

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

Removal 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 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.

1. Isolate the fuel supply.
2. Make a temporary identification mark on the 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”.

Note: Clean up any spillage of fuel immediately.

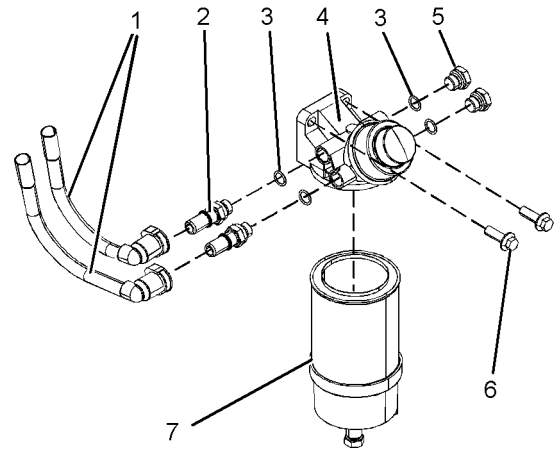


Illustration 1

g01181971

Typical example

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

Removal 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 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.

1. Isolate the fuel supply.

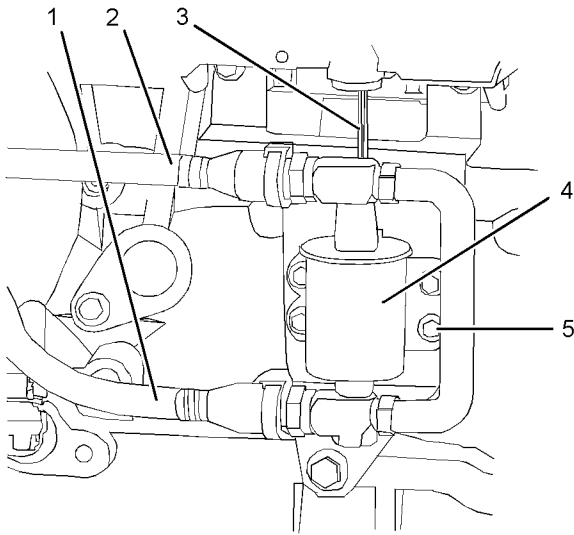


Illustration 2

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Typical example

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

7. Remove the electric priming pump (4) from the mounting bracket.

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 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.

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

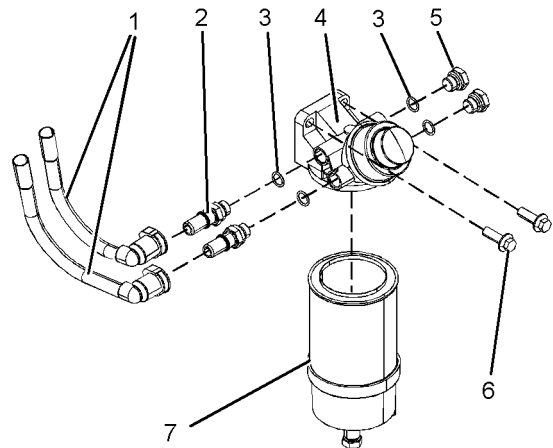


Illustration 3

g01181971

Typical example

2. If necessary, follow Steps 2.a through 2.d in order to assemble the fuel priming pump (4).
 - a. Install new O-ring seals (3) to the connectors (2) and to the plugs (5).
 - b. Install the connectors (2) to the fuel priming pump (4).
 - c. Install the plugs (5) to the fuel priming pump (4).

- d. Tighten the plugs and the connectors to a torque of 20 N·m (14 lb ft).
3. Position the fuel priming pump (4) on the mounting bracket. Install the two setscrews (6) to the fuel priming pump . Tighten the setscrews 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 the plastic tube assemblies (1) to the connectors (2).

Note: Ensure that the plastic tube assemblies are installed in the original positions.

6. Install a new primary filter (7) to the 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”.

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 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.

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

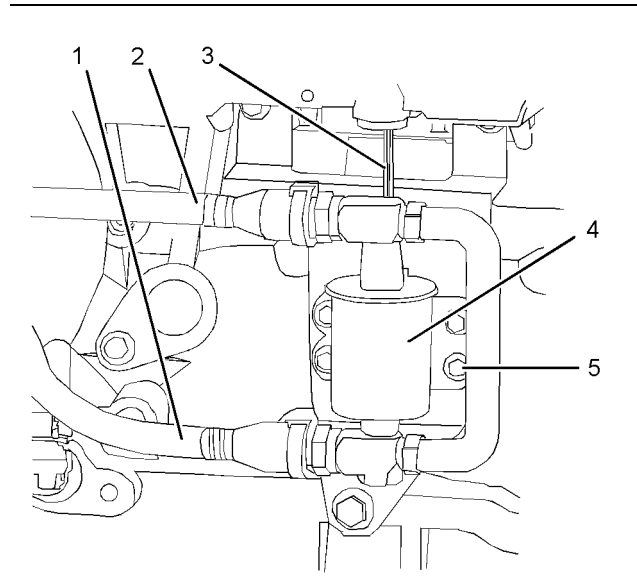


Illustration 4

g01186418

Typical example

2. Position the electric priming pump (4) on the mounting bracket. Install the four setscrews (5) to the electric priming pump (4).
 3. Tighten the setscrews (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 the plastic tube assemblies (1) and (2) to the electric priming pump (4).
- Note:** Ensure that the plastic tube assemblies are installed in the original positions.
6. Connect the electrical lead (3) for the 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”.

i02295889

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 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.

1. Isolate the fuel supply.

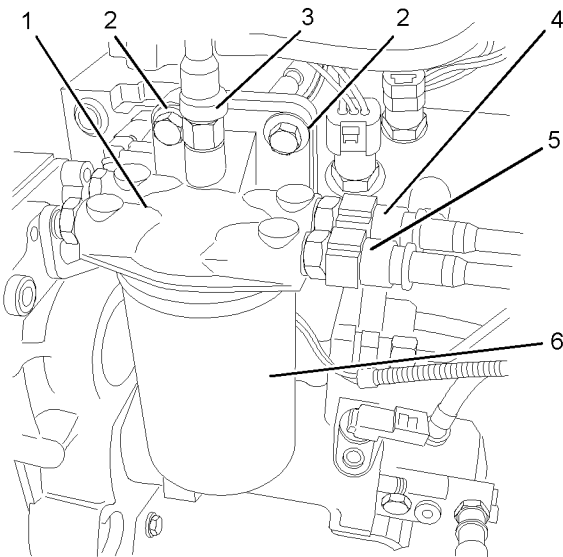


Illustration 5
Typical example g01165584

2. Make temporary identification marks on the plastic tube assemblies (3), (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.

Note: Clean up any spillage of fuel immediately.

4. Disconnect the plastic tube assemblies (3), (4) and (5) from the 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 the fuel filter (6). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace”.
6. Remove the two setscrews (2) from the 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 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.

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

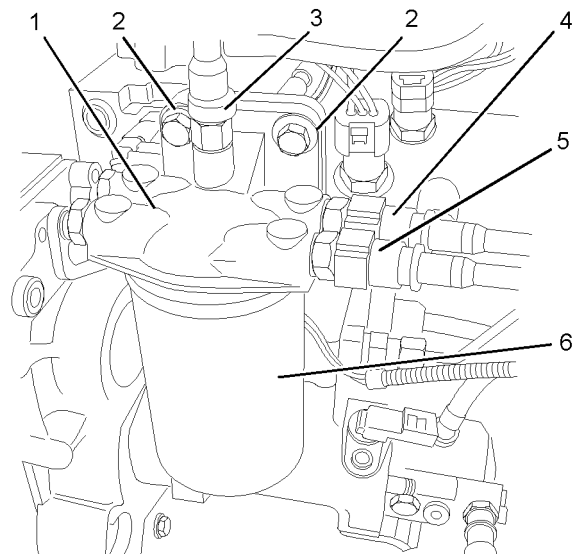


Illustration 6
Typical example g01165584

2. Position the fuel filter base (1) on the mounting bracket. Install the setscrews (2). Tighten the setscrews 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 the plastic tube assemblies (3), (4) and (5) to the fuel filter base (1).

Note: 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.

5. If necessary, install a new fuel filter (6) to the 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".

i02296828

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 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.

1. Isolate the fuel supply.
2. Place a suitable container below the fuel transfer pump (1) in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

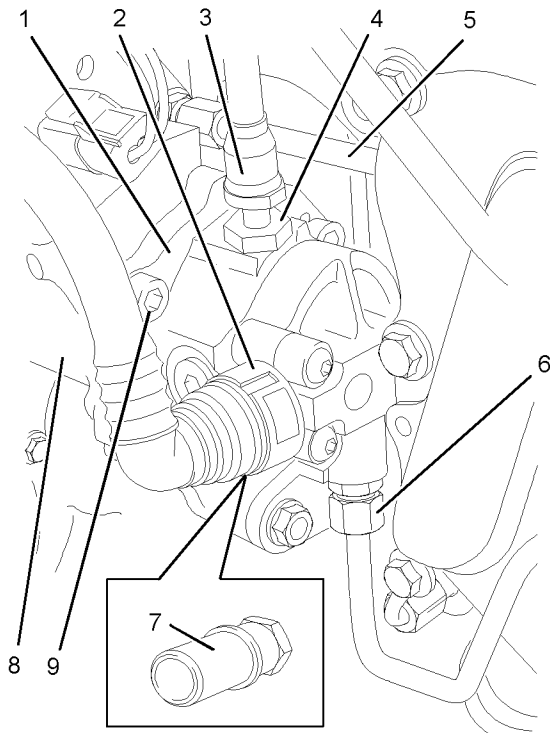


Illustration 7
Typical example g01162545

3. Remove the plastic tube assembly (2) from the fuel transfer pump (1).
4. Disconnect the plastic tube assembly (3) from the outlet of the fuel transfer pump (1).
5. Remove the connector (4) from the fuel transfer pump (1). Remove the O-ring seal (not shown) from the connector (4). Discard the O-ring seal.

If necessary, remove the connector (7) from the fuel transfer pump (1). Remove the O-ring seal (not shown) from the connector (7). Discard the O-ring seal.

6. Remove the tube assembly (6) 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 the tube assembly (5) for the engine oil supply from the fuel injection pump (8).
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 the five allen head screws (9) that secure the fuel transfer pump to the fuel injection pump (8).

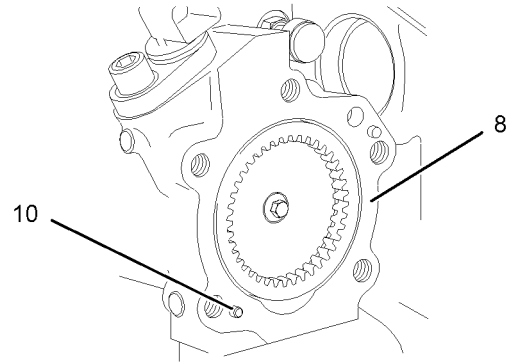


Illustration 8 g01162543

10. Remove fuel transfer pump (1) from the fuel injection pump (8).

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

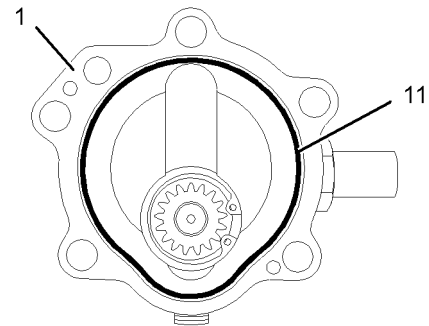


Illustration 9 g01162544

11. Remove the O-ring seal (11) from the fuel transfer pump (1). Discard the O-ring seal.

i02296829

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 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.

1. Ensure that the mating faces of the fuel injection pump (8) and the fuel transfer pump (1) are clean and free from damage.

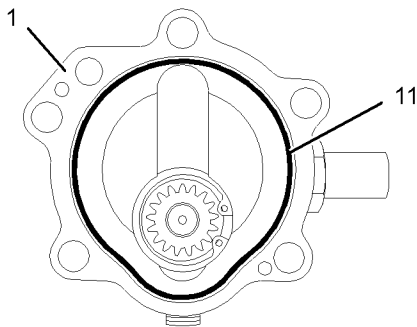


Illustration 10

g01162544

2. Install a new O-ring seal (11) to fuel transfer pump (1). Lubricate the O-ring seal with clean engine oil.

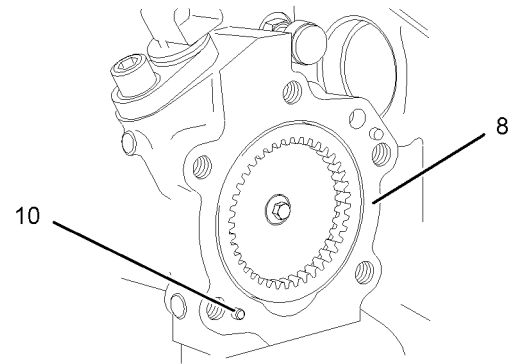


Illustration 11

g01162543

3. Align the holes in the fuel transfer pump (1) with the dowels (10) in the fuel injection pump (8). Install the fuel transfer pump to the fuel injection pump.

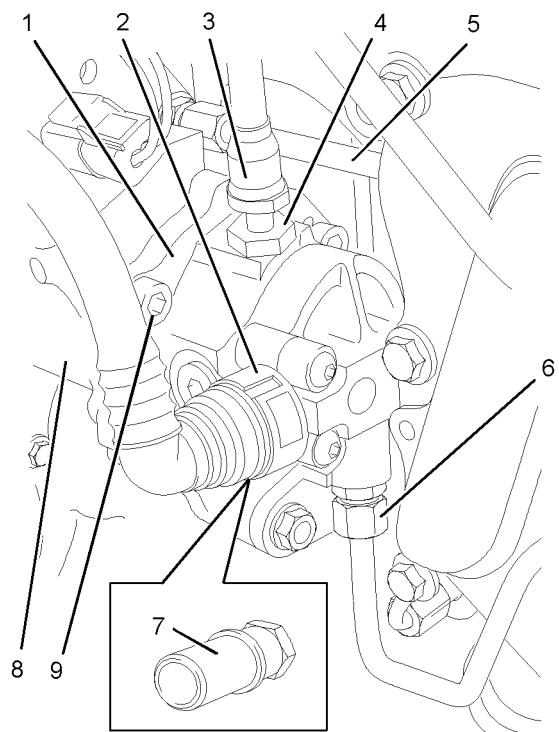


Illustration 12

g01162545

Typical example

4. Use an allen wrench with a ball end to install the five allen head screws (9). 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 the tube assembly (5) for the engine oil supply to the fuel injection pump (8) and to the cylinder block.
7. Install the tube assembly (6) for the fuel return to the fuel transfer pump (1) and to the cylinder head.
8. Install a new O-ring seal (not shown) to the connector (4). Install the connector (4) to the fuel transfer pump (1). Tighten the connector to torque of 15 N·m (11 lb ft).
9. If necessary, install a new O-ring seal (not shown) to the connector (7) and install the connector (7) to the fuel transfer pump (1). Tighten the connector to torque of 15 N·m (11 lb ft).
10. Connect the plastic tube assembly (3) to the outlet of the fuel transfer pump (1).
11. Install the plastic tube assembly (2) to the fuel transfer pump (1).
12. Restore the fuel supply.
13. Remove the air from the fuel system. Refer to Testing and Adjusting Manual, "Fuel System - Prime".

i02295890

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 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.

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

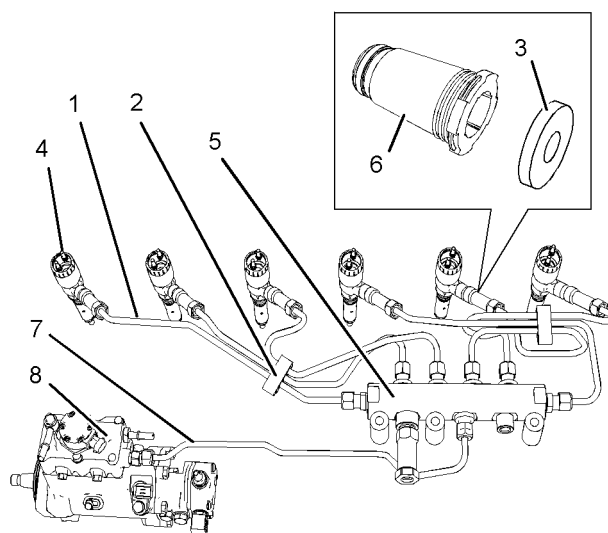


Illustration 13

g01178882

Typical example

3. Remove the two plastic clamps (2) from the fuel injection lines (1). Discard the plastic clamps.
4. Slide the dust seal (3) from the nut on the fuel injection line (1).
5. Disconnect the fuel injection line (1) at the electronic unit injector (4).
6. Disconnect the fuel injection line (1) at the fuel manifold (5).
7. Remove the fuel injection line (1). Discard the fuel injection line.

Note: Clean up any spillage of fuel immediately.

8. Plug the open port in the fuel manifold (5) immediately. Use Tooling (A) in order to plug the open port in the fuel manifold.

9. Remove the seal (6) from the electronic unit injector (4) and the base of the valve mechanism cover (not shown).

Note: The seal can be damaged by contact with fuel.

10. Plug the open port in electronic unit injector (4) immediately. Use Tooling (A) in order to plug the open port in the electronic unit injector.

11. Repeat Steps 4 through 11 in order to remove the remaining fuel injection lines from the fuel manifold to the electronic unit injectors.

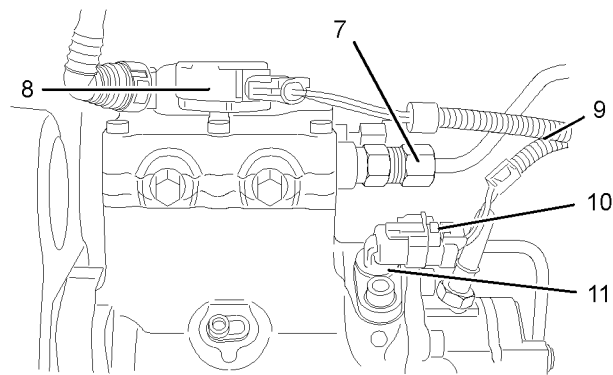


Illustration 14
Typical Example

12. Disconnect the harness assembly (9) from the fuel injection pump (8). Slide the locking tab (10) into the unlocked position. Disconnect the harness assembly (9) from the position sensor (11). Position the harness assembly (9) so that the harness assembly is clear of the fuel injection line (7).

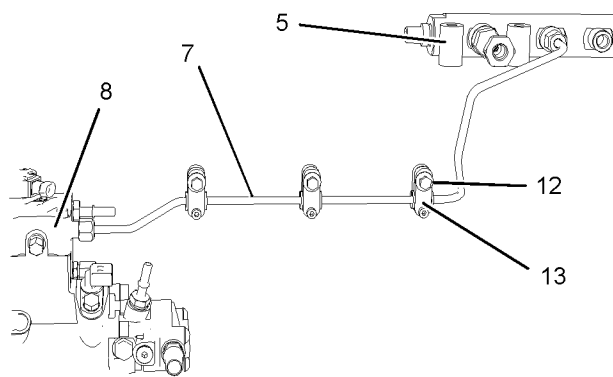


Illustration 15

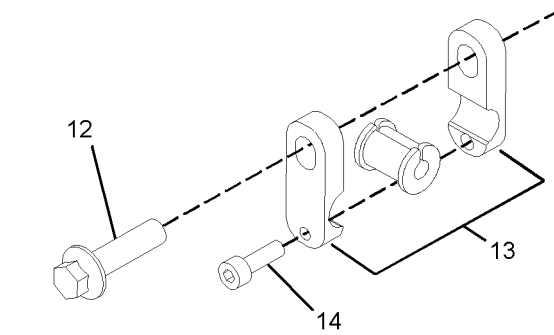


Illustration 16
Assembly of the tube clip

13. Remove the fasteners (12) from the three tube clips (13) that secure the fuel injection line (7). Loosen the three allen head screws (14). Position the tube clips in order to allow removal of the fuel injection line.

14. Disconnect the fuel injection line (7) at the fuel injection pump (8).

15. Disconnect the fuel injection line (7) at the fuel manifold (5).

16. Plug all open ports immediately. Use Tooling (A) in order to plug the open ports in the fuel manifold (5) and in the fuel injection pump (8).

17. Remove the fuel injection line (7).

Note: Clean up any spillage of fuel immediately.

18. Remove the allen head screws (14) and the assemblies of the three tube clips (13) from fuel injection line (7). Discard the fuel injection line.

i02295912

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 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.

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 Manual, "Electronic Unit Injector - Install" and Disassembly and Assembly Manual, "Fuel Manifold - Install" for more information.

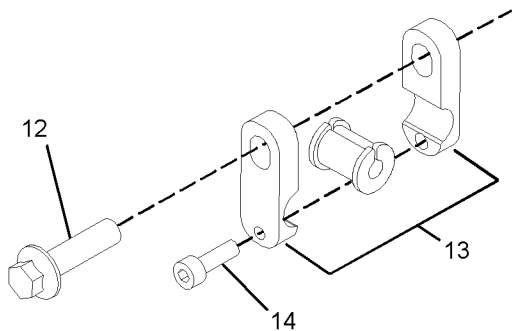


Illustration 17
Assembly of the tube clip

g01208399

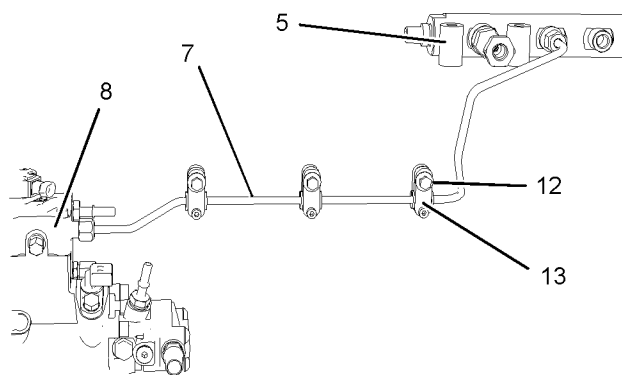


Illustration 18

g01208398

1. Loosely install the assemblies of the three tube clips (13) and the allen head screws (14) to the fuel injection line (7).
2. Place the fuel injection line (7) in position.
3. Remove the caps from the port in the fuel injection pump (8) and from the appropriate port in the fuel manifold (5). Remove the caps from the new fuel injection line (7).
4. Loosely connect the nuts at both ends of the fuel injection line (7), to the fuel manifold (5) and to the fuel injection pump (8). 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 the fuel injection line (7) to a torque of 30 N·m (22 lb ft).
6. Install the setscrews (12) for the three tube clips (13) that secure the fuel injection line (7). Tighten the setscrews (12) to a torque of 22 N·m (16 lb ft). Tighten the M5 allen head screws (14) to a torque of 10 N·m (89 lb in). Ensure that fuel injection line does not contact any other engine component.

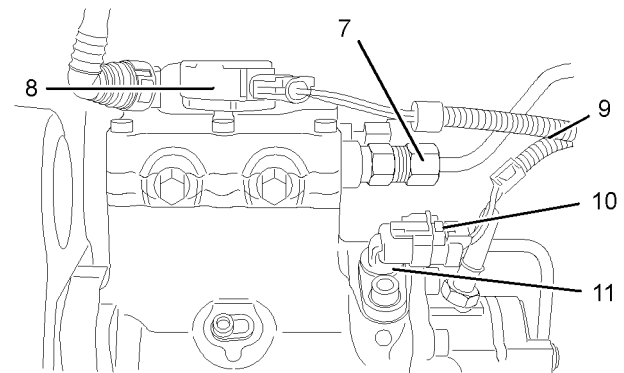


Illustration 19
Typical example

g01198424

7. Connect the harness assembly (9) to the position sensor (11). Slide the locking tab (10) into the locked position. Connect the harness assembly (9) to the fuel injection pump (8).

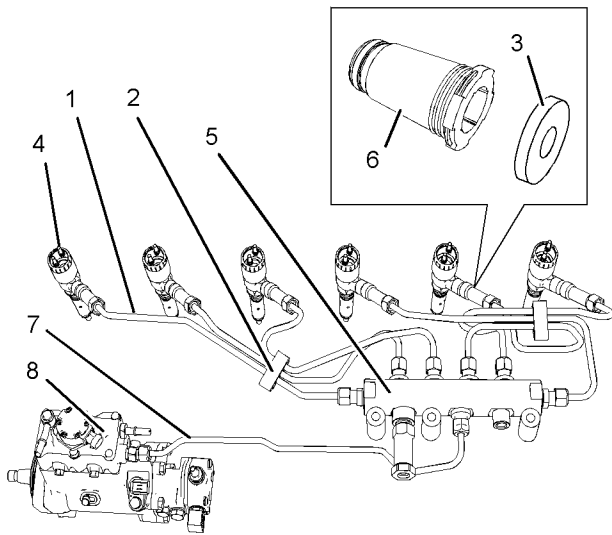


Illustration 20

g01178882

Typical example

8. Thoroughly clean the seal (6). Inspect the seal for damage. If necessary, replace the seal.

Note: The seal can be damaged by contact with fuel. If the seal has been in contact with fuel for a prolonged period, the seal should be replaced.

9. Install the seal (6) to the electronic unit injector (4). Ensure that the flange on the seal is flush with the valve mechanism cover base.

10. Remove the caps from the new fuel injection line (1). Ensure that a new dust seal (3) is installed to the fuel injection line.

11. Remove the caps from the electronic unit injector (4) and from the appropriate port in the fuel manifold (5).

12. Loosely connect the nuts at both ends of the fuel injection line (1), to the electronic unit injector (4) and to the appropriate port in the fuel manifold (5). Ensure that the ends of the fuel injection line are correctly seated in the electronic unit injector and in the fuel manifold.

13. Use Tooling (A) to tighten the nuts on the fuel injection line (1) to a torque of 30 N·m (22 lb ft). Slide the dust seal (3) into position over the nut on the fuel injection line. Ensure that the dust seal (3) is in contact with the seal (6).

14. Follow Steps 8 through 13 in order to install the remaining fuel injection lines.

15. Install two new clamps (2) 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.

16. Restore the fuel supply.

17. Restore the electrical supply.

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

i02403286

Fuel Manifold (Rail) - Remove and Install

Removal Procedure

Start By:

- Remove the fuel injection lines. Refer to Disassembly and Assembly Manual, "Fuel Injection Lines - Remove".
- If necessary, remove the fuel pressure sensor. Refer to Disassembly and Assembly Manual, "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 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.

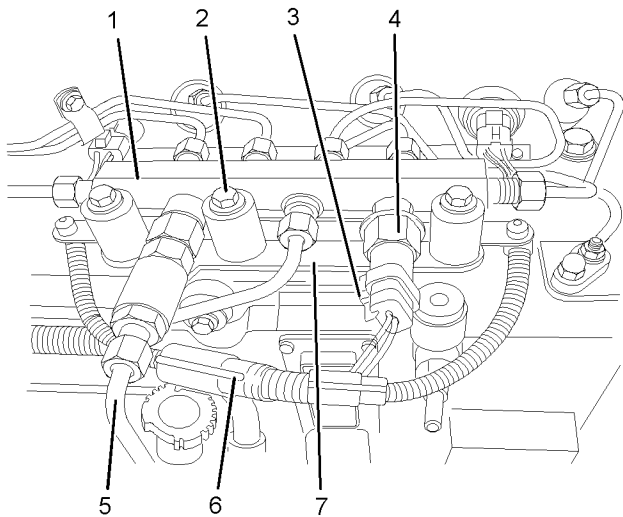


Illustration 21 g01190733

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

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

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 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.

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.

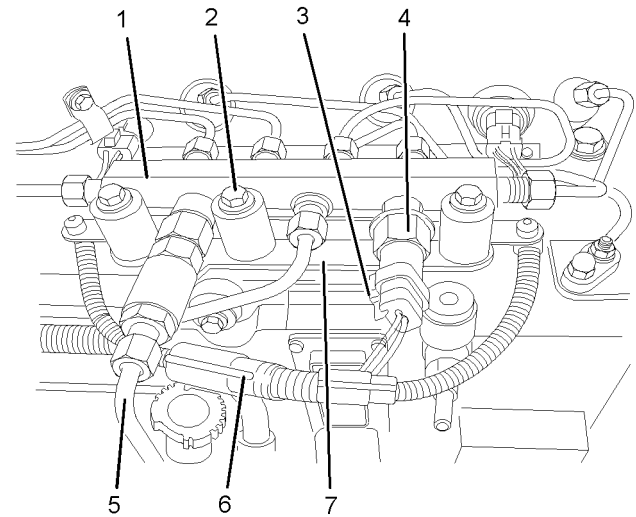


Illustration 22 g01190733

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

2. Position the fuel manifold (1) on the mounting bracket (7).
3. Install the three setscrews (2) to the fuel manifold (1) finger tight.
4. Install a new set of fuel injection lines and seals. Refer to Disassembly and Assembly Manual, “Fuel Injection Lines - Install” for more information.
5. Tighten the setscrews (2) to a torque of 22 N·m (16 lb ft).
6. Remove the plug from the tube assembly (5). Remove the cap from the appropriate port in the fuel manifold (1). Connect the tube assembly (5) to the fuel pressure relief valve on the fuel manifold (1).
7. If the fuel pressure sensor (4) was not removed from the fuel manifold (1), connect the plug on the harness assembly (6) to the fuel pressure sensor (4). slide the locking tab (3) into the locked position.

If the fuel pressure sensor (4) was removed from the fuel manifold (1), install the fuel pressure sensor (4) and a new sealing washer. Refer to Disassembly and Assembly Manual, "Fuel Pressure Sensor - Remove and Install" for more information.

8. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

i02295929

Fuel Injection Pump - Remove

Removal Procedure

Table 3

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
D	-	Cap	2

Start By:

- a. If necessary, remove the fuel filter base. Refer to Disassembly and Assembly Manual, "Fuel Filter Base - Remove and Install".
- b. If necessary, remove the fuel priming pump. Refer to Disassembly and Assembly Manual, "Fuel Priming Pump - Remove".
- c. Remove the front cover. Refer to Disassembly and Assembly Manual, "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 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.

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 Testing and Adjusting Manual, "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.

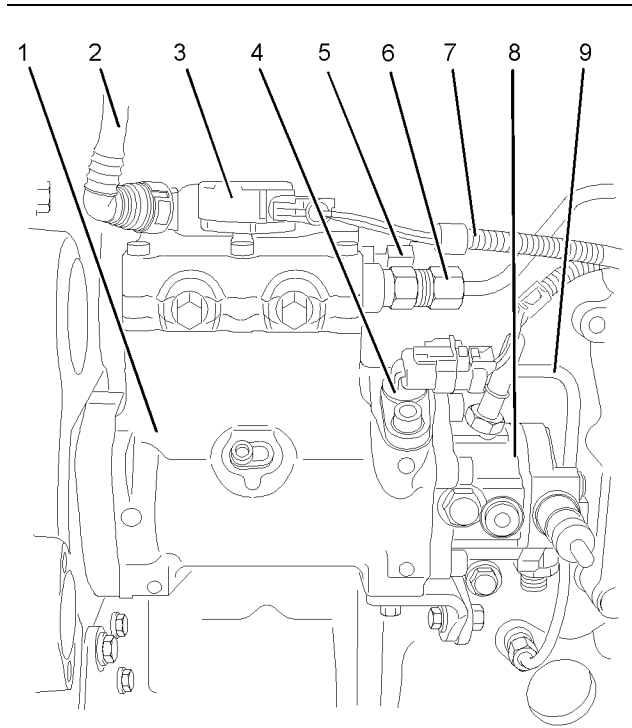


Illustration 23
Typical example

g01173307

6. Place a suitable container below the fuel injection pump (1) in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

7. Disconnect the plastic tube assembly (2) from the fuel injection pump (1).
8. Disconnect the engine wiring harness (7) from the solenoid (3) of the fuel injection pump. Disconnect the engine wiring harness (7) from the position sensor (4) for the fuel injection pump.

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

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

13. Remove the tube assembly (9) for the engine oil supply to the fuel injection pump (1).
14. Plug or cap all open ports and tube assemblies immediately with new plugs or caps.
15. Remove the fuel injection line (6) that connects the fuel injection pump to the fuel manifold. Refer to Disassembly and Assembly Manual, "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.

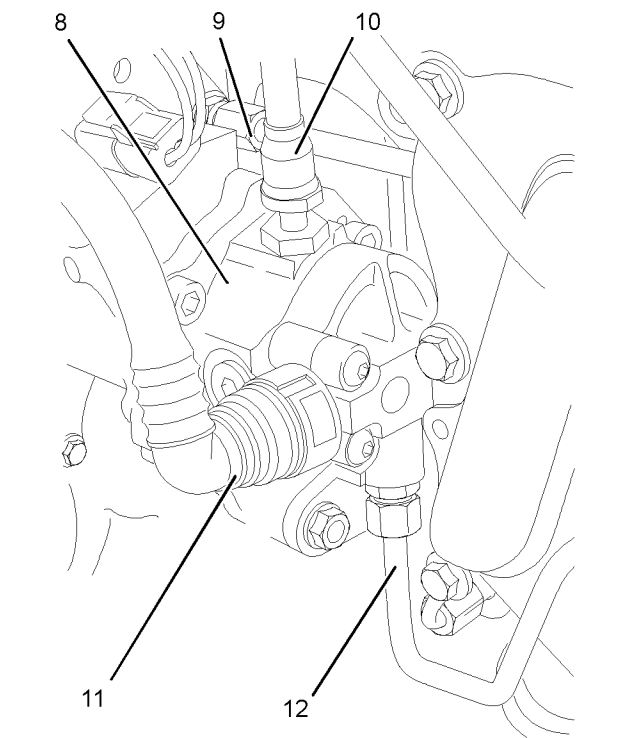


Illustration 24
Typical example

g01173310

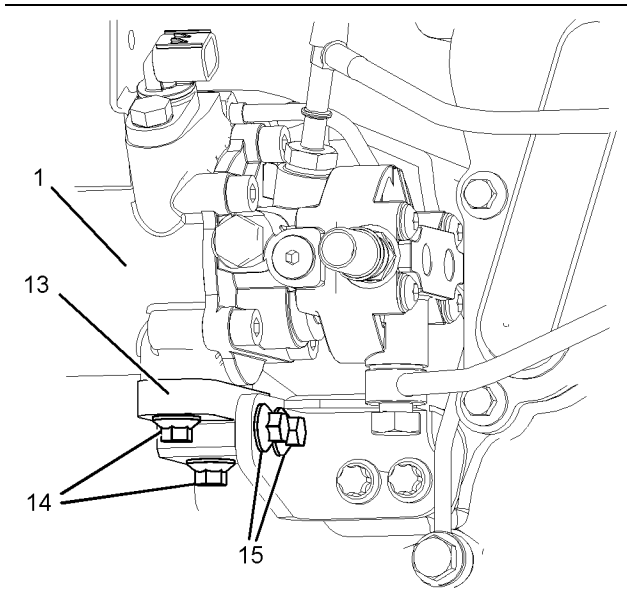


Illustration 25

g01208416

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

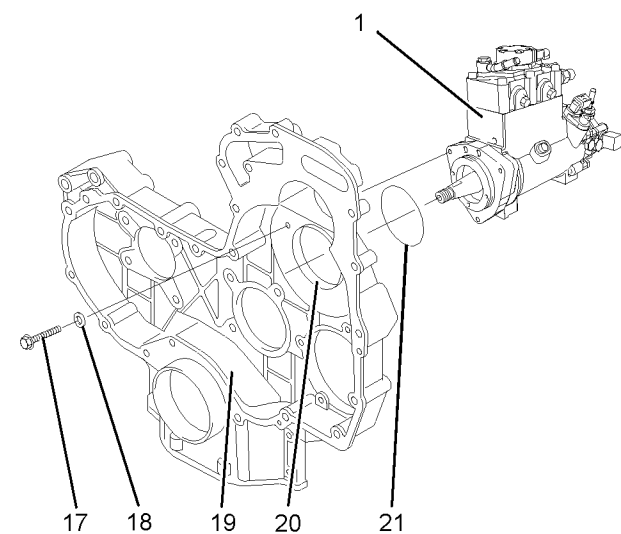


Illustration 26

g01173314

Typical example

17. Remove the three setscrews (17) and sealing washers (18). Discard the sealing washers.

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

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

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

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

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

i02295933

Fuel Injection Pump - Install

Installation Procedure

Table 4

Required Tools			
Tool	Part Number	Part Description	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
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 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.

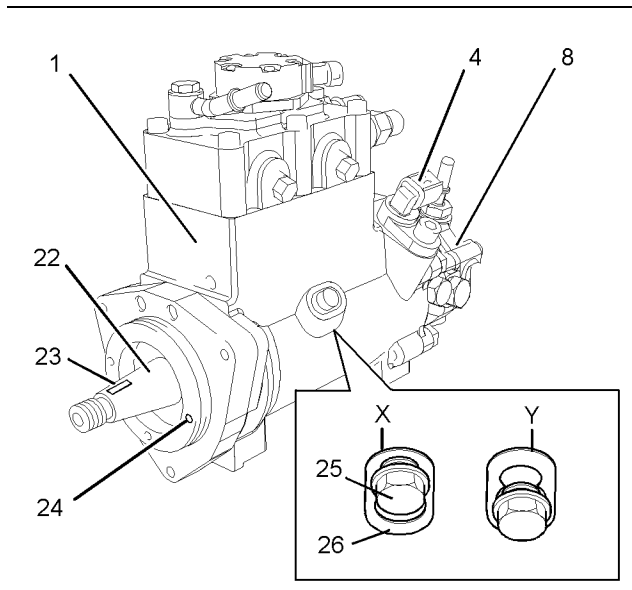


Illustration 27

g01174932

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 the fuel transfer pump (8) to the fuel injection pump (1). Refer to Disassembly and Assembly Manual, "Fuel Transfer Pump - Install".
- b. Install the position sensor (4) to the fuel injection pump (1). Refer to Disassembly and Assembly Manual, "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 the shaft (22) of the fuel injection pump. Align the lever of Tooling (E) with the key slot (23). Engage the lever into the key slot.
- b. Insert the locking pin of Tooling (E) into the 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 the locking screw (25) on the fuel injection pump. Slide the spacer (26) into position (X). Tighten the locking screw (25) to a torque of 9 N·m (80 lb in). This will prevent the locking screw from tightening against the shaft (22).

The fuel injection pump is now unlocked.

- b. Position Tooling (E) onto the shaft (22) of the fuel injection pump. Align the lever of Tooling (E) with the key slot (23) in the fuel injection pump. Engage the lever into the key slot.

- c. Use the lever of Tooling (E) to rotate the shaft (22) until the pin of Tooling (E) can be engaged into the hole (24). Engage the pin of Tooling (E) into the hole.

- d. Loosen the locking screw (25) in the fuel injection pump. Slide the spacer (26) into position (Y). Tighten the 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).

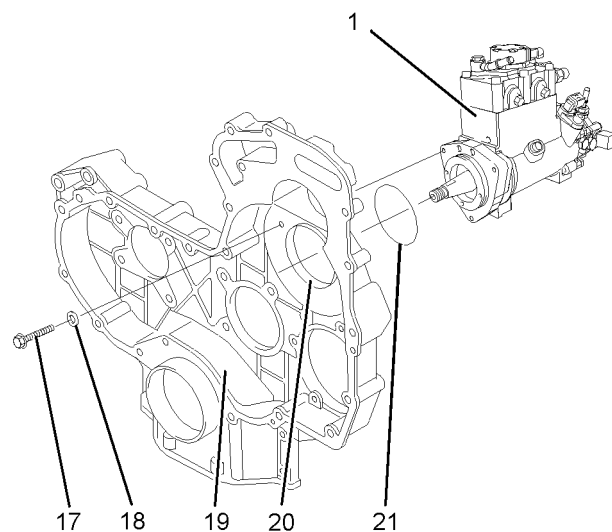


Illustration 28

g01173314

Typical example

- 4. Inspect the bore (20) in the front housing (19) for damage. If the bore is damaged, replace the front housing. Refer to Disassembly and Assembly Manual, "Housing (Front) - Remove" and Disassembly and Assembly Manual, "Housing (Front) - Install".

5. Use Tooling (F) to lubricate a new O-ring seal (21). Install the O-ring seal onto the fuel injection pump (1).
6. Align the holes in the fuel injection pump (1) with the holes in the 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 setscrews are installed.

7. Install the three setscrews (17) and three new sealing washers (18). Tighten the setscrews 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 Testing and Adjusting Manual, "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 Manual, "Fuel Injection Pump Gear - Install" and refer to Disassembly and Assembly Manual, "Gear Group (Front) - Install".
- Note:** Ensure that the spacer (26) on the fuel injection pump is in the 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 Manual, "Front Cover - Remove and Install".

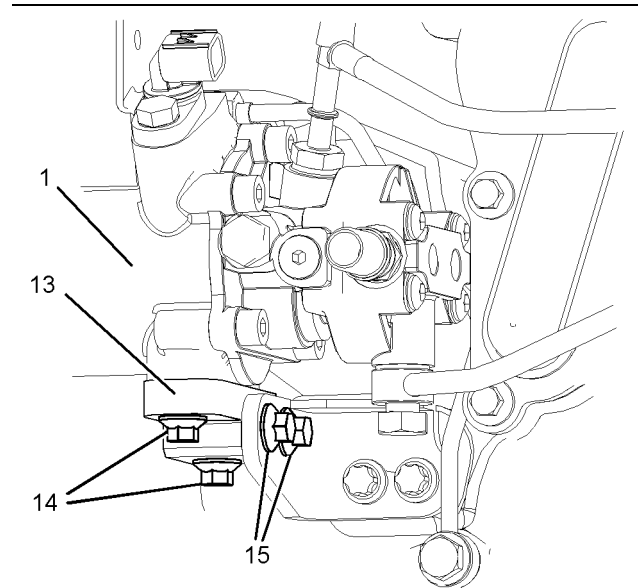


Illustration 29

g01208416

Typical example

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

Some engines have a single M10 nut and a bolt in place of the two setscrews (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.

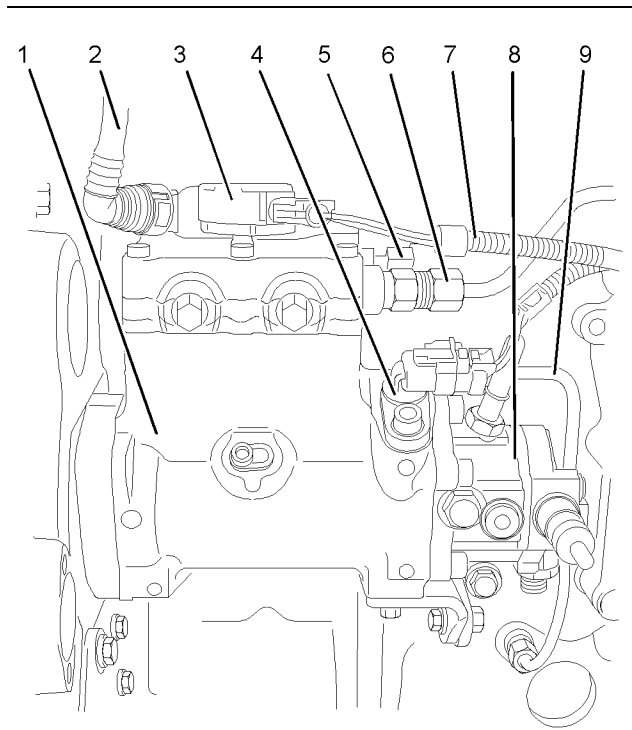


Illustration 30
Typical example

g01173307

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 the tube assembly (9). Tighten the nuts at both ends of the tube assembly.
16. Remove the appropriate caps in order to install the 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 Manual, "Fuel Injection Lines - Install".
17. Remove the plugs and caps from the remaining ports and tube assemblies.
18. Install the tube assembly (12) for the fuel return to the fuel transfer pump and to the cylinder head. Tighten the nuts at both ends of the tube assembly.
19. Install the plastic tube assembly (5) to the fuel injection pump (1).
20. Install the plastic tube assembly (10) for the fuel outlet to the fuel transfer pump (8).
21. Install the plastic tube assembly (11) to the fuel transfer pump (8).
22. Connect the harness assembly (7) to the solenoid (3) on the fuel injection pump. Connect the harness assembly (7) to the position sensor (4) on the fuel injection pump. Slide the locking tab (not shown) into the locked position.
23. If necessary, install the fuel priming pump. Refer to Disassembly and Assembly Manual, "Fuel Priming Pump - Remove and Install".
24. If necessary, install the fuel filter base. Refer to Disassembly and Assembly Manual, "Fuel Filter Base - Remove and Install".
25. Restore the fuel supply.
26. Restore the electrical supply.
27. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

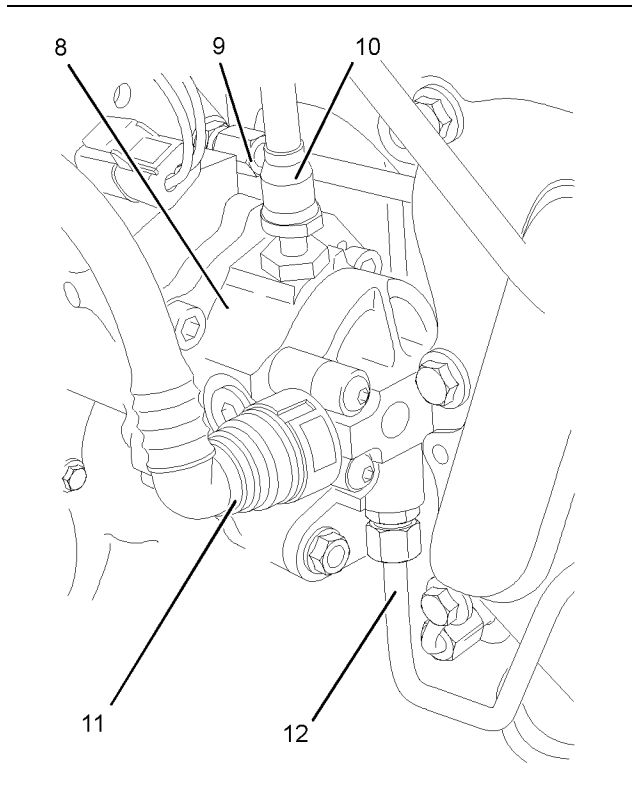


Illustration 31
Typical example

g01173310

i02296762

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 5

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
D	-	Puller (Two Leg)	1

Start By:

- a. Remove the front cover. Refer to Disassembly and Assembly Manual, "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 Testing and Adjusting Manual, "Finding Top Centre Position for No.1 Piston".

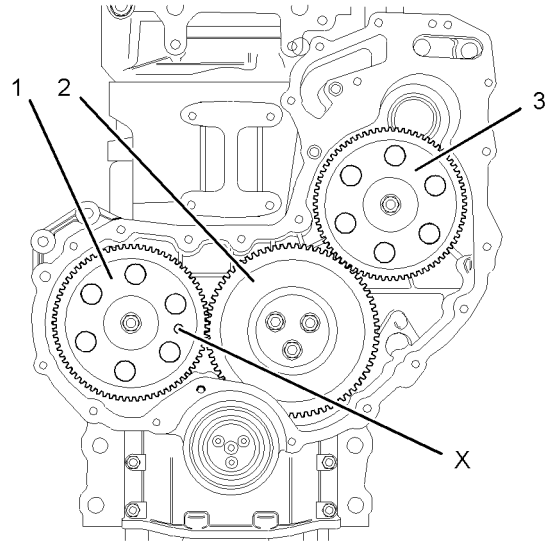


Illustration 32

g01194629

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

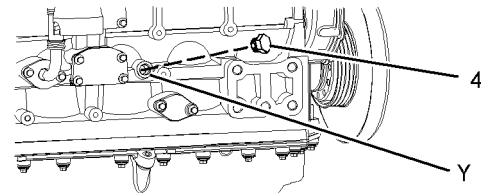


Illustration 33

g01195325

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

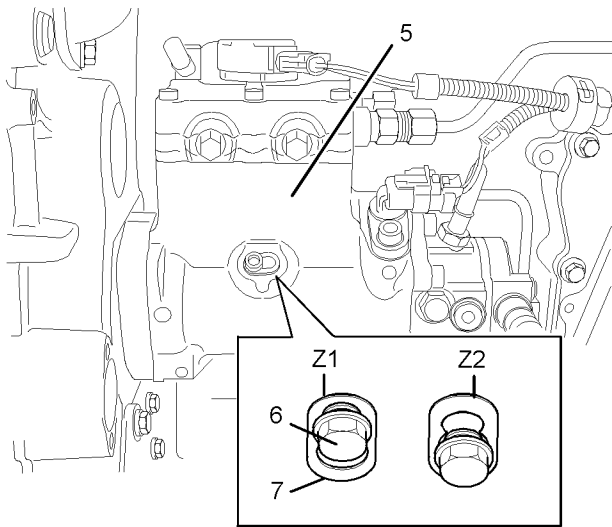


Illustration 34 g01196435

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

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

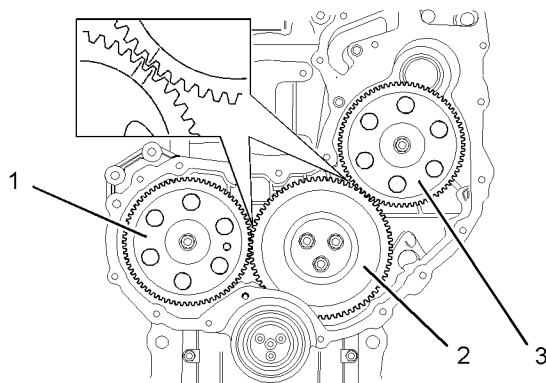


Illustration 35 g01196142
Alignment of timing marks

5. Mark the 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.

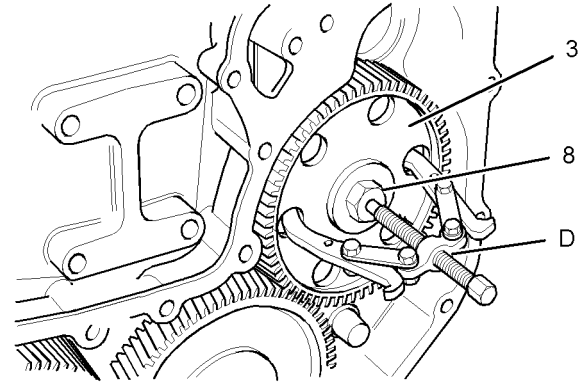


Illustration 36 g01196132

6. Loosen the nut (8) for the fuel pump gear (3).
7. Install Tooling (D) through two opposite holes in the fuel pump gear (3). Tighten Tooling (D) until the fuel pump gear (3) is released.
8. Remove Tooling (D) from the fuel pump gear (3).
9. Remove the nut (8) and washer (not shown) from the fuel pump gear (3). Remove the fuel pump gear.

i02296767

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

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 the Testing and Adjusting Manual, "Finding Top Center for No. 1 Piston".

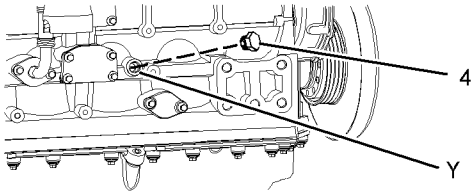


Illustration 37

g01195325

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.

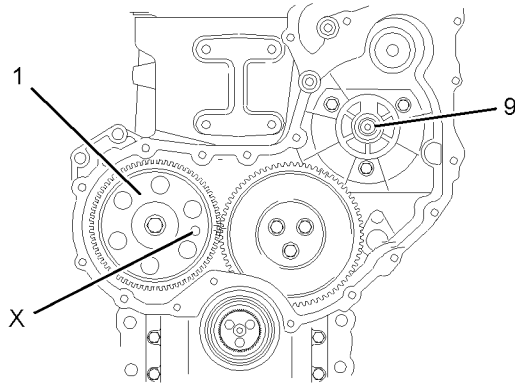


Illustration 38

g01196475

3. Ensure that Tooling (B) is installed into the hole (X) in the camshaft gear (1).
4. Ensure that the 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 Manual, "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.

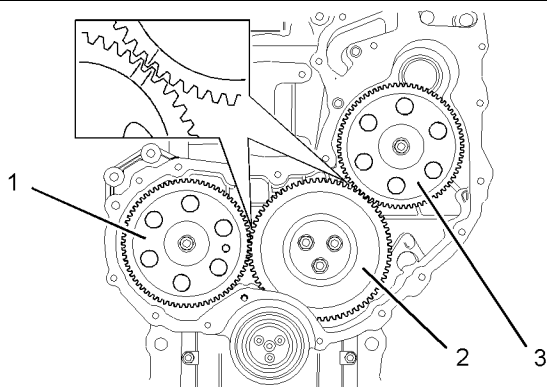


Illustration 39

g01194949

Alignment of timing marks

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

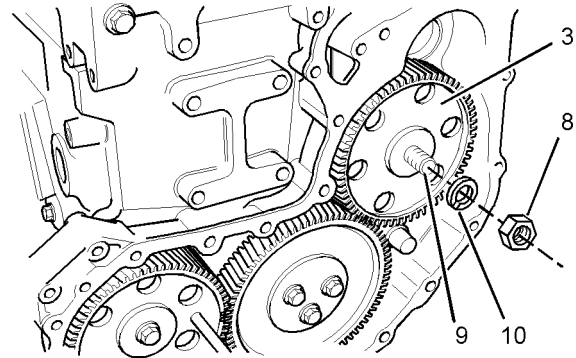


Illustration 40

g01196488

Typical example

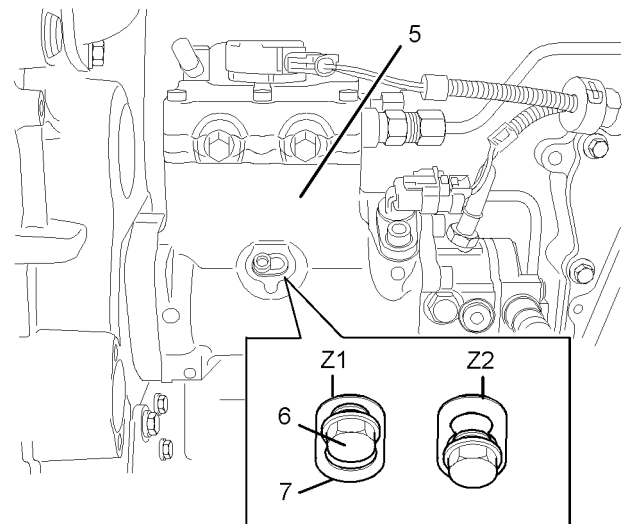


Illustration 41

g01196435

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

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

9. Remove Tooling (B) and (C). Install the plug (4) into hole (Y) in the cylinder block. Refer to Illustration 37.
10. Tighten the nut (8) to a torque of 90 N·m (66.4 lb ft).

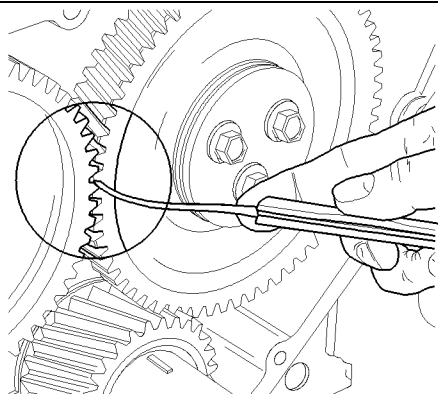


Illustration 42 g00944084
Checking backlash

11. Ensure that the backlash for the gears (2) and (3) is within specified values. Refer to the Specifications Manual, “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 Manual, “Front Cover - Remove and Install”.

i02295935

Electronic Unit Injector - Remove

Removal Procedure (One Injector)

Table 7

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610288	Pry Bar	1

Start By:

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

1. Isolate the fuel supply to the engine.

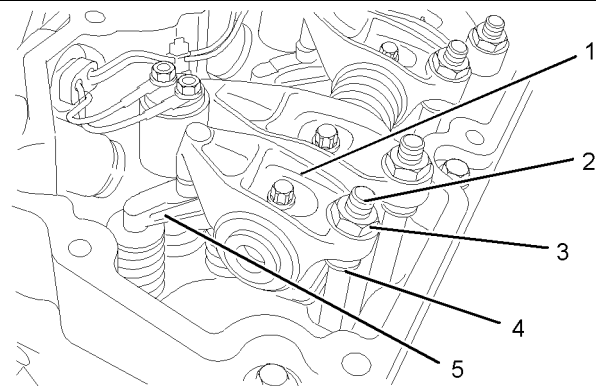


Illustration 43 g01193285
Typical example

2. Use Tooling (A) in order to rotate the crankshaft until the rocker arms (1) for the appropriate cylinder are in the correct position in order to adjust the valve lash. Refer to Testing and Adjusting Manual, “Engine Valve Lash - Inspect/Adjust”.
3. Follow Steps 3.a through 3.c in order to gain access to the assembly of the electronic unit injector.
 - a. Loosen the nuts (3) on the appropriate cylinder. Unscrew the adjusters (2) on the appropriate cylinder until the pushrods (4) can be withdrawn from the balls of the adjusters.
 - b. Withdraw the cups of the pushrods (4) from the balls of the adjusters (2).

- c. Make a temporary mark on the valve bridges (5) in order to show the location and orientation. Remove 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.

4. Place a suitable container below the fuel transfer pump in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

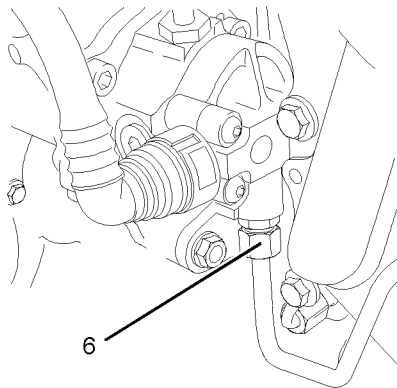


Illustration 44

g01193839

Typical example

5. Disconnect the tube assembly (6) for the injector leak-off from the fuel transfer pump. Allow the fuel to drain from the tube assembly.

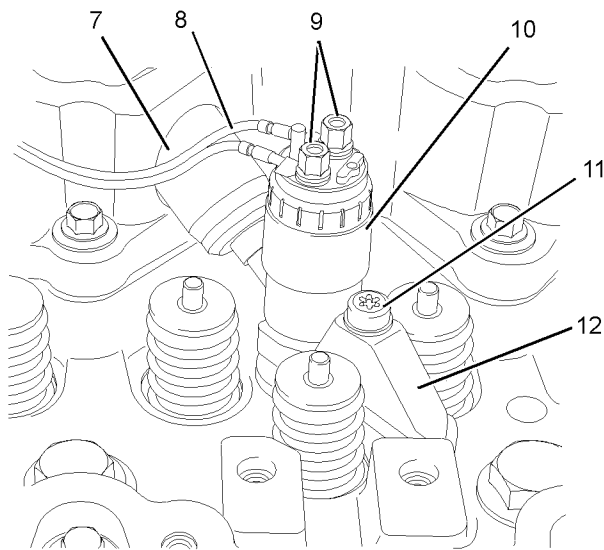


Illustration 45

g01193293

The rocker shaft is not shown for clarity.

6. Remove the fuel injection line (not shown) and the seal (7) from the appropriate electronic unit injector (10). Refer to Disassembly and Assembly Manual, "Fuel Injector Lines - Remove".

Note: Cap all open ports immediately with new caps.

7. Place a temporary identification mark on the connections (9) for the harness assembly (8).
8. Use a deep socket to remove the connections (9) from the electronic unit injectors (10).
9. Slide the rocker arms (1) to one side in order to gain access to the torx screw (11). Use Tooling (B) in order to remove the torx screw from the clamp (12). Discard the torx screw.

10. Place a temporary identification mark on the electronic unit injector (10). The electronic unit injector must be reinstalled in the original location in the cylinder head.

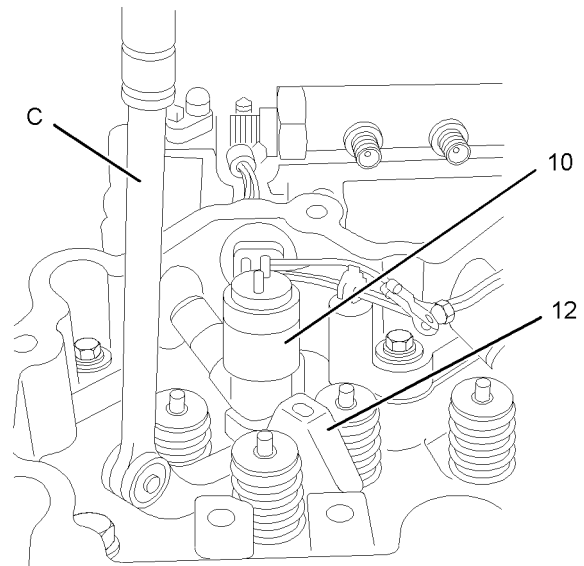


Illustration 46

g01193295

The rocker shaft is not shown for clarity.

11. Use Tooling (C) to pry beneath the clamp (12) and free the electronic unit injector (10) from the cylinder head.
12. Remove the electronic unit injector (10) and the clamp (12) from the cylinder head.

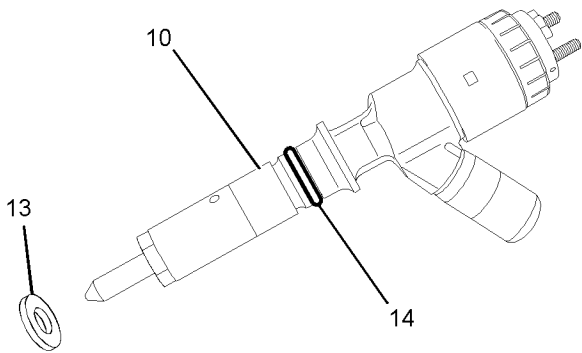


Illustration 47

g01193297

- 13. Remove the sealing washer (13) from the base of the electronic unit injector (10) or from the bore in the cylinder head. Discard the sealing washer.
- 14. Remove the O-ring seal (14) from the electronic unit injector (10). Discard the O-ring seal.

Removal Procedure (All Injectors)

Table 8

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	T40 Torx Socket	1
C	27610288	Pry Bar	1

Start By:

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

⚠ 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 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.

1. Isolate the fuel supply to the engine.
2. Place a suitable container below the fuel transfer pump in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

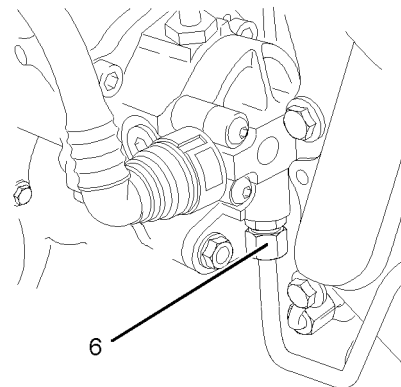


Illustration 48

g01193839

Typical example

3. Disconnect the tube assembly (6) for the injector leak-off from the fuel transfer pump. Allow the fuel to drain from the tube assembly.

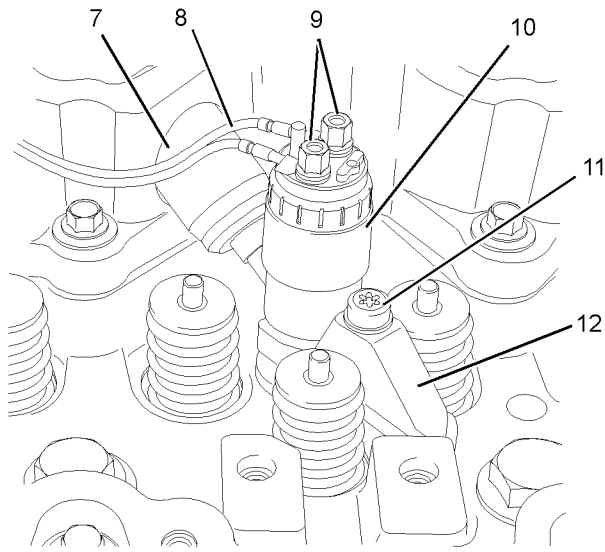


Illustration 49

g01193293

4. Place a temporary identification mark on the connections (9) for the harness assembly (8).
5. Use a deep socket to remove the connections (9) from the electronic unit injectors (10).
6. Use Tooling (B) in order to remove the torx screw (11) from the clamp (12). Discard the torx screw.
7. Place a temporary identification mark on the electronic unit injector (10). The electronic unit injector must be reinstalled in the original location in the cylinder head.

8. Use Tooling (C) to pry beneath the clamp (12) and free the electronic unit injector (8) from the cylinder head.
9. Remove the electronic unit injector (10) and the clamp (12) from the cylinder head.

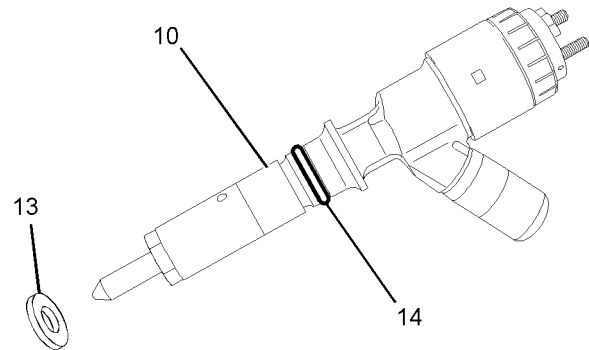


Illustration 51

g01193297

10. Remove the sealing washer (13) from the base of the electronic unit injector (10) or from the bore in the cylinder head. Discard the sealing washer.
11. Remove the O-ring seal (14) from the electronic unit injector (8). Discard the O-ring seal.
12. Repeat Steps 4 through 11 in order to remove the remaining electronic unit injectors.

i02295941

Electronic Unit Injector - Install

Installation Procedure (One Injector)

Table 9

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

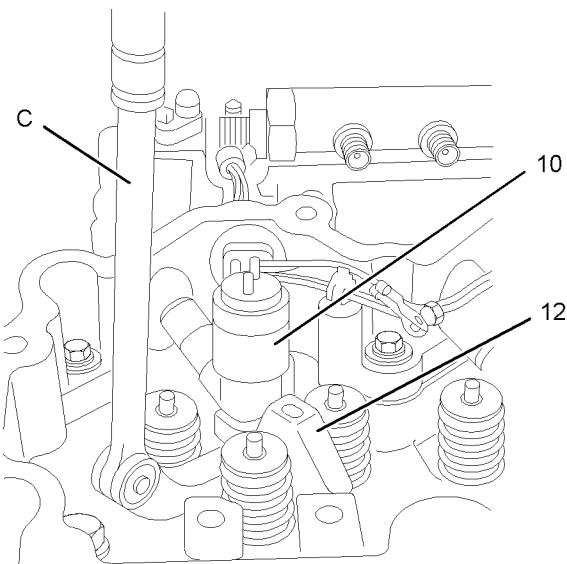


Illustration 50

g01193295

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 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.

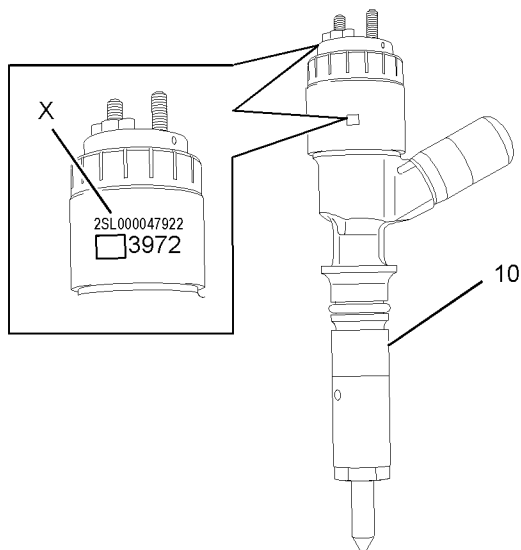


Illustration 52 g01194240

The location of the calibration code

1. If a replacement electronic unit injector is installed, the calibration code that is located at position (X) must be programmed into the electronic control module. Refer to Troubleshooting Guide, “Injector Trim File” for more information.

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.

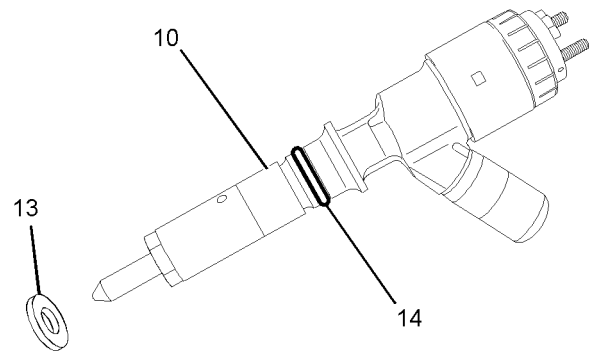


Illustration 53 g01193297

4. Install a new O-ring seal (14) to the electronic unit injector (10).

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. Position a new sealing washer (13) onto the seat for the electronic unit injector in the cylinder head.

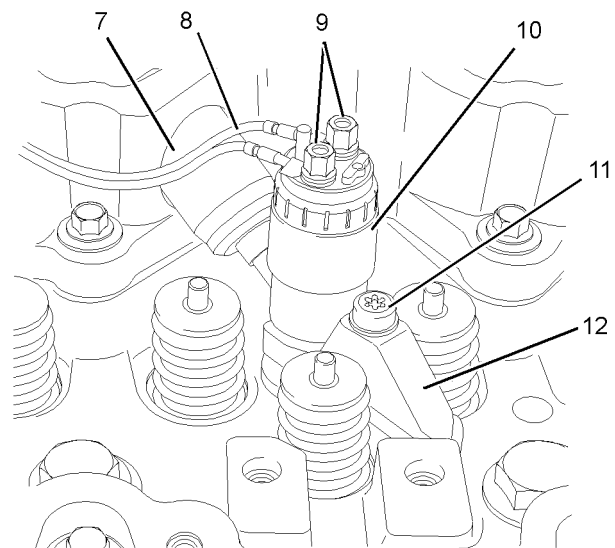


Illustration 54 g01193293

The rocker shaft is not shown for clarity.

6. Install the clamp (12) to the electronic unit injector (10). Install the electronic unit injector assembly into the cylinder head.

Note: Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head.

7. Install a new torx screw (11) to the clamp (12). Tighten the torx screw finger tight.
8. Thoroughly clean the seal (7). Inspect the seal for damage. If necessary, replace the seal.

Note: The seal can be damaged by contact with fuel.

9. Remove the cap from the electronic unit injector (10). Install the seal (7) to the electronic unit injector (10). Ensure that the flange on the seal is flush with the valve mechanism cover base.
10. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line (not shown). Refer to Disassembly and Assembly Manual, "Fuel Injector 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.

11. Use Tooling (B) to tighten the torx screw (11) to a torque of 27 N·m (20 lb ft).
12. Use Tooling (E) to tighten the fuel injection line (not shown) to a torque of 30 N·m (22 lb ft). Refer to Disassembly and Assembly Manual, "Fuel Injector Lines - Install".
13. Use a deep socket to install the harness assembly (8) to the electronic unit injector (10). Use Tooling (F) to tighten the connections to a torque of 2.4 N·m (21 lb in).

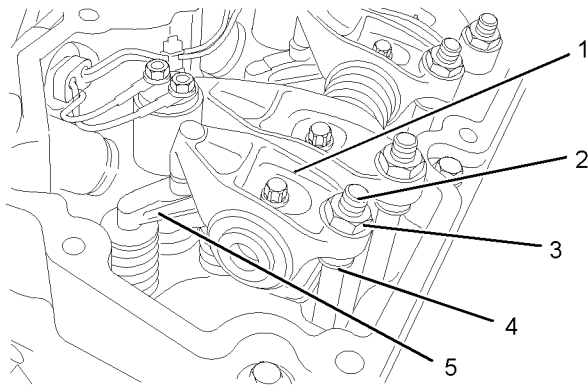


Illustration 55
Typical example

14. Install 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.

15. Ensure that the bottoms of the pushrod are seated in the cups of the valve lifters. Locate the balls of the adjusters (2) into the cups of the pushrods (4). Adjust the valve lash. Refer to Testing and Adjusting Manual, "Engine Valve Lash - Inspect/Adjust".

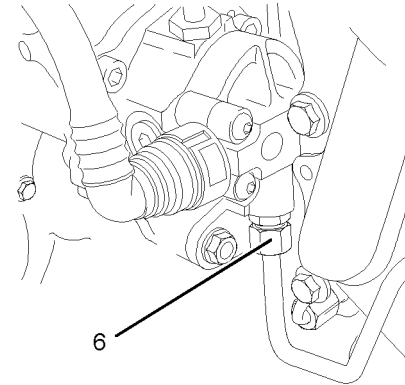


Illustration 56
Typical example

16. Connect the tube assembly (6) for the injector leak-off to the fuel transfer pump.
17. Restore the fuel supply to the engine.
18. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

End By:

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

Installation Procedure (All Injectors)

Table 10

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	T40 Torx Socket	1
D	-	Vacuum Pump	1
	-	Tube 7.9 mm (0.31 inch) OD	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 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.

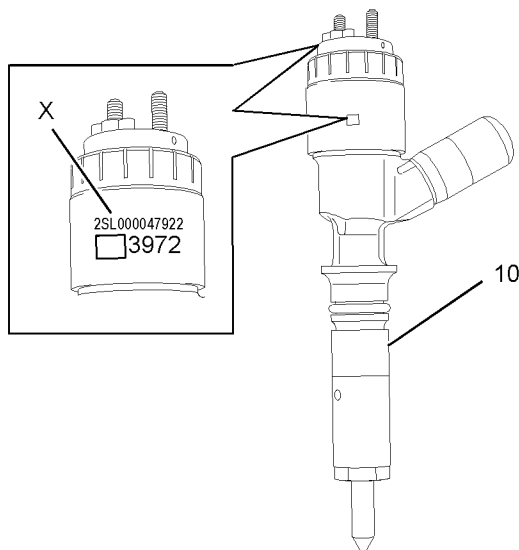


Illustration 57 g01194240

The location of the calibration code

1. If a replacement electronic unit injector is installed, the calibration code that is located at position (X) must be programmed into the electronic control module. Refer to Troubleshooting Guide, “Injector Trim File” for more information.

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.

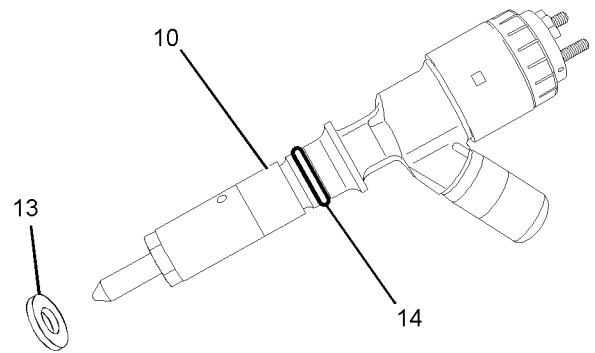


Illustration 58 g01193297

4. Install a new O-ring seal (14) to the electronic unit injector (10).

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. Position a new sealing washer (13) on the seat for the electronic unit injector in the cylinder head.

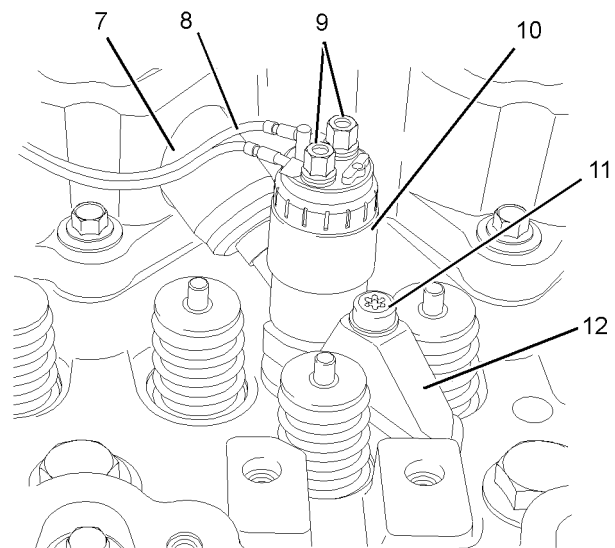


Illustration 59 g01193293

6. Install the clamp (12) to the electronic unit injector (10). 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.

7. Install a new torx screw (11) to the clamp (12). Tighten the torx screw finger tight.
8. Thoroughly clean the seal (7). Inspect the seal for damage. If necessary, replace the seal.

Note: The seal can be damaged by contact with fuel.

9. Remove the cap from the electronic unit injector (10). Install the seal (7) to the electronic unit injector (10). Ensure that the flange on the seal is flush with the valve mechanism cover base.
10. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line (not shown). Refer to Disassembly and Assembly Manual, "Fuel Injector 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.

11. Use Tooling (B) to tighten the torx screw (11) to a torque of 27 N·m (20 lb ft).
12. Use Tooling (E) to tighten the fuel injection line (not shown) to a torque of 30 N·m (22 lb ft). Refer to Disassembly and Assembly Manual, "Fuel Injector Lines - Install".
13. Use a deep socket to install the harness assembly (8) to the electronic unit injector (10). Use Tooling (F) to tighten the connections to a torque of 2.4 N·m (21 lb in).
14. Repeat Steps 2 through 13 in order to install the remaining electronic unit injectors.
15. Install the rocker shaft assembly. Refer to Disassembly and Assembly, "Rocker Shaft - Install".

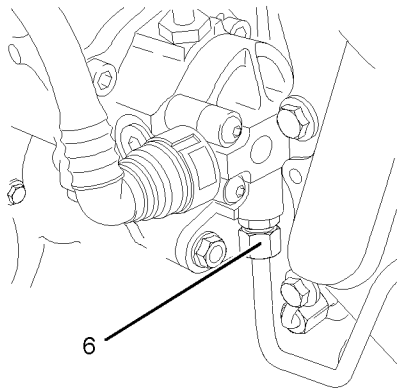


Illustration 60
Typical example

g01193839

16. Connect the tube assembly (6) for the injector leak-off to the fuel transfer pump.
17. Restore the fuel supply to the engine.
18. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.

Turbocharger - Remove

Removal Procedure (Side Mounted Turbochargers)

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. Disconnect the air hose for the turbocharger inlet and for the turbocharger outlet (not shown). Refer to OEM information for the correct procedure.
2. If the turbocharger has a remote wastegate solenoid, disconnect the hose to the solenoid (not shown) from the turbocharger.
3. Disconnect the exhaust pipe (not shown). Refer to OEM information for the correct procedure.
4. If the turbocharger has an exhaust elbow, remove the exhaust elbow (not shown). Refer to Disassembly and Assembly Manual, "Exhaust Elbow - Remove and Install".

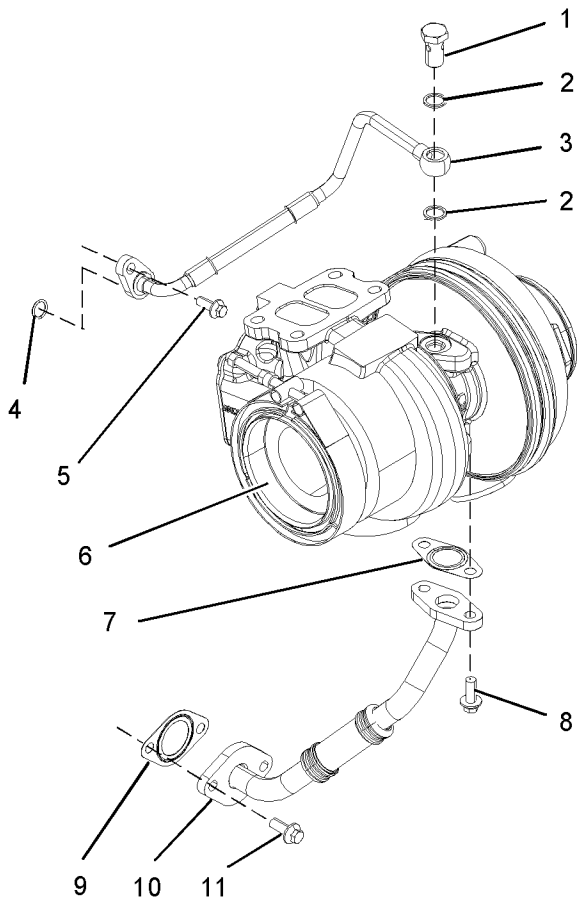


Illustration 61

g01165546

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

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 the tube assembly (10) for the oil drain.
 - a. Remove the two setscrews (11).
 - b. Remove the two setscrews (8) and remove the tube assembly (10) from the turbocharger (6).
 - c. Remove the joint (7) and remove the joint (9). Discard the joints.

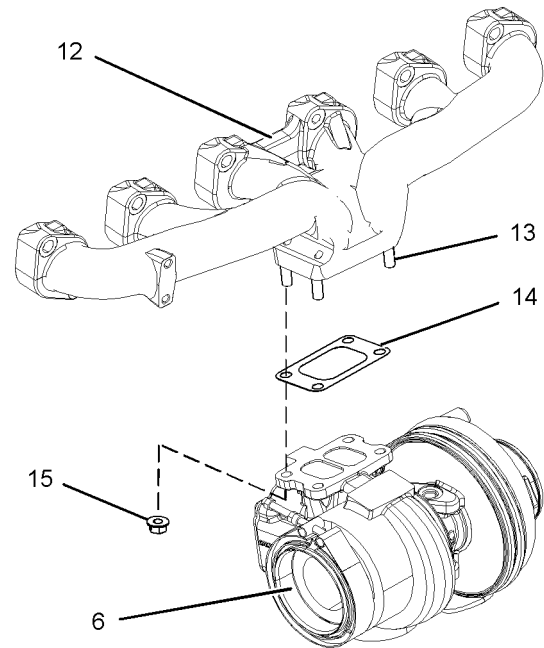


Illustration 62

g01171991

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

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

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

Removal Procedure (Top Mounted Turbochargers)

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. Disconnect the air hose for the turbocharger inlet and for the turbocharger outlet (not shown). Refer to OEM information for the correct procedure.
2. If the turbocharger has a remote wastegate solenoid, disconnect the hose to the solenoid (not shown) from the turbocharger.
3. Disconnect the exhaust pipe (not shown). Refer to OEM information for the correct procedure.
4. If the turbocharger has an exhaust elbow, remove the exhaust elbow (not shown). Refer to Disassembly and Assembly Manual, "Exhaust Elbow - Remove and Install".

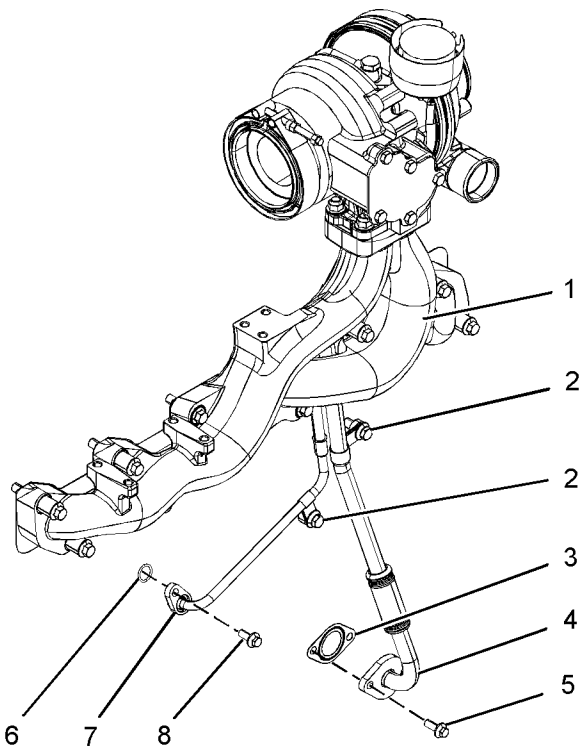


Illustration 63

g01183875

5. Remove the two setscrews (5) in order to disconnect the tube assembly (4) from the cylinder block. Remove the joint (3). Discard the joint.

6. Remove the setscrew (8) in order to disconnect the tube assembly (7) from the cylinder block.
7. Remove the fasteners for the tube clips (2).
8. Loosen the four nuts (11). Refer to Illustration 64.
9. Remove the exhaust manifold (1) and the assembly of the turbocharger from the cylinder head. Refer to Disassembly and Assembly Manual, "Exhaust Manifold - Remove and Install" for the correct procedure.

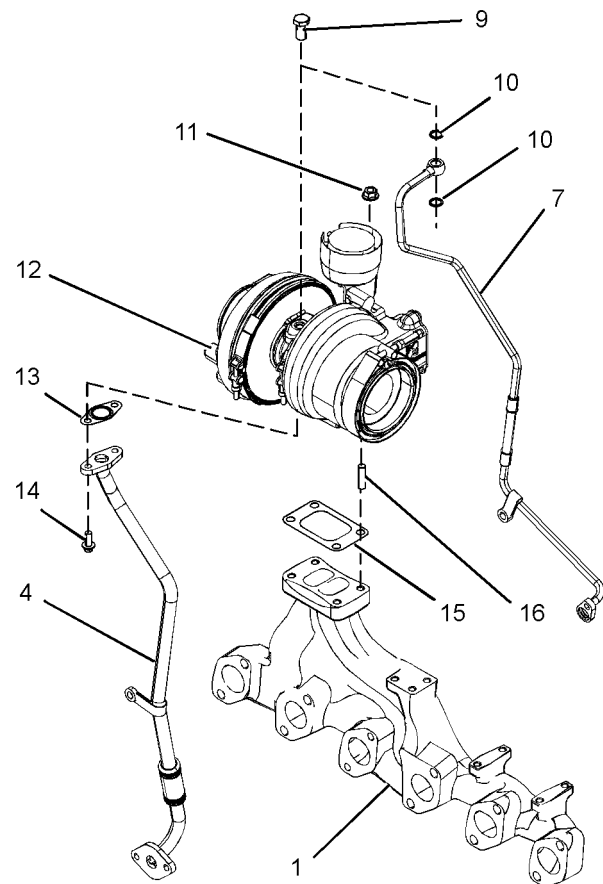


Illustration 64

g01185011

10. Remove the banjo bolt (9) and remove the tube assembly (7) for the oil feed from the turbocharger (12). Remove the two sealing washers (10). Discard the sealing washers.

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

11. Remove the O-ring seal (6) from the tube assembly (7). Refer to Illustration 63. Discard the O-ring seal.

12. Remove the two setscrews (14) and remove the tube assembly (4) for the oil drain from the turbocharger (12).
13. Remove the joint (13). Discard the joint.
14. Remove the four nuts (11) and remove the turbocharger (12) from the exhaust manifold (1).

Note: Ensure that the exhaust manifold and the turbocharger are adequately supported during the removal of the turbocharger.

15. Remove the joint (15) from the exhaust manifold (1). Discard the joint.
16. If necessary, remove the four studs (16) from the exhaust manifold (1).

i02347778

Turbocharger - Disassemble

Disassembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

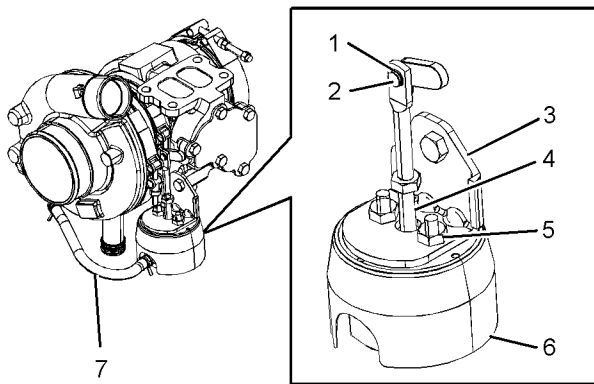


Illustration 65

g01176032

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

i02347770

Turbocharger - Assemble

Assembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

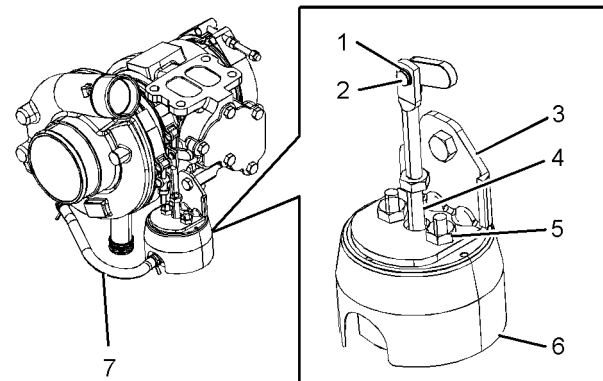


Illustration 66

g01176032

1. Install the actuator (6) to the bracket (3). Install the nuts (5) to the bracket (3).
 2. Tighten the nuts to a torque of 5 N·m (44 lb in).
 3. Connect the bottom of the 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 the actuator (6) and hold the arm in position. Slowly apply air pressure to the actuator (6) until the pin (2) will fit into the actuator rod (4). Install the circlip (1) into the groove in the 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 the boost pressure (7) to the actuator (6).

End By:

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

i02295957

Turbocharger - Install

Installation Procedure (Side Mounted Turbochargers)

Table 11

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.

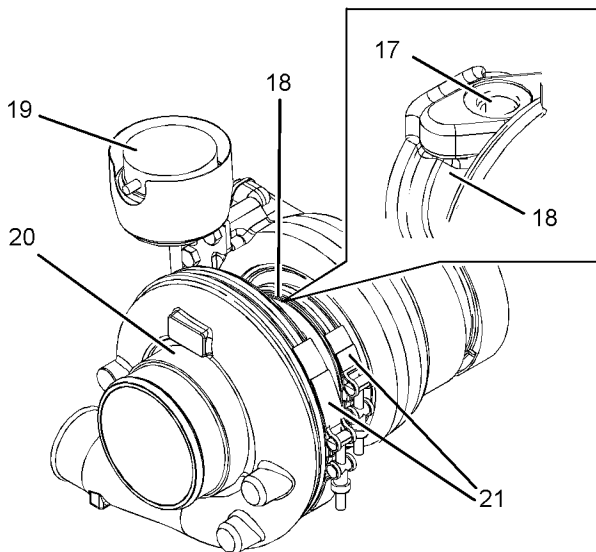


Illustration 67

g01187836

Typical example

1. Ensure that the turbocharger is clean and free from damage. Inspect the turbocharger for wear. Refer to Testing and Adjusting Manual, "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 Testing and Adjusting Manual, "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 Manual, "Turbocharger - Dissassemble" and refer to Disassembly and Assembly Manual, "Turbocharger - Assemble" for more information.

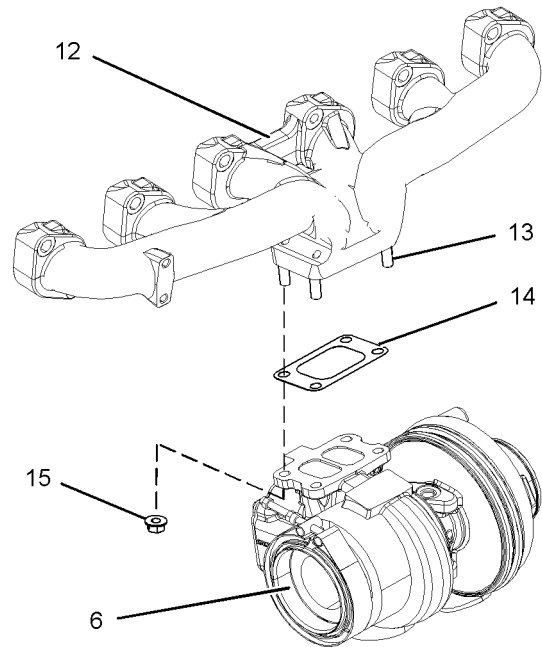


Illustration 68

g01171991

Typical example

3. Clean the mating surfaces of the exhaust manifold (12). If necessary, install the four 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 the exhaust manifold (12).
 5. Position the turbocharger (6) on the exhaust manifold.
- Note:** Ensure that the turbocharger is correctly oriented.
6. Install the four nuts (15). Tighten the nuts to a torque of 44 N·m (32 lb ft).

7. If a new turbocharger is installed, the bearing housing (18) and the 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 the two 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 the bearing housing (18) until the port for the oil feed (17) is upward.
- c. Rotate the 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 the band clamps (21) are correctly oriented. Refer to the turbocharger that was originally installed for the correct orientation. Tighten the band clamps finger tight.

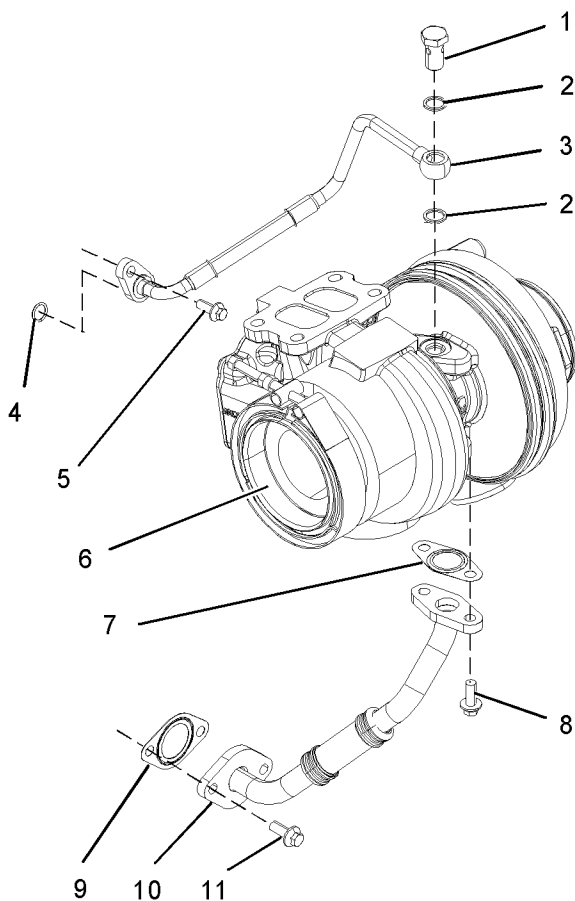


Illustration 69

g01165546

8. Ensure that the tube assemblies (3) and (10) are clean and free from damage. Replace any damaged components.
9. Position a new joint (7) and the two setscrews (8) onto the tube assembly (10).
10. Install the tube assembly (10) to the turbocharger (6). Tighten the setscrews (8) finger tight.
11. Position a new joint (9) between the flange of the tube assembly (10) and the cylinder block. Install the two setscrews (11) finger tight.
12. If a new turbocharger has been installed, check that the orientation of the bearing housing (18) is correct. If the orientation of the bearing housing is not correct, rotate the bearing housing until the tube assembly (10) fits correctly. Tighten the two band clamps (21) to a torque of 13 N·m (9.6 lb ft).
13. Tighten the setscrews (8) and (11) to a torque of 22 N·m (16 lb ft).
14. Remove the plug from the 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 the O-ring seal (4) to the tube assembly (3).
16. Install the banjo bolt (1) and two new sealing washers (2) to the tube assembly (3).
17. Install the tube assembly (3) to the cylinder block and to the turbocharger (6). Tighten the banjo bolt (1) finger tight.
18. Install the setscrew (5) finger tight. Ensure that the tube assembly (3) fits correctly.
19. Tighten the banjo bolt (1) to a torque of 20 N·m (14 lb ft). Tighten the setscrew (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 Manual, "Exhaust Elbow - Remove and Install".
21. Connect the exhaust pipe (not shown). Refer to OEM information for the correct procedure.
22. If the turbocharger has a remote wastegate solenoid, connect the hose for the solenoid (not shown) to the turbocharger.
23. Connect the air inlet hose and connect the air outlet hose (not shown) to the turbocharger. Refer to OEM information for the correct procedure.

Installation Procedure (Top Mounted Turbochargers)

Table 12

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.

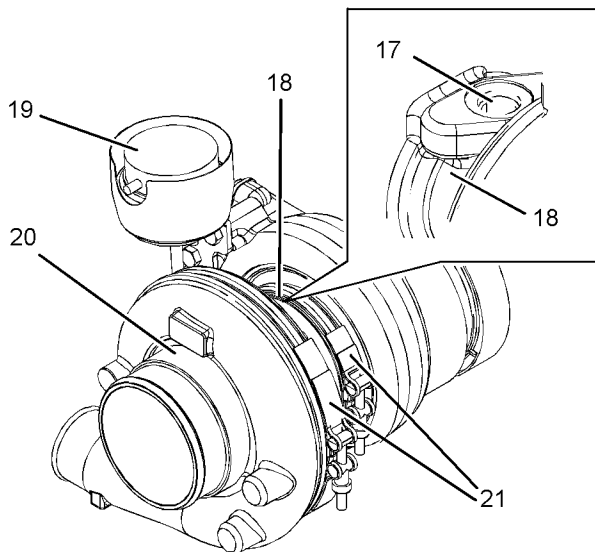


Illustration 70
Typical example
g01187836

1. Ensure that the turbocharger is clean and free from damage. Inspect the turbocharger for wear. Refer to Testing and Adjusting Manual, "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 Testing and Adjusting Manual, "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 Manual, "Turbocharger - Disassemble" and refer to Disassembly and Assembly Manual, "Turbocharger - Assemble" for more information.

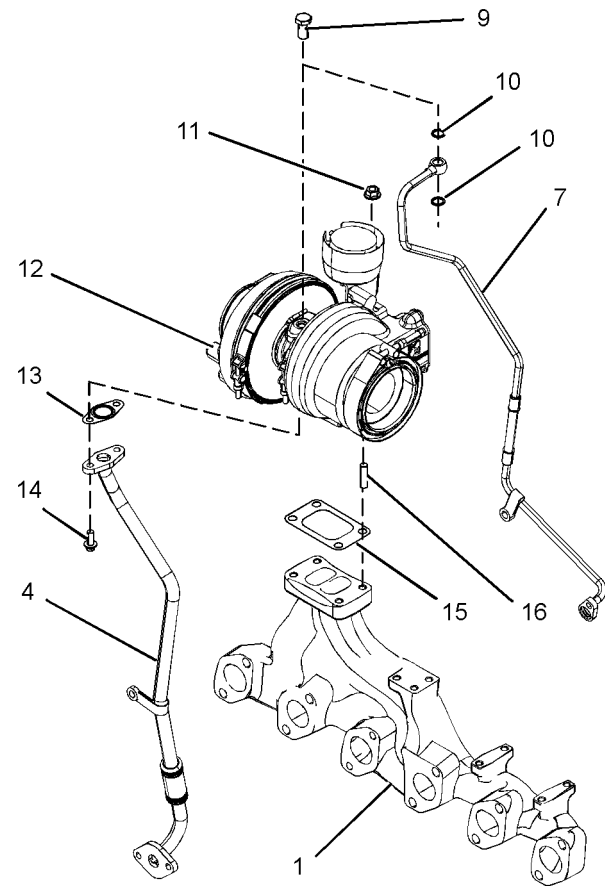


Illustration 71
g01185011

3. Clean the mating surfaces of the exhaust manifold (1). If necessary, install the four 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 the exhaust manifold (1).
5. Position the turbocharger (12) on the exhaust manifold (1).

Note: Ensure that the turbocharger is correctly oriented.

6. Install the four nuts (11). Tighten the nuts to a torque of 44 N·m (32 lb ft).

7. If a new turbocharger is installed, the bearing housing (18) and the compressor housing (20) must be oriented to the correct positions. Refer to Illustration 70. Follow Steps 7.a through 7.d in order to orient the bearing housing and the compressor housing.
- Loosen the two band clamps (21) sufficiently in order to allow the housings to rotate.
- Note:** If the band clamps are damaged, replace the band clamps.
- Carefully turn the bearing housing (18) until the port for the oil feed (17) is upward.
 - Rotate the compressor housing (20) until the compressor outlet is in the correct position. Refer to the turbocharger that was originally installed for the correct orientation.
 - Ensure that the band clamps (21) are correctly oriented. Refer to the turbocharger that was originally installed for the correct orientation. Tighten the band clamps finger tight.

- Ensure that the tube assemblies (4) and (7) are clean and free from damage. Replace any damaged components.
- Position a new joint (13) and the two setscrews (14) onto the tube assembly (4).
- Install the tube assembly (4) to the turbocharger (12). Tighten the setscrews (14) finger tight.
- Remove the plug from the oil inlet port (17). Refer to Illustration 70. 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.
- Install the banjo bolt (9) and two new sealing washers (10) to the tube assembly (7).
- Use Tooling (A) in order to lubricate a new O-ring seal (6). Install the O-ring seal (6) to the tube assembly (7). Refer to Illustration 72.
- Install the tube assembly (7) to the turbocharger (12). Tighten the banjo bolt (9) finger tight.

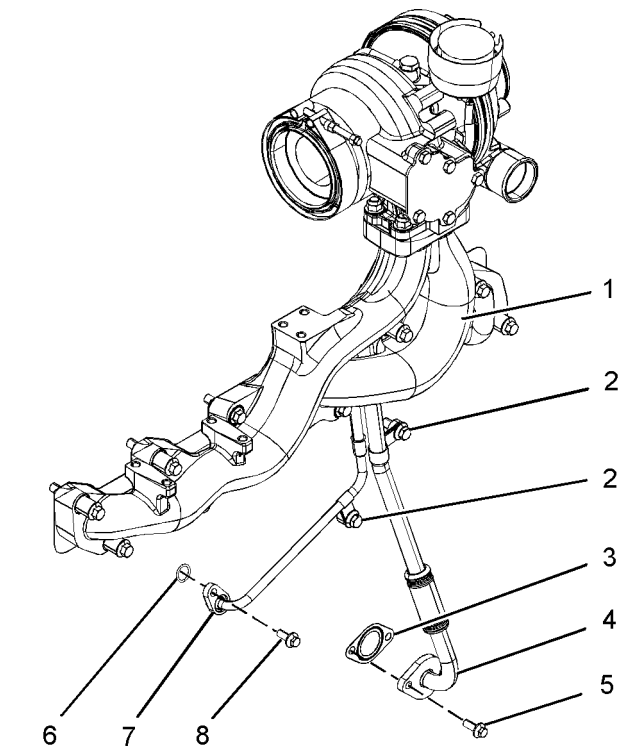


Illustration 72

g01183875

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

22. Connect the exhaust pipe (not shown). Refer to OEM information for the correct procedure.
23. If the turbocharger has a remote wastegate solenoid, connect the hose for the solenoid (not shown) to the turbocharger.
24. Connect the air inlet hose and connect the air outlet hose (not shown) to the turbocharger. Refer to OEM information for the correct procedure.

i02347765

Wastegate Solenoid - Remove and Install

Removal Procedure

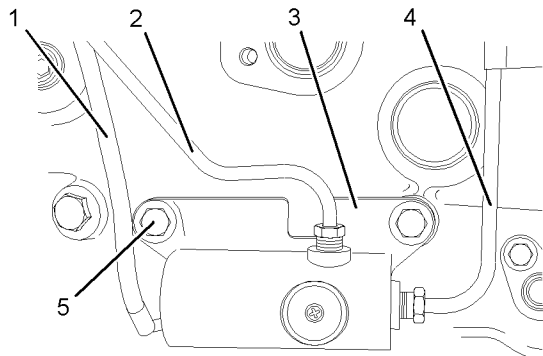


Illustration 73

g01165640

Typical example

1. Follow Steps 1.a through 1.c in order to disconnect the wire lead (1).
 - a. Disconnect the wire lead (1) from the harness assembly (not shown).
 - b. If the harness assembly (1) is secured with a cable tie, remove the cable tie.
 - c. Remove the wire lead (1) from the tube assembly (2).
- Note:** The wire lead is secured to the tube assembly with clips.
2. Disconnect the tube assembly (2) from the wastegate solenoid (3).
3. Disconnect the tube assembly (4) from the wastegate solenoid (3). If the tube assembly (4) is secured with tube clips, loosen the fasteners for the tube clips.

Note: The tube clips must be loose in order to release the tube assembly from the wastegate solenoid.

4. Remove the two setscrews (5) and remove the 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.

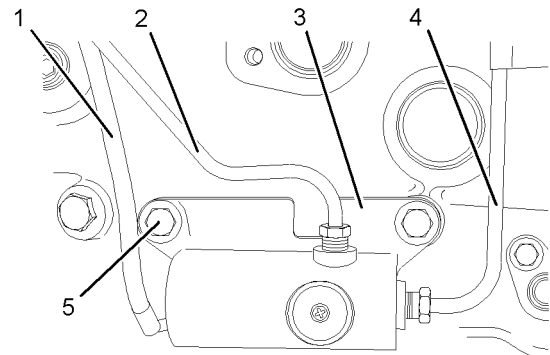


Illustration 74

g01165640

Typical example

2. Loosely install the wastegate solenoid (3) to the tube assembly (2).
3. Loosely install the tube assembly (4) to the wastegate solenoid (3).
4. Install the two setscrews (5) to the wastegate solenoid (3). Tighten the setscrews (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 the tube assembly (4) is secured with tube clips, tighten the fasteners for the tube clips.

Tighten M8 fasteners to a torque of 22 N·m (16 lb ft). Tighten M10 fasteners to a torque of 44 N·m (32.5 lb ft).
7. Follow Steps 7 through 7.c in order to connect the wire lead (1).
 - a. Install the wire lead (1) to the tube assembly (2).
 - b. Connect the wire lead (1) to the harness assembly for the engine (not shown).

- c. If the wire lead (1) is secured with a cable tie, install a new cable tie.

i02295960

Exhaust Manifold - Remove and Install

Removal Procedure (Side Mounted Exhaust Manifold)

Start By:

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

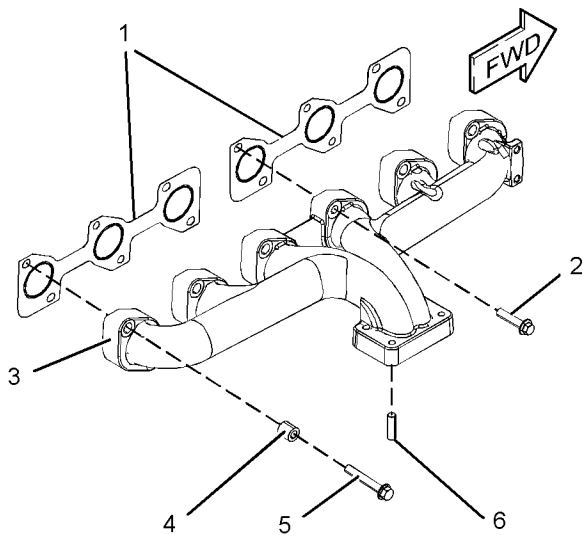


Illustration 75

g01174489

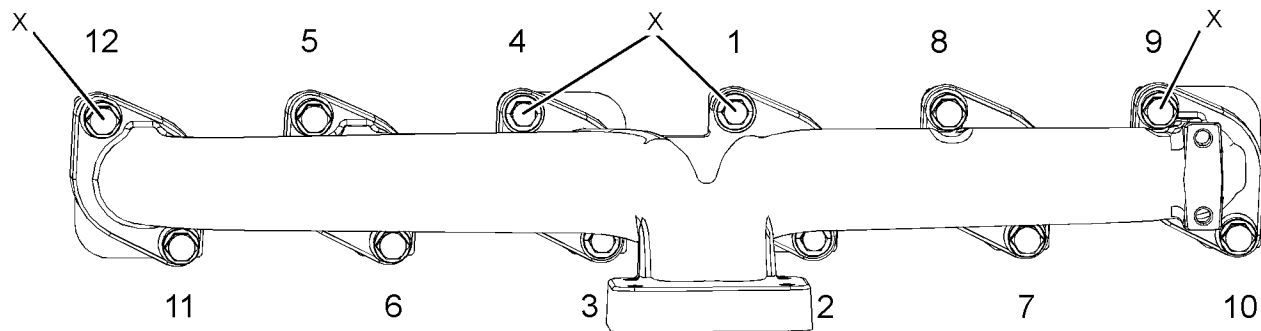


Illustration 76

g01176473

- 1. Loosen the setscrews (2) and (5) in reverse numerical order. Refer to Illustration 76.

- 2. Remove the center four setscrews (2) from the exhaust manifold (3). Remove the outer eight setscrews (5) and the spacers (4) from the exhaust manifold (3).

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

Note: Support the manifold as the setscrews are removed.

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

Removal Procedure (Top Mounted Exhaust Manifold)

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

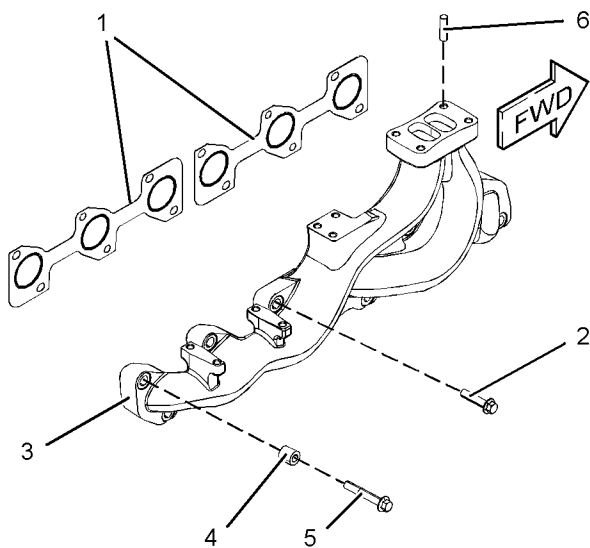


Illustration 77

g01176186

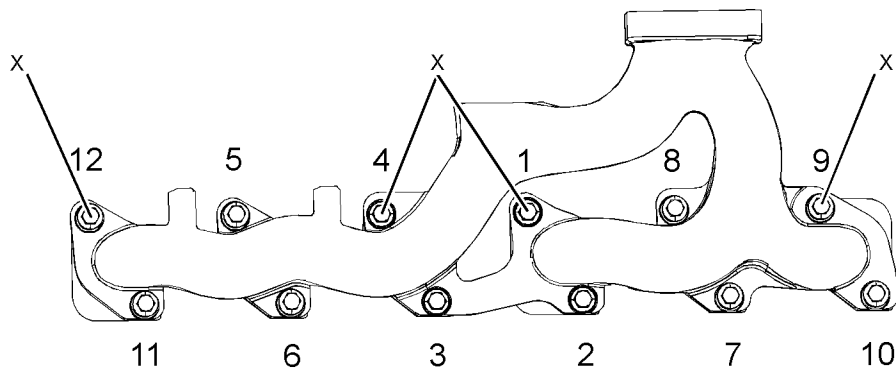


Illustration 78

g01176487

2. Loosen the setscrews (2) and (5) in reverse numerical order. Refer to Illustration 78.

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

- Remove the center four setscrews (2) from the exhaust manifold (3). Remove the outer eight setscrews (5) and the spacers (4) from the exhaust manifold (3).

Note: Support the manifold as the setscrews are removed.

- Remove the assembly of the exhaust manifold (3) and the turbocharger.
- Remove the two exhaust manifold gaskets (1). Discard the gaskets.
- Remove the turbocharger from the exhaust manifold (3). Refer to Disassembly and Assembly Manual, "Turbocharger - Remove" Steps 8 through 15.
- If necessary, remove the four studs (6) from the 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	-

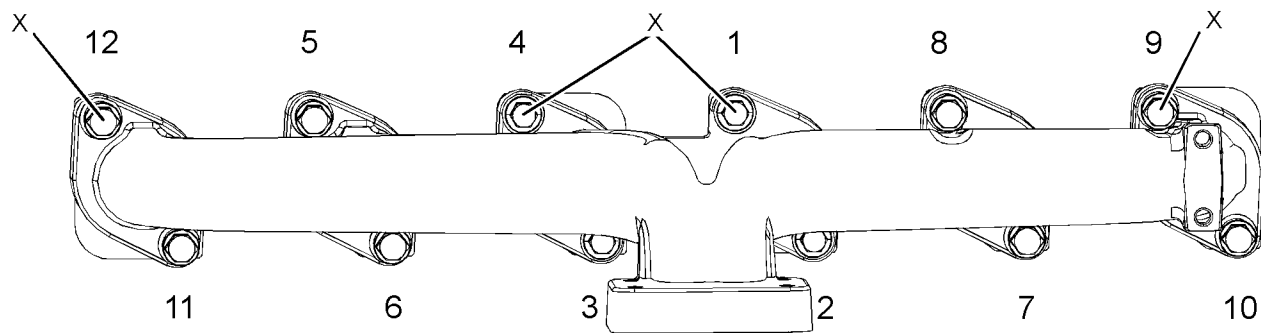


Illustration 79

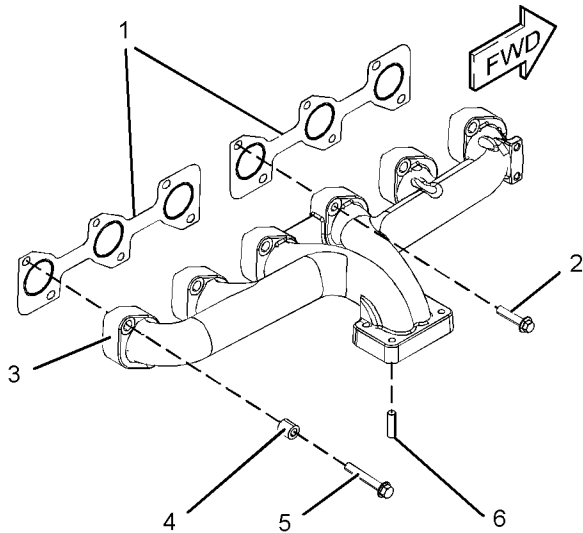


Illustration 80

g01174489

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 the four studs (6) to the 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 the positions (X). Refer to Illustration 79.
4. Position two new exhaust manifold gaskets (1) onto Tooling (A).

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

5. Align the exhaust manifold (3) with Tooling (A). Install the exhaust manifold to the cylinder head.
6. If the setscrews (2) and (5) have been previously used, the setscrews should be thoroughly cleaned. Tooling (B) should be applied to the first two threads of the setscrews.

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

7. Install the setscrews (2) finger tight. Install the setscrews (5) and the spacers (4) finger tight.
8. Remove Tooling (A). Install the remaining setscrews (2) finger tight. Install the remaining setscrews (5) and spacers (4) finger tight.
9. Tighten the setscrews (2) and (5) to a torque of 44 N·m (32 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 79.

End By:

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

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	-	Loctite 575	-

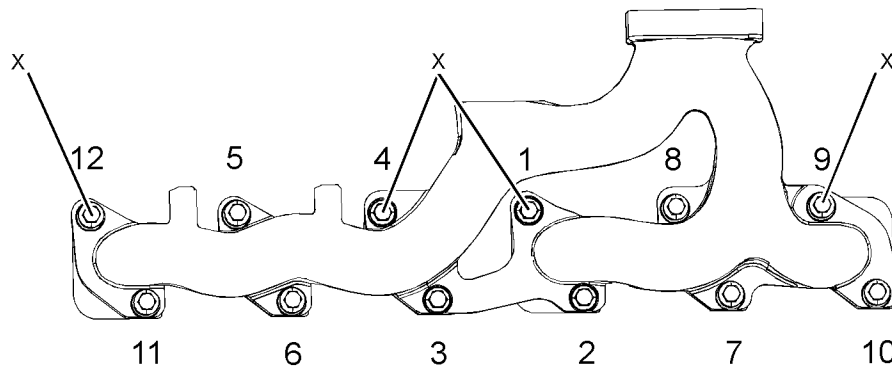


Illustration 81

g01176487

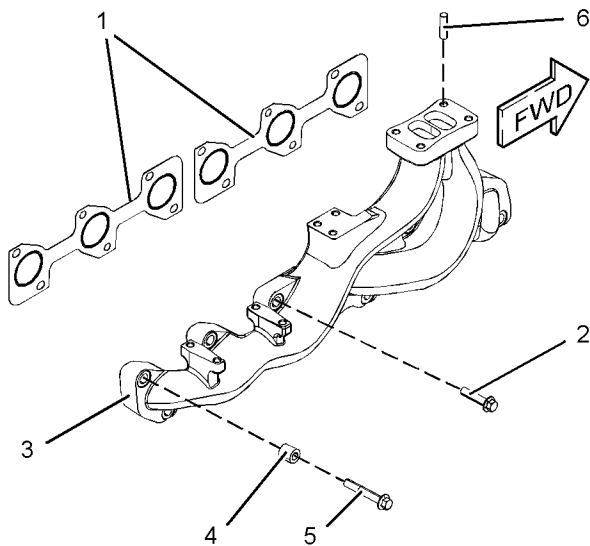


Illustration 82

g01176186

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 the four studs (6) to the 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 the positions (X). Refer to Illustration 81.
5. Position two new exhaust manifold gaskets (1) onto Tooling (A).

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

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

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

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

8. Install the setscrews (2) finger tight. Install the setscrews (5) and the spacers (4) finger tight.
9. Remove Tooling (A). Install the remaining setscrews (2) finger tight. Install the remaining setscrews (5) and spacers (4) finger tight.
10. Tighten the setscrews (2) and (5) to a torque of 44 N·m (32 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 81.
11. Connect all hoses, tube assemblies and wire leads from the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install" Steps 16 through 24.

i02296079

Exhaust Elbow - Remove and Install

Removal Procedure

Start By:

- a. Remove the exhaust pipe. Refer to OEM information for the correct procedure in order to remove the exhaust pipe.

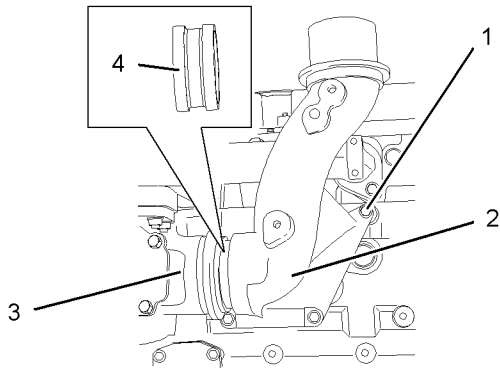


Illustration 83

g01163679

Typical example

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

Installation Procedure

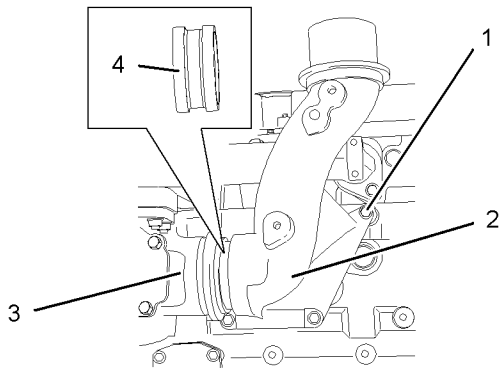


Illustration 84

g01163679

Typical example

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

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

i02352176

Inlet Manifold - Remove and Install

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Disconnect the breather hose from the separator for the crankcase breather (not shown). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Remove".

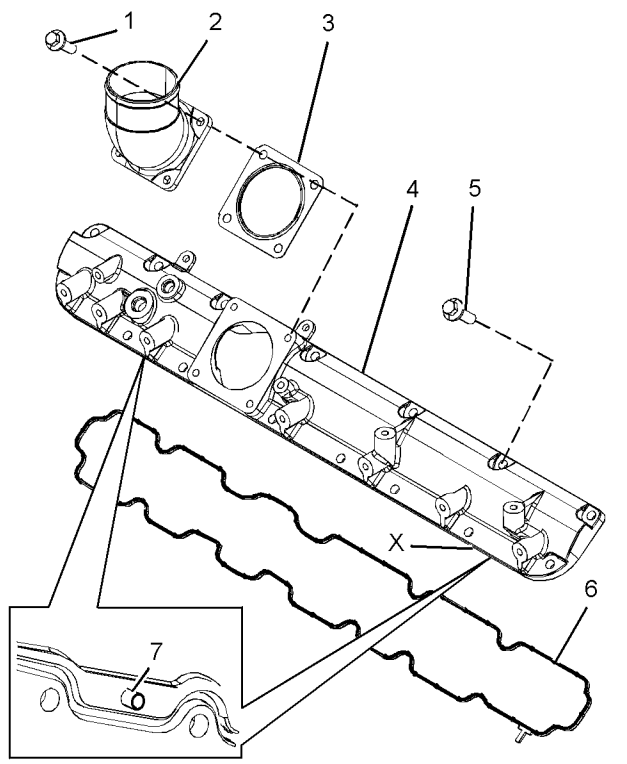


Illustration 85

g01208825

2. Cut the cable ties that secure the harness assembly (not shown) to the inlet manifold (4). Position the harness assembly away from the inlet manifold.
3. Remove the setscrews (1) from the inlet connection (2).
4. Remove the inlet connection (2) and the gasket (3) from the inlet manifold (4). Discard the gasket.
5. Remove the setscrews (5).
6. Remove the 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.
7. Remove the inlet manifold seal (6) from the recess in the inlet manifold (4). Discard the seal.

8. Do not remove the two dowel pins (7).

Installation Procedure

Table 15

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

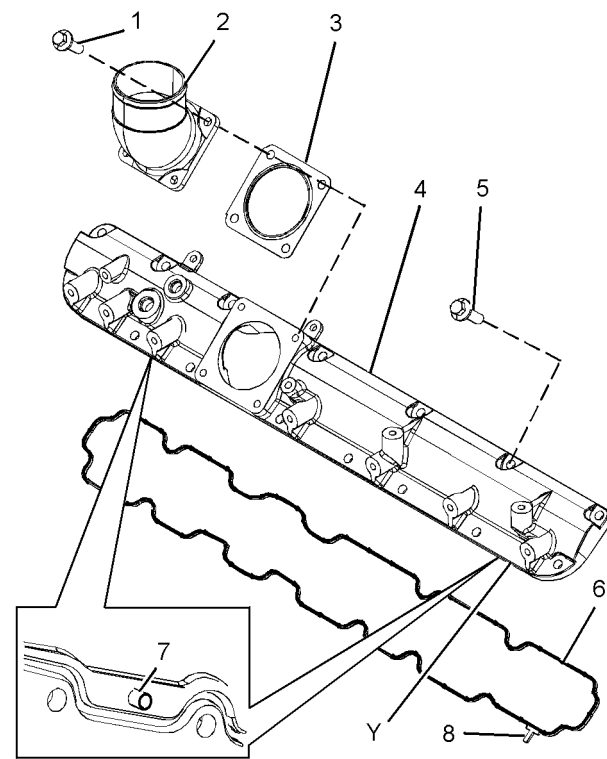


Illustration 86

g01215536

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 the inlet manifold (4).
- Note:** Do not install dowel pins to the cylinder head.
2. Clean the joint face of the cylinder head.
3. Align the tag (8) to the slot at position (Y) on the inlet manifold. Install the new seal (6) to the groove in the inlet manifold (4). Ensure that the seal is correctly located.

4. Align the dowel pins (7) to the holes in the cylinder head. Install the inlet manifold (4) to the cylinder head.
5. Apply Tooling (A) to the setscrews (5). Install the setscrews to the inlet manifold (4).

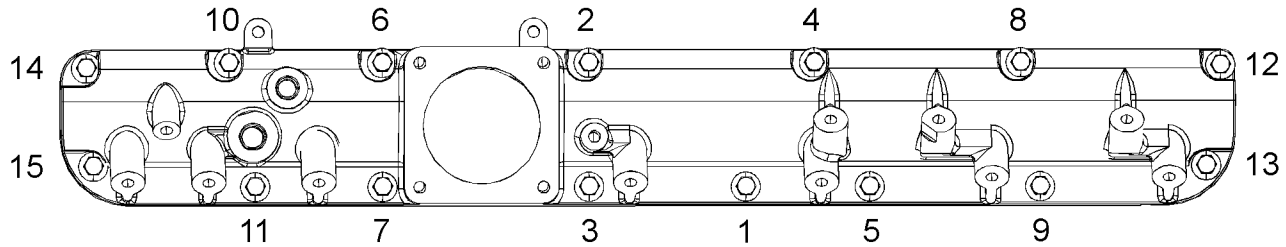


Illustration 87

g01175792

6. Tighten the setscrews to a torque of 22 N·m (16 lb ft) in the sequence that is shown in Illustration 87.
7. Ensure that the 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 the inlet connection (2) to the inlet manifold (4).
9. Install setscrews (1) to the inlet connection (2). Tighten the setscrews to a torque of 22 N·m (16 lb ft).
10. Install the air temperature sensor. Refer to Disassembly and Assembly Manual, "Inlet Air Temperature Sensor - Remove and Install".
11. Install the boost pressure sensor. Refer to Disassembly and Assembly Manual, "Boost Pressure Sensor - Remove and Install".
12. Position the harness assembly (not shown) on the inlet manifold. Use new cable ties 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 Manual, "Crankcase Breather - Install".

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

i02296083

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
C	27610295	Head	1
	21825576	Crankshaft Turning Tool	1
C	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1

End By:

- a. Install the ECM mounting bracket. Refer to Disassembly and Assembly Manual, "ECM Mounting Bracket - Remove and Install".

Start By:

- a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly Manual, "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 Manual, "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.

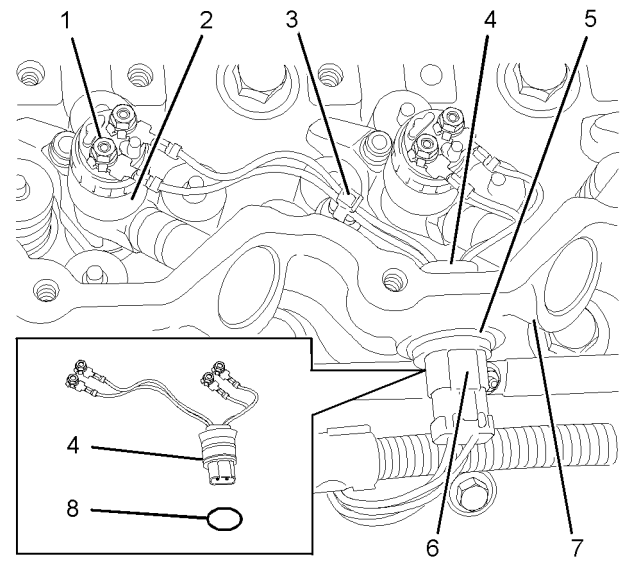


Illustration 88

g01163262

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

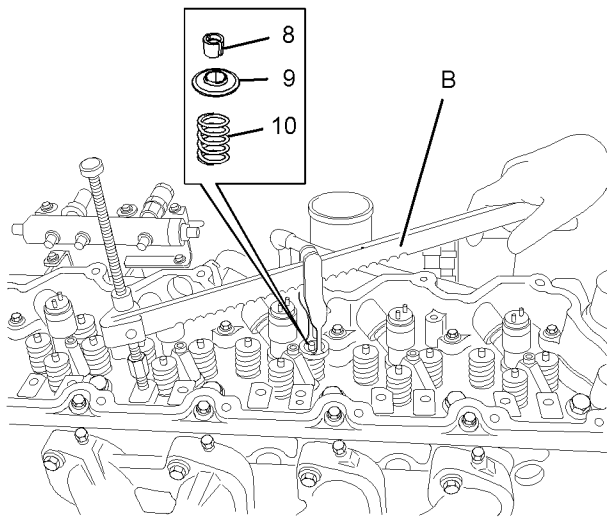


Illustration 89

g01182190

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 (10) for the appropriate piston.
 - b. Use Tooling (B) in order to compress the valve spring (10) and open the valve slightly.

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

- 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 the valve keepers (8).

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

Remove the valve keepers (8).

4. Slowly release the pressure on Tooling (B).
5. Remove the valve spring retainer (9) and remove the valve spring (10).
6. If necessary, remove the valve stem seals (not shown).
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
C	27610295	Head	1
	21825576	Crankshaft Turning Tool	1
C	27610289	Crankshaft Turning Tool	1
	27610290	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.

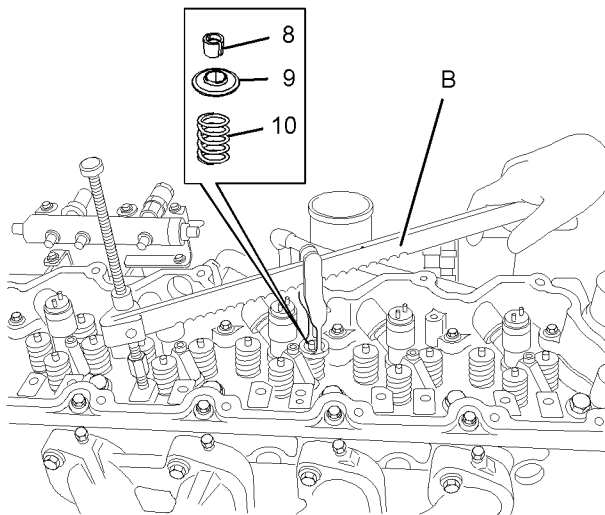


Illustration 90

g01182190

1. Inspect the valve springs (10) for damage and for the correct length. Refer to Specifications Manual, "Cylinder Head Valves".

2. If necessary, install a new valve stem seal (not shown) 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 the valve spring (10) onto the cylinder head. Position the valve spring retainer (9) on the valve spring (10).

! 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 the valve spring (10).

5. Apply sufficient pressure to Tooling (B) in order to install the valve keepers (8).

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

Install the valve spring keepers.

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

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

! WARNING

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

8. Remove the 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 the valve keepers (10) 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.

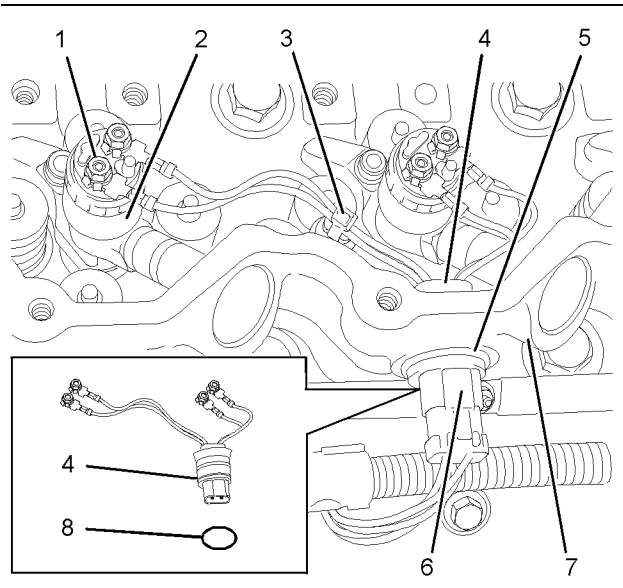


Illustration 91

g01163262

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

- a. Ensure that the harness assembly (4) for the electronic unit injectors and the bore in the valve mechanism cover base (7) are clean and free from damage. Replace any damaged components.
- b. Use Tooling (D) to lubricate a new O-ring seal. Install the new O-ring seal (8) onto the harness assembly (4) for the electronic unit injectors.
- c. From the inside of the valve mechanism cover base (7), push the harness assembly (4) into the valve mechanism cover base.
- d. Use Tooling (A) to install the circlip (5).
- e. Connect the plug (6) to the harness assembly (4) for the electronic unit injectors.
- f. Use a deep socket to install the connections (1) to the electronic unit injectors (2). Use Tooling (E) to tighten the connections to a torque of 2.5 N·m (22 lb in).
- g. Install a new cable tie (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 Manual, "Rocker Shaft and Pushrod - Install".

i02296088

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 Manual, "Cylinder Head - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bottom face of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications Manual, "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.

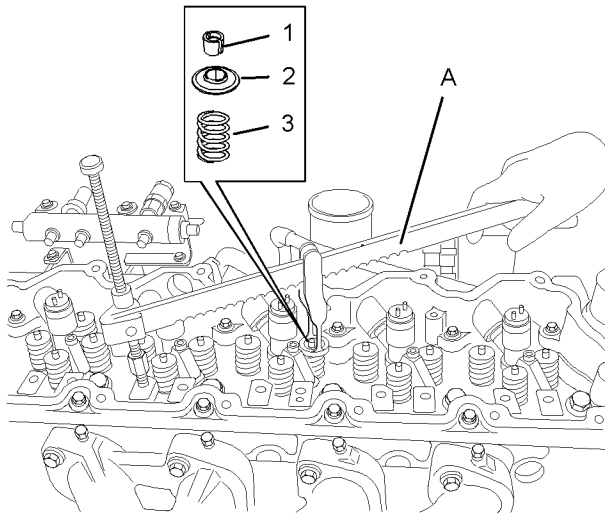


Illustration 92 g01162648
Typical example

4. Install Tooling (A) in position on the cylinder head in order to compress the 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 the valve keepers (1).

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

6. Slowly release the pressure on Tooling (A).

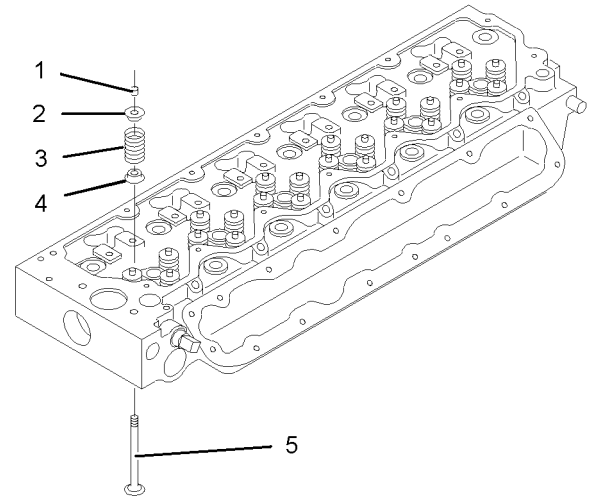


Illustration 93 g01162650

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

- 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 Testing and Adjusting Manual, "Cylinder Head Inspect".
- b. Inspect the valve seats for wear and for damage. Refer to Specifications Manual, "Cylinder Head Valves" for further information.
- c. Inspect the valve guides for wear and for damage. Refer to Specifications Manual, "Cylinder Head Valves" and Testing and Adjusting Manual, "Valve Guide - Inspect" for further information.
- d. Inspect the valves for wear and for damage. Refer to Specifications Manual, "Cylinder Head Valves".
- e. Inspect the valve springs (3) for damage and for the correct length. Refer to Specifications Manual, "Cylinder Head Valves".

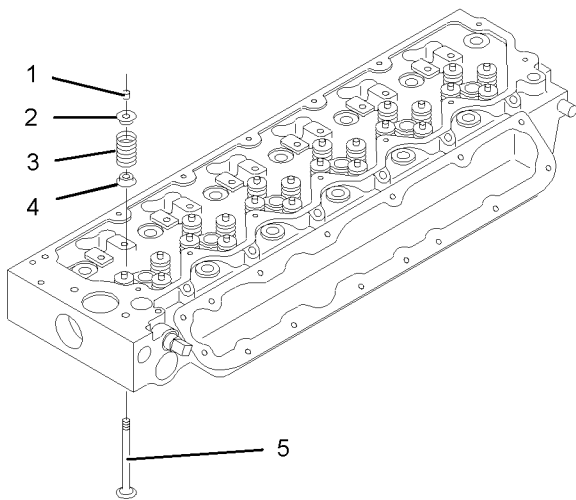


Illustration 94

g01162650

2. Lubricate the stems of the valves (5) with clean engine oil. Install the 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 Testing and Adjusting Manual, "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 the valve stem seals (4).

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

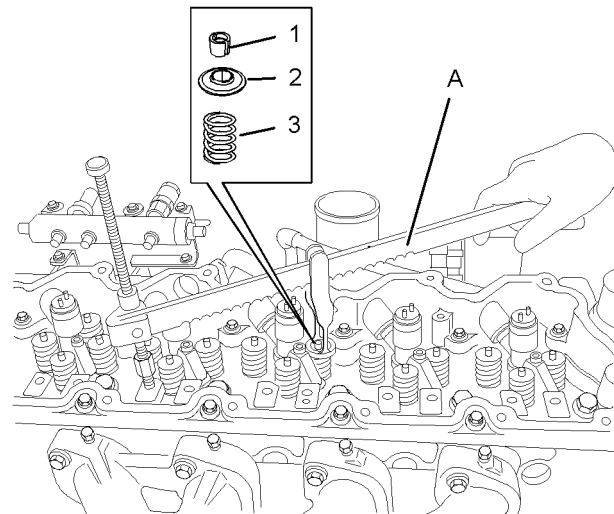


Illustration 95

g01162648

6. Install Tooling (A) in the appropriate position on the cylinder head in order to compress the 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 the valve keepers (1).

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

WARNING

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

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 the valve keepers (1) are properly installed.

End By:

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

i02296099

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 the engine oil filter base (3) in order to catch any oil that might be spilled.

Note: Clean up any spillage of oil immediately.

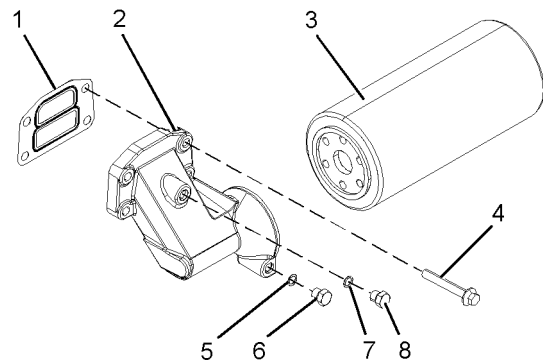


Illustration 96

g01162867

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

7. If necessary, remove the plug (8) from the engine oil filter base (2). Remove the O-ring seal (7) from the plug (8). Discard the O-ring seal.

i02296106

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

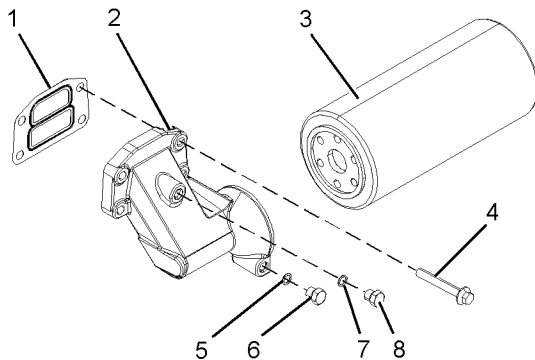


Illustration 97

g01162867

Typical example

1. Clean the 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 the plugs (6) and (8). Install the plugs (6) and (8) to the engine oil filter base (2). Tighten the plugs to a torque of 12 N·m (106 lb in).

Note: Drain plug (8) is only installed to engines with a horizontal engine oil filter.

3. Install the setscrews (4) to the engine oil filter base (2). Ensure that setscrews 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 the setscrews (4). Install the assembly of the engine oil filter base to the cylinder block or the engine oil cooler.
5. Tighten the setscrews (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

Removal Procedure

Start By:

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

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.

Note: Clean up any spillage immediately.

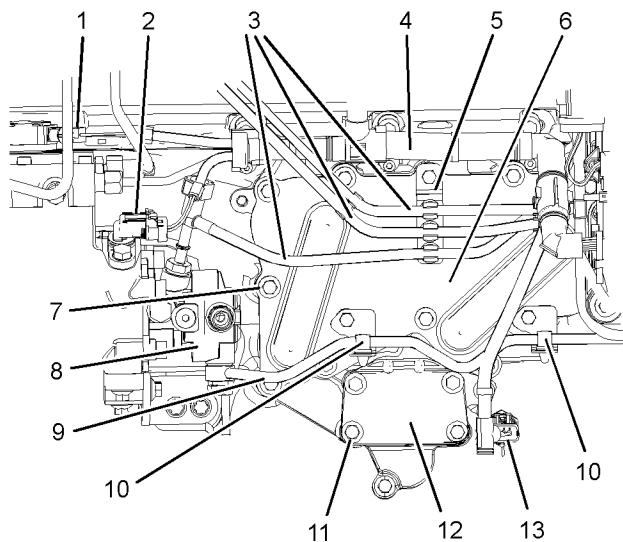


Illustration 98 g01181109
Typical example of an engine oil cooler with a blanking plate

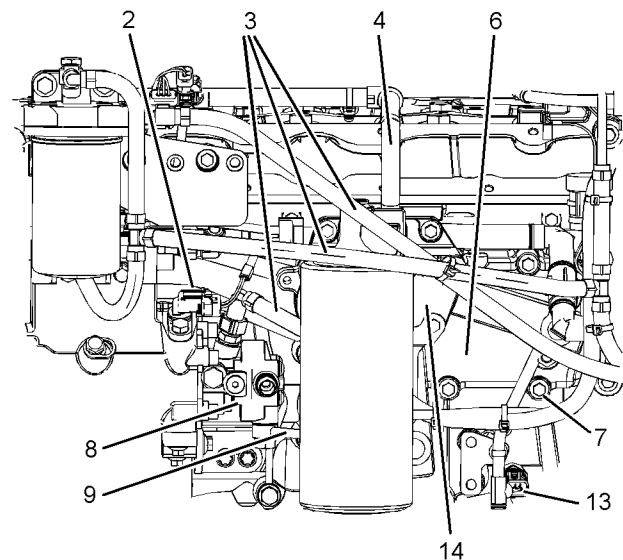


Illustration 99 g01204901
Typical example of an engine oil cooler with a high mounted filter base

3. If the engine has a left hand side oil filter, remove the oil filter base. Refer to Disassembly and Assembly Manual, "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 98.

- a. Remove the four setscrews (11).
- b. Remove the blanking plate (12).

- c. Remove the joint (not shown). Discard the joint.
- 4. Make temporary identification marks on the plastic tube assemblies (3) in order to show the correct position of the tube assemblies.
- 5. Remove the 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 the engine wiring harness (4) from the position sensor (2) for the fuel injection pump.
 - b. Disconnect the engine wiring harness (4) from the solenoid (1) for the fuel injection pump.
 - c. Disconnect the engine wiring harness (4) from the oil pressure sensor (13).
 - d. Cut the cable ties that secure the engine wiring harness (4) to the assembly of the oil cooler (6). Position the harness away from the assembly of the oil cooler.
- 7. Remove the tube assembly (9) for the fuel return from the cylinder head (not shown) and from the transfer pump (8). Plug the tube assembly with new plugs. Cap all open ports with new caps.

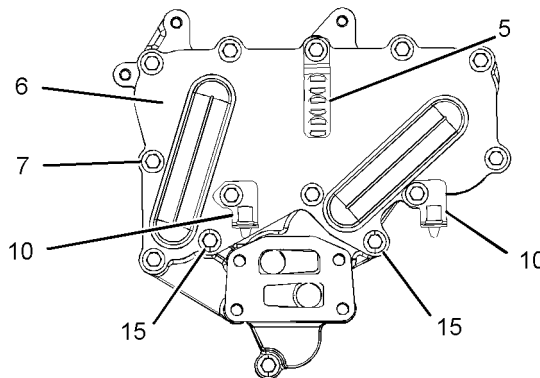


Illustration 100 g01205285
Typical example of engine oil cooler with a blanking plate or with a low mounted filter base

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

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

9. Remove the joint (16). Refer to Illustration 101 and Illustration 102. Discard the joint.

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

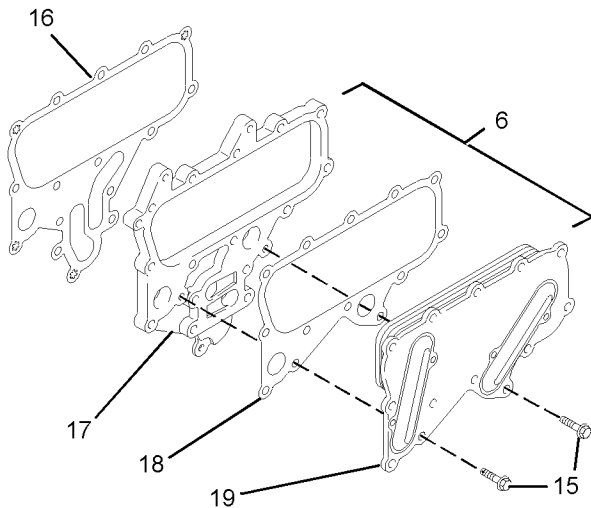


Illustration 101

g01174007

Typical example

1. Remove the two setscrews (15).
2. Remove the cooler matrix (19) from the spacer plate (17).
3. Remove the joint (18). Discard the joint.

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

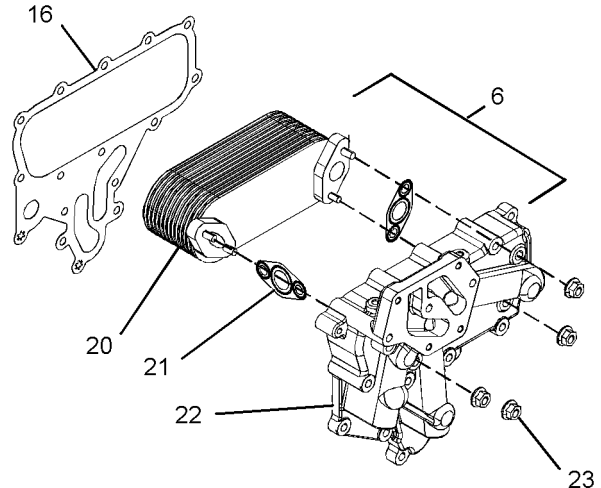


Illustration 102

g01180538

1. Remove the four nuts (23) from the assembly of the oil cooler (6).
2. Remove the cooler matrix (20) from the housing (22).
3. Remove the two joints (21). Discard the joints.

i02296110

Engine Oil Cooler - Install

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

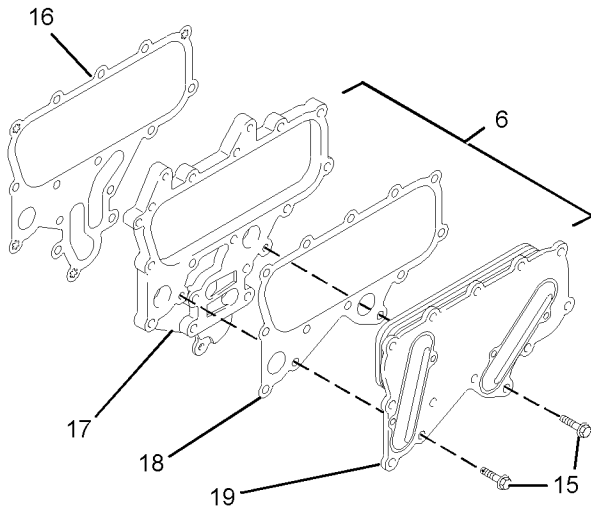


Illustration 103

g01174007

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

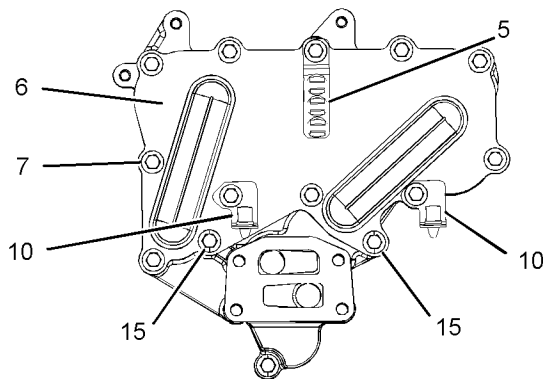


Illustration 104

g01205285

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

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

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

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

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

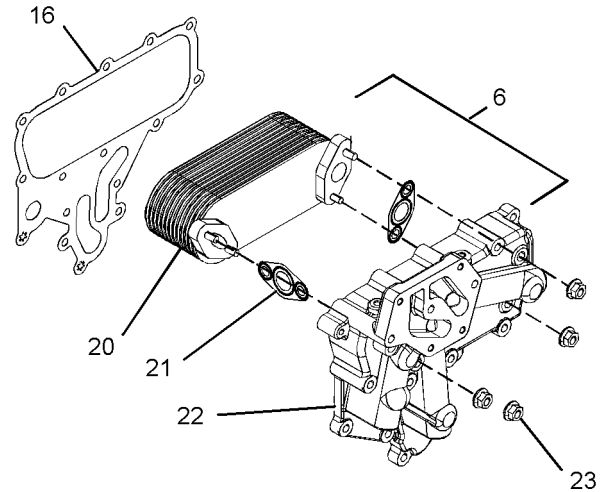


Illustration 105

g01180538

1. Ensure that the cooler matrix (20) and the housing (22) are clean and free from damage. Replace any damaged components.
2. Install two new joints (21) to the cooler matrix (20).
3. Install the cooler matrix (20) to the housing (22).
4. Install the four nuts (23) to the assembly of the oil cooler (6). Tighten the nuts to a torque of 22 N·m (16 lb ft).

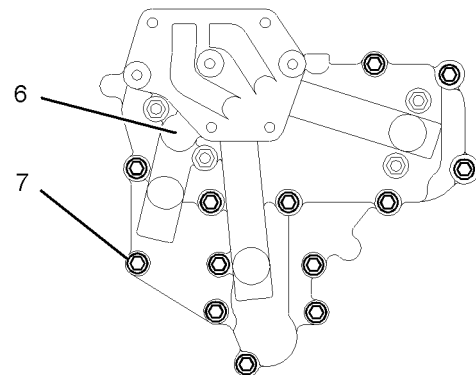


Illustration 106

g01205691

5. Install the setscrews (7) to the assembly of the oil cooler (6).

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

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

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

Installation Procedure

1. Clean the joint face of the cylinder block.

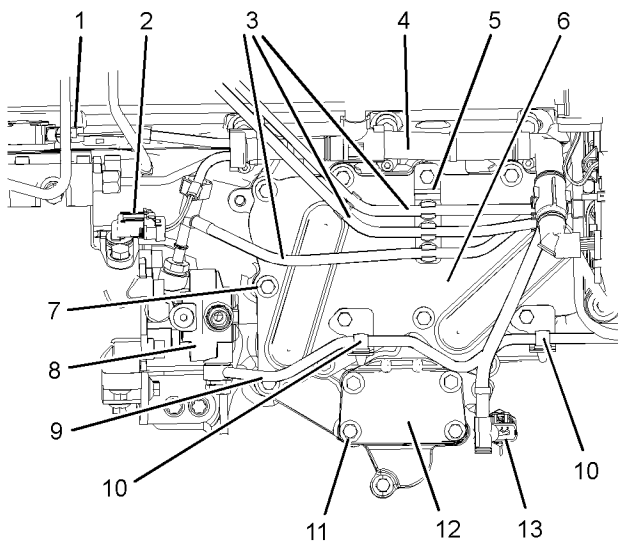


Illustration 107 g01181109
Typical example of an engine oil cooler with a blanking plate

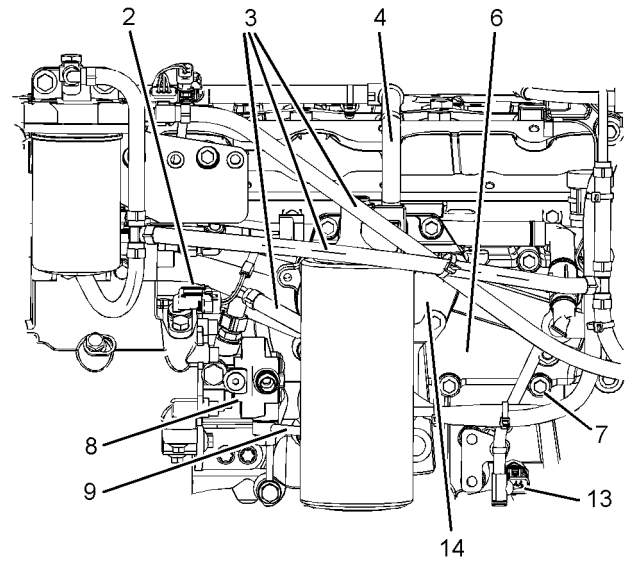


Illustration 108 g01204901
Typical example of an engine oil cooler with a high mounted filter base

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

If the engine has a high mounted oil filter base, install the oil filter base (14) finger tight. Refer to Illustration 108 and refer to Disassembly and Assembly Manual, "Engine Oil Filter Base - Remove and Install".

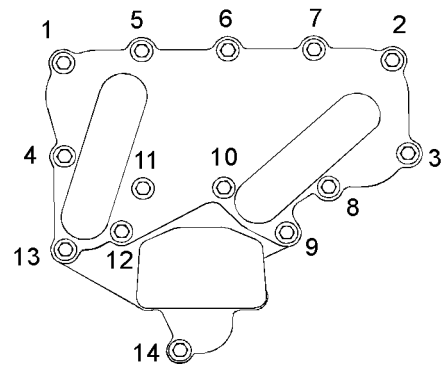


Illustration 109 g01179352
Tightening sequence for an engine oil cooler with a blanking plate or with a low mounted oil filter base

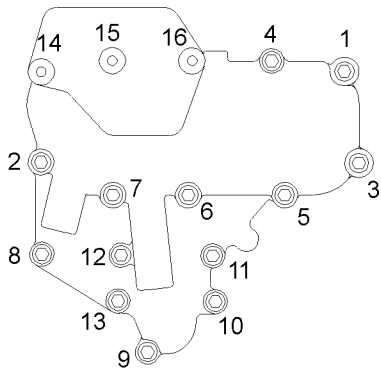


Illustration 110

g01180321

Tightening sequence for an engine oil cooler with a high mounted oil filter base

3. If the engine has a low mounted oil filter base or a blanking plate, tighten the setscrews to a torque of 22 N·m (16 lb ft) in the sequence that is shown in Illustration 109.

If the engine has a high mounted oil filter base, tighten the setscrews to a torque of 22 N·m (16 lb ft) in the sequence that is shown in Illustration 110. Tighten the remaining setscrews that secure the oil filter base to a torque of 22 N·m (16 lb ft).

4. Remove the plugs from the tube assembly (9). Remove the caps for the fuel return from the cylinder head and from the transfer pump (8). Install the tube assembly (9) to the cylinder head and to the transfer pump (8).
5. Follow Steps 5.a through 5.e in order to connect the engine wiring harness (4).
 - a. Place the harness in position.
 - b. Connect the engine wiring harness (4) to the position sensor (2) for the fuel injection pump.
 - c. Connect the engine wiring harness (4) to the oil pressure sensor (13).
 - d. Connect the engine wiring harness (4) to the solenoid (1) for the fuel injection pump.
 - e. Install new cable ties in order to secure the engine wiring harness (4) to the assembly of the oil cooler (6).
6. Remove the plugs from all plastic tube assemblies (3). Remove the caps from the appropriate ports. Install the plastic tube assemblies (3).
7. If the engine has a low mounted oil filter on the left hand side, install the oil filter base. Refer to Disassembly and Assembly Manual, "Oil Filter Base - Remove and Install".

If the engine has a right hand side oil filter, follow Steps 7.a through 7.d in order to install the blanking plate (12).

- a. Install the four setscrews (11) to the blanking plate (12).
 - b. Position a new joint (not shown) onto the blanking plate (12).
 - c. Install the assembly of the blanking plate to the assembly of the oil cooler (6).
 - d. Tighten the setscrews (11) to a torque of 22 N·m (16 lb ft).
8. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Fill" 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 Manual, "ECM Bracket - Remove".

i02296785

Engine Oil Relief Valve - Remove and Install

Removal Procedure

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly Manual, "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.

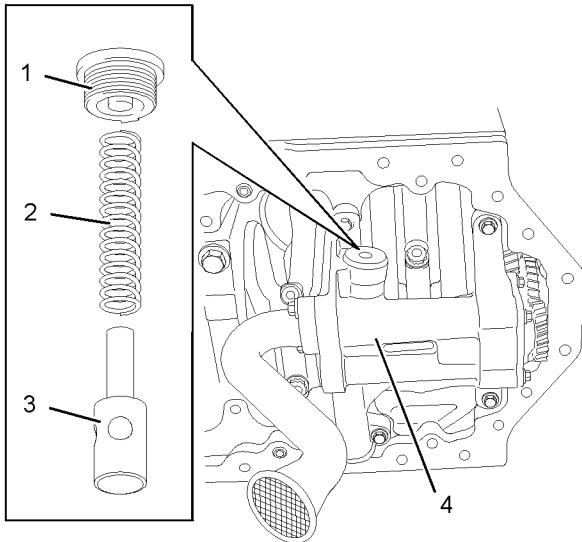


Illustration 111 g01158341

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

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

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

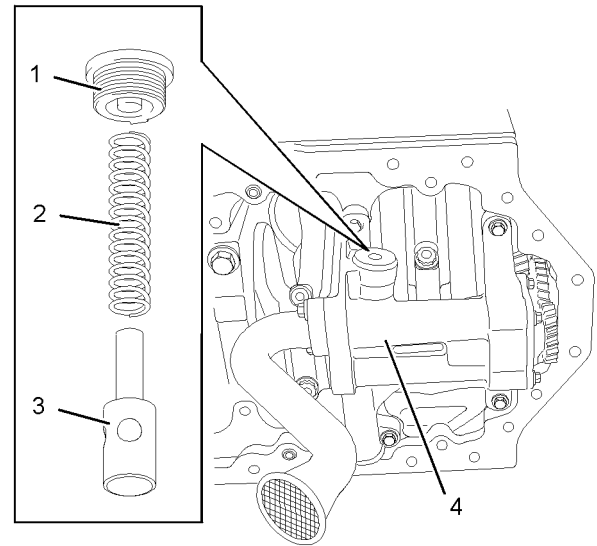


Illustration 112 g01158341

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 the 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 the plunger (3) with clean engine oil. Use long nose pliers to install the plunger (3) and the spring (2) into the bore for the relief valve in the housing of the 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 the cap (1). Use an allen wrench to install the cap (1) to the 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 Manual, "Engine Oil Pan - Install".

i02296116

Engine Oil Pump - Remove

Removal Procedure

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly Manual, "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.

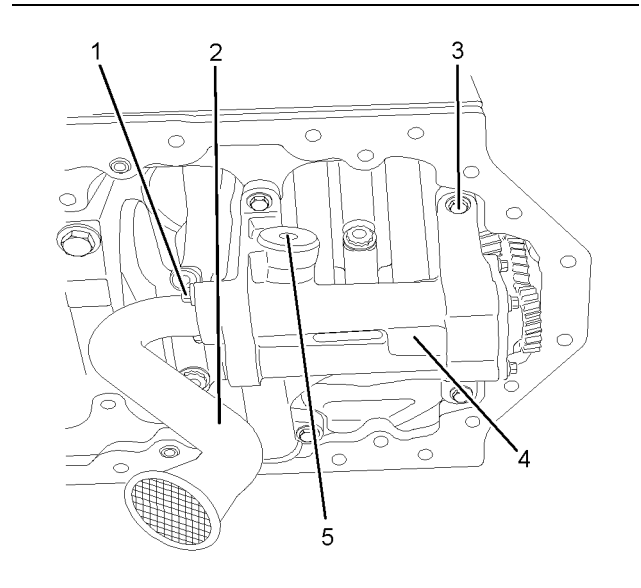


Illustration 113

g01158368

Typical example

- 2. Remove the two setscrews (1) and the suction pipe (2).
- 3. Remove the joint (not shown) from the suction pipe. Discard the joint.
- 4. Remove the setscrews (3). Remove the assembly of the engine oil pump from the cylinder block.
- 5. If necessary, remove the pressure relief valve (5) from the housing of the engine oil pump (4). Refer to Disassembly and Assembly Manual, "Engine Oil Relief Valve - Remove and Install".

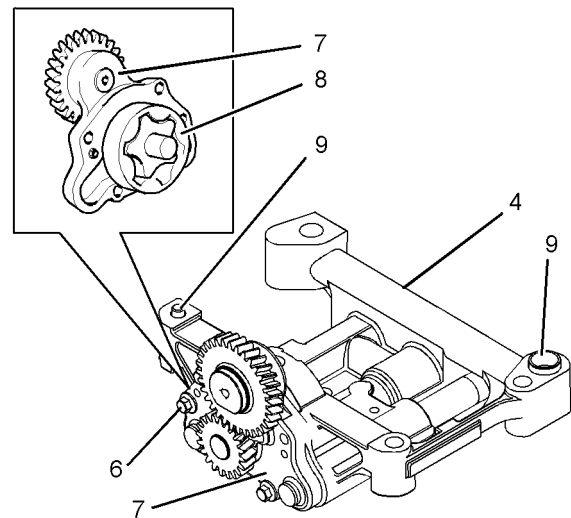


Illustration 114

g01160736

- If necessary, remove the allen head screws (6) and the front cover assembly (7). Remove the outer rotor (8) from the housing of the engine oil pump (4).

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

i02296126

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.

- Ensure that all components of the engine oil pump are clean and free from wear or damage. Refer to Testing and Adjusting Manual, "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.

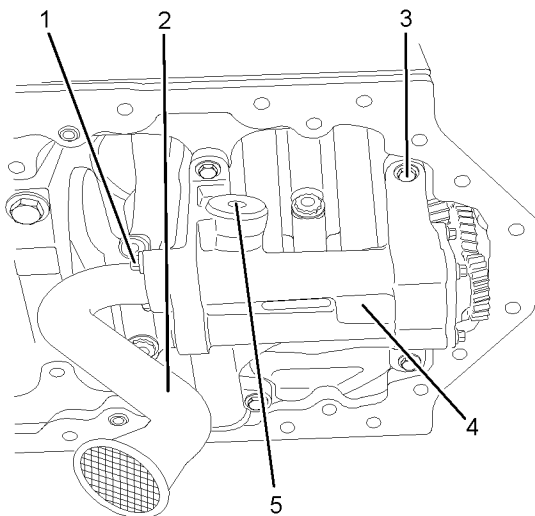


Illustration 115

g01158368

Typical example

- If necessary, install the pressure relief valve (5). Refer to Disassembly and Assembly Manual, "Engine Oil Relief Valve - Remove and Install" for further information.

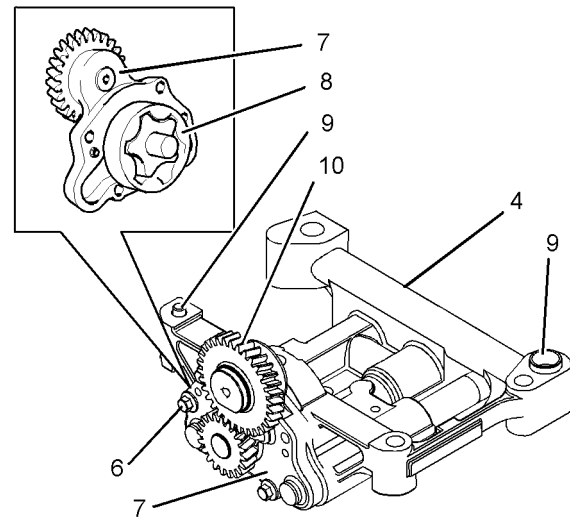


Illustration 116

g01160744

- If necessary, lubricate the internal components for the assembly of the engine oil pump with clean engine oil. Install the outer rotor (8) and the front cover (7) to the housing of the engine oil pump (4). Install the allen head screws (6). Tighten the allen head screws to a torque of 22 N·m (16 lb ft).
- Ensure that the two dowels (9) are correctly located in the housing of the 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.

- Install the setscrews (3). Tighten the setscrews to a torque of 22 N·m (16 lb ft).
- Check the backlash between the idler gear (10) and the crankshaft gear. Refer to Specifications Manual, "Gear Group (Front)" for further information.
- Install the suction pipe (2) and a new joint (not shown) to the assembly of the engine oil pump.
- Install the setscrews (1). Tighten the setscrews to a torque to 22 N·m (16 lb ft).
- 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 setscrews finger tight in order to align the components of the support bracket.
- c. Tighten the M10 setscrew to a torque of 44 N·m (32.5 lb ft). Tighten the M8 fasteners to a torque of 22 N·m (16 lb ft).

End By:

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

i02296130

Water Pump - Remove

Removal Procedure

Start By:

- a. Remove the fan and the fan pulley. Refer to Disassembly and Assembly Manual, "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 - Drain" for the correct procedure.
2. Loosen the hose clamps and remove the hose (not shown) from the water pump inlet.

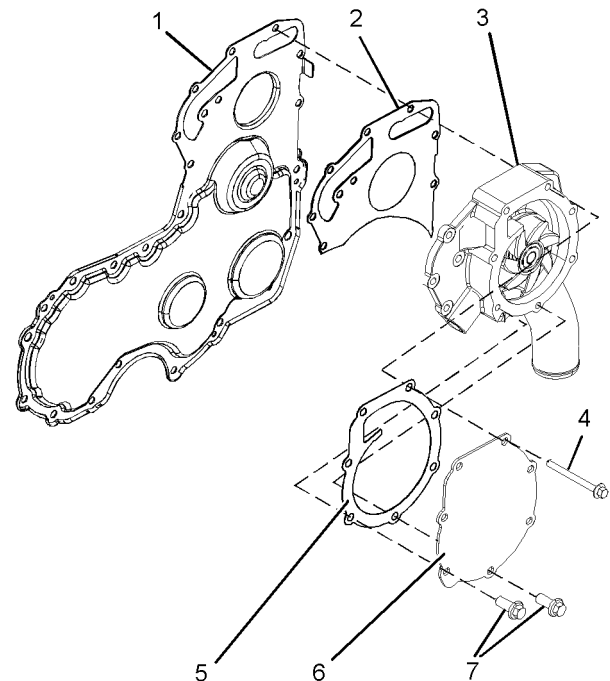


Illustration 117

g01212581

3. Remove the setscrews (4).

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

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

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

5. Remove the joint (2). Discard the joint.
6. If necessary, remove the cover (6) from the water pump. Follow Steps 6.a through 6.c in order to remove the cover.
 - a. Remove the two setscrews (7).
 - b. Remove the cover (6).
 - c. Remove the joint (5). Discard the joint.

i02296136

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.

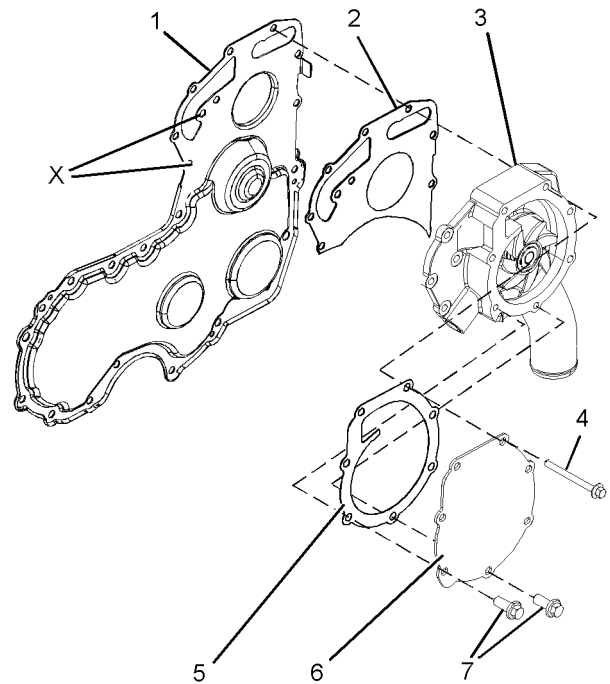


Illustration 118

g01204002

2. If necessary, install the cover (6) to the water pump (3). Follow Steps 2.a through 2.d in order to install the cover.
 - a. Clean the joint face of the cover (6).
 - b. Position a new joint (5) on the water pump (3).
 - c. Install the cover (6) to the water pump (3).
 - d. Install the two setscrews (7) to the cover (6). Tighten the setscrews finger tight.
3. Clean the joint face of the front cover (1).

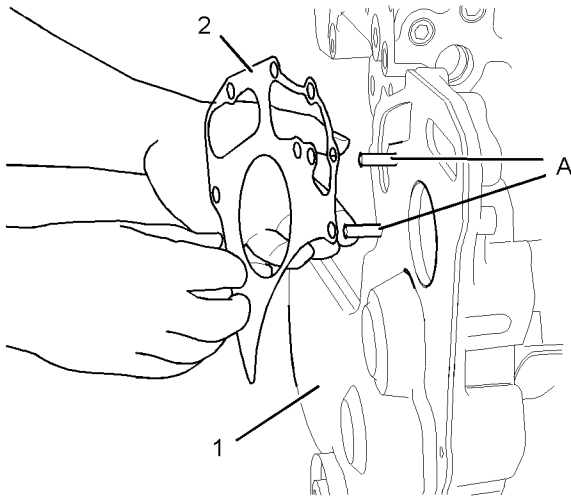


Illustration 119

g01204116

4. Install Tooling (A) in position (X).
5. Use Tooling (A) in order to align the new joint (2) to the front cover (1). Install the joint to the front cover.
6. Align the water pump (3) to Tooling (A). Install the water pump to the front cover (1).

Note: Ensure that the gear of the water pump and the gear of the fuel injection pump mesh.

7. Install the setscrews (4). Refer to Illustration 118. Tighten the setscrews finger tight.

Note: Ensure that all setscrews of different lengths are installed in the correct positions.

8. Remove Tooling (A) and install the two remaining setscrews (4).

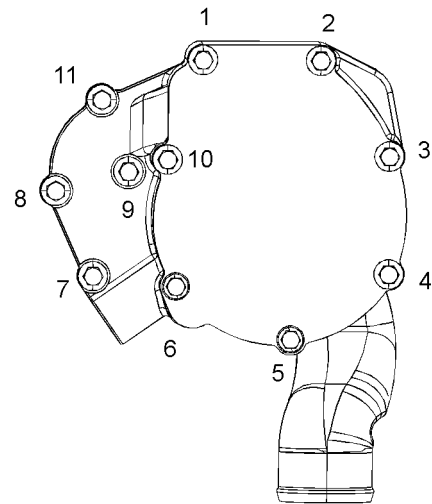


Illustration 120

g01183807

9. Tighten the setscrews (4) and (7) in the sequence that is shown in Illustration 120 to a torque of 22 N·m (16 lb ft).
10. Install the hose (not shown) to the water pump inlet. Tighten the hose clamps.
11. Fill the cooling system with coolant. Refer to the Operation and Maintenance Manual, "Cooling System Coolant - Fill" for the correct procedure.

End By:

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

i02296653

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 - Drain" for the correct draining procedure.
2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from the water temperature regulator housing (2).

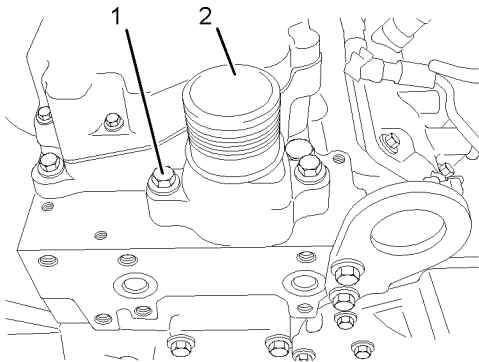


Illustration 121
Typical example

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

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

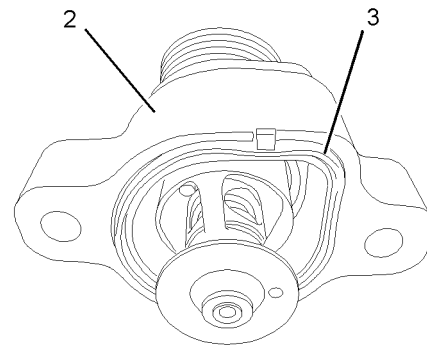


Illustration 122
Typical example

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of the water temperature regulator housing (2) are clean and free of wear or damage. Check the water temperature regulator for correct operation. Refer to Testing and Adjusting Manual, "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.

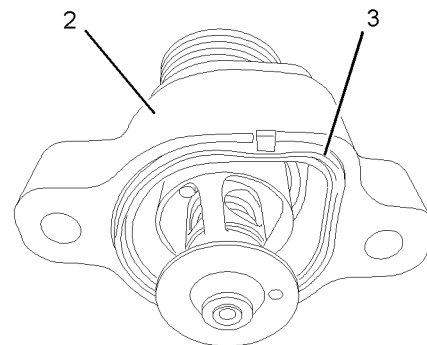


Illustration 123
Typical example

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

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

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

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

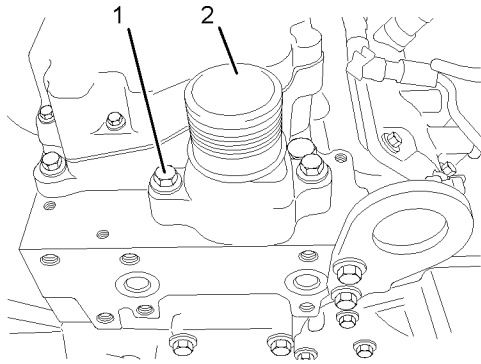


Illustration 124 g01158622

Typical example

4. Install the setscrews (1). Tighten the setscrews (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 - Fill" for the correct filling procedure.

i02296654

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 Manual, "Electric Starting Motor - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

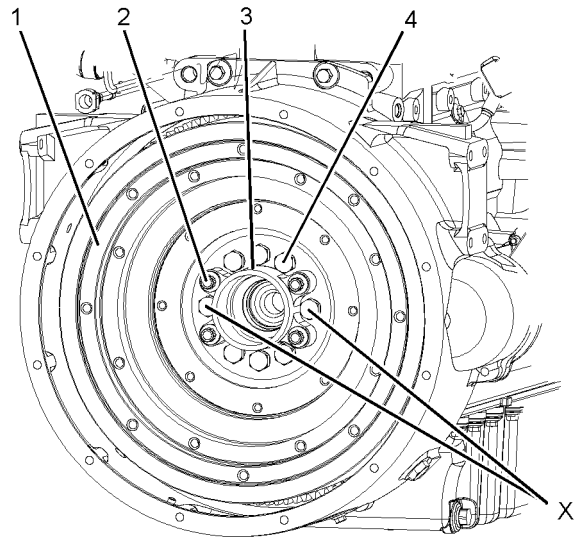


Illustration 125 g01159176

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

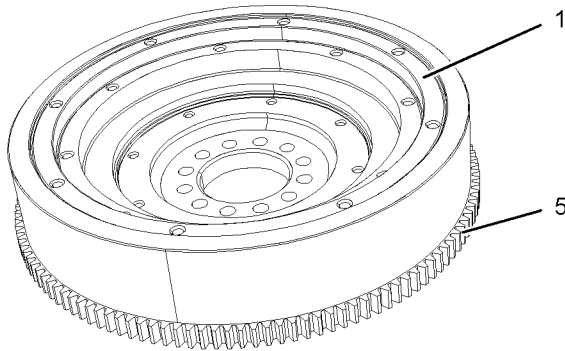


Illustration 126

g01162553

7. Inspect the flywheel (1) and the ring gear (5) for wear or damage. Replace any worn components or damaged components.
8. To remove the 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 the ring gear (5) from the flywheel (1).

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

i02296655

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.

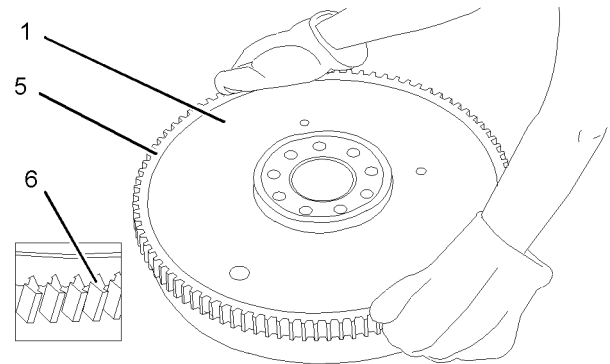


Illustration 127

g01163617

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

Note: The chamfered side of the 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 the 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 the ring gear (5) is correct and quickly install the ring gear onto the 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 Manual, "Crankshaft Rear Seal - Remove".

i02296656

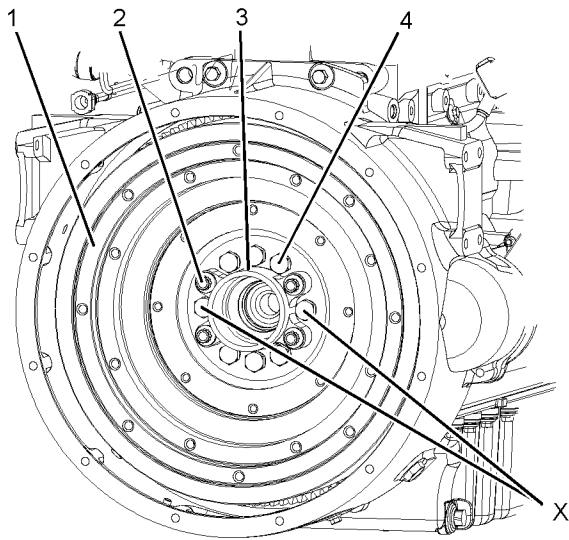


Illustration 128

g01159176

3. Install a suitable lifting device to the 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 the flywheel (1) onto Tooling (A).
6. If necessary, install the pilot bearing (3) and the setscrews (2) to the flywheel (1).
7. Install setscrews (4) to the flywheel (1).
8. Remove Tooling (A) and install the remaining setscrews (4) to the flywheel (1).
9. Use a suitable tool to prevent the flywheel from rotating. Tighten the setscrews (2) and (4) to a torque of 120 N·m (88 lb ft).
10. Remove the lifting device from the flywheel (1).
11. Check the run out of the flywheel. Refer to Specifications Manual, "Flywheel" for further information.

End By:

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

Crankshaft Rear Seal - Remove

Removal Procedure

Table 25

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

Start By:

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

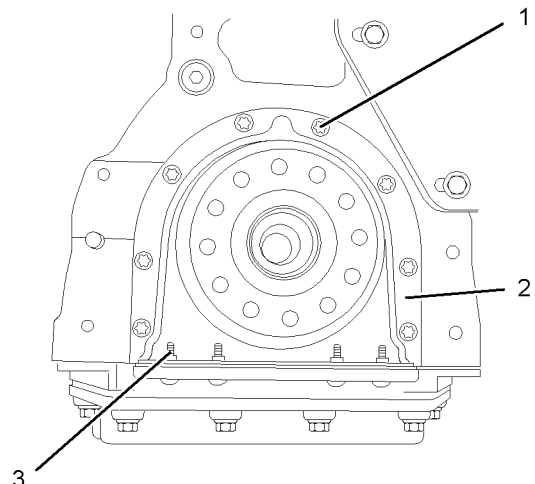


Illustration 129

g01174488

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

i02296657

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

Note: The crankshaft rear seal and the housing for the crankshaft rear seal are manufactured as one assembly. The crankshaft rear seal is lubricated during manufacture. Do not lubricate the seal or the crankshaft palm before installation. Never install a used crankshaft rear seal.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

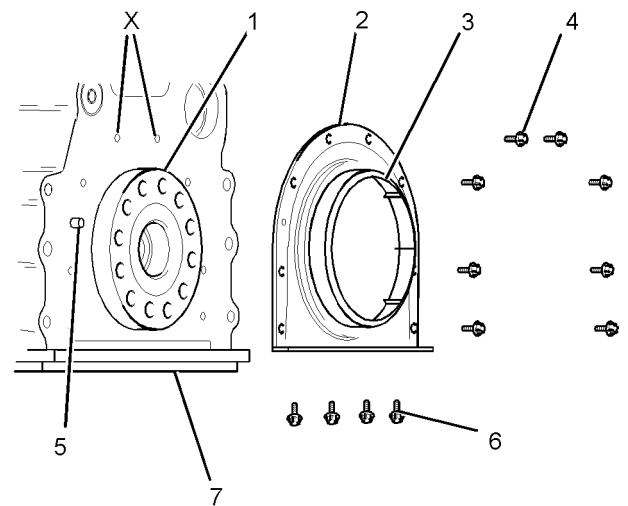


Illustration 130

g01182868

1. Ensure that the crankshaft palm (1) is clean, dry and free from damage. If the crankshaft palm is worn or damaged, install a crankshaft wear sleeve. Refer to Disassembly and Assembly Manual, "Crankshaft Wear Sleeve (Rear) - Remove and Install".
2. Ensure that the mating face of the cylinder block is clean and dry. Ensure that the mating face of the isolating frame (7) is clean and dry.
3. Ensure that the plastic sleeve (3) is squarely installed within the new crankshaft rear seal (2).

Note: The plastic sleeve (3) is included in order to protect the lip of the seal as the crankshaft rear seal is pushed over the crankshaft palm (1). Do not attempt to install a crankshaft rear seal without the plastic sleeve.

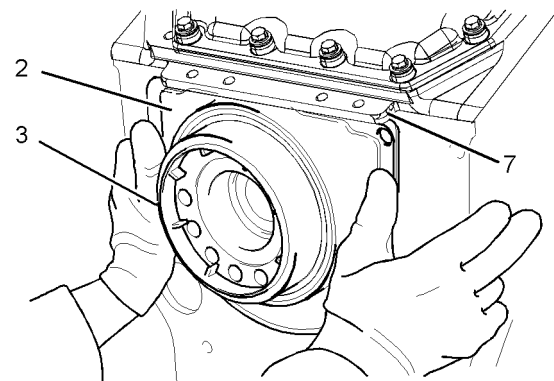


Illustration 131

g01183033

Typical example

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

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

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

End By:

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

Installation Procedure Without Isolating Frame for the Oil Pan

Table 27

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Alignment Tool	1
	-	Setscrew (M8 by 20 mm)	4

Note: The crankshaft rear seal and the housing for the crankshaft rear seal are manufactured as one assembly. The crankshaft rear seal is lubricated during manufacture. Do not lubricate the seal or the crankshaft palm before installation. Never install a used crankshaft rear seal.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

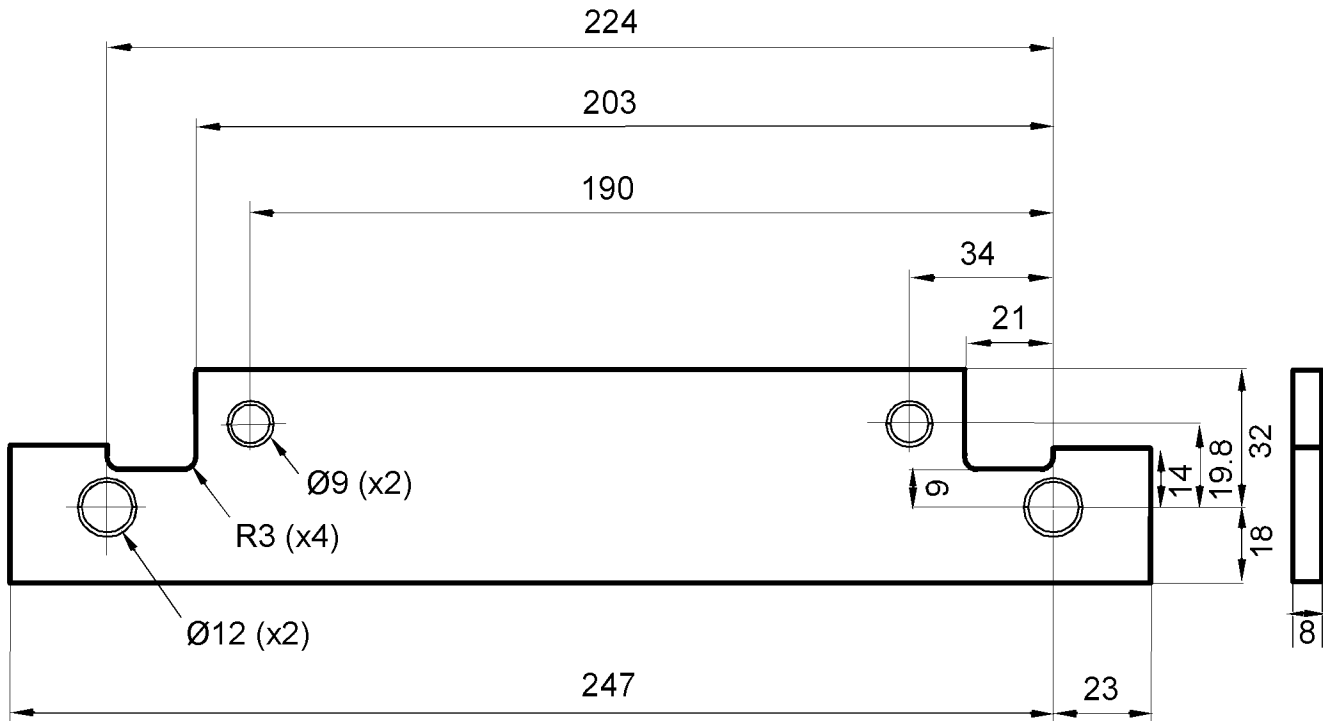


Illustration 132

g01183431

Alignment tool

1. To install the crankshaft rear seal without the isolating frame for the oil pan in position, Tooling (B) 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 132. All dimensions are shown in millimeters.

2. Ensure that the crankshaft palm (1) is clean, dry and free from damage. If the crankshaft palm is worn or damaged, install a crankshaft wear sleeve. Refer to Disassembly and Assembly Manual, "Crankshaft Wear Sleeve (Rear) - Remove and Install".
3. Ensure that the mating face of the cylinder block is clean and dry.
4. Ensure that the plastic sleeve (3) is squarely installed within the new crankshaft rear seal (2).

Note: The plastic sleeve (3) is included in order to protect the lip of the seal as the crankshaft rear seal is pushed over the crankshaft palm (1). Do not attempt to install a crankshaft rear seal without the plastic sleeve.

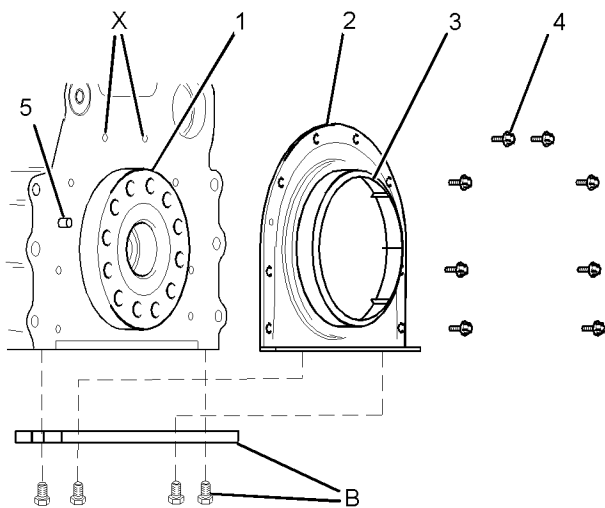


Illustration 133

g01201564

i02403282

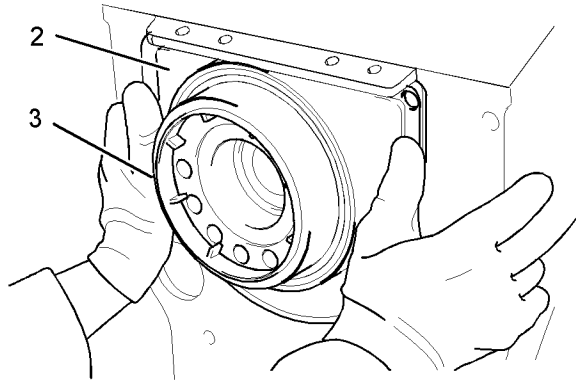


Illustration 134

g01201892

5. Place the assembly of the crankshaft rear seal over the crankshaft palm (1). Align the dowel (5) with the slot in the crankshaft rear seal.
 6. Ensure that the plastic sleeve (3) is engaged on the crankshaft palm (1). Push the crankshaft rear seal (2) squarely onto the crankshaft. Ensure that the crankshaft rear seal is seated against the cylinder block. During this process, the plastic sleeve (3) will be forced out of the crankshaft rear seal. Discard the plastic sleeve.
- Note:** Ensure that the dowel (5) is engaged in the hole in the crankshaft rear seal.
7. Install the Tooling (B) to the cylinder block and to the crankshaft rear seal (2). Tighten the four M8 setscrews to a torque of 15 N·m (11 lb ft).
 8. Install two torx screws (4) to the crankshaft rear seal (3) in position (X). Tighten the two torx screws (4) to a torque of 22 N·m (16 lb ft).
 9. Unscrew the two M8 screws of Tooling (B) that are installed to the base of the crankshaft rear seal (2) one complete turn.
 10. Install the remaining torx screws (4). Tighten all torx screws (4) to a torque of 22 N·m (16 lb ft).
 11. Remove Tooling (B).

Crankshaft Wear Sleeve (Rear) - Remove and Install

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: Wear sleeves are used to reclaim worn seal surfaces or damaged seal surfaces. Wear sleeves are not original equipment.

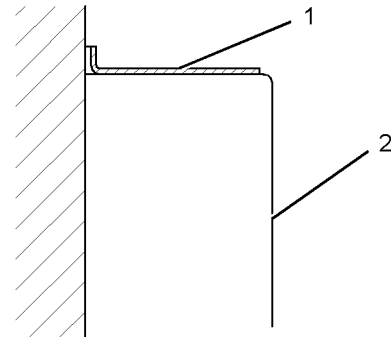


Illustration 135

g01200315

1. Use a sharp tool to score a deep line across the crankshaft wear sleeve (1).
- Note:** Take care to avoid damaging the crankshaft.
2. Insert a thin blade between the crankshaft wear sleeve (1) and the crankshaft (2) below the scored line. The crankshaft wear sleeve will separate along the line.
 3. Remove the crankshaft wear sleeve (1) from the crankshaft (2).
 4. Discard the crankshaft wear sleeve.

Installation Procedure

Table 28

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft is thoroughly clean and dry.

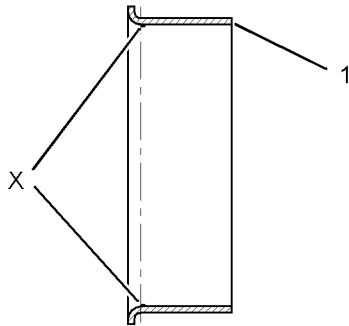


Illustration 136

g01200285

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

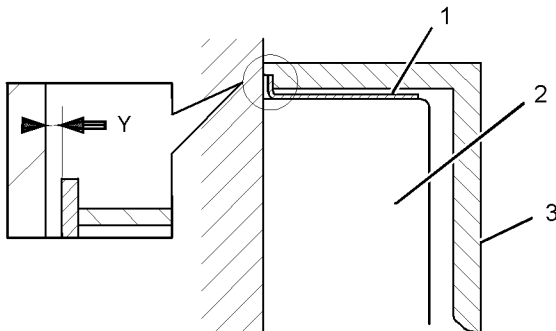


Illustration 137

g01200290

3. Align the crankshaft wear sleeve (1) with the crankshaft (2). Position the installation tool (3) that is provided with the crankshaft wear sleeve over the crankshaft. Use a hammer to drive the crankshaft wear sleeve onto the crankshaft. Ensure that the flange of the crankshaft wear sleeve is 0.40 to 0.60 mm (0.017 to 0.024 inch) from the cylinder block.

Note: Measure the distance (Y) between the flange of the crankshaft wear sleeve (1) and the cylinder block in two places that are 180 degrees from each other.

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

End By:

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

i02296661

Flywheel Housing - Remove and Install

Removal Procedure (Standard Housing)

Start By:

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

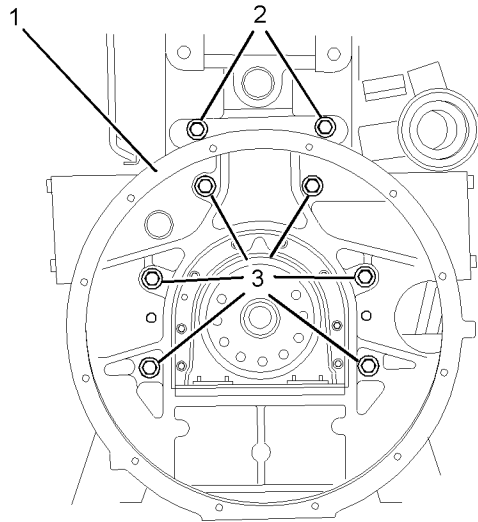


Illustration 138 g01165544

2. Remove the two M12 setscrews (2) and six M10 setscrews (3) from the flywheel housing (1).
3. Use the lifting device in order to remove the flywheel housing (1) from the cylinder block.

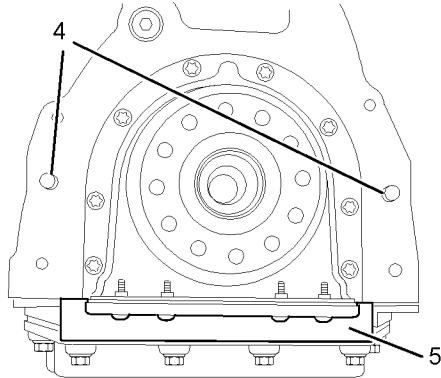


Illustration 139 g01202952
Typical example

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

Removal Procedure (Wet Back End Housing)

Start By:

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

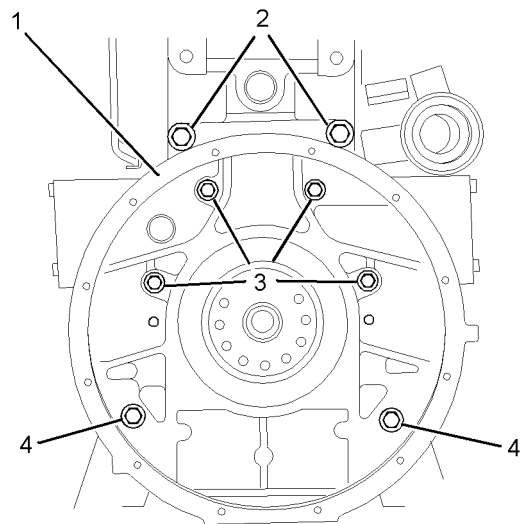


Illustration 140 g01202953

2. Remove the two M16 setscrews (2). Remove the two M12 setscrews (4). Remove the four M10 setscrews (3) from the flywheel housing (1).
3. Use the lifting device in order to remove the flywheel housing (1) from the cylinder block.

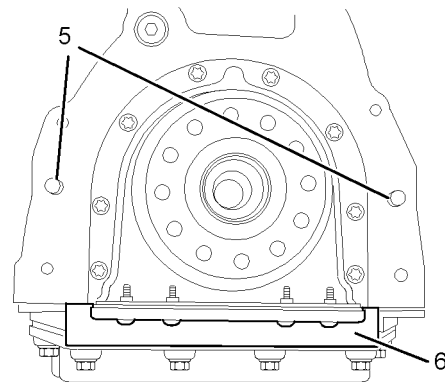


Illustration 141 g01215182
Typical example

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

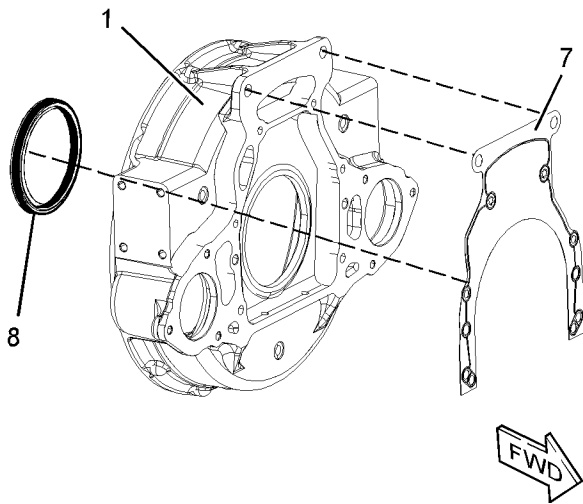


Illustration 142 g01215183

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

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.

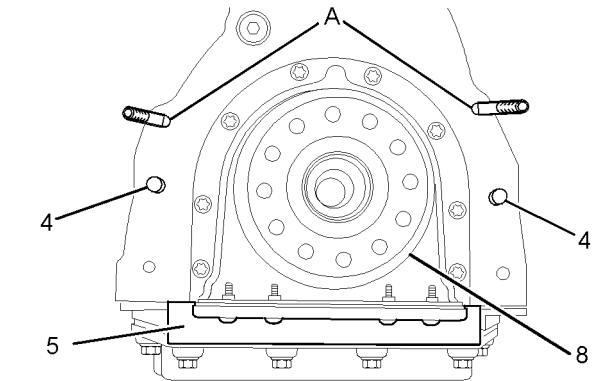


Illustration 143 g01202954
Engine with an aluminum oil pan

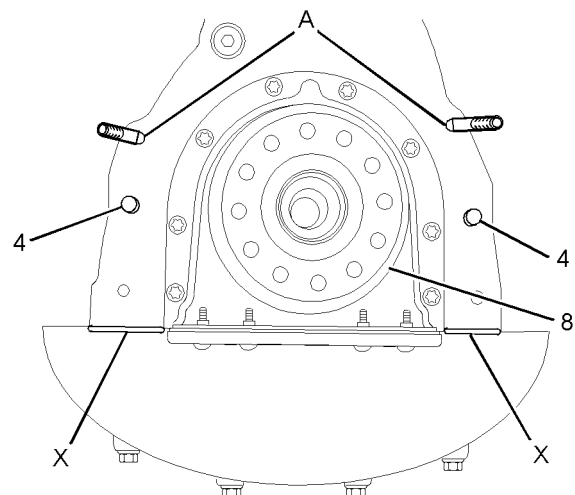


Illustration 144 g01202955
Engine with a cast iron oil pan

2. Inspect the crankshaft rear seal (8) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly Manual, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly Manual, "Crankshaft Rear Seal - Install".
3. Clean the rear face of the cylinder block. If necessary, install the two dowels (4) to the cylinder block.
4. Install the Tooling (A) to the cylinder block.
5. If the engine has an aluminum oil pan, install the dust seal (5).

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

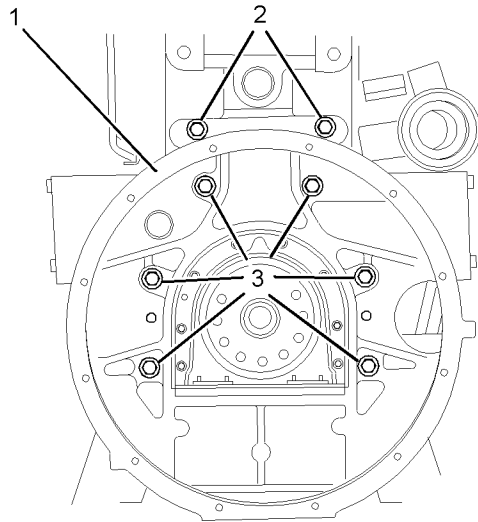


Illustration 145

g01165544

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 the flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
8. Install the two M12 setscrews (2) and four M10 setscrews (3).
9. Remove Tooling (A). Install the remaining two M10 setscrews (3).
10. Tighten the setscrews (3) to a torque of 63 N·m (46 lb ft).
11. Tighten the setscrews (2) to a torque of 78 N·m (57.5 lb ft).
12. Check the alignment of the flywheel housing (1) with the crankshaft. Refer to Testing and Adjusting Manual, "Flywheel Housing - Inspect".

End By:

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

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.

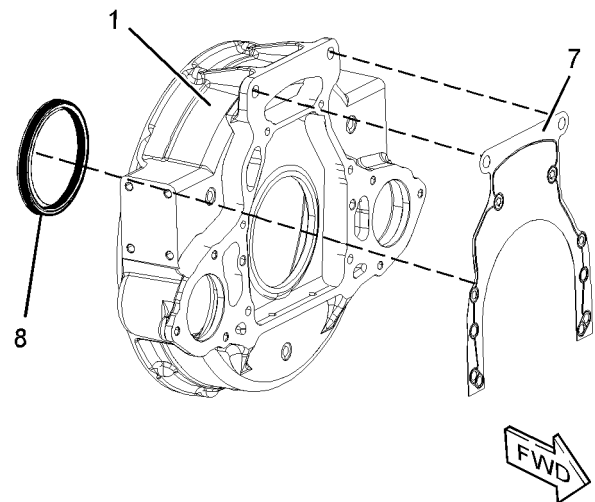


Illustration 146

g01215183

2. Install a new oil seal (8) to the 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 the crankshaft rear seal (9) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly Manual, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly Manual, "Crankshaft Rear Seal - Install".

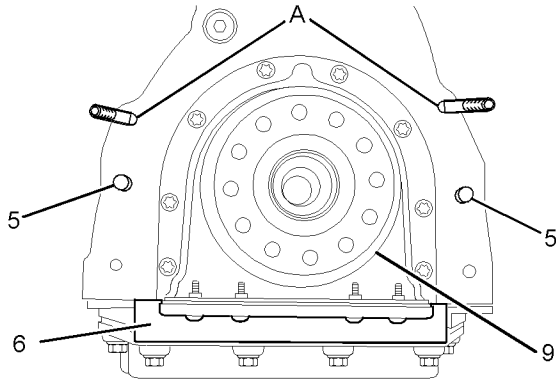


Illustration 147
Engine with an aluminum oil pan

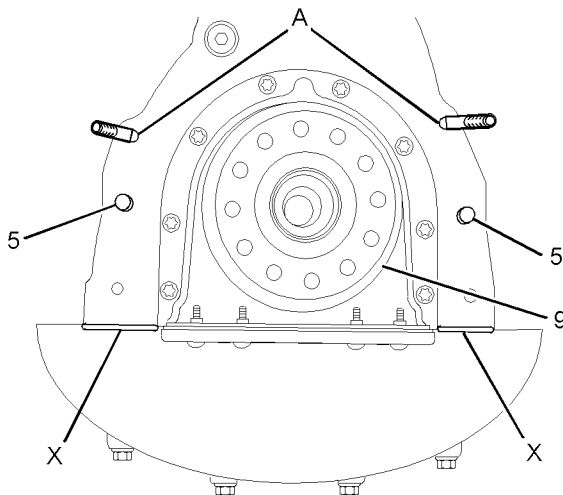


Illustration 148
Engine with cast iron oil pan

4. Clean the rear face of the cylinder block. If necessary, install the two dowels (5) to the cylinder block.
5. Install the 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 the 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).

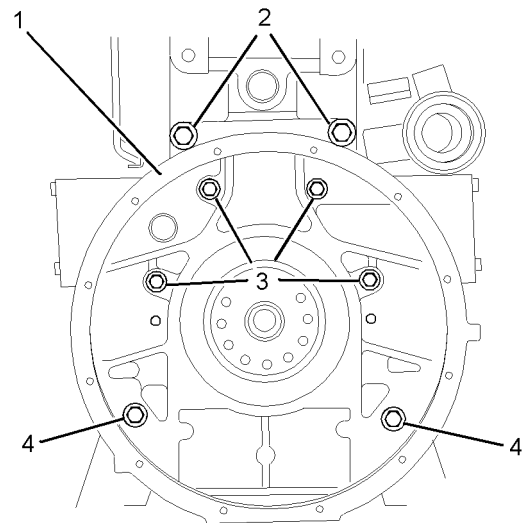


Illustration 149
g01202953

9. Use the lifting device to align the flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
10. Install the two M16 setscrews (2), two M12 setscrews (4) and two M10 setscrews (3).
11. Remove Tooling (A). Install the remaining two M10 setscrews (3).
12. Tighten the M16 setscrews (2) to a torque of 190 N·m (140 lb ft).

Tighten the M12 setscrews (4) to a torque of 115 N·m (85 lb ft).

Tighten the M10 setscrews (3) to a torque of 63 N·m (46 lb ft).
13. Check the alignment of the flywheel housing (1) with the crankshaft. Refer to Testing and Adjusting Manual, "Flywheel Housing - Inspect".

End By:

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

i02296662

Vibration Damper and Pulley - Remove

Removal Procedure (Pulleys with Split Lock Rings)

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".

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.

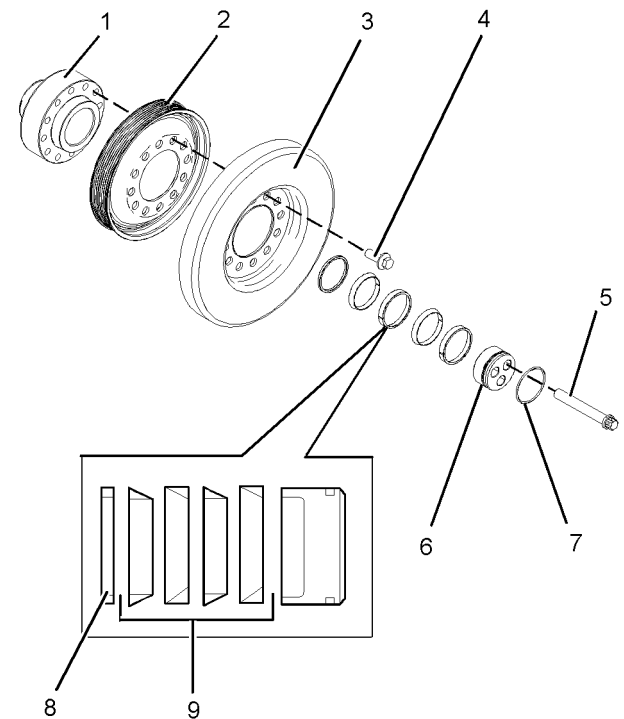


Illustration 150

g01171908

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

Removal Procedure (Pulleys without Split Lock Rings)

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 Manual, "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.

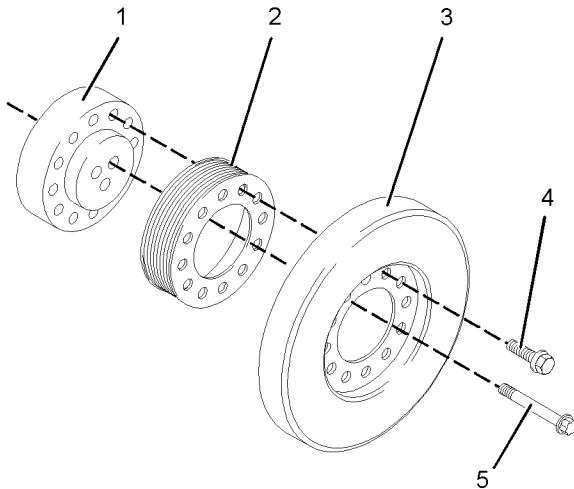


Illustration 151

g01167596

1. Remove one of the setscrews (4). Install Tooling (A) into the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter.
2. Remove the five remaining setscrews (4).
3. Remove the vibration damper (3) and the crankshaft pulley (2) from the crankshaft adapter (1). Remove Tooling (A) from the crankshaft adapter (1).

4. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to remove the three torx screws (5).
5. Remove the crankshaft adapter (1) from the crankshaft.

i02296663

Vibration Damper and Pulley - Install

Installation Procedure (Pulleys with Split Lock Rings)

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.

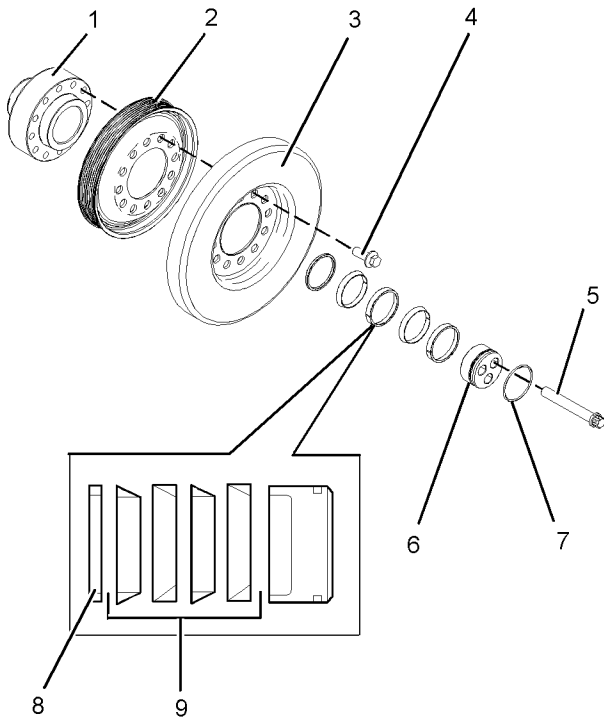


Illustration 152

g01171908

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 the thrust block (6).
 3. Install the spacer (8) to the crankshaft adapter (1).
 4. Install both pairs of split lock rings (9) to the 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 152.
- 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 the crankshaft adapter (1) onto the crankshaft.
 6. Align the holes in the thrust block with the holes in the crankshaft. Install the thrust block (6) into the crankshaft adapter (1).
 7. Install the three torx screws (5) to the 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 the crankshaft adapter (1).
11. Align the crankshaft pulley (2) with Tooling (A). Install the crankshaft pulley to the crankshaft adapter (1).
12. Inspect the vibration damper for damage. If necessary, replace the vibration damper.
13. Align the vibration damper (3) with Tooling (A). Install the vibration damper to the crankshaft adapter (1).
14. Install the four setscrews (4) to the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter. The setscrews should be evenly spaced. Remove Tooling (A).
15. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the setscrews (4) to a torque of 115 N·m (85 lb ft).

End By:

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

Installation Procedure (Pulleys without Split Lock Rings)

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.

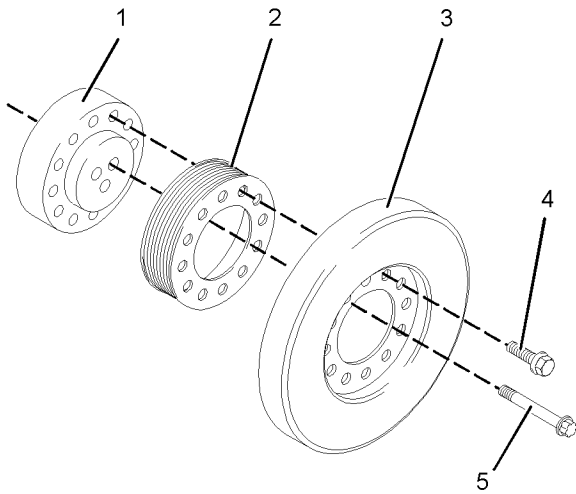


Illustration 153

g01167596

1. Ensure that the crankshaft adapter and the front of the crankshaft are clean and free from damage. Install the crankshaft adapter (1) to the crankshaft.
 2. Install the three torx screws (3) to the crankshaft adapter (1).
 3. Use a suitable tool 2 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 the crankshaft adapter (1).
 6. Align the crankshaft pulley (2) with Tooling (A). Install the crankshaft pulley to the crankshaft adapter (1).
 7. Inspect the vibration damper for damage. If necessary, replace the vibration damper.
 8. Align the vibration damper (3) with Tooling (A). Install the vibration damper to the crankshaft adapter (1).
 9. Install the setscrews (4) to the assembly of the crankshaft pulley, the vibration damper and the crankshaft adapter. Remove Tooling (A). Install the remaining setscrew (4).
- Note:** The setscrews should be evenly spaced.
10. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the setscrews (4) to a torque of 115 N·m (85 lb ft).

End By:

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

i02403280

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.

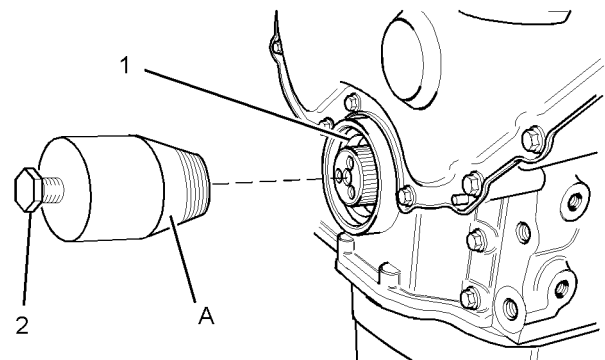


Illustration 154

g01195333

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.

- Screw the setscrew (2) into Tooling (A) in order to remove the crankshaft front seal (1). Discard the crankshaft front seal (1).

Installation Procedure

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610284	Front Seal Installer	1
	21825577	Stud	1
	21825578	Plate	1
	27610292	Anchor Plate	1
	-	Setscrews	3
	21825576	Sleeve	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

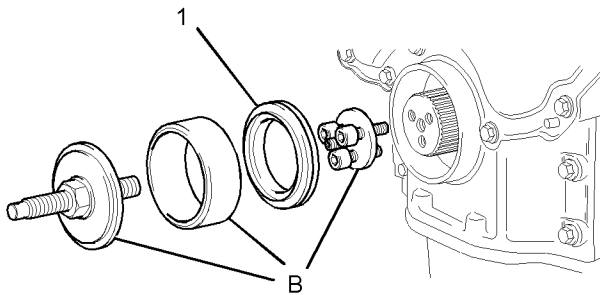


Illustration 155
Typical example

g01200784

- Assemble Tooling (B).
- Align the 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.

- Use Tooling (B) to install the 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.

- Remove Tooling (B) from the crankshaft.

End By:

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

i02403281

Crankshaft Wear Sleeve (Front) - Remove and Install

Removal Procedure

Start By:

- Remove the assembly of the crankshaft pulley. Refer to Disassembly and Assembly Manual, "Vibration Damper and Pulley - Remove".
- Remove the crankshaft front seal. Refer to Disassembly and Assembly Manual, "Crankshaft Front Seal - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

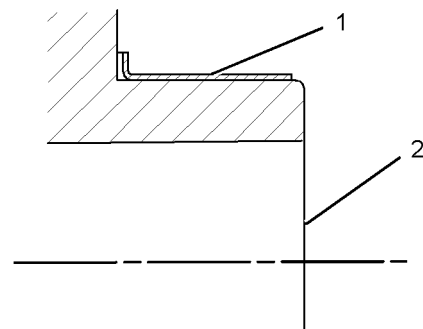


Illustration 156

g01200363

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

Note: Take care to avoid damaging the crankshaft adapter.

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

Installation Procedure

Table 37

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the crankshaft adapter is thoroughly clean and dry.

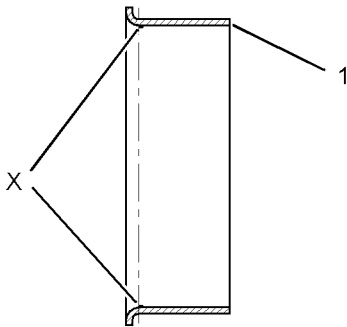


Illustration 157

g01200285

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

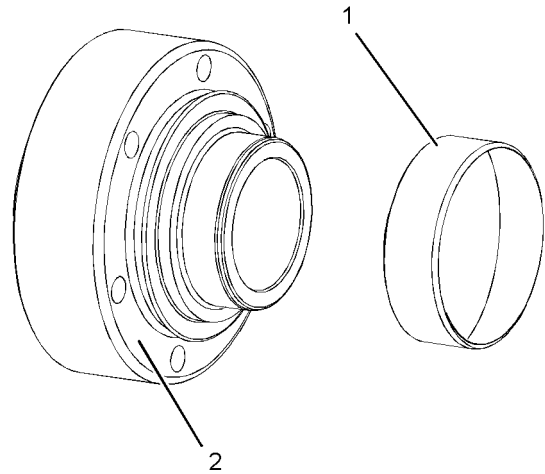


Illustration 158

g01191372

3. Align the wear sleeve (1) with the crankshaft adapter (2). Use the installation tool that is provided with the wear sleeve and use a press in order to install the wear sleeve (1) onto the crankshaft adapter (2).
4. Remove the installation tool from the wear sleeve (1).
5. Ensure that the wear sleeve (2) has no rough edges.

End By:

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

i02296668

Front Cover - Remove and Install

Removal Procedure

Start By:

- a. If the engine has a fan, remove the fan. Refer to Disassembly and Assembly Manual, "Fan - Remove and Install".

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

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

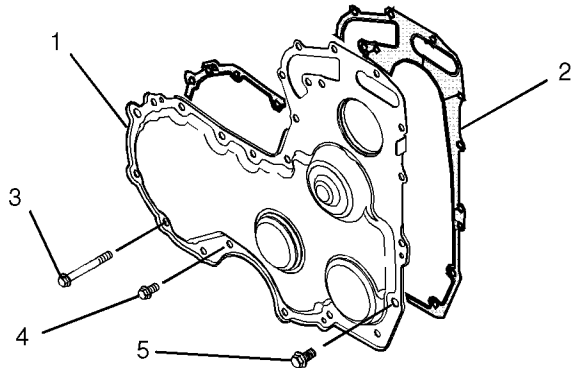


Illustration 159
Typical example g01156385

1. Remove the M8 setscrews (3) and (4). Remove the M10 setscrew (5). Identify the positions of the different setscrews.

Note: The M10 setscrew (5) may not be installed to some engines.

2. Remove the front cover (1) from the front housing.
3. Remove the joint (2) from the front cover (1). Discard the joint.

Installation Procedure

Table 38

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

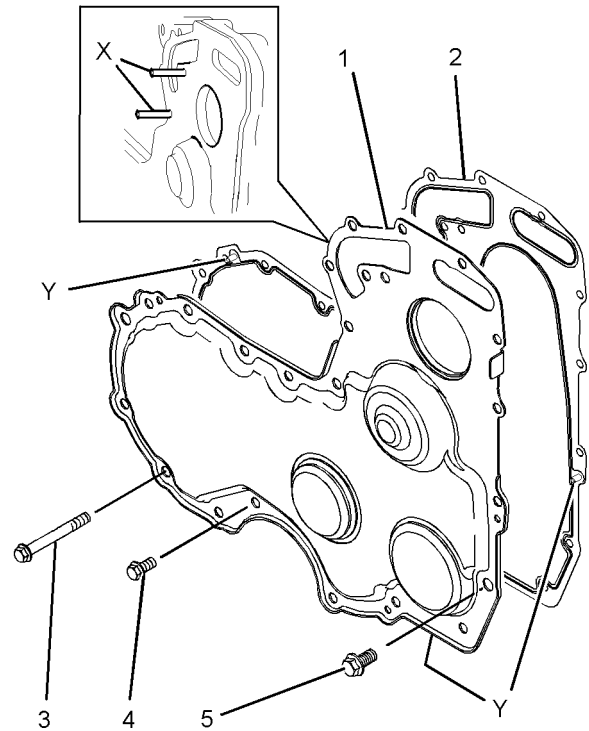


Illustration 160
Typical example g01172809

1. Thoroughly clean the joint face of the front housing.
2. If the original front cover is installed, follow Steps 2.a through 2.b.
 - a. Thoroughly clean the front cover (1).
 - b. Install a new joint (2) to the front cover (1). Engage the 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 the M8 setscrews (3) and (4). Install the M10 setscrew (5) finger tight. Ensure that the different setscrews are installed in the correct positions.

Note: The M10 setscrew (5) may not be installed to some engines.

6. Loosely install the water pump assembly and remove Tooling (A). Refer to Disassembly and Assembly Manual, "Water Pump - Install" for the correct procedure.

7. Tighten the setscrews (3), (4) and (5) to a torque of 22 N·m (16 lb ft).
8. Tighten the setscrews 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 Manual, "Fan - Remove and Install".

i02296792

Gear Group (Front) - Remove and Install

Removal Procedure

Table 39

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

Start By:

- a. Remove the front cover. Refer to Disassembly and Assembly Manual, "Front Cover - Remove and Install".
- b. Remove the valve mechanism cover. Refer to Disassembly and Assembly Manual, "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 Testing and Adjusting Manual, "Finding Top Centre Position for No.1 Piston".

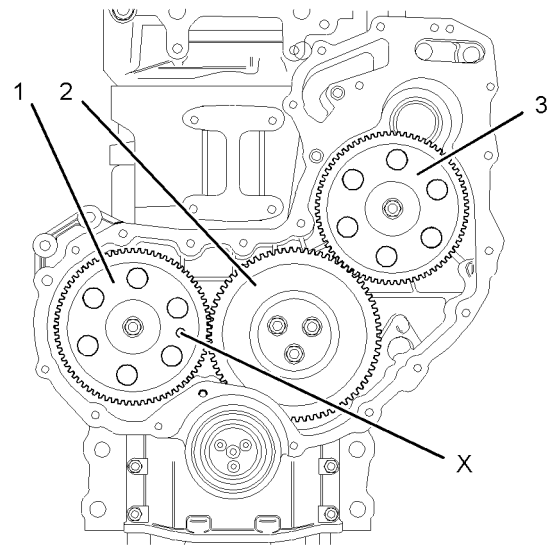


Illustration 161

g01194629

Typical example

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

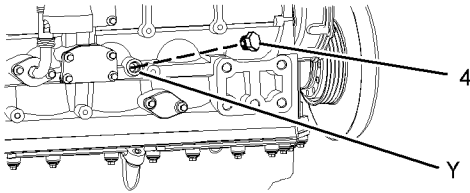


Illustration 162

g01195325

3. Remove the plug (4) from the cylinder block. Install Tooling (C) into the hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Testing and Adjusting Manual, "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.

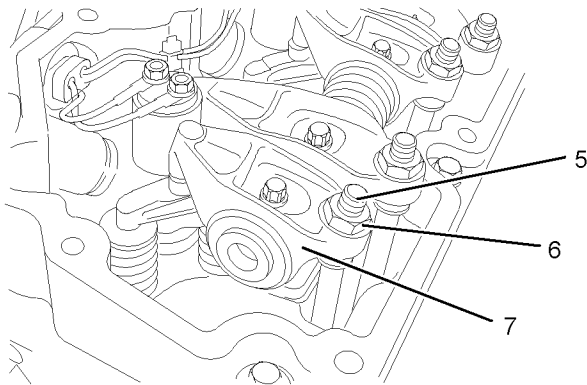


Illustration 163

g01198767

4. Loosen the nuts (6) on all rocker arms (7). Unscrew the 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 the 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.

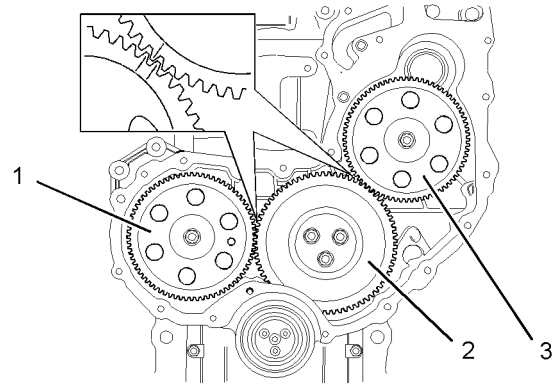


Illustration 164

g01194949

Typical example

6. Mark the gears (1), (2) and (3) in order to show alignment. Refer to Illustration 164.

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

7. Remove the fuel pump gear (3). Refer to Disassembly and Assembly, "Fuel Pump Gear - Remove and Install" for the correct procedure.

8. Remove the camshaft gear (1). Refer to Disassembly and Assembly Manual, "Camshaft Gear - Remove and Install".

9. Remove the idler gear (2). Refer to Disassembly and Assembly Manual, "Idler Gear - Remove and Install".

Installation Procedure

Table 40

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	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 the Testing and Adjusting Manual, "Finding Top Center for No. 1 Piston".

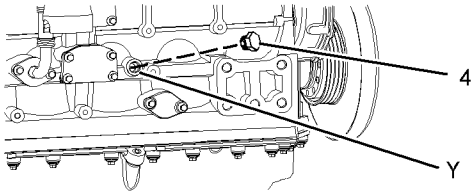


Illustration 165

g01195325

- If necessary, install Tooling (C) into the hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct position. Refer to Testing and Adjusting Manual, "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.

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

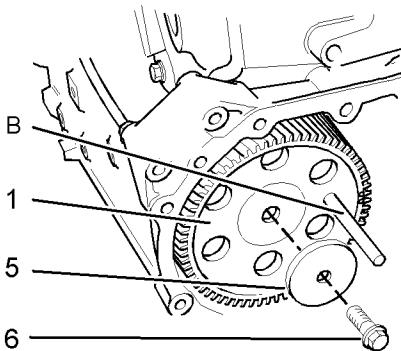


Illustration 166

g01198768

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

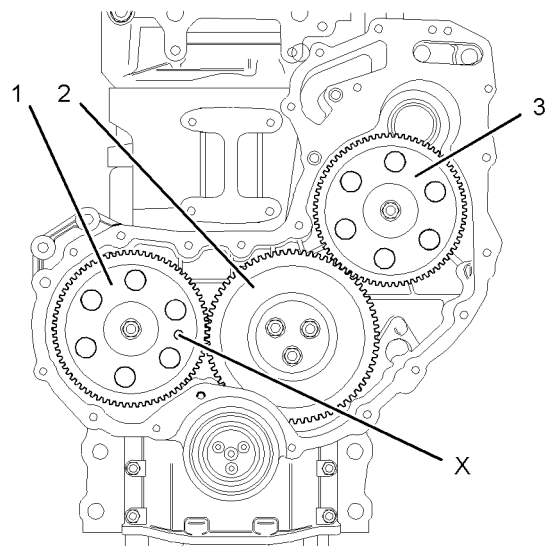


Illustration 167

g01194629

Typical example

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

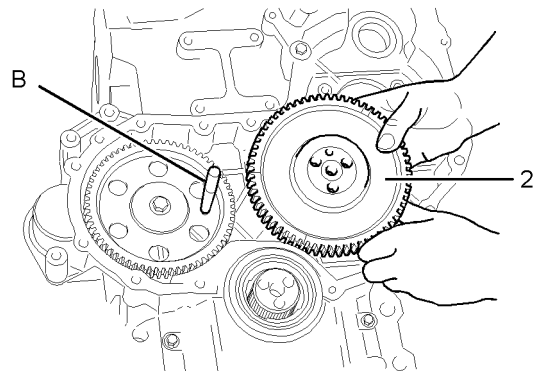


Illustration 168

g01194951

Typical example

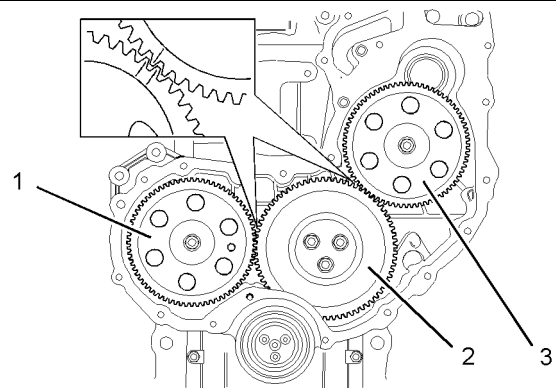


Illustration 169

g01194949

Alignment of timing marks

6. Install the idler gear (2). Ensure that the timing marks on the gears (1) and (2) are in alignment and that the mesh of the gears is correct. Refer to Disassembly and Assembly Manual, "Idler Gear - Remove and Install". Check the end play of the idler gear. Refer to the Specifications Manual, "Gear Group (Front)" and refer to Disassembly and Assembly Manual, "Idler Gear - Remove and Install" for further information.
7. Tighten the setscrew (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 Manual, "Camshaft" for more information.
8. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly Manual, "Fuel Injection Pump - Install".
9. Install the fuel injection pump gear (3). Ensure that the timing marks on the gears (2) and (3) are in alignment. See Illustration 169. Ensure that the mesh of the gears is correct. Refer to Disassembly and Assembly Manual, "Fuel Injection Pump Gear - Install" for more information.
10. Remove the Tooling (B) and (C). Install the plug (4) into hole (Y) in the cylinder block. Refer to Illustration 165.

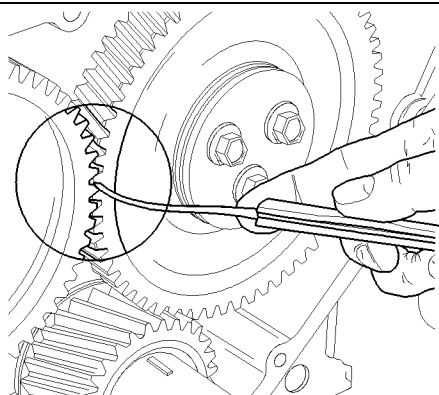


Illustration 170

g00944084

Checking backlash

11. Ensure that the backlash for the gears (1), (2) and (3) is within specified values. Refer to the Specifications Manual, "Gear Group (Front)" for further information.
12. Lubricate each gear with clean engine oil.
13. Adjust the engine valve lash. Refer to Testing and Adjusting Manual, "Engine Valve Lash - Inspect/Adjust".

End By:

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

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

i02403283

Idler Gear - Remove

Removal Procedure (Standard Idler Gear)

Table 41

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

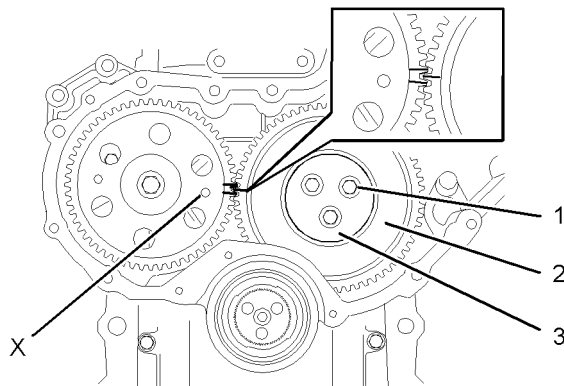


Illustration 171

g01197578

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 171.

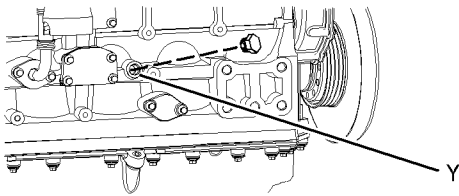


Illustration 172

g01197252

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.

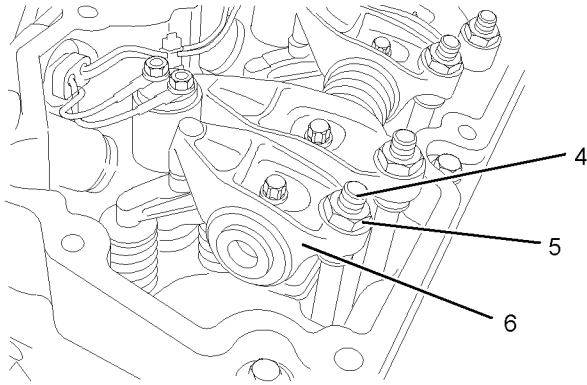


Illustration 173

g01197580

3. Loosen the nuts (5) on all rocker arms (6). Unscrew the 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 the plate (3) in order to show orientation.

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

5. Remove the three setscrews (1).
6. Remove the plate (3).

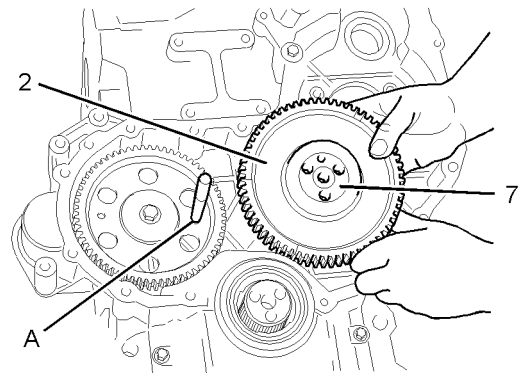


Illustration 174

g01197246

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

Note: The idler gear must be tilted during removal.

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

Removal Procedure (Heavy-Duty Idler Gear)

Table 42

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

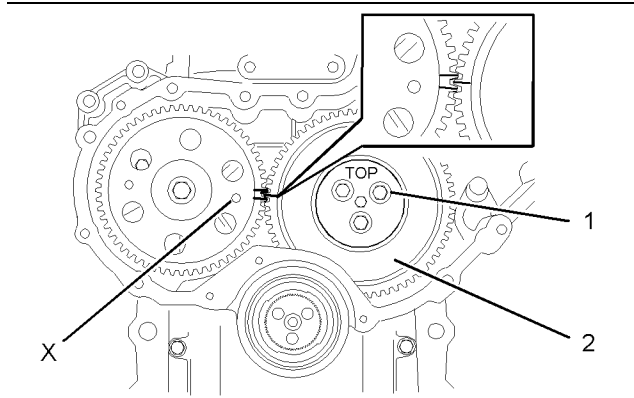


Illustration 175 g01197287

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 175.

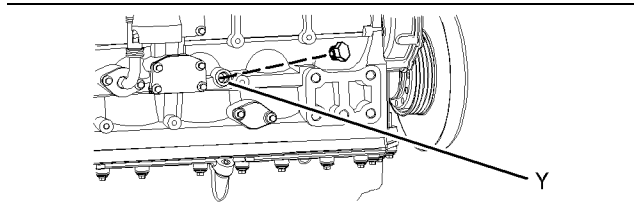


Illustration 176 g01197252

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.

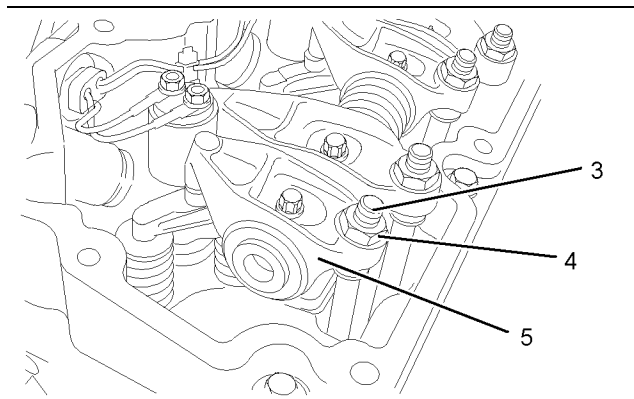


Illustration 177 g01197581

3. Loosen the nuts (4) on all rocker arms (5). Unscrew the 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 the three setscrews (1) from the assembly of heavy-duty idler gear (2).

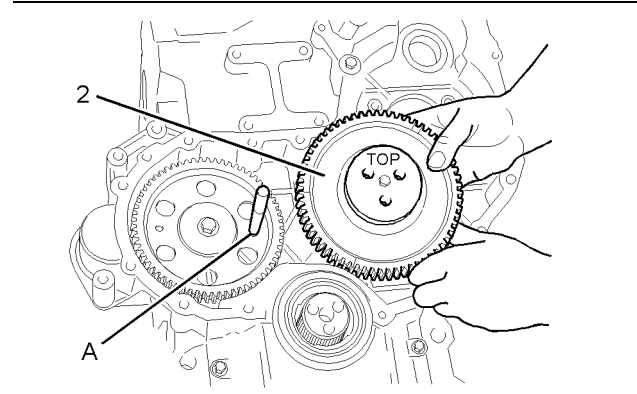


Illustration 178 g01197288

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

Note: The idler gear must be tilted during removal.

i02403284

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

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 the Testing and Adjusting Manual, "Finding Top Center for No. 1 Piston".

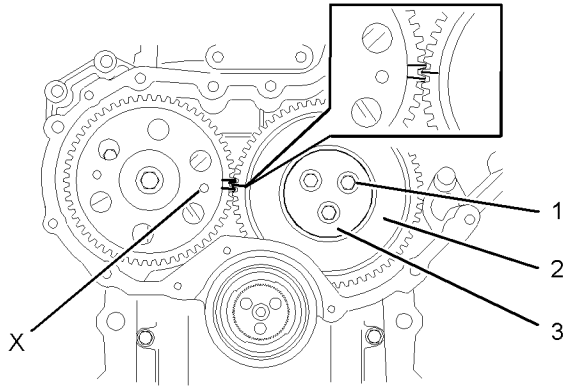


Illustration 179

g01197578

Alignment of timing marks

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

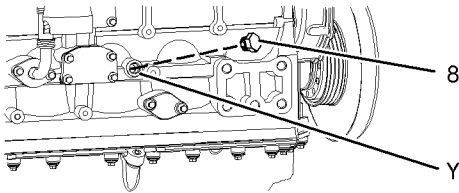


Illustration 180

g01198121

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

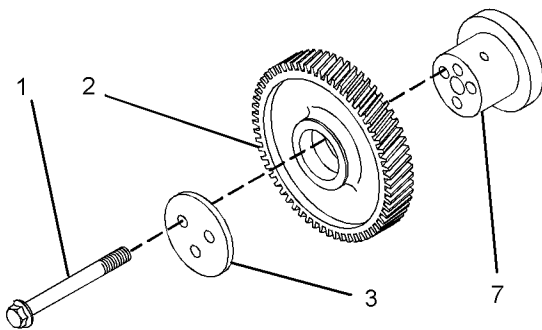


Illustration 181

g01198127

4. Clean the idler gear (2) and inspect the idler gear for wear or damage. Refer to Specifications Manual, "Gear Group (Front)" for more information. If necessary, replace the idler gear.
5. Clean the hub (7) and inspect the hub for wear or damage. Refer to Specifications Manual, "Gear Group (Front)" for more information. If necessary, replace the hub.

6. Lubricate the hub (7) with clean engine oil. Slide the hub (7) into the idler gear (2). Ensure that the timing marks are toward the front of the idler gear.

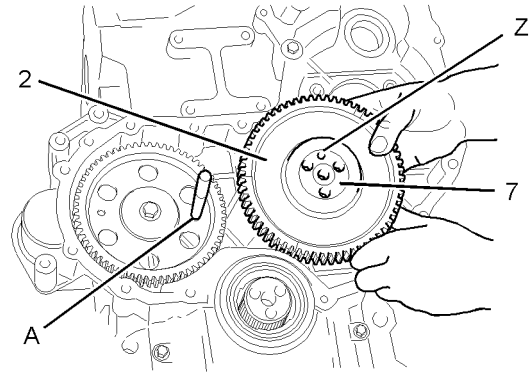


Illustration 182

g01198122

7. Align the timing mark on the idler gear (2) with the timing mark on the camshaft gear. Refer to the illustration 179. Install the assembly of the idler gear (2) and the hub (7) into the recess in the timing case. Ensure that the 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 the plate (3) and inspect the plate for wear or damage. If necessary, replace the plate.
9. Lubricate the plate (3) with clean engine oil. Align the holes in the plate (3) with the holes in the hub (7). Install the plate in the original orientation.
10. Install the setscrews (1).
11. Remove Tooling (A) and (B). Install the plug (8) to the cylinder block. Refer to Illustration 180.
12. Tighten the setscrews (1) to a torque of 44 N·m (32 lb ft).

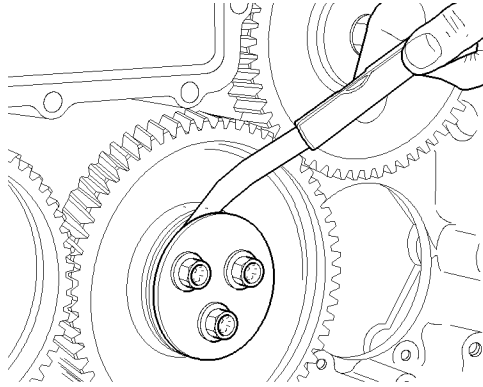


Illustration 183 g00944081
Checking end play by using a set of feeler gauge's

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

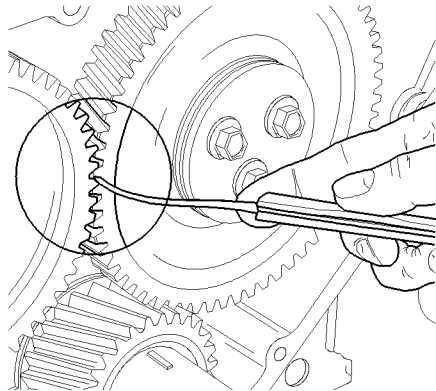


Illustration 184 g00944084
Checking backlash

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

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

16. 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 (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
C	21825496	Dial gauge	1
	-	Magnetic Base	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 the Testing and Adjusting Manual, "Finding Top Center for No. 1 Piston".

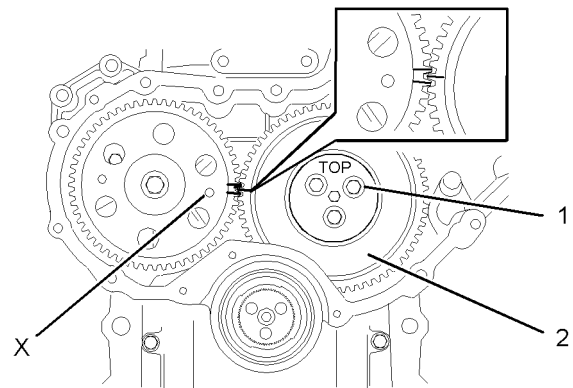


Illustration 185 g01197287
Alignment of timing marks

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

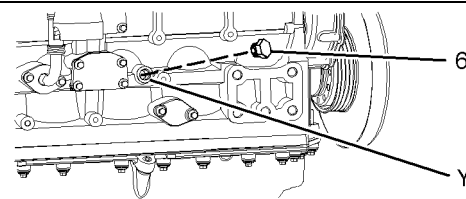


Illustration 186 g01198126

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

4. Clean the assembly of the idler gear (2) and inspect the assembly of the idler gear for wear or damage. Refer to Specifications Manual, "Gear Group (Front)" for more information. If necessary, replace the assembly of the idler gear.
5. Lubricate the bearings in the assembly of the idler gear (2) with clean engine oil.

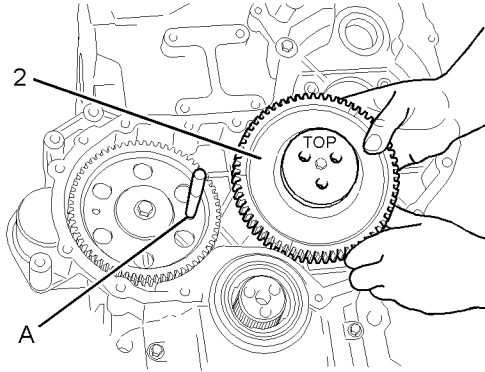


Illustration 187

g01197288

6. Align the timing mark on the idler gear (2) with the timing mark on the camshaft gear. Refer to the illustration 185. Install the assembly of the 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 the setscrews (1).
8. Remove Tooling (A) and (B). Install the plug (6) to the cylinder block. Refer to Illustration 186.
9. Tighten the setscrews (1) to a torque of 44 N·m (32 lb ft).

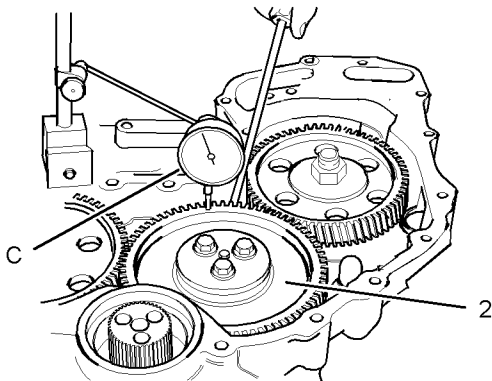


Illustration 188

g01198143

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

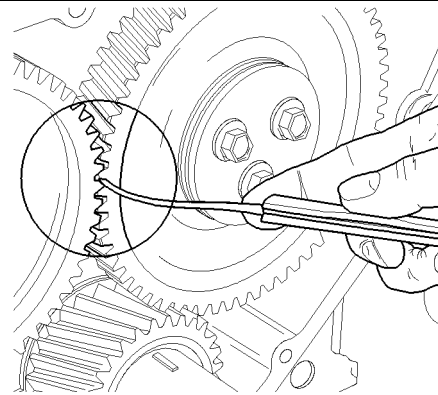


Illustration 189

g00944084

Checking backlash

11. Check the backlash between the idler gear and the camshaft gear. Refer to the Specifications Manual, "Gear Group (Front)" for more information.
12. Check the backlash between the idler gear and the crankshaft gear. Refer to the Specifications Manual, "Gear Group (Front)" for more information.
13. 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".

i02296670

Housing (Front) - Remove

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly Manual, "Fan - Remove and Install".
- b. If necessary, remove the alternator. Refer to Disassembly and Assembly Manual, "Alternator - Remove".
- c. Remove the front pulley. Refer to Disassembly and Assembly Manual, "Vibration Damper and Pulley - Remove".

- d. Remove the engine oil pan. Refer to Disassembly and Assembly Manual, "Engine Oil Pan - Remove".
- e. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly Manual, "Accessory Drive - Remove and Install".
- f. Remove the timing gears. Refer to Disassembly and Assembly Manual, "Gear Group (Front) - Remove and Install".
- g. Remove the fuel injection pump. Refer to Disassembly and Assembly Manual, "Fuel Injection Pump - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

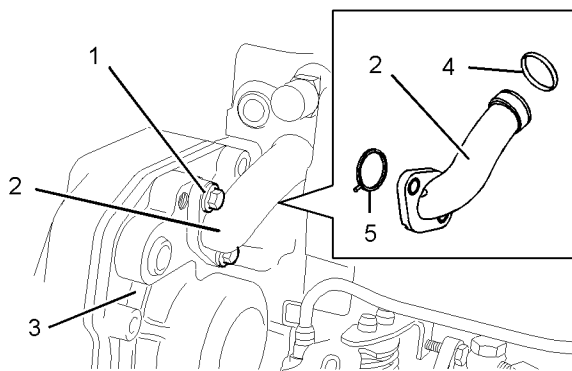


Illustration 190

g01180542

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

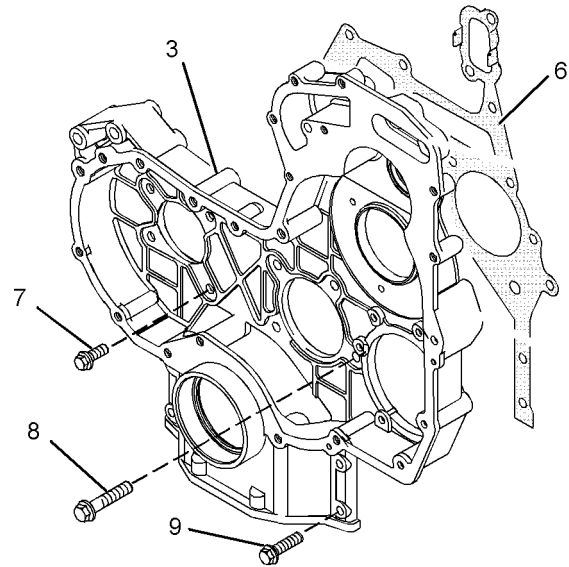


Illustration 191

g01176043

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

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

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

- 5. Remove the joint (6). Discard the joint.

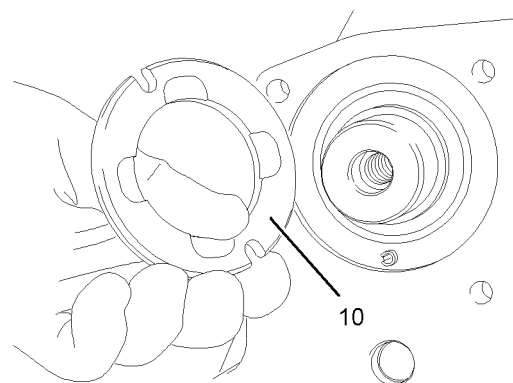


Illustration 192

g01175068

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

i02296671

Housing (Front) - Install

Installation Procedure

Table 45

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	3 Bond 1386D	1
B	-	Guide Stud (M8 by 70 mm)	2
C	27610216	Alignment Tool	1
	-	Setscrews (M10 by 50 mm)	3
D	-	Straight Edge	1
E	21820221	POWERPART Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

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

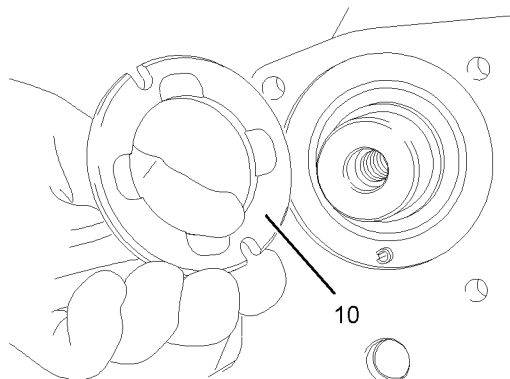


Illustration 193

g01175068

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

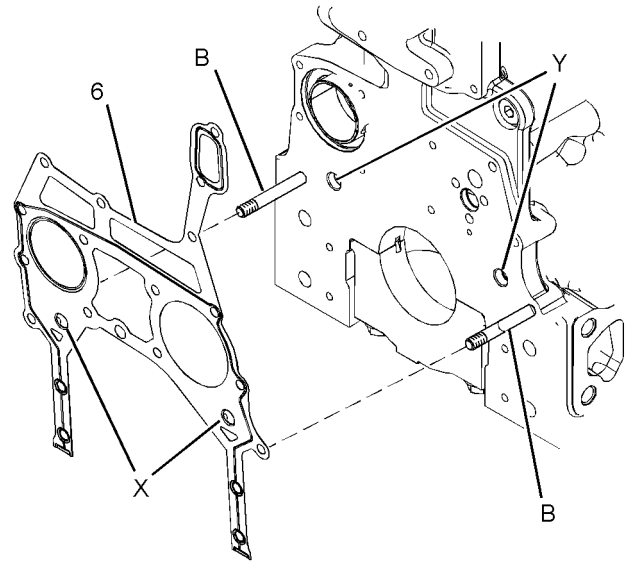


Illustration 194

g01191265

5. Install Tooling (B) to the cylinder block. Refer to Illustration 194.
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 the two holes (Y) in the cylinder block.

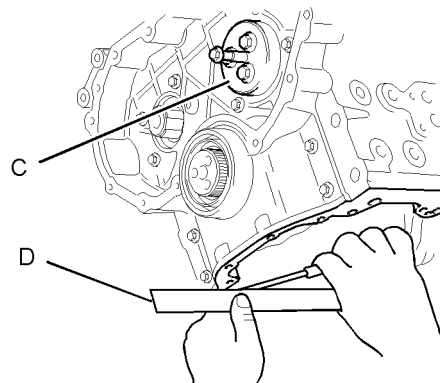


Illustration 195

g01182264

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.

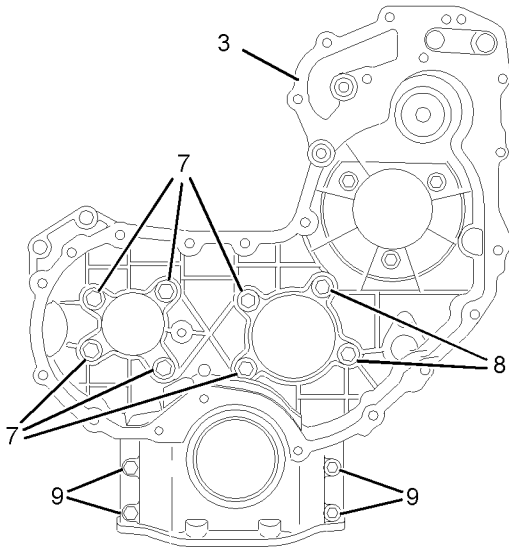


Illustration 196 g01203928

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

9. Install the four setscrews (9) to the front housing (3) finger tight.
10. Remove Tooling (B).
11. Loosely install the setscrews (7) and (8). Refer to Illustration 196 for the correct position of the setscrews.
12. Align the bottom face of the 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 195. Refer to Specifications, "Front Housing and Covers" for further information.

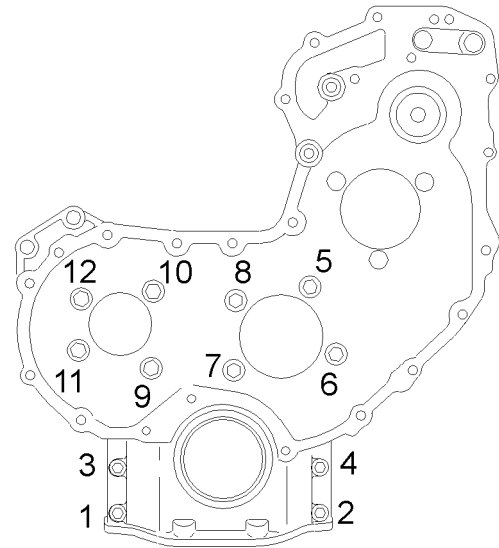


Illustration 197 g01203927

13. Tighten the setscrews (6), (7) and (8) in the sequence that is shown in illustration 197 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 Manual, "Crankshaft Front Seal - Remove and Install".

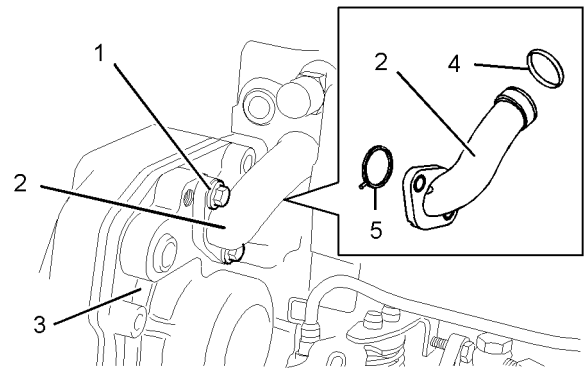


Illustration 198 g01180542

Typical example

16. Install two new O-ring seals (4) and (5) to the bypass tube (1). Use Tooling (E) in order to lubricate the O-ring seals. Install the bypass tube (2) to the cylinder head. Install the two setscrews (1). Tighten the setscrews to a torque of 22 N·m (16 lb ft).
17. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Fill" for the correct procedure.

End By:

- a. Install the fuel injection pump. Refer to Disassembly and Assembly Manual, "Fuel Injection Pump - Install".
- b. Install the timing gears. Refer to Disassembly and Assembly Manual, "Gear Group (Front) - Install".
- c. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly Manual, "Accessory Drive - Remove and Install".
- d. Install the engine oil pan. Refer to Disassembly and Assembly Manual, "Engine Oil Pan - Install".
- e. Install the front pulley. Refer to Disassembly and Assembly Manual, "Vibration Damper and Pulley - Install".
- f. If necessary, install the alternator. Refer to Disassembly and Assembly Manual, "Alternator - Install".
- g. Install the fan. Refer to Disassembly and Assembly Manual, "Fan - Remove and Install".

i02296672

Accessory Drive - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

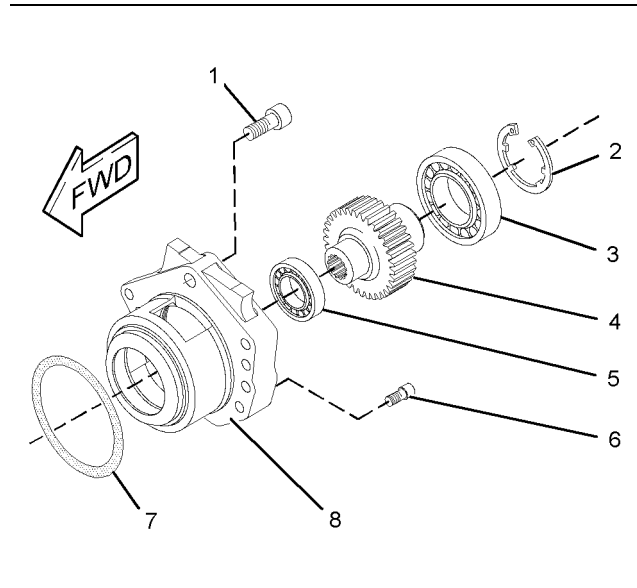


Illustration 199

g01212859

1. Remove the M10 Allen head screw (1) from the accessory drive housing (8). Remove the five M8 Allen head screws (6) from the accessory drive housing (8).
2. Remove the 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 the circlip (2) from the accessory drive housing (8).
 - b. Place the accessory drive housing (8) onto a suitable support. Press the assembly of the gear (4) and the bearings (3) and (5) out of the accessory drive housing (8). Use a suitable puller in order to remove the bearings (3) and (5) from the gear (4).
 - c. Remove the O-ring seal (7) from the accessory drive housing (8). Discard the O-ring seal.

Installation Procedure

Table 46

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

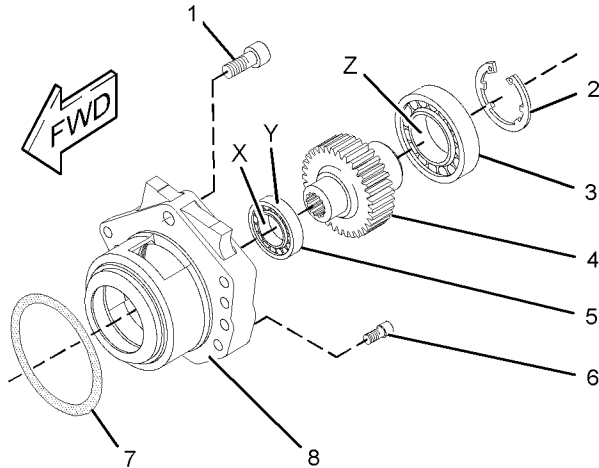


Illustration 200

g01193304

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 the gear (4) for wear or damage. Inspect the bearings (3) and (5), the 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 the inner surface (X) of the bearing (5). Place the gear shaft on a suitable support. Press on the inner race of the bearing (5) until the bearing (5) is against the shoulder of the gear (4). Remove any excess sealant.
 - c. Apply a small continuous bead of Tooling (A) to the inner surface (Z) of the bearing (3). Place the front face of the inner race of the bearing (3) onto a suitable support. Press the shaft of the gear (4) into the 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 the outer surface (Y) of the bearing (5). Place the accessory drive housing (8) on a suitable support. Press the assembly of the gear (4) and the bearings (3) and (5) into the accessory drive housing. Ensure that the bearing (5) is against the front face of the recess in the accessory drive housing (8). Remove any excess sealant.
 - e. Install the circlip (2) into the groove in the accessory drive housing (8). Ensure that the 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 the accessory drive housing (8).
 3. Inspect the bore in the front housing (not shown) for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly Manual, "Housing (Front) - Remove" and Disassembly and Assembly Manual, "Housing (Front) - Install".
 4. Lightly lubricate the bearing (3), the bearing (5), and the gear (4) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing.
 5. Apply Tooling (C) to the Allen head screws (1) and (6). Install the five M8 Allen head screws (6) to the accessory drive housing (8). Install the M10 Allen head screw (1) to the 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.

i02403278

Crankcase Breather - Remove

Removal Procedure (Unfiltered Breather)

Table 47

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.

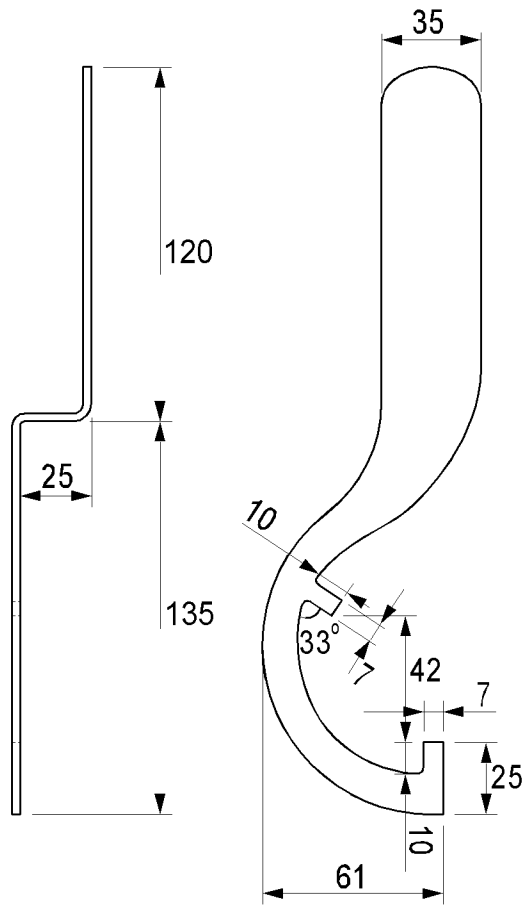


Illustration 201
Breather tool

g01206039

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 201. All dimensions are shown in millimeters.

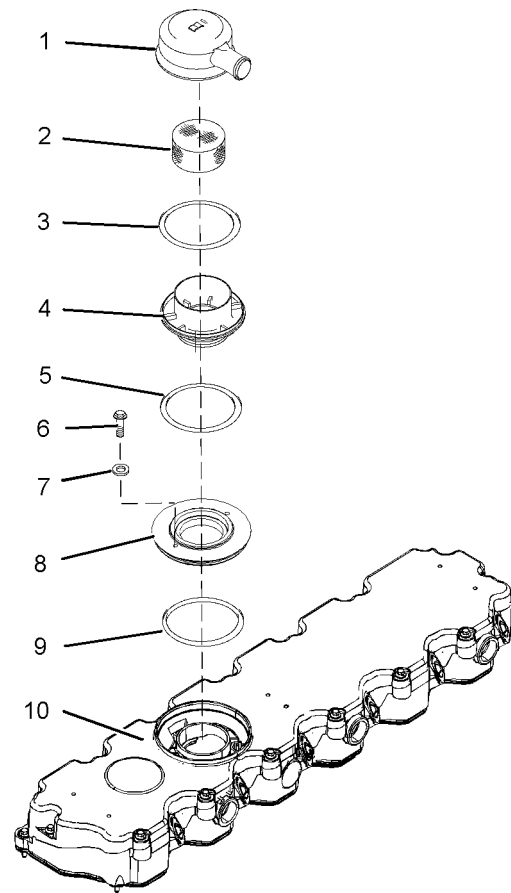


Illustration 202

g01200785

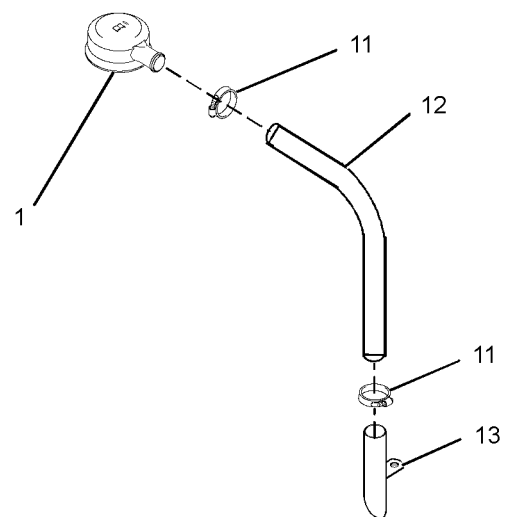


Illustration 203

g01200791

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

- Carefully pry the cover (1) from the breather body (4).

Note: Note the orientation of the outlet.

- Remove the gauze (2) from the breather body (4).
- Remove the O-ring seal (3) from the breather body (4). Discard the O-ring seal.
- Use Tooling (A) in order to unscrew the breather body (4) from the adapter plate (8).
- Remove the O-ring seal (5) from breather body (4). Discard the O-ring seal.
- Remove the two setscrews (6) and the washers (7) from adapter plate (8).
- Remove adapter plate (8) from the valve mechanism cover (10).
- Remove the O-ring seal (9) from adapter plate (8). Discard the O-ring seal.

Removal Procedure (Filtered Breather)

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.

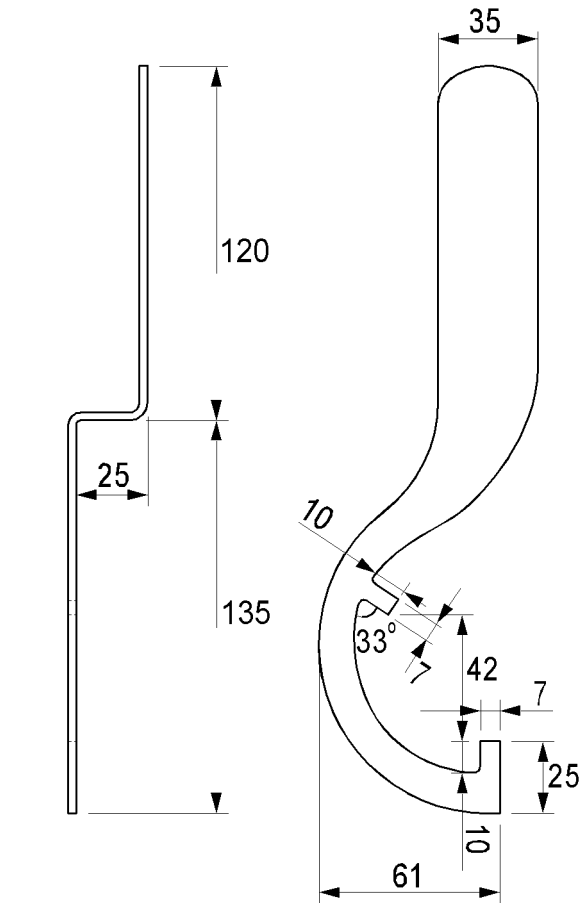


Illustration 204
Breather tool

g01206039

- 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 204. All dimensions are shown in millimeters.

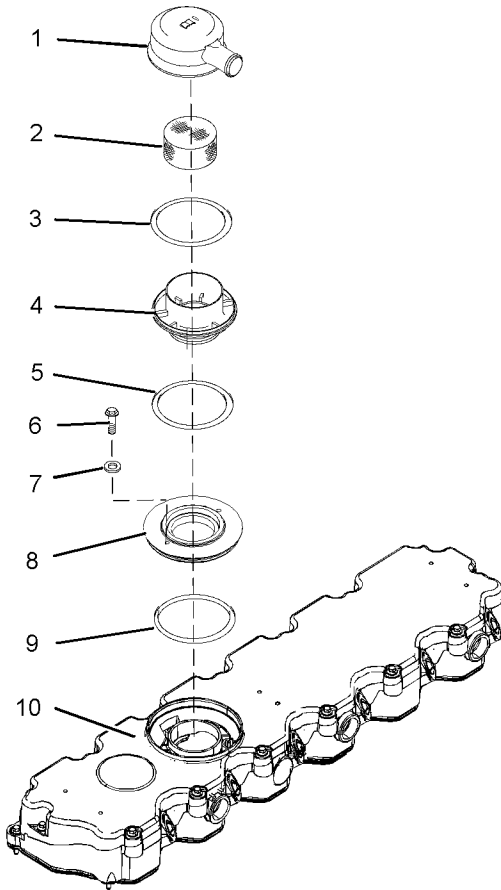


Illustration 205

g01200785

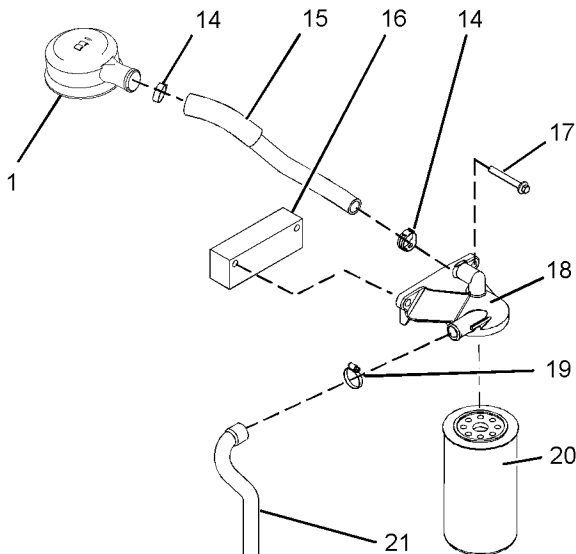


Illustration 206

g01200786

2. Remove the canister (20) for the breather. Refer to Operation and maintenance Manual, "Crankcase Breather (Canister) - Replace".

3. Loosen the clamp (19) and remove the hose (21).

4. Release the two spring clamps (14) in order to remove the hose (15). Remove the hose.

5. Remove the two setscrews (17). Remove the base (18) from the inlet manifold (not shown).

If a spacer is installed between the base and the inlet manifold, remove the spacer (16).

6. Carefully pry the cover (1) from the breather body (4).

Note: Note the orientation of the outlet.

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

8. Remove the O-ring seal (3) from the breather body (4). Discard the O-ring seal.

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

10. Remove the O-ring seal (5) from breather body (4). Discard the O-ring seal.

11. Remove the two setscrews (6) and the washers (7) from adapter plate (8).

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

13. Remove the O-ring seal (9) from adapter plate (8). Discard the O-ring seal.

i02403277

Crankcase Breather - Install

Installation Procedure (Unfiltered Breather)

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.

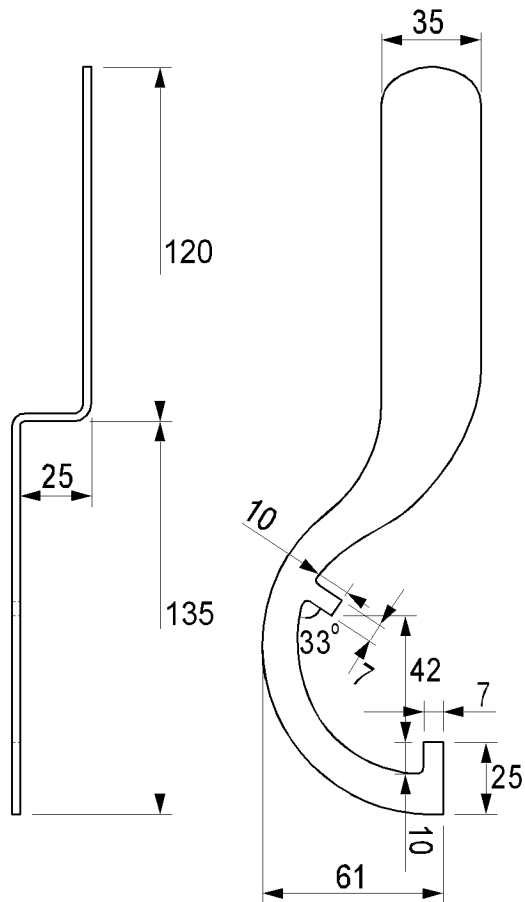


Illustration 207
Breather tool

g01206039

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 207. All dimensions are shown in millimeters.

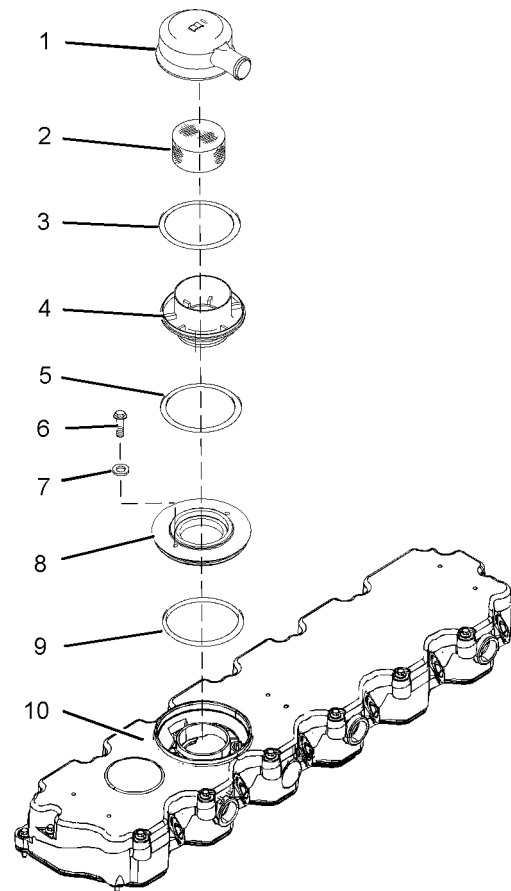


Illustration 208

g01200785

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

10. Install the cover (1) to the breather body (4).

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

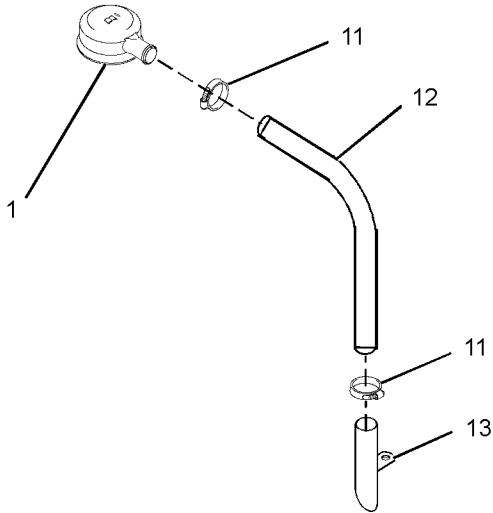


Illustration 209

g01200791

11. Install the two clamps (11) to the hose (12).

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

Installation Procedure (Filtered Breather)

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.

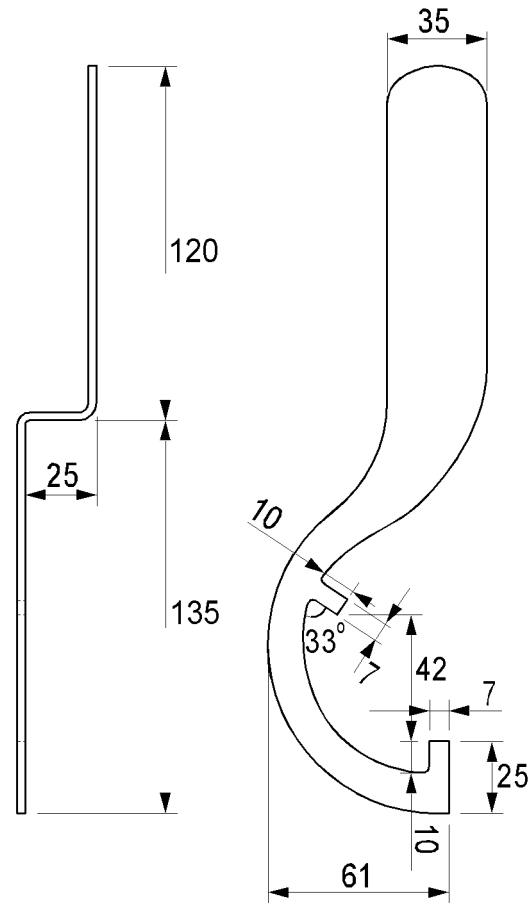


Illustration 210

g01206039

Breather tool

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 207. All dimensions are shown in millimeters.

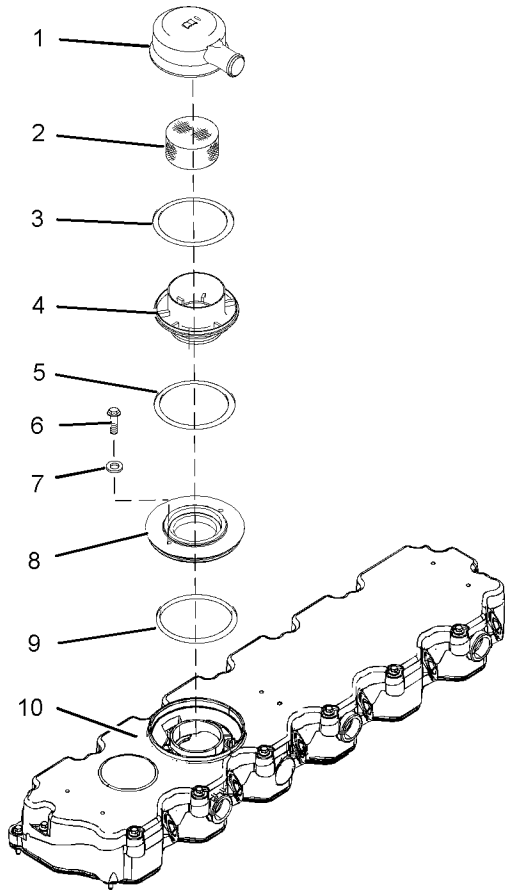


Illustration 211

g01200785

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

10. Install the cover (1) to the breather body (4).

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

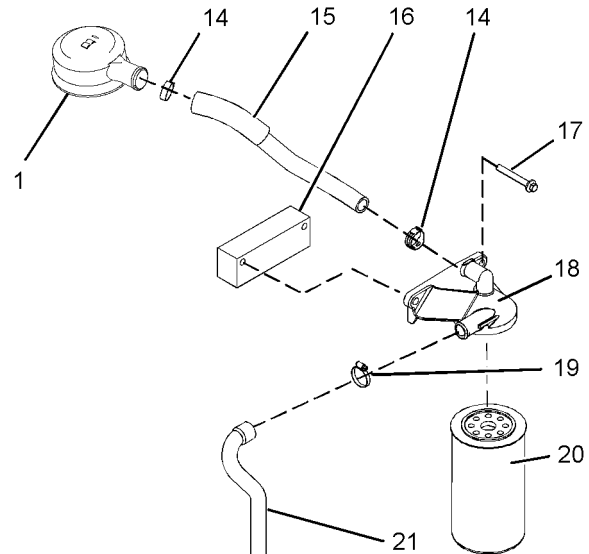


Illustration 212

g01200786

11. Install the two setscrews (17) to the base (18).

If a spacer is installed, position the spacer (16) to the setscrews.

12. Install the assembly of the base to the inlet manifold (not shown).

13. Tighten the setscrews (17) to a torque of 22 N·m (16 lb ft).

14. Install a new canister (20) to the base (18). Refer to Operation and maintenance Manual, "Crankcase Breather (Canister) - Replace".

15. Install the spring clamps (14) to the hose (15). Install the hose (15) to the cover (1) and to the base (18).

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

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

i02296674

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

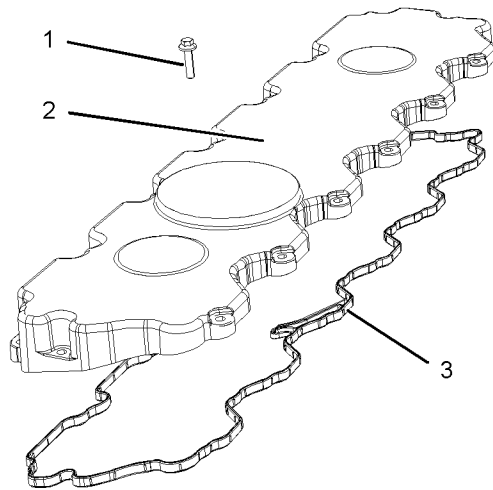


Illustration 213

g01161175

Typical example

1. Disconnect the breather hose from the separator for the crankcase breather (not shown). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Remove".
2. Remove the setscrews (1) from the valve mechanism cover (2).
3. Remove the valve mechanism cover (2) from the valve mechanism cover base.
4. Remove the joint (3) from the valve mechanism cover (2). Discard the joint.
5. If necessary, remove the separator for the crankcase breather from the valve mechanism cover base. Refer to Disassembly and Assembly Manual, "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 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 (not shown) to the valve mechanism cover (2). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Install".

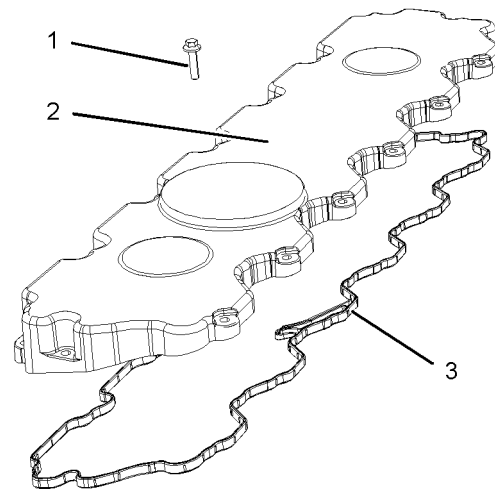


Illustration 214

g01161175

Typical example

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

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

i02296675

Valve Mechanism Cover Base - Remove and Install

Removal Procedure

Table 51

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

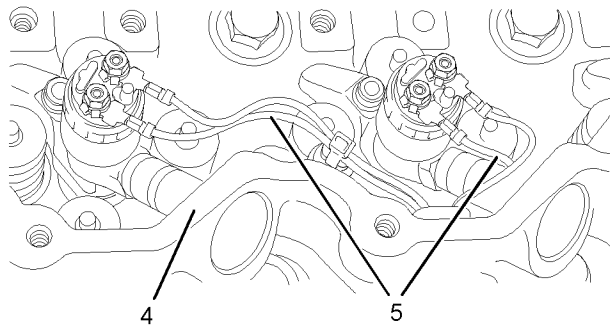


Illustration 215

g01202951

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

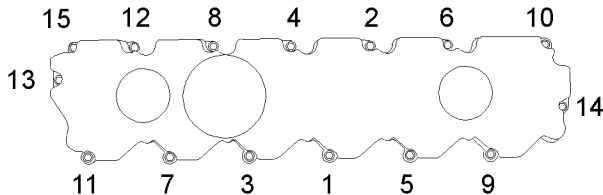


Illustration 216

g01158787

5. Tighten the setscrews in the numerical sequence that is shown in Illustration 216. Tighten the setscrews to a torque of 9 N·m (79 lb in).
6. Connect the breather hose to the separator for the crankcase breather (not shown). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Install".

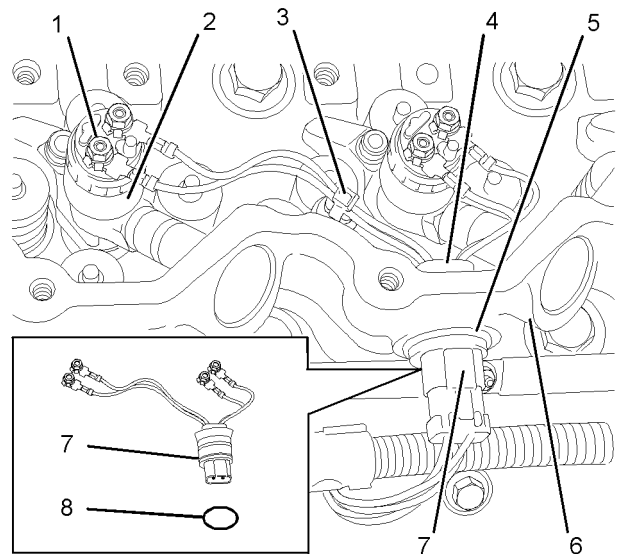


Illustration 217

g01182384

1. Place a temporary identification mark on the connections (1) for the harness assembly (4).
2. Use a deep socket to remove the connections (1) from the electronic unit injectors (2).

3. If necessary, follow steps 3.a through 3.f in order to remove the harness assemblies (4) from the valve mechanism cover base (6).
 - a. Cut the cable ties (3).
 - b. Disconnect the plug (7) from the harness assembly (4).
 - c. Use Tooling (A) to remove the circlip (5).
 - d. From the outside of the valve mechanism cover base (6), push the harness assembly (4) inward. Withdraw the harness assembly from the valve mechanism cover base (6).
 - e. Remove the O-ring seal (8) from the harness assembly (4). Discard the O-ring seal.
 - f. Repeat steps 3.b through 3.e in order to remove the remaining harness assemblies.

4. Loosen the isolated screws (9) in reverse numerical order. Refer to illustration 219. This will help prevent distortion of the valve mechanism cover base (6).
5. Remove valve mechanism cover base (6) from the cylinder head.
6. Remove the isolated setscrews (9) from the valve mechanism cover base (6).
7. Remove the seal (10) from the valve mechanism cover base (6). Discard the seal.

Installation Procedure

Table 52

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 seal surfaces are free from damage.

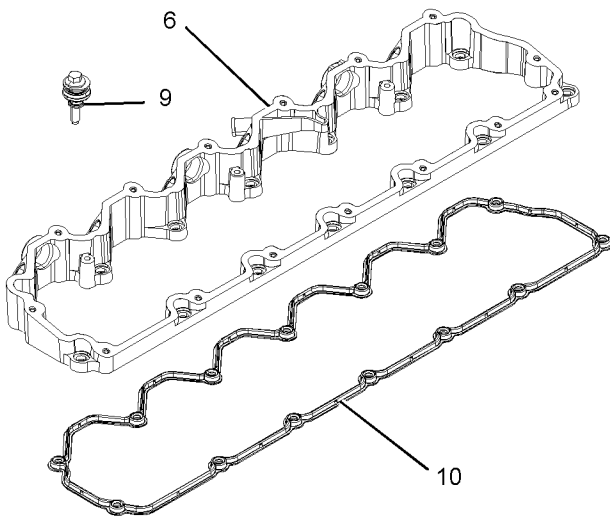


Illustration 218

g01164741

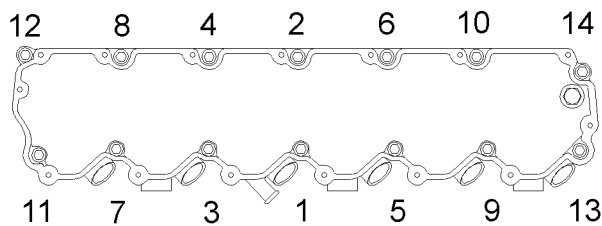


Illustration 219

g01167668

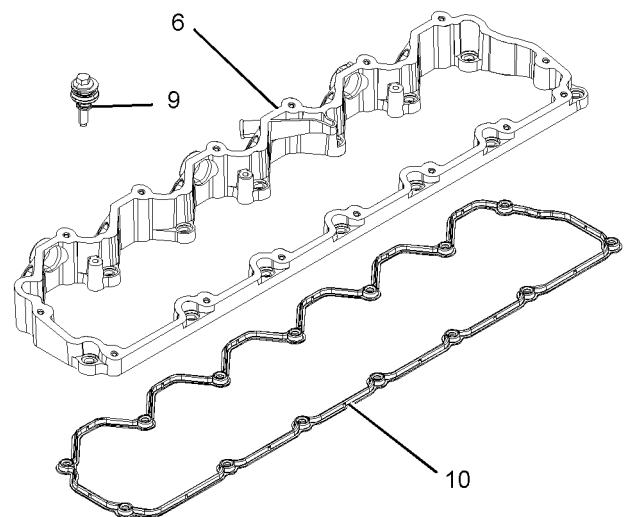


Illustration 220

g01164741

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

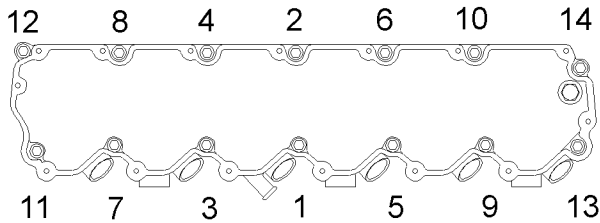


Illustration 221

g01167668

4. Position the valve mechanism cover base (6) on the cylinder head. Tighten the isolated screws (9) to a torque of 9 N·m (79 lb in) in the sequence that is shown in illustration 221.

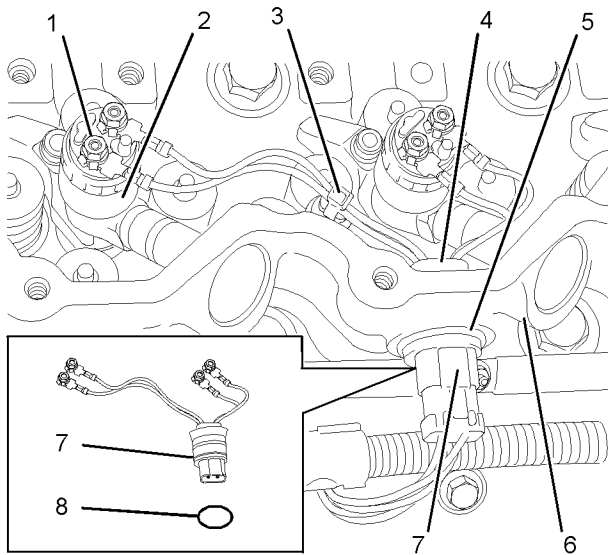


Illustration 222

g01182384

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 the harness assembly (4) and the bore in the 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 the new O-ring seal (8) onto the harness assembly (4).
- c. From the inside of the valve mechanism cover base (6), push the harness assembly (4) into the valve mechanism cover base (6).
- d. Use Tooling (A) to install the circlip (5).
- e. Connect the plug (7) to the harness assembly (4).
- f. Use a deep socket to connect the harness (4) to the electronic unit injectors (2). Use Tooling (C) to tighten the connectors (1) to a torque of 2.4 N·m (21 lb in).
- g. Install a new cable tie (3) to the harness assembly (4).

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

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

End By:

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

i02296677

Rocker Shaft and Pushrod - Remove

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

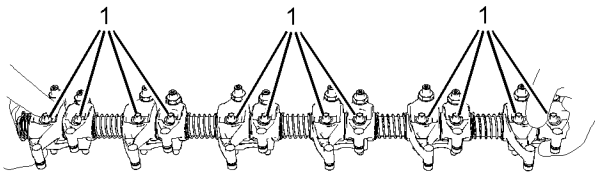


Illustration 223

g01182556

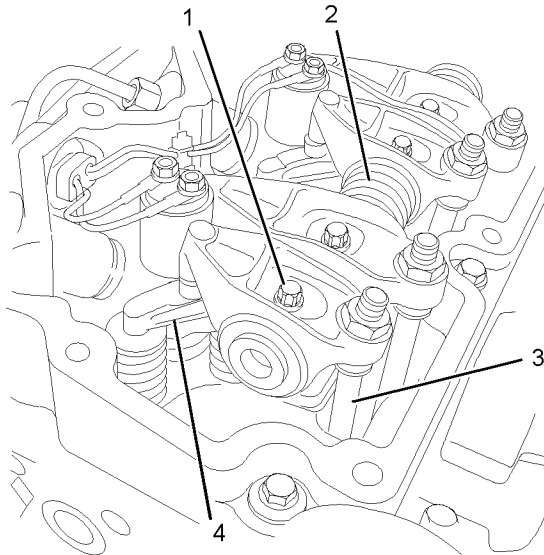


Illustration 224

g01182277

1. Progressively loosen the 12 torx screws (1). Begin at the ends of the rocker shaft assembly and work toward the center.

Note: To avoid distortion of the rocker shaft assembly (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 the 12 torx screws (1) from the rocker shaft assembly (2).
3. Remove the rocker shaft assembly (2) from the cylinder head.
4. Place an identification mark on the 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 the 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.

i02296678

Rocker Shaft - Disassemble

Disassembly Procedure

Start By:

- a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly Manual , "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.

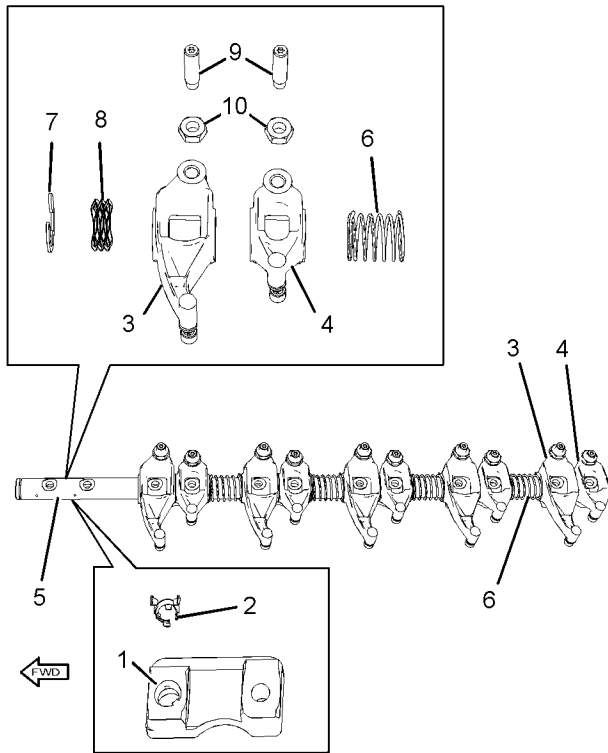


Illustration 225

g01181179

2. Remove the pedestals (1) from the rocker shaft (5). It is not necessary to remove the locators (2) from the pedestals.
 3. Remove the 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 the spring (6) from the rocker shaft (5).
 5. Repeat Steps 3 and 4 in order to remove the remaining rocker arms from the rocker shaft (5).

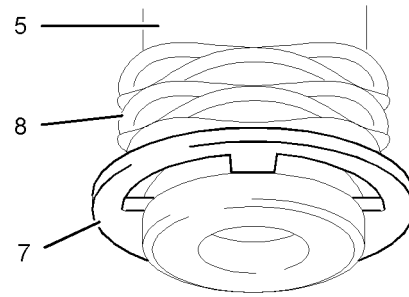


Illustration 226

g01181801

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

i02296680

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 Manual, "Rocker Shaft" for more information. If necessary, replace any components that are worn or damaged.

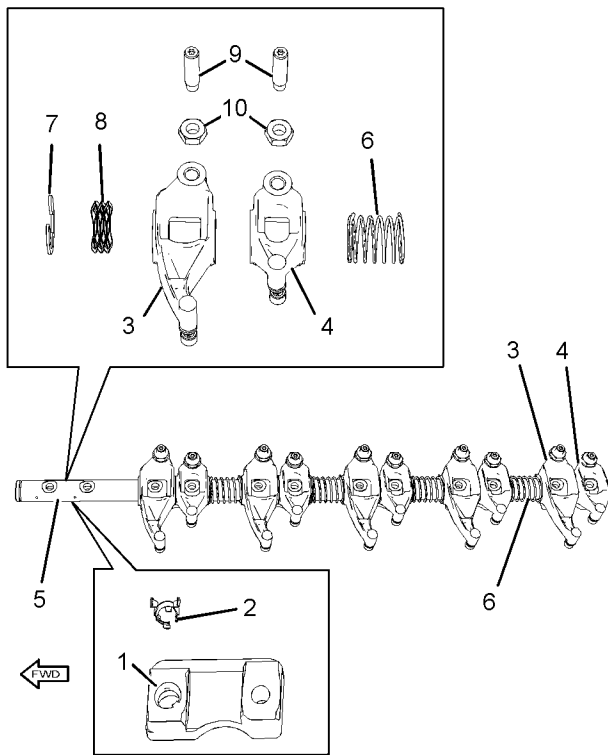


Illustration 227

g01181179

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

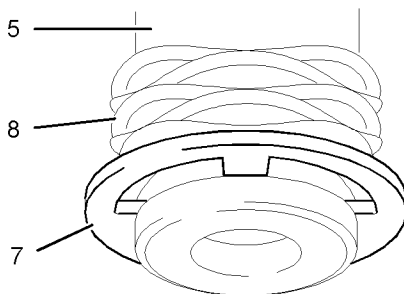


Illustration 228

g01181801

3. Install the retaining clip (7) and the spring (8) to the front end of the rocker shaft (5).
4. Lubricate the bores of the rocker arm assemblies (3) and (4) and the rocker shaft (5) with clean engine oil.

5. Install the rocker arm assembly (3) for number 1 inlet valve to the rocker shaft. Install the rocker arm assembly (4) for number 1 exhaust valve to the 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 the locator (2) is correctly seated in the pedestal (1). Ensure that the counterbores for the holes in the rocker shaft (5) are upward. Align the locator (2) with the hole to the front of the 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 the spring (6) to the rocker shaft (5).

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

End By:

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

i02296681

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 53

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.

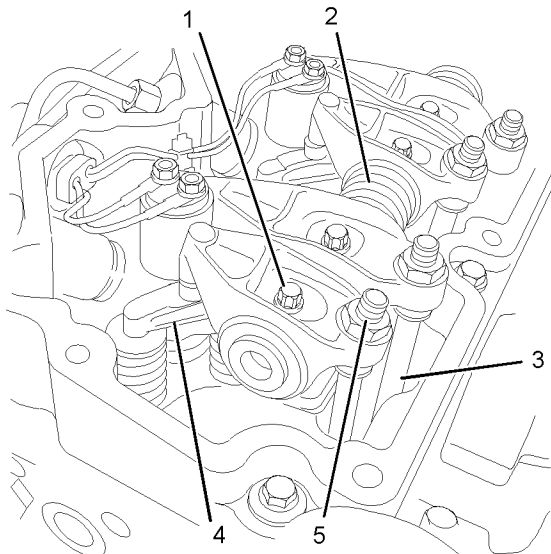


Illustration 229 g01182565

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

3. Clean the pushrods. Inspect the pushrods for wear or damage. Replace any pushrods that are worn or damaged.
4. Apply clean engine lubricating oil to both ends of the pushrods (3). Install the pushrods to the engine with the cup upward.

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

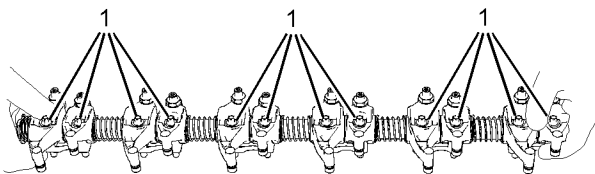


Illustration 230 g01182556

5. Ensure that the rocker shaft assembly is clean and free from wear or damage. Install the 12 torx screws (1) in the rocker shaft.

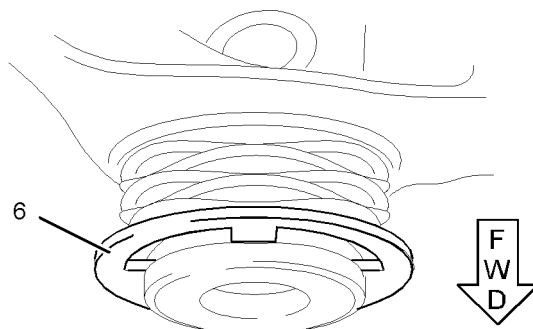


Illustration 231 g01182557

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

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

7. Gradually tighten the torx screws (1).

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

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

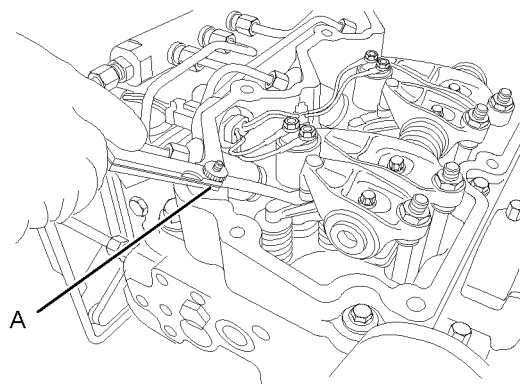


Illustration 232 g01182558

8. Use Tooling (A) in order to check the valve lash. Refer to Testing and Adjusting Manual, "Engine Valve Lash - Inspect/Adjust". If necessary, adjust the valve lash. Refer to Testing and Adjusting Manual, "Engine Valve Lash - Inspect/Adjust" for the correct procedure.

End By:

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

i02296682

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

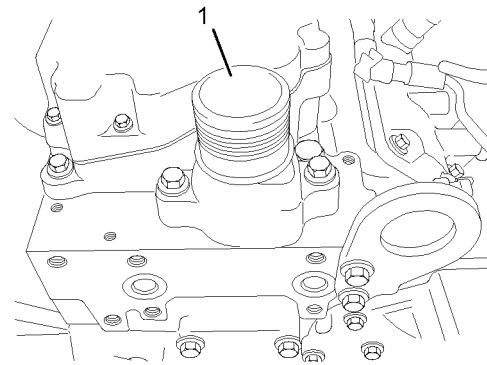


Illustration 233

g01176154

Typical example

2. Disconnect the upper radiator hose (not shown) from the water temperature regulator housing (1) on the cylinder head.

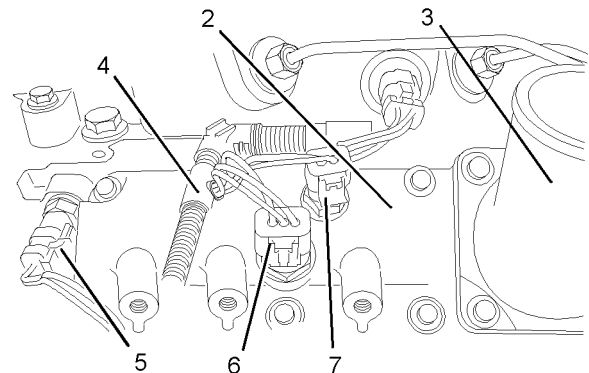


Illustration 234

g01175424

Typical example

3. Remove the air inlet hose (not shown) from the inlet connection (3) on the inlet manifold (2).

4. Follow Steps 4.a and 4.b in order to disconnect the harness assembly (4) from the coolant temperature sensor (5).
 - a. Slide the locking tab (not shown) into the unlocked position.
 - b. Disconnect the harness assembly (4) from the coolant temperature sensor (5).
5. Follow Steps 5.a and 5.b in order to disconnect the harness assembly (4) from the boost pressure sensor (6).
 - a. Slide the locking tab (not shown) into the unlocked position.
 - b. Disconnect the harness assembly (4) from the boost pressure sensor (6).
6. Follow Steps 6.a and 6.b in order to disconnect the harness assembly (4) from inlet air temperature sensor (7).
 - a. Slide the locking tab (not shown) into the unlocked position.
 - b. Disconnect the harness assembly (4) from the inlet air temperature sensor (7).
7. Remove all cable ties that secure the 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.

9. If the engine has a wastegate solenoid, loosen the tube clips for the tube assembly (9). Remove the tube assembly (9) from the wastegate solenoid (not shown) and from the cylinder head. Plug the port in the wastegate solenoid with a new plug. Cap the tube assembly with new caps.

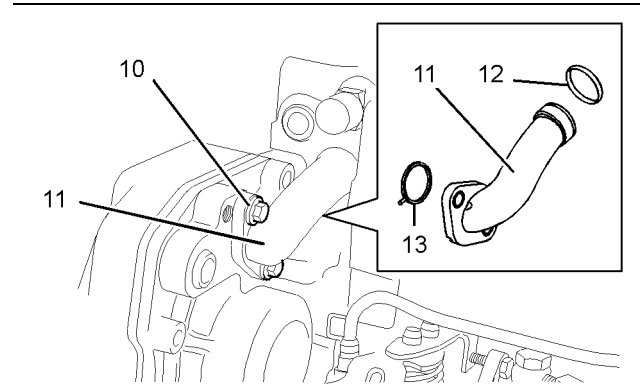


Illustration 236

g01175680

Typical example

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

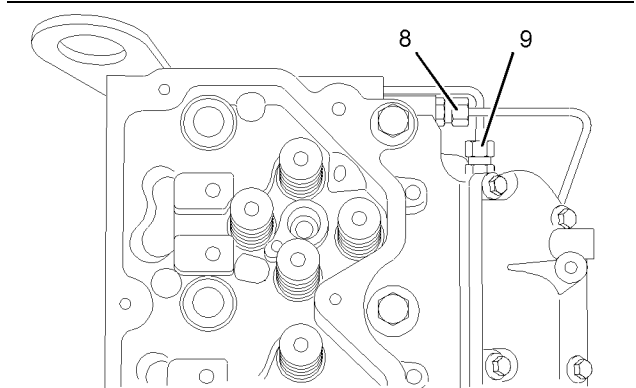


Illustration 235

g01176031

Typical example

8. Loosen the tube clips for the tube assembly (8). Remove the tube assembly (8) for the fuel return from the cylinder head and from the transfer pump (not shown). Plug the port in the transfer pump with a new plug. Cap the tube assembly with new caps.

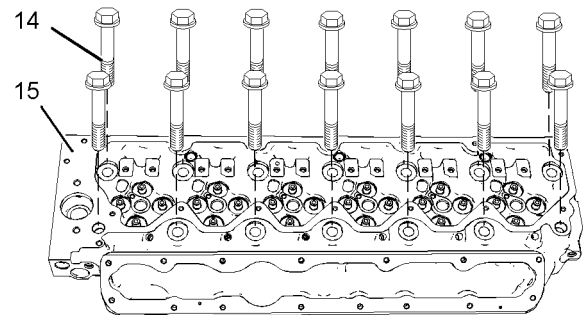


Illustration 237

g01190301

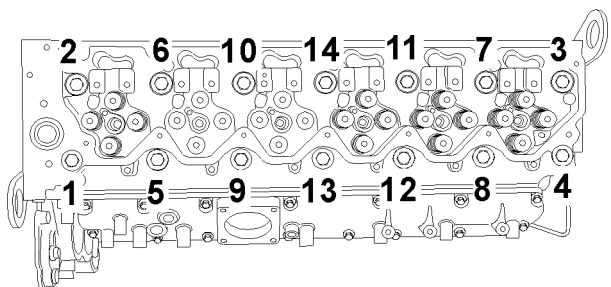


Illustration 238

g01176030

Sequence for tightening the setscrews for the cylinder head

11. Gradually loosen the setscrews (14) in the reverse numerical order to the tightening sequence. Refer to the illustration 238.

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

12. Remove the setscrews (14) from the cylinder head (15).

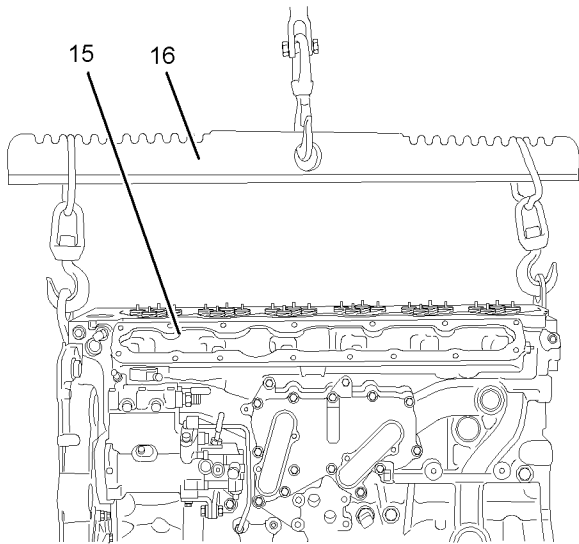


Illustration 239
Typical example
g01175427

13. Attach a suitable lifting device (16) to the 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 the suitable lifting device (16) to carefully lift the 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.

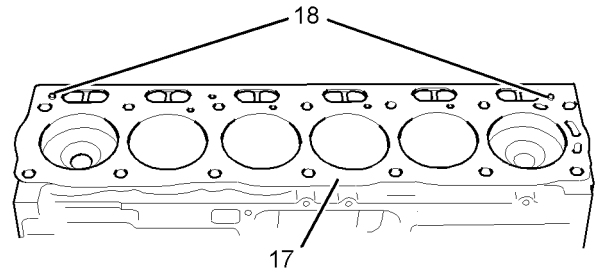


Illustration 240
Typical example
g01175687

15. Remove the cylinder head gasket (17). Discard the cylinder head gasket.

16. Note the position of the dowels (18) in the cylinder block.

17. If necessary, remove the water temperature regulator (1) from the cylinder head (15). Refer to Disassembly and Assembly Manual, "Water Temperature Regulator - Remove and Install".

18. If necessary, remove the inlet manifold (2) from the cylinder head (15). Refer to Disassembly and Assembly Manual, "Inlet manifold - Remove and Install".

i02296683

Cylinder Head - Install

Installation Procedure

Table 54

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 Manual, "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 Manual, "Inlet manifold - Remove and Install".

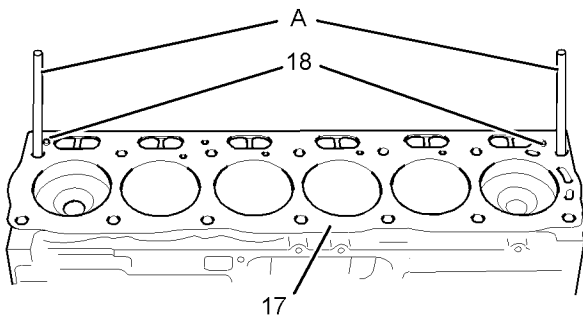


Illustration 241

g01177295

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

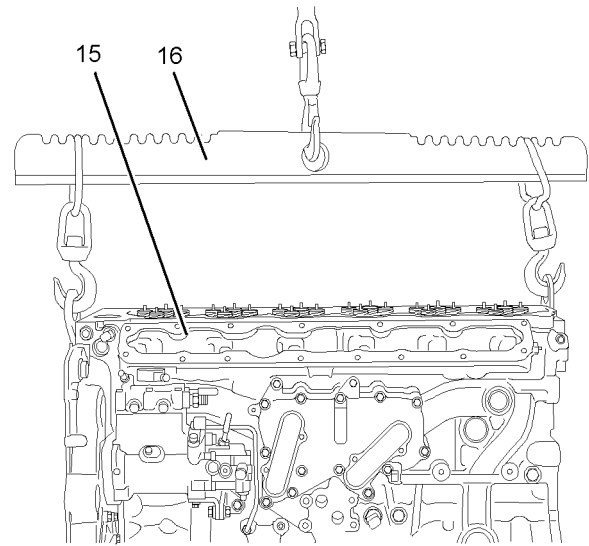


Illustration 242

g01175427

Typical example

7. Use a suitable lifting device (16) to lift the cylinder head (15). 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.

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 the dowels (18).

9. Remove Tooling (A).

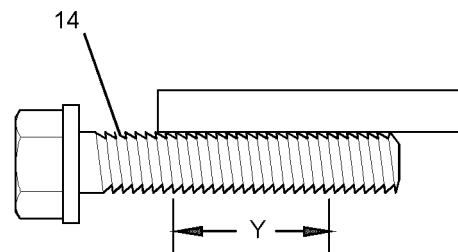


Illustration 243

g01177673

10. Clean the setscrews (14). Follow Steps 10.a and 10.b for the procedure to inspect the setscrews.
 - a. Check the length of the setscrews. Some engines have all setscrews of the same length. Some engines have two longer setscrews.

- b. Use a straight edge to check the threads of the setscrews. Refer to Illustration 243. Replace any setscrews that show visual reduction in the diameter of the thread over length (Y).

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

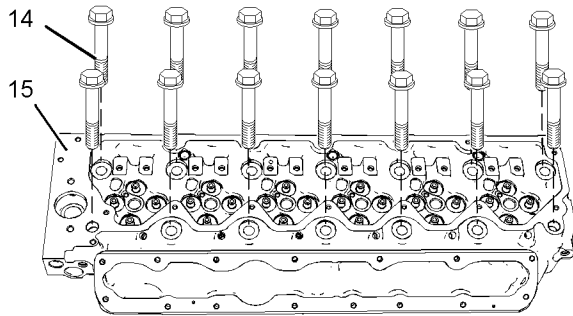


Illustration 244

g01190301

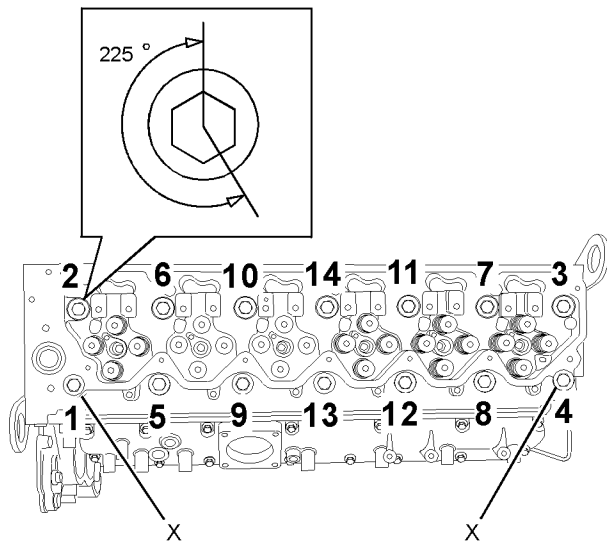


Illustration 245

g01215926

Sequence for tightening the setscrews for the cylinder head

12. Install the setscrews (14) to the cylinder head (16).

Note: If the engine has two longer setscrews, install the longer setscrews in holes (X).

13. Tighten the setscrews to a torque of 50 N·m (37 lb ft) in the numerical sequence. Refer to Illustration 245.

14. Tighten the setscrews to a torque of 100 N·m (74 lb ft) in the numerical sequence. Refer to Illustration 245.

15. Turn the setscrews through an additional 225 degrees in the numerical sequence. Refer to Illustration 245. Use Tooling (B) to achieve the correct final torque.

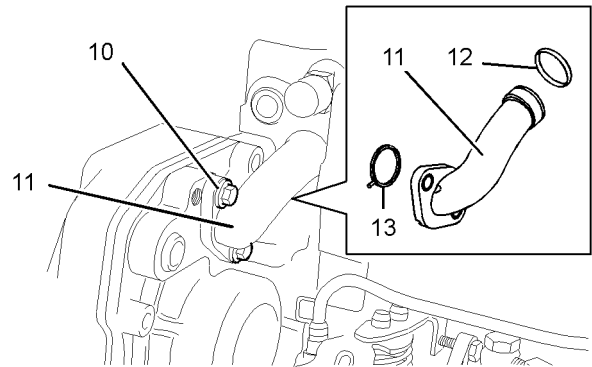


Illustration 246

g01175680

Typical example

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

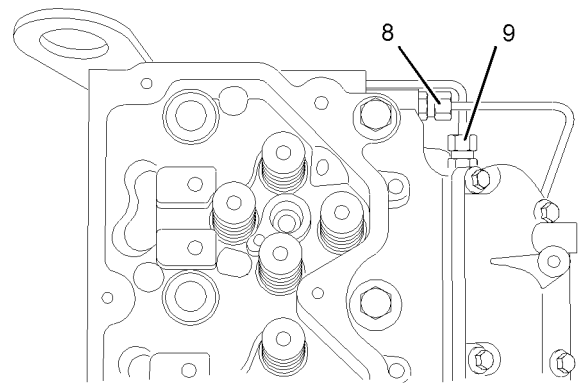


Illustration 247

g01176031

Typical example

17. Remove the plugs and caps from the ports and tube assemblies.

18. Install the tube assembly (8) for the fuel return to the cylinder head and to the transfer pump. Secure the tube clips for the tube assembly (8).

19. If the engine has a wastegate solenoid, install the tube assembly (9) for the wastegate solenoid to the cylinder head. Secure the tube clips for the tube assembly (9).

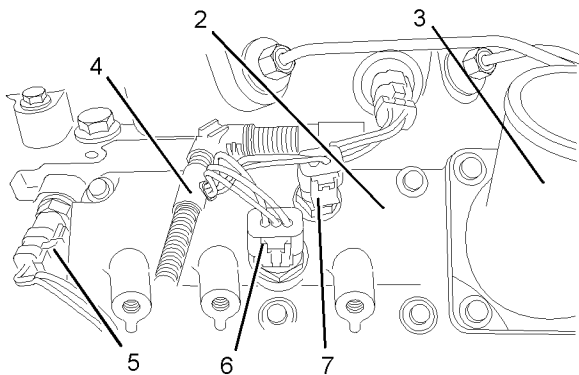


Illustration 248

g01175424

Typical example

20. Follow Steps 20.a and 20.b in order to connect the harness assembly (4) to the inlet air temperature sensor (7).

- a. Connect the harness assembly (4) to the inlet air temperature sensor (7).
- b. Slide the locking tab (not shown) into the locked position.

21. Follow Steps 21.a and 21.b in order to connect the harness assembly (4) to the boost pressure sensor (6).

- a. Connect the harness assembly (4) to the boost pressure sensor (6).
- b. Slide the locking tab (not shown) into the locked position.

22. Follow Steps 22.a and 22.b in order to connect the harness assembly (4) to the coolant temperature sensor (5).

- a. Connect the harness assembly (4) to the coolant temperature sensor (5).
- b. Slide the locking tab (not shown) into the locked position.

23. Use new cable ties 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 (not shown) to the inlet connection (3) on the inlet manifold (2).

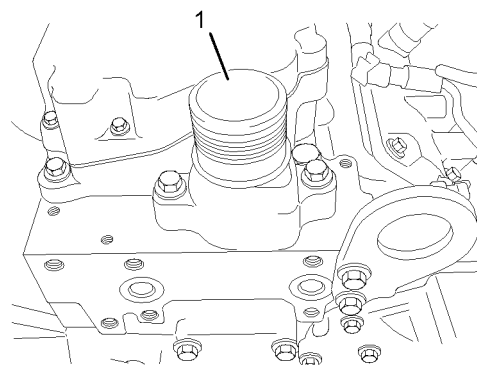


Illustration 249

g01176154

Typical example

25. If necessary, install the water temperature regulator housing (1) to the cylinder head. Refer to Disassembly and Assembly Manual, "Water Temperature Regulator Housing - Remove and Install".

26. Connect the upper radiator hose (not shown) to the 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".

End By:

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

b. Install the valve mechanism cover base. Refer to Disassembly and Assembly Manual, "Valve Mechanism Cover Base - Install".

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

d. Install the electronic control module and the mounting bracket. Refer to Disassembly and Assembly Manual, "Electronic Control Module - Remove and Install".

e. Install the fuel manifold. Refer to Disassembly and Assembly Manual, "Fuel Manifold - Remove and Install".

- f. Install the exhaust manifold. Refer to Disassembly and Assembly, "Exhaust Manifold - Remove and Install".
- g. If necessary, install the fuel filter base and the secondary fuel filter. Refer to Disassembly and Assembly Manual, "Fuel Filter Base - Remove and Install".
- h. If necessary, install the fuel priming pump and the primary fuel filter. Refer to Disassembly and Assembly Manual, "Fuel Priming Pump - Remove and Install".

i02296684

Lifter Group - Remove and Install

Removal Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1
B	-	Telescopic Magnet	1

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Remove".
- b. Remove the camshaft. Refer to Disassembly and Assembly Manual, "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 the appropriate lifters (1).

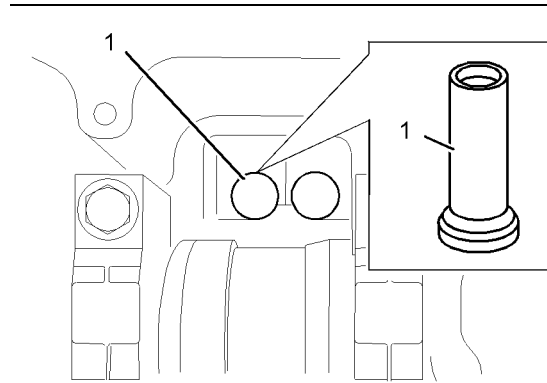


Illustration 250

g01167267

2. Use Tooling (B) in order to remove the 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 56

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	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 Manual, "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 the appropriate lifters (1).
 3. Lubricate the lifters (1) with clean engine oil.

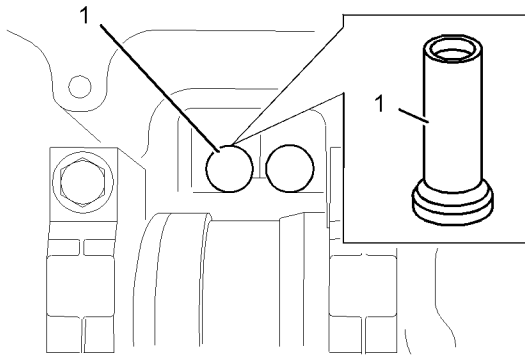


Illustration 251

g01167267

4. Use Tooling (B) to install the 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 Manual, "Camshaft - Remove and Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Install".

i02296685

Camshaft - Remove and Install

Removal Procedure

Start By:

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

- b. Remove the front housing. Refer to Disassembly and Assembly Manual, "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.

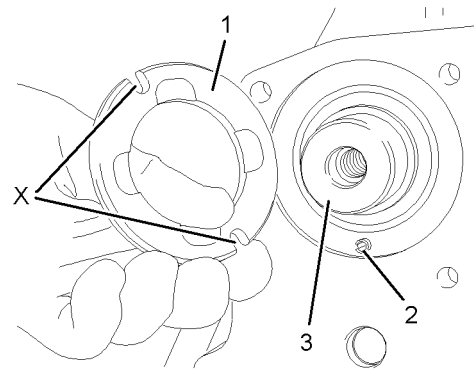


Illustration 252

g01167327

Typical example

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

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

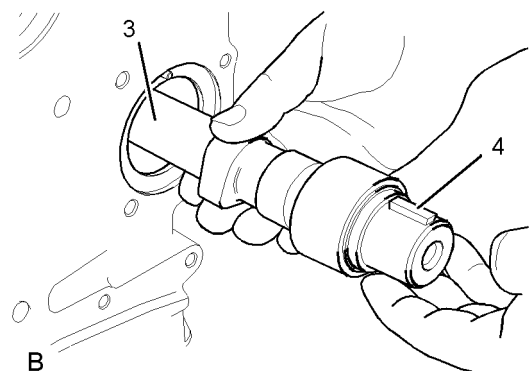


Illustration 253

g01167301

NOTICE

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

3. Carefully remove the camshaft (3) from the cylinder block.

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

NOTICE

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

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

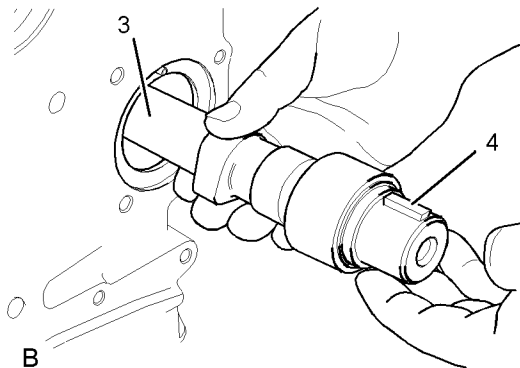


Illustration 254

g01167301

- If necessary, install a new key (4) into the camshaft (3).
- Lubricate the bearing surfaces of the 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.

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

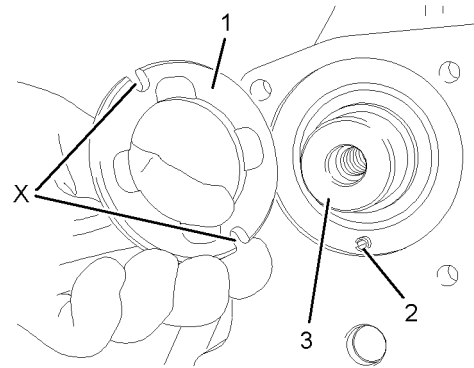


Illustration 255

g01167327

Typical example

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

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

End By:

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

i02296687

Camshaft Gear - Remove and Install

Removal Procedure

Table 57

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

Start By:

- a. Remove the valve mechanism cover. Refer to Disassembly and Assembly Manual, "Valve Mechanism Cover - Remove and Install".
- b. Remove the front cover. Refer to Disassembly and Assembly Manual, "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 Testing and Adjusting Manual, "Finding Top Centre Position for No.1 Piston".

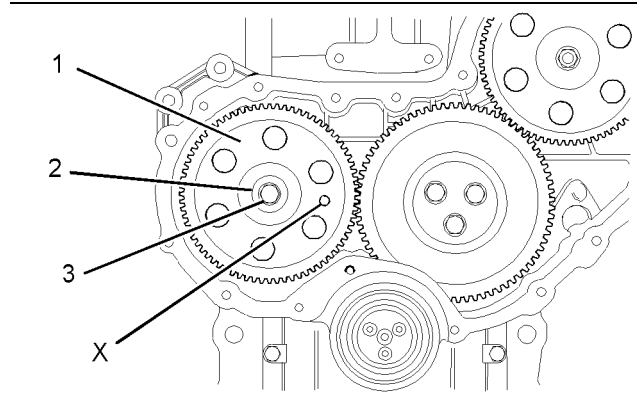


Illustration 256

g01196831

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

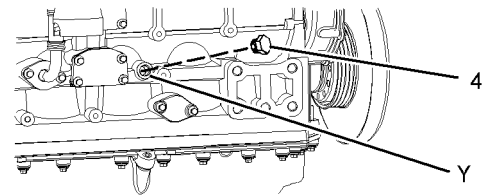


Illustration 257

g01196832

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

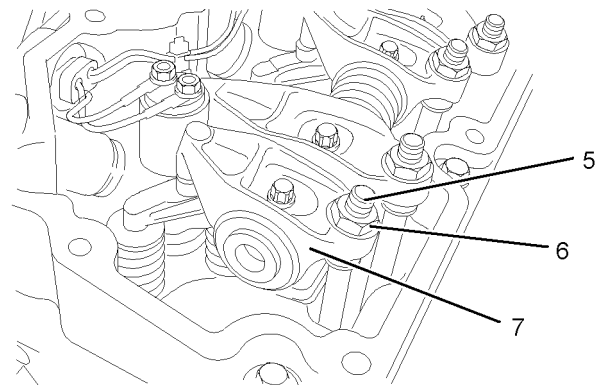


Illustration 258

g01196833

4. Loosen the nuts (6) on all rocker arms (7). Unscrew the 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.

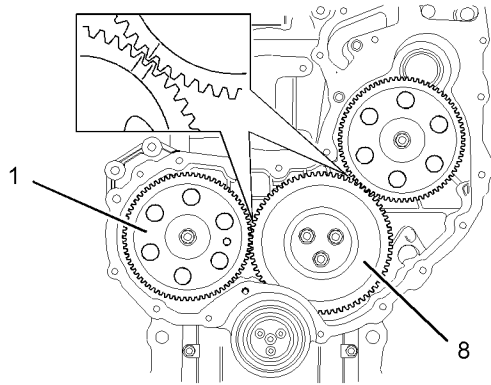


Illustration 259 g01196847
Alignment of timing marks

5. Mark the gears (1) and (8) in order to show alignment. Refer to Illustration 259.

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

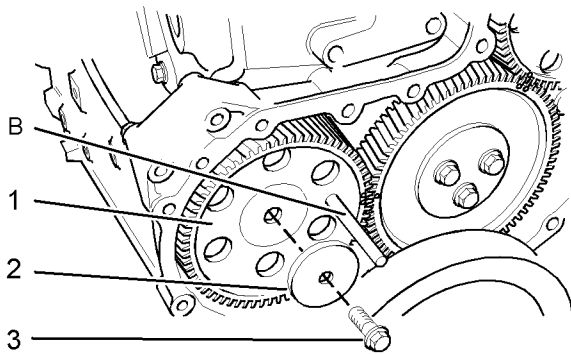


Illustration 260 g01196850

6. Remove Tooling (B). Remove the setscrew (3) and the washer (2) from camshaft gear (1).
7. Remove the 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 (not shown) from the nose of the camshaft.

Installation Procedure

Table 58

Required Tools			
Tool	Part Number	Part Name	Qty
B	27610212	Camshaft Timing Pin	1
C	27610286	Crankshaft Timing Pin	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 the Testing and Adjusting Manual, "Finding Top Center for No. 1 Piston".

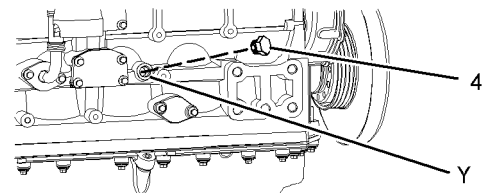


Illustration 261 g01195325

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 Testing and Adjusting Manual, "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.

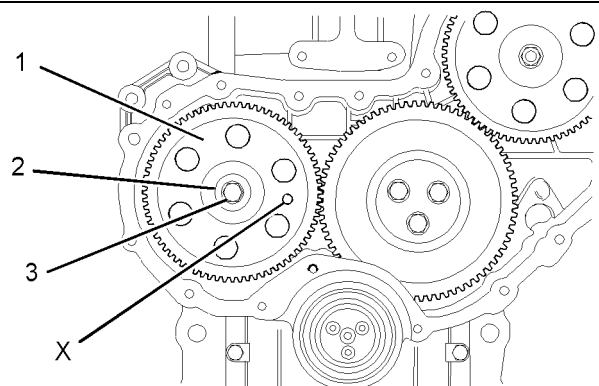


Illustration 262

g01196831

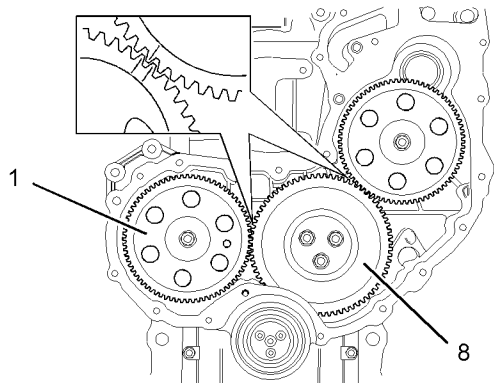


Illustration 263

g01196847

Alignment of timing marks

5. Align the keyway in the 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 263.

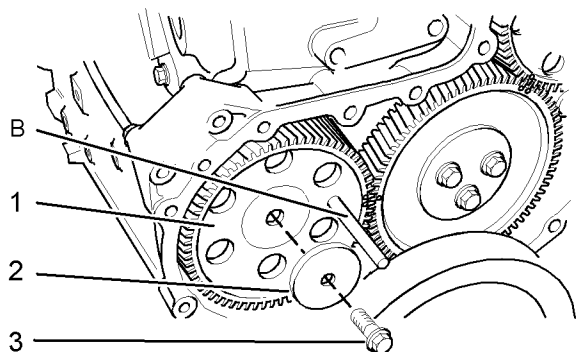


Illustration 264

g01196850

6. Install Tooling (B) through the hole (X) in the camshaft gear into the front housing. Install the washer (2) and the setscrew (3) to the camshaft gear (1).
7. Remove Tooling (B) and (C). Install the plug (4) into hole (Y) in the cylinder block. Refer to Illustration 261.
8. Tighten the setscrew (3) to a torque of 95 N-m (70 lb ft).

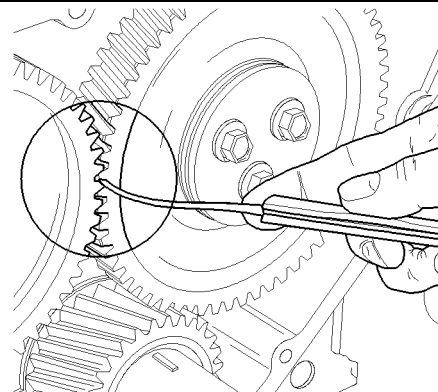


Illustration 265

g00944084

Checking backlash

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

End By:

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

i02296689

Camshaft Bearings - Remove and Install

Removal Procedure

Table 59

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 Manual, "Engine Oil Pump - Remove".
- b. Remove the camshaft. Refer to Disassembly and Assembly Manual, "Camshaft - Remove and Install".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

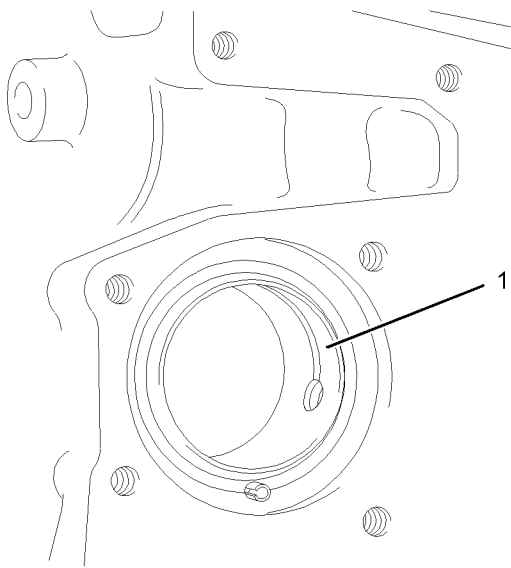


Illustration 266

g01178163

1. Inspect the camshaft bearing (1). Refer to Specifications Manual, "Camshaft Bearings" for more information.
2. If the 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.

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

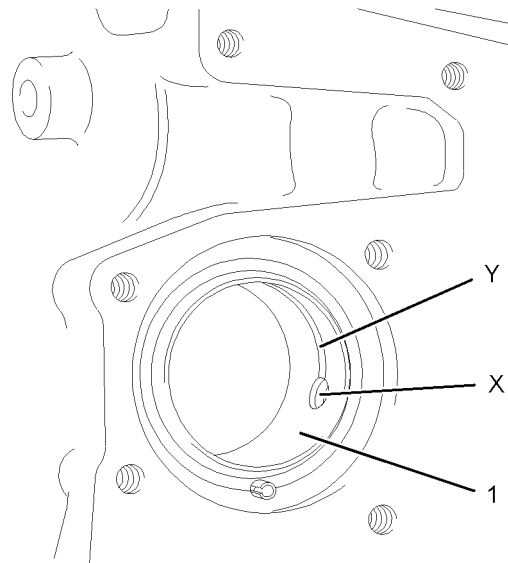


Illustration 267

g01167595

2. Lubricate the bearing housing in the cylinder block with clean engine oil.
 3. Accurately align the 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 the 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 Manual, "Camshaft - Remove and Install".

i02296799

Engine Oil Pan - Remove

Removal Procedure (Aluminum Oil Pan)

Table 60

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

Start By:

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

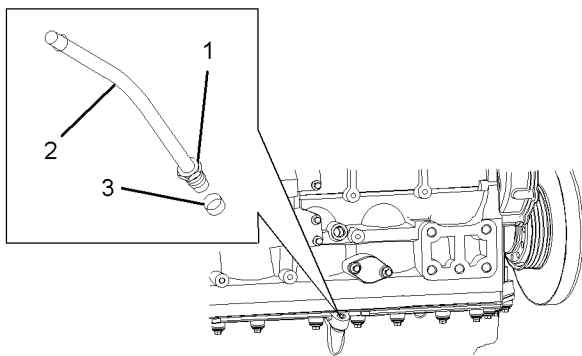


Illustration 268
Typical example

g01212465

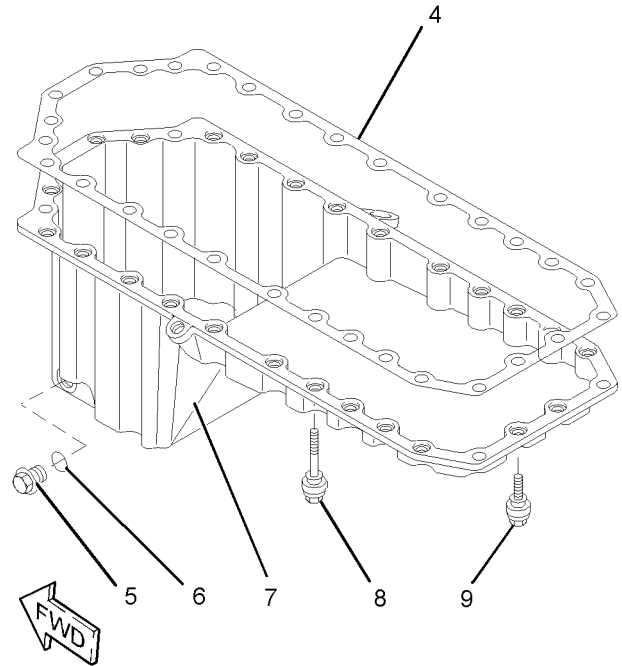


Illustration 269

g01176667

Typical example

1. Place a suitable container below the engine oil pan (7). Remove the drain plug (5) and drain the engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.

Note: Clean up any spillage of oil immediately.

2. Remove the O-ring seal (6) from the drain plug (5). Discard the O-ring seal.
3. Disconnect the breather hose (not shown) from the clip that secures the hose to the engine oil pan. Position the breather hose away from the engine oil pan.
4. If necessary, remove the assembly of dipstick tube. Loosen the nut (1) and remove the tube assembly (2). Remove the seal (3) from the tube assembly. Discard the seal.

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

5. 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 the breather hose (not shown). Remove the clip.

Note: The isolating screws are held captive by the joint (1).

6. Remove the assembly of the engine oil pan from the engine.
7. Remove the isolating screws (8) and (9) from the engine oil pan (7). Remove the joint (4) from the engine oil pan (7). Discard the joint.

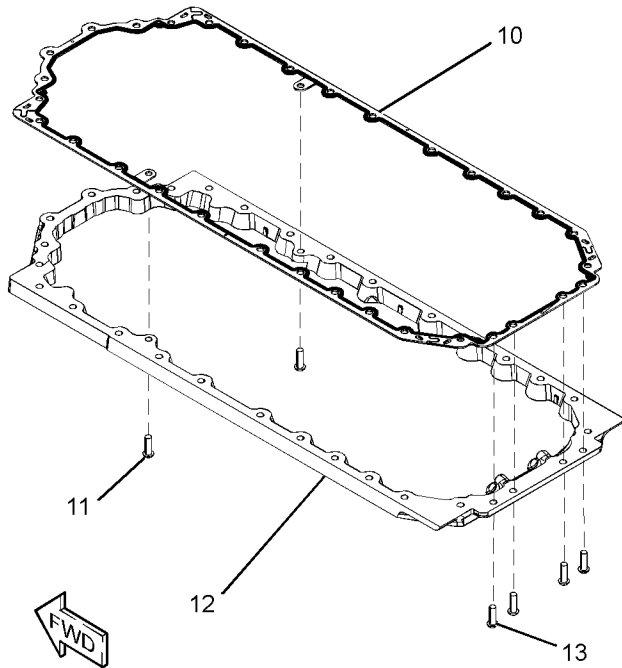


Illustration 270

g01176954

8. If necessary, follow Steps 8.a through 8.c in order to remove the isolating frame from the cylinder block.
 - a. Support the isolating frame (12). Use Tooling (A) to remove the torx screws (11) and (13).
 - b. Remove the isolating frame (12) from the cylinder block.
 - c. Remove the joint (10). Discard the joint.

Removal Procedure (Cast Iron Oil Pan)

Table 61

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. Refer to OEM information for the correct procedure. 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 (not shown) from the clip that secures the hose to the engine oil pan. Position the breather hose away from the engine oil pan.

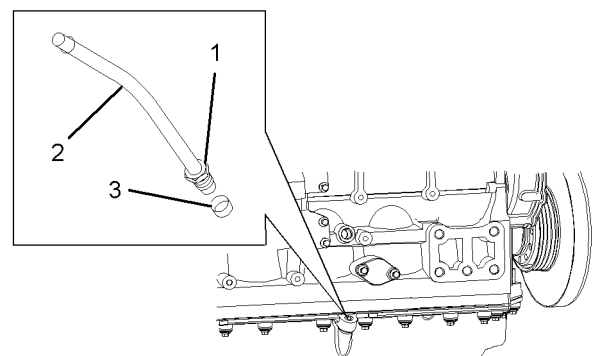


Illustration 271

g01212465

Typical example

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

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

Engine Oil Pan - Install

Installation Procedure (Aluminum Oil Pan)

Table 62

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	-
D	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.

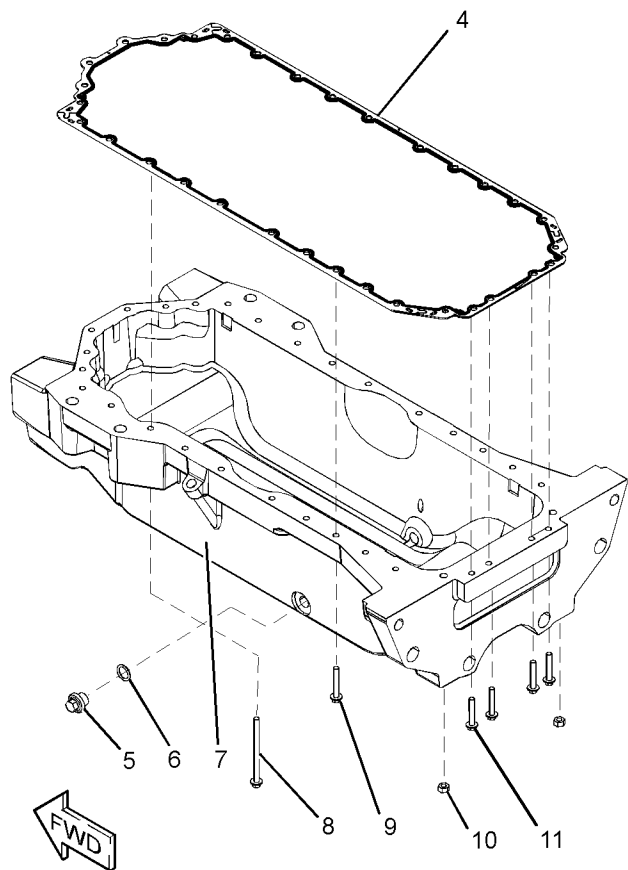


Illustration 272

g01178884

Typical example

4. Attach a suitable lifting device to the 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 the nuts (10). Remove the setscrews (8) and (9).
- Note:** The setscrews are different lengths. Note the position of the different setscrews.
7. Use the lifting device to remove the engine oil pan (7) from the cylinder block.
 8. Remove the joint (4) from the cylinder block. Discard the joint.
 9. Remove the drain plug (5).
 10. Remove the O-ring seal (6) from the oil drain plug (5). Discard the O-ring seal.

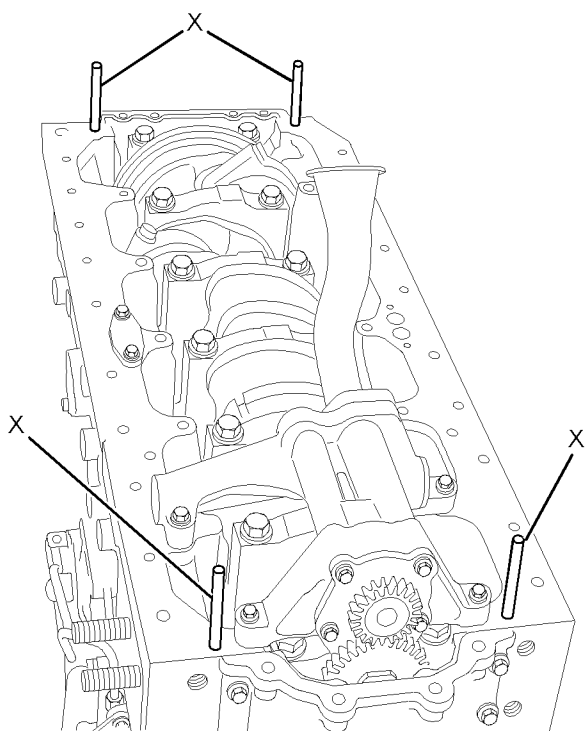


Illustration 273

g01215700

1. Install Tooling (B) to positions (X) in the cylinder block.
2. If necessary, 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.

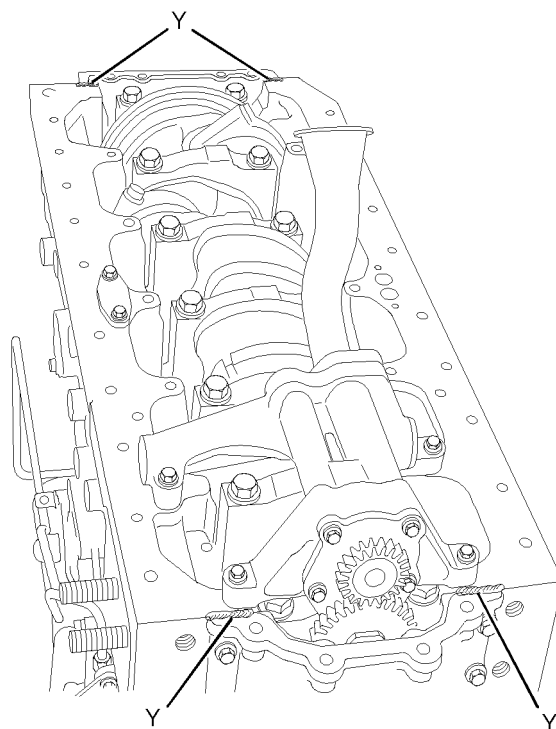


Illustration 274

g01215533

Tooling (B) is not shown for clarity.

- c. Apply a bead of Tooling (C) to positions (Y).

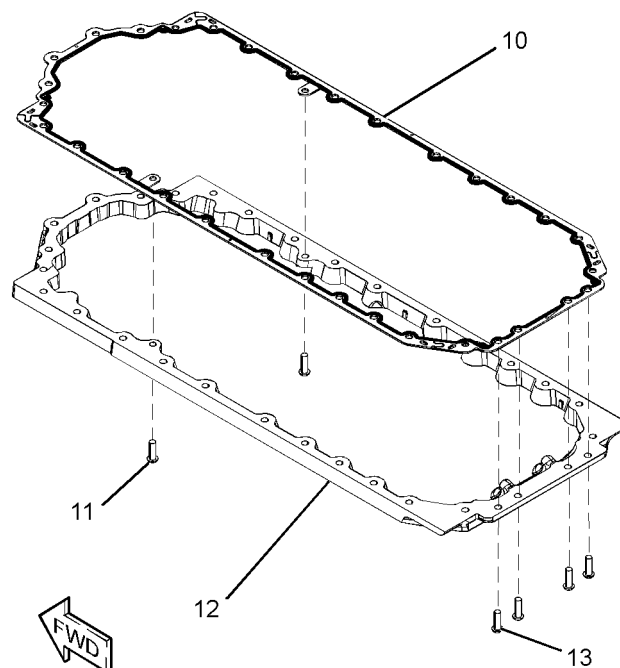


Illustration 275

g01176954

- d. Position a new joint (10) onto the isolating frame (12).
 - e. Align the isolating frame (10) with Tooling (B). Install the isolating frame to the cylinder block.
 - f. Use Tooling (A) to install the two torx screws (11) and the four torx screws (13) to the isolating frame. Tighten the torx screws (11) to a torque of 22 N·m (16 lb ft). Tighten the torx screws (13) to a torque of 22 N·m (16 lb ft).
6. Align the assembly of the engine oil pan with Tooling (B). Install the assembly of the engine oil pan to the isolating frame (12). Install the clip that secures the breather hose (not shown) in the correct position.

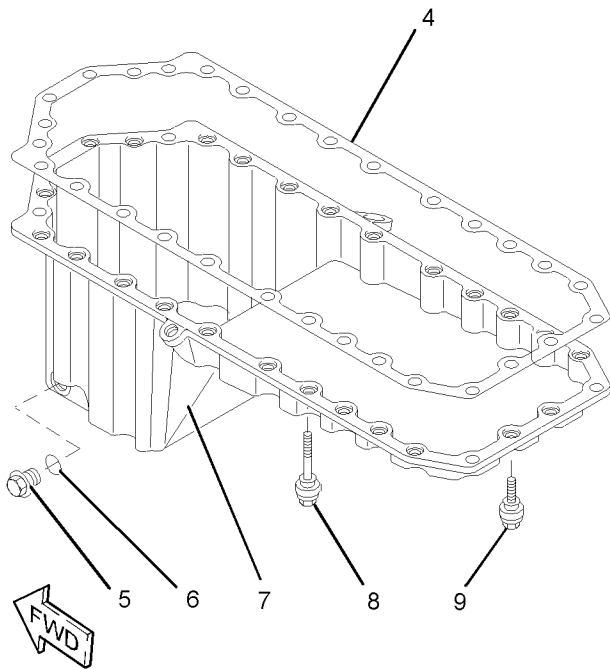


Illustration 276

g01176667

3. 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 joint face 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.

4. Position a new joint (4) onto the engine oil pan (7).
5. 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 273.

Note: The isolating screws are held captive by the joint.

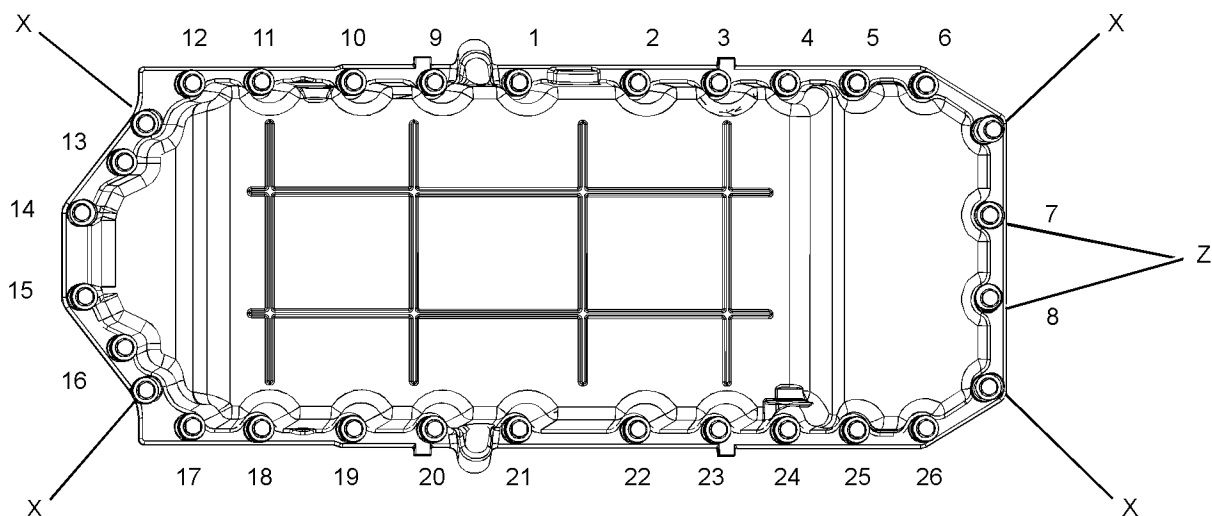


Illustration 277

g01215571

(X) Position of guide studs.

(Z) Position of short isolating screws.

7. 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 277.

8. Remove Tooling (B).

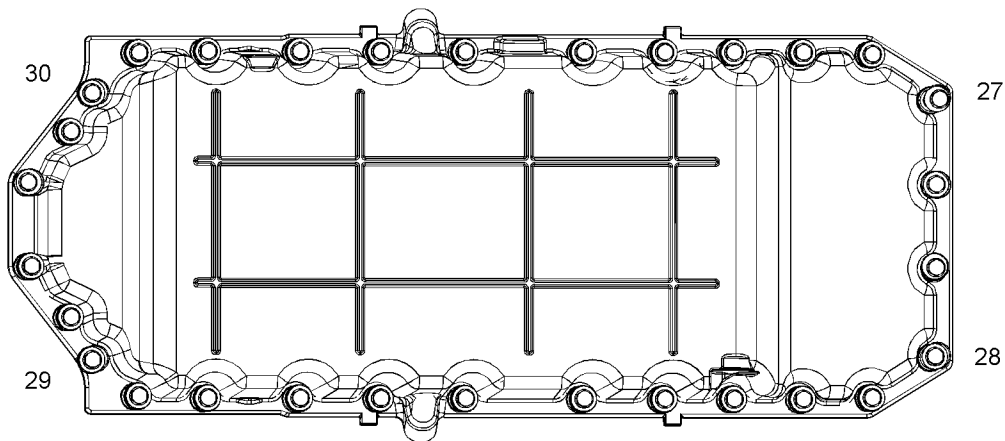


Illustration 278

g01184167

9. 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 278.

10. 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 276. Tighten the oil drain plug to a torque of 34 N·m (25 lb ft).

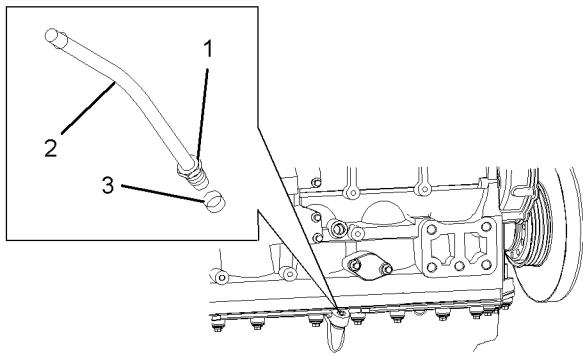


Illustration 279 g01212465

Typical example

11. If necessary, follow Steps 11.a through 11.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 (D) 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).

12. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, "Oil Filter Change" for the procedure.

End By:

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

Installation Procedure (Cast Iron Oil Pan)

Table 63

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.

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 (not show) for damage. If necessary, replace the studs.
2. Ensure that the engine oil pan is clean and free from damage.

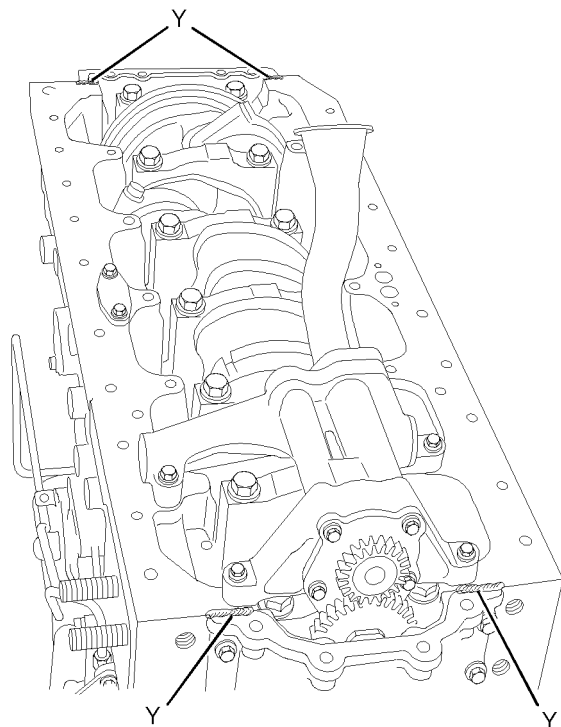


Illustration 280

g01215533

Typical example

3. Apply a bead of Tooling (C) to positions (Y).

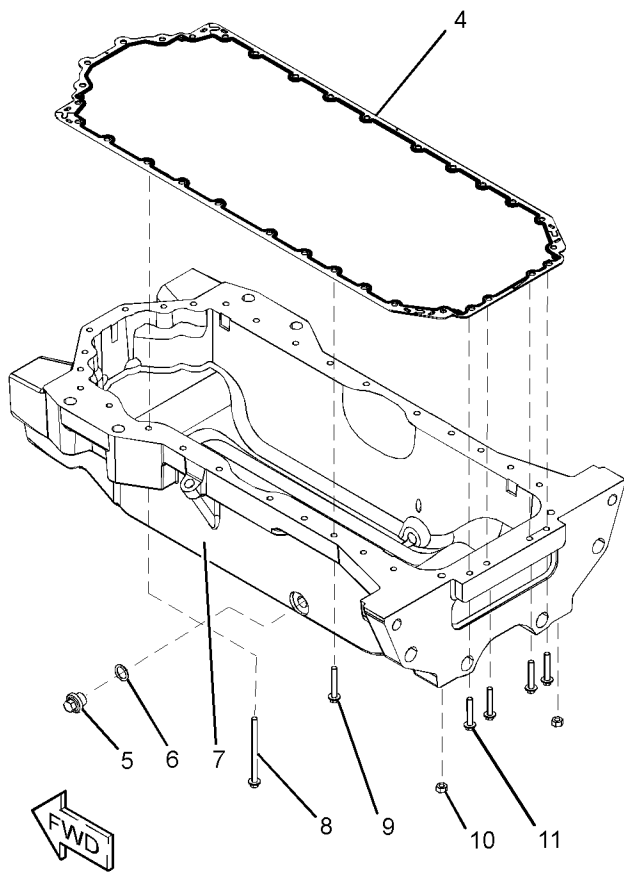


Illustration 281

g01178884

4. Align a new joint (4) with the studs (not shown) 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 (not shown). Install the engine oil pan to the cylinder block.
7. Install the setscrews (8) and (9), the 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.

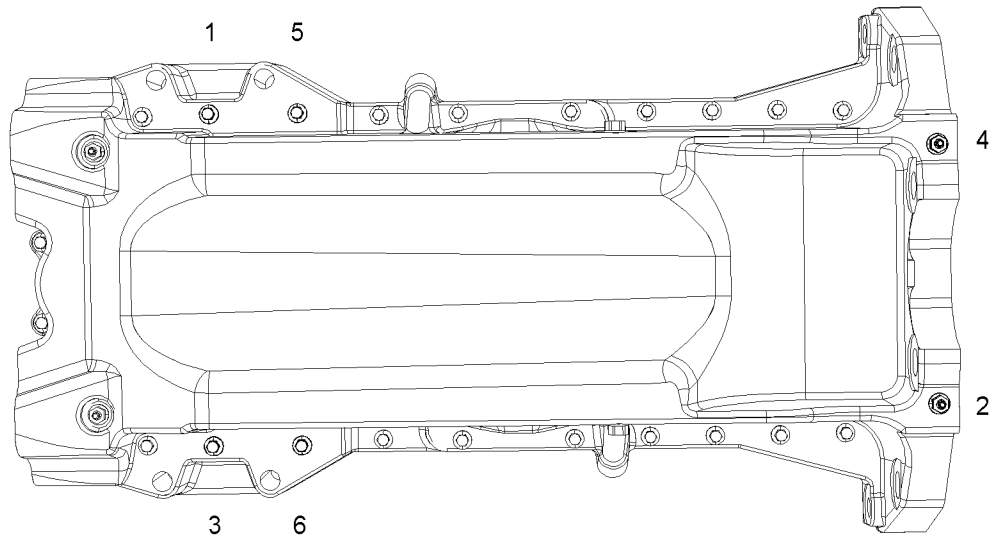


Illustration 282

g01212463

9. Tighten the setscrews (8) and the nuts (10) to a torque of 22 N·m (16 lb ft). Tighten the fasteners in the sequence that is shown in Illustration 282.

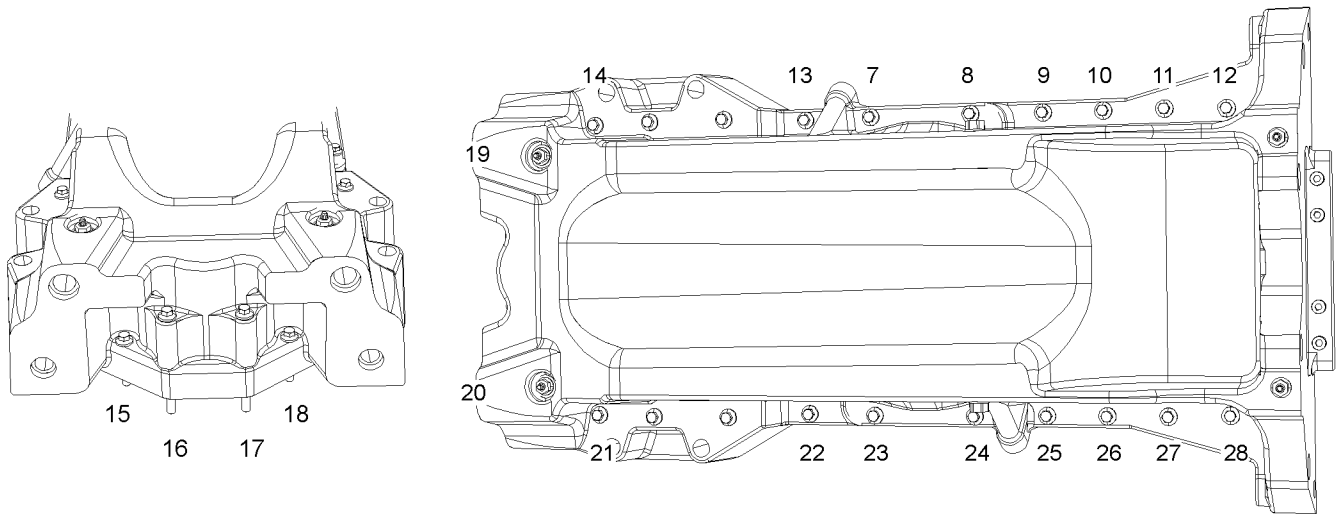


Illustration 283

g01212464

10. Tighten the remaining setscrews to a torque of 22 N·m (16 lb ft). Tighten the setscrews in the sequence that is shown in Illustration 283.
11. Use Tooling (A) to tighten the torx screws to a torque of 22 N·m (16 lb ft). Refer to Illustration 281.
12. Install a new O-ring seal (6) to the drain plug (5). Install the drain plug (5) to the engine oil pan (7). Tighten the drain plug to a torque of 34 N·m (25 lb ft).

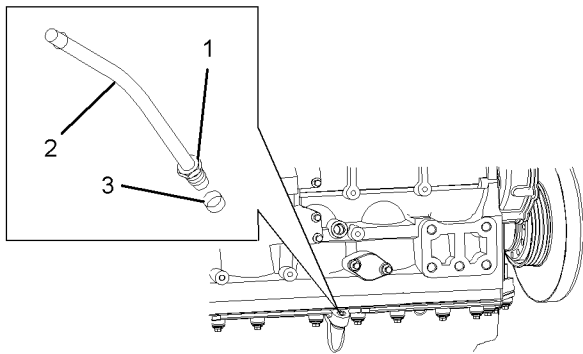


Illustration 284
Typical example

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 the tube assembly (2).
- b. Apply Tooling (D) 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 to a torque of 18 N·m (13 lb ft). Install the dipstick (not shown).

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.

i02296690

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual , “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.

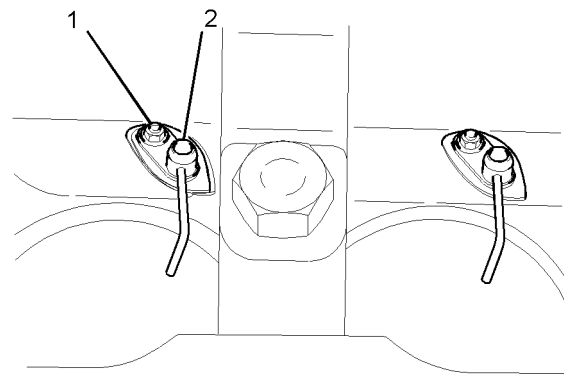


Illustration 285

- 2. Remove the setscrew (1) and the piston cooling jet (2) from the cylinder block.
- 3. Repeat steps 1 and 2 for the remaining piston cooling jets.

Installation Procedure

Table 65

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	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.

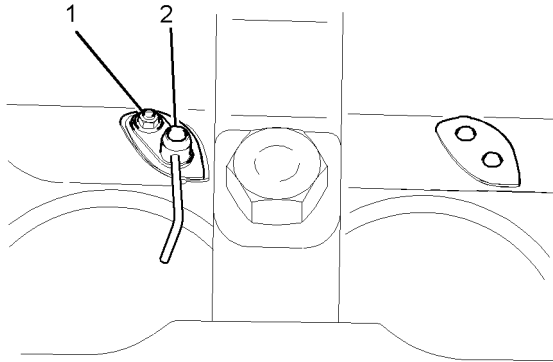


Illustration 286

g01152132

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 Manual, "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 the piston cooling jet (2) in the cylinder block. Install the setscrew (1). Tighten the setscrew (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 Manual, "Engine Oil Pump - Install".

Pistons and Connecting Rods - Remove

Removal Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1
B	27610274	Ridge Reamer	1

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly Manual, "Cylinder Head - Remove".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Remove".
- c. Remove the piston cooling jets. Refer to Disassembly and Assembly Manual, "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.

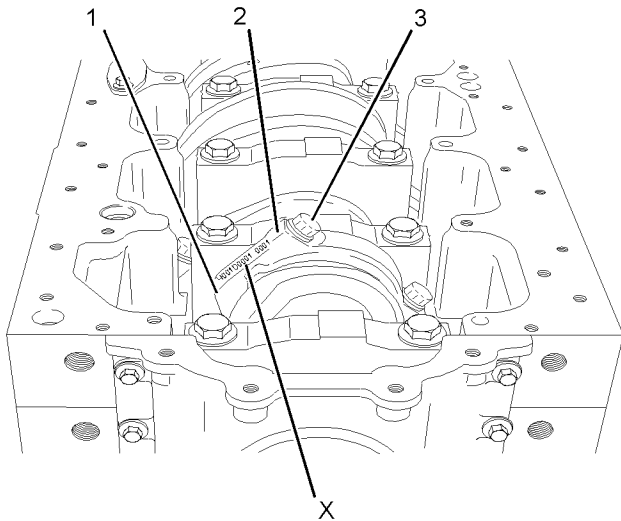


Illustration 287

g01154161

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 the connecting rod (1) and the 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 the two setscrews (3) and the connecting rod cap (2) from the connecting rod (1).

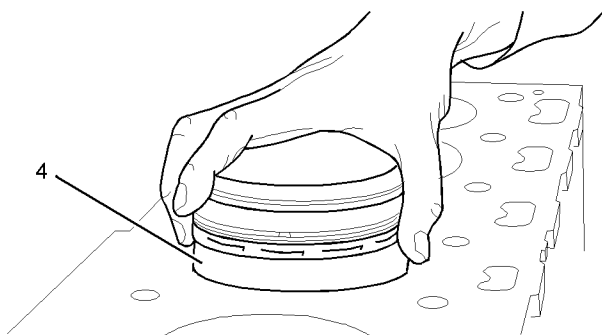


Illustration 288

g01154509

5. Carefully push the piston (4) and the connecting rod out of the cylinder bore. Lift the 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 the connecting rod cap (2) and the setscrews (3) to the 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 the setscrews (3) to a torque of 20 N·m (14 lb ft).

i02296694

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 67

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 Manual, "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.

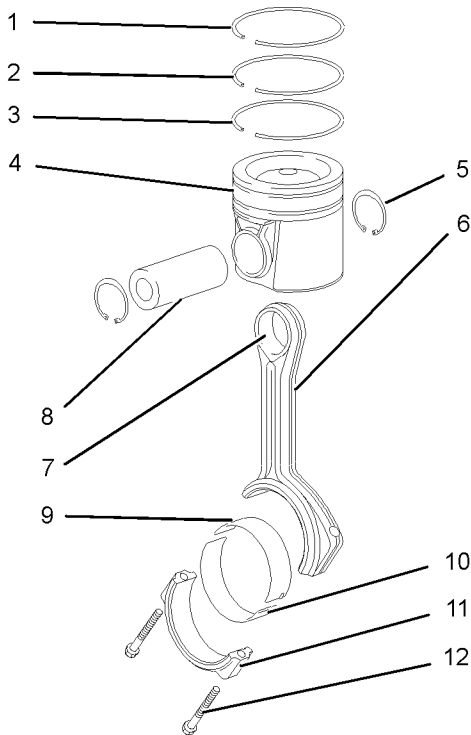


Illustration 289

g01154810

1. Remove the two setscrews (12) and the connecting rod cap (11) from the connecting rod (6). Discard the setscrews.

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 Manual, "Piston and Connecting Rods - Assemble" and Disassembly and Assembly Manual, "Piston and Connecting Rods - Install".

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

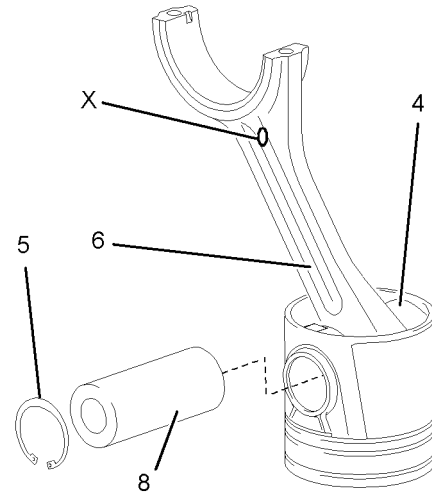


Illustration 290

g01162291

3. Place the piston and connecting rod assembly on a suitable surface with the connecting rod upward. Use Tooling (A) in order to remove the 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 the piston pin (8) and the connecting rod (6) from the 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 the connecting rod (6) and the piston (4).

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

Note: Identify the position and orientation of the compression rings (1) and (2), and the 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 the connecting rod (6) or replace the bush for the piston pin (7).

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 Manual, "Connecting Rods".

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

i02296695

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 68

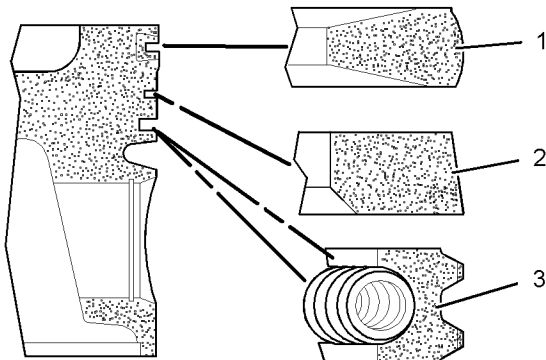
Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Circlip Pliers	1
B	-	Piston Ring Expander	1

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 the oil control ring (3) into the oil ring groove in the piston (4). The central wire must be located inside the end of the spring.



- b. Use Tooling (B) to install the 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 the intermediate compression ring (2) into the second groove in the piston (4). The word "TOP" must be upward. The chamfer on the inner face must be downward.
- d. Use Tooling (B) to install the top compression ring (1) into the top groove in the 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 the connecting rod assembly (6), (7), (11) and (12) or the bush for the piston pin (7) is replaced, ensure that the height grade of the connecting rod is correct. Refer to Specifications Manual, "Connecting Rods" for further information.

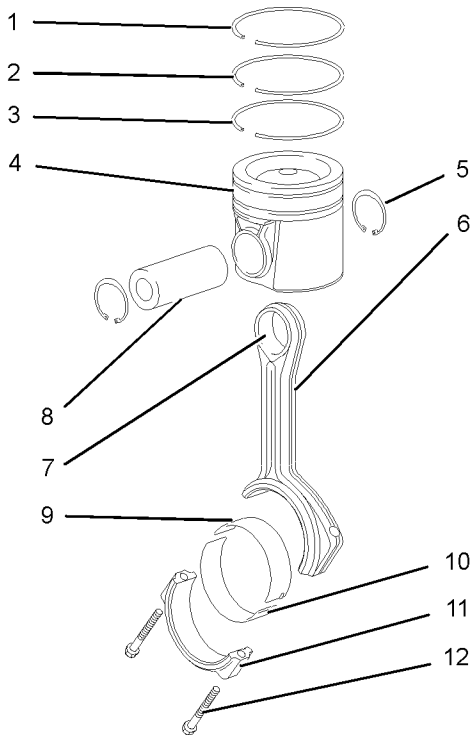


Illustration 292

g01154810

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

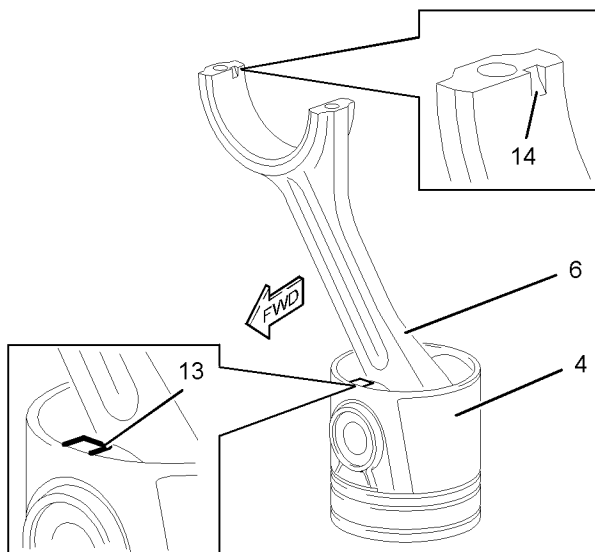


Illustration 293

g01154811

5. Place the piston on a suitable surface with the crown downward. Install the connecting rod (6) and the piston pin (8) to the piston (4). Ensure that the square (13) on the piston, and the slot (14) on the connecting rod are in the correct position. See illustration 293.

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 the circlips (5) to the piston pin bore in the piston (4).

Note: Ensure that the circlips are seated in the grooves in the piston.

7. Install the upper bearing shell (9) into the 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 the lower bearing shell (10) into the 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 Manual, "Piston and Connecting Rods - Install".

End By:

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

i02296696

Pistons and Connecting Rods - Install

Installation Procedure

Table 69

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	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 Manual, "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.

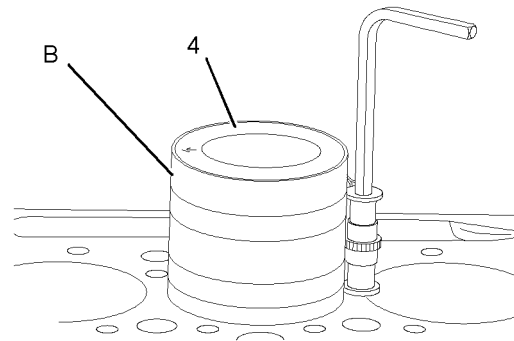


Illustration 294

g01154542

4. Install Tooling (B) onto the piston (4).

Note: Ensure that Tooling (B) is installed correctly and that the 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.

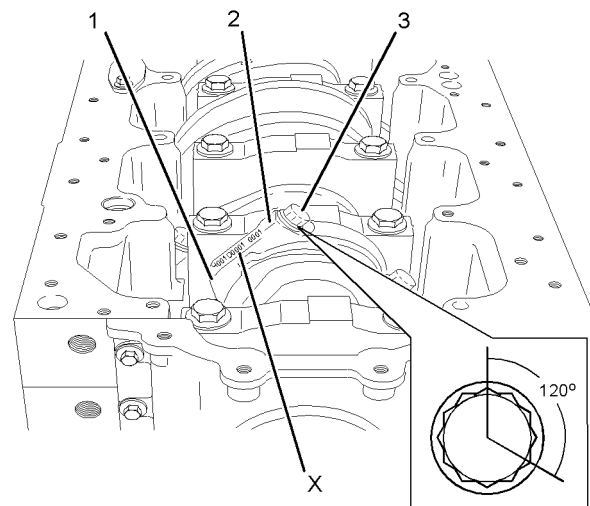


Illustration 295

g01158589

6. Install the connecting rod cap (2) onto the connecting rod (1).

Note: Ensure that the etched number (X) on connecting rod cap (2) matches the etched number (X) on connecting rod (1). Ensure the correct orientation of the 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 two new setscrews (3) to the connecting rod (1). Tighten the setscrews evenly to a torque of 18 N·m (13 lb ft).

Note: Do not reuse the old setscrews in order to secure the connecting rod cap.

8. Tighten the setscrews evenly to a torque of 70 N·m (52 lb ft).

9. Turn the setscrews 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 Testing and Adjusting Manual, "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".

Connecting Rod Bearings - Remove (Connecting rods in position)

Removal Procedure

Table 70

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, "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.

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

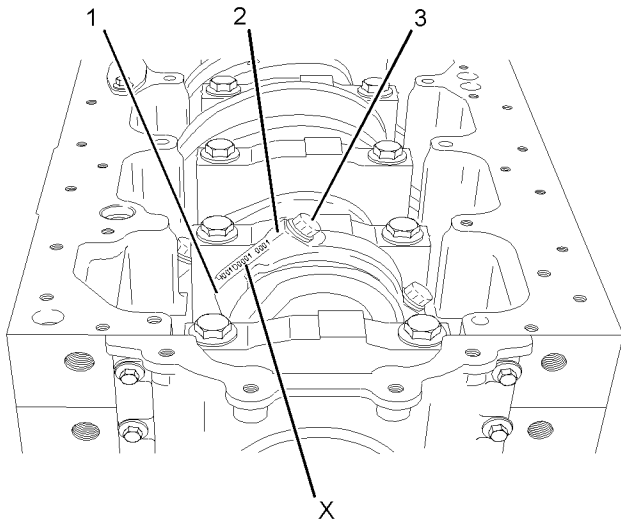


Illustration 296

g01154161

i02296698

- Carefully push the connecting rod (5) into the cylinder bore until the connecting rod (5) is clear of the crankshaft. Remove the 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.

- 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 Manual, "Connecting Rod Bearings - Install".

Connecting Rod Bearings - Install (Connecting rods in position)

Installation Procedure

Table 71

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	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.

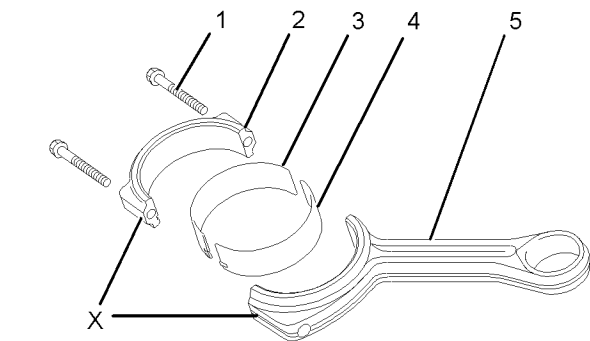


Illustration 297

g01153570

- 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 the connecting rod (5) and the 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.

- Remove the two setscrews (1) and the connecting rod cap (2) from the connecting rod (5). Discard the setscrews (1).
- Remove the lower bearing shell (3) from the connecting rod cap (2). Keep the bearing shell and the connecting rod cap together.

1. Inspect the pins of the crankshaft for damage. If the crankshaft is damaged, replace the crankshaft. Refer to Disassembly and Assembly Manual, "Crankshaft - Remove" and Disassembly and Assembly Manual, "Crankshaft - Install". Ensure that the bearing shells are clean and free from wear or damage. If necessary, replace the bearing shells.

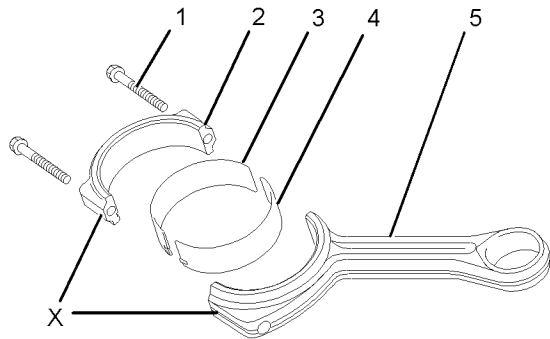


Illustration 298

g01153570

2. Install the upper bearing shell (4) into the 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 the 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 the 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 the lower bearing shell (3) into the 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 the lower bearing shell (3) with clean engine oil.

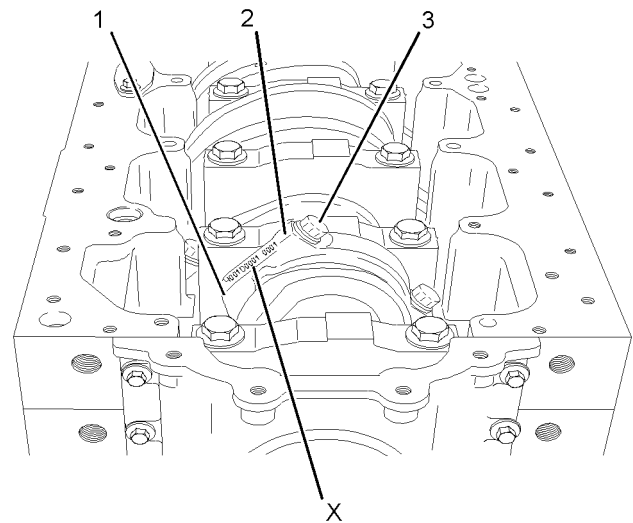


Illustration 299

g01154161

8. Install the connecting rod cap (2) to the connecting rod (5).

Note: Ensure that the etched number (X) on connecting rod cap (2) matches the 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 two new setscrews (1) to the connecting rod. Tighten the setscrews evenly to a torque of 18 N·m (13 lb ft).

Note: Do not reuse the old setscrews in order to secure the connecting rod cap.

10. Tighten the setscrews evenly to a torque of 70 N·m (52 lb ft).

11. Turn the setscrews 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.

End By:

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

i02296801

Crankshaft Main Bearings - Remove and Install (Crankshaft in position)

Removal Procedure

Table 72

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825576	Crankshaft Turning Tool	1
A	27610289	Crankshaft Turning Tool	1
	27610290	Gear	1

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Remove".
- b. Remove the crankshaft rear seal. Refer to Disassembly and Assembly Manual, "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.

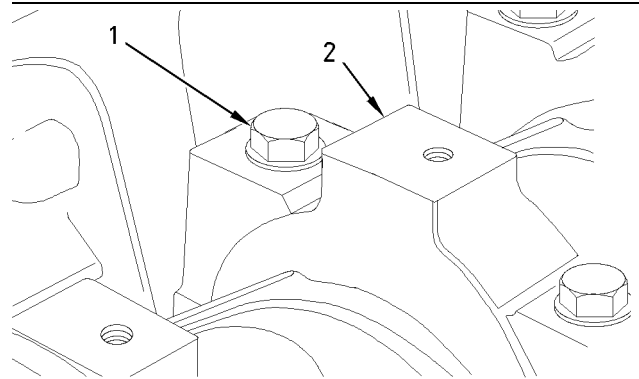


Illustration 300

g00947823

2. Remove the two setscrews (1) and the main bearing cap (2) from the cylinder block.

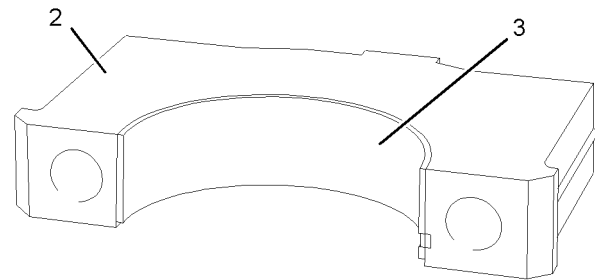


Illustration 301

g01152971

3. Remove the lower main bearing shell (3) from the 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.

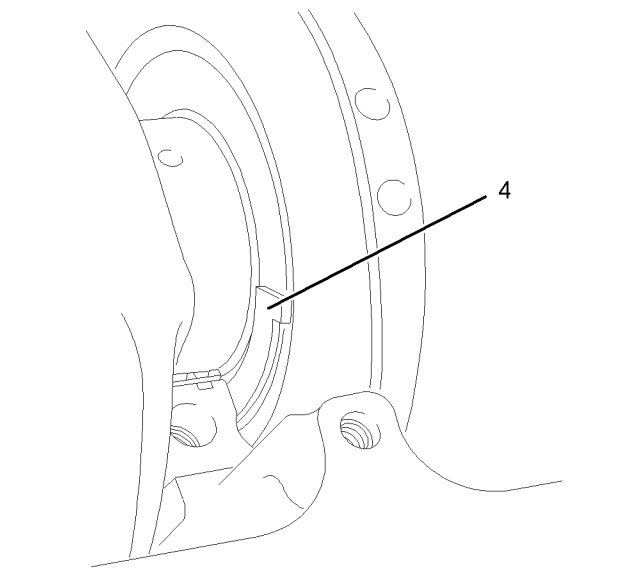


Illustration 302

g01152973

4. For number six main bearing, remove the two thrust washers (4) from the cylinder block. In order to remove the 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.

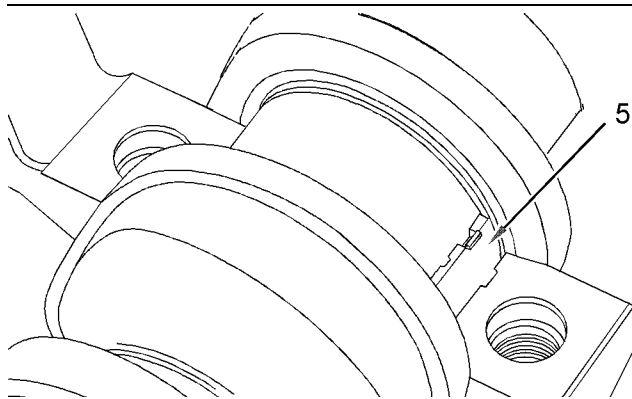


Illustration 303

g01151373

5. Push out the 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 the 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 73

Required Tools			
Tool	Part Number	Part Description	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.

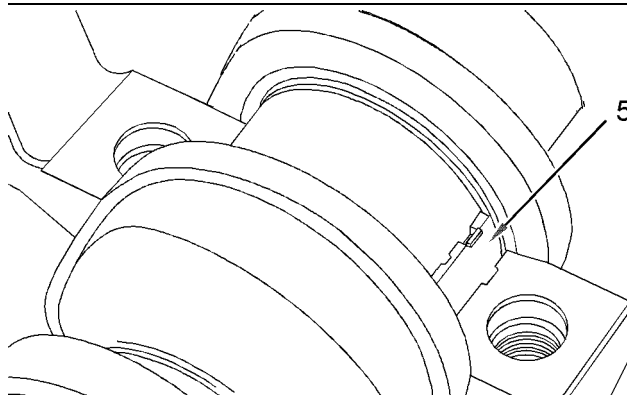


Illustration 304

g01151373

3. Lubricate the crankshaft journal and the upper main bearing shell (5) with clean engine oil. Slide the 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.

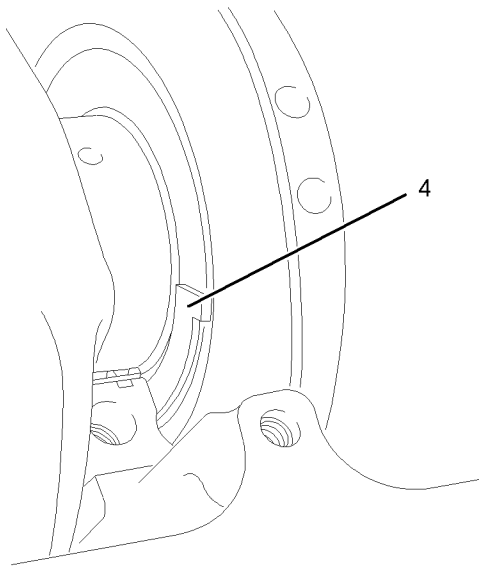


Illustration 305

g01152973

4. For number six main bearing, ensure that the two thrust washers (4) are clean and free from wear or damage. If necessary, replace the thrust washers. Lubricate the thrust washers (4) with clean engine oil. Slide the thrust washers (4) into position between the crankshaft and the cylinder block. Ensure that the locating tab is correctly seated in the cylinder block.

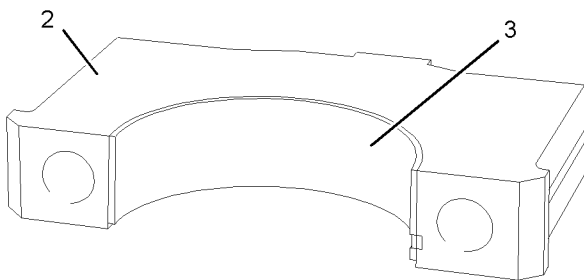


Illustration 306

g01152971

5. Install the lower main bearing shell (3) into the 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.

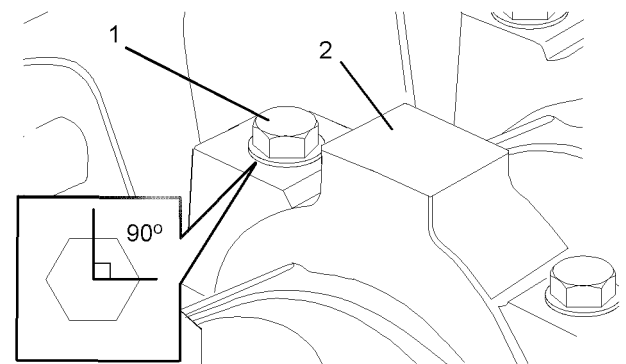


Illustration 307

g01158224

6. Lubricate the crankshaft journal and the lower main bearing shell with clean engine oil. Install the 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 the setscrews (1) with clean engine oil. Lubricate the underside of the heads of the setscrews (1) with clean engine oil.
8. Install the setscrews (1) to the main bearing cap (2). Evenly tighten the setscrews in order to pull the 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 the setscrews (1) to a torque of 80 N·m (59 lb ft).

Turn the setscrews (1) through an additional 90 degrees. Use Tooling B to achieve the correct final torque.

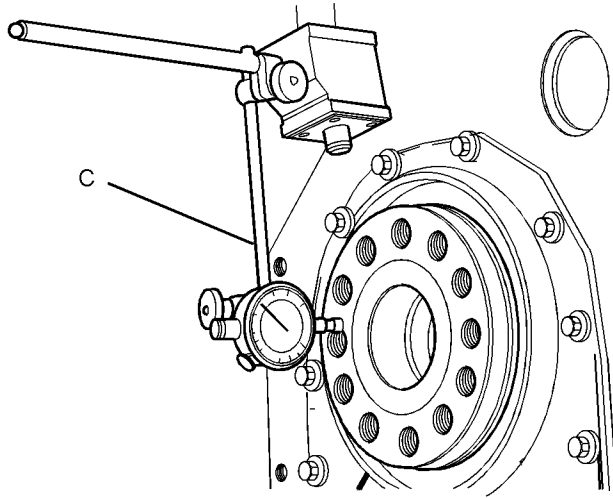


Illustration 308
Typical example
g01151432

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 0.17 mm (0.007 inch) to 0.41 mm (0.016 inch).

End By:

- a. Install the crankshaft rear seal. Refer to Disassembly and Assembly Manual, “Crankshaft Rear Seal - Install”.
- b. Install the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Install”.

i02296700

Crankshaft - Remove

Removal Procedure

Start By:

- a. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, “Engine Oil Pump - Remove”.
- b. Remove the front housing. Refer to Disassembly and Assembly Manual, “Housing (Front) - Remove”.

- c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly Manual, “Crankshaft Rear Seal - Remove”.
- d. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly Manual, “Rocker Shaft and Pushrod - Remove”.
- e. If necessary, remove the cylinder head. Refer to Disassembly and Assembly Manual, “Cylinder Head - Remove”.
- f. If necessary, remove the pistons and connecting rods. Refer to Disassembly and Assembly Manual, “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 Manual, “Connecting Rod Bearings - Remove”.
- 3. Ensure that the main bearing caps are marked for the location and orientation.

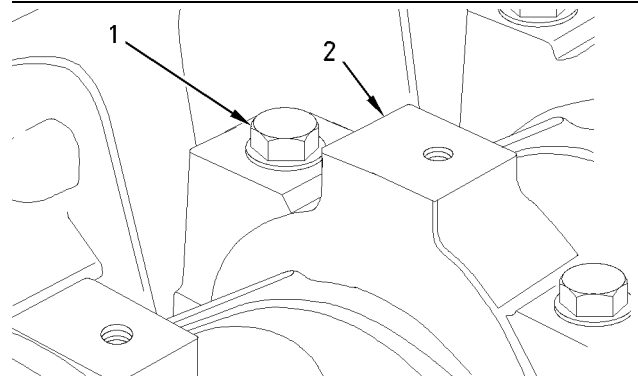


Illustration 309
g00947823

- 4. Remove the setscrews (1) and the main bearing caps (2) from the cylinder block.

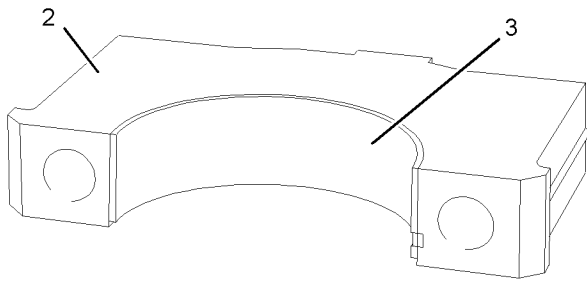


Illustration 310

g01152971

5. Remove the lower main bearing shells (3) from the 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.

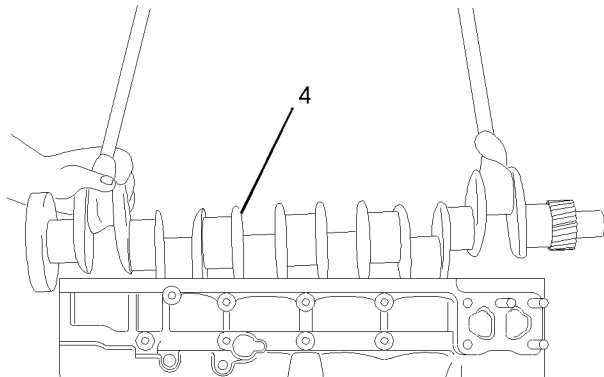


Illustration 311

g01162288

6. Attach lifting straps and a suitable lifting device to the crankshaft (4). Lift the 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.

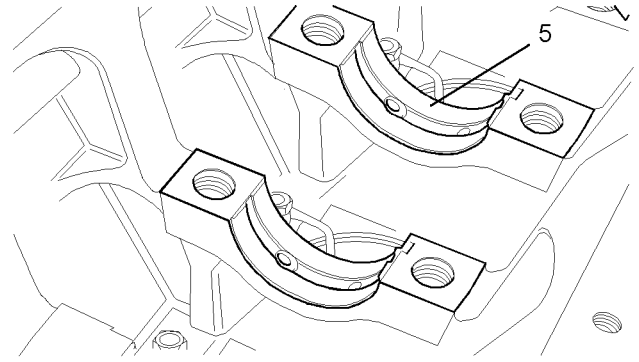


Illustration 312

g01153150

7. Remove the 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.

8. Remove the two thrust washers from number six main bearing in the cylinder block.

9. If necessary, remove the crankshaft timing ring. Refer to Disassembly and Assembly Manual, "Crankshaft Timing Ring - Remove and Install".

10. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly Manual, "Crankshaft Gear - Remove and Install".

i02296701

Crankshaft - Install

Installation Procedure

Table 74

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825607	Angle Gauge	1
B	21825496	Dial Gauge	1
	-	Magnetic Base	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 Manual, "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 Manual, "Crankshaft Gear - Remove and Install".
3. If necessary, install a new crankshaft timing ring. Refer to Disassembly and Assembly Manual, "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 setscrews 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.

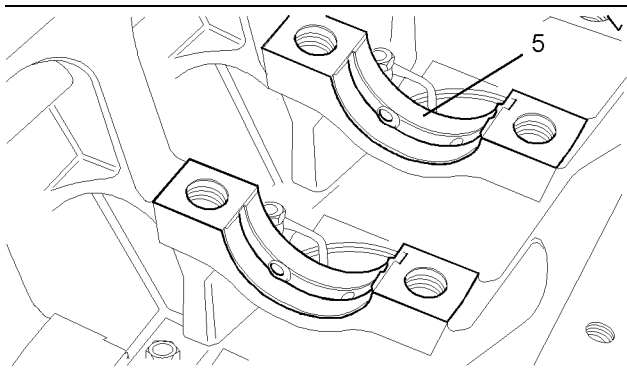


Illustration 313

g01153150

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 the upper main bearing shells (5) with clean engine oil.

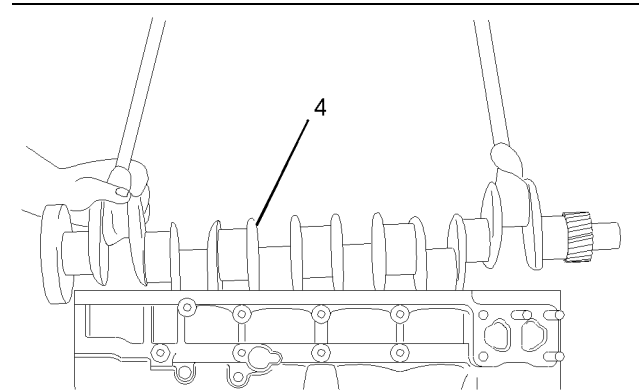


Illustration 314

g01162288

8. Attach lifting straps and a suitable lifting device to the crankshaft (4). Lift the 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.

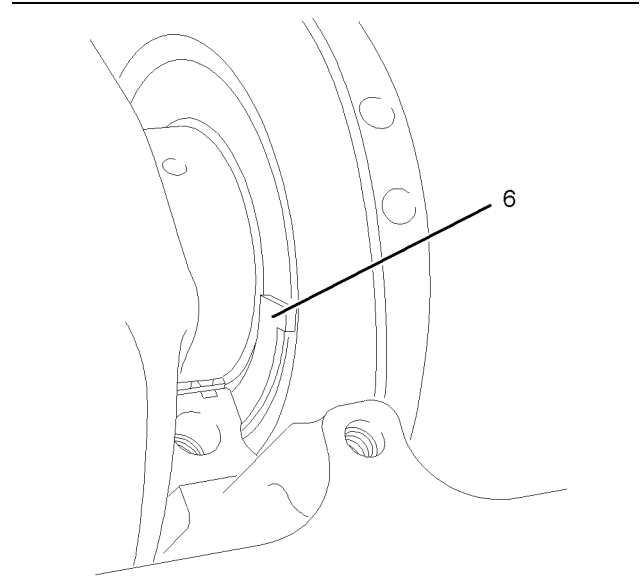


Illustration 315

g01178160

9. Lubricate the thrust washers (6) with clean engine oil. Install the thrust washers (6) into number six main bearing in the cylinder block.

Note: The thrust washers have a locating tab at one end. Ensure that the locating tabs are correctly seated in the cylinder block.

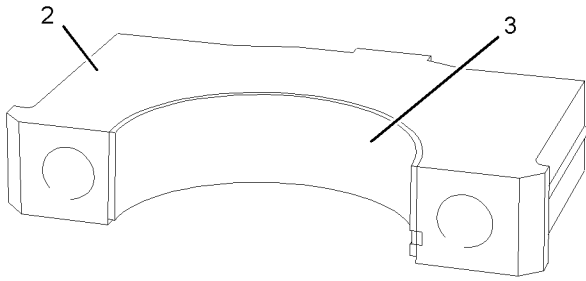


Illustration 316

g01152971

10. Install lower main bearing shells (3) into the 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 the lower main bearing shells (3) and lubricate the journals of the crankshaft (4) with clean engine oil. Install the main bearing caps (2) to the cylinder block.

Note: Ensure the correct location and orientation of the 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.

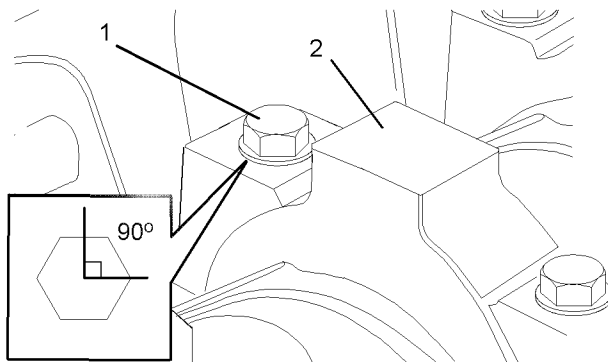


Illustration 317

g01158224

12. Lubricate the threads of the setscrews (1) with clean engine oil. Lubricate the underside of the heads of the setscrews (1) with clean engine oil.

13. Install the setscrews (1) to the main bearing caps (2). Evenly tighten the setscrews 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 the setscrews (1) to a torque of 80 N·m (59 lb ft).

Turn the setscrews (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.

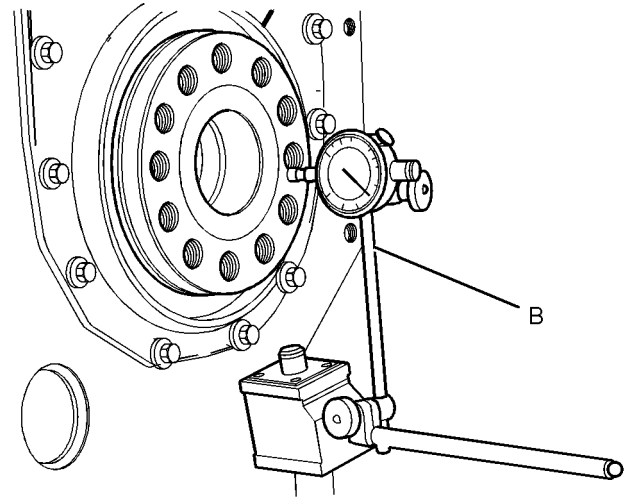


Illustration 318

g01156735

Typical example

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 0.17 mm (0.007 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 Testing and Adjusting Manual, "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 Manual, "Connecting Rod Bearings - Install".

End By:

- a. If necessary, install the pistons and connecting rods. Refer to Disassembly and Assembly Manual, "Pistons and Connecting Rods - Install".
- b. If necessary, install the cylinder head. Refer to Disassembly and Assembly Manual, "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 Manual, "Crankshaft Rear Seal - Install".
- e. Install the front housing. Refer to Disassembly and Assembly Manual, "Housing (Front) - Install".
- f. Install the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Install".

i02296702

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 Manual, "Crankshaft Wear Sleeve - Remove".
- b. Remove the crankshaft. Refer to Disassembly and Assembly Manual, "Crankshaft - Remove".

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

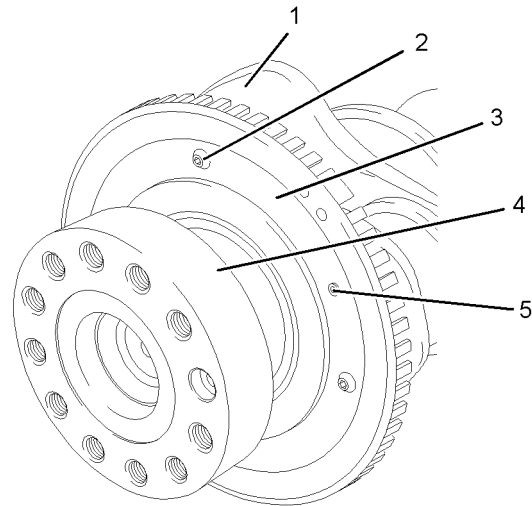


Illustration 319

g01159924

1. Support the crankshaft (1) on a suitable stand.
2. Remove the three allen head screws (2) from the crankshaft timing ring (3). Discard the allen head screws.
3. Carefully remove the crankshaft timing ring (3) from the crankshaft (1). Discard the crankshaft timing ring.

Note: Ensure that the seal surface (4) of the crankshaft is not damaged when the crankshaft timing ring is removed.

Note: Do not remove the dowel (5) from the 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 the crankshaft (1) on a suitable stand.

i02296703

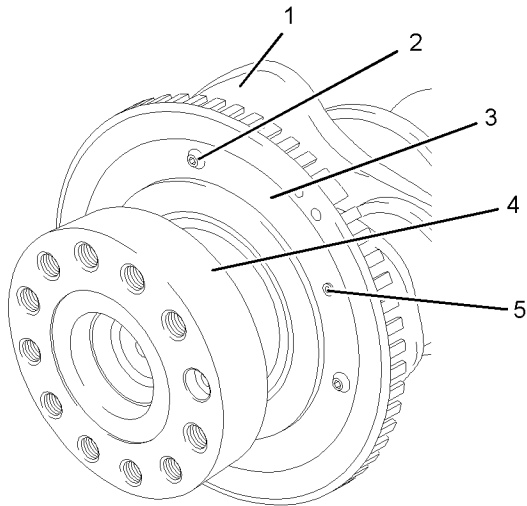


Illustration 320

g01159924

3. If the dowel (5) was removed, install a new dowel to the crankshaft (1).
4. Position the crankshaft timing ring (3) on the crankshaft with the teeth toward the crankshaft web. Align the hole in the crankshaft timing ring (3) with the dowel (5) in the crankshaft. Carefully install the crankshaft timing ring (3) to the crankshaft (1).

Note: Ensure that the seal surface (4) on the crankshaft is not damaged when the crankshaft timing ring is installed.

5. Install three 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 Manual, "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 Manual, "Crankshaft Wear Sleeve - Install".

Crankshaft Gear - Remove and Install

Removal Procedure

Table 75

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 Manual, "Housing (Front) - Remove".
- b. Remove the engine oil pump. Refer to Disassembly and Assembly Manual, "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.

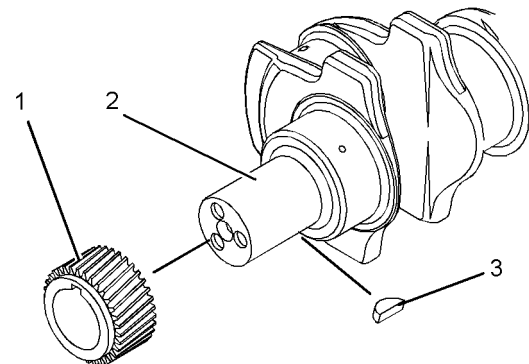


Illustration 321

g01155166

Typical example

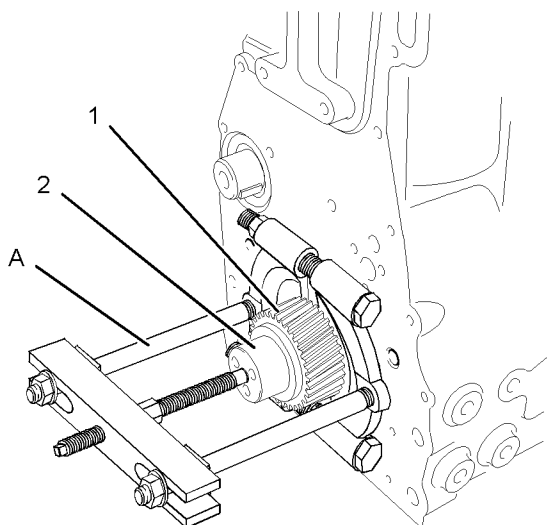


Illustration 322 g01158655
Typical example

1. If the crankshaft gear is a sliding fit on the crankshaft, remove the crankshaft gear (1) from the 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 the key (3) from the crankshaft (2).

Note: Do not remove the key from the crankshaft unless the key is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear or damage. If necessary, replace any components that are worn or damaged.

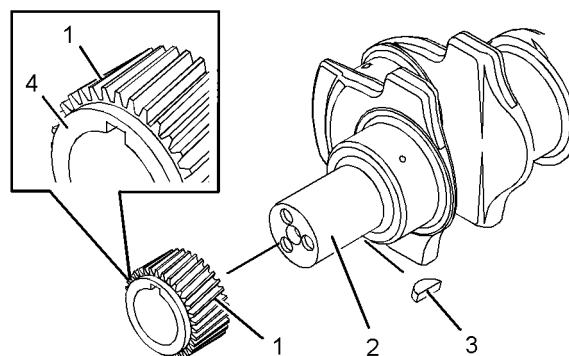


Illustration 323 g01169343
Typical example

2. If necessary, install a new key (3) to the 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 the crankshaft gear (1) with the key (3) in the crankshaft. Install the crankshaft gear (1) to the crankshaft (2).

If the crankshaft gear is an interference fit on the crankshaft, heat the 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 the crankshaft gear (1) with the key (3) in the crankshaft. Install the crankshaft gear (1) to the crankshaft (2).

Ensure that the shoulder (4) of the crankshaft gear (1) is toward the front of the engine.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly Manual, "Housing (Front) - Install".
- b. Install the engine oil pump. Refer to Disassembly and Assembly Manual, "Engine Oil Pump - Install".

i02347769

Bearing Clearance - Check

Measurement Procedure

Table 76

Required Tools	
Description	Qty
Plastigauge (Green) 0.025 to 0.076 mm (0.001 to 0.003 inch)	1
Plastigauge (Red) 0.051 to 0.152 mm (0.002 to 0.006 inch)	1
Plastigauge (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. However, if the technician still wants to measure the clearance of the bearing shell, the use of Plastigauge is an acceptable method. Plastigauge is less accurate on journals with small diameters if clearances are less than 0.10 mm (0.004 inch).

Note: The bearing clearance for the crankshaft should be within specifications if the crankshaft journals and the crankshaft pins were checked before installing the crankshaft and the correct bearing shells are installed. No further checks should be necessary.

NOTICE

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

The technician must be very careful to use Plastigauge correctly. The following points must be observed:

- Ensure that the backs of the bearing shells and the bores of the bearing shells are clean and dry.
- If the bearing shells have locating tabs ensure that the locating tabs are properly seated in the tab grooves.
- The crankshaft must be clean and free of oil at the contact points of the Plastigauge.

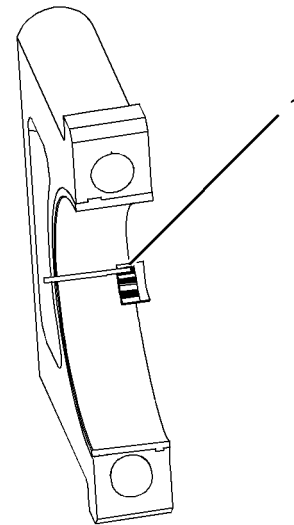


Illustration 324

g01010832

Typical example

1. Place a piece of the Plastigauge (1) onto the crown of the bearing shell that is in the cap.

Note: Do not allow the Plastigauge (1) to extend over the edge of the bearing shell.

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 shell when the cap is installed.

Note: Do not turn the crankshaft when the Plastigauge (1) is installed.

3. Carefully remove the bearing cap, but do not remove the Plastigauge (1). Measure the width of the Plastigauge (1) while the Plastigauge is in the bearing cap or on the crankshaft journal. Refer to the Illustration 324.

4. Remove all of the Plastigauge (1) before you install the bearing cap.

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

i02399486

Crankshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

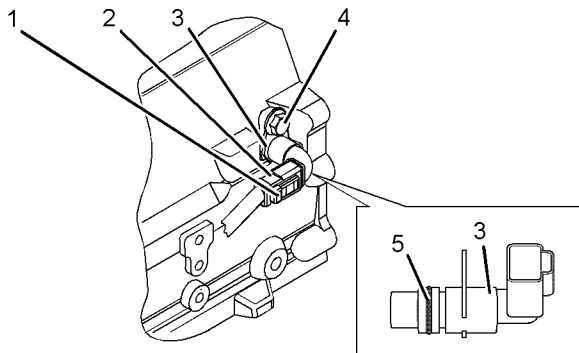


Illustration 325

g01160322

1. Slide the locking tab (1) into the unlocked position.
2. Disconnect the harness assembly (2) from the position sensor (3).
3. Remove the setscrew (4).
4. Carefully remove the position sensor (3) from the cylinder block.

Note: Do not use a lever to remove the position sensor from the cylinder block.

5. Remove the O-ring seal (5) from the position sensor (3).
6. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

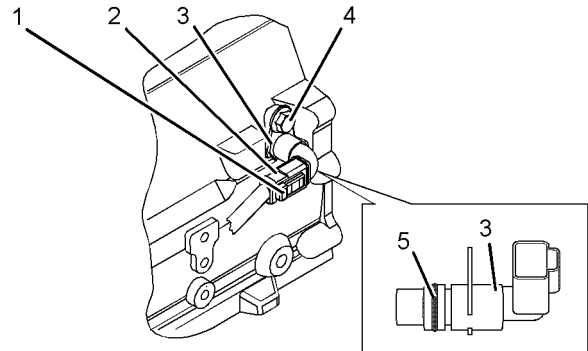


Illustration 326

g01160322

1. Lubricate a new O-ring seal (5) with clean engine oil. Install the new O-ring seal to the first groove on the position sensor (3).
 2. Align the hole in the position sensor (3) with the hole in the cylinder block. Install the position sensor to the cylinder block.
- Note:** Do not use the setscrew (4) to pull the position sensor into position against the cylinder block.
3. Install the setscrew (4). Tighten the setscrew to a torque of 22 N·m (16 lb ft).
 4. Connect the harness assembly (2) to the position sensor (3).
 5. Slide the locking tab (1) into the locked position.

i02296705

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.

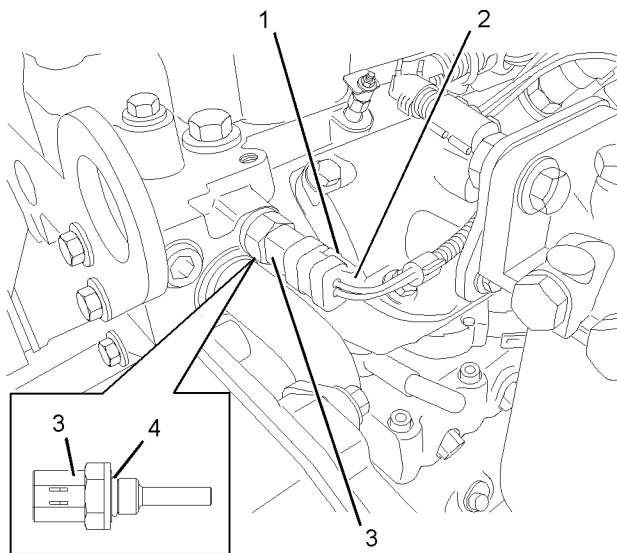


Illustration 327

g01159987

2. Slide the locking tab (1) into the unlocked position.
3. Disconnect the harness assembly (2) from the coolant temperature sensor (3).
4. Use a deep socket in order to remove the coolant temperature sensor (3) from the cylinder head.
5. Remove the O-ring seal (4) from the coolant temperature sensor (3).
6. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

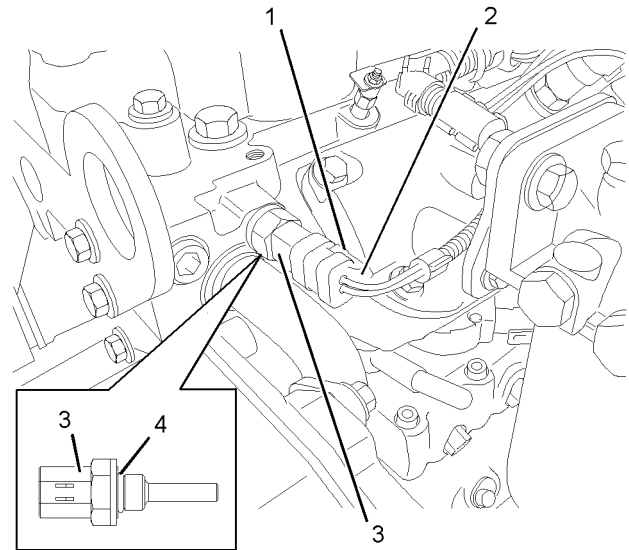


Illustration 328

g01159987

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto the coolant temperature sensor (3).
2. Use a deep socket in order to install the 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 the harness assembly (2) to the coolant temperature sensor (3).
4. Slide the 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.

i02296726

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.

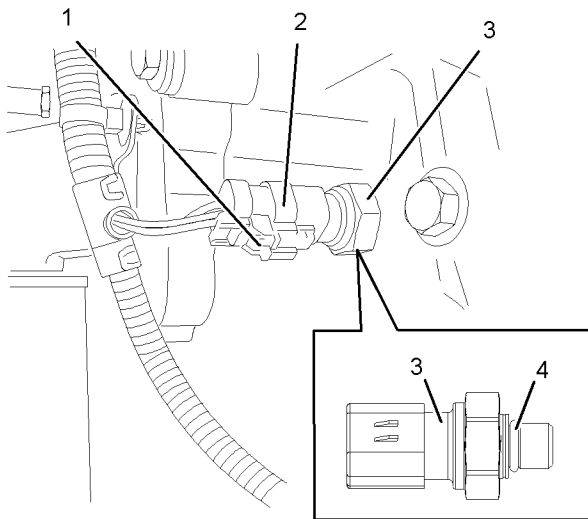


Illustration 329

g01158690

1. Slide the locking tab (1) into the unlocked position.
2. Disconnect the harness assembly (2) from the engine oil pressure sensor (3).
3. Use a deep socket to remove the engine oil pressure sensor (3) from the cylinder block.
4. Remove the O-ring seal (4) from the engine oil pressure sensor (3).
5. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

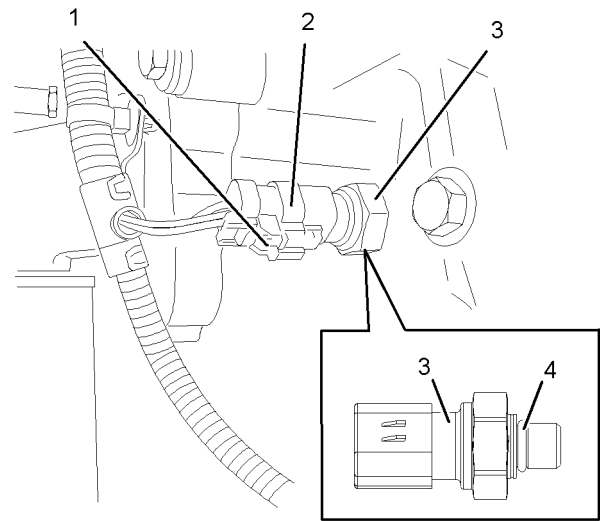


Illustration 330

g01158690

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto the engine oil pressure sensor (3).
2. Use a deep socket to install the 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 the harness assembly (2) to the engine oil pressure sensor (3).
4. Slide the 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".

i02343353

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.

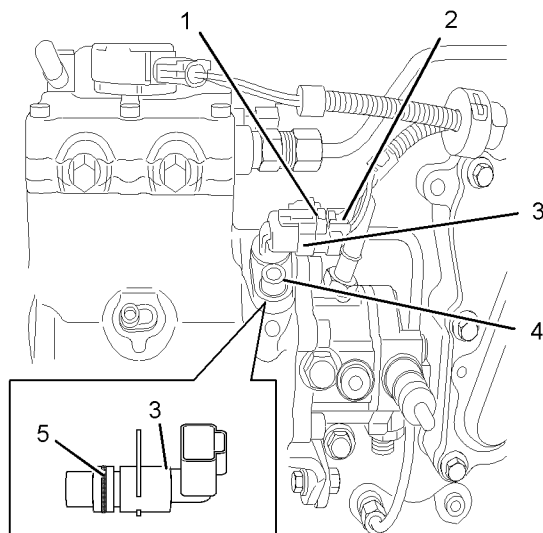


Illustration 331

g01169154

Typical example

1. Slide the locking tab (1) into the unlocked position.
2. Disconnect the harness assembly (2) from the position sensor (3).
3. Remove the setscrew (4).
4. Carefully remove the 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 the O-ring seal (5) from the position sensor (3).
7. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

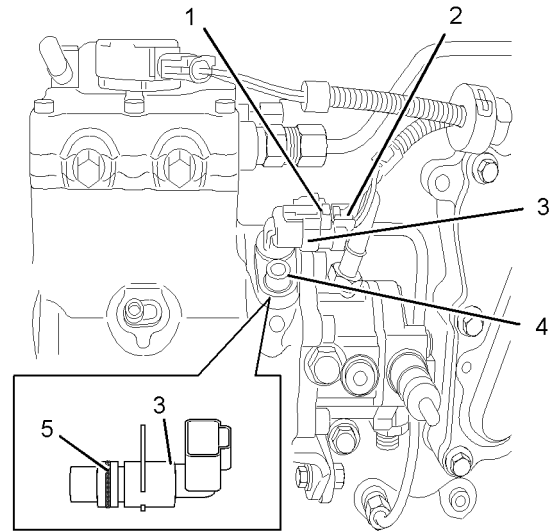


Illustration 332

g01169154

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 the position sensor (3).
 2. Remove the plug from the hole in the fuel injection pump for the position sensor.
 3. Align the hole in the position sensor (3) with the hole in the fuel injection pump. Install the position sensor to the fuel injection pump.
- Note:** Do not use the setscrew (4) to pull the position sensor into position against the fuel injection pump.
4. Install the setscrew (4). Tighten the setscrew to a torque of 22 N·m (16 lb ft).
 5. Connect the harness assembly (2) to the position sensor (3).
 6. Slide the locking tab (1) into the locked position.

i02296806

Fuel Pressure Sensor - Remove and Install

Removal Procedure

Table 77

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 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.

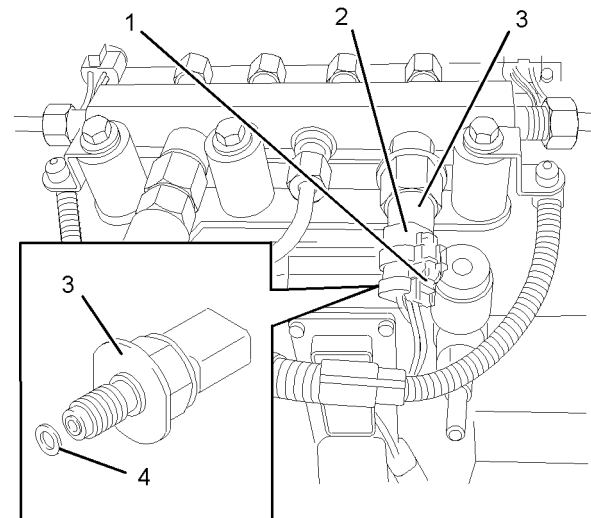


Illustration 333

g01175003

1. Slide the locking tab (1) into the unlocked position.
2. Disconnect the harness assembly (2) from the fuel pressure sensor (3).
3. Place a suitable container below the fuel pressure sensor (3) in order to catch any fuel that might be spilled.

Note: Clean up any spillage of fuel immediately.

4. Use a deep socket to remove the fuel pressure sensor (3) from the fuel manifold.
5. Use Tooling (A) in order to remove the sealing washer (4) from the fuel manifold.

Note: Ensure that no debris enters the fuel manifold during the removal of the sealing washer.

6. Plug the open port in the fuel manifold immediately with a new plug.
7. Discard the sealing washer.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

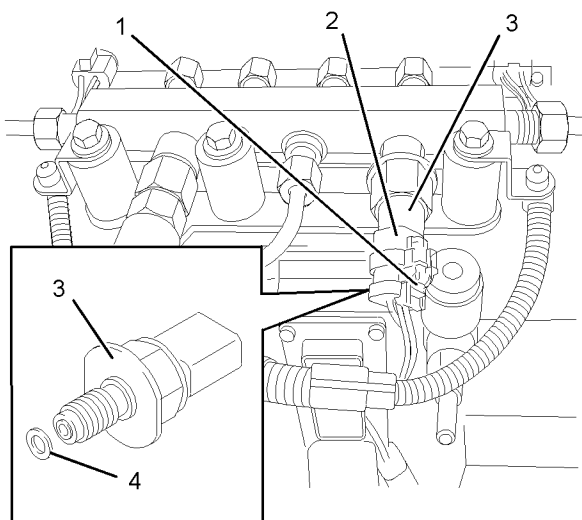


Illustration 334

g01175003

1. Position a new sealing washer (4) on the fuel pressure sensor (3).
2. Remove the plug from the fuel manifold.
3. Use a deep socket to install the 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 the harness assembly (2) to the fuel pressure sensor (3).
5. Slide the locking tab (1) into the locked position.
6. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime".

i02296728

Boost Pressure Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

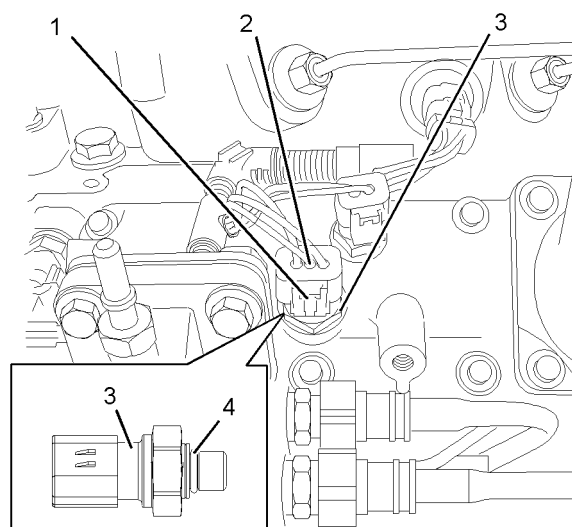


Illustration 335

g01160297

1. Slide the locking tab (1) into the unlocked position.
2. Disconnect the harness assembly (2) from the boost pressure sensor (3).

Note: The boost pressure sensor has a three-wire plug.

3. Use a deep socket to remove the boost pressure sensor (3) from the inlet manifold.
4. Remove the O-ring seal (4) from the boost pressure sensor (3).
5. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

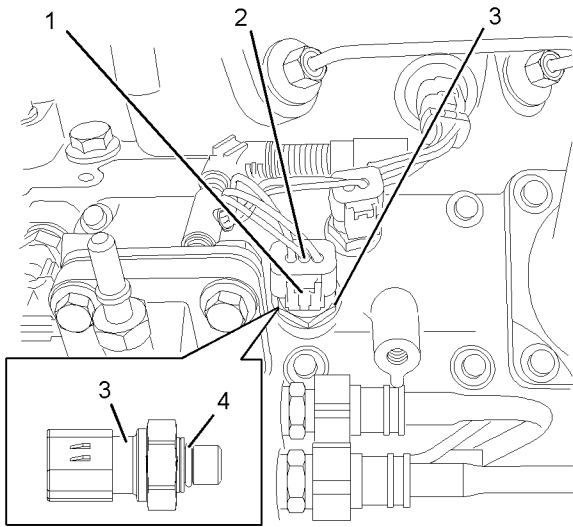


Illustration 336

g01160297

1. Lubricate a new O-ring seal (4) with clean engine oil. Install the new O-ring seal onto the boost pressure sensor (3).
2. Use a deep socket to install the 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 the harness assembly (2) to the boost pressure sensor (3).
4. Slide the locking tab (1) into the locked position.

i02296730

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.

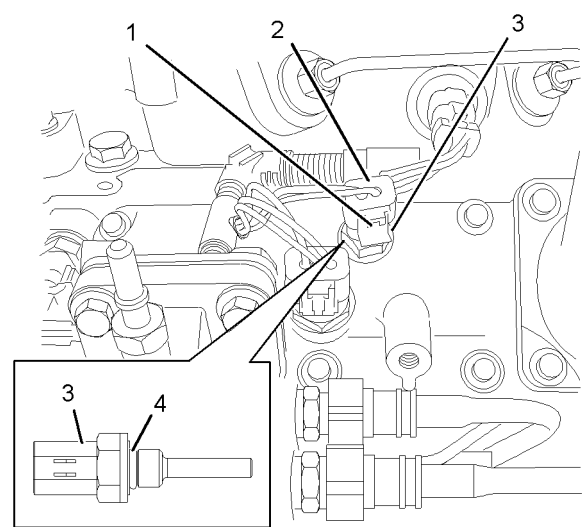


Illustration 337

g01160296

1. Slide the locking tab (1) into the unlocked position.
 2. Disconnect the harness assembly (2) from the 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 the inlet air temperature sensor (3) from the inlet manifold.
 4. Remove the O-ring seal (4) from the inlet air temperature sensor (3).
 5. Discard the O-ring seal.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

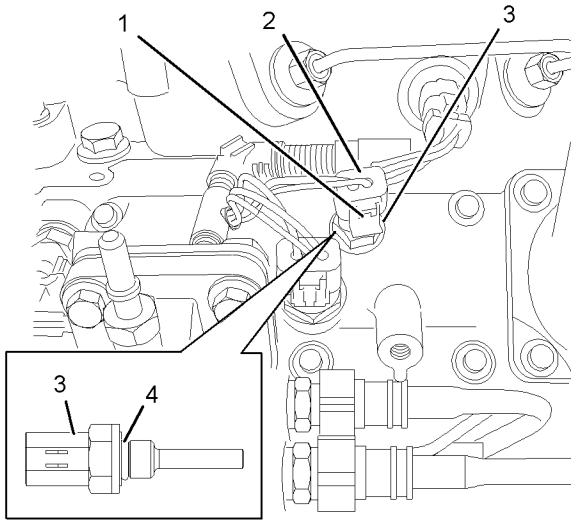


Illustration 338

g01160296

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 the 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 15 N·m (11 lb ft).
3. Connect the harness assembly (2) to the inlet air temperature sensor (3).
4. Slide the locking tab (1) into the locked position.

i02296733

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 (not shown). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Remove".

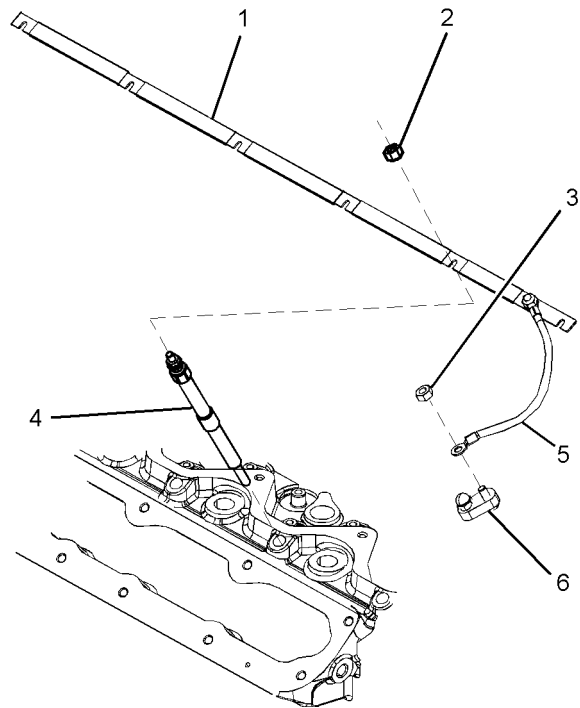


Illustration 339

g01172800

3. Remove the nut (3) from the terminal insulator (6).
4. Disconnect the wire (5) from the terminal insulator (6).
5. Remove the six nuts (2) that secure the bus bar (1) to the glow plugs (4).
6. Remove the bus bar (1) from the glow plugs (4).
7. Remove the glow plugs (4) from the cylinder head.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

i02296810

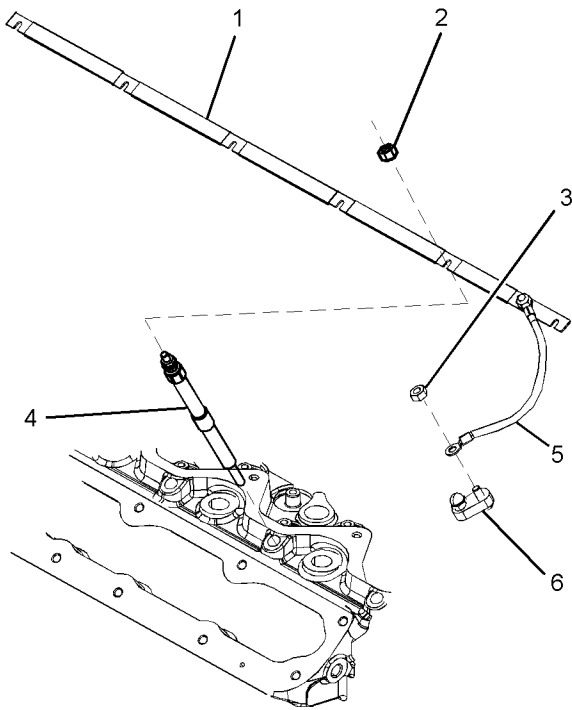


Illustration 340

g01172800

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.
2. Install the glow plugs (4) into the cylinder head. Tighten the glow plugs to a torque of 15 N·m (132 lb in).
3. Position the bus bar (1) onto the glow plugs (4). Install the six nuts (2) onto the glow plugs. Tighten the nuts to a torque of 2 N·m (17 lb in).
4. Connect the wire (5) to the stud on the terminal insulator (6).
5. Install the nut (3) to the stud on the 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 (not shown). Refer to Disassembly and Assembly Manual, "Crankcase Breather - Install".
7. Restore the electrical supply to the engine.

Alternator Belt - Remove and Install

Removal Procedure

Table 78

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.

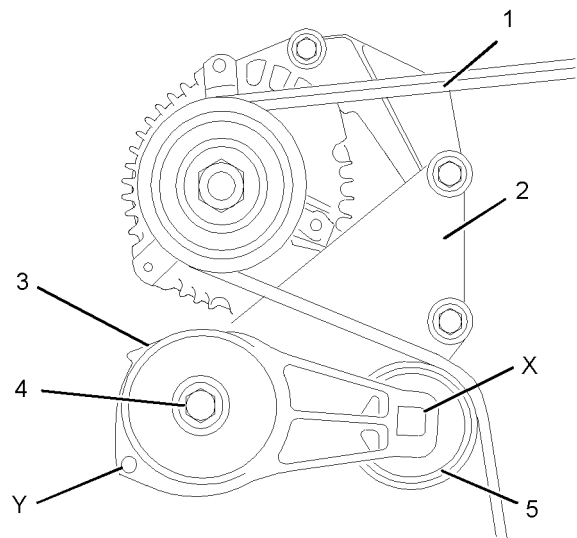


Illustration 341

g01156850

2. Install a suitable square drive tool into hole (X) in the 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 the 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 the mounting bracket (2).
 - a. Remove the setscrew (4) that secures the tensioner (3) to the mounting bracket (2).
 - b. Remove the tensioner (3) from the mounting bracket (2).

Installation Procedure

Table 79

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Locking Pin (Ø 8mm by 85 mm)	1

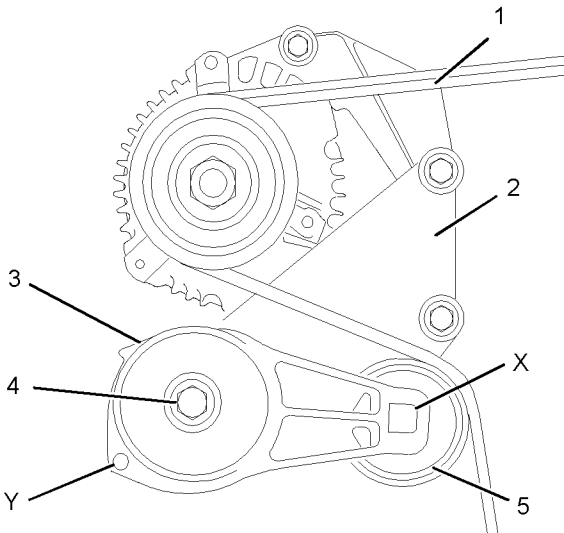


Illustration 342

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 (not shown) in the back of tensioner (3) with the hole in the mounting bracket (2).
 - b. Install the tensioner (3) to the mounting bracket (2).
 - c. Install the setscrew (4). Tighten the setscrew to a torque of 45 ± 5 N·m (33 ± 3 lb ft).

2. Install a suitable square drive tool into hole (X) in the 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 the alternator belt (1). Ensure that the alternator belt is centered on the pulley (5). A used alternator belt should be installed in the original direction of rotation.

Note: The ribs on the alternator belt must be located into the ribs of all pulleys.

5. From the front of the engine, turn the square drive tool in a clockwise direction. Release the pressure on Tooling (A). Remove Tooling (A) from hole (Y).
6. Release the pressure on the square drive tool until the alternator belt is tensioned. Remove the tool from hole (X).

Note: The tensioner should be at the nominal position.

7. If the engine has fan guards, install the fan guards.

i02296734

Fan - Remove and Install

Removal Procedure

Start By:

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

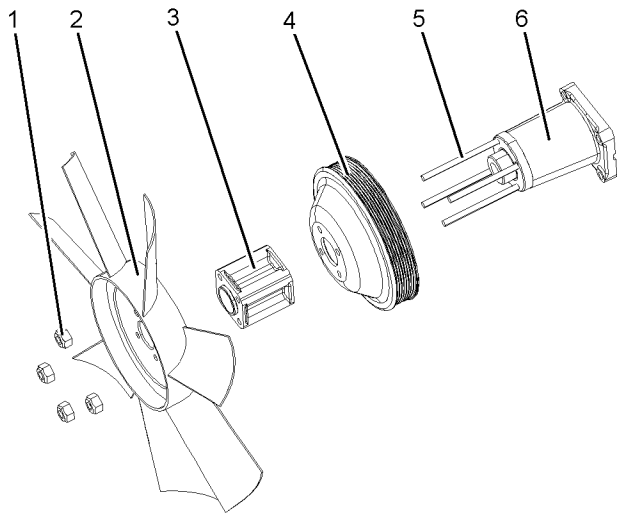


Illustration 343
Typical example g01159068

1. Remove the locking nuts (1).
 2. Remove the fan (2).
- Note:** Note the orientation of the fan.
3. Remove the fan adapter (3).
 4. Remove the fan pulley (4).
 5. If necessary, remove the four studs (5) from the 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.

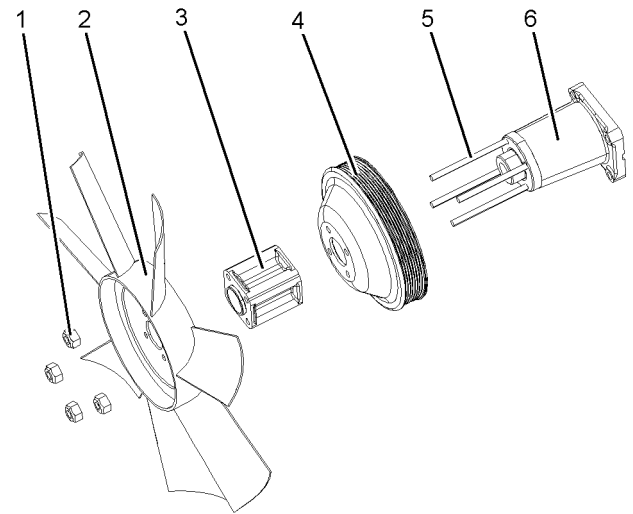


Illustration 344
Typical example g01159068

2. If necessary, install the four studs (5) to the fan drive (6).
 3. Install the fan pulley (4).
 4. Install the fan adapter (3).
 5. Install the fan (2).
- Note:** Ensure that the fan is correctly oriented.
6. Inspect the condition of the locking nuts (1). If necessary, replace the locking nuts. Install the locking nuts (1). Tighten the 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 Manual, "Alternator Belt - Remove and Install".

i02296735

Fan Drive - Remove and Install

Removal Procedure

Start By:

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

i02296737

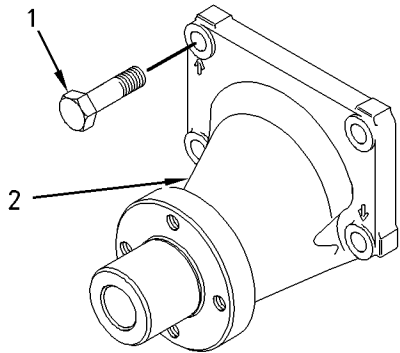


Illustration 345

g00944500

1. Remove the setscrews (1) from the fan drive (2).

Note: Identify the orientation and the position of the fan drive.

2. Remove the fan drive (2).

Installation Procedure

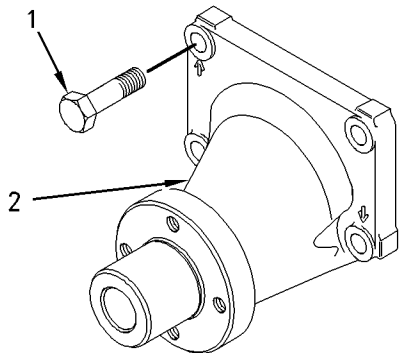


Illustration 346

g00944500

1. Check the fan drive for wear or damage. If the fan drive is worn or damaged, replace the fan drive.
2. Install the fan drive (2).
3. Install the setscrews (1). Tighten the setscrews to a torque of 44 N·m (32 lb ft).

End By:

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

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 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.

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

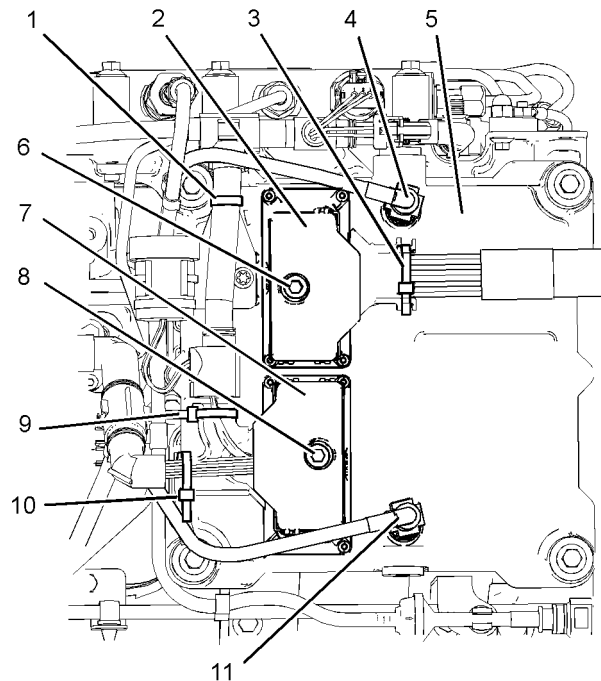


Illustration 347

g01202267

Typical example

3. Cut the 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 ties (1), (9) and (10). Unscrew the fastener (8) that secures the engine harness (7) to the electronic control module (5). Disconnect the engine harness from the electronic control module.
5. Make temporary identification marks on the 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.

Note: Clean up any spillage of fuel immediately.

7. Disconnect the plastic tube assemblies (4) and (11). Plug the plastic tube assemblies with new plugs. Drain the fuel from the electronic control module (5). Cap the connectors in the electronic control module with new caps.

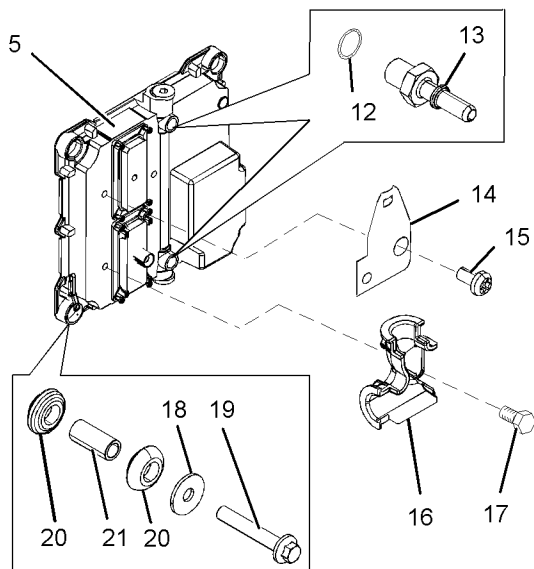


Illustration 348

g01201994

Typical example

8. Loosen the four setscrews (19) and remove the assembly of the electronic control module. Note the orientation of the electronic control module.
9. Remove the setscrews (19) and remove the washers (18) from the 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 the isolation mounts (20) and the spacers (21).
- b. Remove the connectors (13). Remove the O-ring seals (12) from the connectors. Discard the O-ring seals.
- c. Remove the torx screw (15) and remove the bracket (14) for the engine wiring harness. Note the orientation of the bracket.
- d. Remove the setscrew (17) and remove the 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.

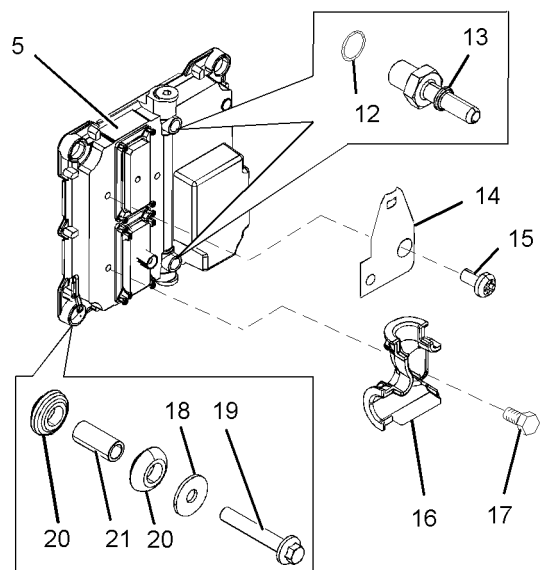


Illustration 349

g01201994

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 the connectors (13). Install the 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 the bracket (14) on the electronic control module. Ensure that the bracket is correctly oriented. Install the torx screw (15). Tighten the torx screw to a torque of 20 N·m (14 lb ft).
 - c. Position the bracket (16) on the electronic control module (5). Ensure that the bracket is correctly oriented. Install the setscrew (17). Tighten the setscrew to a torque of 20 N·m (14 lb ft).
 - d. Install the isolation mounts (20) and the spacers (21) to the electronic control module.
4. Install the washers (18) and the setscrews (19) to the electronic control module (5).

Note: Ensure that the ground strap for the electronic control module is clamped between the washer and the appropriate setscrew.

5. Install the assembly of the electronic control module to the mounting bracket (not shown). Tighten the setscrews (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 setscrew is tightened.

6. Remove the plugs from the plastic tube assemblies (4) and (11). If necessary, remove the caps from the connectors in the electronic control module. Connect the plastic tube assemblies (4) and (11).

7. Connect the engine wiring harness (7) to the 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 the brackets (14) and (16). Use new cable ties (1), (9) and (10) in order to secure the harness assembly to the brackets.

9. Connect the OEM wiring harness (2) to the electronic control module (5). Tighten the 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 tie (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".

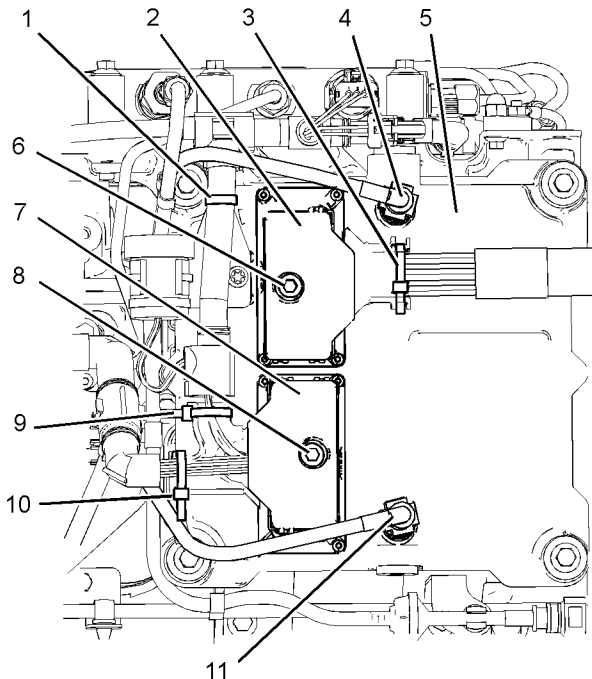
i02407622

ECM Mounting Bracket - Remove and Install

Removal Procedure

Start By:

- a. Remove the electronic control module. Refer to Disassembly and Assembly Manual, "Electronic Control Module - Remove and Install".



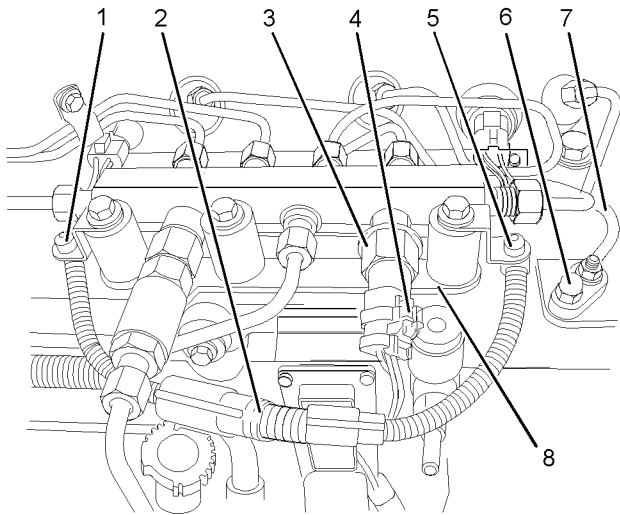


Illustration 351 g01202607

1. Follow Steps 1.a through 1.c in order to disconnect the engine wiring harness (2) .
 - a. Slide the locking tab (4) into the unlocked position.
 - b. Disconnect the harness assembly (2) from the fuel pressure sensor (3).
 - c. Cut the two cable ties (1) and (5). Position the harness assembly (2) so that the harness assembly is clear of the mounting bracket (8).
2. Disconnect the wire (7) for the glow plugs. Remove the terminal insulator (6) from the mounting bracket (8). Refer to Disassembly and Assembly Manual, "Glow Plugs - Remove and Install" for the correct procedure.

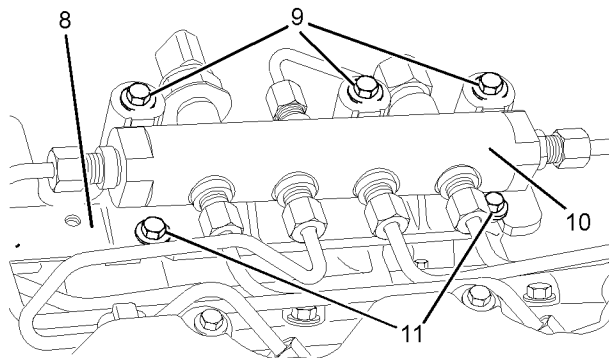


Illustration 352 g01202608

3. Remove the three setscrews (9) from the fuel manifold (10).
4. Loosen the two setscrews (11) that secure the mounting bracket (8) to the inlet manifold.

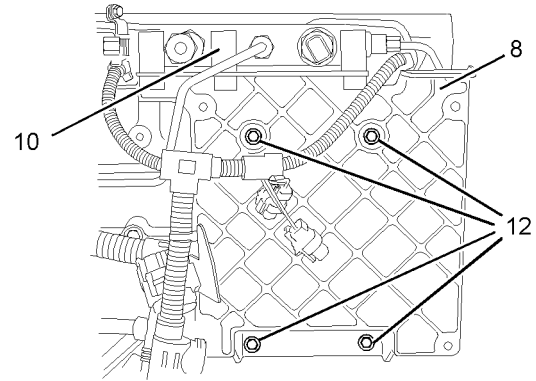


Illustration 353 g01177811

5. Remove the four setscrews (12) that secure the mounting bracket (8) to the cylinder block.
6. Slide the 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.

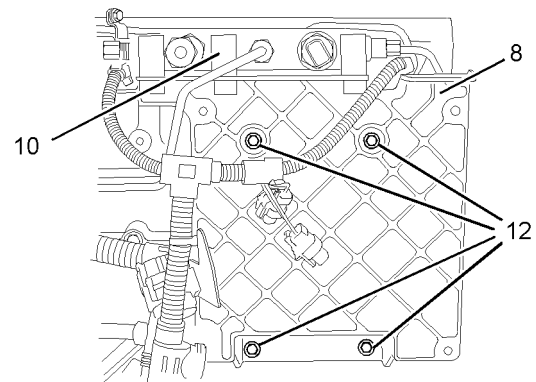


Illustration 354 g01177811

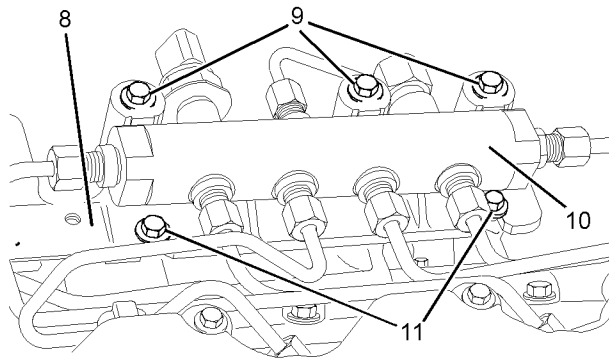


Illustration 355

g01202608

2. Position the mounting bracket (8) against the cylinder block. Ensure that the two slots in the top face of the mounting bracket are aligned with the setscrews (11). Slide the mounting bracket into position against the cylinder block.
3. Install the four setscrews (12) finger tight.
4. Install the three setscrews (9) that secure the fuel manifold (10) to the mounting bracket (8) finger tight.

Note: Ensure that the fuel manifold is seated against the mounting bracket before the setscrews (9) are tightened. Ensure that the fuel injection lines are not stressed when the setscrews are tightened.

5. Tighten the two setscrews (11) to a torque of 22 N·m (16 lb ft).
6. Tighten the four setscrews (12) to a torque of 22 N·m (16 lb ft). Tighten the three setscrews (9) to a torque of 22 N·m (16 lb ft).

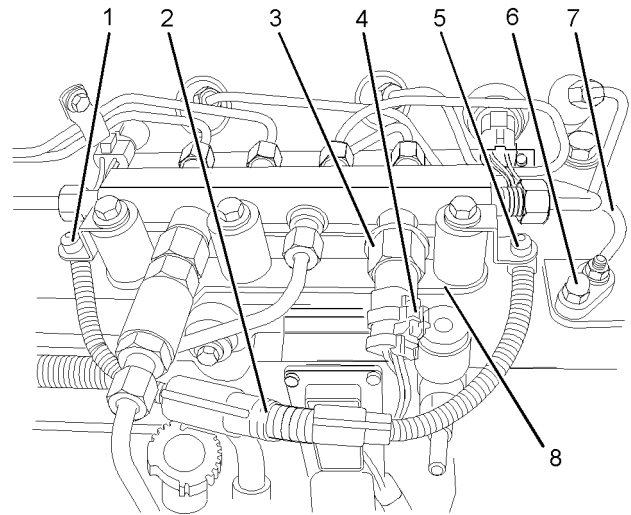


Illustration 356

g01202607

7. Install the terminal insulator (6) to the mounting bracket (8). Connect the wire (7) to the terminal insulator. Refer to Disassembly and Assembly Manual, "Glow Plugs - Remove and Install" for the correct procedure.
8. Follow Steps 1.b through 1.c in order to connect the engine wiring harness (2).
 - a. Connect the harness assembly (2) to the fuel pressure sensor (3).
 - b. Slide the locking tab (4) into the locked position.
 - c. Position the harness assembly (2) onto the mounting bracket (8). Use two new cable ties (1) and (5) in order to secure the harness assembly.

End By:

- a. Install the electronic control module. Refer to Disassembly and Assembly Manual, "Electronic Control Module - Remove and Install".

i02296739

Alternator - Remove

Removal Procedure (Alternators with Mounting Lugs)

Start By:

- a. Remove the alternator belt. Refer to Disassembly and Assembly Manual , "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 (not shown).
-

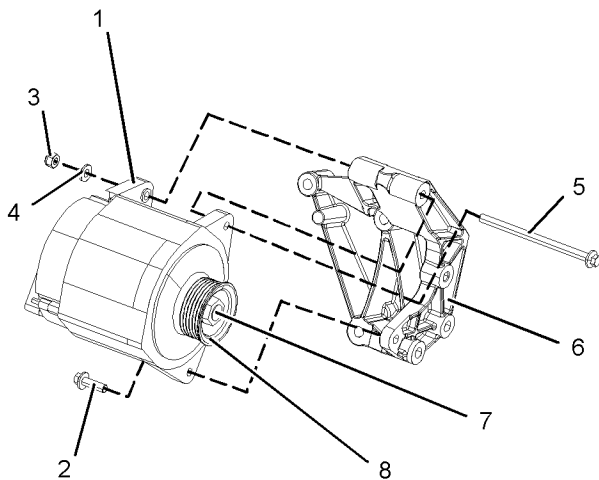


Illustration 357

g01160737

Typical example

3. Disconnect the wiring harness assembly (not shown) from the alternator (1).
4. Remove the setscrew (2) from the alternator (1).
5. Remove the nut (3) and the washer (4). Remove the bolt (5) from the alternator (1). Remove the alternator from the alternator bracket (6).
6. If necessary, follow Steps 6.a and 6 in order to remove the pulley (8) from the alternator (1).

- a. Hold the shaft of the alternator (1) with an allen wrench. Use a cranked ring spanner to loosen the nut (7).
- b. Remove the nut (7) and the pulley (8) from the alternator (1).

Removal Procedure (Alternators with Mounting Pads)

Start By:

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

1. Isolate the electrical supply.
 2. Place identification marks on all of the wiring harness connections (not shown).
-

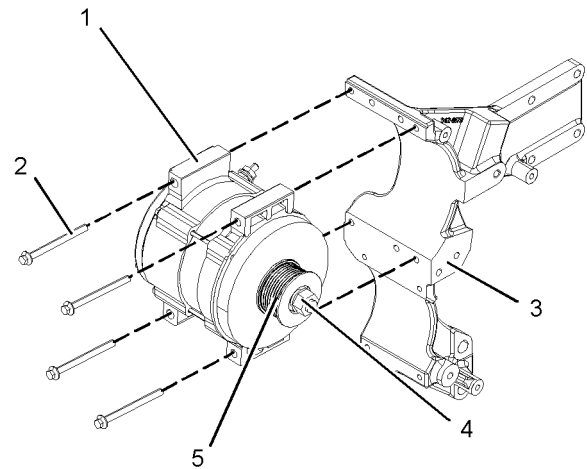


Illustration 358

g01167352

3. Disconnect the wiring harness assembly (not shown) from the alternator (1).
4. Remove the four setscrews (2) and the alternator (1) from the alternator bracket (3).
5. If necessary, follow Steps 5.a and 5.b in order to remove the pulley (5) from the alternator (1).
 - a. Hold the shaft of the alternator (1) with an allen wrench. Use a cranked ring spanner to loosen the nut (4).
 - b. Remove the nut (4) and the pulley (5) from the alternator (1).

i02296740

Alternator - Install

Installation Procedure (Alternators with Mounting Lugs)

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

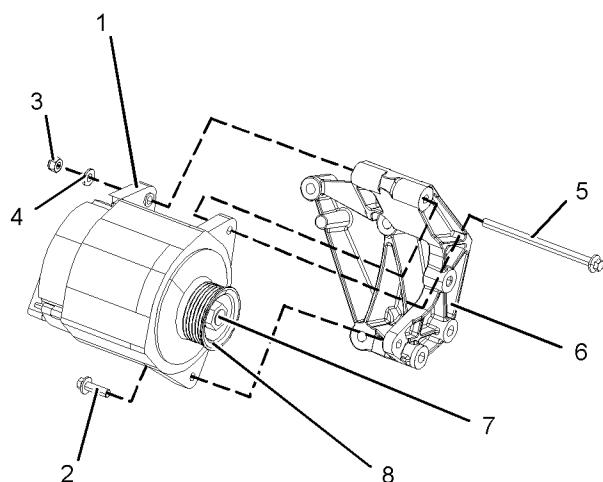


Illustration 359

g01160737

Typical example

1. If necessary, install the pulley (8) and the nut (7) to the alternator (1). Hold the shaft of the alternator (1) with an allen wrench. Use a cranked ring spanner in order to tighten the nut (7).

Note: Different types of alternator have different sizes of nut. Ensure that the correct torque value is used for the nut.

Tighten M16 and M17 nuts to a torque of 80 N·m (59 lb ft). Tighten 5/8 inch - 18 UNF nuts to a torque of 102 N·m (75 lb ft).

2. Position the alternator (1) on the alternator mounting bracket (6).
3. Install the bolt (5) to the alternator (1). Install the washer (4) and the nut (3) to the bolt (5).
4. Install the setscrew (2) to the alternator (1).

5. Tighten the nut (3) and the setscrew (2) to a torque of 22 N·m (16 lb ft).
6. Connect the wiring harness assembly (not shown) to the alternator (1).
7. Install the alternator belt. Refer to Disassembly and Assembly Manual, "Alternator Belt - Remove and Install".
8. Restore the electrical supply.

Installation Procedure (Alternators with Mounting Pads)

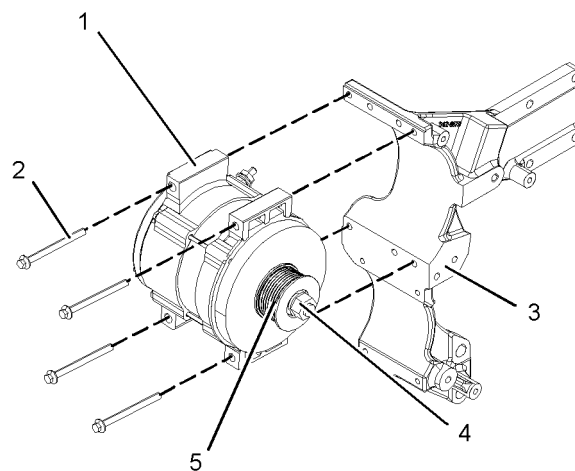


Illustration 360

g01167352

1. If necessary, install the pulley (5) and the nut (4) to the alternator (1). Hold the shaft of the alternator (1) with an allen wrench. Use a cranked ring spanner in order to tighten the nut (4). Tighten the nut to a torque of 127 N·m (93 lb ft).
2. Position the alternator (1) on the alternator mounting bracket (3). Install the four setscrews (2) into the alternator bracket. Tighten the setscrews to a torque of 44 N·m (32 lb ft).
3. Connect the wiring harness assembly (not shown) to the alternator (1).
4. Install the alternator belt. Refer to Disassembly and Assembly Manual, "Alternator Belt - Remove and Install".
5. Restore the electrical supply.

i02296742

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 (not shown) that is connected to the electric starting motor and the solenoid.

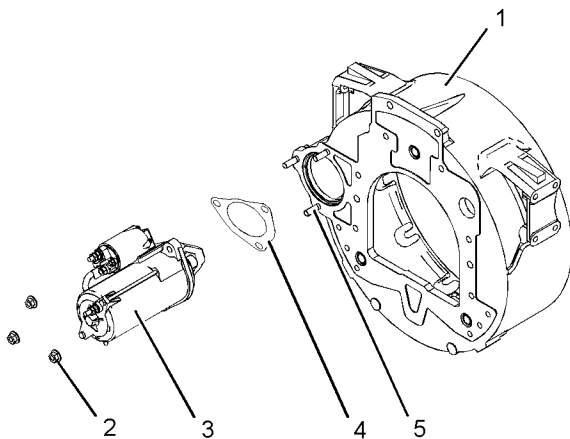


Illustration 361
Typical example

g01159172

3. Disconnect the harness assembly from the electric starting motor and the solenoid.
4. Remove the nuts (2) for the electric starting motor (3).
5. Remove the electric starting motor (3).

6. If a joint is installed, remove the joint (4). Discard the joint.
7. If necessary, remove the studs (5) from the flywheel housing (1).

Installation Procedure

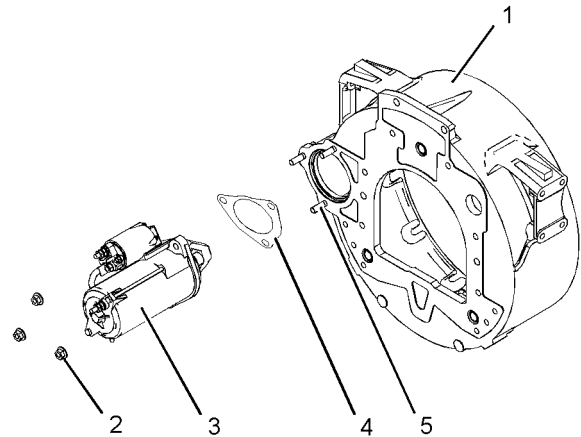


Illustration 362
Typical example

g01159172

1. If necessary, install the studs (5) into the flywheel housing (1).
2. If necessary, install a new joint (4) onto the studs in the flywheel housing (1).
3. Position the electric starting motor (3) onto the studs in the flywheel housing (1).
4. Install the 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 (not shown) to the electric starting motor and the solenoid.
6. Connect the battery.

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