procedure

Table 62

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

Start By:

- a. 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.

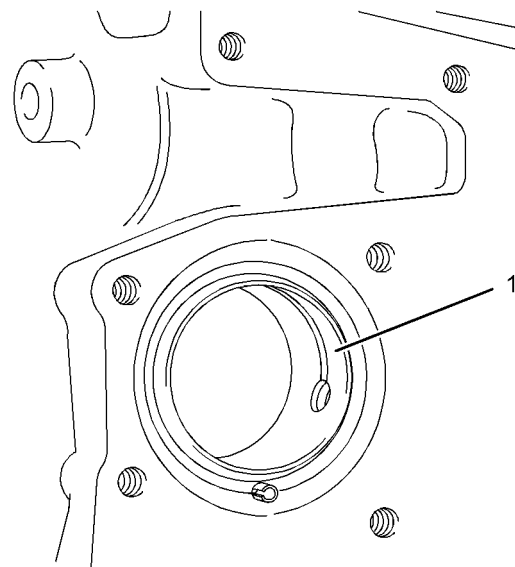


Illustration 282

g01340581

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i02654412

1. Clean the bearing housing in the cylinder block. Ensure that the oil hole in the bearing housing is free from debris.

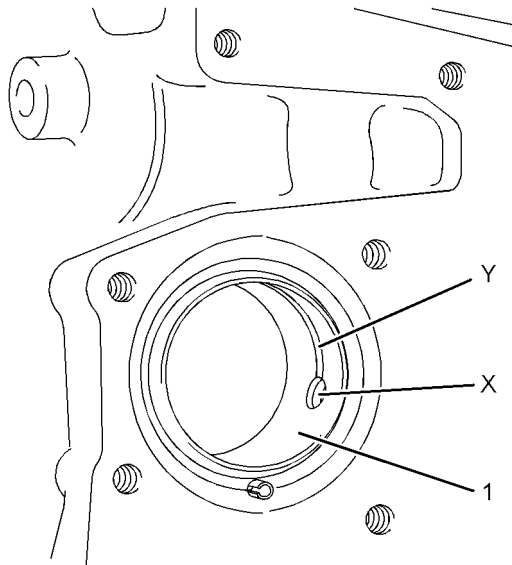


Illustration 283

g01340583

2. Lubricate the bearing housing in the cylinder block with clean engine oil.
3. Accurately align large oil hole (X) in camshaft bearing (1) with the oil hole 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 the oil holes are correctly aligned. If the oil is not correctly aligned, the camshaft bearing should be removed.

End By:

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

Engine Oil Pan - Remove (Aluminum Oil Pan)

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.

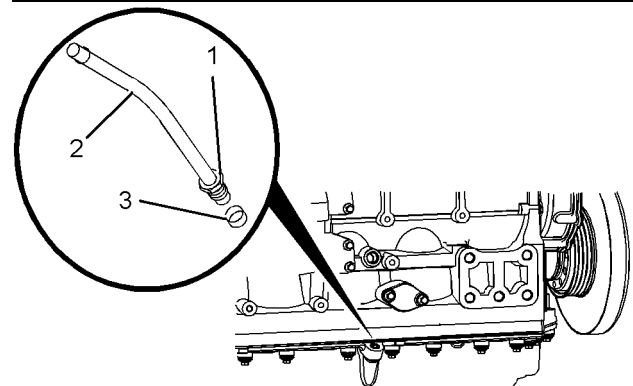


Illustration 284

g01340605

Typical example

1. If necessary, remove the assembly of dipstick tube. Loosen nut (1) and remove tube assembly (2). remove seal (3) from the tube assembly.

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

i02654413

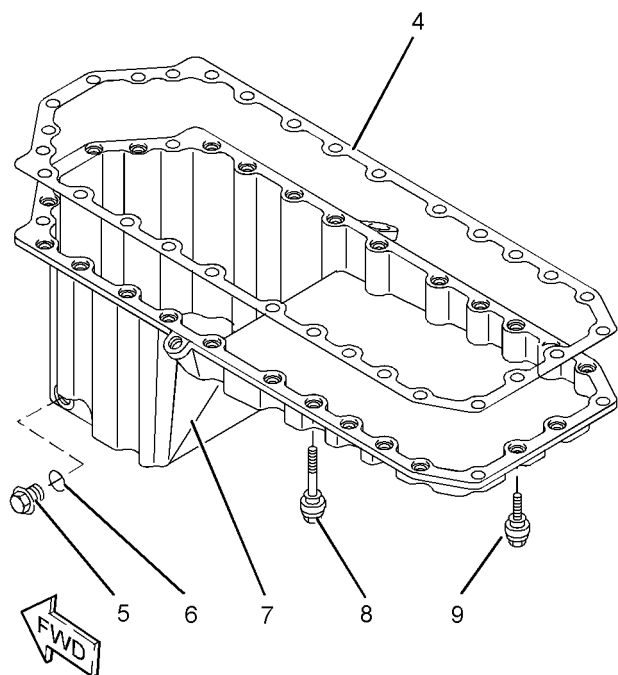


Illustration 285

g01340606

Typical example

1. Place a suitable container below engine oil pan (7). 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.
 2. Remove O-ring seal (6) from drain plug (5).
 3. Disconnect breather hose from the clip that secures the hose to the engine oil pan. Position the breather hose away from the engine oil pan.
 4. Support the assembly of the engine oil pan. Loosen the long isolating screws (8) and the two short isolating screws (9). Mark the position of the clip that secures breather hose. Remove the clip.
- Note:** The isolating screws are held captive by joint (4).
5. Remove the assembly of the engine oil pan from the engine.
 6. If necessary, remove the plate for the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan Plate - Remove and Install".

Engine Oil Pan - Remove (Cast Iron Oil Pan)

Removal Procedure

Table 63

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1

Note: In order to remove a cast iron oil pan, the engine must be removed from the application. 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.
2. Disconnect the breather hose from the clip that secures the hose to the engine oil pan. Position the breather hose away from the engine oil pan.

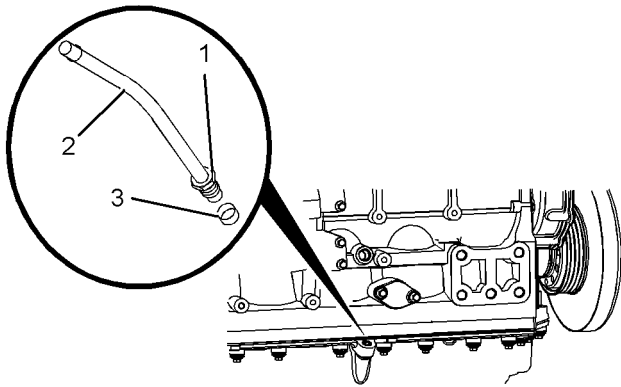


Illustration 286
Typical example g01340605

3. If necessary, remove the assembly of dipstick tube. Loosen nut (1) and remove tube assembly (2). Remove seal (3) from the tube assembly.

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

4. Attach a suitable lifting device to engine oil pan (7) and support the weight of the engine oil pan. The engine oil pan can weigh 100 kg (220 lb).

5. Use Tooling (A) in order to remove the four torx screws (11).

6. Remove nuts (10). Remove bolts (8) and (9).

Note: The bolts are different lengths. Note the position of the different bolts.

7. Use the lifting device to remove engine oil pan (7) from the cylinder block.

8. Remove joint (4) from the cylinder block.

9. Remove drain plug (5).

10. Remove O-ring seal (6) from oil drain plug (5).

i02654410

Engine Oil Pan - Install (Cast Iron Oil Pan)

Installation Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1
C	21826038	POWERPART Silicon Rubber Sealant	-
D	21820117	POWERPART Threadlock and Nutlock	-
E	-	Straight Edge	1

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

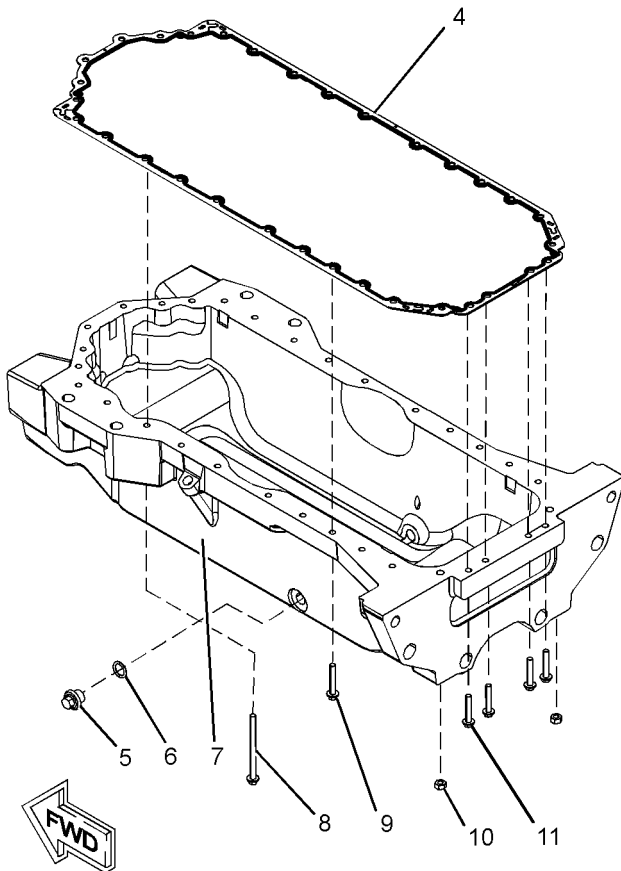


Illustration 287
Typical example g01340731

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 joint face 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.

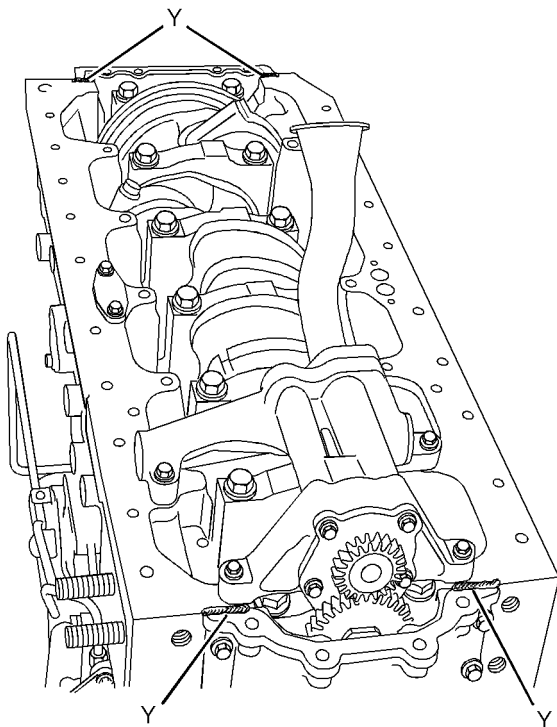


Illustration 288
Typical example

g01340933

3. Apply a bead of Tooling (C) to positions (Y).

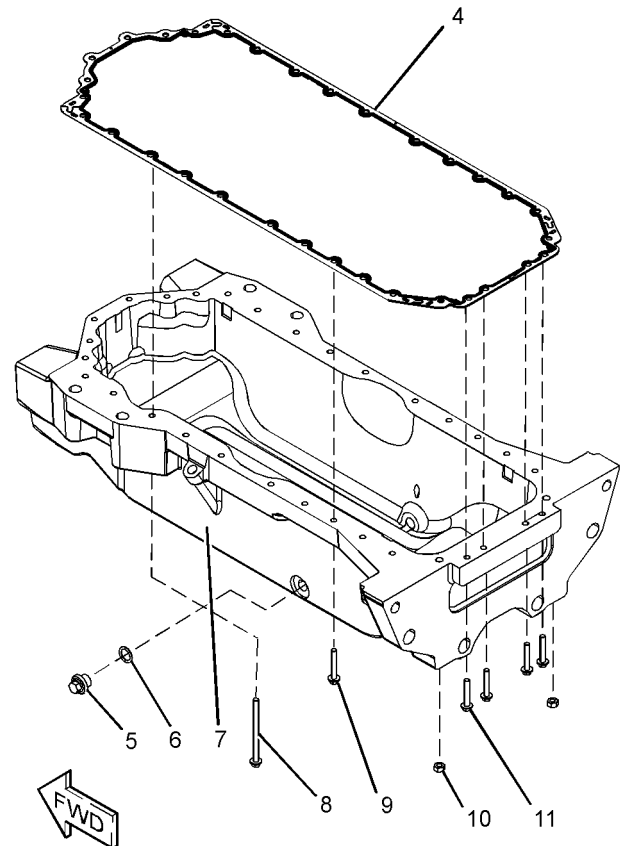


Illustration 289

g01340934

4. Align a new joint (4) with the studs and install the joint to the cylinder block.
5. Attach a suitable lifting device to the engine oil pan (7). The engine oil pan can weigh 100 kg (220 lb).
6. Use the lifting device to align the engine oil pan (7) with the studs. Install the engine oil pan to the cylinder block.
7. Install bolts (8) and (9), nuts (10) and the torx screws (11) finger tight.
8. Align the rear face of the engine oil pan to the rear face of the cylinder block. Use Tooling (E) and a feeler gauge in order to check the alignment between the engine oil pan and the cylinder block.

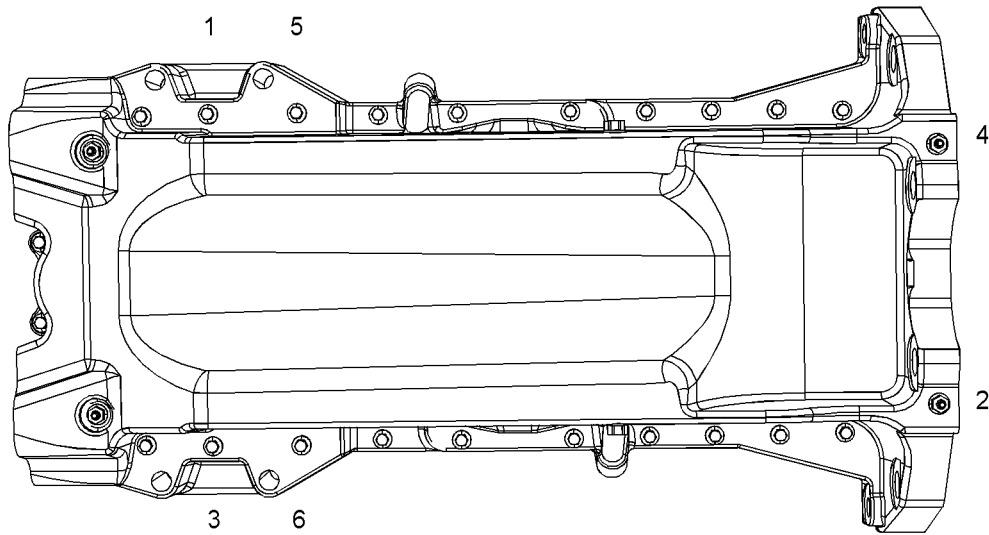


Illustration 290

g01340935

9. Tighten bolts (8) and nuts (10) to a torque of 22 N·m (16 lb ft). Tighten the fasteners in the sequence that is shown in Illustration 290.

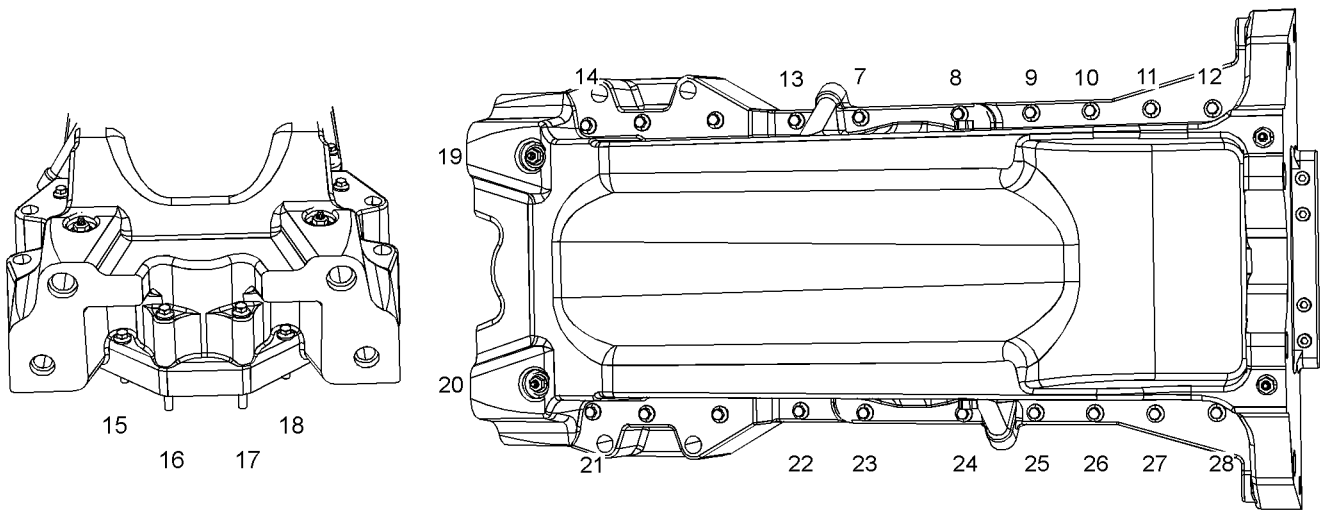


Illustration 291

g01340936

10. Tighten the remaining bolts to a torque of 22 N·m (16 lb ft). Tighten the bolts in the sequence that is shown in Illustration 291.
11. Use Tooling (A) to tighten the torx screws to a torque of 22 N·m (16 lb ft). Refer to Illustration 289.
12. Install a new O-ring seal (6) to drain plug (5). Install drain plug (5) to engine oil pan (7). Tighten the drain plug to a torque of 34 N·m (25 lb ft).

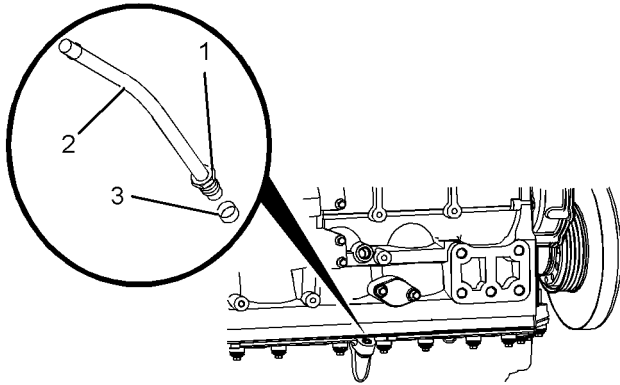


Illustration 292

g01340605

13. If necessary, follow Steps 13 through 13.c in order to install the assembly of the dipstick tube.

- a. Install a new seal (3) to tube assembly (2).
- b. Apply Tooling (D) to nut (1). 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.

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, “Oil Filter Change” for the correct procedure.

i02654409

Engine Oil Pan - Install (Aluminum Oil Pan)

Installation Procedure

Table 65

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

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 necessary, install the plate for the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove and Install”.

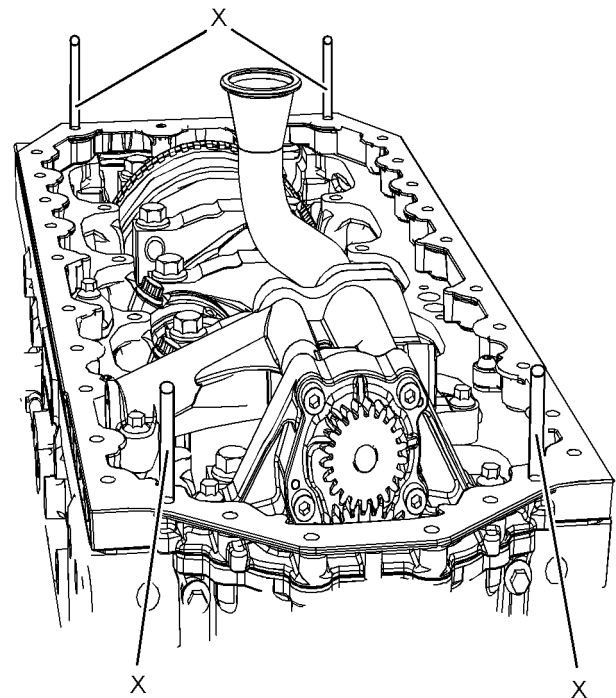


Illustration 293

g01340664

Typical example

1. Install Tooling (A) to positions (X) in the cylinder block.

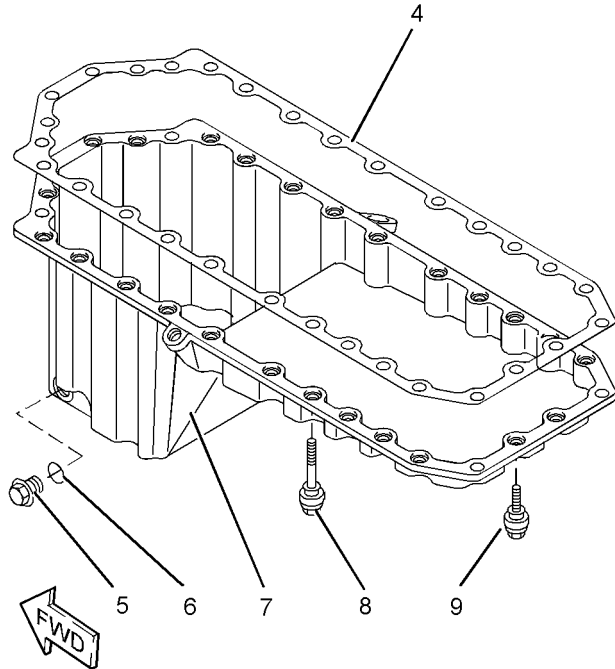


Illustration 294

g01340606

Typical example

2. Ensure that the engine oil pan (7) is clean and free from damage. Clean the isolating screws (8) and (9). Inspect the isolating screws for deterioration or damage. If necessary, replace the isolating screws. If necessary, ensure that the mating surface of the isolating frame is clean.

Note: The isolating screws must be replaced as a complete set in order to ensure the correct clamping of the engine oil pan.

3. Position a new joint (4) onto the engine oil pan (7).
4. Install the isolating screws (8) and (9) to the engine oil pan. Do not install the isolating screws (8) in positions (X). Refer to Illustration 293.

Note: The isolating screws are held captive by the joint.

5. Align the assembly of the engine oil pan with Tooling (A). Install the assembly of the engine oil pan to the isolating frame (12). Install the clip that secures the breather hose in the correct position.

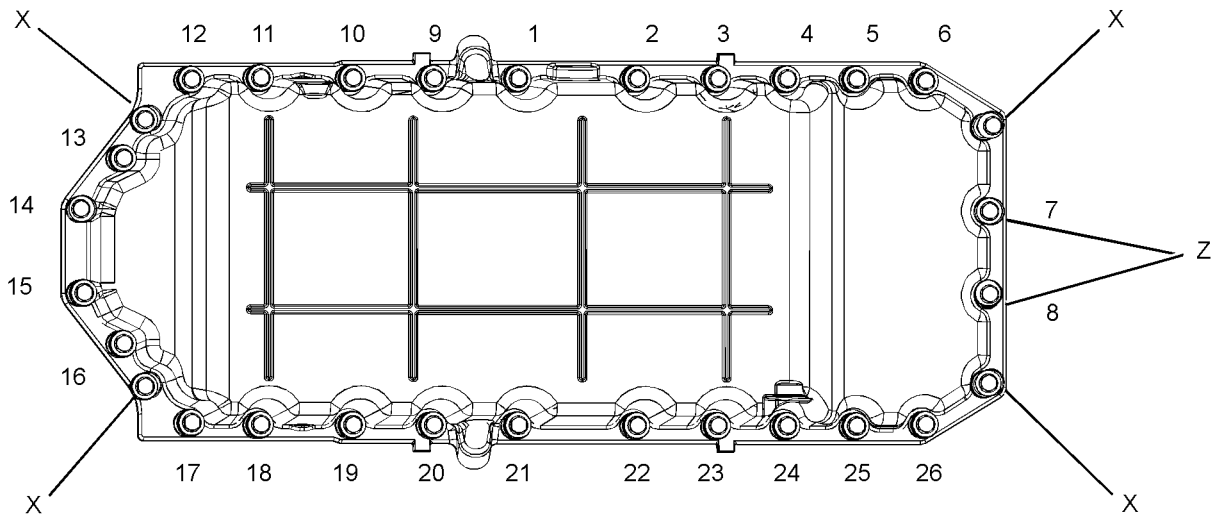


Illustration 295

g01340724

(X) Position of guide studs.

(Z) Position of short isolating screws.

6. Tighten the isolating screws to a torque of 22 N·m (16 lb ft). Tighten the isolating screws in the sequence that is shown in Illustration 295.

7. Remove Tooling (A).

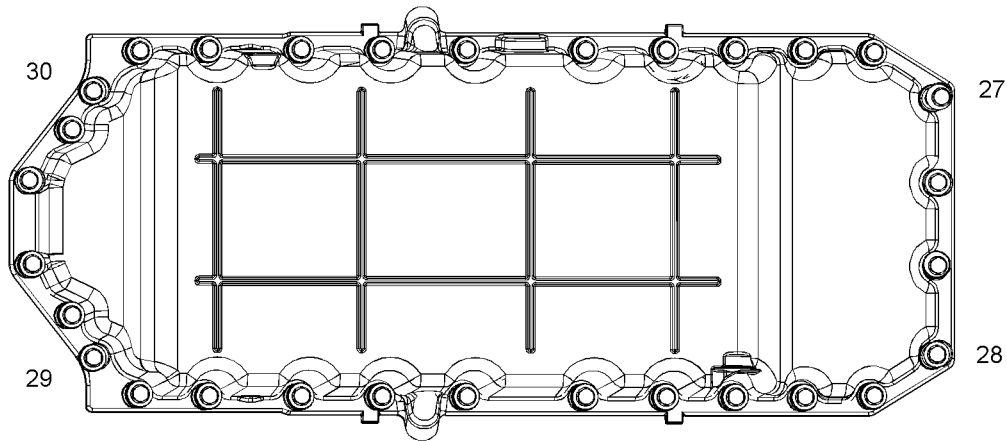


Illustration 296

g01340725

8. Install the four remaining isolating screws. Tighten the isolating screws to a torque of 22 N·m (16 lb ft). Tighten the isolating screws in the sequence that is shown in Illustration 296.

9. Install a new O-ring seal (6) to the drain plug (5). Install the drain plug (5) to the engine oil pan (7). Refer to Illustration 294. Tighten the oil drain plug to a torque of 34 N·m (25 lb ft).

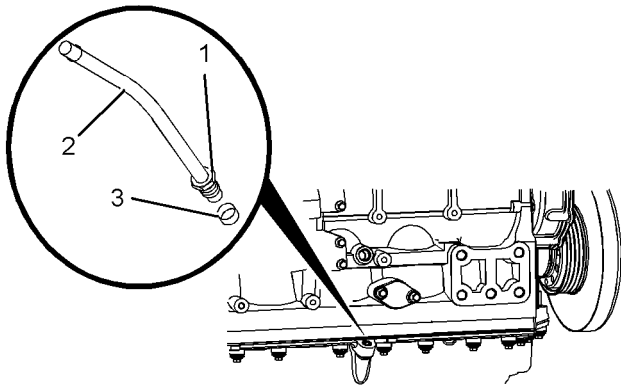


Illustration 297 g01340605

Typical example

10. If necessary, follow Steps 10.a through 10.c in order to install the assembly of the dipstick tube.
 - a. Install a new seal (3) to the tube assembly (2).
 - b. Apply Tooling (B) to the nut (1). Install the tube assembly to the engine oil pan.

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

- c. Tighten the nut (1) to a torque of 18 N·m (13 lb ft). Install the dipstick (not shown).

11. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Oil Filter Change" for the procedure.

i02652928

Engine Oil Pan Plate - Remove and Install (Aluminum Oil Pan)

Removal Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

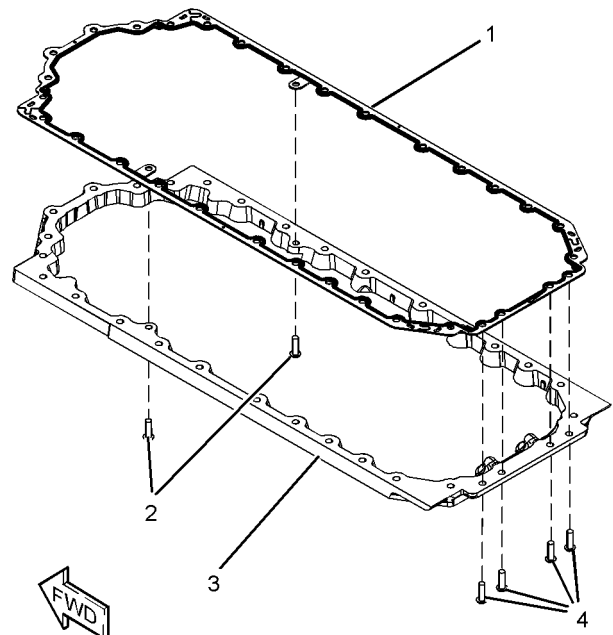


Illustration 298

g01342059

1. Remove isolating frame from the cylinder block. Follow steps 1.a through 1.c in order to remove the isolating frame from the cylinder block.
 - a. Support the isolating frame (3). Use Tooling (A) to remove the torx screws (2) and (4).
 - b. Remove the isolating frame (3) from the cylinder block.
 - c. Remove the joint (1).

Installation Procedure

Table 67

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	T40 Torx Socket	1
B	-	Guide Stud (M8 by 100 mm)	4
C	21826038	POWERPART Silicon Rubber Sealant	-

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.

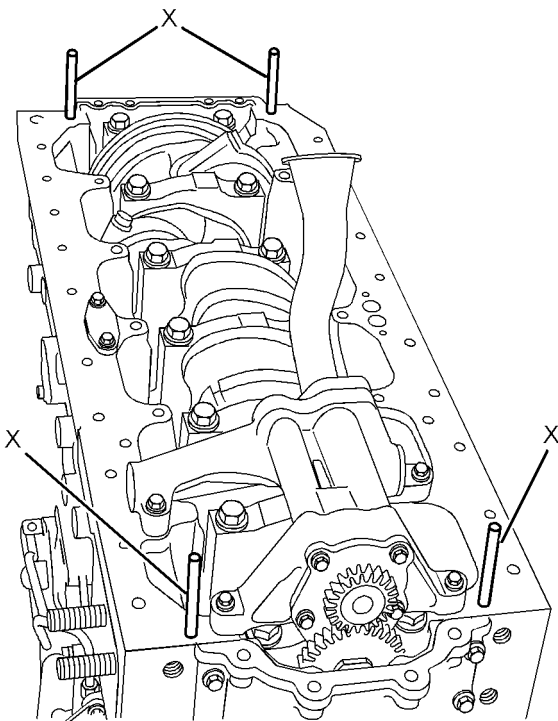


Illustration 299
Typical example

g01342186

1. Install Tooling (B) to positions (X) in the cylinder block.
2. Install the isolating frame to the cylinder block. Follow Steps 2.a through 2.f in order to install the isolating frame.
 - a. Ensure that the joint face of the cylinder block is clean and free from damage.
 - b. Ensure that the isolating frame is clean and free from damage. If necessary, replace the isolating frame.

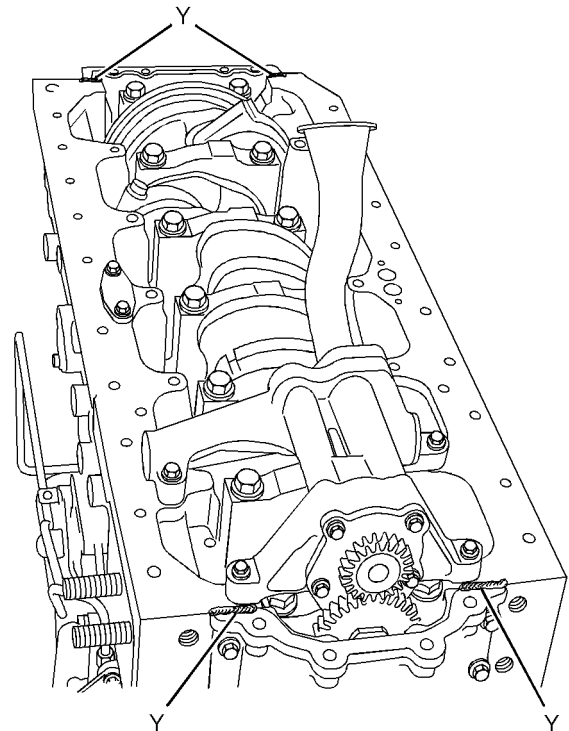


Illustration 300

g01342058

Tooling (B) is not shown for clarity.

- c. Apply a bead of Tooling (C) to positions (Y).

i02654527

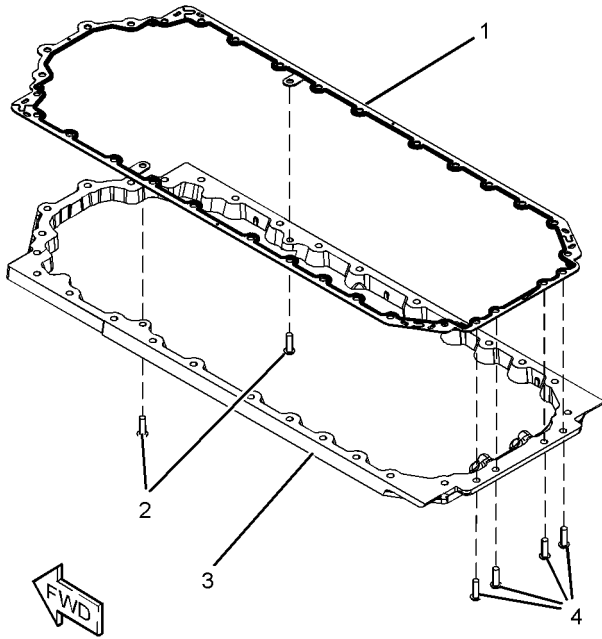


Illustration 301

g01342059

- d. Position a new joint (1) onto the isolating frame (3).
- e. Align the isolating frame (3) with Tooling (B). Install the isolating frame to the cylinder block.
- f. Use Tooling (A) to install the two torx screws (2) and the four torx screws (4) to the isolating frame. Tighten the torx screws (2) to a torque of 22 N·m (16 lb ft). Tighten the torx screws (4) to a torque of 22 N·m (16 lb ft).

End By:

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

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 68

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

Start By:

- a. 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.

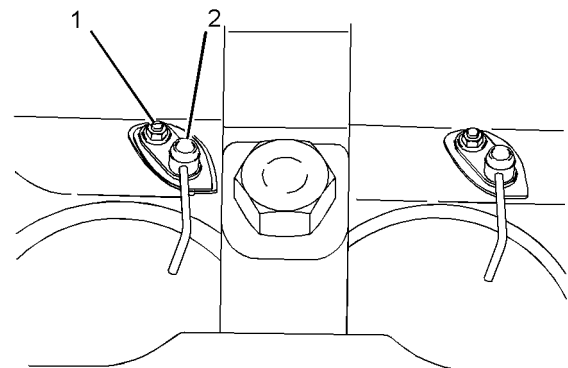


Illustration 302

g01340939

- 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

i02654533

Table 69

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	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.

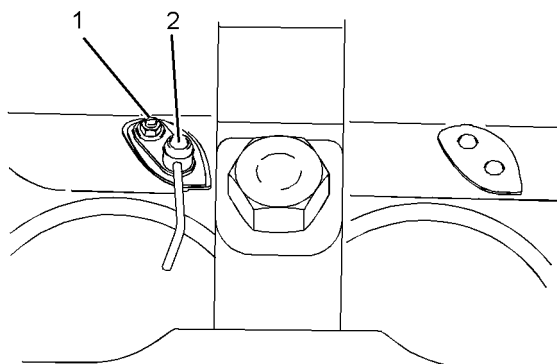


Illustration 303

g01340940

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. The procedure for checking the alignment of the piston cooling jets is described in Specifications, "Piston Cooling Jet Alignment".
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 bolt (1) to a torque of 9 N·m (80 lb in).
4. Repeat steps 2 through 3 for the remaining piston cooling jets.

End By:

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

Pistons and Connecting Rods - Remove

Removal Procedure

Table 70

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

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove".
- c. Remove the piston cooling jets. Refer to Disassembly and Assembly, "Piston Cooling Jets - Remove and Install".

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

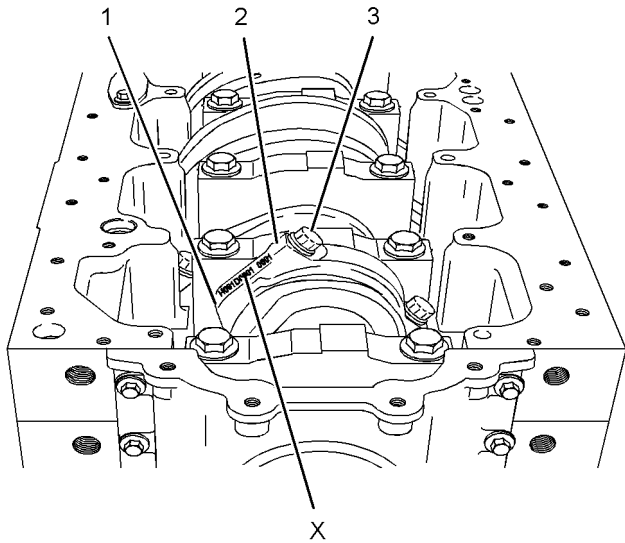


Illustration 304

g01341291

3. 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 connecting rod (1) 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.

4. Remove bolts (3) and connecting rod cap (2) from connecting rod (1).

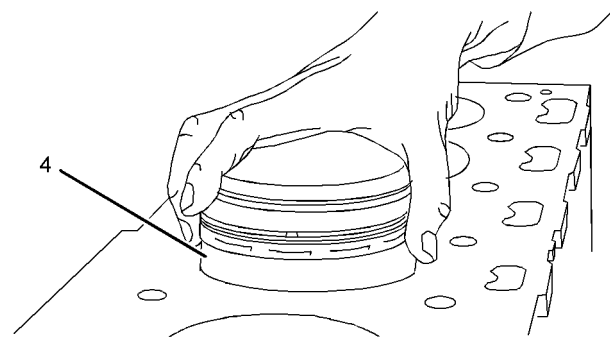


Illustration 305

g01341292

5. Carefully push piston (4) and the connecting rod out of the cylinder bore. Lift piston (4) 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. Repeat Steps 1 through 5 for the remaining pistons and connecting rods.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. Temporarily install connecting rod cap (2) and bolts (3) to connecting rod (1) when the assembly is out of the engine. 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. The locating tab for the upper bearing shell and the lower bearing shell should be on the same side. Tighten bolts (3) to a torque of 20 N·m (14 lb ft).

i02654530

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 71

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".

Note: 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.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

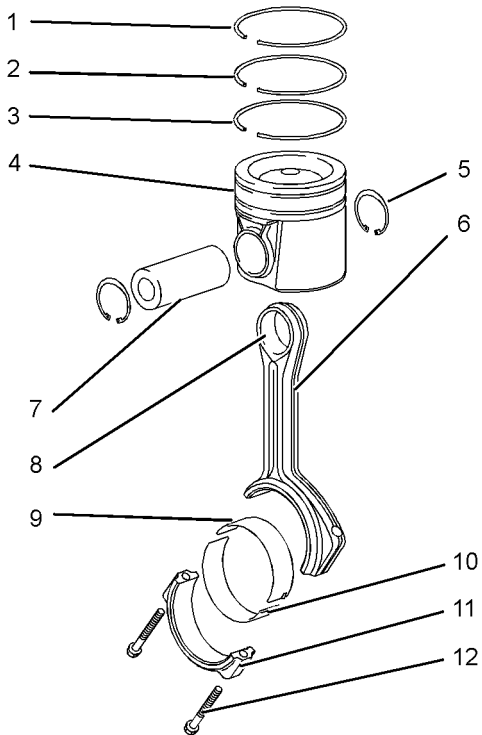


Illustration 306

g01341306

1. 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".

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

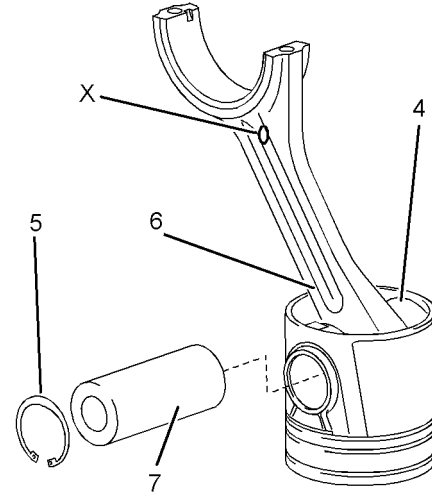


Illustration 307

g01341307

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

Note: The forged marks (X) may be on the front of the connecting rod assembly, or on the rear of the connecting rod assembly. The forged marks should not be used for the purposes of orientation.

4. Remove piston pin (7) and connecting rod (6) from piston (4).

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of $45 \pm 5 \text{ }^\circ\text{C}$ ($113 \pm 9 \text{ }^\circ\text{F}$). Do not use a torch to heat the piston. Note the orientation of connecting rod (6) and piston (4).

5. 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).

NOTICE

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

6. Inspect the connecting rod for wear or damage. If necessary, replace connecting rod (6) or replace the bush for piston pin (8).

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 Rods".

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

i02654529

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 72

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.

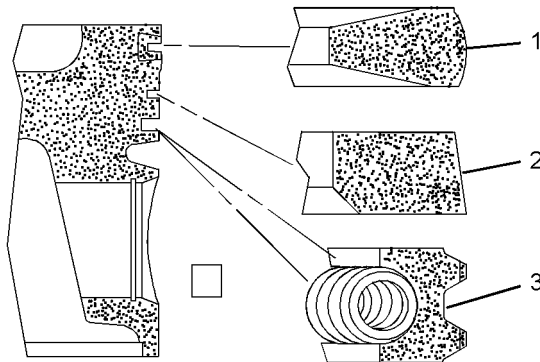


Illustration 308

g01341312

- 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 dealer or your Perkins distributor.

3. If connecting rod assembly (6), (8), (11) and (12) or the bush for piston pin (8) is replaced, ensure that the height grade of the connecting rod is correct. Refer to Specifications, "Connecting Rods" for further information.

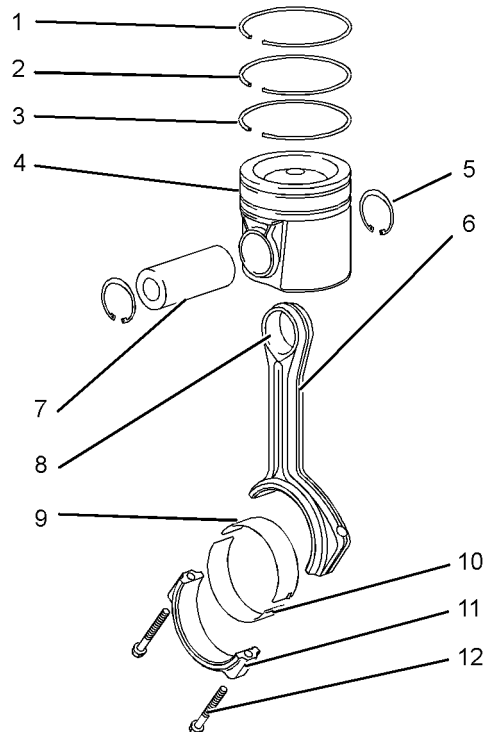


Illustration 309

g01341306

4. Lubricate the bush for piston pin (8) in the connecting rod and lubricate the bore for the piston pin in piston (4) with clean engine oil.

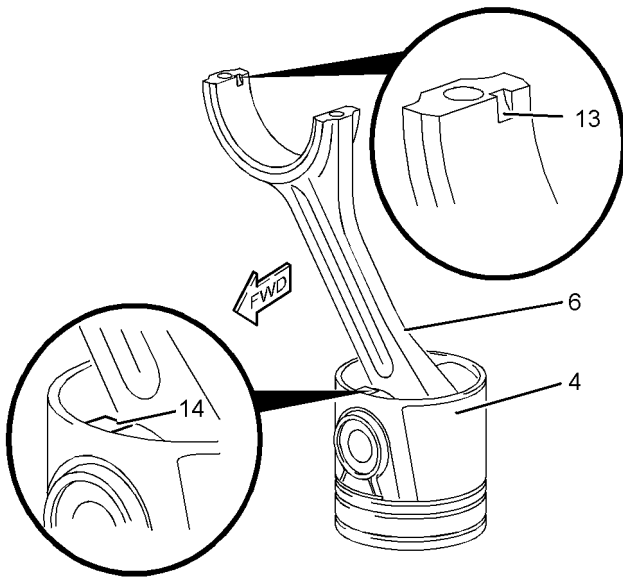


Illustration 310

g01341313

5. Place the piston on a suitable surface with the crown downward. Install connecting rod (6) and piston pin (7) to piston (4). Ensure that square (14) on the piston, and slot (13) on the connecting rod are in the correct position. See illustration 310.

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 circlips (5) to the piston pin bore in piston (4).

Note: Ensure that the circlips are seated in the grooves in the piston.

7. Install upper bearing shell (9) into connecting rod (6). Ensure that the locating tab for the upper bearing shell is correctly seated in the slot in the connecting rod.
8. Install lower bearing shell (10) into connecting rod cap (11). Ensure that the locating tab for the lower bearing shell is correctly seated in the slot in the connecting rod cap.
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".

i02654531

Pistons and Connecting Rods - Install

Installation Procedure

Table 73

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	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 fasteners.

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 bearing shells for the connecting rod.

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

Note: Ensure that the piston and the connecting rod assembly is installed in the correct cylinder.

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.

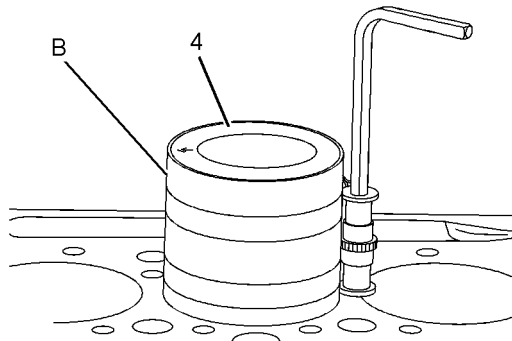


Illustration 311

g01341299

4. Install Tooling (B) onto piston (4).

Note: Ensure that Tooling (B) is installed correctly and that piston (4) can easily slide from the tool.

Note: The arrow on the top of the piston must be toward the front of the engine. The locating tab for the bearing shell of the connecting rod must be on the same side of the engine as the piston cooling jet.

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.

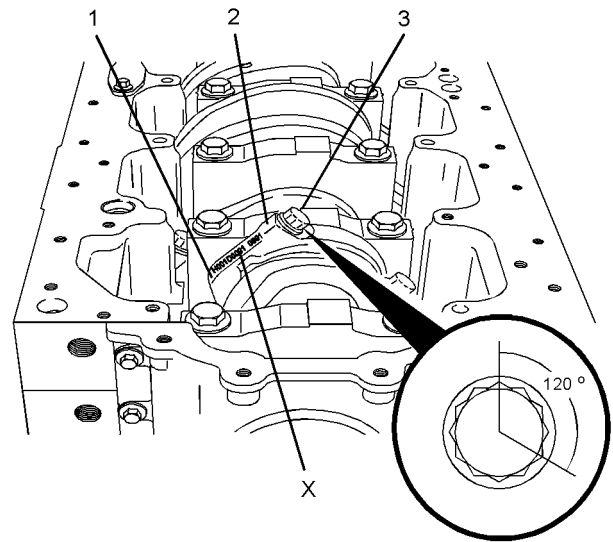


Illustration 312

g01341300

6. Install connecting rod cap (2) onto connecting rod (1).

Note: Ensure that etched number (X) on connecting rod cap (2) matches etched number (X) on connecting rod (1). Ensure the correct orientation of connecting rod cap (2). The locating tab for the upper bearing shell and the lower bearing shell should be on the same side.

7. Install new bolts (3) to connecting rod (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.

8. Tighten the bolts evenly to a torque of 70 N·m (52 lb ft).
9. Turn the bolts for an additional 120 degrees. Use Tooling (C) to achieve the correct final torque.
10. Ensure that the installed connecting rod assembly has tactile side play. Rotate the crankshaft in order to ensure that there is no binding.
11. Repeat Steps 2 through 10 in order to install the remaining pistons and connecting rods.
12. Check the height of the pistons above the top face of the cylinder block. Refer to System 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. 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".

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

Note: Removal of glow plug aids removal of the connecting rod bearing. It is not essential.

i02654459

Connecting Rod Bearings - Remove (Connecting rods in position)

Removal Procedure

Table 74

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

Start By:

- a. 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 fasteners.

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 6, 2 with 5, and 3 with 4. **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.

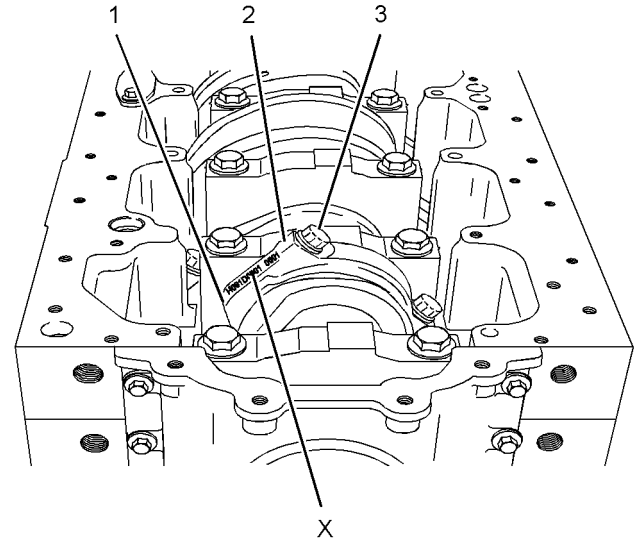


Illustration 313

g01341291

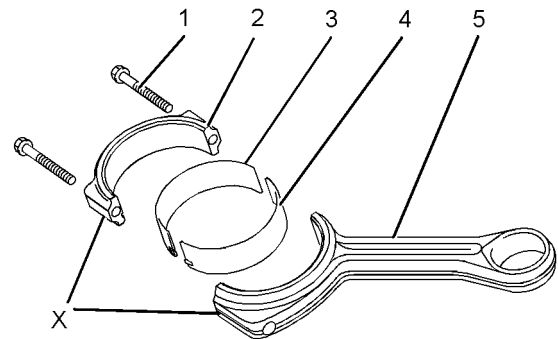


Illustration 314

g01341322

- 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 bolts (1).

4. Remove lower bearing shell (3) from connecting rod cap (2). Keep the bearing shell and the connecting rod cap together.
5. Carefully push connecting rod (5) into the cylinder bore until connecting rod (5) is clear of the crankshaft. Remove upper bearing shell (4) from the connecting rod. Keep the bearing shells 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.

6. Repeat Steps 1 through 5 for the remaining bearing shells.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the bearing shells is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

i02654458

Connecting Rod Bearings - Install (Connecting rods in position)

Installation Procedure

Table 75

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	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 fasteners.

1. Inspect the pins of the crankshaft for damage. If the crankshaft is damaged, replace the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove" and Disassembly and Assembly, "Crankshaft - Install". Ensure that the bearing shells are clean and free from wear or damage. If necessary, replace the bearing shells.

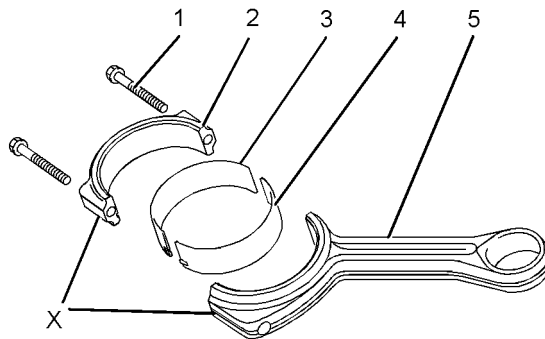


Illustration 315

g01341322

2. Install the upper bearing shell (4) into connecting rod (5). Ensure that the locating tab for the upper bearing shell is correctly seated in the slot in the connecting rod.

Note: The ends of the upper bearing shell must be centered in the connecting rod. The ends of the upper bearing shell must be equally positioned in relation to the mating faces of the connecting rod.

3. Lubricate upper bearing shell (4) with clean engine oil.
4. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom dead center position.
5. Carefully pull connecting rod (5) against the crankshaft pin.

Note: Do not allow the connecting rod to contact the piston cooling jet.

6. Clean connecting rod cap (2). Install lower bearing shell (3) into connecting rod cap (2). Ensure that the locating tab for the lower bearing shell is correctly seated in the slot in the connecting rod cap.

Note: The ends of the lower bearing shell must be centered in the connecting rod cap. The ends of the lower bearing shell must be equally positioned in relation to the mating faces of the connecting rod cap.

7. Lubricate the pin of the crankshaft and lubricate lower bearing shell (3) with clean engine oil.

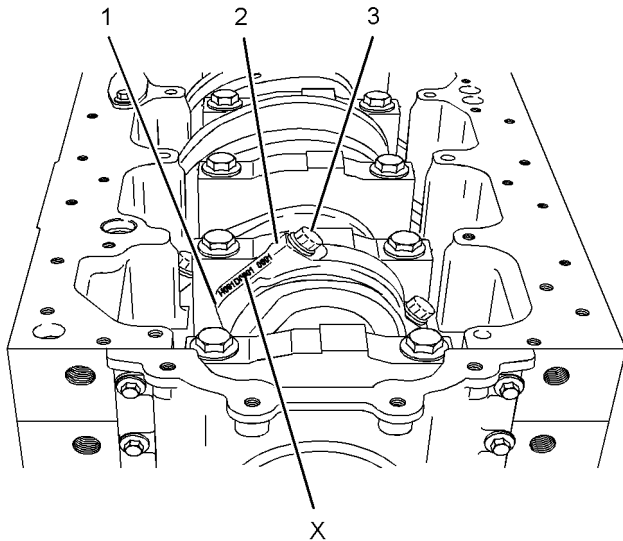


Illustration 316

g01341291

8. Install connecting rod cap (2) to connecting rod (5).

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 locating tab for the upper bearing shell and the lower bearing shell should be on the same side.

9. Install new bolts (1) to the connecting rod. 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. Turn the bolts through an additional 120 degrees. Use Tooling (B) to achieve the correct final torque.

12. Ensure that the installed connecting rod assembly has tactile side play. 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 6, 2 with 5, and 3 with 4. **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".

14. If the glow plugs were removed, install the glow plugs. Ref to Disassembly and Assembly, "Glow Plugs - Remove and Install"

End By:

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

i02654465

Crankshaft Main Bearings - Remove and Install (Crankshaft in position)

Removal Procedure

Table 76

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

Start By:

- a. 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.

1. Ensure that the main bearing cap is marked for the correct location and orientation.

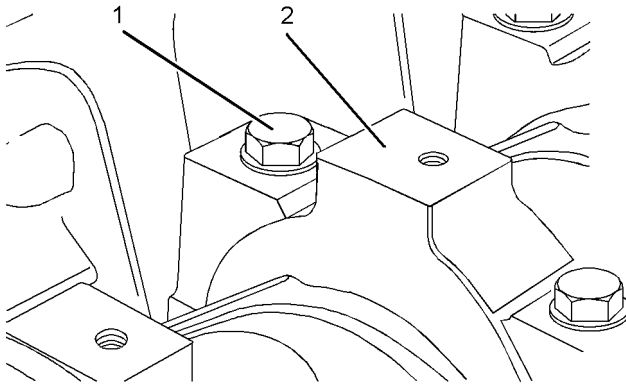


Illustration 317

g01341323

2. Remove bolts (1) and main bearing cap (2) from the cylinder block.

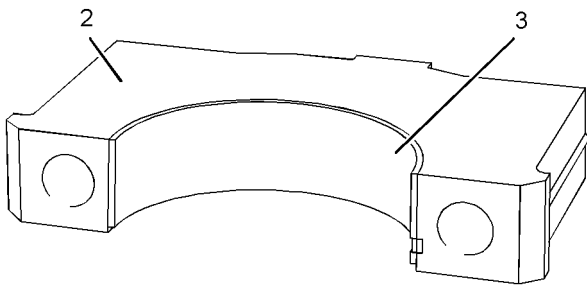


Illustration 318

g01341324

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

Note: The lower main bearing shell is a plain bearing that has no oil holes.

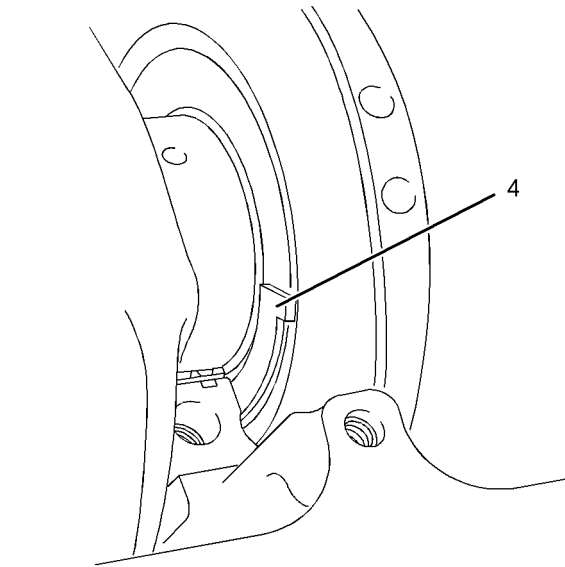


Illustration 319

g01341325

4. For number six main bearing, remove two thrust washers (4) from the cylinder block. In order to remove thrust washers (4), use Tooling (A) to rotate the crankshaft in the correct direction. If necessary, push the crankshaft toward the front of the engine or push the crankshaft toward the rear of the engine while you rotate the crankshaft, in order to aid removal.

Note: The thrust washers have a locating tab at one end.

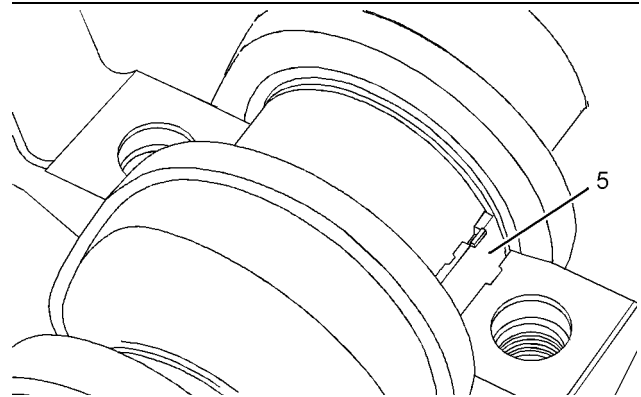


Illustration 320

g01341335

5. Push out upper main bearing shell (5) with a suitable tool from the side opposite the locating tab. Carefully rotate the crankshaft while you push on the bearing shell. Remove upper main bearing shell (5) from the cylinder block. Keep the bearing shells together.

Note: The upper main bearing shell has a groove and two oil holes.

Installation Procedure

Table 77

Required Tools			
Tool	Part Number	Part Name	Qty
B	21825607	Angle Gauge	1
B	21825496	Dial Gauge	1
	-	Magnetic Base	1

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 bearing shells are clean and free from wear or damage. If necessary, replace the main bearing shells.
2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

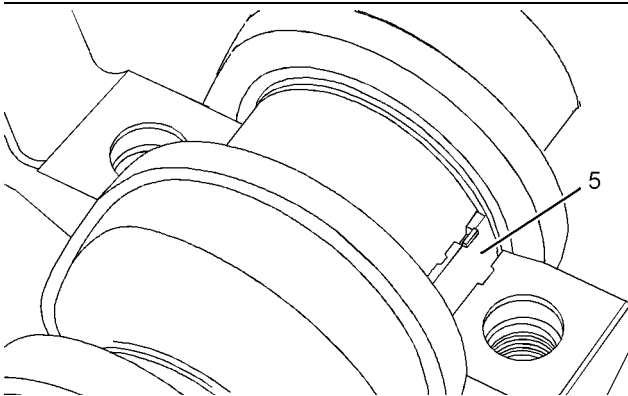


Illustration 321

g01341335

3. Lubricate the crankshaft journal and upper main bearing shell (5) with clean engine oil. Slide upper main bearing shell (5) into position between the crankshaft journal and the cylinder block. Ensure that the locating tab for the upper main bearing shell is correctly seated in the slot in the cylinder block.

Note: The upper main bearing shell has a groove and two oil holes.

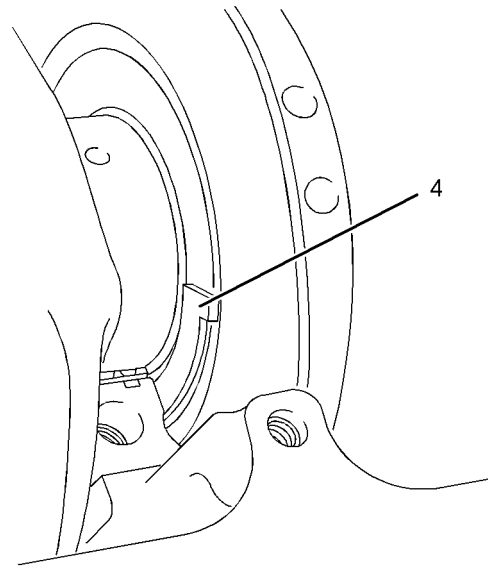


Illustration 322

g01341325

4. For number six main bearing, ensure that two thrust washers (4) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate thrust washers (4) with clean engine oil. Slide thrust washers (4) into position between the crankshaft and the cylinder block. Ensure that the locating tab is correctly seated in the cylinder block.

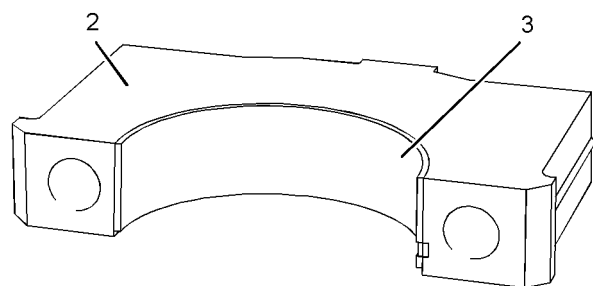


Illustration 323

g01341324

5. Install lower main bearing shell (3) into main bearing cap (2). Ensure that the locating tab for the lower main bearing shell is correctly seated into the slot in the bearing cap.

Note: The lower main bearing shell is a plain bearing that has no oil holes.

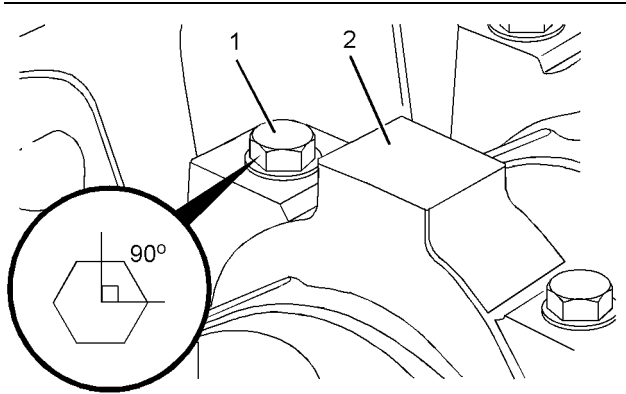


Illustration 324

g01341327

6. Lubricate the crankshaft journal and the lower main bearing shell with clean engine oil. Install main bearing cap (2) 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.

7. Lubricate the threads of bolts (1) with clean engine oil. Lubricate the underside of the heads of bolts (1) with clean engine oil.
8. Install bolts (1) to main bearing cap (2). Evenly tighten the bolts in order to pull cap (2) into position. Ensure that the cap is correctly seated.

Note: Do not tap the main bearing cap into position as the bearing shell may be dislodged.

9. Tighten bolts (1) to a torque of 80 N·m (59 lb ft).

Turn bolts (1) through an additional 90 degrees. Use Tooling B to achieve the correct final torque.

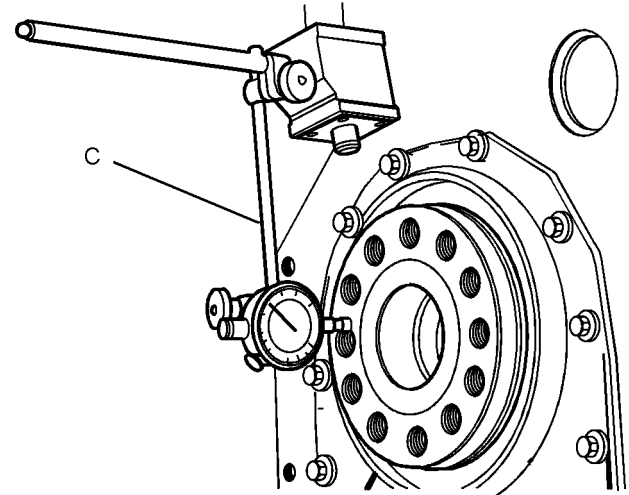


Illustration 325

g01341329

10. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (C) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (C) to measure the crankshaft end play. The permissible crankshaft end play is 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).

End By:

- a. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install”.
- b. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install”.

i02654462

Crankshaft - Remove

Removal Procedure

Table 78

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

Start By:

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

- b. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove".
- c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove".
- d. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove".
- e. If necessary, remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove".
- f. If necessary, remove the pistons and connecting rods. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - 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.

- 1. The engine should be mounted on a suitable stand and placed in the inverted position.
- 2. If the cylinder head, the pistons and the connecting rods have not been removed already, remove the connecting rod bearings. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Remove".
- 3. Ensure that the main bearing caps are marked for the location and orientation.

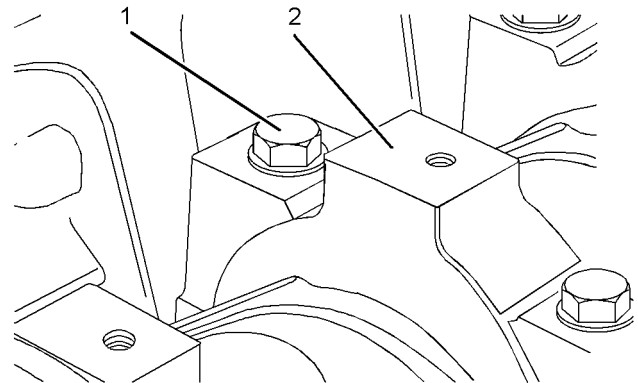


Illustration 326

g01341323

- 4. Remove bolts (1) and main bearing caps (2) from the cylinder block.

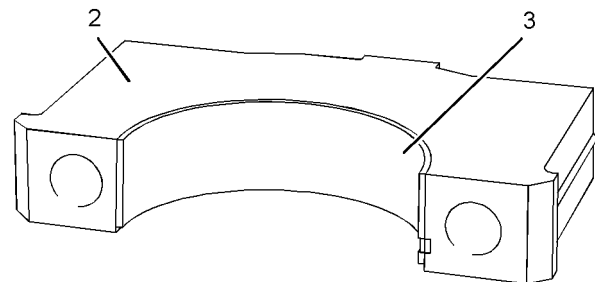


Illustration 327

g01341324

- 5. Remove lower main bearing shells (3) from main bearing caps (2). Keep the lower main bearing shells with the respective main bearing caps.

Note: The lower main bearing shells are plain bearings that have no oil holes.

- 6. Remove the two thrust washers from number six main bearing in the cylinder block.

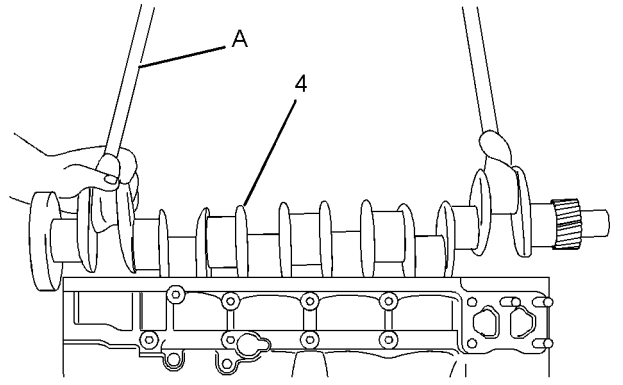


Illustration 328

g01333482

7. Attach Tooling (A) and a suitable lifting device to crankshaft (4). Lift crankshaft (4) out of the cylinder block. The weight of the crankshaft is approximately 61 kg (134.5 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. When the crankshaft is removed from the engine, the crankshaft must be supported on a suitable stand in order to prevent damage to the crankshaft timing ring.

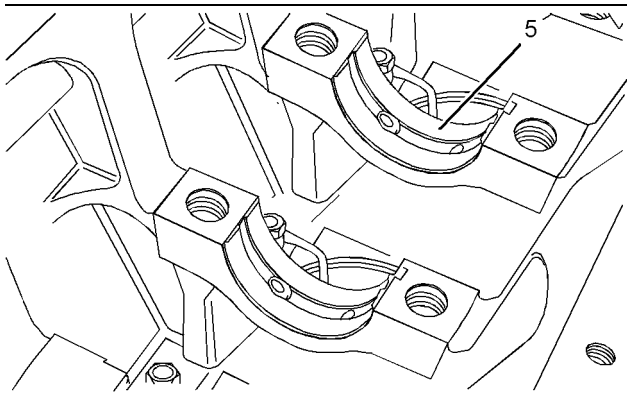


Illustration 329

g01341389

8. Remove upper main bearing shells (5) from the cylinder block. Keep the upper main bearing shells with the respective main bearing caps.

Note: The upper main bearing shells have a groove and two oil holes.

9. If necessary, remove the crankshaft timing ring. Refer to Disassembly and Assembly, "Crankshaft Timing Ring - Remove and Install".

10. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install".

Crankshaft - Install

Installation Procedure

Table 79

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825607	Angle Gauge	1
B	21825617	Dial Indicator Group	1
C	-	Lifting Strap	1

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".
3. If necessary, install a new crankshaft timing ring. Refer to Disassembly and Assembly, "Crankshaft Timing Ring - Remove and Install".
4. Ensure that the parent bores for the bearing shells in the cylinder block are clean. Ensure that the threads for the main bearing bolts in the cylinder block are clean and free from damage.
5. Clean the main bearing shells and the thrust washers. Inspect the main bearing shells and the thrust washers for wear or damage. If necessary, replace the main bearing shells and the thrust washers.

Note: If the main bearing shells are replaced, check whether oversize main bearing shells were previously installed. If the thrust washers are replaced, check whether oversize thrust washers were previously installed.

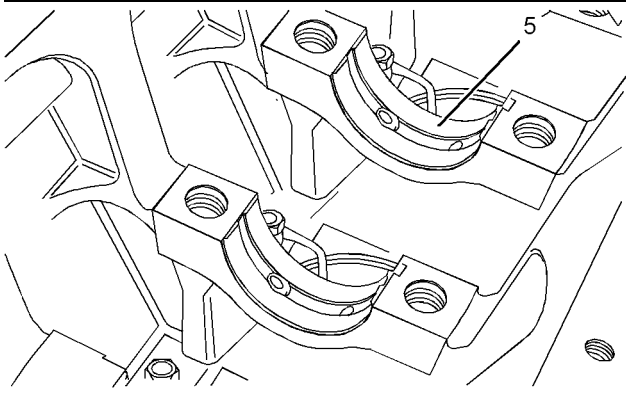


Illustration 330

g01341389

6. Install upper main bearing shells (5) to the cylinder block. Ensure that the locating tabs for the upper main bearing shells are seated in the slots in the cylinder block.

Note: The upper main bearing shells have a groove and two oil holes.

7. Lubricate upper main bearing shells (5) with clean engine oil.

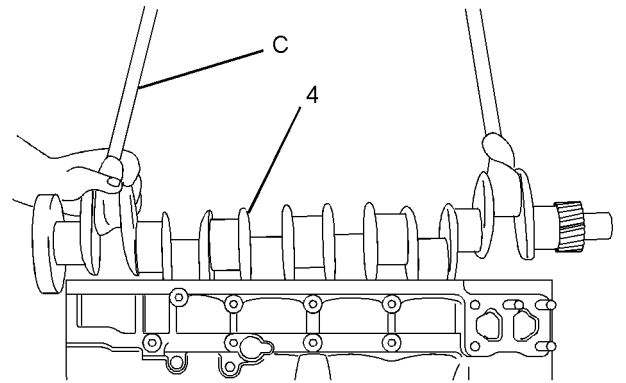


Illustration 331

g01333465

8. Attach Tooling (C) and a suitable lifting device to the crankshaft (4). Lift crankshaft (4) into the cylinder block. The weight of the crankshaft is approximately 61 kg (134.5 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. Do not damage the main bearing shells.

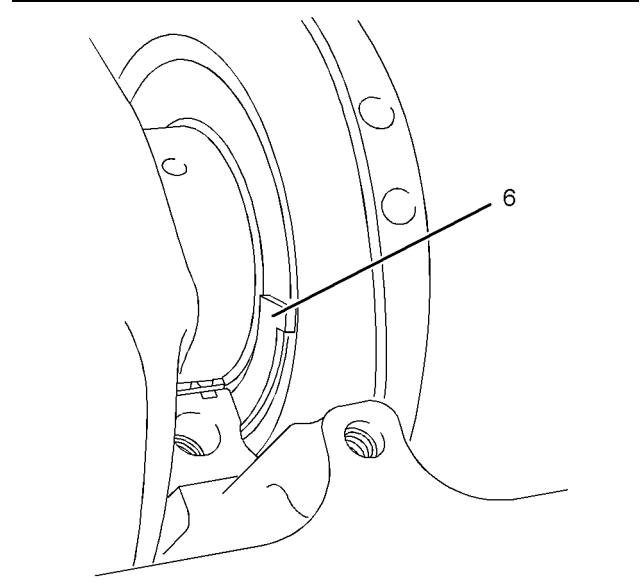


Illustration 332

g01341402

9. Lubricate thrust washers (6) with clean engine oil. Install thrust washers (6) into number six main bearing in the cylinder block.

Note: The grooves in the thrust washers must be located against the crankshaft. The thrust washers have a locating tab at one end. Ensure that the locating tabs are correctly seated in the cylinder block.

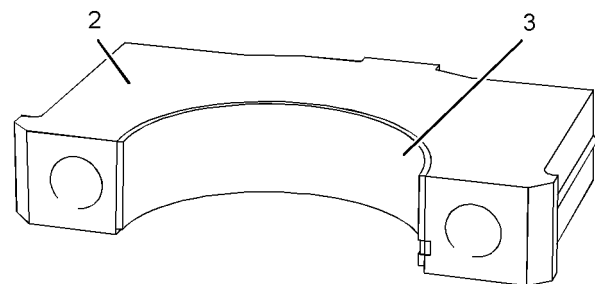


Illustration 333

g01341324

10. Install lower main bearing shells (3) into main bearing caps (2). Ensure that the locating tabs for the lower main bearing shells are correctly seated into the slots in the bearing caps.

Note: The lower main bearing shells are plain bearings that do not have oil holes.

11. Lubricate lower main bearing shells (3) and lubricate the journals of crankshaft (4) with clean engine oil. Install main bearing caps (2) to the cylinder block.

Note: Ensure the correct location and orientation of main bearing caps (2). The locating tabs for the upper and the lower main bearing shells should be on the same side of the engine.

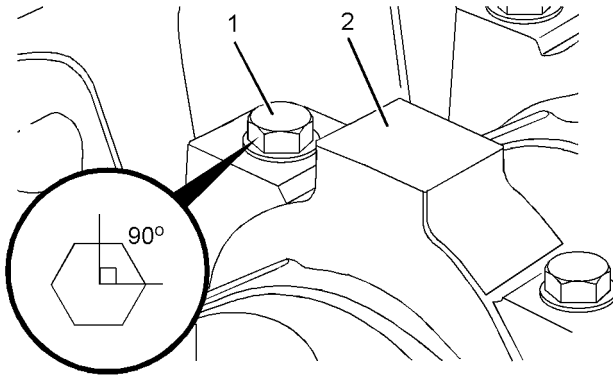


Illustration 334

g01341327

- 12. Lubricate the threads of bolts (1) with clean engine oil. Lubricate the underside of the heads of bolts (1) with clean engine oil.
 - 13. Install bolts (1) to main bearing caps (2). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.
- Note:** Do not tap the main bearing caps into position as the bearing shells may be dislodged.
- 14. Tighten bolts (1) to a torque of 80 N·m (59 lb ft).
Turn bolts (1) through an additional 90 degrees. Use Tooling A to achieve the final torque.
 - 15. Rotate the crankshaft in order to ensure that there is no binding.

- 16. 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 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).
- 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 System Operation, Testing and Adjusting, "Piston Height - Inspect" for more information.
- 18. If the crankshaft has not been replaced or the crankshaft has not been reconditioned, install the connecting rod bearings. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install".

End By:

- a. If necessary, install the pistons and connecting rods. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - Install".
- b. If necessary, install the cylinder head. Refer to Disassembly and Assembly, "Cylinderhead - Install".
- c. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, "Rockershaft and Push Rods - Install".
- d. Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install".
- e. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- f. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

i02654471

Crankshaft Timing Ring - Remove and Install

Removal Procedure

Start By:

- a. If a crankshaft wear sleeve is installed to the crankshaft, remove the crankshaft wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Wear Sleeve - Remove".

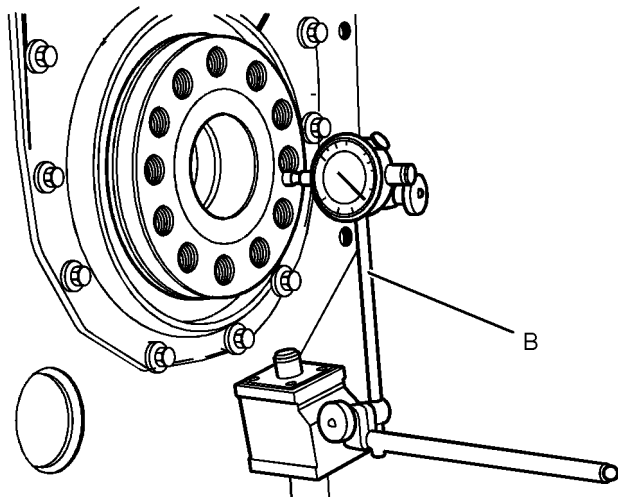


Illustration 335

g01341405

- b. Remove the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

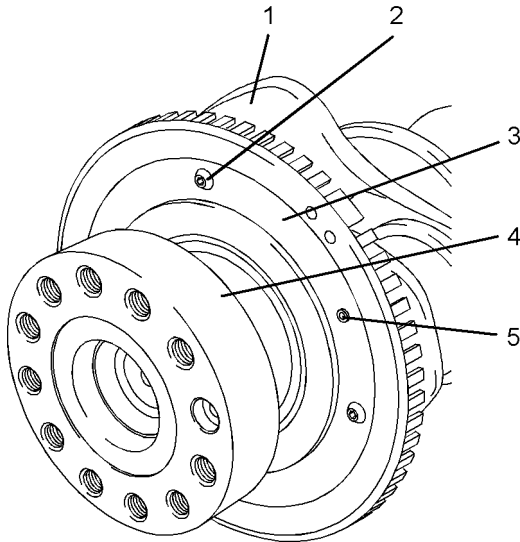


Illustration 336

g01341462

1. Support crankshaft (1) on a suitable stand.
2. Remove Allen head screws (2) from the crankshaft timing ring (3). Do not reuse the allen head screws.
3. Carefully remove crankshaft timing ring (3) from crankshaft (1). Do not reuse the crankshaft timing ring.

Note: Ensure that seal surface (4) of the crankshaft is not damaged when the crankshaft timing ring is removed.

Note: Do not remove dowel (5) from crankshaft (1) unless the dowel is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the flange for the crankshaft timing ring on the crankshaft is clean and free from damage.

2. Support crankshaft (1) on a suitable stand.

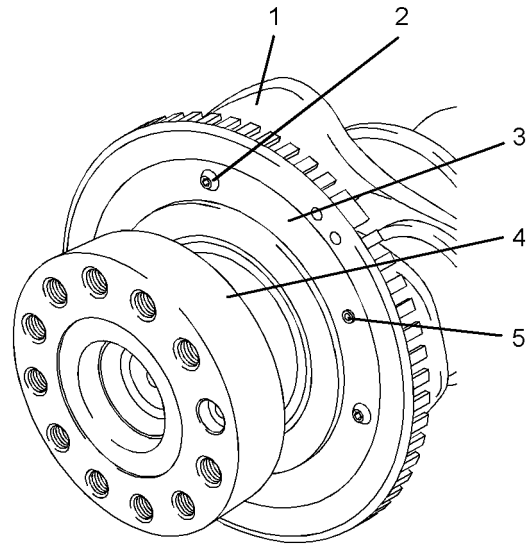


Illustration 337

g01341462

3. If dowel (5) was removed, install a new dowel to crankshaft (1).
4. Position new crankshaft timing ring (3) on the crankshaft with the teeth toward the crankshaft web. Align the hole in crankshaft timing ring (3) with dowel (5) in the crankshaft. Carefully install crankshaft timing ring (3) to the crankshaft (1).

Note: Ensure that seal surface (4) on the crankshaft is not damaged when the crankshaft timing ring is installed.

5. Install new Allen head screws (2). Tighten the Allen head screws to a torque of 9 N·m (80 lb in).

End By:

- a. Install the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Install".
- b. If a crankshaft wear sleeve was previously installed to the crankshaft, install a new crankshaft wear sleeve. Refer to Disassembly and Assembly, "Crankshaft Wear Sleeve - Install".

i02654464

Crankshaft Gear - Remove and Install

Removal Procedure

Table 80

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. 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.

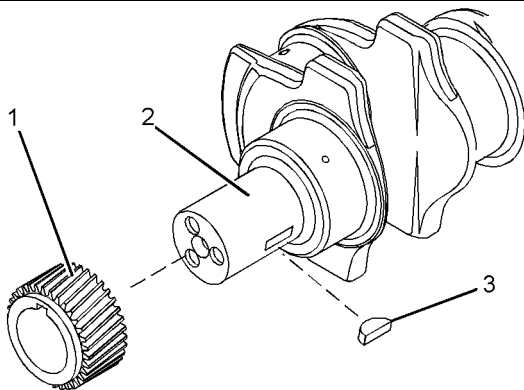


Illustration 338

g01341481

Typical example

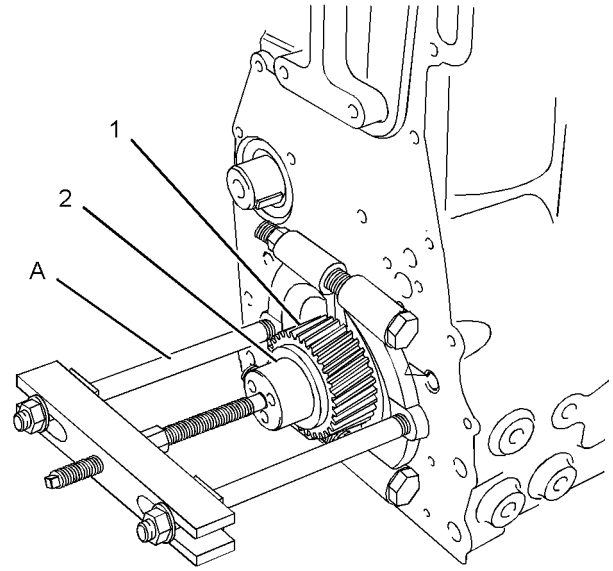


Illustration 339

g01341488

Typical example

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.

i02748526

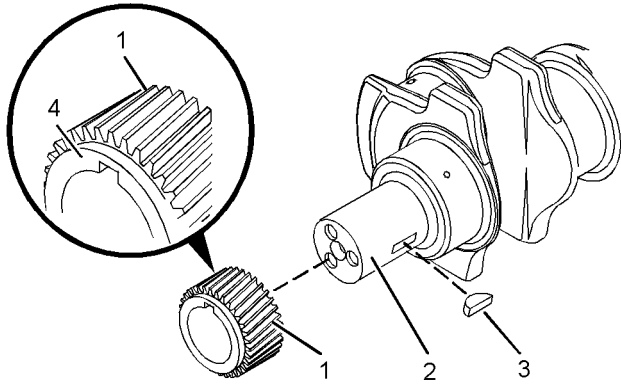


Illustration 340

g01341493

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 on 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 on crankshaft gear (1) with key (3) in the crankshaft. Install crankshaft gear (1) to crankshaft (2).

Ensure that shoulder (4) of crankshaft gear (1) is toward the front of the engine.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install".

Bearing Clearance - Check

Measurement Procedure

Table 81

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:

i02654468

- 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 341.

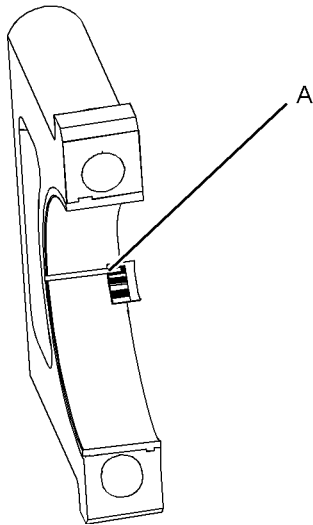


Illustration 341
Typical Example g01152855

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.

Crankshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

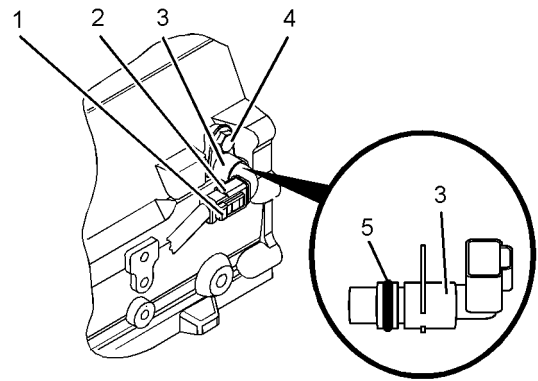


Illustration 342 g01341527

1. Slide locking tab (1) into the unlocked position.
 2. Disconnect harness assembly (2) from position sensor (3).
 3. Remove bolt (4).
 4. Carefully remove position sensor (3) from the cylinder block.
- Note:** Do not use a lever to remove the position sensor from the cylinder block.
5. Remove O-ring seal (5) from position sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

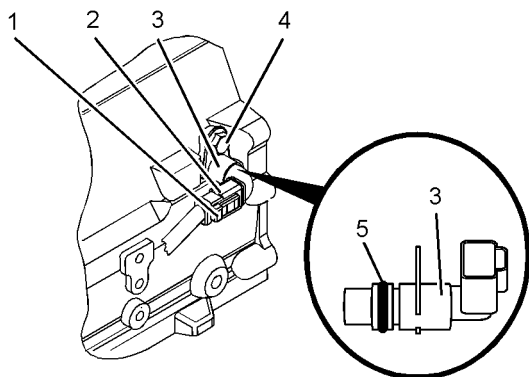


Illustration 343

g01341527

1. Lubricate a new O-ring seal (5) with clean engine oil. Install the new O-ring seal to the first groove on position sensor (3).
 2. Align the hole in position sensor (3) with the hole in the cylinder block. Install the position sensor to the cylinder block.
- Note:** Do not use bolt (4) to pull the position sensor into position against the cylinder block.
3. Install bolt (4). Tighten the bolt to a torque of 22 N·m (16 lb ft).
 4. Connect harness assembly (2) to position sensor (3).
 5. Slide locking tab (1) into the locked position.

i02654535

Position Sensor (Fuel Injection Pump) - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

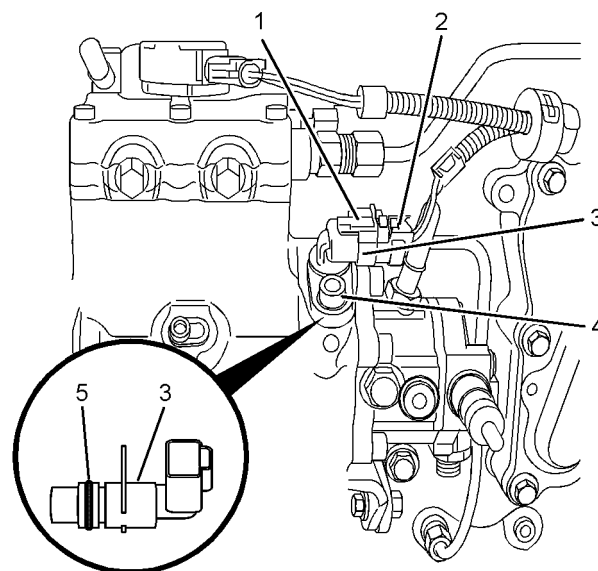


Illustration 344

g01341704

Typical example

1. Slide locking tab (1) into the unlocked position.
 2. Disconnect harness assembly (2) from position sensor (3).
 3. Remove bolt (4).
 4. Carefully remove position sensor (3) from the fuel injection pump.
- Note:** Do not use a lever to remove the position sensor from the fuel injection pump.
5. Plug the hole for the position sensor in the fuel injection pump with a new plug.
 6. Remove O-ring seal (5) from position sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

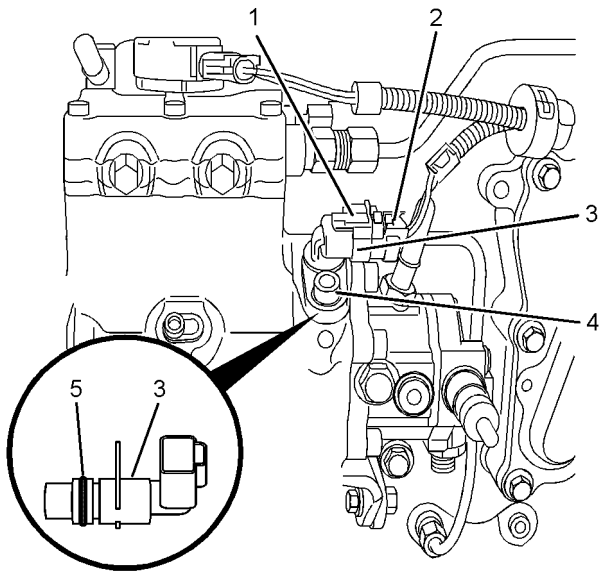


Illustration 345 g01341704
Typical example

1. Lubricate a new O-ring seal (5) with clean engine oil. Install the new O-ring seal into the first groove in position sensor (3).
 2. Remove the plug from the hole in the fuel injection pump for the position sensor.
 3. Align the hole in position sensor (3) with the hole in the fuel injection pump. Install the position sensor to the fuel injection pump.
- Note:** Do not use bolt (4) to pull the position sensor into position against the fuel injection pump.
4. Install bolt (4). Tighten the bolt to a torque of 22 N·m (16 lb ft).
 5. Connect harness assembly (2) to position sensor (3).
 6. Slide locking tab (1) into the locked position.

i02654460

Coolant Temperature Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system, to a level below the coolant temperature sensor, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.

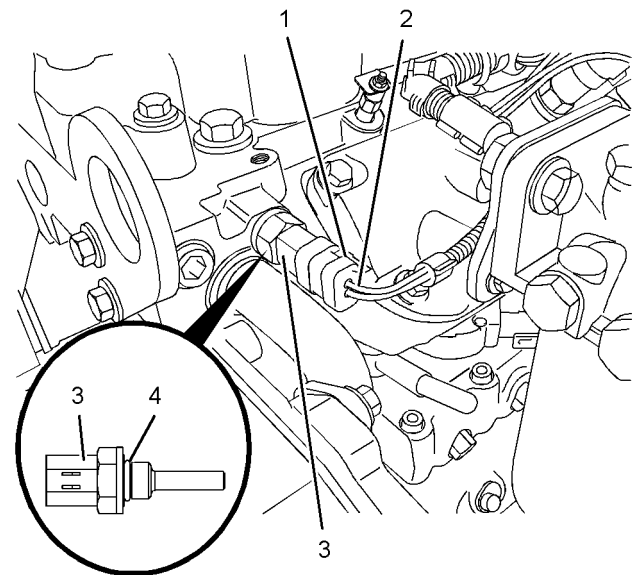


Illustration 346 g01341684

2. Slide locking tab (1) into the unlocked position.
3. Disconnect harness assembly (2) from coolant temperature sensor (3).
4. Use a deep socket in order to remove coolant temperature sensor (3) from the cylinder head.
5. Remove O-ring seal (4) from the coolant temperature sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

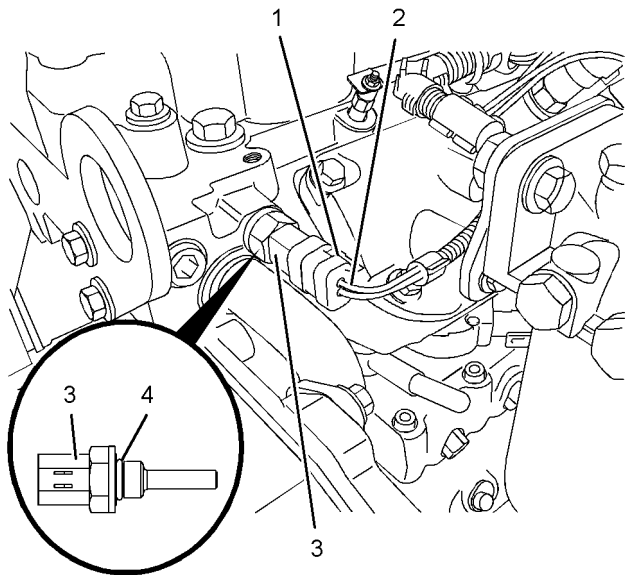


Illustration 347

g01341684

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto coolant temperature sensor (3).
2. Use a deep socket in order to install coolant temperature sensor (3) to the cylinder head. Tighten the coolant temperature sensor to a torque of 15 N·m (11 lb ft).
3. Connect harness assembly (2) to coolant temperature sensor (3).
4. Slide locking tab (1) into the locked position.
5. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant Level - Check" and refer to Operation and Maintenance Manual, "Cooling System Coolant - Test/Add" for the correct filling procedure.

i02654485

Engine Oil Pressure Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

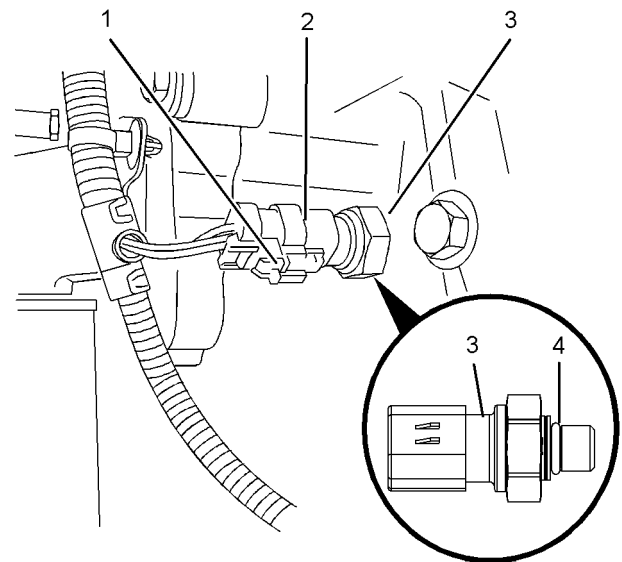


Illustration 348

g01341698

1. Slide locking tab (1) into the unlocked position.
2. Disconnect harness assembly (2) from engine oil pressure sensor (3).
3. Use a deep socket to remove engine oil pressure sensor (3) from the cylinder block.
4. Remove O-ring seal (4) from engine oil pressure sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

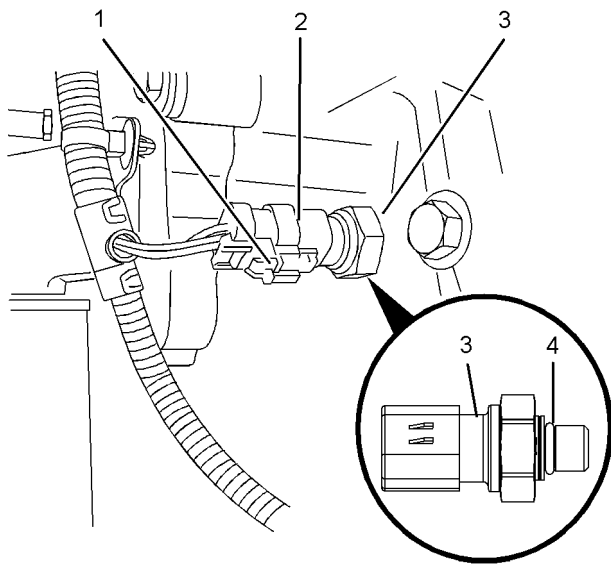


Illustration 349

g01341698

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto engine oil pressure sensor (3).
2. Use a deep socket to install engine oil pressure sensor (3) to the cylinder block. Tighten the engine oil pressure sensor to a torque of 10 N·m (89 lb in).
3. Connect harness assembly (2) to engine oil pressure sensor (3).
4. Slide locking tab (1) into the locked position.
5. If necessary, fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check".

i02654511

Fuel Pressure Sensor - Remove and Install

Removal Procedure

Table 82

Required Tools			
Tool	Part Number	Part Name	Qty
A	-	Seal Pick	1

WARNING

Contact with high pressure fuel may cause fluid penetration and burn hazards. High pressure fuel spray may cause a fire hazard. Failure to follow these inspection, maintenance and service instructions may cause personal injury or death.

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorised personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

1. If the engine is equipped with a cover over the fuel system this will need to be removed.

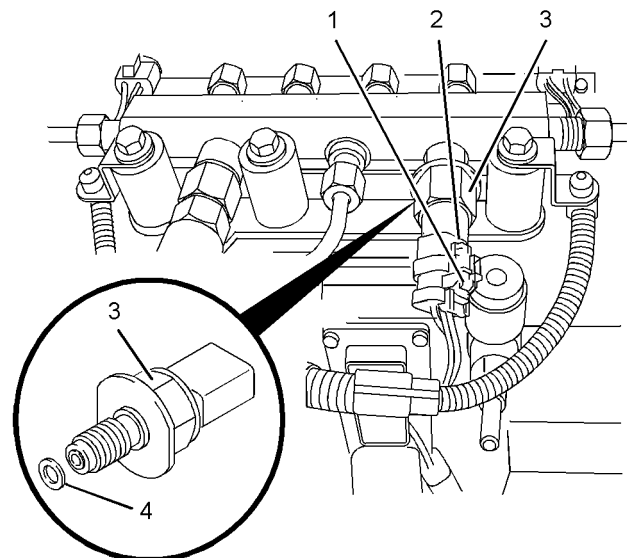


Illustration 350

g01341712

- 1.
2. Slide locking tab (1) into the unlocked position.
3. Disconnect harness assembly (2) from fuel pressure sensor (3).
4. Place a suitable container below fuel pressure sensor (3) in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

5. Use a deep socket to remove fuel pressure sensor (3) from the fuel manifold.
6. Use Tooling (A) in order to remove sealing washer (4) from the fuel manifold.

Note: Ensure that no debris enters the fuel manifold during the removal of the sealing washer.

7. Plug the open port in the fuel manifold immediately with a new plug.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

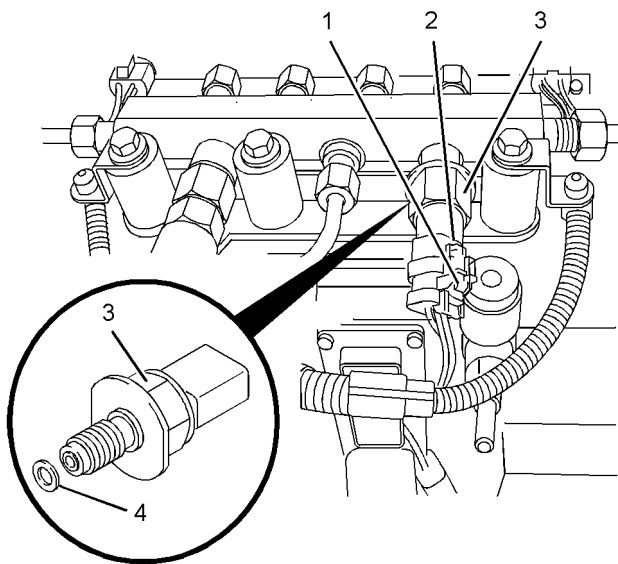


Illustration 351

g01341712

1. Position a new sealing washer (4) on fuel pressure sensor (3).
2. Remove the plug from the fuel manifold.
3. Use a deep socket to install fuel pressure sensor (3) to the fuel manifold. Tighten the fuel pressure sensor to a torque of 34 N·m (25 lb ft).
4. Connect harness assembly (2) to fuel pressure sensor (3).
5. Slide locking tab (1) into the locked position.

6. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".
7. If the engine is equipped with a cover over the fuel system this will need to be installed.

i02654454

Boost Pressure Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

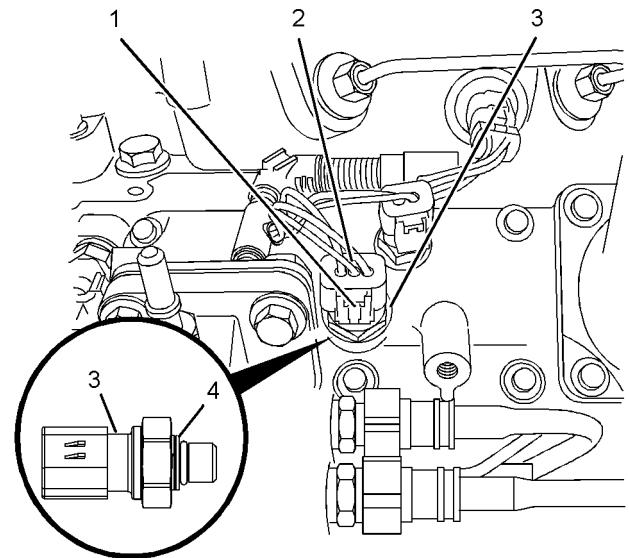


Illustration 352

g01341717

1. Slide locking tab (1) into the unlocked position.
2. Disconnect harness assembly (2) from boost pressure sensor (3).

Note: The boost pressure sensor has a three-wire plug.

3. Use a deep socket to remove boost pressure sensor (3) from the inlet manifold.
4. Remove O-ring seal (4) from the boost pressure sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

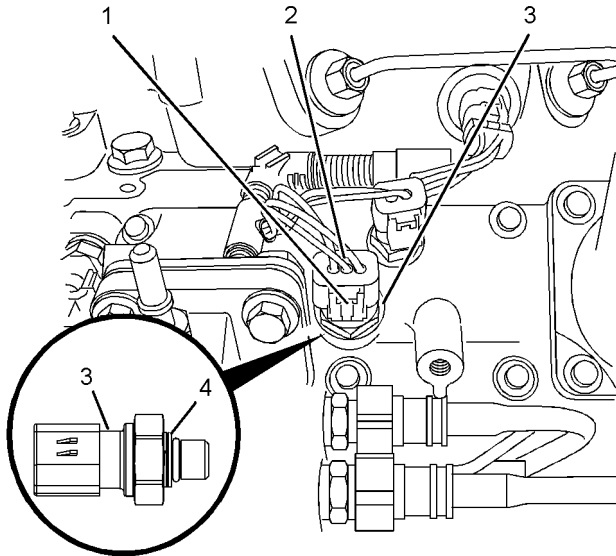


Illustration 353

g01341717

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto boost pressure sensor (3).
2. Use a deep socket to install boost pressure sensor (3) to the inlet manifold. Tighten the boost pressure sensor to a torque of 10 N·m (89 lb in).
3. Connect harness assembly (2) to boost pressure sensor (3).
4. Slide locking tab (1) into the locked position.

i02654521

Inlet Air Temperature Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

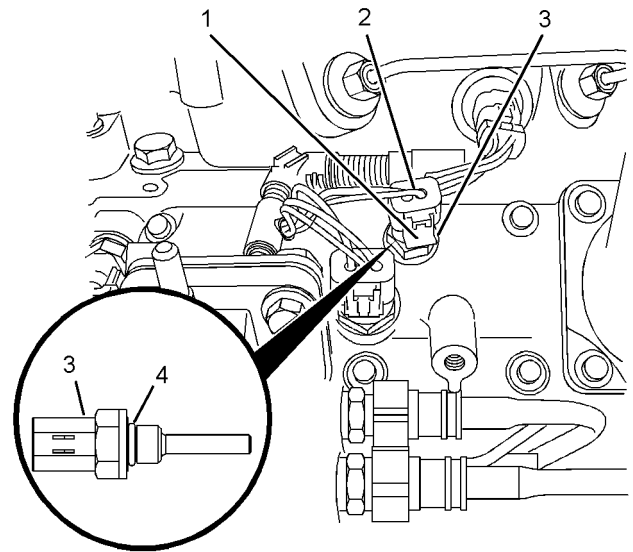


Illustration 354

g01341729

1. Slide locking tab (1) into the unlocked position.
2. Disconnect harness assembly (2) from inlet air pressure sensor (3).

Note: The inlet air temperature sensor has a two wire plug.

3. Use a deep socket in order to remove inlet air temperature sensor (3) from the inlet manifold.
4. Remove O-ring seal (4) from inlet air temperature sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

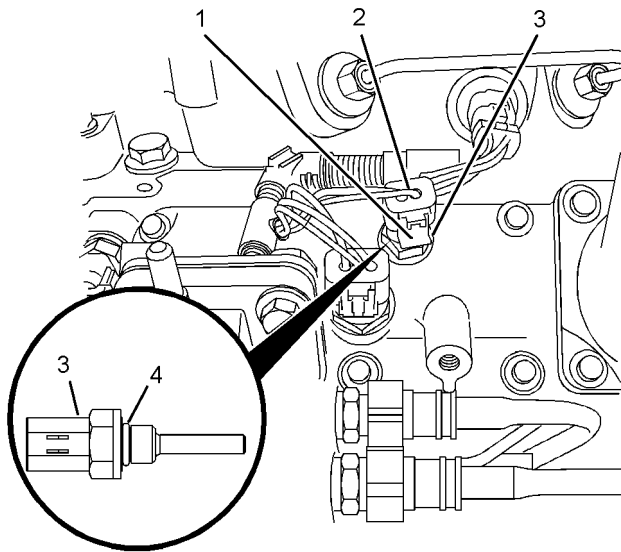


Illustration 355

g01341729

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto the inlet air temperature sensor.
2. Install inlet air temperature sensor (3) to the inlet manifold. Use a deep socket in order to tighten the inlet air temperature sensor to a torque of 20 N·m (15 lb ft).
3. Connect harness assembly (2) to inlet air temperature sensor (3).
4. Slide locking tab (1) into the locked position.

i02654516

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. Disconnect the breather hose from the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove".

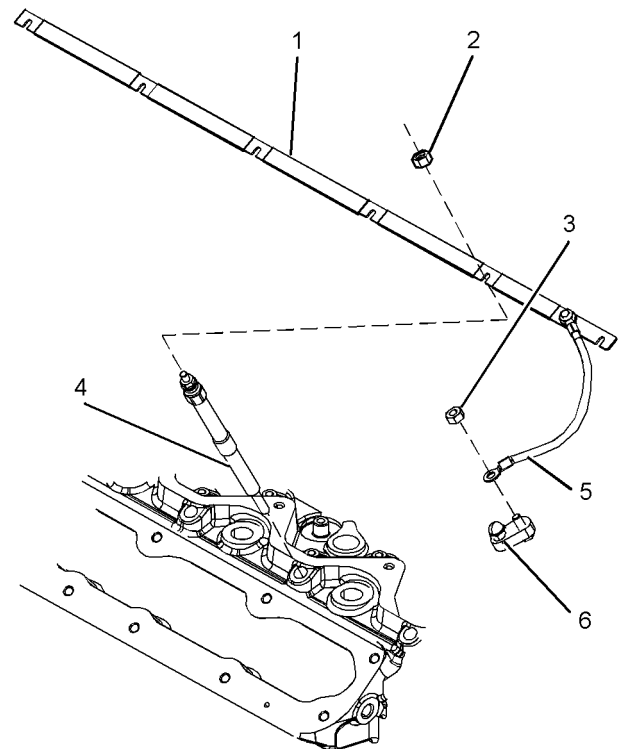


Illustration 356

g01341735

3. Remove nut (3) from terminal insulator (6).
4. Disconnect wire (5) from terminal insulator (6).
5. Remove nuts (2) that secure bus bar (1) to glow plugs (4).
6. Remove bus bar (1) from glow plugs (4).
7. Remove glow plugs (4) from cylinder head.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i02654452

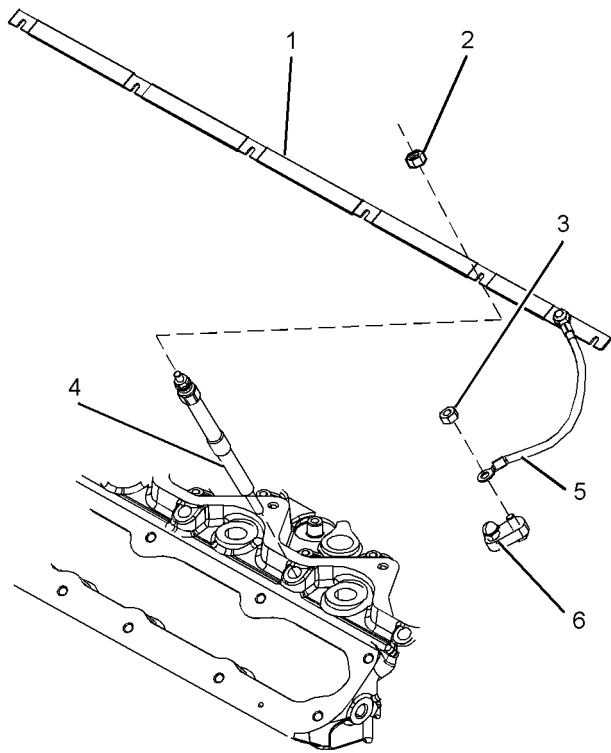


Illustration 357

g01341735

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.
2. Install glow plugs (4) 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 (4). Install nuts (2) onto the glow plugs. Tighten the nuts to a torque of 2 N·m (17 lb in).
4. Connect wire (5) to the stud on terminal insulator (6).
5. Install nut (3) to the stud on terminal insulator (6). Tighten the nut to a torque of 6 N·m (53 lb in).
6. Connect the breather hose to the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Install".
7. Restore the electrical supply to the engine.

Alternator Belt - Remove and Install

Removal Procedure

Table 83

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.

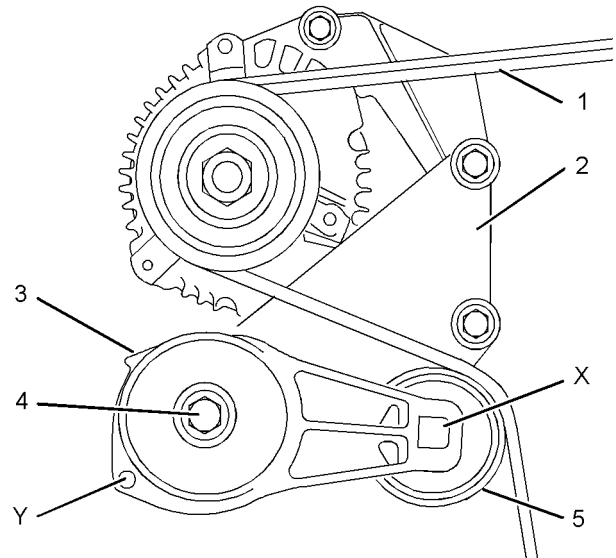


Illustration 358

g01341758

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 the 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 84

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Locking Pin (Ø 8mm by 85 mm)	1

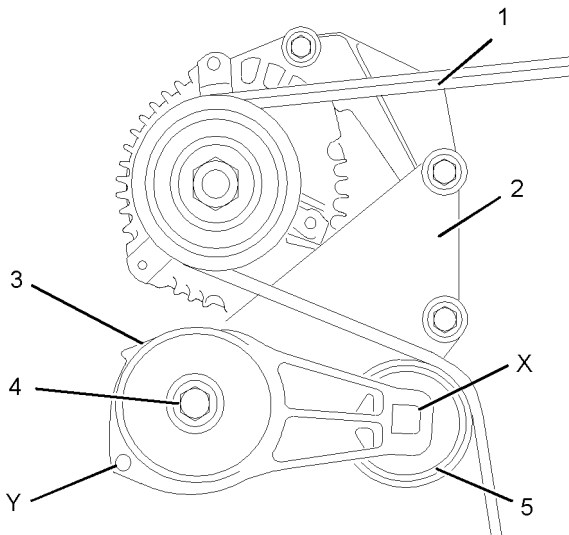


Illustration 359

g01156850

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 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 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.

i02654363

Fan - Remove and Install

Removal Procedure

Start By:

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

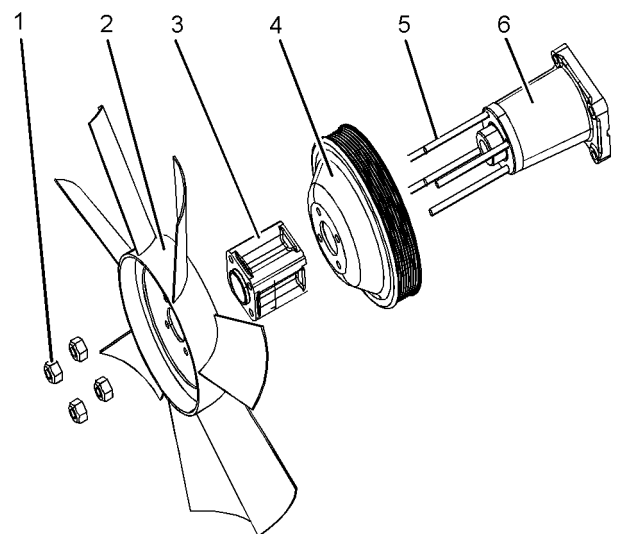


Illustration 360

g01341776

Typical example

i02654491

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.

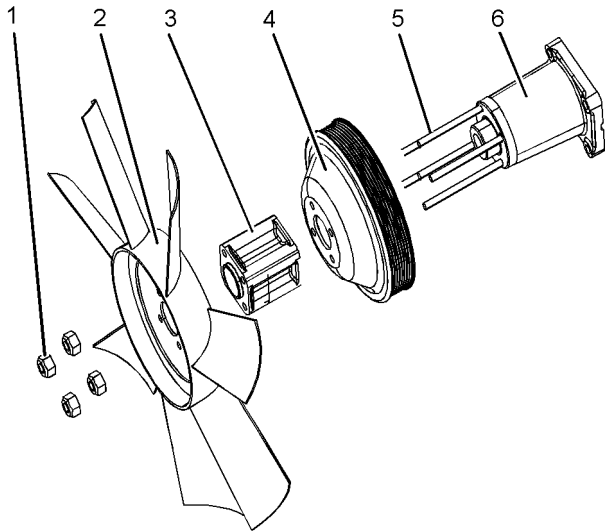


Illustration 361 g01341776
Typical example

2. If necessary, install studs (5) to fan drive (6). Tighten studs (5) to a torque of 11 N·m (97 lb in).
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). Tighten locking nuts (1) to a torque of 22 N·m (16 lb ft).

End By:

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

Fan Drive - Remove and Install

Removal Procedure

Start By:

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

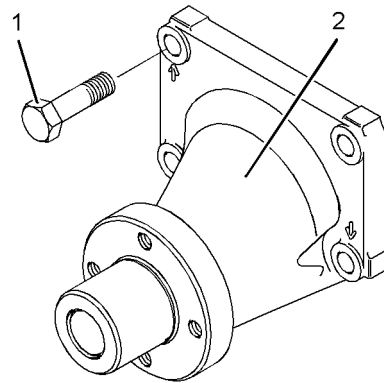


Illustration 362 g01341855

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

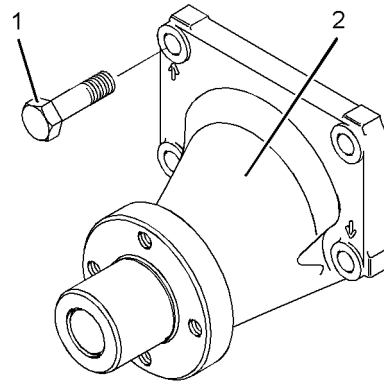


Illustration 363 g01341855

1. Check the fan drive for wear or damage. If the fan drive is worn or damaged, replace the fan drive.
2. Install fan drive (2).
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".

i02654480

Electronic Control Module - Remove and Install

Removal Procedure

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the fuel system, refer to Operation and Maintenance Manual, "General Hazard Information and High Pressure Fuel Lines" for safety information.

Refer to System Operation, Testing and Adjusting, "Cleanliness of Fuel System Components" for detailed information on the standards of cleanliness that must be observed during ALL work on the fuel system.

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

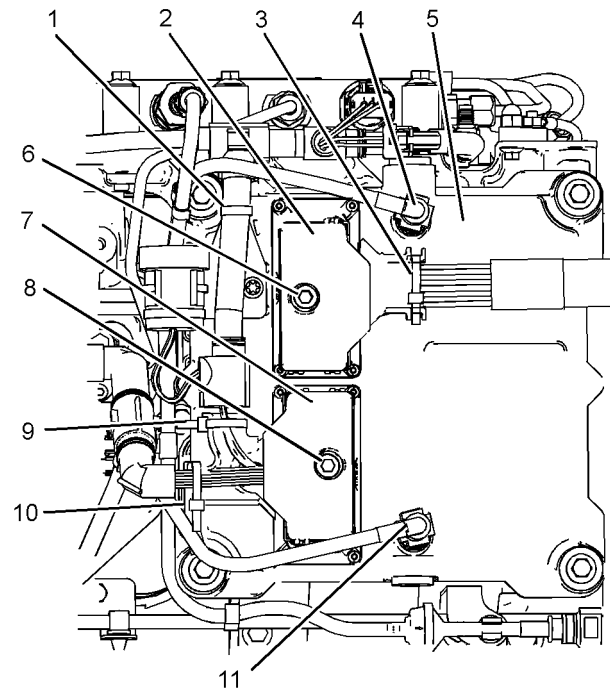


Illustration 364

g01341877

Typical example

3. Cut cable tie (3). Unscrew the fastener (6) that secures the OEM harness (2) to the electronic control module (5). Disconnect the OEM harness from the electronic control module.
4. Cut the cable straps (1), (9) and (10). Unscrew the fastener (8) that secures engine harness (7) to electronic control module (5). Disconnect the engine harness from the electronic control module.
5. Make temporary identification marks on plastic tube assemblies (4) and (11) in order to show the correct position of the tube assemblies.
6. Place a suitable container below the electronic control module (5) in order to catch any fuel that might be spilled.
7. Disconnect plastic tube assemblies (4) and (11). Plug the plastic tube assemblies with new plugs. Drain the fuel from electronic control module (5). Cap the connectors in the electronic control module with new caps.

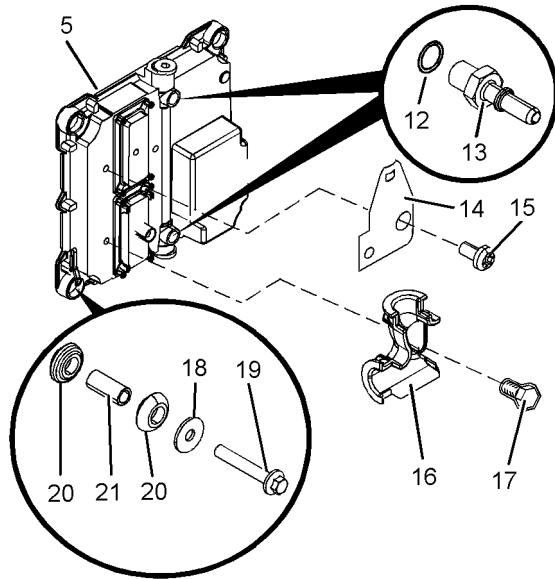


Illustration 365
Typical example g01341878

8. Loosen bolts (19) and remove the assembly of the electronic control module. Note the orientation of the electronic control module.
9. Remove bolts (19) and remove washers (18) from electronic control module (5). Note the position of the ground strap for the electronic control module.
10. If necessary, follow Steps 10.a through 10.d in order to disassemble the electronic control module.
 - a. Remove isolation mounts (20) and spacers (21).
 - b. Remove connectors (13). Remove the O-ring seals (12) from the connectors.
 - c. Remove torx screw (15) and remove bracket (14) for the engine wiring harness. Note the orientation of the bracket.
 - d. Remove bolt (17) and remove bracket (16) from the engine wiring harness. Note the orientation of the bracket.

Installation Procedure

1. If a replacement electronic control module is installed, the module must be programmed with the correct information. Refer to Troubleshooting Guide, "Replacing the ECM" and refer to Troubleshooting Guide, "Flash Programming" for the correct procedure.
2. Ensure that the electronic control module is clean and free from damage. If necessary, replace the electronic control module.

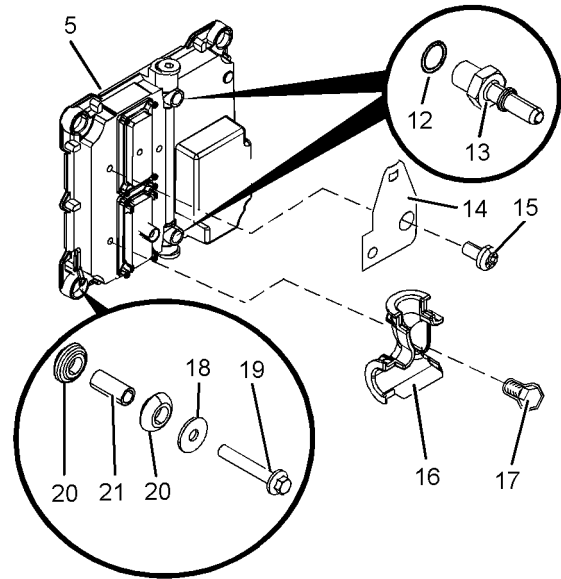


Illustration 366
Typical example g01341878

3. If necessary, follow Steps 3.a through 3.d in order to assemble the electronic control module.
 - a. Install new O-ring seals (12) to connectors (13). Install two connectors (13) to the electronic control module. Tighten the connectors to a torque of 18.5 N·m (13.6 lb ft).
 - b. Position bracket (14) on the electronic control module. Ensure that the bracket is correctly oriented. Install torx screw (15). Tighten the torx screw to a torque of 20 N·m (14 lb ft).
 - c. Position bracket (16) on electronic control module (5). Ensure that the bracket is correctly oriented. Install bolt (17). Tighten the bolt to a torque of 20 N·m (14 lb ft).
 - d. Install isolation mounts (20) and spacers (21) to the electronic control module.
4. Install washers (18) and bolts (19) to electronic control module (5).

Note: Ensure that the ground strap for the electronic control module is clamped between the washer and the appropriate bolt.

5. Install the assembly of the electronic control module to the mounting bracket. Tighten bolts (19) to a torque of 22 N·m (16 lb ft).

Note: Ensure that the electronic control module is correctly oriented. Ensure that the ground strap is not strained as the bolt is tightened.

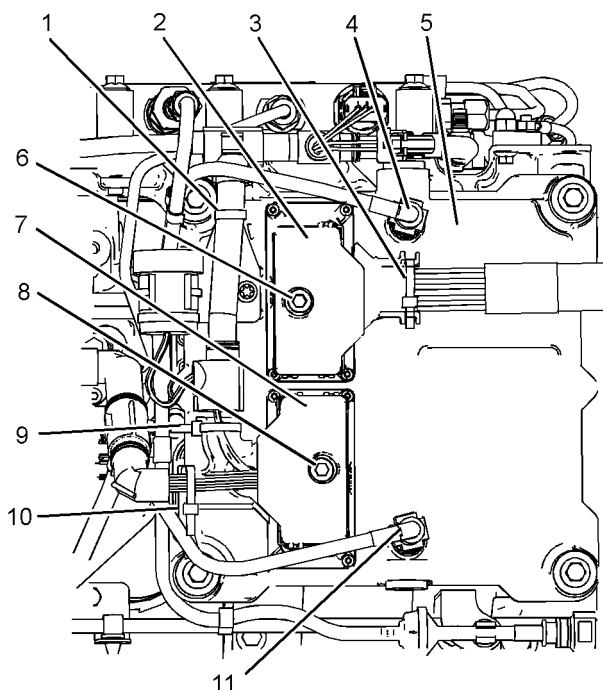


Illustration 367

g01341877

Typical example

6. Remove the plugs from plastic tube assemblies (4) and (11). If necessary, remove the caps from the connectors in the electronic control module. Connect plastic tube assemblies (4) and (11).

7. Connect engine wiring harness (7) to electronic control module (5). Tighten the fastener (8) to a torque of 5 N·m (3 lb ft).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness.

8. Position the assembly of the engine wiring harness onto brackets (14) and (16). Use new cable straps (1), (9) and (10) in order to secure the harness assembly to the brackets.

9. Connect OEM wiring harness (2) to electronic control module (5). Tighten fastener (6) to a torque of 5 N·m (3 lb ft).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness.

10. Use a new cable strap (3) in order to secure the harness assembly.

11. Restore the fuel supply to the engine.

12. Restore the electrical supply to the engine.

13. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i02654477

ECM Mounting Bracket - Remove and Install

Removal Procedure

Start By:

- a. Remove the electronic control module. Refer to Disassembly and Assembly, "Electronic Control Module - Remove and Install".

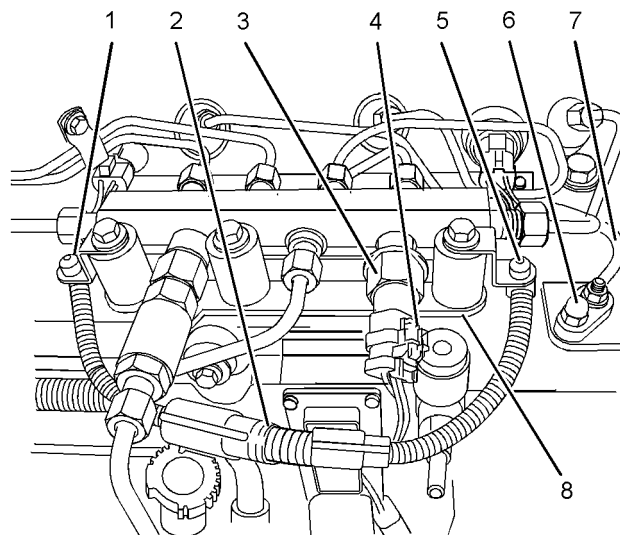


Illustration 368

g01342045

1. Follow Steps 1.a through 1.c in order to disconnect engine wiring harness (2) .

a. Slide locking tab (4) into the unlocked position.

b. Disconnect harness assembly (2) from fuel pressure sensor (3).

c. Cut cable straps (1) and (5). Position harness assembly (2) so that the harness assembly is clear of mounting bracket (8).

2. Disconnect wire (7) for the glow plugs. Remove terminal insulator (6) from mounting bracket (8). Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install" for the correct procedure.

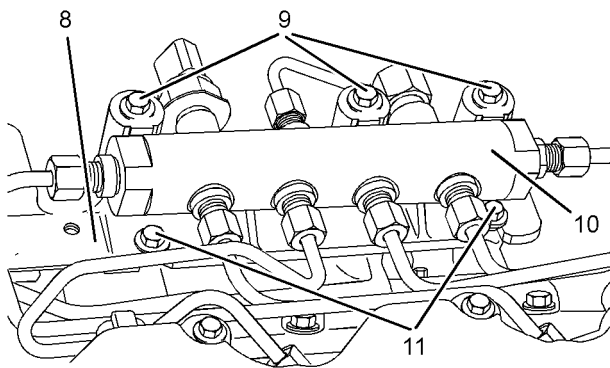


Illustration 369

g01342046

3. Remove bolts (9) from fuel manifold (10).
4. Loosen bolts (11) that secure mounting bracket (8) to the inlet manifold.

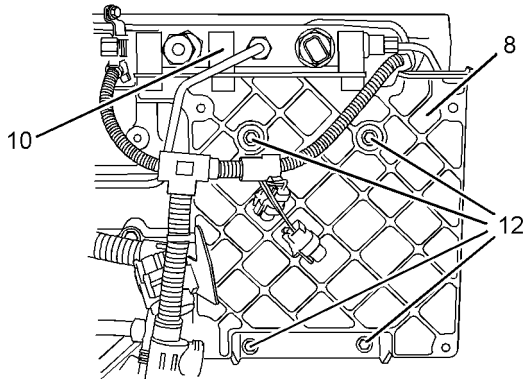


Illustration 370

g01342051

5. Remove bolts (12) that secure mounting bracket (8) to the cylinder block.
6. Slide mounting bracket (8) horizontally away from the cylinder block in order to remove the mounting bracket.

Note: Avoid placing any strain on the fuel injection lines when the fuel manifold is not supported by the mounting bracket.

Installation Procedure

1. Ensure that the mounting bracket for the electronic control module is clean and free from damage. If the mounting bracket is damaged, replace the bracket.

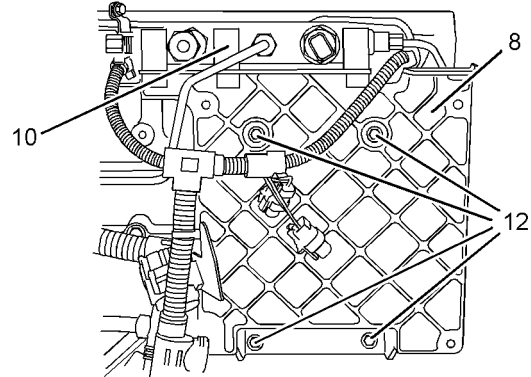


Illustration 371

g01342051

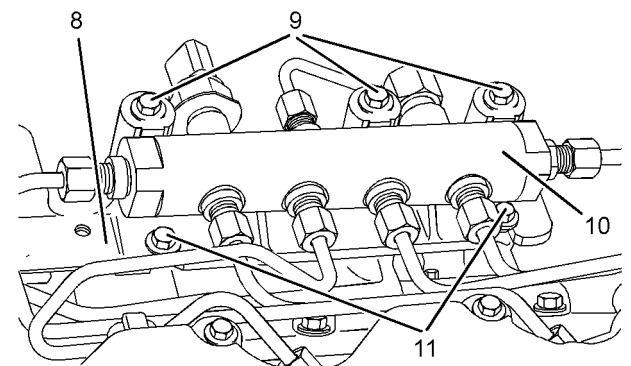


Illustration 372

g01342046

2. Position mounting bracket (8) against the cylinder block. Ensure that the two slots in the top face of the mounting bracket are aligned with bolts (11). Slide the mounting bracket into position against the cylinder block.
3. Install bolts (12) finger tight.
4. Install bolts (9) that secure fuel manifold (10) to mounting bracket (8) finger tight.

Note: Ensure that the fuel manifold is seated against the mounting bracket before bolts (9) are tightened. Ensure that the fuel injection lines are not stressed when the bolts are tightened.

5. Tighten bolts (11) to a torque of 22 N·m (16 lb ft).
6. Tighten bolts (12) to a torque of 22 N·m (16 lb ft). Tighten bolts (9) to a torque of 22 N·m (16 lb ft).

i02654421

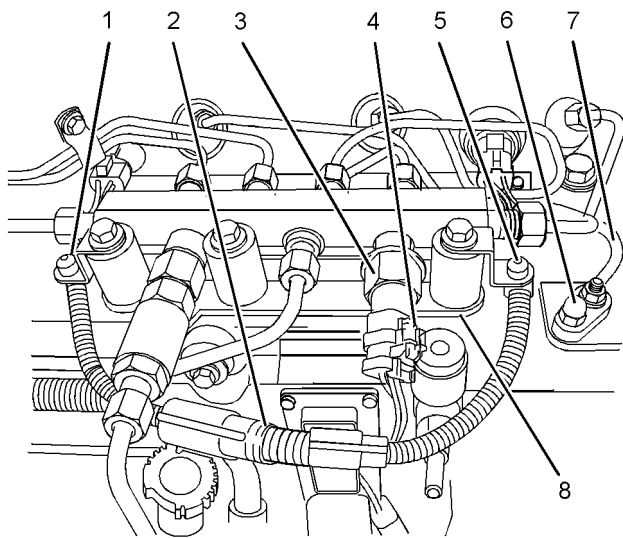


Illustration 373

g01342045

7. Install terminal insulator (6) to mounting bracket (8). Connect wire (7) to the terminal insulator. Refer to Disassembly and Assembly, "Glow Plugs - Remove and Install" for the correct procedure.
8. Follow Steps 1.b through 1.c in order to connect engine wiring harness (2).
 - a. Connect harness assembly (2) to fuel pressure sensor (3).
 - b. Slide locking tab (4) into the locked position.
 - c. Position harness assembly (2) onto mounting bracket (8). Use new cable straps (1) and (5) in order to secure the harness assembly.

End By:

- a. Install the electronic control module. Refer to Disassembly and Assembly, "Electronic Control Module - Remove and Install".

Alternator - Remove (Alternators with Mounting Lugs)

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.
2. Place identification marks on all of the wiring harness connections.

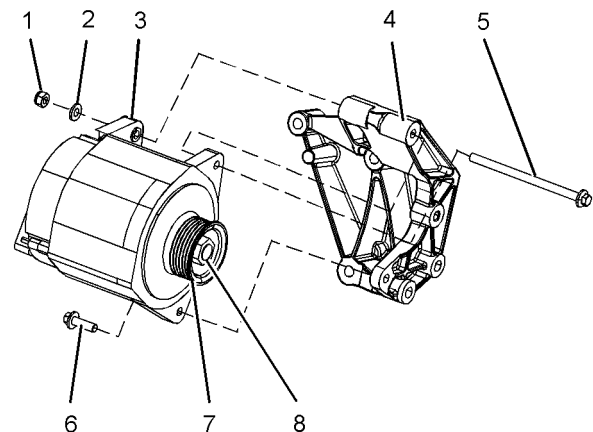


Illustration 374

g01334584

Typical example

3. Disconnect the wiring harness assembly from alternator (3).
4. Remove bolt (2) from alternator (3).
5. Remove nut (1) and washer (2). Remove bolt (5) from alternator (3). Remove the alternator from alternator bracket (4).

6. If necessary, follow Steps 6.a and 6 in order to remove pulley (7) from alternator (3).
 - a. Hold the shaft of alternator (3) with an allen wrench. Use a cranked ring spanner to loosen nut (8).
 - b. Remove nut (8) and pulley (7) from alternator (3).

i02654420

Alternator - Remove (Alternators with Mounting Pads)

Removal Procedure

Start By:

- a. Remove the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".
1. Isolate the electrical supply.
2. Place identification marks on all of the wiring harness connections.

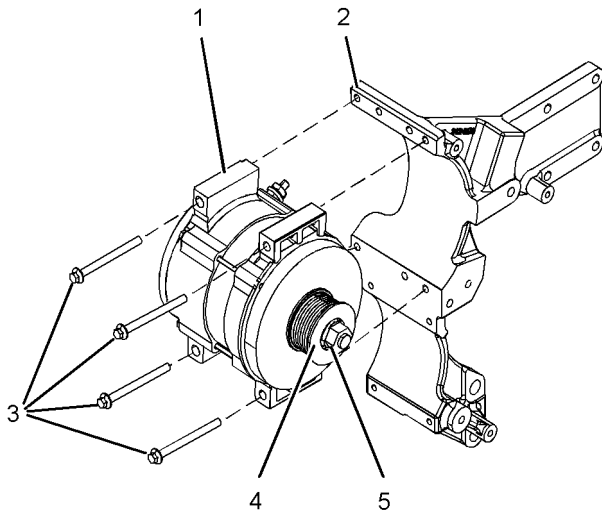


Illustration 375

g01334617

3. Disconnect the wiring harness assembly from alternator (1).
4. Remove bolts (2) and alternator (1) from alternator bracket (2).
5. If necessary, follow Steps 5.a and 5.b in order to remove pulley (4) from alternator (1).

- a. Hold the shaft of alternator (1) with an allen wrench. Use a cranked ring spanner to loosen nut (5).
- b. Remove nut (5) and pulley (4) from alternator (1).

i02654429

Alternator - Install (Alternators with Mounting Lugs)

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

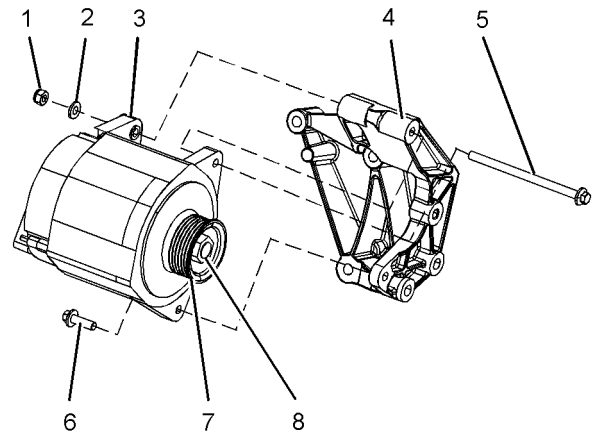


Illustration 376

g01334584

Typical example

1. If necessary, install pulley (7) and nut (8) to alternator (3). Hold the shaft of alternator (3) with an allen wrench. Use a cranked ring spanner in order to tighten nut (8).

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 (5) to alternator (3). Install washer (2) and nut (1) to bolt (5).
4. Install bolt (6) to alternator (3).
5. Tighten nut (1) and bolt (6) to a torque of 22 N·m (16 lb ft).
6. Connect wiring harness assembly to alternator (3).
7. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".
8. Restore the electrical supply.

i02654426

Alternator - Install (Alternators with Mounting Pads)

Installation Procedure

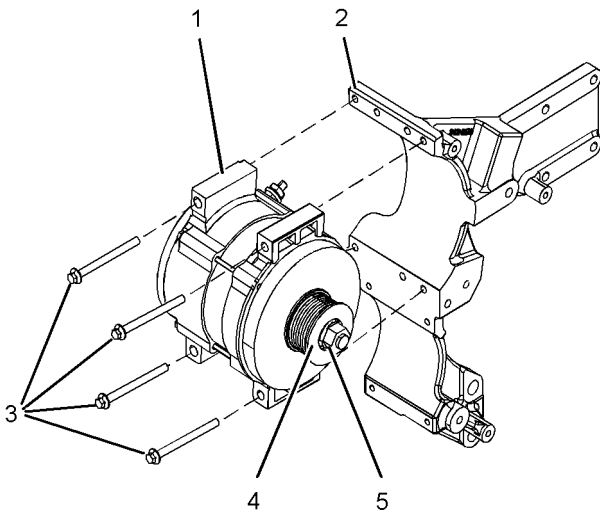


Illustration 377

g01334617

1. If necessary, install pulley (4) and nut (5) to alternator (1). Hold the shaft of alternator (1) with an allen wrench. Use a cranked ring spanner in order to tighten nut (5). Tighten the nut to a torque of 127 N·m (93 lb ft).

2. Position alternator (1) on alternator mounting bracket (2). Install bolts (3) into the alternator bracket. Tighten the bolts to a torque of 44 N·m (32 lb ft).
3. Connect the wiring harness assembly to alternator (1).
4. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install".
5. Restore the electrical supply.

i02654479

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. Place identification marks on the harness assembly that is connected to the electric starting motor and the solenoid.

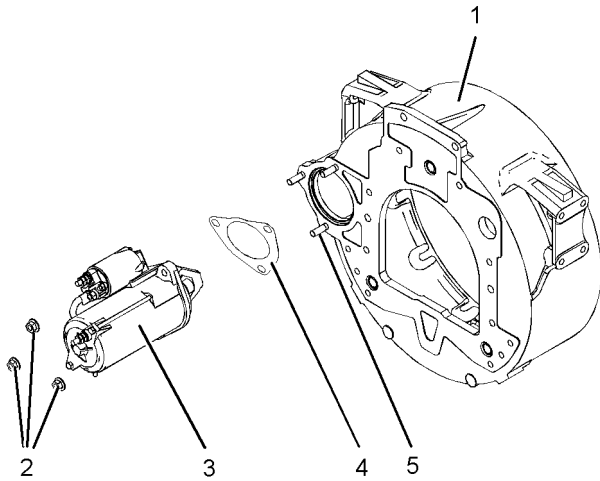


Illustration 378 g01342054
Typical example

3. Disconnect the harness assembly from the electric starting motor and the solenoid.
4. Remove nuts (2) for electric starting motor (3).
5. Remove electric starting motor (3).
6. If a joint is installed, remove joint (4).
7. If necessary, remove studs (5) from flywheel housing (1).

Installation Procedure

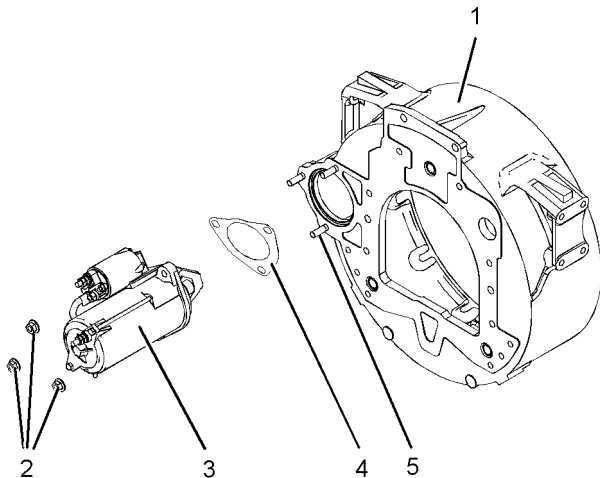


Illustration 379 g01342054
Typical example

1. If necessary, install studs (5) into flywheel housing (1).
2. If necessary, install a new joint (4) onto the studs in flywheel housing (1).
3. Position electric starting motor (3) onto the studs in flywheel housing (1).
4. Install nuts (2).

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).
5. Connect the harness assembly to the electric starting motor and the solenoid.
6. Connect the battery.

i02654446

Air Compressor - Remove and Install

Removal Procedure

Table 85

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
	27610286	Crankshaft Timing Pin	1
B	27610287	Adapter	1
	-	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. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump.
4. 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.

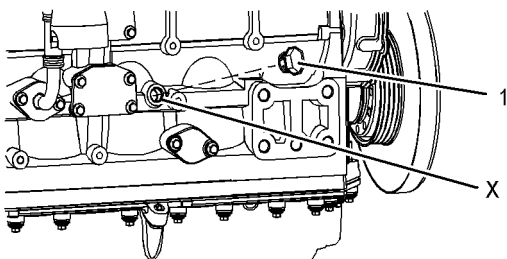


Illustration 380
Typical example

g01353468

5. Remove the plug (1) from the cylinder block. Install Tooling (B) into the hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

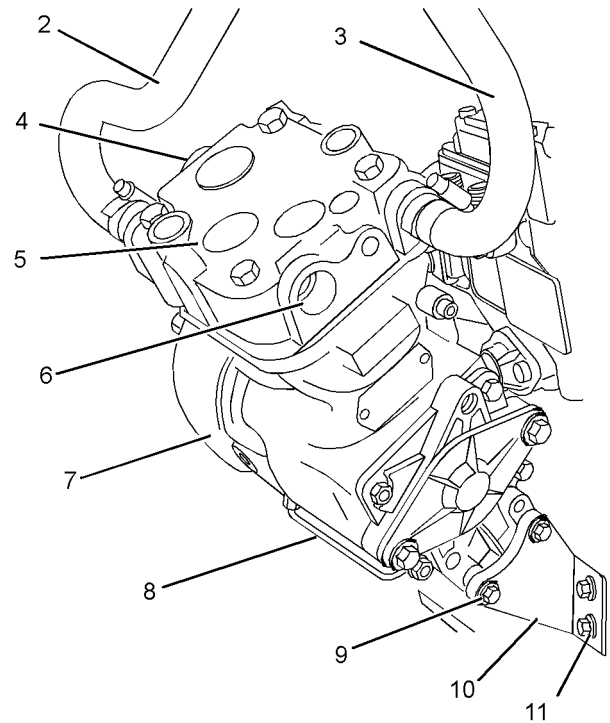


Illustration 381
Typical example

g01353469

6. Disconnect coolant hoses (2) and (3) from air compressor (5).
7. Disconnect the air lines from ports (4) and (6).
8. Remove tube assembly (8) from air compressor (5) and from the cylinder block.
9. Remove bolts (9) and (11) from support bracket (10) and remove the support bracket.

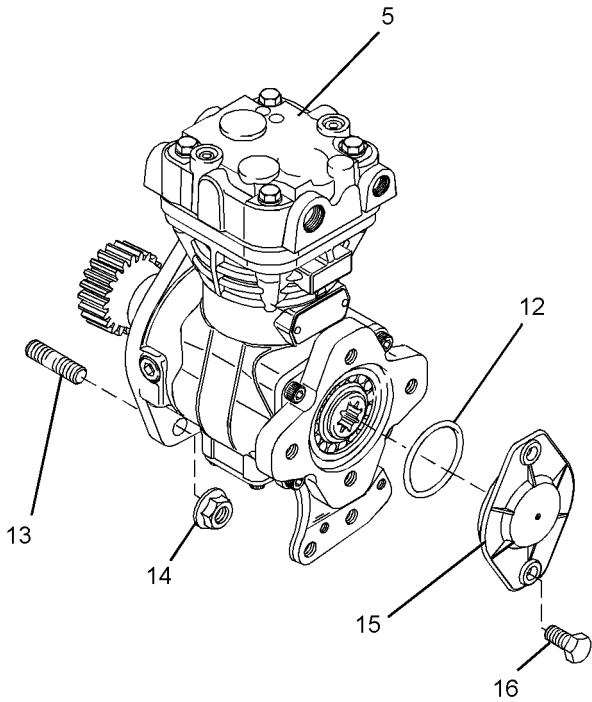


Illustration 382
Typical example
g01353470

10. Support air compressor (5). Remove nuts (14) and remove the air compressor from front housing (7).

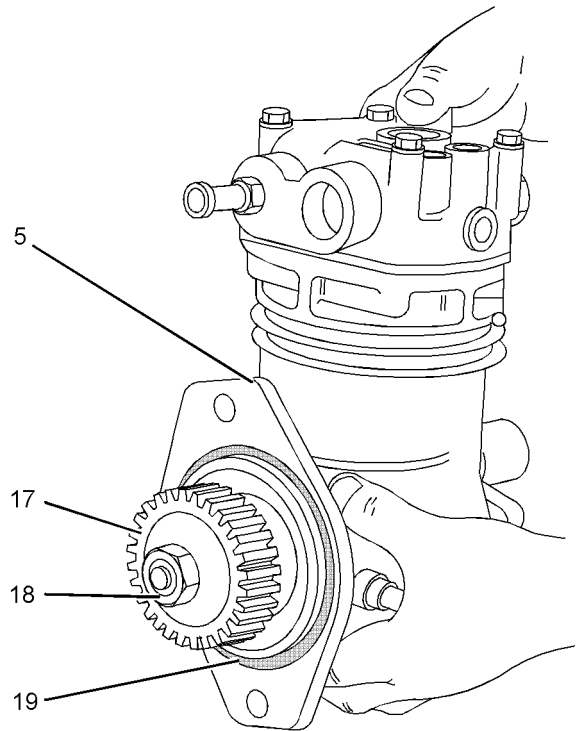


Illustration 383
Typical example
g01353471

11. Remove O-ring seal (19) from air compressor (5).

12. If necessary, remove bolts (16) and remove plate (15). Remove O-ring seal (12) from plate (15). Refer to Illustration 382.

13. If necessary, remove nut (18) and remove the spring washer. Use Tooling (C) in order to remove gear (17) from the crankshaft of the air compressor.

Installation Procedure

Table 86

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610286	Crankshaft Timing Pin	1
	27610287	Adapter	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.

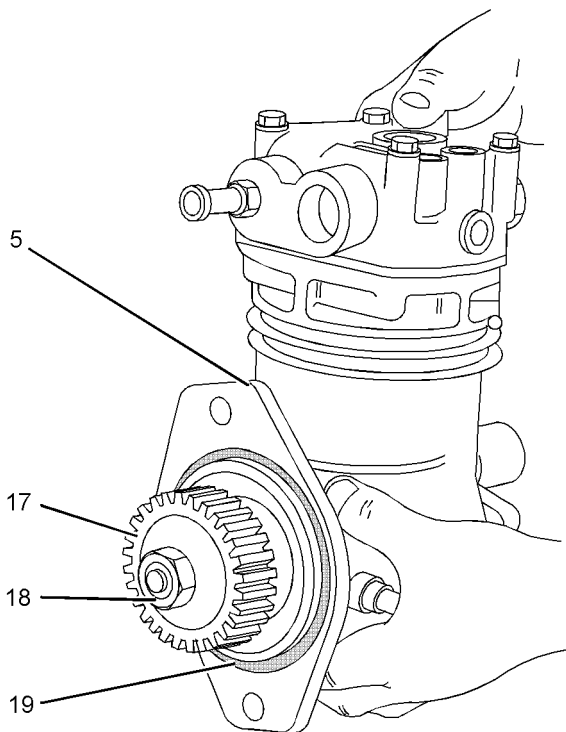


Illustration 384
Typical example
g01353471

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 (5) is clean and dry. Ensure that gear (17) is clean and free from damage.
 - b. Install gear (17) and a new spring washer to the shaft of the air compressor.

- c. Apply Tooling (D) to the threads of the shaft. Install nut (18) to the shaft of air compressor (5). Tighten the nut to a torque of 120 N·m (89 lb ft).

2. Install the O-ring seal to air compressor (5). 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.

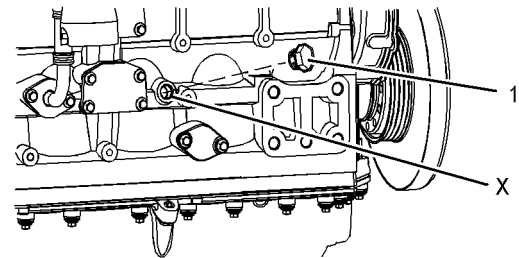


Illustration 385
Typical example
g01353468

4. Ensure that Tooling (B) is installed in hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

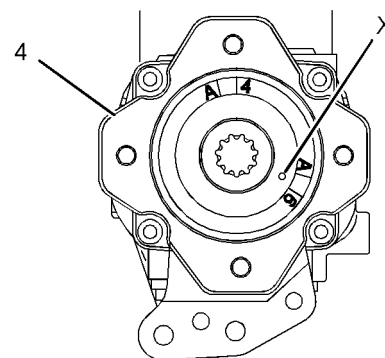


Illustration 386
Typical air compressor with a SAE drive
g01333452

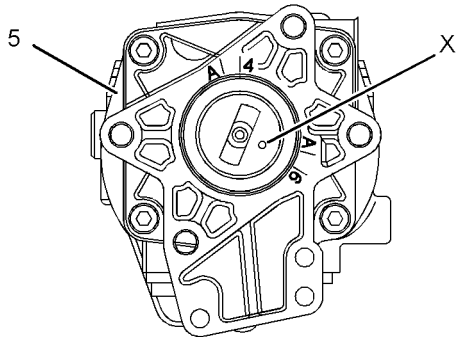


Illustration 387
Typical air compressor with a DIN drive
g01333453

5. Rotate the crankshaft of the air compressor until the timing mark (X) is aligned with the timing mark A6 on the rear face of air compressor (5). Refer to Illustration 386 for air compressors with a SAE drive. Refer to Illustration 387 for air compressors with a DIN drive.

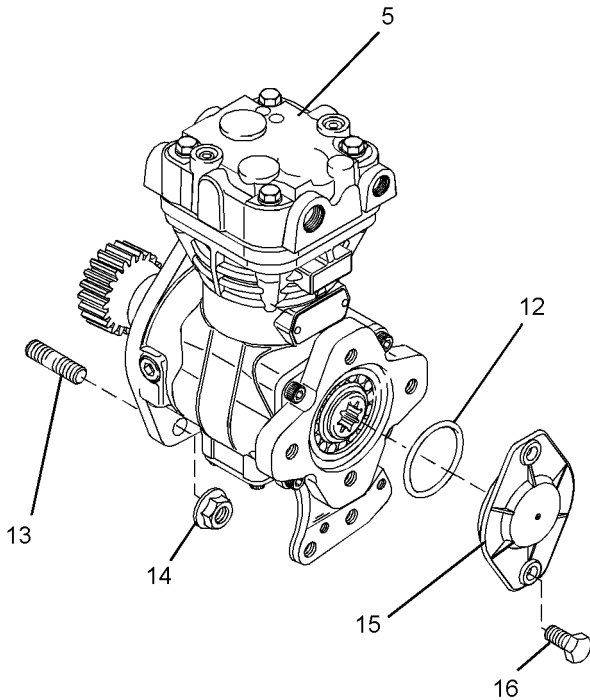


Illustration 388
Typical example
g01353470

6. Align the air compressor (5) with studs (13). 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 A6. Refer to Illustration 386 for air compressors with a SAE drive. Refer to Illustration 387 for air compressors with a DIN drive.

7. Install nuts (14). 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 (15).
 - a. Install a new O-ring seal (12) to cover (15). Use Tooling (E) in order to lubricate the O-ring seal.
 - b. Install cover (15) to air compressor (5).
 - c. Install bolts (16). Tighten the bolts to a torque of 13 N·m (9.5 lb ft).

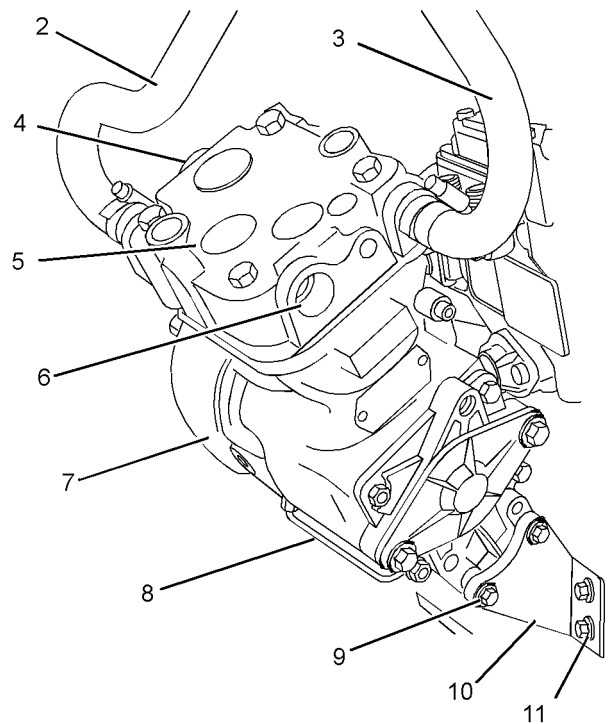


Illustration 389
Typical example
g01353469

9. Position support bracket (10) onto air compressor (5). Install bolts (9) finger tight.
10. Install bolts (11) finger tight.
11. Tighten the bolts (9) 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 (8) to air compressor (5) 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 cylinder block. Install plug (1) to the cylinder block. Refer to Illustration 385.
- 14.** If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump.
- 15.** Connect the air lines to ports (4) and (6) in the air compressor.
- 16.** Connect coolant hoses (2) and (3) to air compressor (5).
- 17.** Fill the cooling system with coolant to the correct level. Refer to the Operation and Maintenance Manual.

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