KENR9100-01
February 2011

Disassembly and Assembly

1206E-E70TTA Industrial Engine

BL (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.

⚠ WARNING

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.

⚠ WARNING

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 (Electric Fuel Lift Pump (EFLP))

Removal Procedure

Table 1

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Cap Kit	1

NOTICE

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

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

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

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. Turn the fuel supply to the OFF position.
2. Turn the battery disconnect switch to the OFF position.

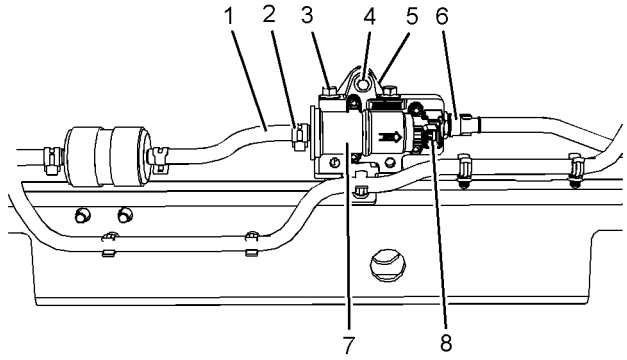


Illustration 1 g02237533

3. Make a temporary identification mark on plastic tube assembly and hose assembly in order to show the correct position of the tube assemblies.
4. Slide hose clamp (2) along hose assembly (1). Disconnect hose assembly (1) from the assembly of fuel priming pump (7).
5. Use Tooling (A) in order to plug the hose assembly with new plug. Use Tooling (A) in order to cap all open connectors on the fuel priming pump with new caps.
6. Disconnect plastic tube assembly (6) from the assembly of fuel priming pump (7). Use Tooling (A) in order to plug the tube assemblies with new plugs. Use Tooling (A) in order to cap all open connectors on the fuel priming pump with new caps.
7. Disconnect the harness assembly from fuel priming pump connection (8).
8. Remove bolts (3) and bolt (4).
9. Remove the assembly of priming pump (7) from bracket (5).

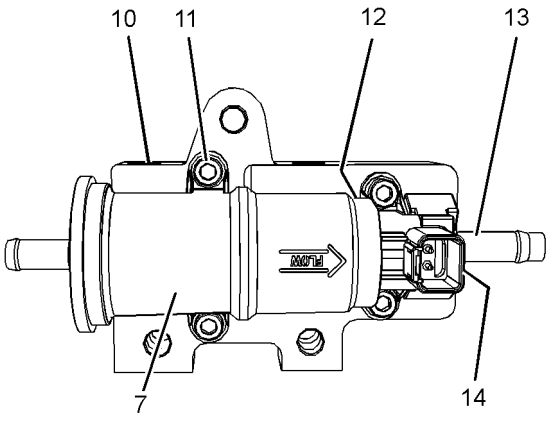


Illustration 2 g02237534

10. If necessary, follow Step 10.a through Step 10.d in order to disassemble the assembly of the fuel priming pump (7).

a. Remove allen head screws (11) from fuel priming pump (7).

b. Remove fuel priming pump (7) from manifold (10).

c. Remove O-ring seal (12) (not shown).

d. If necessary, remove connection (13) from manifold (10). Remove O-ring seal (14) (not shown) from connection (13).

Installation Procedure

NOTICE

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

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

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

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

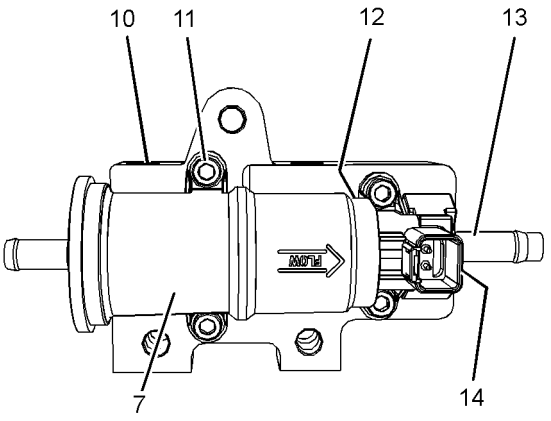


Illustration 3 g02237534

2. If necessary, follow Step 2.a through Step 2.c in order to assemble fuel priming pump (7).

a. If necessary, install a new O-ring seal (14) (not shown) to connection (13). Install connection (13) to manifold (10). Tighten the connection to a torque of 20 N·m (177 lb in).

b. Install a new O-ring seal (12) (not shown) to fuel priming pump (7).

c. Position fuel priming pump (7) onto manifold (10). Install allen head screws (11). Tighten the allen head screws to a torque of 9 N·m (80 lb in).

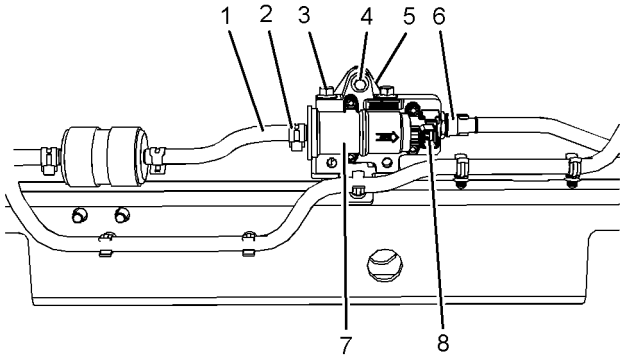


Illustration 4 g02237533

3. Position assembly of fuel priming pump (7) onto mounting bracket (5).

4. Install bolt (4) and bolts (3) to the fuel priming pump. Tighten bolt (4) and bolts (3) to a torque of 22 N·m (195 lb in).

5. Remove plug from hose assembly. Remove cap from connector on the fuel priming pump. Connect hose assembly (1) to fuel priming pump (7). Slide hose clamp (2) along hose assembly (1).

Note: Ensure that the hose clamp is correctly positioned.

6. Remove plug from plastic tube assembly. Remove cap from connector on the fuel priming pump. Connect plastic tube assembly (6) to fuel priming pump (7).

7. Connect the harness assembly to fuel priming pump connection (8).

8. Turn the fuel supply to the ON position.

9. Turn the battery disconnect switch to the ON position.

10. Prime the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime”for the correct procedure.

i04203700

Flow Control Valve - Remove and Install

Removal Procedure

Table 2

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping 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 authorized personnel that have the correct training.

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

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

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

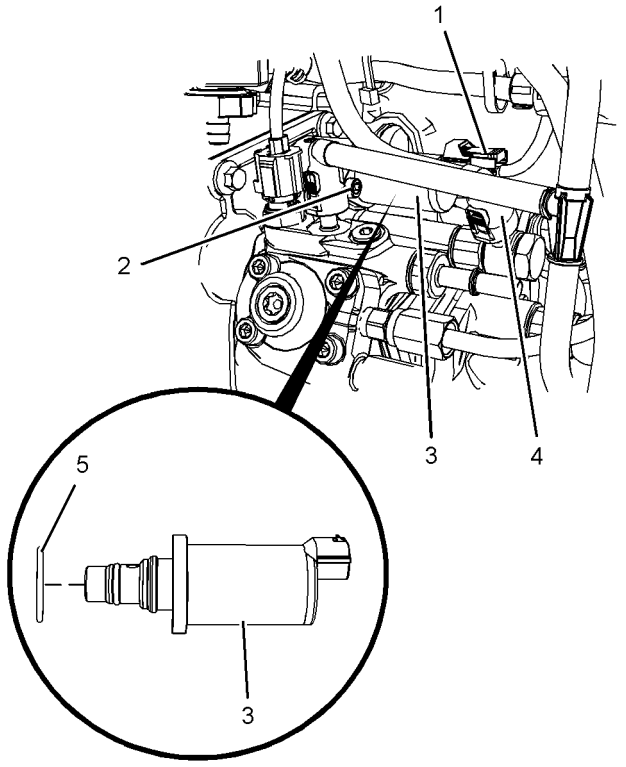


Illustration 5 g02210473

3. Clean the area around flow control valve (3) and fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.

4. Disconnect harness assembly (1) from flow control valve (3).

5. Disconnect plastic tube assembly (4). Use Tooling (A) in order to plug and cap the open port on the fuel injection pump and the plastic tube assembly with new plug and new cap.

6. Make temporary marks on flow control valve (3) and the fuel injection pump for installation purpose.

7. Remove allen heads screws (2) from flow control valve (3).

8. Remove flow control valve (3) from the fuel injection pump.

9. Remove O-ring seal (5) from fuel injection pump.

Installation Procedure

1. Ensure that all component at free from wear and damage. If any part of the flow control valve is worn or damaged, the flow control valve must be replaced as an assembly. The flow control valve kit contains the guide pins in order to install the flow control valve assembly.

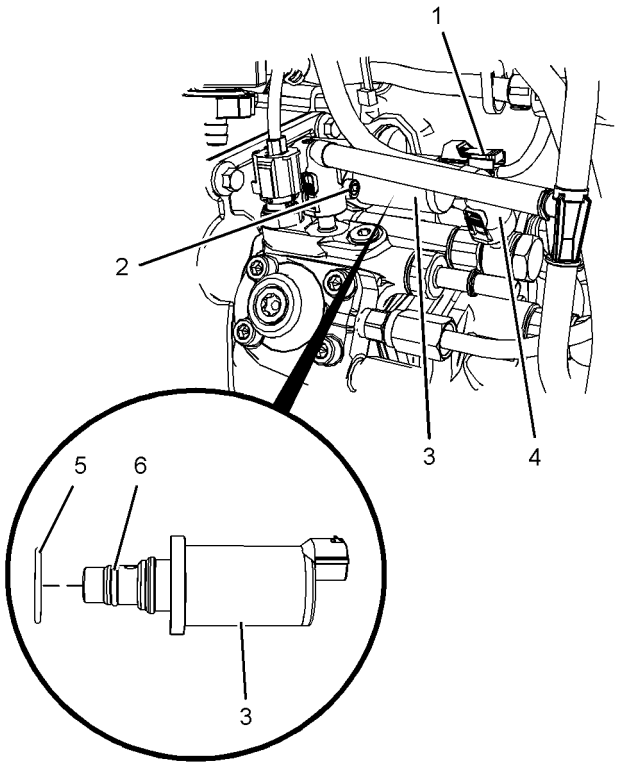


Illustration 6 g02208673

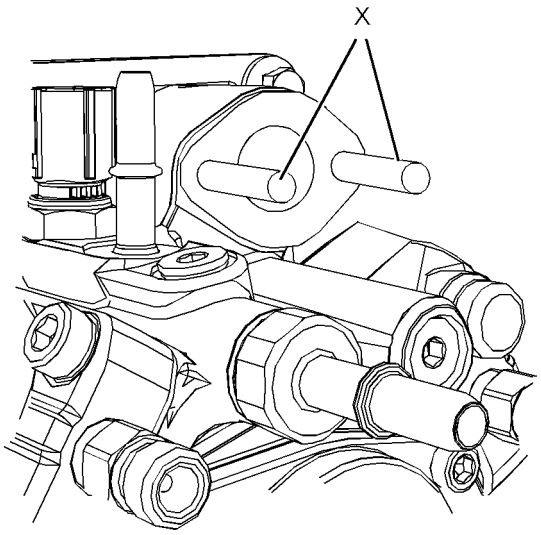


Illustration 7 g02306933

Flow control valve guide pins

2. Position a new O-ring seal (5) onto the flow control valve assembly.

3. Check O-ring seal (6) is correctly positioned. Ensure that O-ring seal (6) is not damaged.

Note: If O-ring seal (6) is damaged, a new flow control valve assembly must be installed.

4. Install guide pins into Position (X) on the fuel injection pump.

Note: Note the guide pins are part of the flow control valve repair kit.

5. Lubricate O-ring seal (6) with clean fuel.

Note: Ensure that the O-ring seals are not damaged or misaligned.

6. Align flow control valve (3) onto guide pins.

7. Install flow control valve (3) to the fuel injection pump.

8. Remove guide pins from the fuel injection pump.

9. Install allen head screws (2) from the flow control valve repair kit.

10. Tighten allen head screws (2) equally until the flow control valve is seated correctly onto the fuel injection pump.

Note: Ensure that the allen screws are tightened equally. Failure to ensure that the allen screws are tightened equally will result in damage to the fuel injection pump.

11. Tighten the allen head screws to a torque of 9 N·m (80 lb in).

12. Connect harness assembly (1) to flow control valve (3).

13. Remove plug and cap from ports from the fuel injection pump and the plastic tube assembly.

14. Connect plastic tube assembly (4).

15. Replace the filters for primary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Primary (Water Separator) Element - Replace” for the correct procedure.

16. Replace the filters for secondary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

17. Turn the fuel supply to the ON position.

18. Turn the battery disconnect switch to the ON position.

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

End By:

a. After replacement of the flow control valve, the fuel injection pump requires a high-pressure fuel pump calibration procedure to be performed. Refer to Troubleshooting, “Fuel Rail Pressure Problem” for the correct procedure.

i04203713

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

Removal Procedure

Table 3

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

NOTICE

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

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

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

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. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

3. Drain the secondary filters. Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

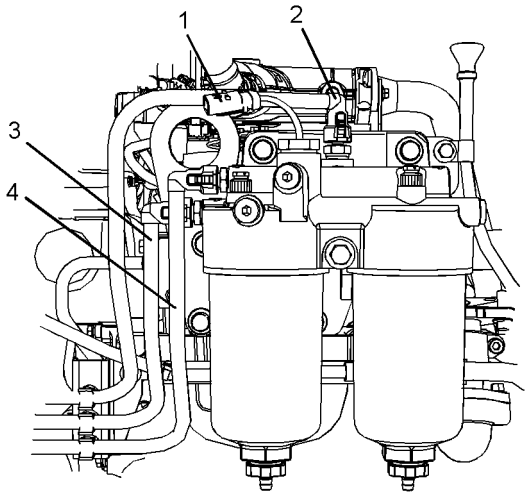


Illustration 8 g02241236

4. Make temporary identification marks on all the plastic tube assemblies in order to show the correct position of the tube assemblies.

5. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.

6. Disconnect plastic tube assembly (2), plastic tube assembly (3), and plastic tube assembly (4) from the fuel filter base.

7. Use Tooling (A) in order to plug the plastic tube assemblies with new plugs. Use Tooling (A) in order to cap the ports in the fuel filter base with new caps.

8. Disconnect Original Equipment Manufactures (OEM) harness assembly from harness assembly (1) for the differential pressure switch.

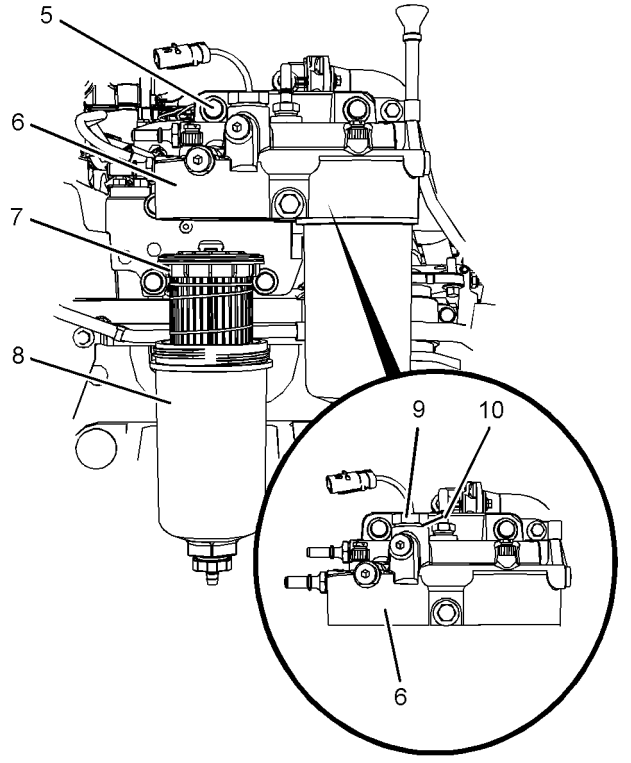


Illustration 9 g02227513

9. Remove secondary filters (7) from canisters (8). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

10. Remove bolts (5) from fuel filter base (6). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

11. If necessary, follow Step 11.a through Step 11.b in order to remove differential pressure switch (9) from fuel filter base (6).

   a. Remove differential pressure switch (9) from fuel filter base (6).

   b. Remove O-ring seal (10) (not shown) from the differential pressure switch.

Installation Procedure

NOTICE

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

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

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

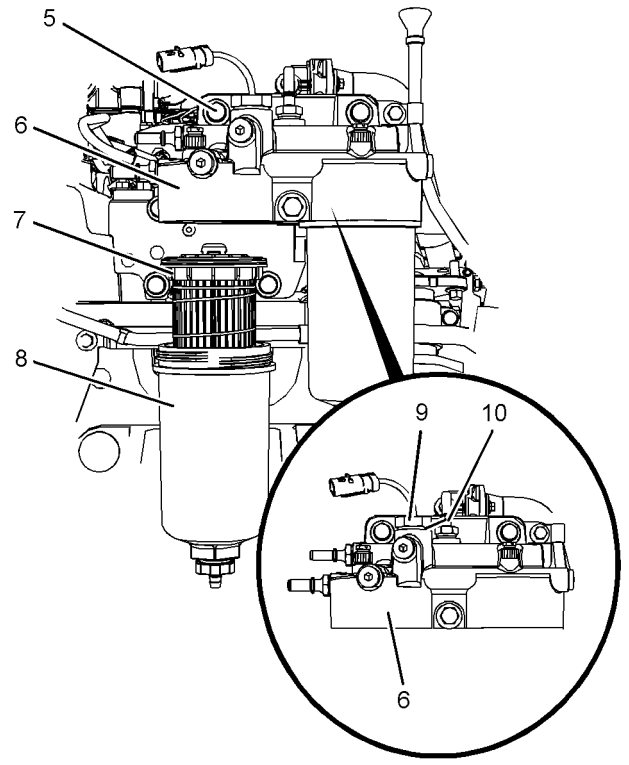


Illustration 10 g02227513

1. Ensure that fuel filter base (6) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.

2. If necessary, follow Step 2.a through Step 2.c in order to install differential pressure switch (9) to fuel filter base (6).

a. Install a new O-ring seal (10) (not shown) to the differential pressure switch.

b. Install differential pressure switch (9) to fuel filter base (6).

c. Tighten differential pressure switch (9) to a torque of 20 N·m (177 lb in).

3. Position fuel filter base (6) on the mounting bracket. Install bolts (5). Tighten the bolts to a torque of 44 N·m (32 lb ft).

4. If necessary, install new fuel filters (7) to canisters (8). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

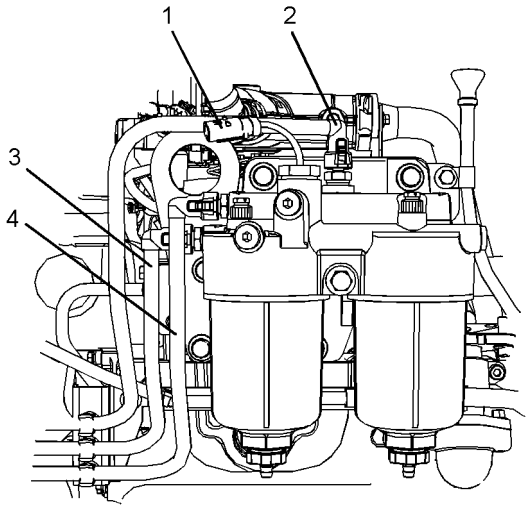


Illustration 11 g01962657

5. 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. Serious damage to the engine will result if contaminated fuel enters the fuel system.

6. Connect plastic tube assembly (2), plastic tube assembly (3), and plastic tube assembly (4) to fuel filter base (6).

7. Connect OEM harness assembly to harness assembly (1) for the differential pressure switch.

8. Turn the fuel supply to the ON position.

9. Turn the battery disconnect switch to the ON position.

End By:

a. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203712

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

Removal Procedure

Table 4

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

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

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

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

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. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

3. Drain the secondary filter. Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

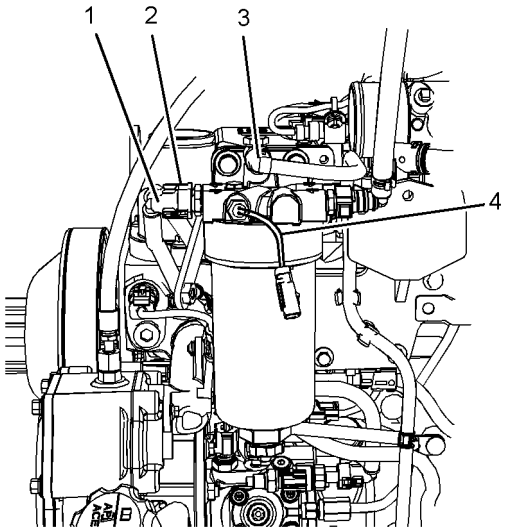


Illustration 12 g02239633

4. Make temporary identification marks on plastic tube assemblies in order to show the correct position of the plastic tube assemblies.

5. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.

6. Disconnect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (3) from the fuel filter base. Use Tooling (A) in order to plug the plastic tube assemblies with new plugs. Use Tooling (A) in order to cap the ports in the fuel filter base with new caps.

7. If necessary, disconnect Original Equipment Manufactures (OEM) harness assembly from harness assembly (4) for the differential pressure switch.

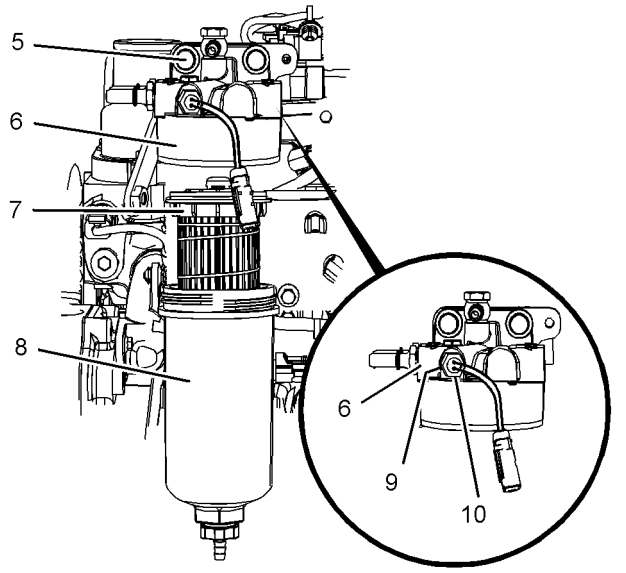


Illustration 13 g02204636

8. Remove secondary filter (7) from canister (8). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

9. Remove bolts (5) from fuel filter base (6). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

10. If necessary, follow Step 10.a through Step 10.b in order to remove differential pressure switch (10) from fuel filter base (6).

a. Remove differential pressure switch (10) from fuel filter base (6).

b. Remove O-ring seal (9) (not shown) from the differential pressure switch.

Installation Procedure

NOTICE

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

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

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

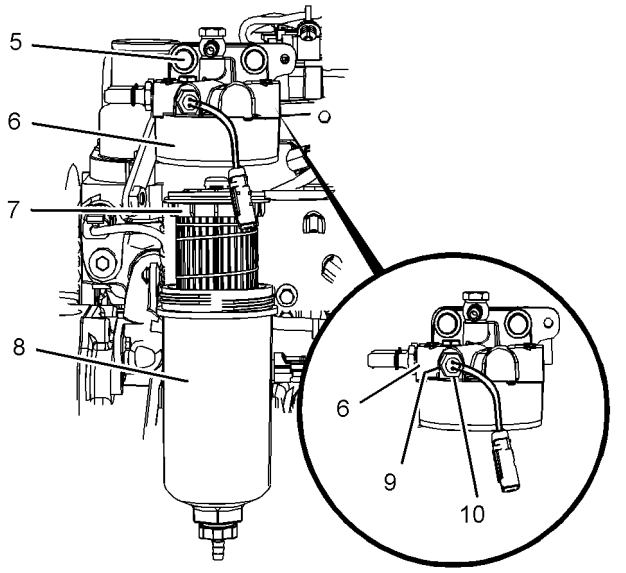


Illustration 14 g02204636

1. Ensure that fuel filter base (6) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.

2. If necessary, follow Step 2.a through Step 2.c in order to install differential pressure switch (10) to fuel filter base (6).

   a. Install a new O-ring seal (9) (not shown) to the differential pressure switch.

   b. Install differential pressure switch (10) to fuel filter base (6).

   c. Tighten differential pressure switch (10) to a torque of 20 N·m (177 lb in).

3. Position fuel filter base (6) on the mounting bracket. Install bolts (5). Tighten the bolts to a torque of 44 N·m (32 lb ft).

4. If necessary, install a new fuel filter (7) to canister (8). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

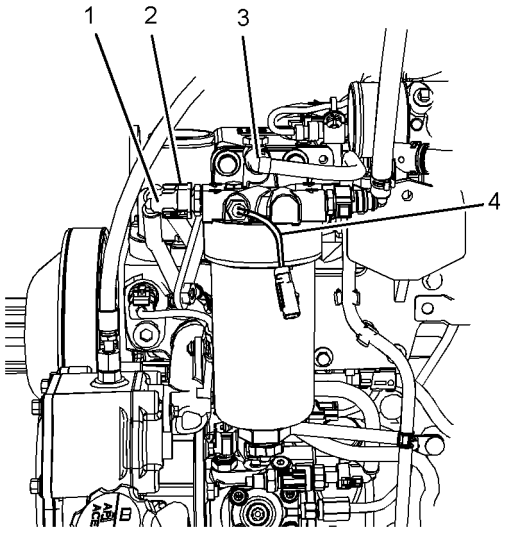


Illustration 15 g02239633

5. 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. Serious damage to the engine will result if contaminated fuel enters the fuel system.

6. Connect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (3) to the fuel filter base.

7. If necessary, connect OEM harness assembly to harness assembly (4) for the differential pressure switch.

8. Turn the fuel supply to the ON position.

9. Turn the battery disconnect switch to the ON position.

End By:

a. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203795

Water Separator and Fuel Filter (Primary) - Remove and Install

Removal Procedure

Table 5

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

NOTICE

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

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

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

1. Turn the battery disconnect switch to the OFF position.
2. Turn the fuel supply to the OFF position.

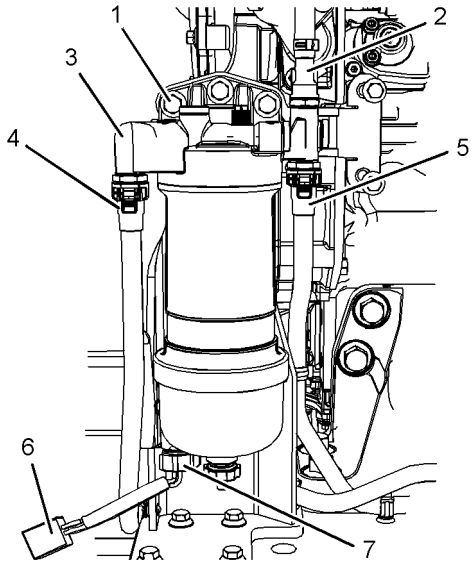


Illustration 16 g02240074

3. Make temporary identification marks on plastic tube assemblies in order to show the correct position of the plastic tube assemblies.
4. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.
5. Disconnect plastic tube assembly (2), plastic tube assembly (4), and plastic tube assembly (5) from the assembly of primary fuel filter (3). Tooling (A) in order to plug the plastic tube assemblies with new plugs. Use Tooling (A) in order to cap the ports in the primary fuel filter with new caps.
6. Disconnect the Original Equipment Manufactures (OEM) harness assembly from the connection on harness assembly (6) for water in fuel sensor (7).
7. Remove bolts (1) and remove the assembly of primary fuel filter (3) from the mounting bracket.

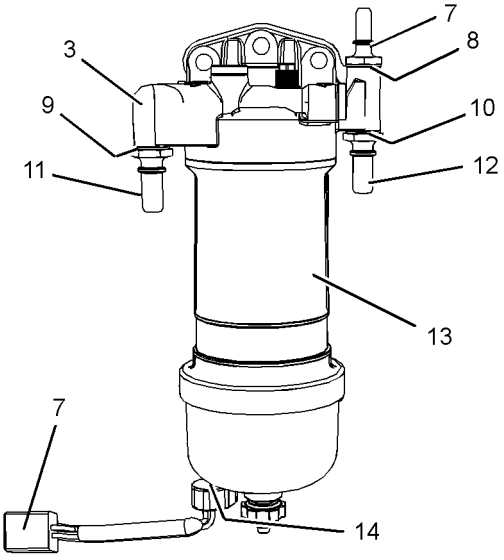


Illustration 17 g02240075

8. If necessary, follow Step 8.a through Step 8.e in order to disassembly the assembly of primary fuel filter (3).
   a. Remove connection (7) and remove O-ring seal (8) (not shown).
   b. Remove connection (11) and remove O-ring seal (9) (not shown).
   c. Remove connection (12) and remove O-ring seal (10) (not shown).
   d. Remove water in fuel sensor (7) and remove O-ring seal (14) (not shown).

e. Remove the filter element from fuel filter canister (13). Refer to Operation and Maintenance Manual, “Fuel System Primary Filter (Water Separator) Element - Replace” for the correct procedure.

Installation Procedure

NOTICE

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

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

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

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

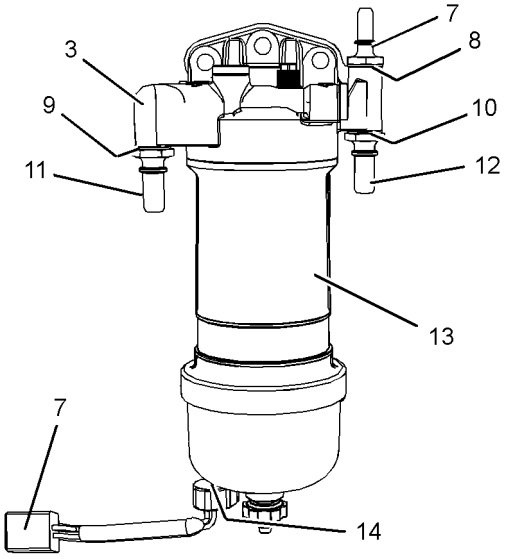


Illustration 18 g02240075

2. If necessary, follow Step 2.a through Step 2.e in order to assembly primary fuel filter (3).

a. Install a new O-ring seal (8) (not shown) to connection (7). Install connection (7) to primary fuel filter (3). Tighten the connection to a torque of 20 N·m (177 lb in).

b. Install a new O-ring seal (9) (not shown) to connection (11). Install connection (11) to primary fuel filter (3). Tighten the connection to a torque of 20 N·m (177 lb in).

c. Install a new O-ring seal (10) (not shown) to connection (12). Install connection (12) to primary fuel filter (3). Tighten the connection to a torque of 20 N·m (177 lb in).

d. Install a new O-ring seal (14) (not shown) to water in fuel sensor (7). Install water in fuel sensor (7) to cannister fuel filter (13). Tighten water in fuel sensor (7) hand tight.

e. Install a new filter element to fuel filter canister (13). Refer to Operation and Maintenance Manual, “Fuel System Primary Filter (Water Separator) Element - Replace” for the correct procedure.

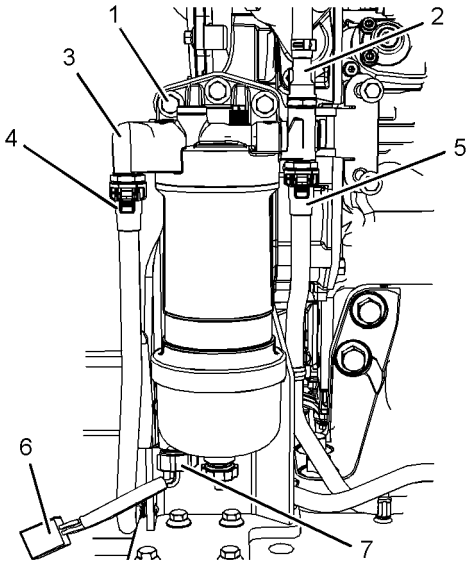


Illustration 19 g02240074

3. Position the assembly of primary fuel filter (3) onto the mounting bracket.

4. Install bolts (1) to the assembly of primary fuel filter (3). Tighten the bolts to a torque of 44 N·m (32 lb ft).

5. 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. Serious damage to the engine will result if contaminated fuel enters the fuel system.

6. Connect plastic tube assembly (2), plastic tube assembly (4), and plastic tube assembly (5) to primary fuel filter (3).

7. Connect the OEM harness assembly to the connection on harness assembly (6) for water in fuel sensor (7).

8. Turn the fuel supply to the ON position.

9. Turn the battery disconnect switch to the ON position.

End By:

a. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203720

Fuel Manifold (Rail) - Remove and Install

Removal Procedure

Table 6

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

Start By:

a. Remove the inlet air control (NRS Induction Mixer) and mounting bracket. Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Remove” for the correct procedure.

b. Remove the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove” for the correct procedure.

⚠ 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 authorized personnel that have the correct training.

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

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

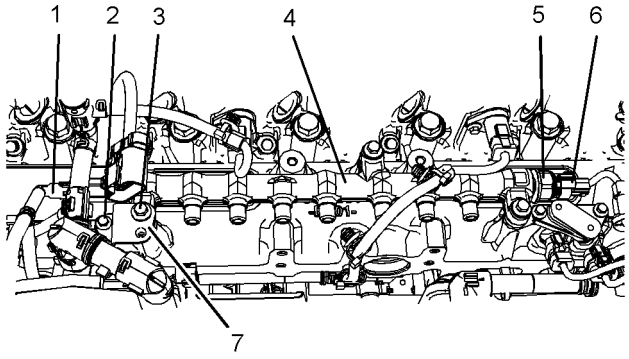


Illustration 20 g02178677

1. Thoroughly clean the area around fuel manifold (4).

2. Disconnect harness assembly (6) from fuel pressure sensor (5).

3. Disconnect plastic tube assembly (1) from the fuel pressure relief valve on fuel manifold (4). Use Tooling (A) to immediately cap the open port in fuel manifold (4) with a new cap. Use Tooling (A) to immediately plug the open end of plastic tube assembly (1) with a new plug.

4. Remove bolt (2) and bolts (3). Remove fuel injection line support bracket (7).

5. Remove fuel manifold (4) from the cylinder head.

6. If necessary, remove the fuel pressure relief valve from fuel manifold (4). Ref to Disassembly and Assembly, “Relief Valve (Fuel) - Remove and Install” for the correct procedure.

Installation Procedure

NOTICE

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

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

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

1. 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 are installed.

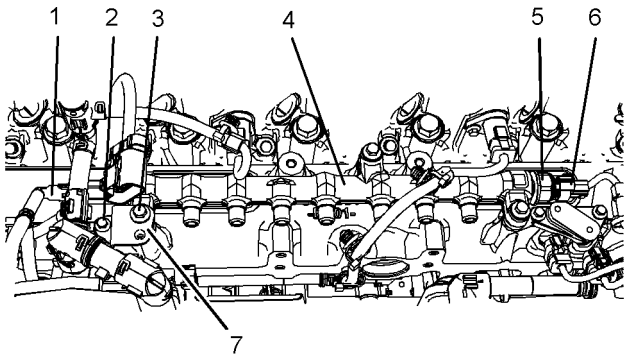


Illustration 21 g02178677

2. If necessary, install the fuel pressure relief valve to fuel manifold (4). Ref to Disassembly and Assembly, "Relief Valve (Fuel) - Remove and Install" for the correct procedure.

3. Position fuel manifold (4) onto the cylinder head. Install bolts (3) to fuel manifold (4) finger tight.

4. Position fuel injection line support bracket (7) onto the fuel rail. Install remaining bolt (3). Install bolt (2) for injection line support bracket (7) finger tight.

5. Install a new set of seals and a new set of fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for the correct procedure.

6. Tighten bolts (3) to a torque of 22 N·m (195 lb in).

7. Tighten bolts (2) to a torque of 9 N·m (80 lb in).

8. Remove the plug from plastic tube assembly (1). Connect plastic tube assembly (1) to the fuel pressure relief valve.

9. Connect harness assembly (6) to fuel pressure sensor (5).

10. Replace the filters for primary fuel system. Refer to Operation and Maintenance Manual, "Fuel System Primary (Water Separator) Element - Replace" for the correct procedure.

11. Replace the filters for secondary fuel system. Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

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

End By:

a. Install the mounting bracket and the inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, "Inlet Air Control (NRS Induction Mixer) - Install" for the correct procedure.

i04203757

Relief Valve (Fuel) - Remove and Install

Removal Procedure

Table 7

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping 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 authorized personnel that have the correct training.

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

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

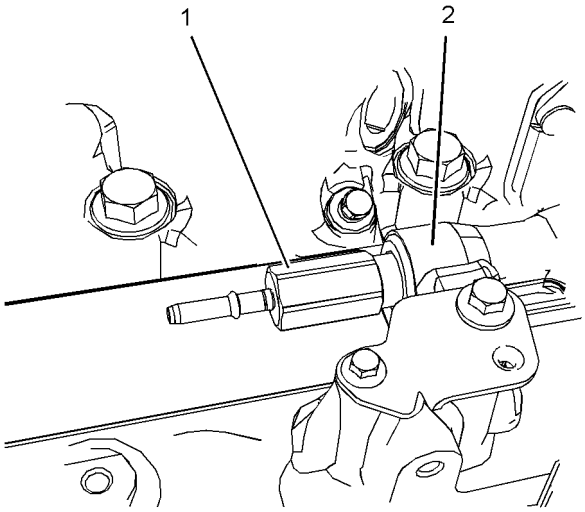


Illustration 22 g02276015

Typical example

1. Thoroughly clean the area around fuel manifold (2) and fuel pressure relief valve (1).

2. Disconnect the plastic tube assembly from fuel pressure relief valve (1) on fuel manifold (2). Use Tooling (A) in order to immediately cap the open port in fuel manifold (2) with a new cap. Tooling (A) in order to immediately plug the open end of the plastic tube assembly with a new plug.

3. Follow Step 3.a through Step 3.c in order to remove the fuel pressure relief valve from the fuel manifold.

   a. Ensure that the area around the fuel pressure relief valve (1) and fuel manifold (2) is still thoroughly clean.

   b. Use a deep socket in order to remove the fuel pressure relief valve (1) from fuel manifold (2).

   c. Use Tooling (A) in order to immediately plug the open port in fuel manifold (2). Use Tooling (A) in order to immediately cap the fuel pressure relief valve (1).

Installation Procedure

NOTICE

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

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

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

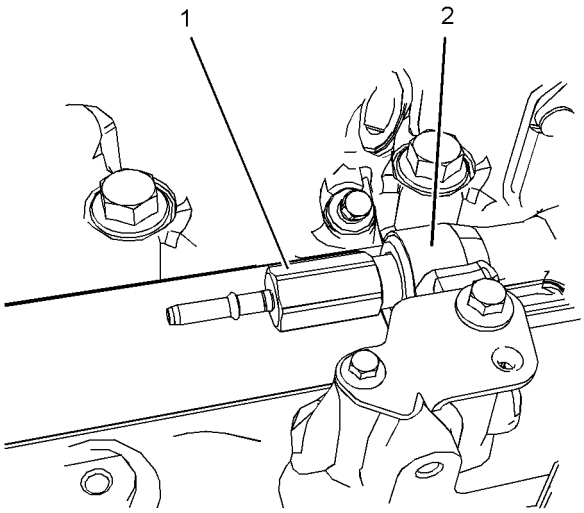


Illustration 23 g02276015

Typical example

1. Follow Step 1.a through Step 1.h in order to install the fuel pressure relief valve to the fuel manifold.

   a. Remove the plug from the port in fuel manifold (2).

   b. Immediately clean the threads in fuel manifold (2) for fuel pressure relief valve (1). Ensure that the thread is clean and free from debris. Ensure that the thread in the fuel manifold (2) is free from damage.

c. Immediately plug the open port in fuel manifold (2) with a new cap after cleaning and inspection.

d. Remove the cap from the threaded end of fuel pressure relief valve (1). lubricate the thread of the pressure relief valve with clean fuel.

e. Remove the plug from the port of fuel manifold (2). Use a deep socket in order to install the fuel pressure relief valve (1) into fuel manifold (2) hand tight.

f. Tighten the fuel pressure relief valve to a snug torque of 30 N·m (266 lb in). Rotate the fuel pressure relief valve in a clockwise direction for an additional 24 degrees in order to achieve the final torque.

g. Remove the cap from fuel pressure relief valve (1) for the plastic tube assembly. Remove the plug from plastic tube assembly to fuel pressure relief valve (1).

h. Connect the plastic tube assembly to fuel pressure relief valve (1).

2. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203722

Fuel Pump (ARD) - Remove and Install

Removal Procedure

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

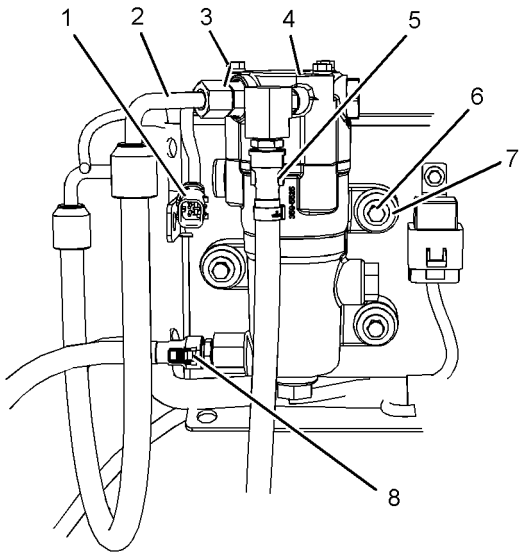


Illustration 24 g02237434

3. Make temporary identification marks on hose tube assemblies in order to show the correct position of the hose tube assemblies. Making temporary identification marks on the hose assemblies will ensure that the hose assemblies are installed in the original positions.

4. Disconnect hose assembly (2) and remove O-ring seal (3) (not shown). Cap the connection on the ARD fuel pump with a new cap. plug the hose assembly with a new plug.

5. Disconnect hose assembly (5) and hose assembly (8). Cap the connections on the ARD fuel pump with new caps. Plug the hose assemblies with new plugs.

6. Slide the locking tab for harness assembly (1) for ARD fuel pump (4) into the unlocked position. Disconnect Original Equipment Manufactures (OEM) harness assembly from harness assembly (1) for ARD fuel pump (4).

7. Remove bolts (6) and washers (7) from ARD fuel pump (4).

8. Remove ARD fuel pump (4) from the mounting bracket.

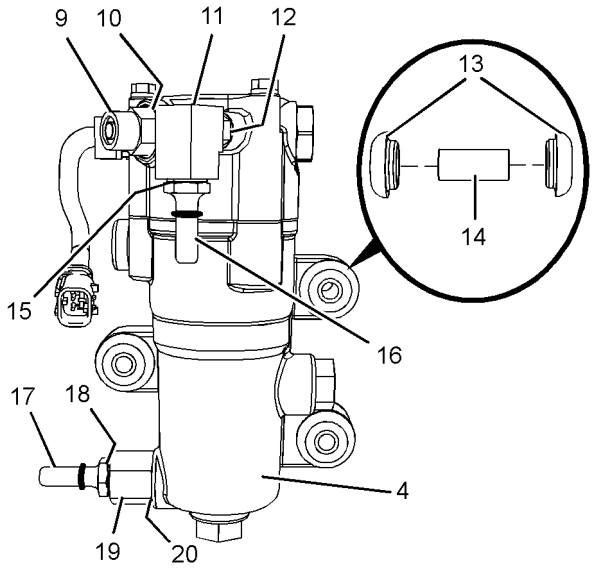


Illustration 25 g02237435

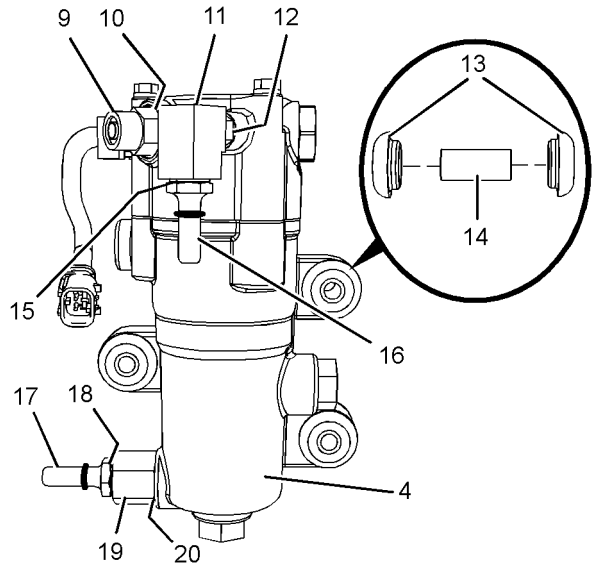


Illustration 26 g02237435

9. If necessary, follow Step 9.a through Step 9.f in order to disassemble fuel pump (4) for the ARD.

a. Remove connection (9) and remove O-ring seal (10) (not shown). Cap the connection and plug the open port of the ARD fuel pump with new plug and cap.

b. Remove connection (16) from adaptor (11). Remove O-ring seal (15) (not shown). Cap the connection and plug the open port of the adaptor with new plug and cap.

c. Remove connection (17) from adaptor (19). Remove O-ring seal (18) (not shown). Cap the connection and plug the open port of the adaptor with new plug and cap.

d. Make temporary identification marks on adaptor (11) in order to show the correct orientation. Remove adaptor (11) and remove O-ring seal (12) (not shown). Cap the connection and plug the open port of the ARD fuel pump with new plug and cap.

e. Remove adaptor (19) and remove O-ring seal (20) (not shown). Cap the adaptor and plug the open port of the ARD fuel pump with new plug and cap.

f. Remove isolation mounts (13) and limit sleeve (14) from ARD fuel pump (4).

Installation Procedure

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

2. If necessary, follow Step 2.a through Step 2.f in order to assemble ARD fuel pump (4).

a. Remove cap from connection (9). Install a new O-ring seal (10) (not shown) to connection (9). Remove plug from ARD fuel pump (4). Install connection (9) to the ARD fuel pump. Tighten the connection to a torque of 25 N·m (221 lb in).

b. Remove cap from adaptor (11). Install a new O-ring seal (12) (not shown) to adaptor (11). Remove plug from ARD fuel pump (4). Install adaptor (11) to the ARD fuel pump. Tighten the adaptor to a torque of 25 N·m (221 lb in).

Note: Ensure that the adaptor is correctly orientated.

c. Remove the cap from connection (16). Install a new O-ring seal (15) (not shown) to connection (16). Remove plug from adaptor (11). Install connection (16) to the adaptor. Tighten the connection to a torque of 25 N·m (221 lb in).

d. Remove cap from adaptor (19). Install a new seal washer (20) (not shown) to adaptor (19). Remove plug from ARD fuel pump (4). Install adaptor (19) to the ARD fuel pump. Tighten the adaptor to a torque of 25 N·m (221 lb in).

e. Remove cap from connection (17). Install a new O-ring seal (18) (not shown) to connection (17). Remove plug from adaptor (19). Install connection (17) to the adaptor. Tighten the connection to a torque of 15 N·m (133 lb in).

f. Install isolation mounts (13) and limit sleeve (14) to ARD fuel pump (4).

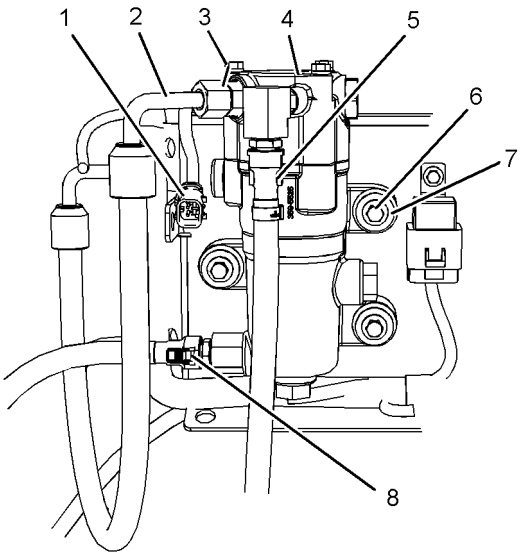


Illustration 27 g02237434

3. Position ARD fuel pump (4) onto the mounting bracket.

4. Install bolts (6) and washers (7) to ARD fuel pump (4). Tighten bolts to a torque of 22 N·m (195 lb in).

5. Remove cap from connection on ARD fuel pump (4). Install a new O-ring seal (3) (not shown) to the connection on ARD fuel pump (4). Remove plug from hose assembly (2). Connect hose assembly (2) and tighten hose assembly securely.

Note: Ensure that the hose assembly is installed in the original position.

6. Remove caps from connections for hose assembly (5) and hose assembly (8). Remove plugs from hose assembly (5) and hose assembly (8).

7. Connect hose assembly (5) and hose assembly (8).

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

8. Connect the OEM harness assembly to harness assembly (1) on ARD fuel pump (4). Slide the locking tab for harness assembly (1) for ARD fuel pump (4) into the locked position.

9. Turn the battery disconnect switch to the ON position.

10. Turn the fuel supply to the ON position.

i04203711

Fuel Control Manifold (ARD) - Remove and Install (Pilot Solenoid Only)

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

3. Cleanliness is an important factor. Thoroughly clean the exterior of the component before commencing the disassembly procedure. Thoroughly cleaning the exterior of the component will help to prevent dirt from entering the internal mechanism.

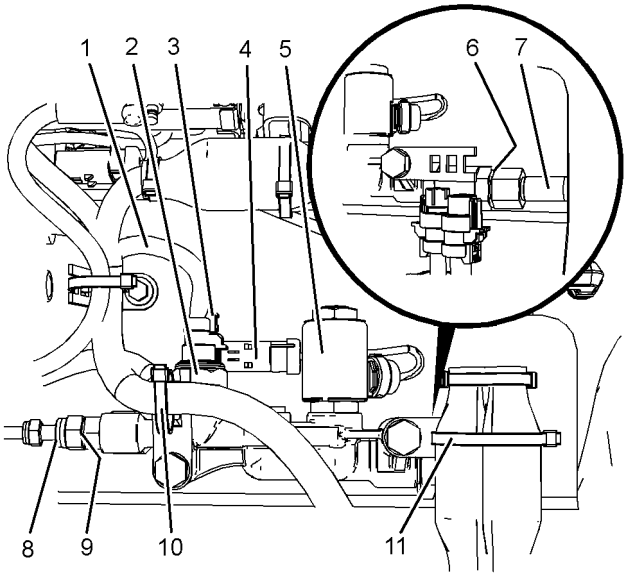


Illustration 28 g02157019

4. Slide locking tab (3) into the unlocked position on connection for harness assembly (1).

5. Disconnect harness assembly (1) from fuel pressure sensors (2).

6. Slide locking tab on connection for harness assembly (4) into the unlocked position.

7. Disconnect harness assembly (4) for solenoid (5).

8. Disconnect hose assembly (8) from the fuel control manifold. Plug the hose assembly with a new plug.

9. Remove O-ring seal (9) (not shown) from the connection on the fuel control manifold. Cap the open connection on the fuel control manifold with a new cap.

10. Disconnect hose assembly (7) from the fuel control manifold. Plug the hose assembly with new plug.

11. Remove O-ring seal (6) (not shown) from the connection on the fuel control manifold. Cap the open connection on the fuel control manifold with a new cap.

12. Cut cable strap (10) and cable strap (11) for the harness assemblies.

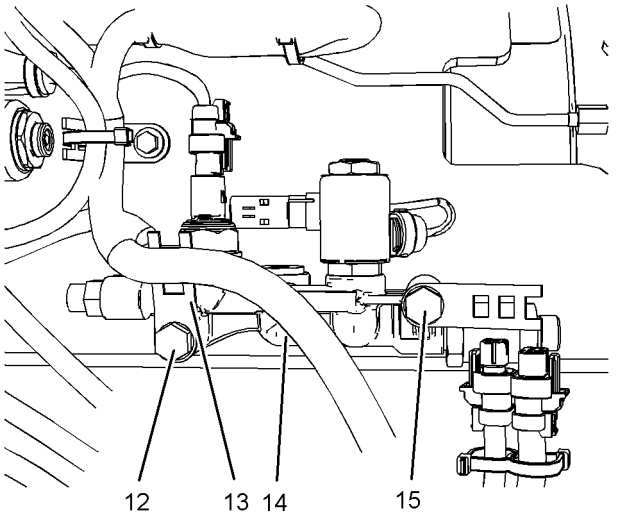


Illustration 29 g02157394

13. Remove bolts (12) from fuel control manifold (14).

Note: Support the fuel control manifold on removal of the bolts.

14. Remove bracket (13) and bracket (15).

Note: Note position and orientation of bracket for installation purposes.

15. Remove fuel control manifold (14) from the bracket for the clean emission module.

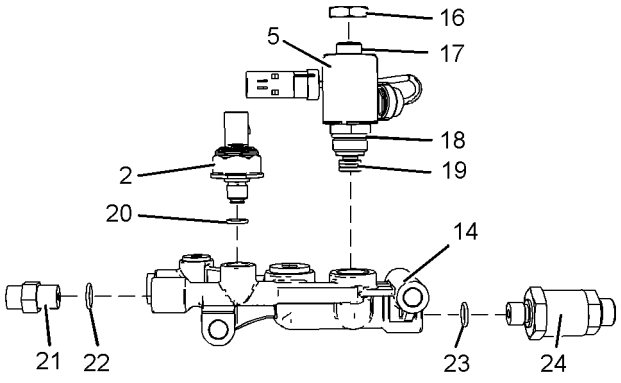


Illustration 30 g02157021

16. If necessary, follow Step 16.a through Step 16.g in order to disassemble fuel control manifold (14).

a. Use a deep socket in order to remove fuel pressure sensor (2) from fuel control manifold (14). Remove O-ring seal (20). Cap the fuel pressure sensor with a new cap. Plug the open port on the fuel control manifold with a new plug.

b. Remove nut (16) from the valve assembly and remove solenoid (5). Use a deep socket in order to remove valve assembly (17) from fuel control manifold (14). Plug the open port on the fuel control manifold with a new plug.

c. Remove O-ring seal (18) and O-ring seal (19). Cap the valve assembly with a new cap.

d. Remove connection (21) from fuel control manifold (14). Plug the open port of the fuel control manifold with new plug.

e. Remove O-ring seal (22). Cap connection (21) with a new cap.

f. Remove connection (24) from fuel control manifold (14). Plug the open port of the fuel control manifold with new plug.

g. Remove O-ring seal (23) from connection (24). Cap the connection with a new cap.

Installation Procedure

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

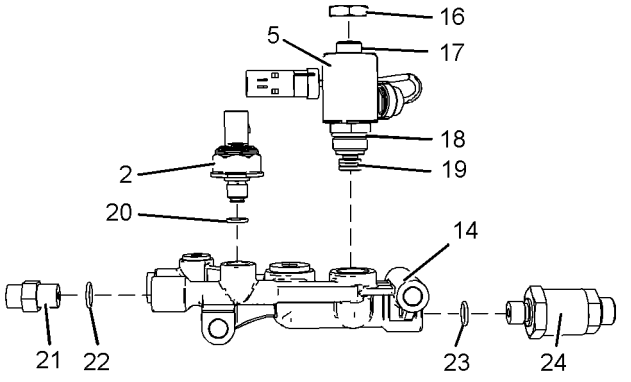


Illustration 31 g02157021

2. If necessary, follow Step 2.a through Step 2.f in order to assemble fuel control manifold (14).

a. Remove the cap from connection (21). Install a new O-ring seal (22) to connection (21). Remove the plug from the fuel control manifold. Install connection (21) to fuel control manifold (14). Tighten the connection to a torque of 43 N·m (32 lb ft).

b. Remove plug from fuel control manifold (14). Install new O-ring seal (23) to connection (24).

c. Install connection (24) to fuel control manifold (14). Tighten connection (24) to a torque of 43 N·m (32 lb ft).

d. Remove the cap from valve assembly (17). Install new O-ring seal (18) and O-ring seal (19) to valve assembly (17). Remove plug from the fuel control manifold. Use a deep socket in order to install valve assembly (17) to fuel control manifold (14). Tighten the valve assembly to a torque of 50 N·m (37 lb ft).

e. Install solenoid (5) to valve assembly (17). Install nut (16). Tighten the nut to a torque of 20 N·m (177 lb in).

f. Remove the cap from fuel pressure sensor (2). Install a new O-ring seal (20) to fuel pressure sensor (2). Remove plug from fuel control manifold (14). Use a deep socket to install the fuel pressure sensor to the fuel manifold. Tighten the fuel pressure sensor to a torque of 20 N·m (177 lb in).

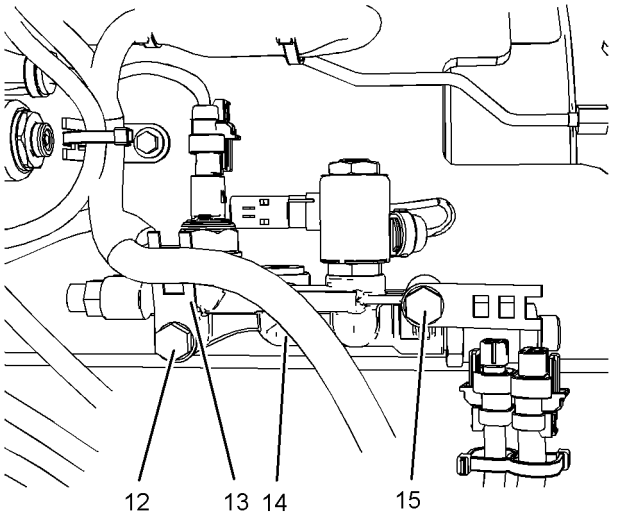


Illustration 32 g02157394

3. Position bracket (13) and bracket (15) onto fuel control manifold (14). Install bolts (12) to fuel control manifold (14).

Note: Ensure the correct position and orientation of the brackets.

4. Position fuel control manifold (14) onto the bracket for the clean emission module. Tighten bolts (12) to a torque of 55 N·m (41 lb ft).

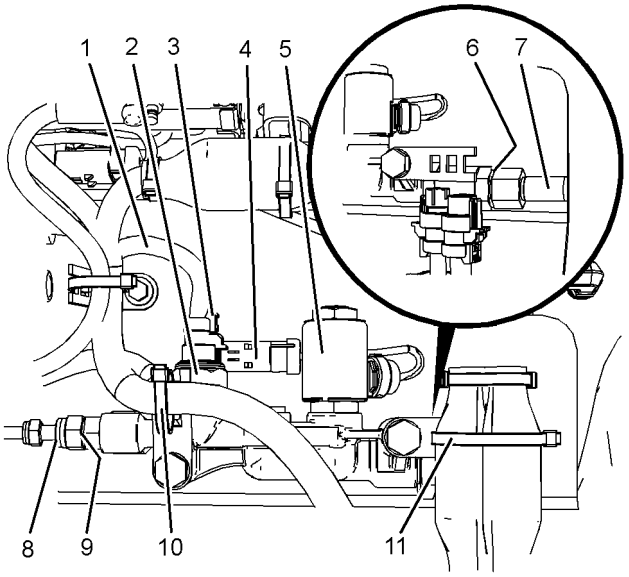


Illustration 33 g02157019

5. Remove cap from hose assembly (8). Flush hose assembly (8). Ensure that the hose assembly is clean and free from restriction.

6. Remove cap from the connection for hose assembly (8). Install new O-ring seal (9) (not shown) to the connection on fuel control manifold (14).

7. Connect hose assembly (8) to fuel control manifold (14). Tighten hose assembly (8) securely.

8. Remove the cap from the connection for hose assembly (7). Install a new O-ring seal (6) (not shown).

9. Remove the plug from hose assembly (7) and flush the hose assembly. Ensure that the hose assembly is clean and free from restriction. Connect hose assembly (7) to the connection on the fuel control manifold. Tighten hose assembly (7) securely.

10. Connect harness assembly (1) to fuel pressure sensors (2). Slide locking tab (3) for harness assembly (1) into the locked position.

11. Connect harness assembly (4) for solenoid (5). Slide locking tab for harness assembly (4) into the locked position.

12. Install new cable strap (10) and new cable strap (11) to the harness assemblies.

Note: Ensure that cable straps meet the OEM specification.

13. Turn the fuel supply to the ON position.

14. Turn the battery disconnect switch to the ON position.

i04203715

Fuel Injection Lines - Remove

Removal Procedure

Table 8

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T41 - 0437	Capping 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 authorized personnel that have the correct training.

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

3. Remove the inlet air control (NRS Induction Mixer) and mounting bracket. Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Remove” for the correct procedure.

4. Remove the crankcase breather cannister and tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

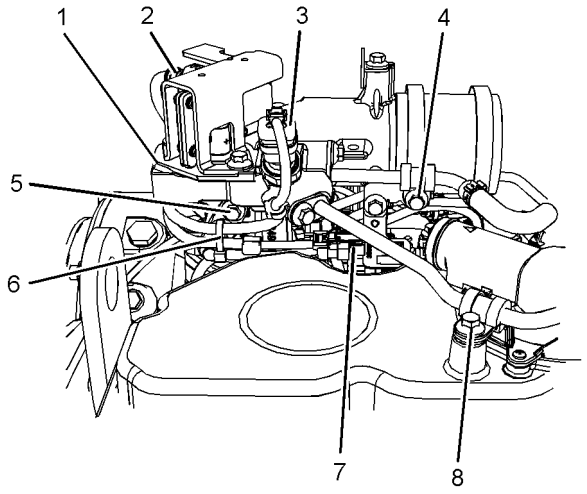


Illustration 34 g02177626

5. Cut cable straps (6) from the wiring harness assemblies.

6. Slide the locking tab for wiring harness connection (2) into the unlocked position. Remove wiring harness connection (2) from the pressure sensor.

7. Slide the locking tab for wiring harness connection (3) into the unlocked position. Remove wiring harness connection (3) from the pressure sensor.

8. Slide wiring harness connection (7) from the mounting bracket and position harness away from the inlet elbow.

9. Remove bolt (4) and bolt (8) from clips for tube assemblies.

10. Remove bolts (5) and remove manifold (1) from the inlet elbow.

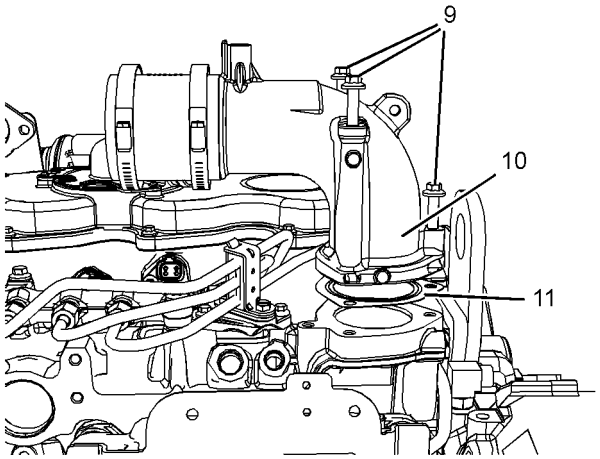


Illustration 35 g02358237

11. Remove bolts (9) and remove inlet elbow (10) from the cylinder head.

12. Remove gasket (11).

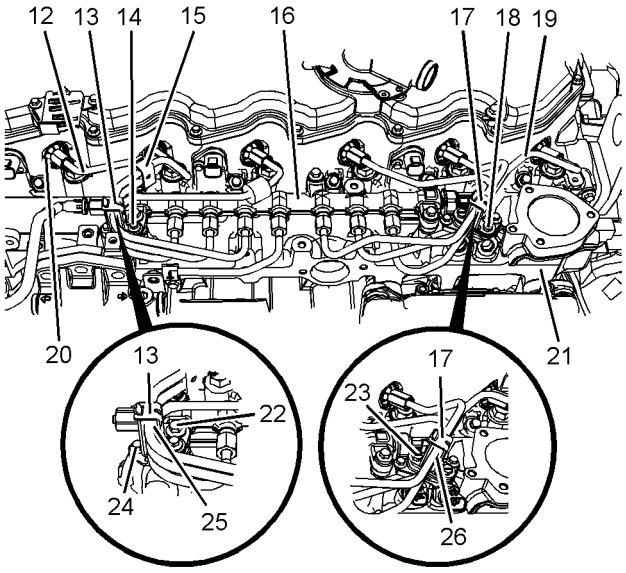


Illustration 36 g02177628

13. Loosen bolt (22) and bolt (24) for tube clamp (13) support bracket.

14. Remove bolt (14) from tube clamp (13). Remove the tube clamp from fuel injection lines (12). Remove rubber separator (25).

15. Use a suitable tool in order to remove tube clamp (15) from fuel injection lines (12).

16. Loosen bolt (23) for tube clamp (17).

17. Remove bolt (18) from tube clamp (17). Remove tube clamp (17) from fuel injection lines (19). Remove rubber separator (26).

18. Clean the area around the nuts for fuel injection lines (12) and fuel injection lines (12). Ensure that the area is free from contamination before beginning disassembly.

19. Disconnect fuel injection line (12) from the electronic unit injector.

20. Disconnect fuel injection line (12) from fuel manifold (16).

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

22. Remove fuel injection line (12). **Discard the fuel injection lines.**

23. Use Tooling (A) in order to plug the open port in fuel manifold (16) immediately.

24. Remove seal (20) from the electronic unit injector and cylinder head (21).

25. Repeat Step 19 through Step 25 in order to remove the remaining fuel injection lines from the fuel manifold to the electronic unit injectors.

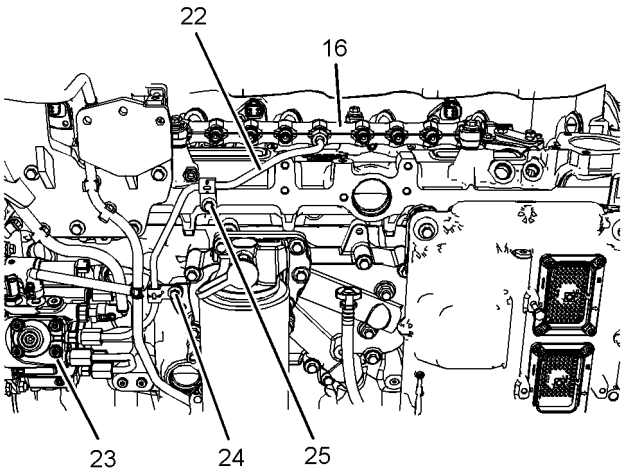


Illustration 37 g02177629

26. Remove bolt (24) and bolt (25) from tube clip for fuel injection line (22).

27. Disconnect fuel injection line (22) from fuel injection pump (23).

28. Disconnect fuel injection line (22) at fuel manifold (16).

29. Remove fuel injection line (22). **Discard the fuel injection lines.**

30. Use Tooling (A) in order to plug all open ports immediately in fuel manifold (16) and in fuel injection pump (23).

i04203714

Fuel Injection Lines - Install

Installation Procedure

Table 9

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	T400030	Injector Pipe Nut Tool	1

NOTICE

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

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

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

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

NOTICE

Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

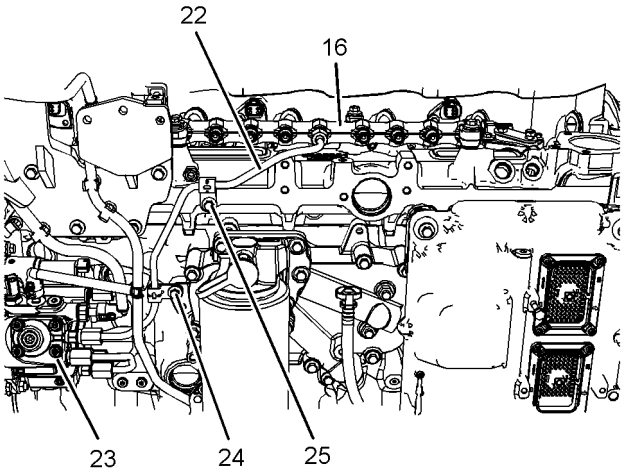


Illustration 38 g02177629

1. Remove plugs from fuel manifold (16) and fuel injection pump (23).
2. Remove the caps from new fuel injection line (22).
3. Position fuel injection line (22) onto fuel injection pump (23) and fuel manifold (16). Loosely install nuts for the fuel injection line onto the fuel manifold and the fuel injection pump.
4. Install bolt (24) and bolt (25) to the tube clip finger tight.
5. Use Tooling (B) to tighten the nuts on fuel injection line (22) to a torque of 40 N·m (30 lb ft).
6. Tighten bolt (24) and bolt (25) to a torque of 10 N·m (88 lb in).

Note: Ensure that fuel injection lines do not contact any other engine component.

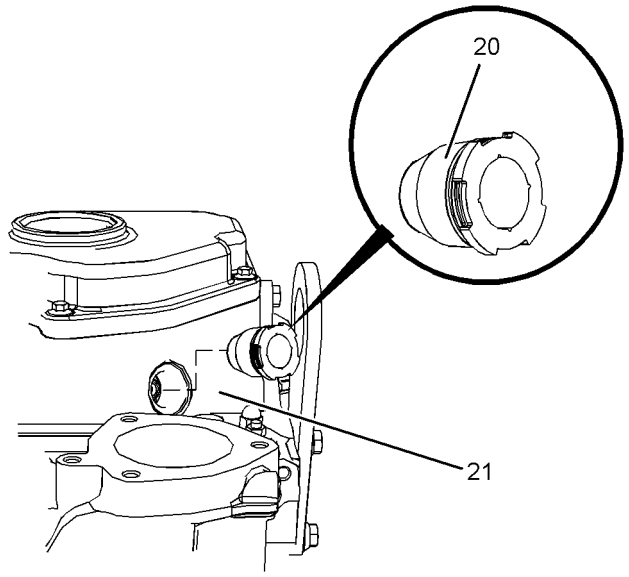


Illustration 39 g02177712

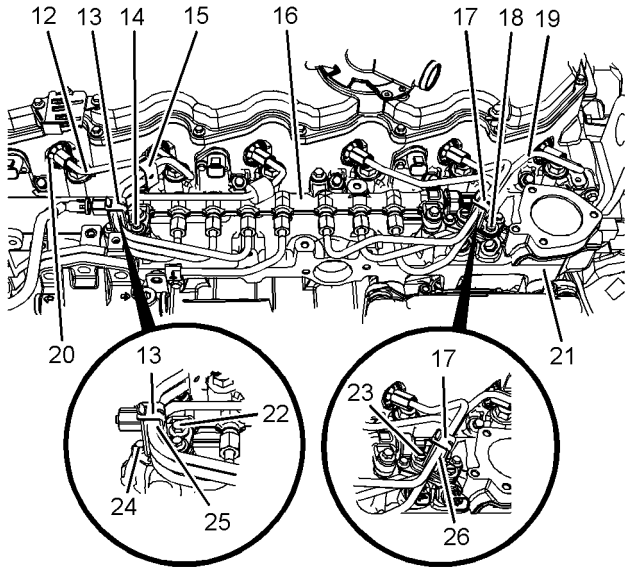


Illustration 40 g02177628

7. Follow Step 7 through Step 15 in order to install fuel injection lines for number one cylinder to number three cylinder.
8. Install new seal (20) to the electronic unit injector and cylinder head (21). Ensure that the flange on the seal is flush with the cylinder head.
9. Remove the caps from the port of the electronic unit injector and from the appropriate port in fuel manifold (16).

10. Loosely connect the nuts at both ends of fuel injection line (12) to the electronic unit injector and to the appropriate port in fuel manifold (16). Ensure that the ends of the fuel injection line are correctly seated in the electronic unit injector and in the fuel manifold.

11. If no further fuel injection lines are to be installed, follow Step 11.a through Step 11.e in order to assemble clamp (13) and clamp (15) for the fuel injection lines.

a. Position rubber separator (25) onto the fuel injection lines.

b. Position clamp (13) and install bolt (14) finger tight.

c. Tighten bolt (24) and bolt (22) finger tight.

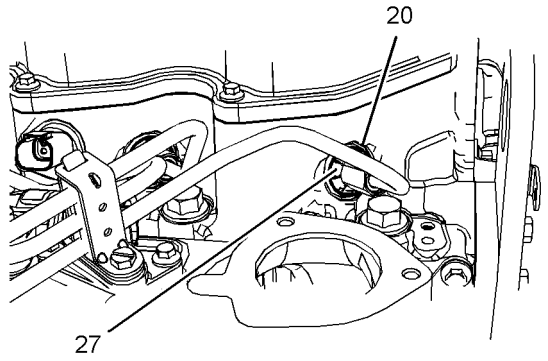


Illustration 41 g02178062

d. Ensure that dust seal (27) is seated correctly against seal (20).

e. Use a suitable tool in order to install tube clamp (15) to fuel injection lines (12).

Note: Ensure that the rubber separator is correctly installed to the fuel injection lines. Ensure that fuel injection lines do not contact any other engine component.

12. Use Tooling (B) to tighten the nuts on fuel injection line (22) to a torque of 40 N·m (30 lb ft).

13. Follow Step 8 through Step 12 in order to install the remaining fuel injection lines.

14. Tighten bolt (14) and bolt (24) for tube clamp (13) to a torque of 10 N·m (88 lb in).

15. Tighten bolt (22) to a torque of 22 N·m (195 lb in).

16. Follow Step 17 through Step 23 in order to install fuel injection lines for number four cylinder to number six cylinder.

17. Install new seal (20) to the electronic unit injector and cylinder head (21). Ensure that the flange on the seal is flush with the cylinder head.

18. Remove the caps from the port of the electronic unit injector and from the appropriate port in fuel manifold (16).

19. Loosely connect the nuts at both ends of fuel injection line (19) to the electronic unit injector and to the appropriate port in fuel manifold (16). Ensure that the ends of the fuel injection line are correctly seated in the electronic unit injector and in the fuel manifold.

20. If no further fuel injection lines are to be installed, follow Step 20.a through Step 20.d in order to assemble clamp (17) for the fuel injection lines.

a. Position rubber separator (26) onto the fuel injection lines.

b. Position clamp (17) and install bolt (18) finger tight.

c. Tighten bolt (23) finger tight.

Note: Ensure that the rubber separator is correctly installed to the fuel injection lines. Ensure that fuel injection lines do not contact any other engine component.

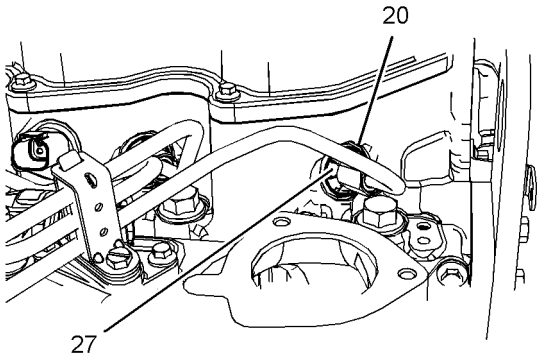


Illustration 42 g02178062

d. Ensure that dust seal (27) is seated correctly against seal (20).

21. Use Tooling (B) to tighten the nuts on fuel injection line (22) to a torque of 40 N·m (30 lb ft).

22. Follow Step 17 through Step 23 in order to install the remaining fuel injection lines.

23. Tighten bolt (23) and bolt (18) for tube clamp (17) to a torque of 10 N·m (88 lb in).

Note: Ensure that the rubber separator is correctly installed to the fuel injection lines.

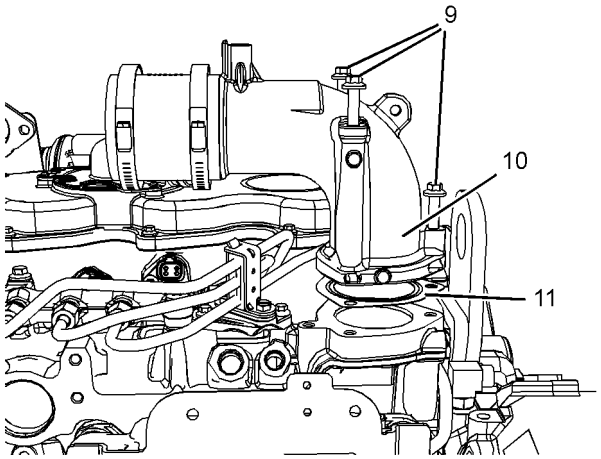


Illustration 43 g02358237

24. Position a new gasket (11) onto the cylinder head.

25. Position inlet elbow (10) onto the cylinder head. Install bolts (9).

26. Tighten bolts (9) to a torque of 22 N·m (195 lb in).

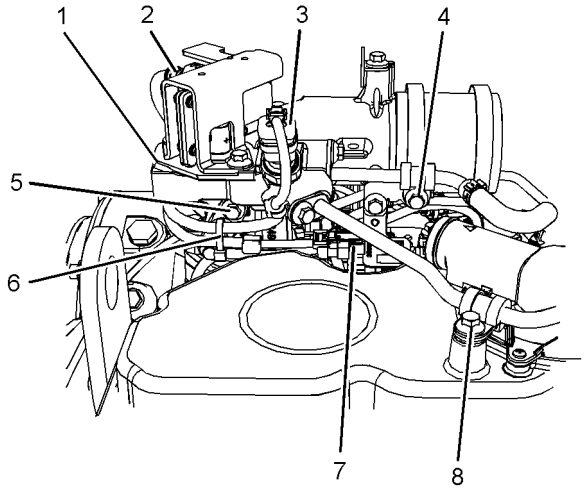


Illustration 44 g02177626

27. Position manifold (1) onto the inlet elbow. Install bolts (5).

28. Tighten bolts (5) to a torque of 22 N·m (195 lb in).

29. Install bolt (4) and bolt (8) to the clips for the tube assemblies. Tighten bolt (4) and bolt (8) to a torque of 22 N·m (195 lb in).

30. Connect wiring harness connection (2) to the pressure sensor. Slide the locking tab for wiring harness connection (2) into the locked position.

31. Connect wiring harness connection (3) to the pressure sensor. Slide the locking tab for wiring harness connection (3) into the locked position.

32. Install new cable straps (6) to the wiring harness assemblies.

33. Install the crankcase breather cannister and tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - Install” for the correct procedure.

34. Install the mounting bracket and inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Install” for the correct procedure.

35. Turn the fuel supply to the ON position.

36. Turn the battery disconnect switch to the ON position.

i04203693

Exhaust Cooler (NRS) - Remove and Install

Removal Procedure

Start By:

a. Remove the second stage turbocharger. Refer to Disassembly and Assembly, “Turbocharger (Second Stage Turbocharger) - Remove” for the correct procedure.

⚠ WARNING

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

Note: Plug or cap all open ports with new plugs or caps.

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

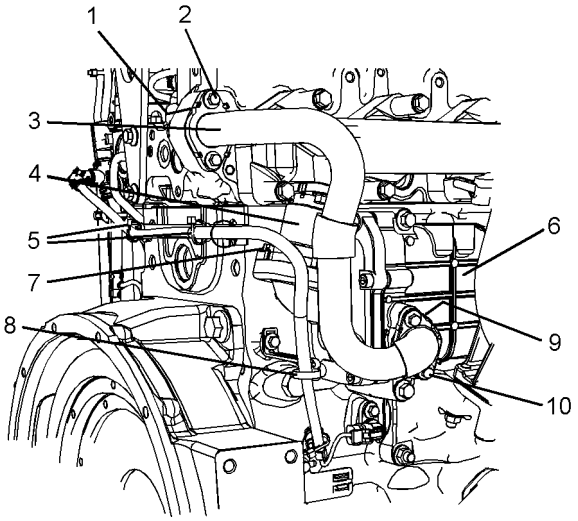


Illustration 45 g02176881

2. Cut cable straps (5) and cable strap (8).

Note: Note the position of cable straps and the type of cable straps.

3. Remove bolts (2) and bolts (10) from tube assembly (3). Remove the tube assembly from NRS exhaust cooler (6) and the cylinder head.

4. Remove gasket (1) (not shown) and gasket (9) (not shown).

5. Prior to and during removal of bolts (7) apply releasing fluid to the bolts. Remove bolts (7) from tube assembly (4).

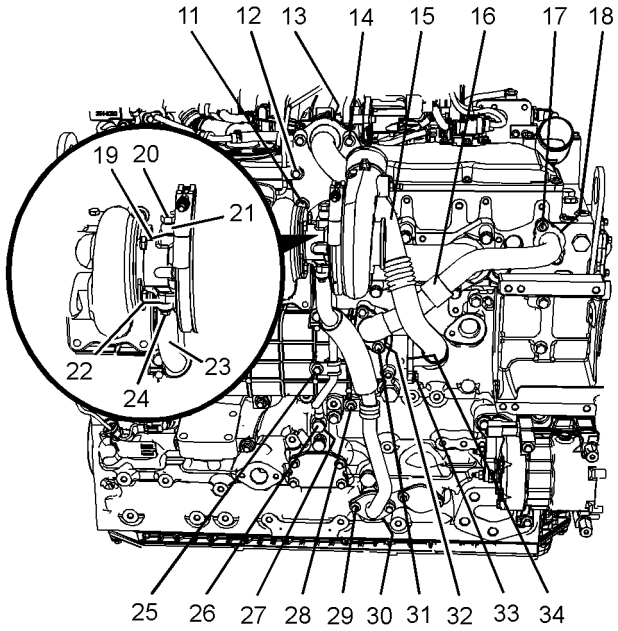


Illustration 46 g02176882

6. Remove bolt (12) from clip for the tube assembly.

7. Loosen bolts (11) for the support bracket. Remove bolts (14) and bolts (33). Remove tube assembly (15) from the NRS exhaust cooler.

8. Remove gasket (13) (not shown) and gasket (34) (not shown).

9. Remove bolts (17) and bolts (31). Remove tube assembly (16) from the NRS exhaust cooler and from the cylinder head.

10. Remove gasket (18) (not shown) and gasket (32) (not shown).

11. Remove banjo bolt (20) from tube assembly (21). Remove sealing washers (19) (not shown).

12. Remove bolt (25) from clip for tube assembly (21).

13. Remove banjo bolt (26) and remove sealing washers (27) (not shown).

14. Remove tube assembly (21) from the turbocharger.

15. Remove bolts (24) and bolts (29) from tube assembly (23).

16. Remove tube assembly (23). Remove gasket (22) (not shown) and gasket (30) (not shown).

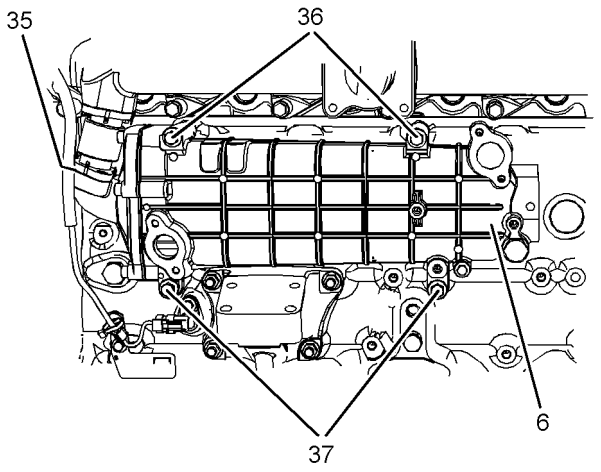


Illustration 47 g02358245

17. Remove bolts (36) and bolts (37) from NRS exhaust cooler (6).

Note: Support the weight of the NRS exhaust cooler as the bolts are removed. Note the position of different length bolts.

18. Remove NRS exhaust cooler (6) from the cylinder block.

19. Remove gasket (35) (not shown).

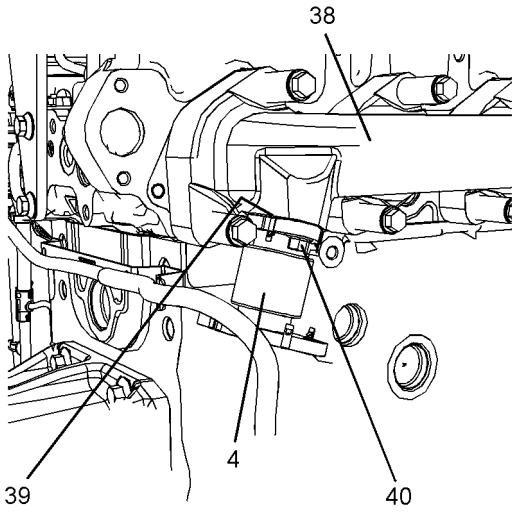


Illustration 48 g02176910

20. Prior to and during removal of bolts (40) apply releasing fluid to the bolts. Remove bolts (40) from exhaust manifold (38).

21. Remove tube assembly (4) and remove gasket (39) (not shown).

Installation Procedure

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

1. Ensure that the NRS exhaust cooler is free from restriction and external damage. Ensure that the NRS exhaust cooler and tube assemblies are free from wear and damage. If necessary, replace any components that are worn or damaged.

Note: The NRS exhaust cooler should not be disassembled or cleaned.

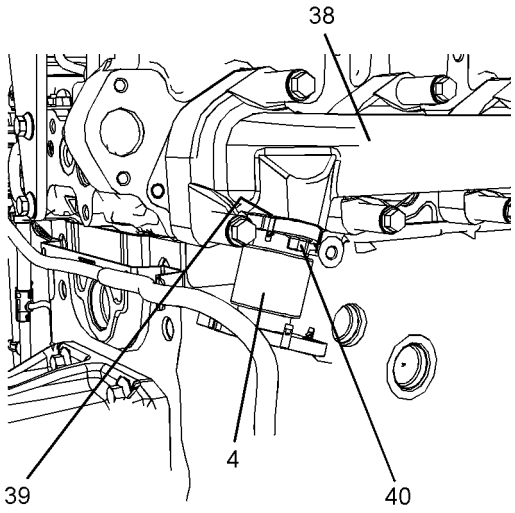


Illustration 49 g02176910

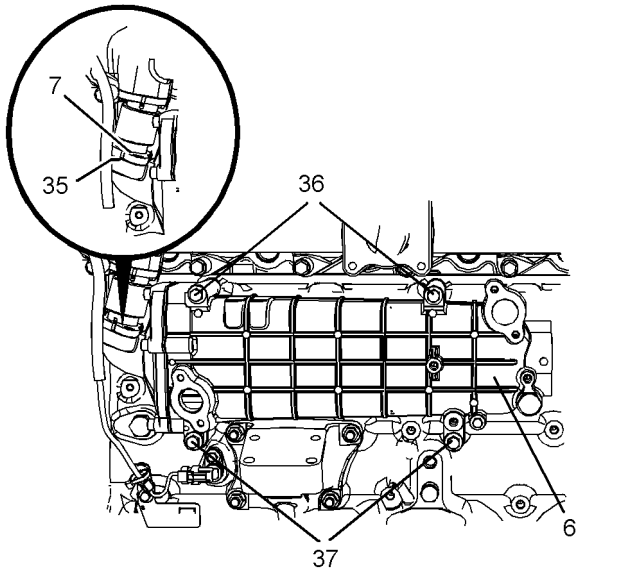


Illustration 50 g02358246

2. Position a new gasket (39) (not shown) onto a new tube assembly (4).

3. Position tube assembly (4) onto exhaust manifold (38). Install new bolts (40) and tighten the bolts ensuring that the tube assembly can still move.

4. Position a new gasket (35) (not shown) onto tube assembly (4).

5. Position NRS exhaust cooler (6) onto the cylinder block. Install bolts (36) and bolts (37) to NRS exhaust cooler (6). Hand tighten bolts (36) and bolts (37).

Note: The NRS exhaust cooler should be supported as the bolts are installed.

6. Install new bolts (7) to tube assembly (4) and tighten the bolts ensuring that the tube assembly can still move.

7. Tighten bolts (36) and bolts (37) to a torque of 44 N·m (32 lb ft).

8. Tighten bolt (7) and bolts (40) to a torque of 22 N·m (195 lb in).

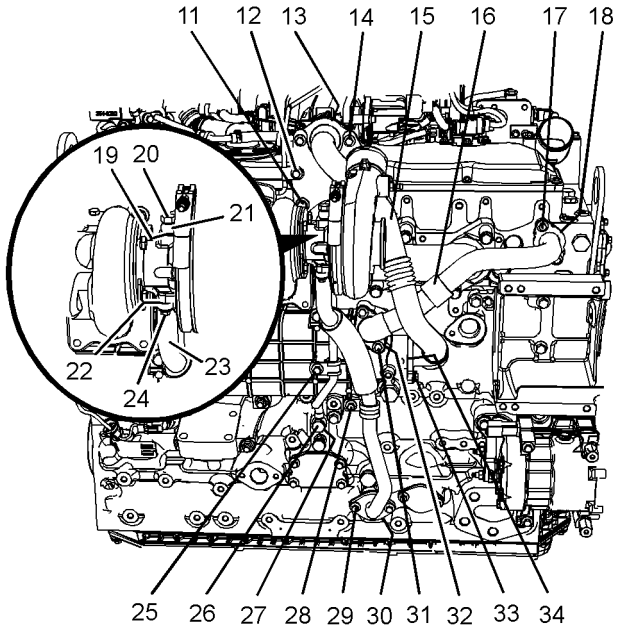


Illustration 51 g02176882

9. Position a new gasket (18) (not shown) and a new gasket (32) (not shown) onto tube assembly (16).

10. Position tube assembly (16) onto the NRS exhaust cooler and the cylinder head. Install bolts (17) and bolts (31) hand tight.

11. Tighten bolts (17) to a torque of 22 N·m (195 lb in).

Tighten bolts (31) to a torque of 18 N·m (159 lb in).

12. Ensure that tube assembly (16) is not stressed as the bolts are tightened.

13. Position a new gasket (13) (not shown) onto Induction mixer.

Note: Ensure that the gasket is correctly installed onto location pins on the Induction mixer.

14. Position a new gasket (34) (not shown) onto tube assembly (15).

15. Position tube assembly (15) between the bracket and Induction mixer and Install bolts (14) finger tight.

16. Position tube assembly (15) onto the NRS exhaust cooler. Install bolts (33) finger tight.

17. Install bolts (12) finger tight to clip for tube assembly.

18. Tighten bolts (33) to a torque of 18 N·m (159 lb in).

19. Tighten bolts (14) to a torque of 18 N·m (159 lb in).

Tighten bolts (11) to a torque of 44 N·m (32 lb ft).

20. Tighten bolt (12) for clip for tube assembly to a torque of 22 N·m (195 lb in).

21. Ensure that tube assembly (15) is not stressed as the bolts are tightened.

22. Remove plugs and caps from tube assemblies. Ensure that tube assembly (21) and tube assembly (23) are clean and free from damage. Replace any damaged components.

23. Position tube assembly (21) onto the turbocharger. Install bolt (25) to clip for tube assembly (21) finger tight.

24. Loosely install banjo bolt (20) and new sealing washers (19) (not shown) to tube assembly (21).

25. Loosely install banjo bolt (26) and new sealing washers (27) (not shown) to tube assembly (21).

26. Tighten banjo bolt (20) to a torque of 15 N·m (133 lb in).

27. Tighten banjo bolt (26) to a torque of 33 N·m (292 lb in).

28. Tighten bolt (25) to a torque of 18 N·m (159 lb in).

29. Position a new gasket (22) (not shown) onto tube assembly (23).

30. Position tube assembly (23) onto turbocharger. Install bolts (24) finger tight.

31. Position a new gasket (30) (not shown) between tube assembly (23) and the cylinder block.

32. Install bolts (29) to tube assembly (23).

33. Install bolt (28) to clip for tube assembly (23).

34. Tighten bolt (29) to a torque of 22 N·m (195 lb in).

35. Tighten bolt (24) to a torque of 9 N·m (80 lb in).

36. Tighten bolt (28) to a torque of 18 N·m (159 lb in).

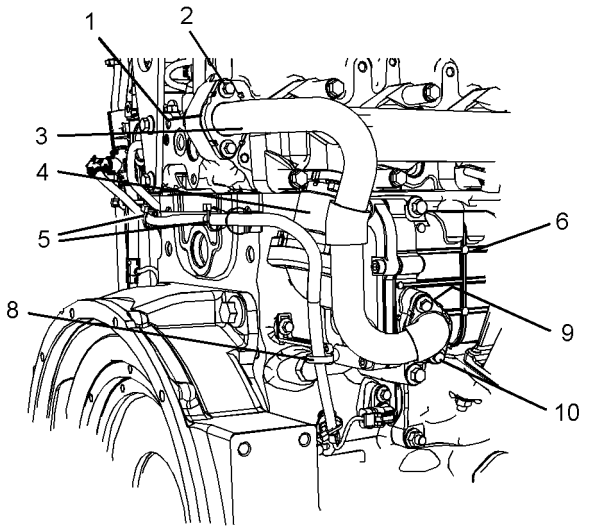


Illustration 52 g02177125

37. Position a new gasket (1) (not shown) and a new gasket (9) (not shown) onto tube assembly (3).

38. Position tube assembly (3) onto NRS exhaust cooler (6) and the cylinder head.

39. Install bolts (2) and bolts (10). Tighten bolts finger tight.

40. Tighten bolts (2) to a torque of 22 N·m (195 lb in).

Tighten bolts (10) to a torque of 18 N·m (159 lb in).

41. Install new cable straps (5) and new cable strap (8).

Note: Ensure that the cable straps meet Original Equipment Manufacturers (OEM) specifications.

42. Install the second stage turbocharger. Refer to Disassembly and Assembly, “Turbocharger (Second Stage Turbocharger) - Remove” for the correct procedure.

43. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

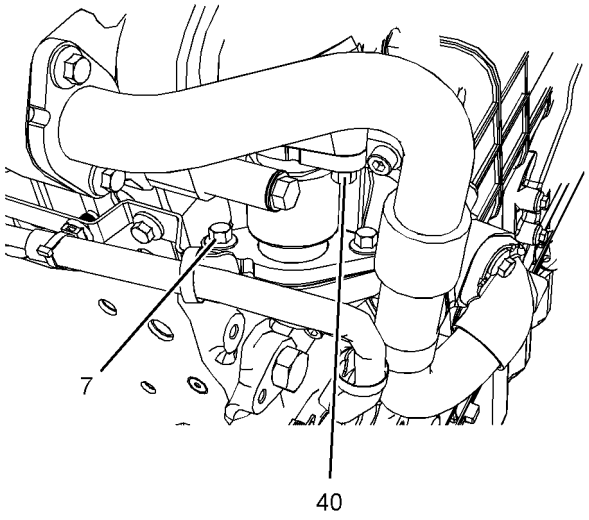


Illustration 53 g02176884

44. After the engine has been operated for 15 minutes, the engine should be stopped. Bolts (7) and bolts (40) should be checked for correct torque. Tighten bolts to a torque of 22 N·m (195 lb in).

i04203741

Inlet Air Control - Remove (NRS Inlet Air Mixer)

Removal Procedure

⚠ WARNING

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

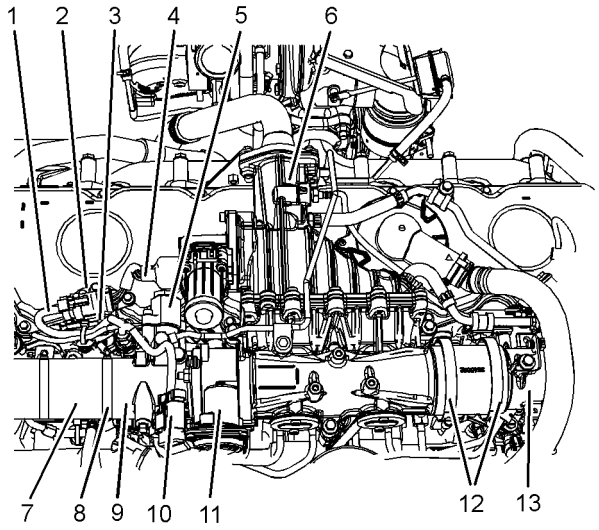


Illustration 54 g02169793

1. Loosen hose clamps (8). Disconnect hose assembly (7) from connection (9) for inlet air control (6).

2. Slide locking tab for engine wiring harness assembly (1) into the unlocked position. Disconnect engine wiring harness assembly (1) from wiring harness assembly (4) for the NRS valve. Slide the connection for wiring harness assembly (4) from bracket (2).

3. Slide locking tab for the engine wiring harness assembly into the unlocked position. Disconnect the engine wiring harness assembly from wiring harness assembly for wastegate solenoid (5). Slide connection for wiring harness assembly for wastegate solenoid (5) from bracket (2).

4. Slide locking tab for engine wiring harness assembly (10) into the unlocked position. Disconnect the engine wiring harness assembly from engine inlet throttle valve (11).

5. Cut all the cable straps in order to allow the engine wiring harness assembly to be positioned away from inlet air control assembly (6).

6. Loosen hose clamps (12) on the hose assembly that connects inlet air control assembly (6) to inlet elbow (13).

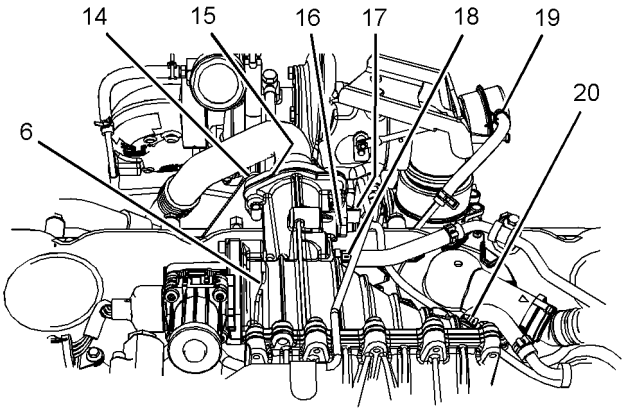


Illustration 55 g02169794

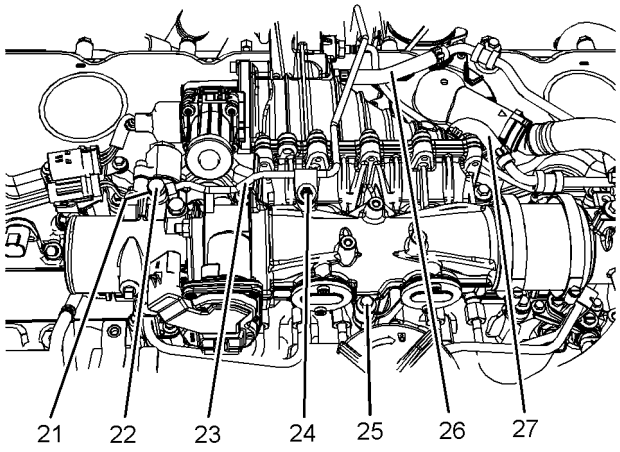


Illustration 56 g02351557

7. Disconnect temperature sensor (16) from the inlet air control assembly. Refer to Disassembly and Assembly, “Temperature Sensor (Cooled Exhaust Gas) - Remove and Install” for the correct procedure.

8. Slide clip (19) along the hose assembly. Remove the hose assembly from the wastegate actuator.

9. Loosen banjo bolt (22) for tube assembly (23).

10. Remove bolt (17) (not shown) and bolt (24) from tube assembly (23).

11. Remove banjo bolt (22) and remove sealing washers (21) (not shown).

12. Remove tube assembly (23) from inlet air control assembly (6).

13. remove hose clamp (18) and hose clamp (20). Remove hose assembly (26) and hose assembly (27) from the connections on inlet air control assembly (6).

14. Remove bolts (14) and remove bolts (25).

15. Remove inlet air control assembly (6).

16. Remove gasket (15) (not shown) from inlet air control assembly (6).

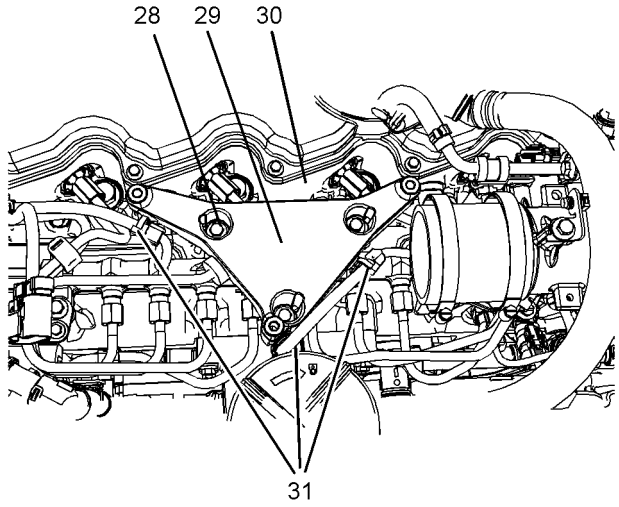


Illustration 57 g02169795

17. If necessary, follow Step 17.a through Step 17.c in order to remove bracket (29).

a. Cut cable straps (31).

b. Remove bolts (28).

c. Remove bracket (29) from cylinder head (30).

i04203740

Inlet Air Control - Install (NRS Inlet Air Mixer)

Installation Procedure

⚠ WARNING

Sulfuric Acid Burn Hazard may cause serious personal injury or death.

The exhaust gas cooler may contain a small amount of sulfuric acid. The use of fuel with sulfur levels greater than 15 ppm may increase the amount of sulfuric acid formed. The sulfuric acid may spill from the cooler during service of the engine. The sulfuric acid will burn the eyes, skin and clothing on contact. Always wear the appropriate personal protective equipment (PPE) that is noted on a material safety data sheet (MSDS) for sulfuric acid. Always follow the directions for first aid that are noted on a material safety data sheet (MSDS) for sulfuric acid.

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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 and damage. If necessary, replace any components that are worn or damaged.

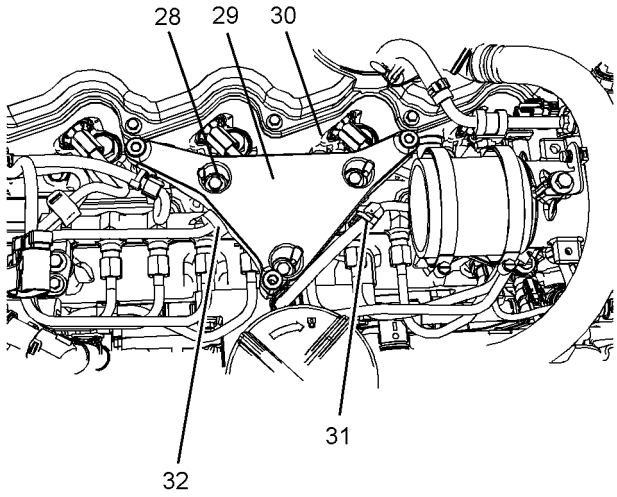


Illustration 58 g02173073

2. If necessary, follow Step 2.a through Step 2.d in order to install bracket (29).
   a. Position bracket (29) onto cylinder head (30).
   b. Install bolts (28) hand tight. Ensure that rubber sleeve (32) is correctly positioned into recess of bracket (29).
   c. Tighten bolts (28) to a torque of 22 N·m (195 lb in).
   d. Install new cable straps (31).

Note: Ensure that the cable straps meet Original Equipment Manufacturers (OEM) specification.

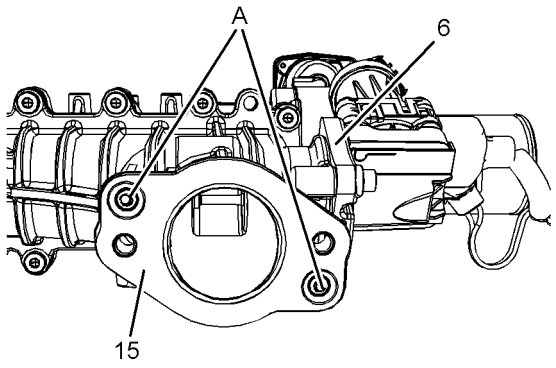


Illustration 59 g02169940

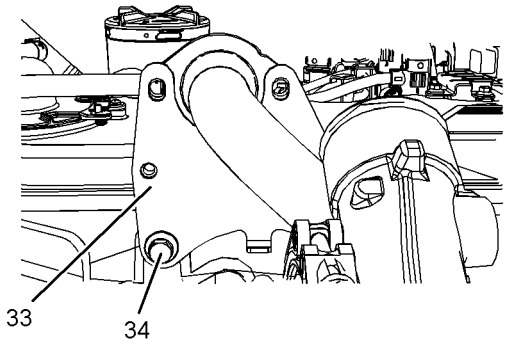


Illustration 60 g02169941

3. Position a new gasket (15) onto inlet air control assembly (6). Ensure gasket (15) is correctly installed into locating Pins (A).

4. Loosen bolts (34) for bracket (33).

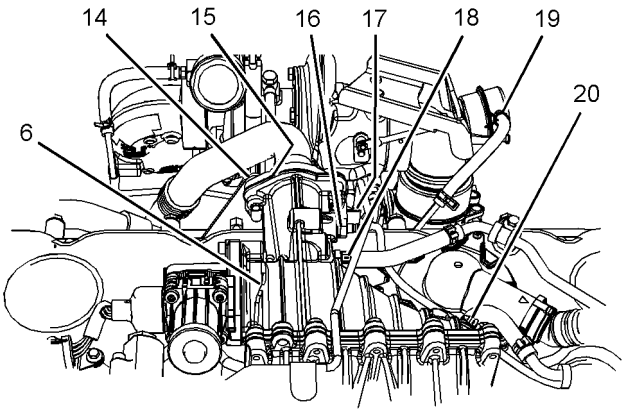


Illustration 61 g02169794

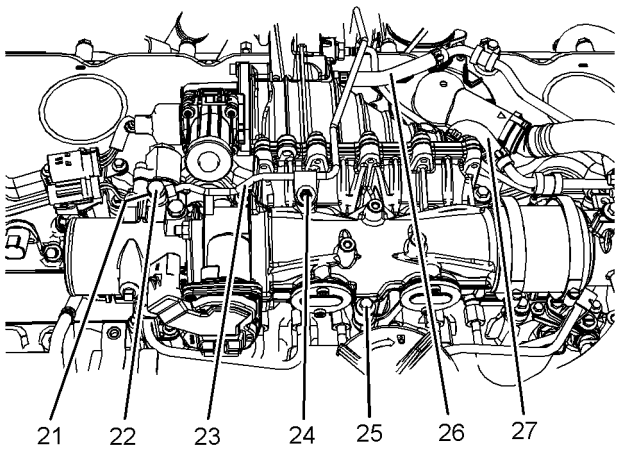


Illustration 62 g02351557

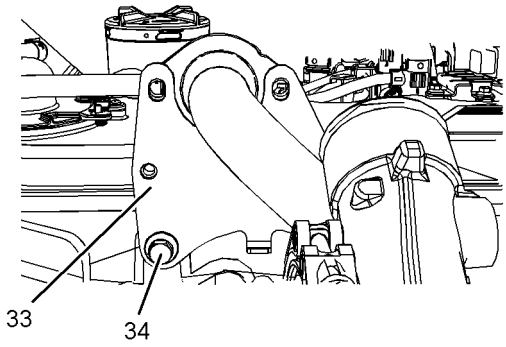


Illustration 63 g02169941

5. Position inlet air control assembly (6) onto bracket.

Note: Ensure that the inlet air control assembly is correctly installed onto hose assembly for the inlet elbow.

6. Install bolts (25) and bolts (14) hand tight.

7. Tighten bolts (25) to a torque of 22 N·m (195 lb in).

8. Tighten bolts (14) to a torque of 22 N·m (195 lb in).

9. Tighten bolts (34) for bracket (33) to a torque of 44 N·m (32 lb ft).

10. Connect temperature sensor (16) to the inlet air control assembly. Refer to Disassembly and Assembly, “Temperature Sensor (Cooled Exhaust Gas) - Remove and Install” for the correct procedure.

11. Install a new sealing washer (20) (not shown) to banjo bolt (22). Install banjo bolt (22) to tube assembly (23).

12. Position tube assembly (23) onto inlet air control assembly (6). Install install remaining new sealing washer (20) (not shown) to banjo bolt (22). Install banjo bolt (22) finger tight.

13. Install bolt (17) (not shown) and bolt (25) to clips for tube assembly (23).

14. Tighten banjo bolt (21) to a torque of 15 N·m (133 lb in).

15. Tighten bolt (17) (not shown) and bolt (25) to a torque of 22 N·m (195 lb in).

16. Install hose assembly onto turbocharger wastegate actuator and slide clip (19) along hose assembly.

Note: Ensure that clip for hose assembly is correctly positioned onto the hose assembly.

17. Position a new hose clamp (17) and a new hose clamp (19) onto hose assembly (26) and hose assembly (27).

18. Install hose assembly (26) and hose assembly (27) to the connections on the inlet air control assembly (6).

19. Tighten hose clamp (17) and hose clamp (19) securely.

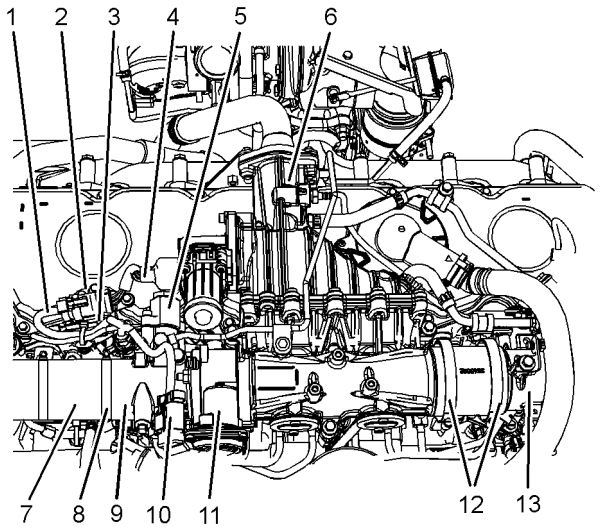


Illustration 64 g02169793

20. Connect hose assembly (7) to inlet connection (19) for inlet air control (6). Tighten hose clamps (8) to a torque of 6 N·m (53 lb in).

21. Tighten hose clamps (12) for the hose assembly that connects inlet air control assembly (6) to inlet elbow (13). Tighten the hose clamps to a torque of 6 N·m (53 lb in).

22. Slide connection for wiring harness assembly for wastegate solenoid (5) onto bracket (2). Connect the engine wiring harness assembly to wiring harness assembly for wastegate solenoid (5). Slide locking tab in to the locked position.

23. Slide connection for wiring harness assembly (4) onto bracket (2). Connect engine wiring harness assembly (1) to wiring harness assembly (4) for the NRS valve. Slide locking tab in to the locked position

24. Connect engine wiring harness assembly (10) to engine inlet throttle valve (11). Slide locking tab in to the locked position.

25. Install new cable straps to engine wiring harness assemblies. Ensure that all cable straps are installed to the harness assemblies.

Note: Ensure that the cable straps meet OEM specification.

i04203766

Throttle Valve (Intake Air) - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Turn the battery disconnect switch to the OFF position.

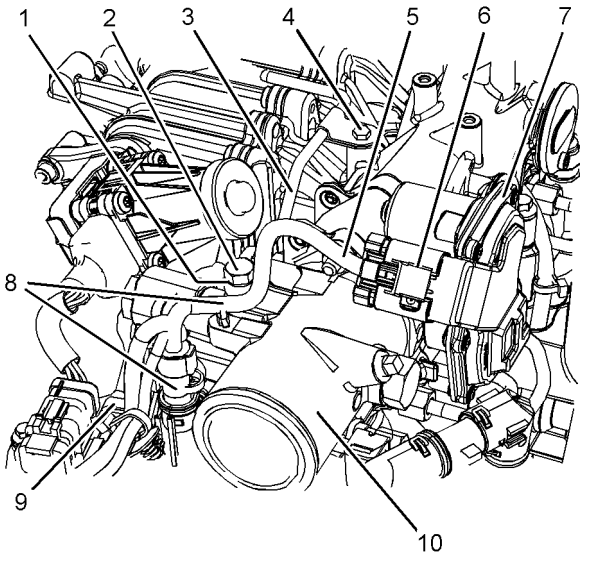


Illustration 65 g02361636

2. Disconnect hose assembly from inlet connection (10).

3. Remove banjo bolt (2) and remove sealing washers (1) (not shown). Remove bolt (4) from clip for tube assembly (3).

4. Slide locking tab (6) into the unlocked position. Disconnect harness assembly (5) for throttle valve (7).

5. Slide the locking tab for harness assembly (9) for the wastegate solenoid into the unlocked position. Disconnect harness assembly (9) for the wastegate solenoid. Slide connection for harness assembly (9) for the wastegate solenoid from the bracket.

6. Cut cable straps (8) and position harness assembly (5) and harness assembly (9) for the wastegate solenoid away from throttle valve (7).

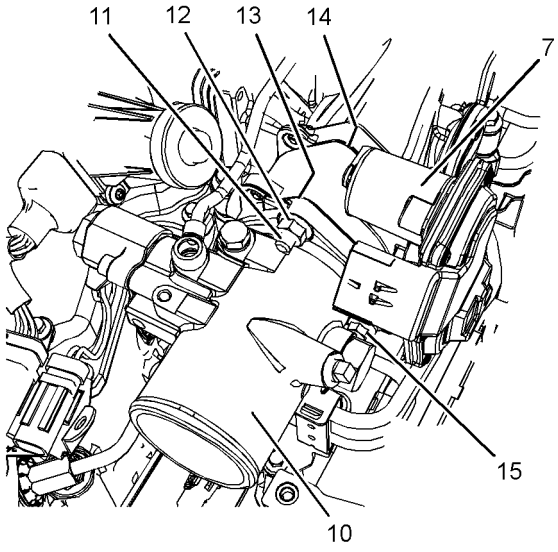


Illustration 66 g02161585

7. Remove bolts (15) and nut (12).

8. Remove inlet connection (10) and gasket (13) (not shown).

9. Remove throttle valve (7). Remove gasket (14) (not shown).

10. If necessary, remove stud (11).

i04203765

Throttle Valve (Intake Air) - Install

Installation Procedure

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

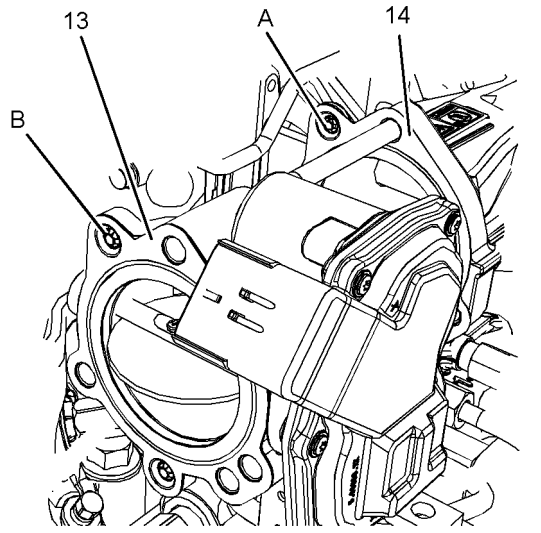


Illustration 67 g02162080

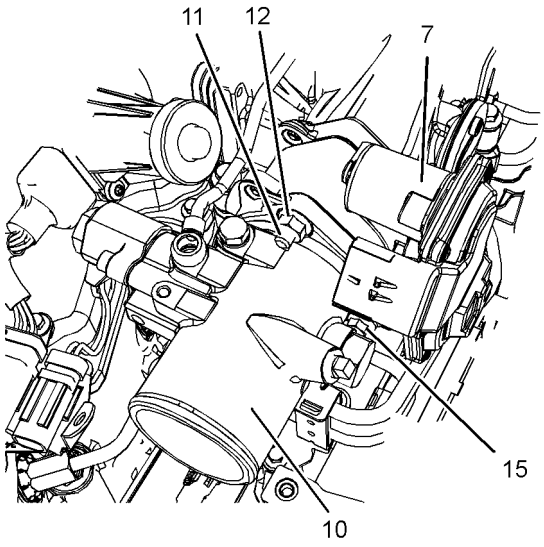


Illustration 68 g02162079

1. Ensure that throttle valve (7) assembly is clean and free from wear and damage. If necessary, replace the throttle valve assembly.

2. If necessary, install stud (11). Tighten the stud to a torque of 11 N·m (97 lb in).

3. Position a new gasket (14) onto inlet air control. Ensure that gasket serrations are correctly located onto locating Pins (A) on the inlet air control.

4. Position a new gasket (13) throttle valve (7) assembly . Ensure that gasket serrations are correctly located onto locating Pins (B) on the throttle valve assembly.

5. Install throttle valve (7) onto inlet air control.

6. Install inlet connection (10) onto throttle valve (7) assembly.

7. Install nut (12) and bolts (15). Tighten the nut and the bolts to a torque of 18 N·m (159 lb in).

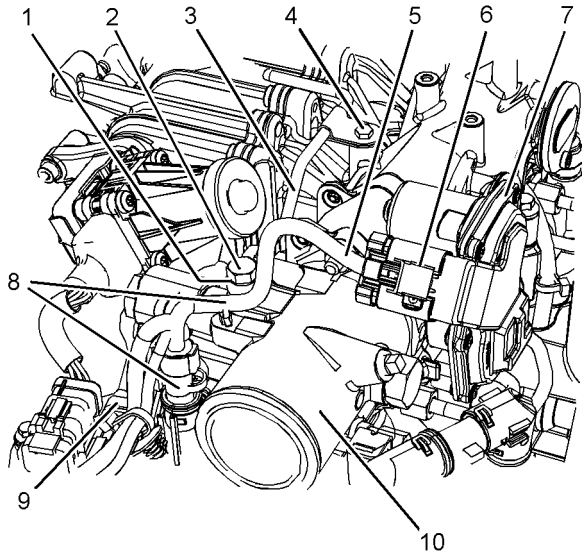


Illustration 69 g02361636

8. Position new sealing washers (1) (not shown) onto banjo connection for tube assembly (3) and install banjo bolt (2) to tube assembly (3).

9. Install bolt (4) to clip for tube assembly (3).

10. Tighten bolts (4) to a torque of 18 N·m (159 lb in).

11. Tighten banjo bolt (2) to a torque of 15 N·m (133 lb in).

12. Connect harness assembly (5) to throttle valve assembly (7). Slide locking tab (6) into the locked position.

13. Slide connection for the harness assembly (9) for wastegate solenoid onto the bracket. Connect harness assembly (9) for wastegate solenoid. Slide locking tab for harness assembly (9) into the locked position.

14. Install new cable straps (8) to harness assembly (5).

Note: Ensure that cable straps meet the Original Equipment Manufacturers (OEM) specification.

15. Connect hose assembly to inlet connection (10) and tighten the hose clamps to a torque of 6 N·m (53 lb in).

16. Turn the battery disconnect switch to the ON position.

i04203717

Fuel Injection Pump - Remove

Removal Procedure

Table 10

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1
D	T410437	Capping Kit	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. If necessary, remove the fuel filter base. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure .

b. If necessary, remove the fuel priming pump. Refer to Disassembly and Assembly, “Fuel Priming Pump - Remove” for the correct procedure.

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 authorized personnel that have the correct training.

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

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

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

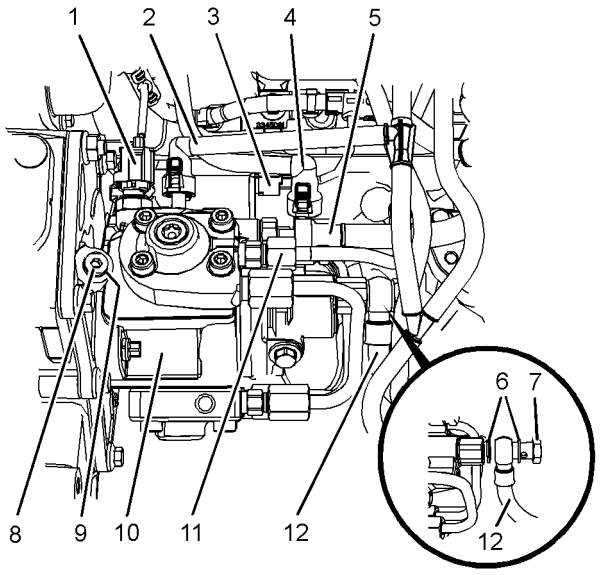


Illustration 70 g01967536

3. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center position . Refer to System Operation, Testing and Adjusting, “Fuel Injection Timing - Check”. Use Tooling (B) in order to lock the crankshaft so that number one piston is at top dead center position.

4. Remove plug (8) and remove O-ring seal (9) (not shown). Use Tooling (C) in order to lock fuel injection pump (10).

5. Place a suitable container below fuel injection pump (10) in order to catch any fuel that might be spilled.

6. Clean fuel injection pump (10) and the area around the fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.

7. Loosen banjo bolt (7) in order to drain fuel from the fuel system. Remove banjo bolt (7). Remove sealing washers (6) and disconnect hose assembly (12) from fuel injection pump (10). Use Tooling (D) in order to plug the tube assembly with a new plug. Cap the port in the fuel injection pump with a new cap.

8. Disconnect plastic tube assembly (2), plastic tube assembly (4), and plastic tube assembly (5) from fuel injection pump (10).

9. Use Tooling (D) in order to plug the plastic tube assemblies. Cap the ports in the fuel injection pump with new caps.

10. Disconnect harness assembly (3) from the solenoid on fuel injection pump (10).

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

11. Disconnect harness assembly (1) from the sensor on fuel injection pump (10).

12. Remove fuel injection line (11) that connects fuel injection pump (10) to the fuel manifold. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove” for the correct procedure.

Note: Discard the fuel injection line.

13. Use Tooling (D) in order to plug the open ports in the fuel injection pump and in the fuel manifold.

14. If necessary, remove the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.

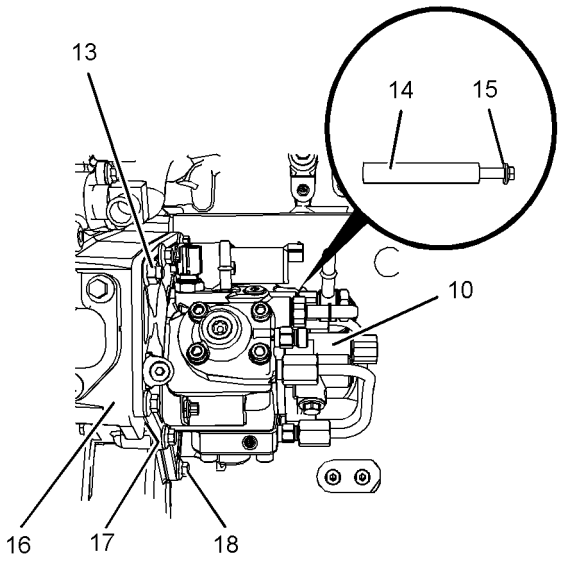


Illustration 71 g01967538

15. Remove nuts (13) and bolts (18) from fuel injection pump (10).

16. Remove Bolt (15) and spacer (14) from fuel injection pump (10).

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

17. Carefully remove fuel injection pump (10) from front housing (16).

18. Remove gasket (17) (not shown).

19. If necessary, remove the fuel injection pump gear and adaptor plate. Refer to Disassembly and Assembly, “Fuel Injection Pump Gear - Remove” for the correct procedure.

i04203716

Fuel Injection Pump - Install

Installation Procedure

Table 11

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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 authorized personnel that have the correct training.

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

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

NOTICE

Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

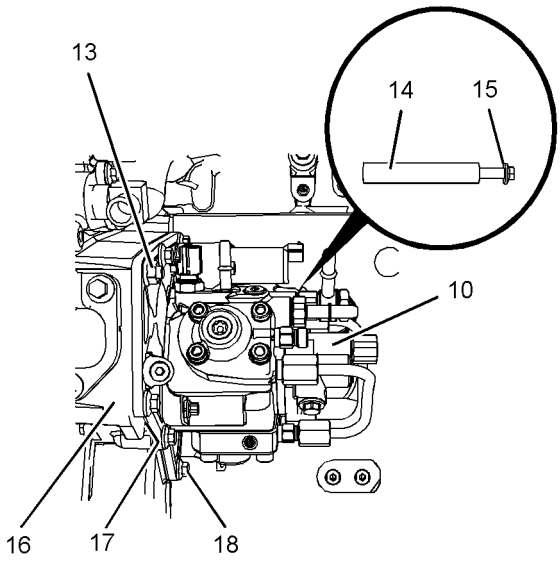


Illustration 72 g01967538

1. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check". Use Tooling (B) in order to lock the crankshaft so that number one piston is at top dead center position.

2. If necessary, install Tooling (C) in order to lock the fuel injection pump in the correct position.

3. Position a new gasket (17) (not shown) onto front housing (16).

4. Position bolt (15) and spacer (14) onto fuel injection pump (10).

5. Carefully install fuel injection pump (10) to front housing (16). Ensure that the bore in front housing (16) is not damaged as the fuel injection pump is installed.

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

6. Tighten bolt (15) for fuel injection pump (10) finger tight.

7. Install nut (13) to fuel injection pump (10) finger tight.

8. Install new bolts (17) to fuel injection pump (10) finger tight.

9. Tighten bolts (17) and bolts (15) to a torque of 22 N·m (195 lb in).

   Tighten nut (13) to a torque of 22 N·m (195 lb in).

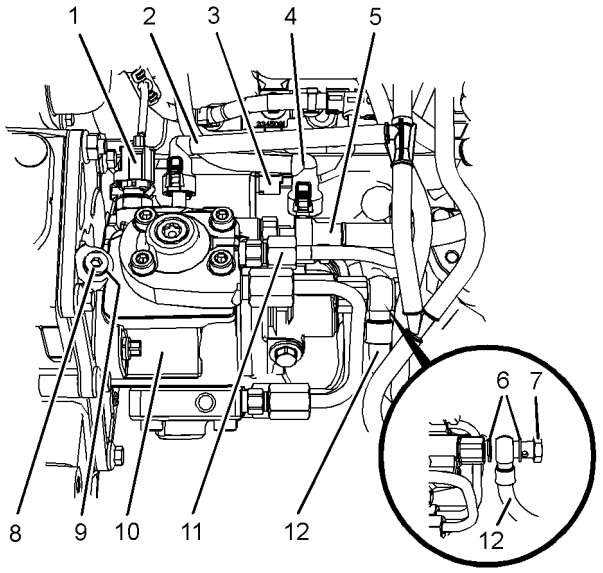


Illustration 73 g01967536

10. Remove Tooling (C) from fuel injection pump (10). Install a new O-ring seal (9) (not shown) to plug (8).

11. Remove Tooling (B) from the cylinder block. Install a new O-ring seal to the plug for the cylinder block. Install the plug to the cylinder block. Tighten the plug to a torque of 21 N·m (186 lb in).

12. Install plug (8) to fuel injection pump (10). Tighten the plug to a torque of 14 N·m (124 lb in).

13. Remove the appropriate caps in order to install fuel injection line (11). Install a new fuel injection line (11) to the fuel injection pump and to the fuel manifold. Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

14. Connect harness assembly (1) to the sensor on fuel injection pump (10).

15. Connect harness assembly (3) from the solenoid on fuel injection pump (10).

16. Remove the appropriate plugs and caps in order to install plastic tube assembly (2), plastic tube assembly (4), and plastic tube assembly (5).

17. Connect plastic tube assembly (2), plastic tube assembly (4), and plastic tube assembly (5) to fuel injection pump (10).

18. Remove the appropriate plugs and caps in order to install hose assembly (12).

19. Install a new sealing washer (6) to banjo bolt (7). Install the banjo bolt to hose assembly (12). Install the remaining new sealing washer (6) to banjo bolt (7) after the banjo bolt is installed to the hose assembly.

20. Install hose assembly (12) to fuel injection pump (10) and tighten banjo bolt (7) finger tight.

21. Tighten banjo bolt (7) to a torque of 22 N·m (195 lb in).

22. If necessary, install the fuel priming pump. Refer to Disassembly and Assembly, “Fuel Priming Pump - Remove and Install”.

23. If necessary, install the fuel filter base. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.

24. Replace the filters for primary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Primary (Water Separator) Element - Replace” for the correct procedure.

25. Replace the filters for secondary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

26. Turn the fuel supply to the ON position.

27. Turn the battery disconnect switch to the ON position.

28. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

End By:

a. After replacement of the fuel injection pump, the fuel injection pump requires a high-pressure fuel pump calibration procedure to be performed. Refer to Troubleshooting, “Fuel Rail Pressure Problem” for the correct procedure.

i04203719

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 12

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Puller (Two Legged)	1
B	-	E10 Torx Socket 1/4" Square Drive	1

Start By:

a. Remove the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” 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.

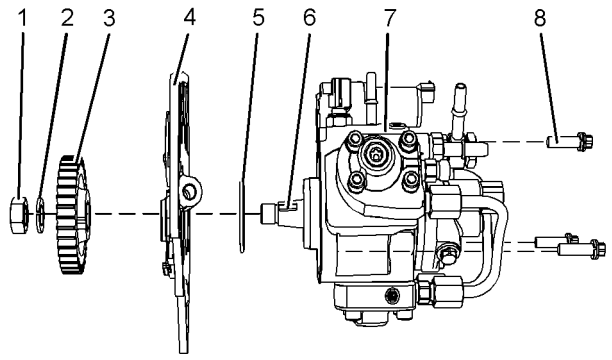


Illustration 74 g01970674

1. Use a suitable tool in order to prevent fuel injection pump gear (3) from rotating.

Note: Do not use timing pin for the fuel injection in order to prevent the fuel injection pump gear from rotating.

2. Remove nut (1) and washer (2).

3. Use Tooling (A) in order to remove gear (3) from the shaft of fuel injection pump (7).

4. Remove key (6) from the shaft of fuel injection pump (7).

5. Use Tooling (B) in order to remove Torx screws (8) and washers.

6. Remove adapter plate (4) from fuel injection pump (7).

7. Remove O-ring seal (5).

i04203718

Fuel Injection Pump Gear - Install

Installation Procedure

Table 13

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	E10 Torx Socket 1/4" Square Drive	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the fuel injection pump gear is clean and free from wear of damage. If necessary, replace the fuel pump gear. Ensure that the shaft for the fuel injection pump is clean and free from wear or damage.

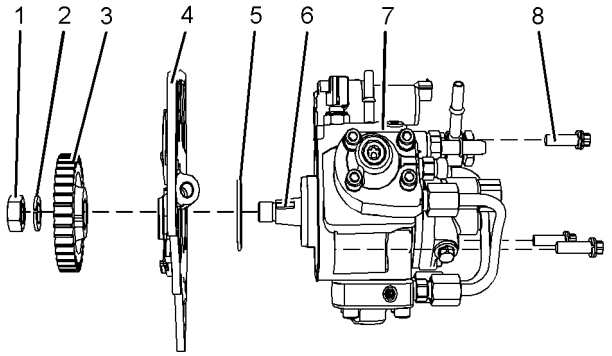


Illustration 75 g01970674

2. Position a new O-ring seal (5) onto fuel injection pump (7).

3. Position adapter plate (4) onto fuel injection pump (7).

4. Install new Torx screws (8) and washers.

5. Use Tooling (B) in order to tighten Torx screws (8) to a torque of 22 N·m (195 lb in).

6. Install key (6) to the shaft of fuel injection pump (7).

7. Position gear (3) from the shaft of fuel injection pump (7).

8. Position a new washer (2) onto the shaft of the fuel injection pump. Install nut (1) and tighten the nut hand tight.

9. Use a suitable tool in order to prevent fuel injection pump gear (3) from rotating.

Note: Do not use timing pin for the fuel injection in order to prevent the fuel injection pump gear from rotating.

10. Tighten nut (1) to a torque of 64 N·m (47 lb ft).

End By:

a. Install the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install” for the correct procedure.

i04203680

Electronic Unit Injector - Remove

Removal Procedure

Table 14

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610307	T40 Torx Socket	1
B	27610288	Pry Bar	1
C	T410437	Capping Kit	1

Start By:

a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft - Remove” for the correct procedure.

b. Remove the fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove” for the correct procedure.

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

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

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

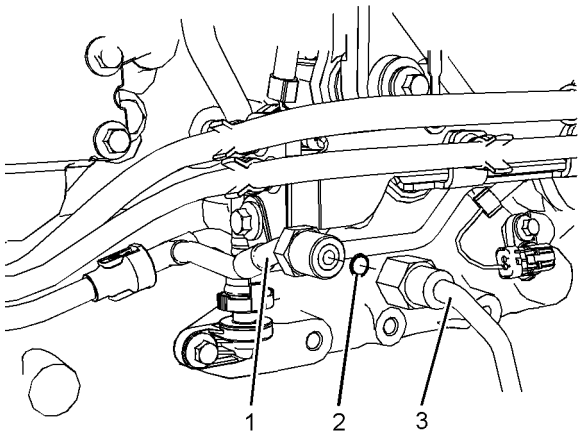


Illustration 76 g01971774

3. Place a suitable container below tube assembly (1) in order to catch any fuel that might be spilled.

4. Loosen the nut on hose assembly (3) in order to allow the fuel to drain from tube assembly (1).

5. Remove hose assembly (3) from tube assembly (1). Remove O-ring seal (2).

6. Use Tooling (C) in order to cap the hose assembly immediately. Use Tooling (C) in order to plug the tube assembly immediately.

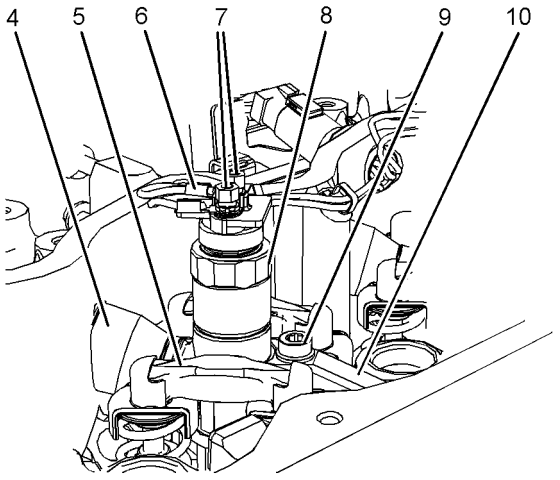


Illustration 77 g01971773

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

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

8. Remove seal (4) from the cylinder head and electronic unit injector (8).

9. Make a temporary mark on wiring harness assembly (6) in order to show the location and orientation.

10. Use a deep socket to remove connections (7) from electronic unit injector (8).

11. Use Tooling (A) in order to remove Torx screw (9) from clamp (10). Discard the Torx screw.

Note: Tooling (A) must be used to ensure no damage to the electronic unit injector.

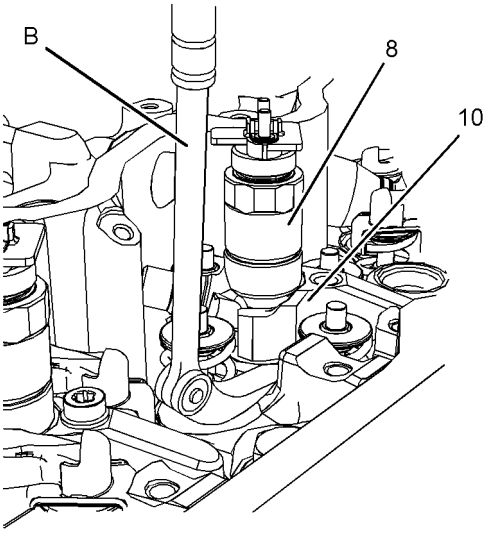


Illustration 78 g01971775

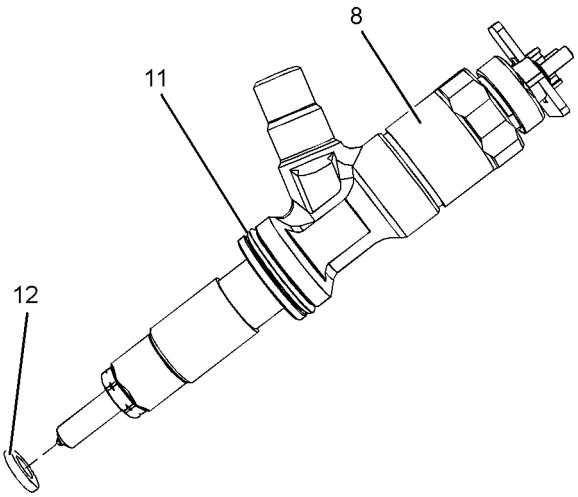


Illustration 79 g01972153

12. Make a temporary mark on electronic unit injector (8) in order to show the original location of the electronic unit injector.

13. Temporarily remove Tooling (C) from the electronic unit injector.

14. Use Tooling (B) to pry beneath clamp (10) and free electronic unit injector (8) from the cylinder head.

Note: Always handle electronic unit injectors with care.

15. Immediately replace Tooling (C) onto the electronic unit injector.

16. If electronic unit injector (8) is to be reused, Follow Step 17 through Step 19 in order to remove sealing washer (12) and O-ring seal (11).

17. Use a suitable tool in order to remove sealing washer (12) from electronic unit injector (8). Ensure that the sealing washer is removed from the cylinder head.

Note: Ensure that the nozzle for the electronic unit injector is not damaged in any way on removal of the sealing washer.

18. Install Tooling (C) to the nozzle for electronic unit injector (8) and the open port of the electronic unit injector.

19. Remove O-ring seal (11) from electronic unit injector (8).

20. If necessary, repeat Step 7 through Step 19 in order to remove the remaining electronic unit injector.

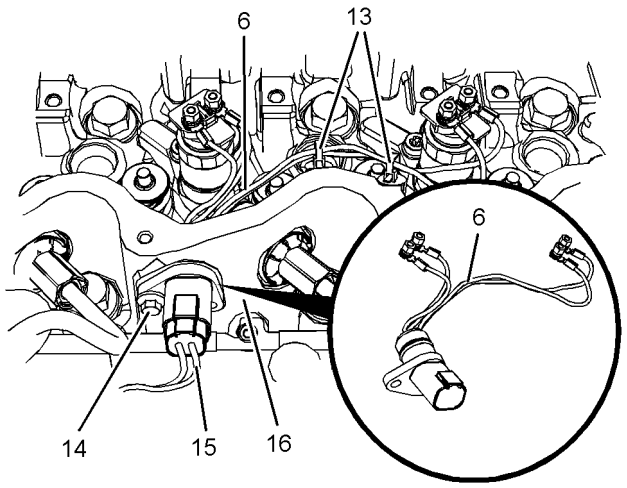


Illustration 80 g02311716

21. If necessary, follow Steps 21.a through 21.f in order to remove harness assemblies (6) from cylinder head (16).

a. Cut cable straps (13).

b. Unscrew the remaining sections of the cable straps from the cylinder head.

c. Disconnect harness assembly (15) from harness assembly (6).

d. Remove bolt (14) for harness assembly (6).

e. Withdraw harness assembly (6) from cylinder head (16).

f. If necessary, repeat Step 21.a through Step 21.f in order to remove the remaining harness assemblies from the cylinder head.

i04203679

Electronic Unit Injector - Install

Installation Procedure

Table 15

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610307	T40 Torx Socket	1
D	GE50028	Vacuum Pump	1
	GE50046	Fluid Sampling Bottle	1
	GE50030	Tube 7.9 mm (0.31 inch) Outside Diameter	1
E	T400030	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 begining ANY work on the fuel system, refer to Operation and Maintenance Manual, “General Hazard Information and High Pressure Fuel Lines” for safety information.

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

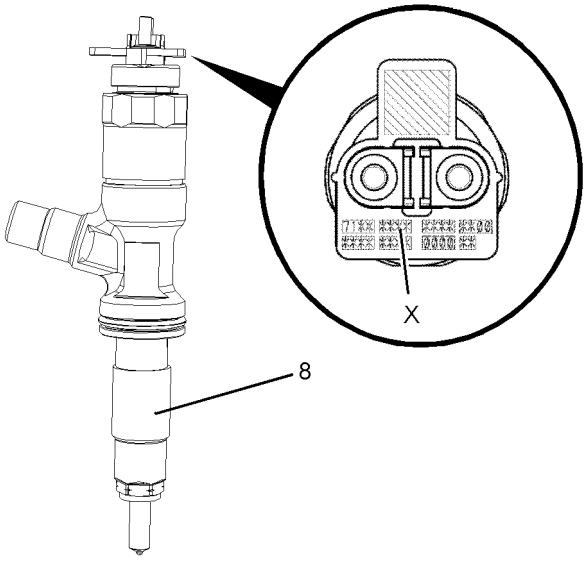


Illustration 81 g02353356

Injector code

1. If the original electronic unit injector (8) is installed, ensure that the electronic unit injector is installed into the original position.

2. If a replacement electronic unit injector is installed, the correct injector code must be programmed into the electronic control module. Refer to Troubleshooting, “Injector Code - Calibrate” for more information. The code that is required is located at Position (X).

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

3. 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.

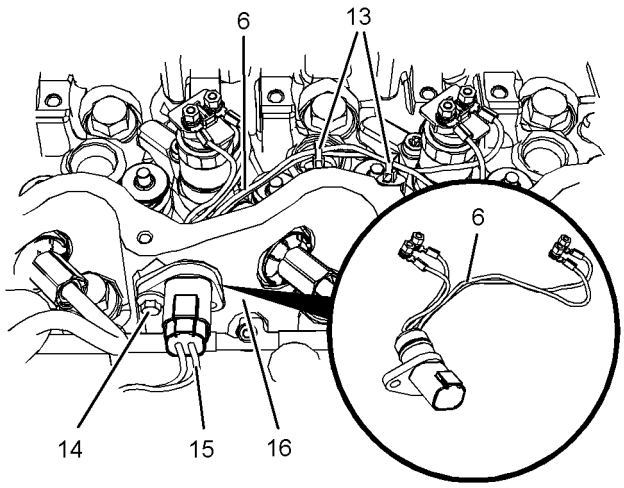


Illustration 82 g02313273

4. If necessary, follow Step 4.a through Step 4.e in order to install a new harness assembly (6) to cylinder head (16).

   a. Install a new harness assembly (6) to cylinder head (16).

Note: Do not lubricate the O-ring seal.

   b. Install a new bolt (14) to harness assembly (6). Tighten the bolt to a torque of 5.5 N·m (49 lb in).

   c. Install new assemblies of cable strap (13) for harness assembly (6) to cylinder head (16).

Note: Ensure that the assemblies of the cable strap are correctly installed into the cylinder head.

   d. Connect harness assembly (15) to harness assembly (6).

   e. If necessary, repeat Step 4.a through Step 4.e in order to install the remaining harness assemblies to the cylinder head.

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

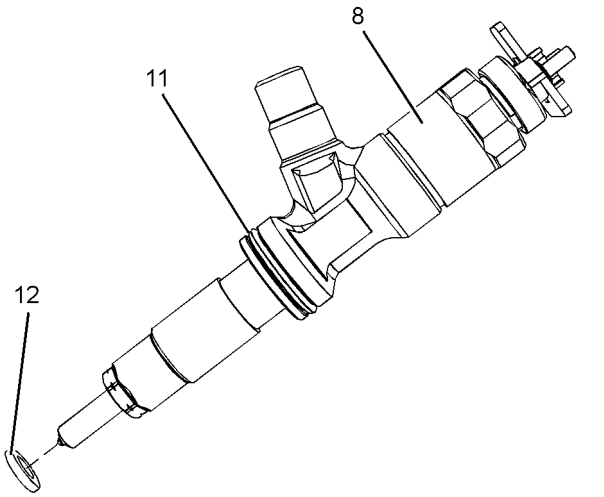


Illustration 83 g01972153

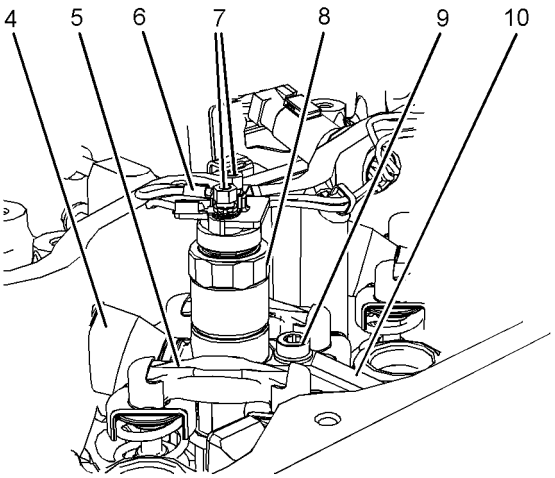


Illustration 84 g01971773

6. New sealing washer (12) should only be installed if the original electronic unit injector (8) is to be reused.

7. On installing an original electronic unit injector, install a new O-ring seal (11).

Note: Do not lubricate the O-ring seal.

8. Use a suitable tool in order to install a new sealing washer (12) to electronic unit injector (8).

Note: Ensure that the nozzle for the electronic unit injector is not damaged in any way on installation of the new sealing washer.

9. Ensure that O-ring seal (11) and sealing washer (12) on a new electronic unit injector are not damaged and in place.

Note: Do not lubricate the O-ring seal.

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

11. Position clamp (10) onto electronic unit injector (8). Align the assembly of electronic unit injector (8) to the bore for the electronic unit injector in the cylinder head.

Note: Ensure that the clamp is correctly positioned onto the electronic unit injector.

12. Push only on injector clamp (10) in order to install electronic unit injector (8). Do not apply pressure on any other part of the electronic unit injector. Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head.

13. Install a new Torx screw (9) to clamp (10). Tighten the Torx screw finger tight.

14. Remove the cap from electronic unit injector (8). Install a new seal (4) to electronic unit injector (8) and to the cylinder head. Ensure that the flange on the seal is flush with the cylinder head.

15. Remove the plugs from the new fuel injection line. Install the fuel injection line hand tight. Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

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

16. Use Tooling (A) to tighten Torx screw (9) to a torque of 27 N·m (239 lb in).

Note: Tooling (A) must be used to ensure no damage to the electronic unit injector.

17. Use Tooling (E) to tighten the fuel injection line to a torque of 50 N·m (37 lb ft). Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

18. Use a deep socket to install harness assembly (6) to electronic unit injector (8). Use Tooling (F) to tighten connections (7) to a torque of 2.0 N·m (18 lb in).

19. If necessary, repeat Step 1 through Step 18 in order to install the remaining electronic unit injectors.

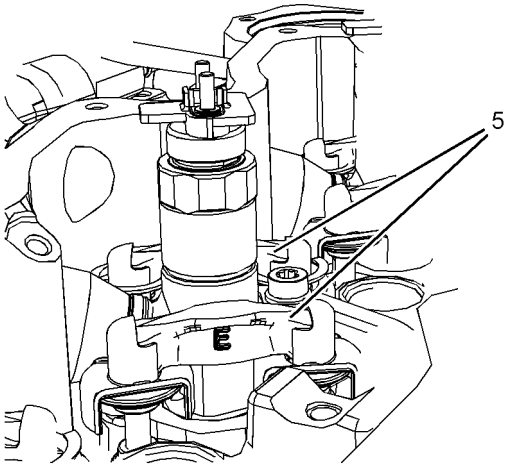


Illustration 85 g01973093

The correct location of valve bridges

NOTICE

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

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

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

21. Install the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft - Install” for the correct procedure.

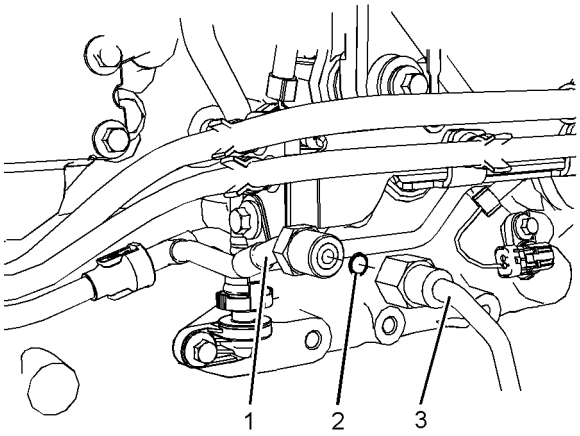


Illustration 86 g01971774

22. Install a new O-ring seal (2) to the connection on tube assembly (1).

23. Install hose assembly (3) to tube assembly (1). Tighten the nut on hose assembly (3) to a torque of 21 N·m (186 lb in).

24. Replace the filters for primary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Primary (Water Separator) Element - Replace” for the correct procedure.

25. Replace the filters for secondary fuel system. Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

26. Turn the fuel supply to the ON position.

27. Turn the battery disconnect switch to the ON position.

28. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203769

Turbocharger - Remove (First Stage Turbocharger)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

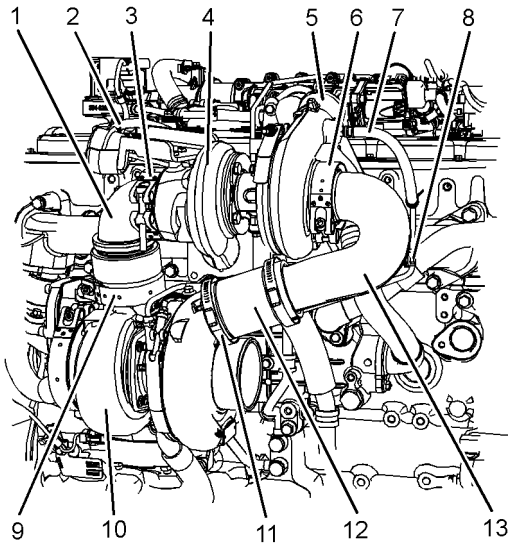


Illustration 87 g02175961

1. Loosen the hose clamp and disconnect hose assembly from air outlet (5) from turbocharger (4).
2. Disconnect hose assembly (2) from the wastegate actuator.
3. Remove bolt (8) from the clip for the tube assembly. Disconnect hose assembly (7) from the connection in the outlet of turbocharger (4).
4. Loosen the allen head bolt on V-band clamp (3) and V-band clamp (9) from elbow (1). Remove the V-band clamps from the elbow.

Note: If V-band clamp (3) and V-band clamp (9) remain tight on the flanges, apply releasing fluid on the V-band clamps. Lightly tap the bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**

5. Remove elbow (1) from turbocharger (4) and turbocharger (10).

Note: Plug the open ports of the turbochargers.

6. Loosen allen head bolt on V-band clamp (6) for air duct (13).
7. Loosen hose clamp (11).
8. Remove hose assembly (12), and V-band clamp (6), air duct (13) as an assembly from the outlet of turbocharger (10) and turbocharger (4).

Note: Plug the open ports of the turbochargers.

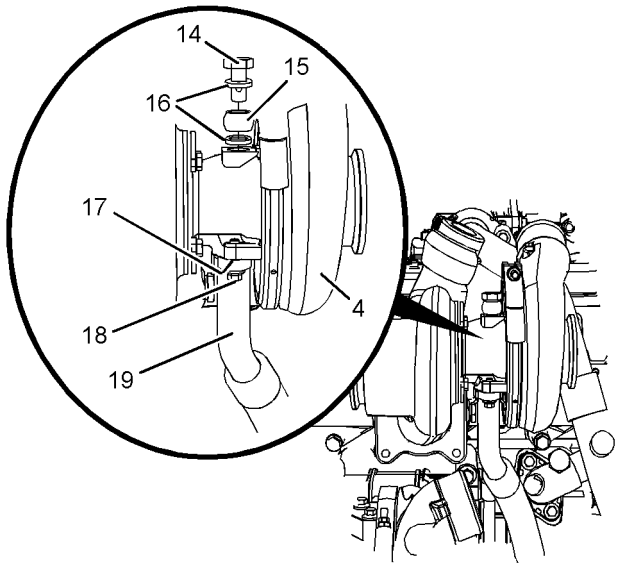


Illustration 88 g02175962

9. Remove banjo bolt (14) from tube assembly (15) for the oil feed for turbocharger (4).

Note: Plug the port for the oil feed in the turbocharger and plug the tube assembly.

10. Remove sealing washers (16).
11. Remove bolts (18) from tube assembly (19).
12. Disconnect tube assembly (19) from turbocharger (4) and remove gasket (17) (not shown).

Note: Plug the drain tube assembly for the turbocharger. Plug the port on the turbocharger.

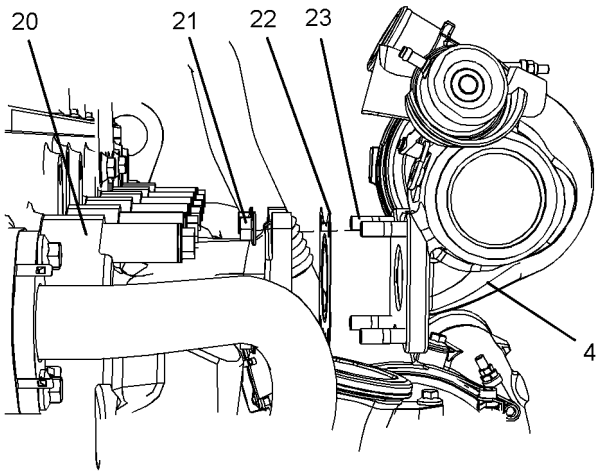


Illustration 89 g02175963

13. Remove nuts (21) from turbocharger (4).

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

14. Remove turbocharger (4) from exhaust manifold (20).

15. Remove gasket (22).

16. If necessary, remove studs (23) from turbocharger (4).

i04203772

Turbocharger - Remove (Second Stage Turbocharger)

Removal Procedure

Start By:

a. Remove the flexible exhaust pipe that connects the turbocharger to the clean emission module. Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - 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. Loosen the hose clamp and disconnect the air inlet hose from the turbocharger.

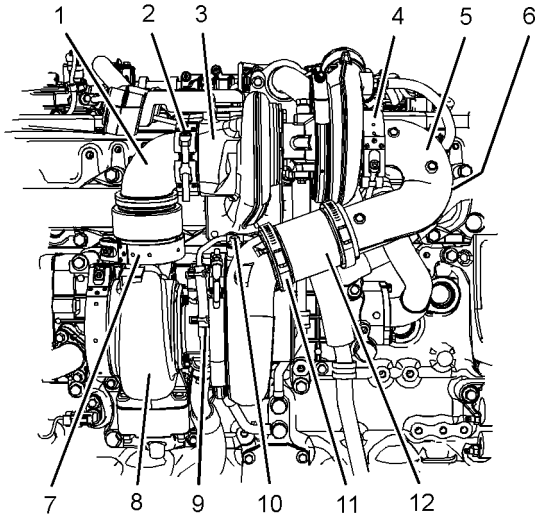


Illustration 90 g02176245

2. Loosen the allen head bolt on V-band clamp (2) and the allen head bolt on V-band clamp (7) from elbow (1).

Note: If V-band clamp (2) and V-band clamp (7) remain tight on the flanges, apply releasing fluid on the V-band clamps. Lightly tap the bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**

3. Remove elbow (1) from turbocharger (3) and turbocharger (8).

Note: Plug the open ports of the turbochargers.

4. Remove bolt (10) and bolt (6) (not shown). Disconnect hose assembly (9) from turbocharger (8). Position the tube and hose assembly (9) away from the turbocharger.

5. Loosen allen head bolt on V-band clamp (4) from air duct (5) and loosen hose clamp (11). Remove hose assembly (12) and air duct (5) from the outlet of turbocharger (8) and inlet for turbocharger (3).

Note: Plug the open ports of the turbochargers.

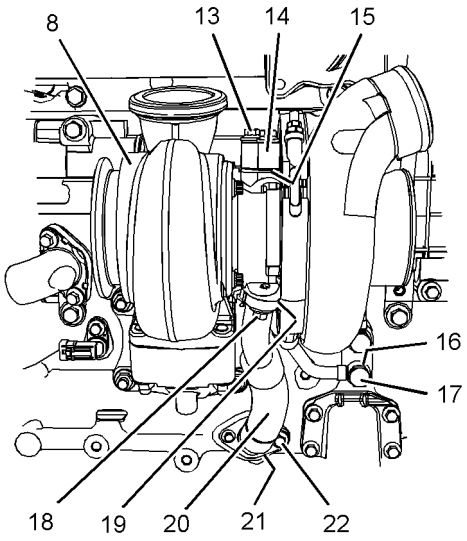


Illustration 91 g02176246

6. Remove bolts (13) and remove banjo bolt (17). Remove sealing washers (16) (not shown).

7. Remove tube assembly (14) from turbocharger (8).

Note: Plug the oil feed tube assembly for the turbocharger. Plug the port on the turbocharger. Plug the port in cylinder block for the oil feed tube assembly.

8. Remove gasket (15) (not shown).

9. Remove bolts (18) and bolts (22).

10. Remove tube assembly (20) from turbocharger (8).

Note: Plug the drain tube assembly for the turbocharger. Plug the port on the turbocharger. Plug the port in cylinder block for the drain tube assembly.

11. Remove gasket (19) (not shown). Remove gasket (21) (not shown) from tube assembly (20).

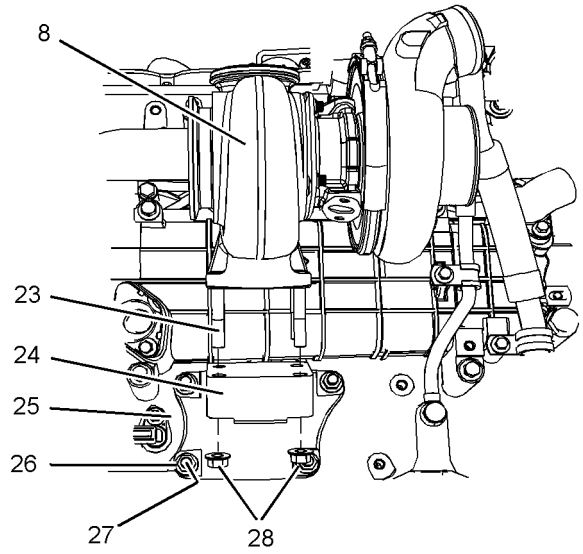


Illustration 92 g02176247

12. Remove nuts (28).

13. Remove turbocharger (8) from bracket (24).

14. If necessary, remove studs (23) from turbocharger (8).

15. If necessary, follow Step 15.a through Step 15.c in order to remove bracket (24) from the cylinder block.

a. Remove nuts (26).

b. Remove bracket (24) from cylinder block (25).

c. If necessary, remove studs (27) (not shown) from the cylinder block.

i04203771

Turbocharger - Install (Second Stage Turbocharger)

Installation Procedure

Table 16

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Anti-Seize Compound	1
B	T400021	Turbocharger Alignment Tool	1
	T406192	V-Band Clamp	1
	T405198	V-Band Clamp	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

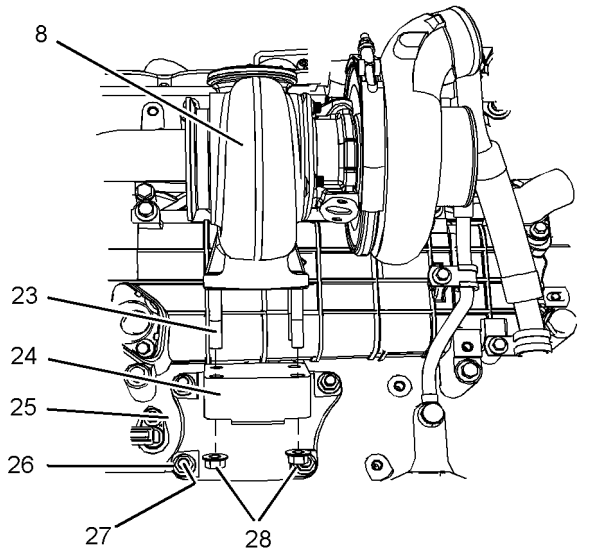


Illustration 93 g02176247

1. Ensure that turbocharger (8) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.

2. If necessary, follow Step 2.a through Step 2.b in order to install bracket (24) onto cylinder block (25).

   a. If necessary, install studs (27) (not shown) to the cylinder block. Tighten the studs to a torque of 18 N·m (159 lb in).

   b. Position bracket (24) onto cylinder block (25). Install nuts (26) hand tight.

3. If necessary, install studs (23) to turbocharger (8). Tighten the studs to a torque of 18 N·m (159 lb in).

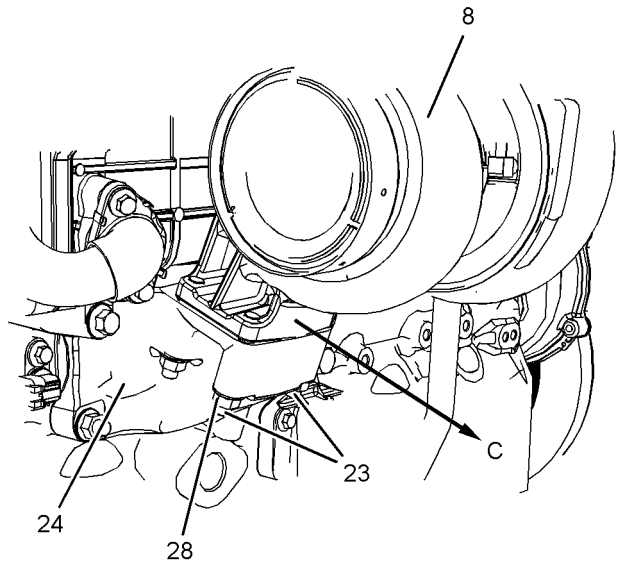


Illustration 94 g02356216

4. Position turbocharger (8) onto bracket (24).

5. Loosely install nuts (28).

6. Move turbocharger (8) in the Direction (C) to ensure that studs (23) of turbocharger (8) is positioned most forward position in the holes in bracket (24).

7. Hand tighten nuts (28).

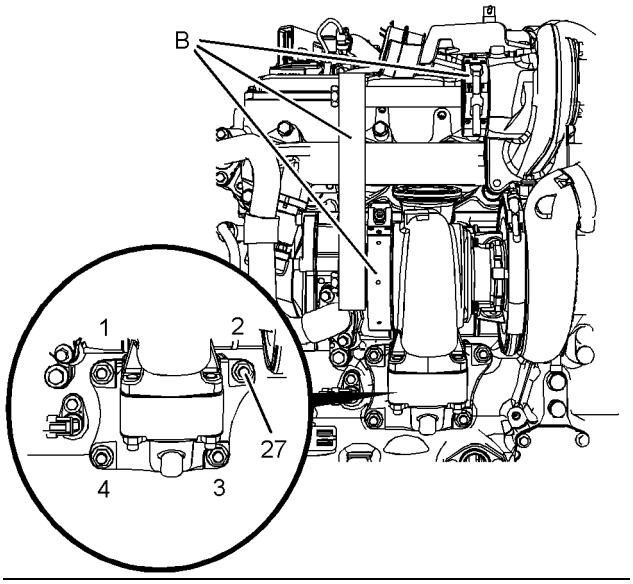


Illustration 95 g02352357

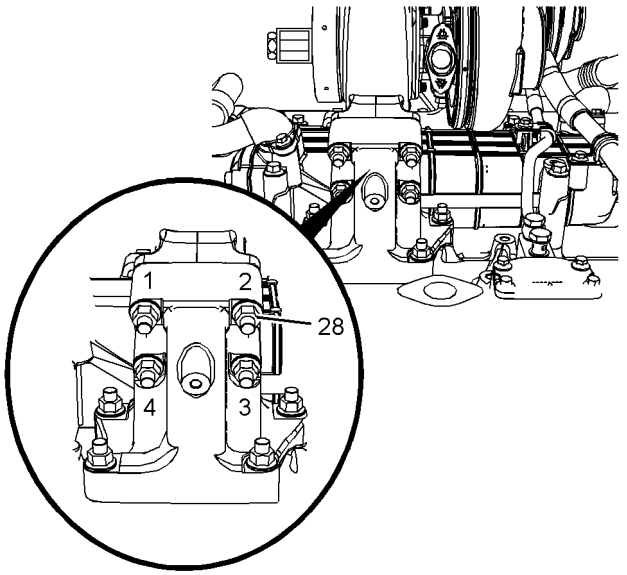


Illustration 96 g02352633

8. Use Tooling (B) in order to align the second stage turbocharger and the first stage turbocharger.

Note: Ensure that the bracket for the turbocharger is correctly positioned onto the turbocharger and the cylinder block.

9. Tighten nuts (28) to a torque of 44 N·m (32 lb ft). Tighten the nuts in the sequence that is shown in Illustration 96.

Tighten nuts (26) to a torque of 44 N·m (32 lb ft). Tighten the nuts in the sequence that is shown in Illustration 95.

10. Remove Tooling (B).

Note: Ensure that the second stage turbocharger and the first stage turbocharger are correctly aligned.

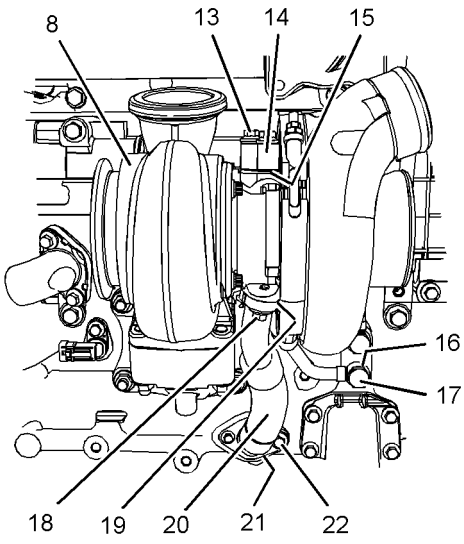


Illustration 97 g02176246

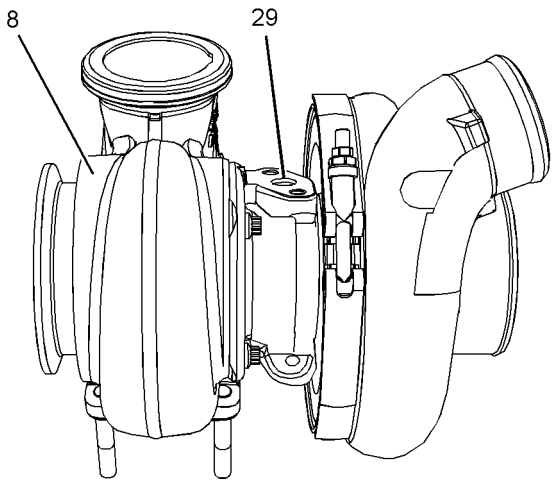


Illustration 98 g02176278

11. Remove plugs and caps from tube assemblies. Ensure that tube assembly (14) and tube assembly (20) are clean and free from damage. Replace any damaged components.

12. Install a new gasket (21) (not shown) onto tube assembly (20).

13. Position a new gasket (19) (not shown) onto tube assembly (20).

14. Remove the plug from the drain port of the turbocharger. Remove the plug from the cylinder block.

15. Position tube assembly (20) into the cylinder block and install bolts (22) finger tight.

16. Position tube assembly (20) onto turbocharger (8) and install bolts (18) finger tight.

17. Tighten bolts (18) and bolt (22) to a torque of 22 N·m (195 lb in).

18. Remove the plug from oil inlet port (29) for turbocharger (8). Lubricate the turbocharger bearings with clean engine oil through oil inlet port (29). Rotate the wheel of the compressor several times in order to lubricate the bearings.

19. Position a new gasket (15) (not shown) onto tube assembly (14) and install bolts (13).

Note: Holes in the gasket have serration that hold the bolts captive.

20. Position tube assembly (14) onto turbocharger (8). Tighten bolts (13) finger tight.

21. Remove plug from cylinder block for the oil feed tube assembly. Install new sealing washers (16) (not shown) and banjo bolt (17) to tube assembly (14). Tighten banjo bolt (17) finger tight.

22. Tighten bolts (13) to a torque of 22 N·m (195 lb in). Tighten banjo bolt (17) to a torque of 33 N·m (292 lb in). Refer to Illustration 97.

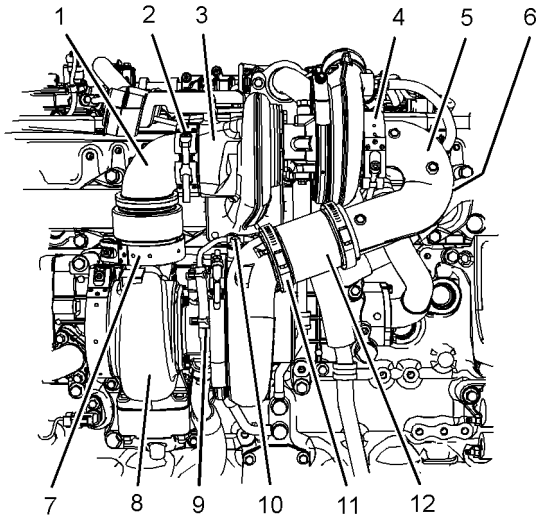


Illustration 99 g02176245

23. Connect hose assembly (9) onto turbocharger (8) and loosely install bolt (10).

24. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (4). Position V-band clamp (4) onto air duct (5).

25. Remove plugs from the ports of the turbochargers

26. Position hose assembly (12) and air duct (5) onto the outlet of turbocharger (8) and the inlet of turbocharger (3). Tighten the allen head bolt for V-band clamp to a torque of 12 N·m (106 lb in).

Note: Ensure that the allen head bolt for the V-band clamp does not contact any other engine component.

27. Tighten hose clamps (11) to a torque of 6 N·m (53 lb in).

28. Install bolt (6) (not shown).

29. Tighten bolt (10) and bolt (6) (not shown) to a torque of 22 N·m (195 lb in).

30. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (2). Position V-band clamp (2) onto elbow (1).

31. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (7). Position V-band clamp (7) onto turbocharger (8).

32. Position elbow (1) onto turbocharger (8) and turbocharger (3).

33. Tighten allen head bolt for V-band clamp (2) and V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.

34. Tighten allen head bolts for V-band clamp (2) and V-band clamp (7) to a torque of 12 N·m (106 lb in).

35. Connect the air inlet hose to the turbocharger and tighten the hose clamp securely.

End By:

a. Install flexible exhaust pipe that connects the turbocharger to the clean emission module. Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

i04203770

Turbocharger - Install (Second Stage Turbocharger)

Installation Procedure Without Alignment Tools

Table 17

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Anti-Seize Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

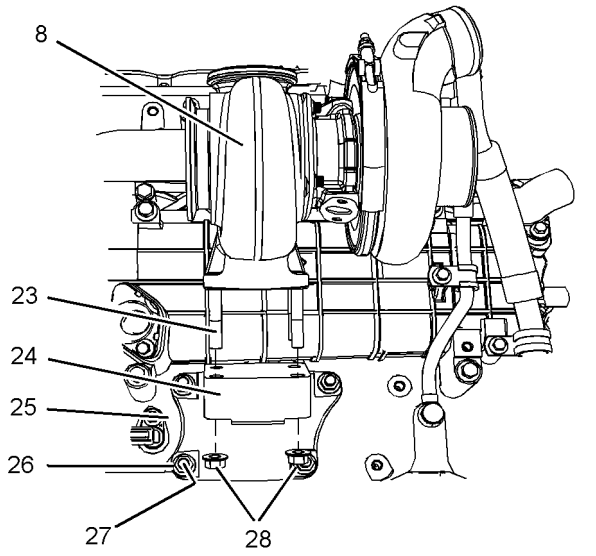


Illustration 100 g02352951

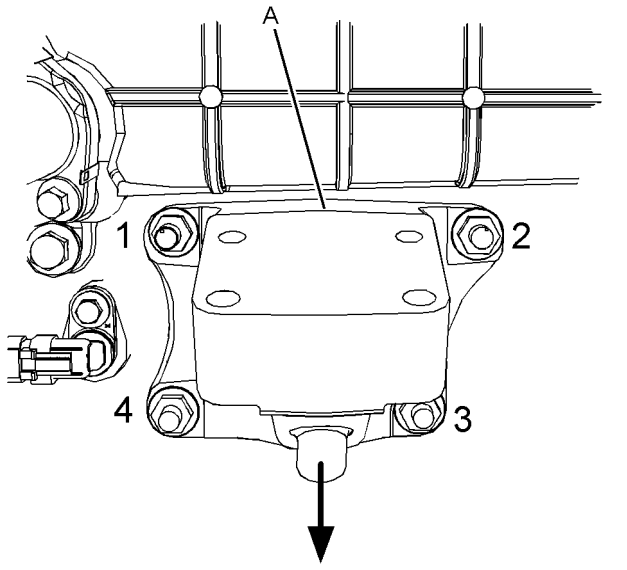


Illustration 101 g02352668

1. Ensure that turbocharger (8) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.

2. If bracket (24) has not been removed, loosen nuts (26). Follow Step3.d through Step 3.e in order to ensure that the bracket is correctly positioned.

Note: Bracket (24) must be able to move freely to allow correct positioning.

3. Follow Step 3.a through Step 3.e in order to install bracket (24) to cylinder block (25).

   a. If necessary, install studs (27) (not shown) to cylinder block (25). Tighten the studs to a torque of 18 N·m (159 lb in).

   b. Position bracket (24) onto studs (27) (not shown)

   c. Loosely install nuts (26).

Note: Bracket (24) must be able to move freely to allow correct positioning.

   d. Apply sufficient pressure in Position (A) to ensure that bracket (24) is at the lowest point on studs (27) (not shown). **Do not release the pressure on bracket (24) in Position (A) until nuts (26) have been tightened securely.**

   e. Tighten the nuts to a torque of 44 N·m (33 lb ft) in the sequence shown in Illustration 101.

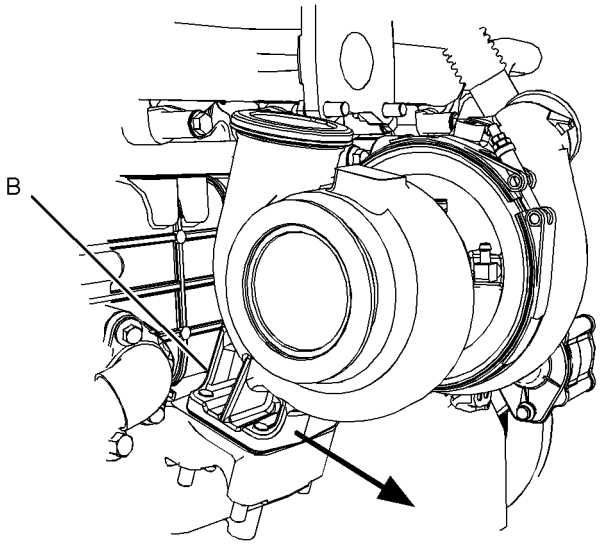


Illustration 102 g02352690

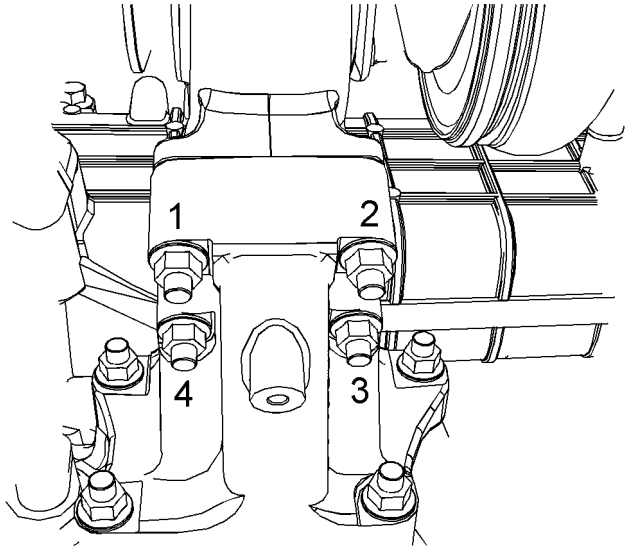


Illustration 103 g02352719

4. Position turbocharger (8) onto bracket (24). Follow Step 4.a through Step 4.c in order to locate the turbocharger in the correct position.

a. Loosely install nuts (28) to studs (23).

Note: Turbocharger (8) must be able to move freely to allow correct positioning.

b. Apply sufficient pressure in Position (B) to ensure that turbocharger (8) is in the furthest position away from the cylinder block. **Do not release the pressure on the turbocharger in Position (B) until nuts (28) have been tightened securely.**

c. Tighten the nuts to a torque of 44 N·m (33 lb ft) in the sequence shown in Illustration 103.

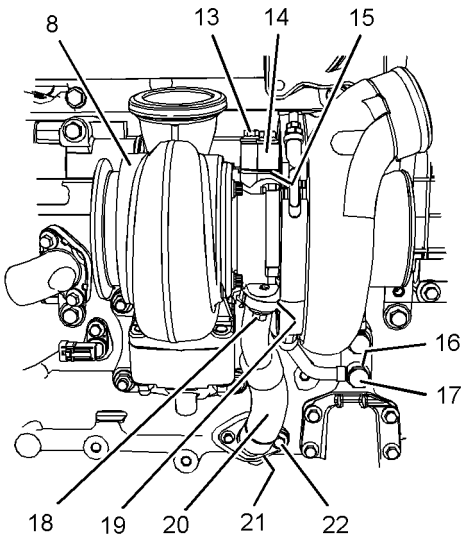


Illustration 104 g02176246

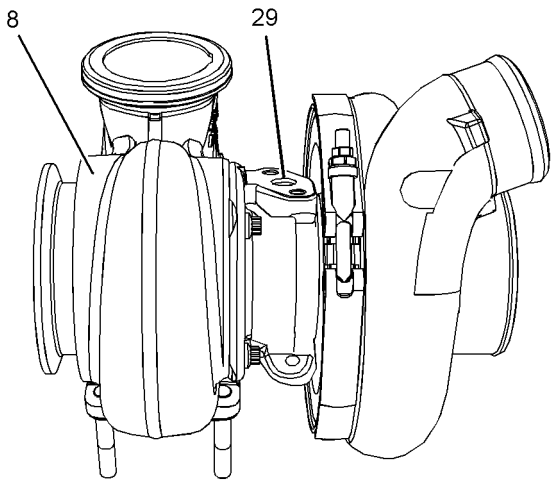


Illustration 105 g02176278

5. Remove plugs and caps from tube assemblies. Ensure that tube assembly (14) and tube assembly (20) are clean and free from damage. Replace any damaged components.

6. Install a new gasket (21) (not shown) onto tube assembly (20).

7. Position a new gasket (19) (not shown) onto tube assembly (20).

8. Remove the plug from the drain port of the turbocharger. Remove the plug from the cylinder block.

9. Position tube assembly (20) into the cylinder block and install bolts (22) finger tight.

10. Position tube assembly (20) onto turbocharger (8) and install bolts (18) finger tight.

11. Tighten bolts (18) and bolt (22) to a torque of 22 N·m (195 lb in).

12. Remove the plug from oil inlet port (29) for turbocharger (8). Lubricate the turbocharger bearings with clean engine oil through oil inlet port (29). Rotate the wheel of the compressor several times in order to lubricate the bearings.

13. Position a new gasket (15) (not shown) onto tube assembly (14) and install bolts (13).

Note: Holes in the gasket have serration that hold the bolts captive.

14. Position tube assembly (14) onto turbocharger (8). Tighten bolts (13) finger tight.

15. Remove plug from cylinder block for the oil feed tube assembly. Install new sealing washers (16) (not shown) and banjo bolt (17) to tube assembly (14). Tighten banjo bolt (17) finger tight.

16. Tighten bolts (13) to a torque of 22 N·m (195 lb in). Tighten banjo bolt (17) to a torque of 33 N·m (292 lb in). Refer to Illustration 102.

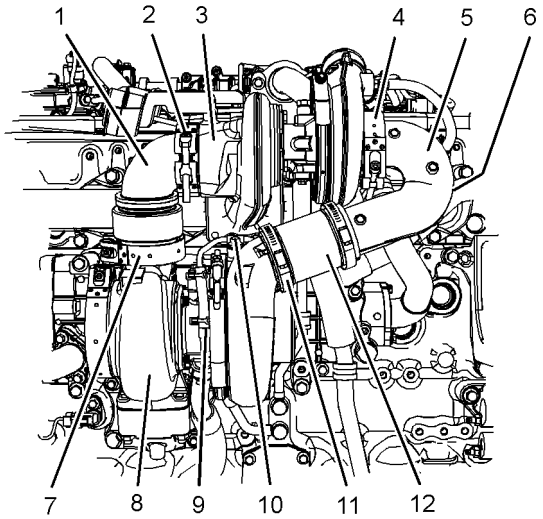


Illustration 106 g02176245

17. Connect hose assembly (9) onto turbocharger (8) and loosely install bolt (10).

18. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (4). Position V-band clamp (4) onto air duct (5).

19. Remove plugs from the ports of the turbochargers.

20. Position hose assembly (12) and air duct (5) onto the outlet of turbocharger (8) and the inlet of turbocharger (3). Tighten the allen head bolt for V-band clamp to a torque of 12 N·m (106 lb in).

Note: Ensure that the allen head bolt for the V-band clamp does not contact any other engine component.

21. Tighten hose clamps (11) to a torque of 6 N·m (53 lb in).

22. Install bolt (6) (not shown).

23. Tighten bolt (10) and bolt (6) (not shown) to a torque of 22 N·m (195 lb in).

24. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (2). Position V-band clamp (2) onto elbow (1).

25. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (7). Position V-band clamp (7) onto turbocharger (8).

26. Position elbow (1) onto turbocharger (8) and turbocharger (3).

27. Tighten allen head bolt for V-band clamp (2) and V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.

28. Tighten allen head bolts for V-band clamp (2) and V-band clamp (7) to a torque of 12 N·m (106 lb in).

29. Connect the air inlet hose to the turbocharger and tighten the hose clamp securely.

End By:

a. Install flexible exhaust pipe that connects the turbocharger to the clean emission module. Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

i04203768

Turbocharger - Install (First Stage Turbocharger)

Installation Procedure Without Alignment Tools

Table 18

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Anti-Seize Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

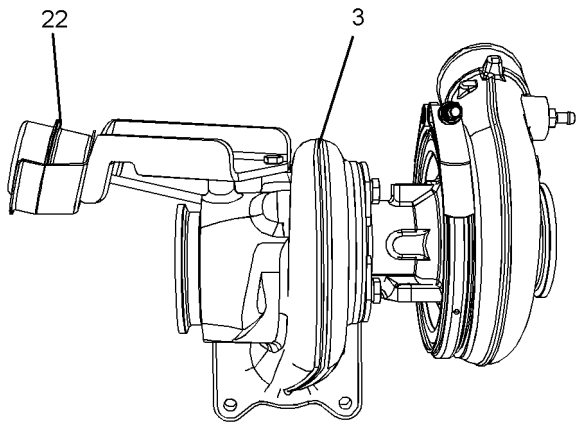


Illustration 107 g02409319

1. Ensure that turbocharger (3) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.

2. Test wastegate actuator (22) for correct operation. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect”. If any part of the wastegate actuator is worn or damaged, the complete turbocharger must be replaced.

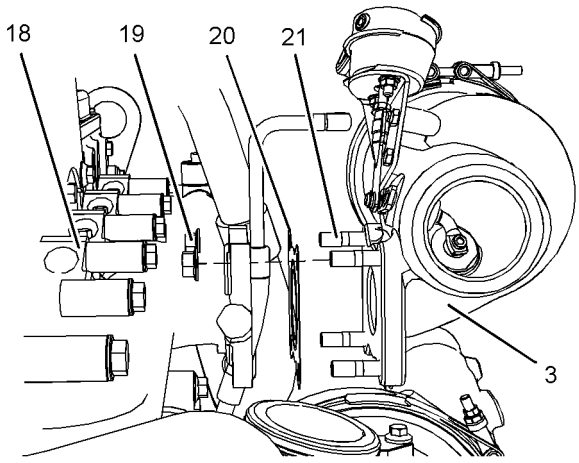


Illustration 108 g01974333

3. Clean the gasket surface of exhaust manifold (18). If necessary, install studs (21) to turbocharger (3). Tighten the studs to a torque of 18 N·m (160 lb in).

4. Install a new gasket (20) to studs (21).

5. Position turbocharger (3) onto the exhaust manifold and loosely install nuts (19).

Note: Ensure that the turbocharger is correctly oriented.

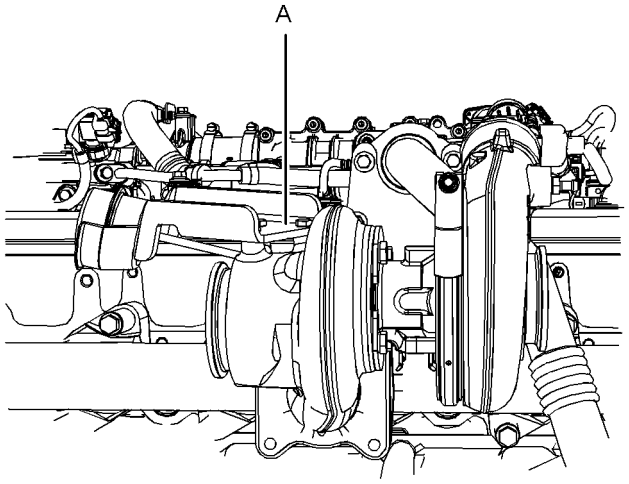


Illustration 109 g02352967

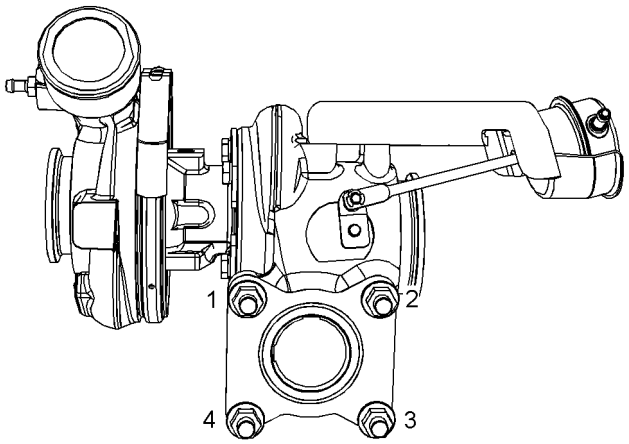


Illustration 110 g02386497

Turbocharger tightening sequence viewed from the exhaust manifold.

6. Apply sufficient pressure in position (A) to ensure that the studs (21) are in the lowest position on manifold (18) and horizontal. **Do not release the pressure from the turbocharger in Position (A) until nuts (19) have been tightened securely.**

7. Tighten nuts (19) in the sequence shown in Illustration 110 to a torque of 44 N·m (32 lb ft).

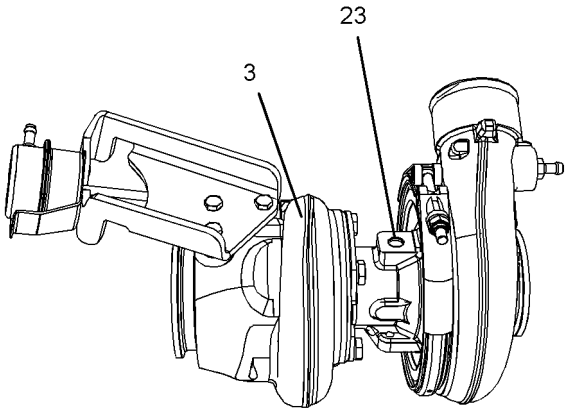


Illustration 111 g02409318

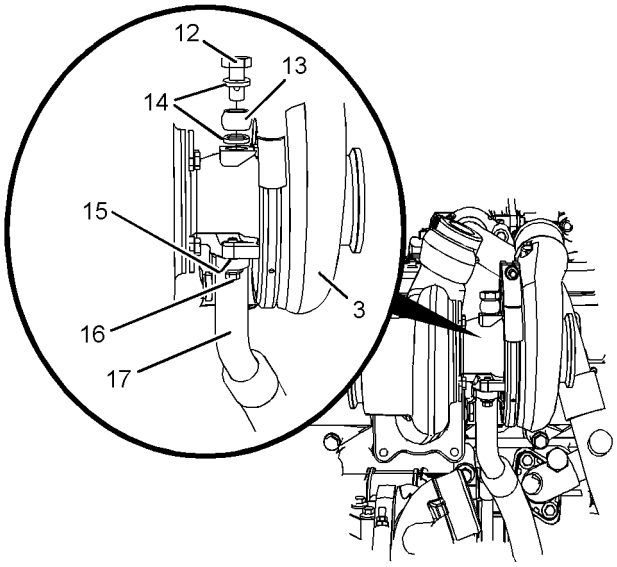


Illustration 112 g01973256

8. Remove plugs and caps from tube assemblies. Ensure that tube assembly (13) and tube assembly (17) are clean and free from damage. Replace any damaged components.

9. Position a new gasket (15) (not shown). Install bolts (8) to tube assembly (17). Tighten bolt (8) to a torque of 22 N·m (195 lb in).

10. Remove the plug from oil inlet port (23). 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.

11. Install a new sealing washer (14) to banjo bolt (12). Install the banjo bolt to tube assembly (13). Install the remaining new sealing washer (14) to banjo bolt (12).

12. Position tube assembly (13) onto turbocharger (3). Tighten banjo bolt (13) to a torque of 20 N·m (177 lb in).

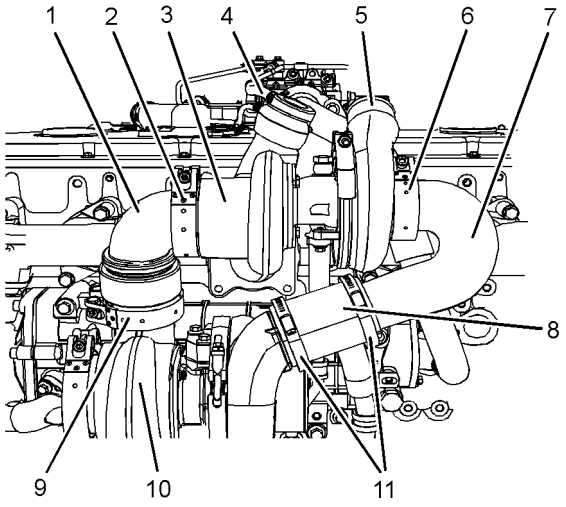


Illustration 113 g01973253

13. Use Tooling (A) to lubricate the bolt for V-band clamp (6). Position V-band clamp (6) onto elbow (7).

14. Position hose assembly (11) and elbow (7) onto the outlet of turbocharger (10) and turbocharger (3). Tighten the V-band clamp to a torque of 12 N·m (106 lb in).

15. Tighten hose clamps (11) securely.

16. Ensure that elbow (1) is free from wear and damage. If necessary, replace the elbow that is worn or damaged.

17. Use Tooling (A) to lubricate the bolt for V-band clamp (2). Position V-band clamp (2) onto elbow (1).

18. Use Tooling (A) to lubricate the bolt for V-band clamp (9). Position V-band clamp (9) onto turbocharger (10).

19. Position elbow (1) onto turbocharger (3) and turbocharger (10).

20. Tighten V-band clamp (2) and V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.

21. Tighten V-band clamp (2) and V-band clamp (9) to a torque of 12 N·m (106 lb in).

22. Connect hose assembly (4) to the wastegate actuator.

23. Connect hose assembly to air outlet (5) to turbocharger (3). Tighten the hose clamps securely.

i04203767

Turbocharger - Install (First Stage Turbocharger)

Installation Procedure

Table 19

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400028	Counterweight Tool	1
B	-	Anti-Seize Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

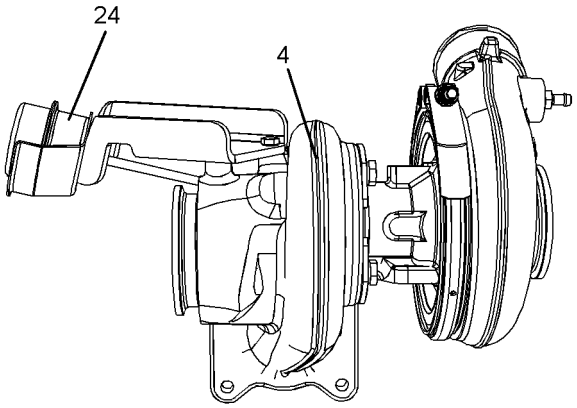


Illustration 114 g02176197

1. Ensure that turbocharger (4) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.

2. Test wastegate actuator (24) for correct operation. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If any part of the wastegate actuator is worn or damaged, the complete turbocharger must be replaced.

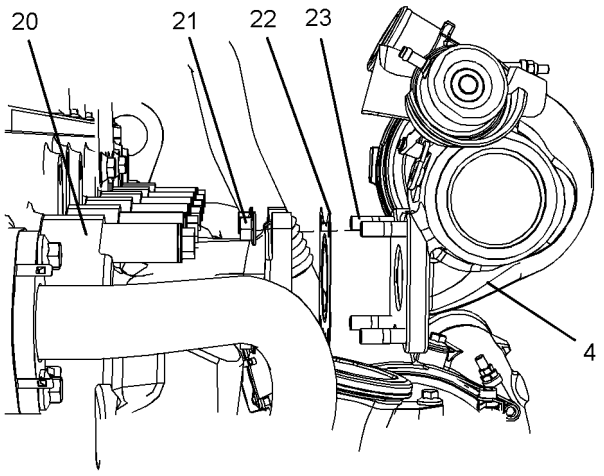


Illustration 115 g02175963

3. Clean the gasket surface of exhaust manifold (20). If necessary, install studs (23) to turbocharger (4). Tighten the studs to a torque of 18 N·m (160 lb in).

4. Install a new gasket (22) to turbocharger (4).

5. Position turbocharger (4) onto the exhaust manifold and install nuts (21) finger tight. The nuts (21) should not constrain the turbocharger and prevent Tooling (A) from correctly positioning the turbocharger onto the exhaust manifold.

6. Use Tooling (A) to align turbocharger (4).

Note: Ensure that the turbocharger is correctly oriented.

7. Tighten nuts (21) to a torque of 44 N·m (32 lb ft).

8. Remove Tooling (A) from turbocharger (4).

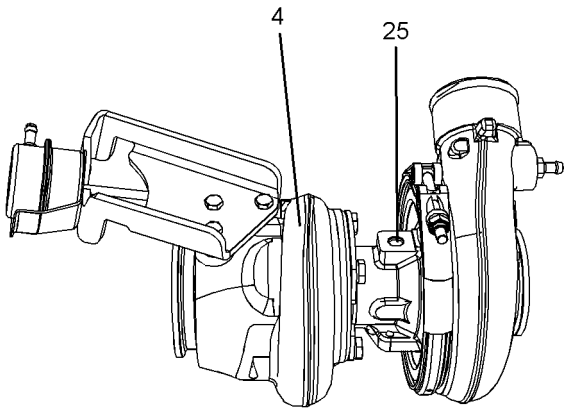


Illustration 116 g02176198

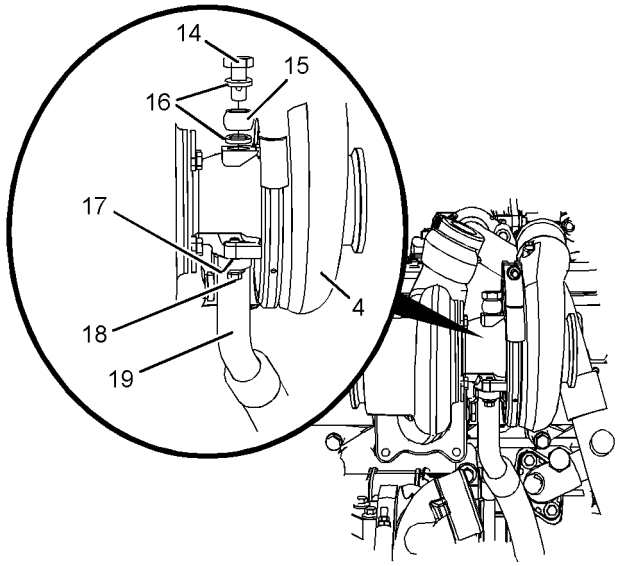


Illustration 117 g02175962

9. Remove plugs and caps from tube assemblies. Ensure that tube assembly (19) and tube assembly (15) are clean and free from damage. Replace any damaged components.

10. Position a new gasket (17) (not shown) onto tube assembly (19).

11. Install bolts (18) to tube assembly (19). Tighten the bolt to a torque of 9 N·m (80 lb in).

12. Remove the plug from oil inlet port (25). 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.

13. Install a new sealing washer (16) to banjo bolt (14). Install banjo bolt (14) to tube assembly (15) and install remaining sealing washers (16) to banjo bolt (14).

14. Tighten banjo bolt (14) to a torque of 20 N·m (177 lb in).

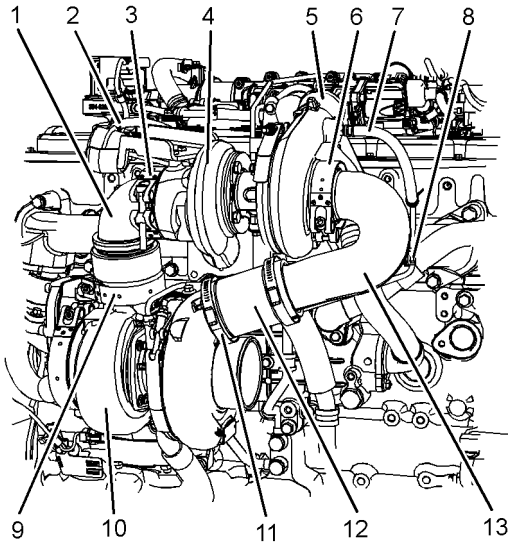


Illustration 118 g02175961

15. Use Tooling (B) to lubricate the allen head bolt for V-band clamp (6). Position V-band clamp (6) onto air duct (13).

16. Position hose assembly (12) and air duct (13) onto the outlet of turbocharger (10) and turbocharger (4). Ensure that the V-band clamp (6) is seated correctly onto the turbochargers.

17. Tighten the allen head bolt for V-band clamp (6) to a torque of 12 N·m (106 lb in).

18. Tighten hose clamps (11) to a torque of 6 N·m (53 lb in).

19. Use Tooling (B) to lubricate the allen head bolt for V-band clamp (9). Position V-band clamp (9) onto turbocharger (10).

20. Use Tooling (B) to lubricate the allen head bolt for V-band clamp (3). Position V-band clamp (3) onto elbow (1).

21. Position elbow (1) onto turbocharger (10) and turbocharger (4).

22. Tighten allen head bolt for V-band clamp (3) and V-band clamp (9) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.

23. Tighten allen head bolt for V-band clamp (3) and V-band clamp (9) to a torque of 12 N·m (106 lb in).

24. Connect hose assembly (2) to the wastegate actuator.

Note: Ensure that the clip for hose assembly is correctly positioned.

25. Connect hose assembly (7) to the connection in outlet of turbocharger (4).

Note: Ensure that the clip for hose assembly is correctly positioned.

26. Install bolt (8) to clip for tube assembly. Tighten the bolt to a torque of 22 N·m (195 lb in).

27. Connect hose assembly to air outlet (5) of turbocharger (4). Tighten the hose clamps securely.

i04203792

Wastegate Solenoid - Remove and Install

Removal Procedure

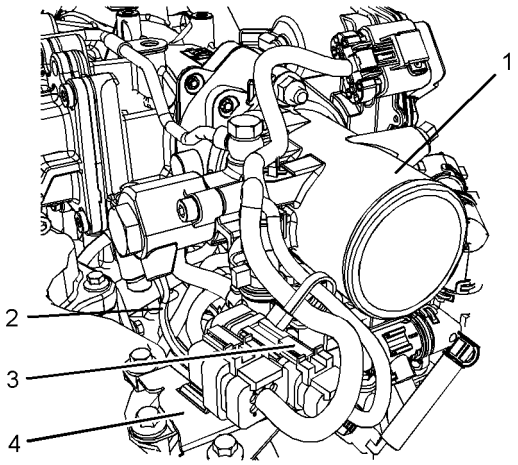


Illustration 119 g02160936

1. Slide locking tab (3) into the unlocked position. Disconnect harness assembly (2). Slide connection for harness assembly (2) from the bracket (4).

2. Remove hose from inlet connection (1).

3. Remove inlet manifold connection (1). Refer to Disassembly and Assembly, “Throttle Valve (Intake air) - Remove” for the correct procedure.

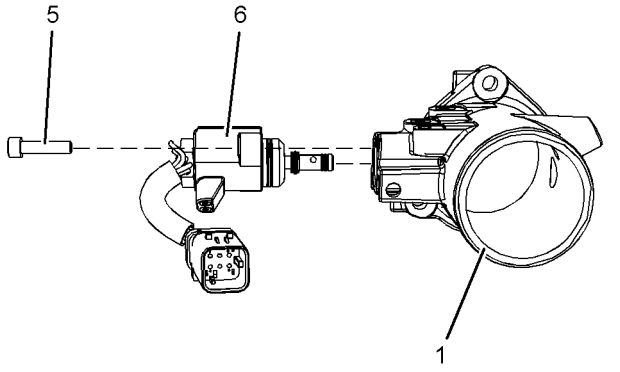


Illustration 120 g02162574

4. Remove allen head bolts (5). Make temporary mark on wastegate solenoid (6) for installation purposes. Remove wastegate solenoid (6) from inlet manifold connection (1).

Installation Procedure

Table 20

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Dephi Lockheed Rubber Grease	1

1. Ensure that all components of wastegate solenoid are clean and free from wear and damage. If necessary, replace the wastegate solenoid as an assembly if any of components are worn or damaged.

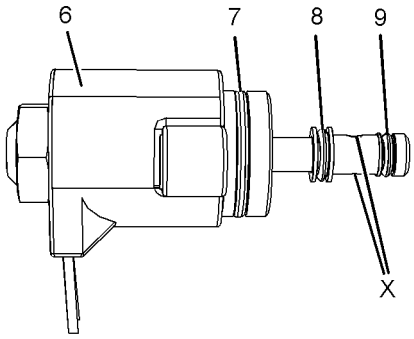


Illustration 121 g02161575

2. Ensure that O-ring seal (7), O-ring seal (8), and O-ring seal (9) on wastegate solenoid (6) are free from damage and wear.

3. If the O-ring seals are damaged or worn, the wastegate solenoid should be replaced as an assembly.

4. Ensure that the ports in Position (X) are clean and free from restriction.

5. Use Tooling (A) in order to lubricate O-ring seal (7), O-ring seal (8), and O-ring seal (9) on wastegate solenoid (6).

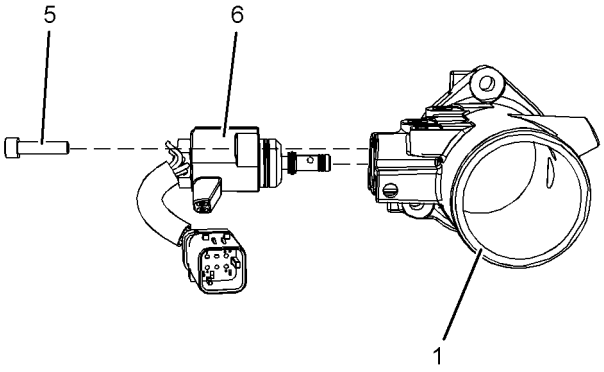


Illustration 122 g02162574

6. Install wastegate solenoid (6) to inlet manifold connection (1).

Note: Ensure that the wastegate solenoid is correctly orientated.

7. Install allen head bolts (5) to wastegate solenoid (6). Tighten allen head bolts (5) to a torque of 9 N·m (80 lb in).

8. Install inlet manifold connection (1). Refer to Disassembly and Assembly, “Throttle Valve (Intake air) - Install” for the correct procedure.

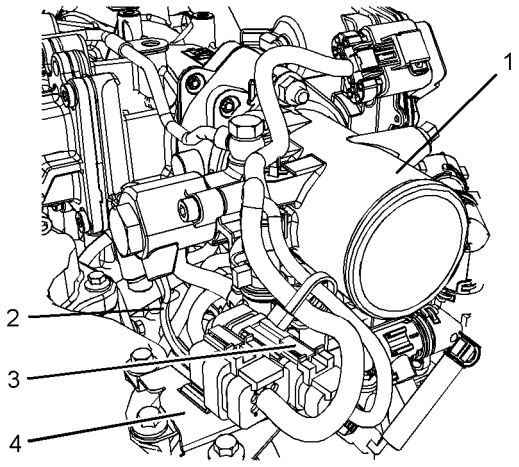


Illustration 123 g02160936

9. Slide the connection for harness assembly (2) onto bracket (4). Connect harness assembly (2). Slide locking tab (3) into the locked position.

10. Install the hose to inlet connection (1). Tighten the hose clamp securely.

i04203639

Air Control Valve - Remove and Install (Clean Emissions Module)

Removal Procedure

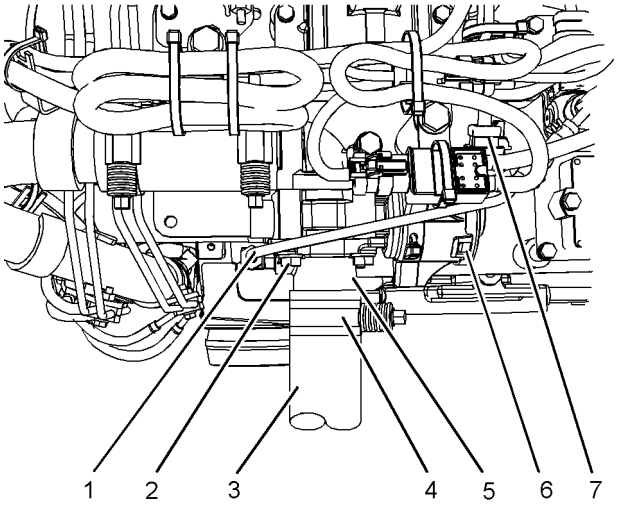


Illustration 124 g02028775

Typical example

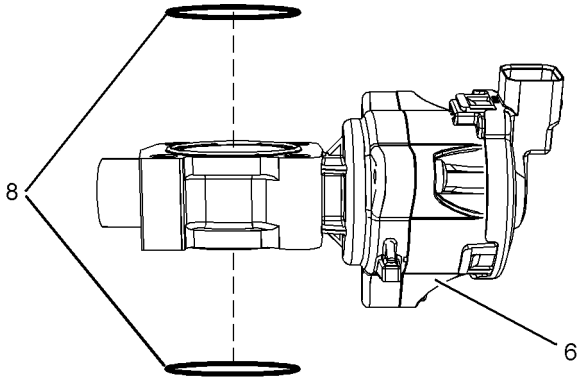


Illustration 125 g02028801

1. Loosen hose clamp (4) and disconnect hose assembly (3) from connection (5) on air control valve (6).

2. Disconnect harness assembly (7) from air control valve (6).

3. Disconnect tube assembly (1) from the assembly of air control valve (6).

4. Remove bolts (2). Remove connection (5) and air control valve (6) as an assembly.

5. Remove O-ring seals (8) from air control valve (6).

Installation Procedure

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

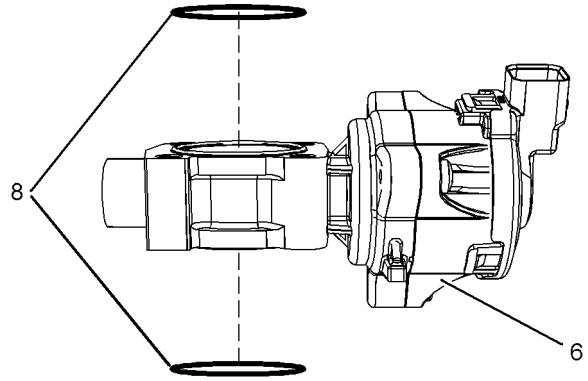


Illustration 126 g02028801

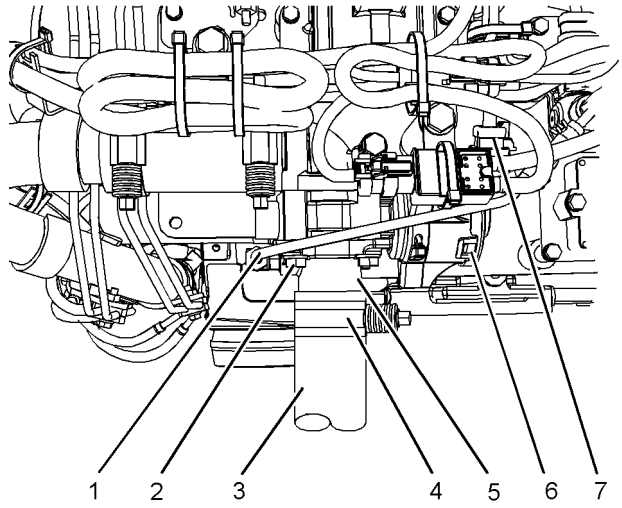


Illustration 127 g02028775

2. Install new O-ring seals (8) to both sides of air control valve (6). Ensure that the O-ring seals are correctly positioned in the air control valve.

3. Install air control valve (6) and connection (5) as an assembly. Install bolts (2) and tighten the bolts to a torque 28 N·m (248 lb in).

4. Connect tube assembly (1) to the assembly of air control valve (6). Tighten the nut for tube assembly (1) securely.

5. Connect harness assembly (7) to air control valve (6).

6. Connect hose assembly (3) to air control valve (6). Tighten hose clamp (4) securely.

i04203643

ARD Spark Plug - Remove and Install

Removal Procedure

Table 21

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	22mm Spark Plug Socket	1

⚠ WARNING

The ignition system may cause an electrical shock hazard, which may cause personal injury or death. Avoid contacting the ignition system components and the ignition system wiring during operation.

NOTICE
If the engine is running or the keyswitch is in the ON position, the ARD spark plug will continue to fire. Turn the keyswitch to the OFF position before servicing the ARD spark plug.

1. Turn the battery disconnect switch to the OFF position.

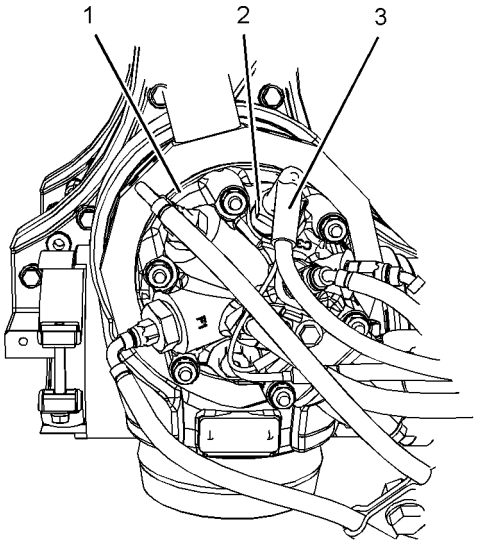


Illustration 128 g02035113

2. Disconnect ignition wire (3) from spark plug (2).

3. Use Tooling (A) in order to remove spark plug (2) from ARD combustion head (1).

Installation Procedure

Table 22

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	22mm Spark Plug Socket	1
B	T400005	Wire Brush	1

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

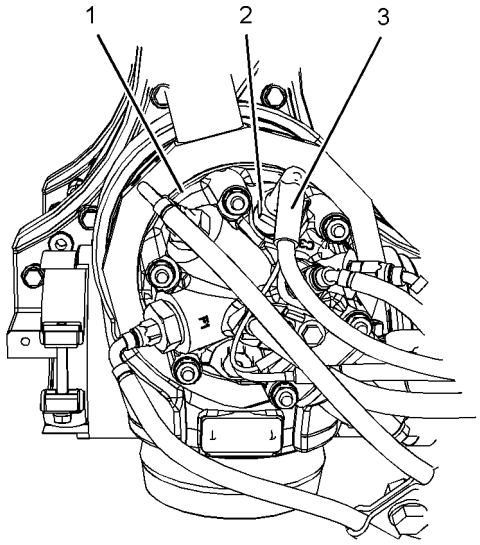


Illustration 129 g02035113

2. Inspect the spark plug and sealing washer for damage or wear. Refer to Operation and Maintenance Manual, “ARD Spark Plug - Inspect/Replace” for the correct procedure.

3. Use Tooling (B) in order to clean the ground electrode in ARD combustion head (1).

Note: Ensure that the threads in ARD combustion head (1) for spark plug (2) are clean and free from damage.

4. Install spark plug (2) to ARD combustion head (1).

5. Use Tooling (A) in order to tighten the spark plug to a torque of 47 N·m (35 lb ft).

6. Connect ignition wire (3) to spark plug (2).

7. Turn the battery disconnect switch to the ON position.

i04203739

Ignition Coil - Remove and Install (Clean Emissions Module)

Removal Procedure

⚠ WARNING

The ignition system may cause an electrical shock hazard, which may cause personal injury or death. Avoid contacting the ignition system components and the ignition system wiring during operation.

NOTICE
If the engine is running or the keyswitch is in the ON position, the ignition coil for the ARD spark plug will continue to fire. Turn the keyswitch to the OFF position before servicing the ignition coil for the ARD spark plug.

1. Turn the battery disconnect switch to the OFF position.

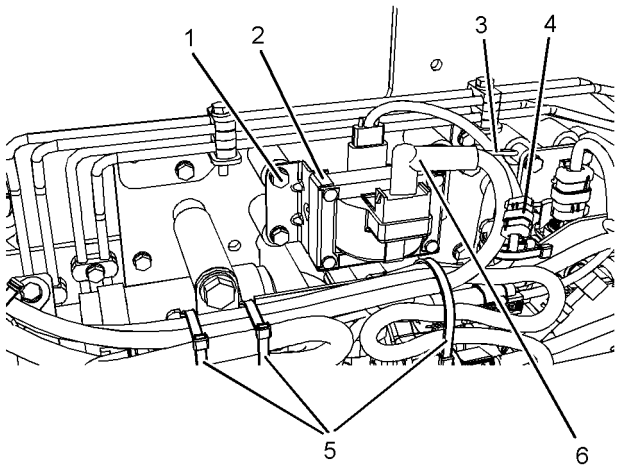


Illustration 130 g02155833
Typical example

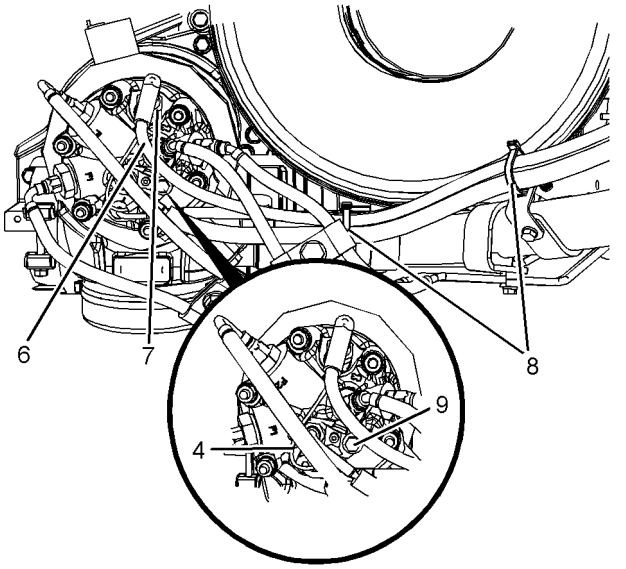


Illustration 131 g02155834
Typical example

2. Cut required cable straps (5) in order to remove harness assemblies.

Note: Note position of cable straps.

3. Slide the locking tab for harness assembly (4) into the unlocked position.

4. Disconnect harness assembly (4) for ignition coil (2) from the harness assembly for the clean emission module.

5. Disconnect ignition wire (6) from ignition coil (2).

6. If necessary, remove bolt (1) in order to remove ground strap (4) from ignition coil (2).

7. If necessary, remove the tube assembly for the pressure sensor for the Diesel Particulate Filter (DPF).

8. Remove bolts (1) and spacers from ignition coil (2). Remove ignition coil (2) from the bracket for the clean emission module.

Note: Note position of any brackets.

9. If necessary, follow Step 9.a through Step 9.e in order to remove ignition wire (6) from clean emission module.

   a. Cut remaining cable straps (5) and cable straps (8) from harness assembly (6).

Note: Note position of cable straps. Ensure that all cable straps are removed from the harness assemblies.

   b. If necessary, remove the nut and washer. Disconnect the ground strap for ignition wire (6) from the bracket for the clean emission module.

   c. Remove bolt (9) for ground strap (4) from the combustion head.

   d. Disconnect ignition wire (6) from spark plug (7).

   e. Make temporary marks on the ignition wire assembly for installation purposes. Remove ignition wire (6) assembly from the clean emission module.

Installation Procedure

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

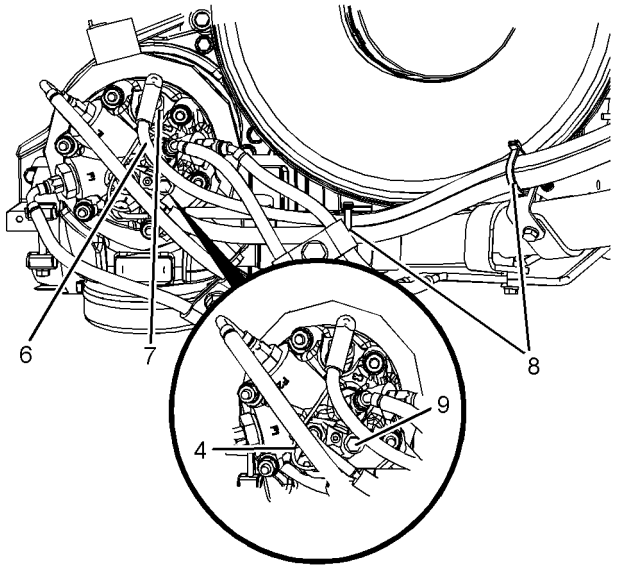


Illustration 132 g02155834
Typical example

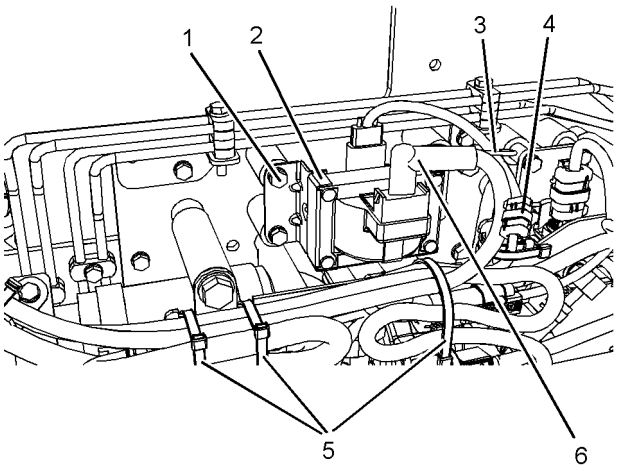


Illustration 133 g02155833

Typical example

2. If necessary, follow Step 2.a through Step 2.e in order to install ignition wire (6) onto clean emission module.

   a. Position ignition wire assembly onto the clean emission module. Ensure that the ignition wire assembly is orientated correctly.

   b. Install ignition wire (6) onto spark plug (7).

   c. Position ground strap (4) onto combustion head and install bolt (9).

   d. Tighten bolt (9) to a torque of 12 N·m (106 lb in).

Note: Ensure that the ground strap is not strained as the bolt is tightened.

   e. If necessary, connect the ground strap for ignition wire (6) to the bracket for the clean emission module. Install the nut and washer and tighten the nut to a torque of 12 N·m (106 lb in).

3. Loosely install bolts (1) and spacers to ignition coil (2).

4. Position ignition coil (2) onto the bracket for the clean emission module. Install all brackets that have been removed during disassembly.

5. If necessary, position ground strap (4) onto ignition coil (2). Install bolt (1) and spacer.

6. Tighten bolts (1) to a torque of 12 N·m (106 lb in).

Note: If necessary, ensure that the ground strap is not strained as the bolt is tightened.

7. Install ignition wire (6) to ignition coil (2).

8. Connect harness assembly (4) for ignition coil (2) to the harness assembly for the clean emission module.

9. Slide the locking tab for harness assembly (4) into the locked position.

10. If necessary, install the tube assembly for the pressure sensor for the Diesel Particulate Filter (DPF). Tighten the nuts on tube assembly to a torque of 16 N·m (142 lb in).

11. Install new cable straps (5) and cable straps (8) to harness assembly (6).

Note: Ensure that cable straps meet the OEM specification.

12. Turn the battery disconnect switch to the ON position.

i04203652

Combustion Head Group (ARD) - Remove and Install (Pilot Only System)

Removal Procedure

WARNING

Fuel leaked or spilled onto hot surfaces or electrical components can cause a fire. To help prevent possible injury, turn the start switch off when changing fuel filters or water separator elements. Clean up fuel spills immediately.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

WARNING

Hot engine components can cause injury from burns. Before performing maintenance on the engine, allow the engine and the components to cool.

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

3. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

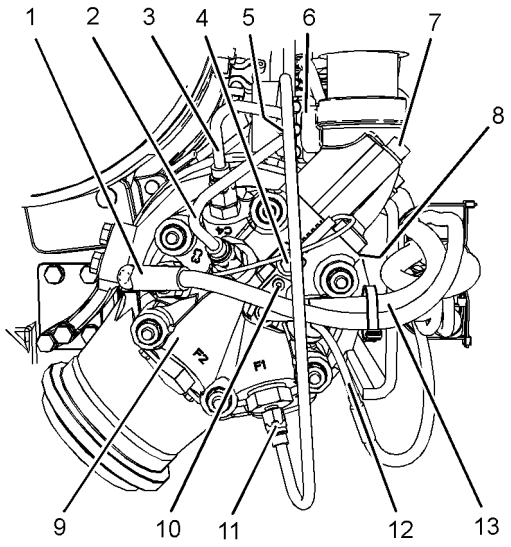


Illustration 134 g02158579

4. Remove allen head bolts (5) (not shown) from tube assembly clamps (6).

5. Disconnected fuel tube assembly (11) from ARD combustion head (9). Plug the tube assembly with new plugs. Cap all open connectors on the combustion head with new caps.

6. Disconnected tube assembly (2) and tube assembly (3) from ARD combustion head (9). Plug the tube assemblies with new plugs. Cap all open connectors on the combustion head with new caps.

7. Remove bolt (4) from the ground strap and disconnect ignition wire (1) from the spark plug.

8. Remove allen head screw (10) and remove clamp from the ARD combustion head (9). Remove heated nozzle connection (13) from the ARD combustion head.

9. Remove flame detection temperature sensor (12) from ARD combustion head (9). Refer to Disassembly and Assembly, “Flame Detection Temperature Sensor - Remove and Install” for the correct procedure.

10. Remove allen head bolts (7) and remove gasket (8) (not shown).

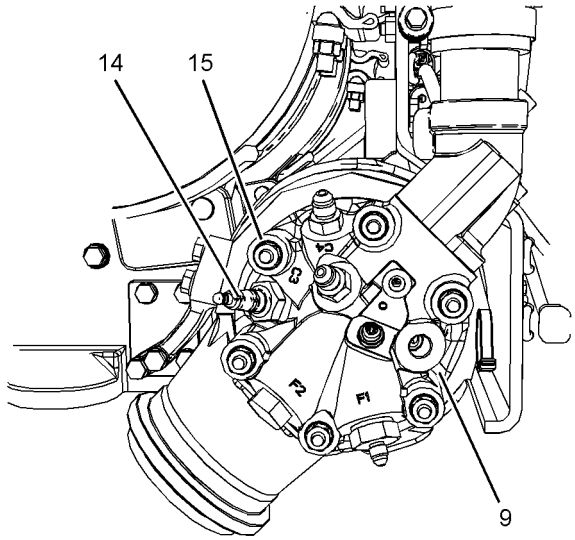


Illustration 135 g02158581

11. Remove spark plug (15) from ARD combustion head (9). Refer to Disassembly and Assembly, “ARD Spark Plug - Remove and Install” for the correct procedure.

12. Loosen nuts (15) in a crisscross pattern. Remove nuts (15) from ARD combustion head (9).

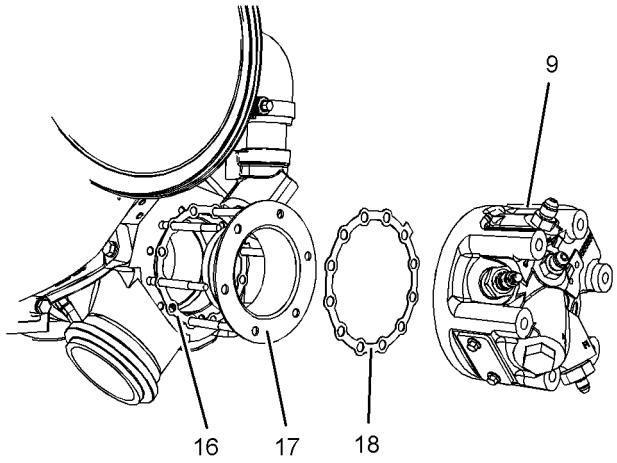


Illustration 136 g02158582

13. Remove ARD combustion head (9).

14. Remove gasket (18). Remove combustion tube assembly (17) and remove gasket (16).

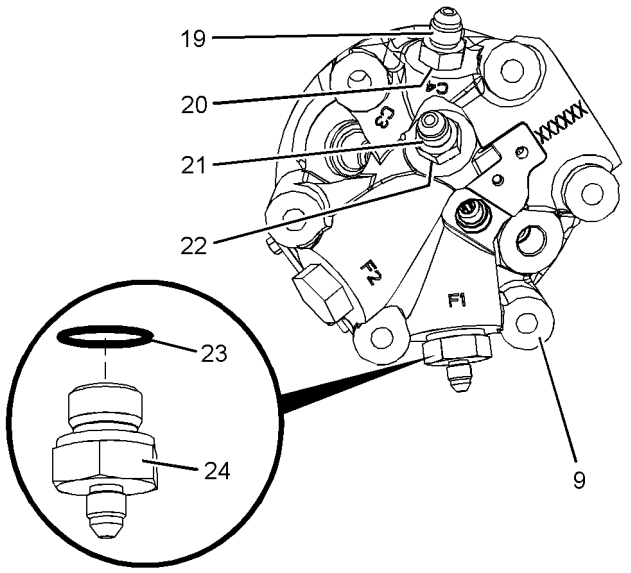


Illustration 137 g02158584

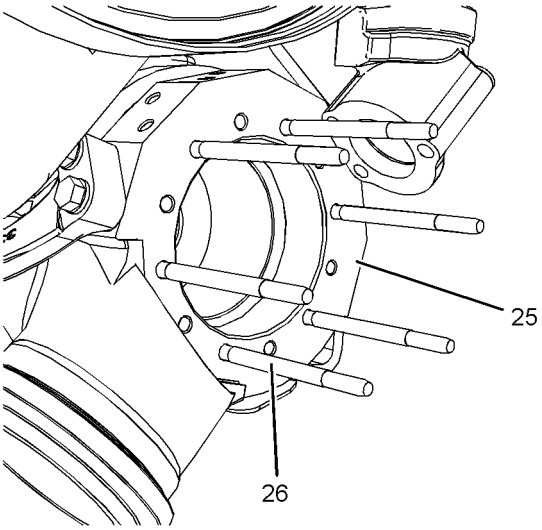


Illustration 138 g02158585

15. If necessary, follow Step 15.a through Step 15.b in order to remove fuel connection and the connections for the coolant from the ARD combustion head.

a. Remove fuel connection (24) from ARD combustion head (9).

b. Remove O-ring seal (23) from connection (24).

c. Remove coolant connection (19) and coolant connection (21) from ARD combustion head (9).

d. Remove O-ring seal (20) (not shown) from coolant connection (19).

e. Remove O-ring seal (22) (not shown) from coolant connection (21).

16. If necessary, remove studs (26) from body (25) of the ARD.

Installation Procedure

Table 23

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Anti-Seize Compound	1
B	-	Bostik Pure Nickel Anti-Seize Compound	1
C	27610296	Torque Wrench	1

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

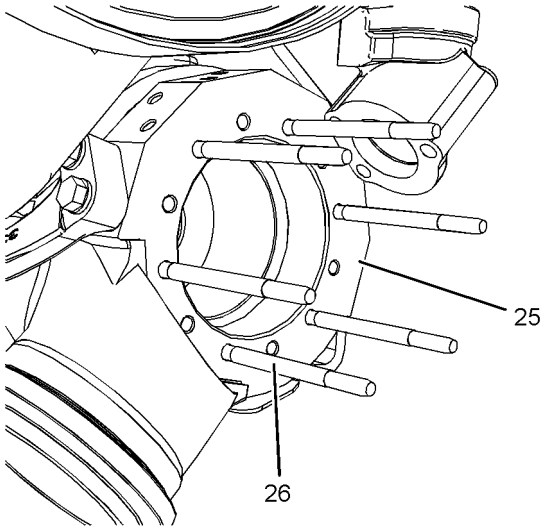


Illustration 139 g02158585

2. If necessary, install studs (26) to ARD body (25). Apply Tooling (A) onto the threads of studs (26). Install the studs to body (25) of the ARD.

Tighten studs (26) to a torque of 17 N·m (150 lb in).

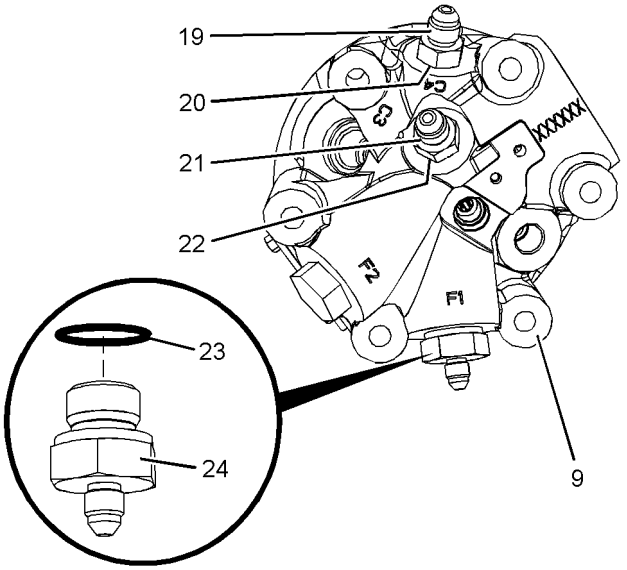


Illustration 140 g02158584

3. If necessary, follow Step 3.a through Step 3.d in order to install the fuel connection and the connections for the coolant to the ARD combustion head.

a. Ensure that the filter in fuel connection (24) is clean and free from damage. Ensure that the filter in the combustion head (9) is clean and free from damage.

b. Install a new O-ring seal (23) to fuel connection (24). Install the connection to ARD combustion head (9). Tighten the connection to a torque of 60 N·m (44 lb ft).

c. Install a new O-ring seal (20) (not shown) to coolant connection (19). Install coolant connection (19) to ARD combustion head (9). Tighten the connections to a torque of 30 N·m (266 lb in).

d. Install a new O-ring seal (22) (not shown) to coolant connection (21). Install coolant connection (21) to ARD combustion head (9). Tighten the connections to a torque of 30 N·m (266 lb in).

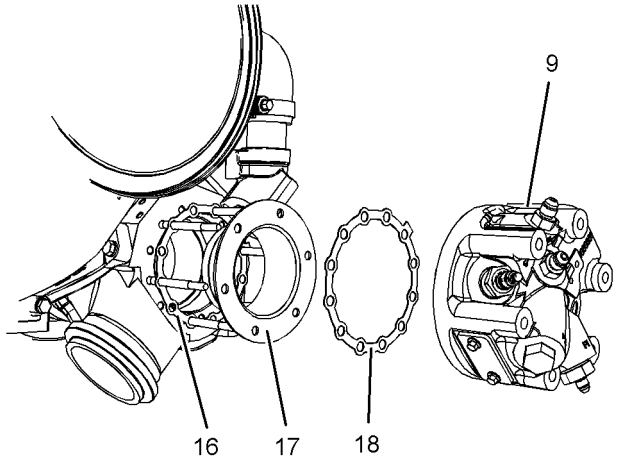


Illustration 141 g02158582

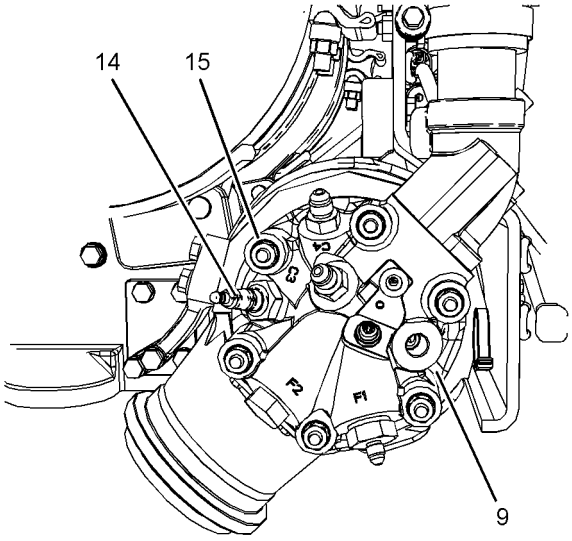


Illustration 142 g02158581

4. Thoroughly clean the gasket surfaces of the ARD combustion head, combustion tube assembly, and the ARD body. Do not damage the gasket surfaces of the combustion head of the ARD body. Ensure that no debris enters the assembly of the clean emission module.

5. Install a new gasket (16) and install combustion tube assembly (17). Install a new gasket (18).

6. Install ARD combustion head (9).

7. Apply Tooling (A) onto the threads of the studs and nuts (15). Install nuts (15) to ARD combustion head (9).

8. Tighten nuts (15) in a crisscross pattern to a torque of 23 N·m (204 lb in). Tighten nuts (15) again in a crisscross pattern to a torque of 28 N·m (248 lb in). Tighten nuts (15) again in a crisscross pattern to a torque of 28 N·m (248 lb in).

9. Install spark plug (14) to ARD combustion head (9). Tighten spark plug (14) to a torque of 47 N·m (35 lb ft). Refer to Disassembly and Assembly, “ARD Spark Plug - Remove and Install” for the correct procedure.

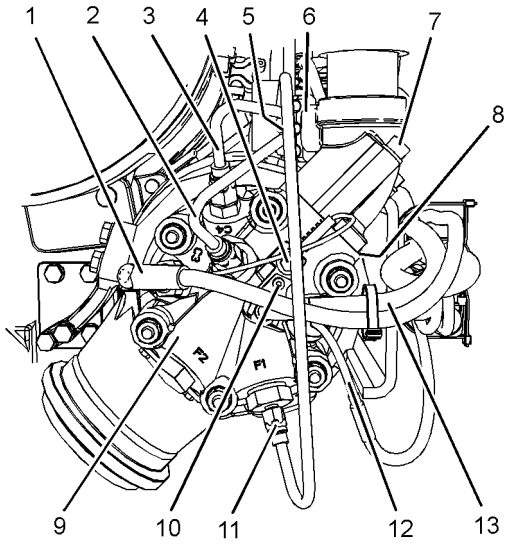


Illustration 143 g02158579

10. Install a new gasket (8) (not shown). Install allen head bolt (7). Tighten allen head bolts (7) to a torque of 28 N·m (248 lb in).

11. Apply Tooling (B) to the thread of flame detection temperature sensor (12). Install flame detection temperature sensor (12) to the ARD combustion head. Tighten flame detection temperature sensors (12) to a torque of 45 N·m (33 lb ft). Refer to Disassembly and Assembly, “Flame Detection Temperature Sensor - Remove and Install” for the correct procedure.

12. Install heated nozzle connection (13) to the ARD combustion head. Install allen head bolt (10).

13. Use Tooling (C) in order to tighten the allen head bolt to a torque of 1.7 N·m (15 lb in).

14. Connect ignition wire (1) to the spark plug. Install bolt (4) to the ground strap. Tighten bolt (4) to a torque of 12 N·m (106 lb in).

15. Remove the plug from fuel tube assembly (11). Remove the cap from connection on the ARD combustion head. Connect fuel tube assembly (11) to the ARD combustion head. Hand tighten fuel tube assembly.

16. Remove the plug from coolant tube assembly (2) and coolant tube assembly (3). Remove the cap from coolant connections on the ARD combustion head. Connect coolant tube assembly (2) and coolant tube assembly (3) to the ARD combustion head. Hand tighten coolant tube assemblies.

17. Position tube assembly clamps (6) onto tube assemblies. Install allen head bolts (5) (not shown) to tube assembly clamps (6). Hand tighten allen head bolts (5).

18. Tighten coolant tube assembly (2) and coolant tube assembly (3) to a torque of 20 N·m (177 lb in).

19. Tighten fuel tube assembly (11) to a torque of 16 N·m (142 lb in).

20. Tighten allen head bolts (5) to a torque of 12 N·m (106 lb in).

21. Turn the fuel supply to the ON position.

22. Turn the battery disconnect switch to the ON position.

23. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Check” and Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct filling procedure.

24. Perform the ARD ignition test. Refer to Troubleshooting, “ARD Ignition - Test” for the correct filling procedure.

i04203756

Relay (ARD Nozzle Heater) - Remove and Install (Clean Emissions Module)

Removal Procedure

1. Turn the battery disconnect switch to the OFF position.

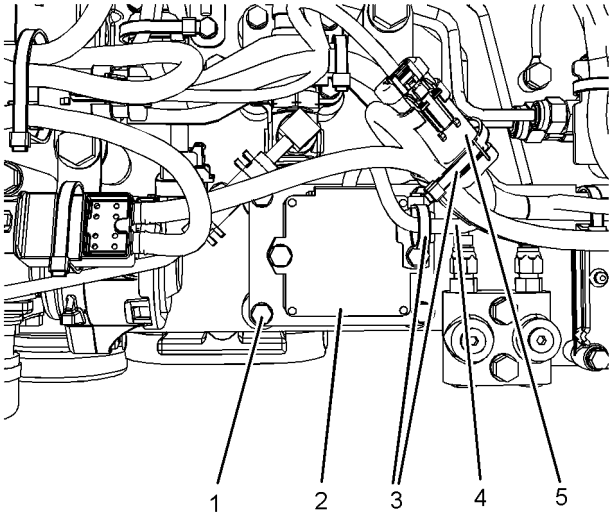


Illustration 144 g02156274

Typical example

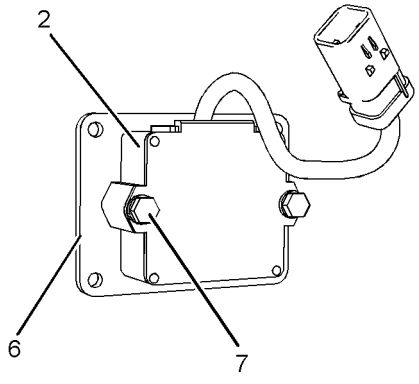


Illustration 145 g02156273

2. Cut cable straps (3) from harness assembly (4).

Note: Note position of cable straps. Ensure that all cable straps are removed for the harness assemblies.

3. Slide the locking tab for the harness assembly (4) into the unlocked position.

4. Disconnect harness assembly (4) from harness assembly connection (5) for the clean emission module.

5. Remove bolts (1) and spacers.

Note: Note position and orientation of any brackets that are attached to the relay assembly.

6. Remove relay assembly (2) from the bracket for the clean emission module.

7. If necessary, follow Step 7.a through Step 7.b in order to remove relay assembly (2) from bracket (6).

   a. Remove bolts (7) from relay assembly (2) and remove bracket (6).

Note: Note the orientation of the bracket for installation purposes.

   b. Remove relay (2) from bracket (6).

Installation Procedure

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

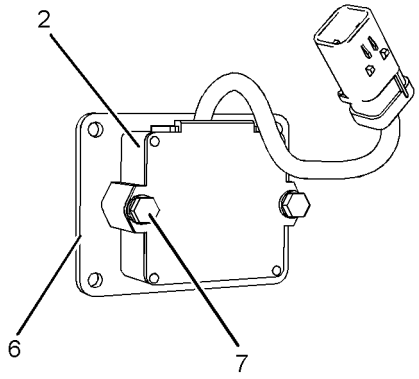


Illustration 146 g02156273

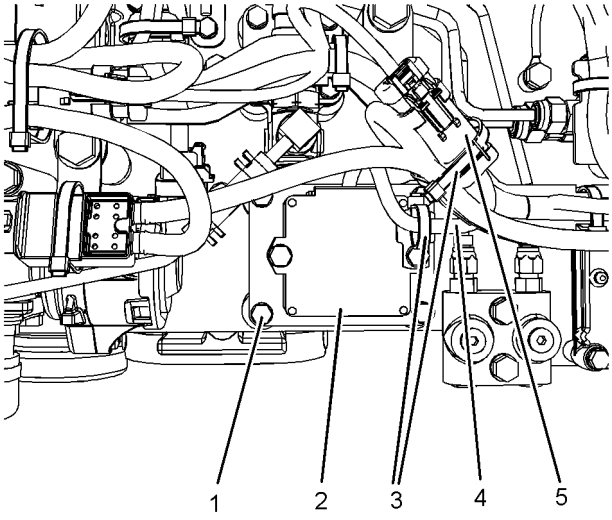


Illustration 147 g02156274
Typical example

2. If necessary, follow Step 2.a through Step 2.b in order to install relay assembly (2) to bracket (6).

a. Position relay assembly (2) onto bracket (6).

Note: Ensure the correct orientation of the relay assembly on the bracket.

b. Install bolts (7) to relay assembly (2) and tighten the bolts to a torque of 9 N·m (80 lb in).

3. Position brackets onto relay assembly (2) and install bolts (1) and spacers.

Note: Ensure correct position and orientation of the brackets.

4. Position relay assembly (2) onto the bracket for the clean emission module.

Note: Ensure that the relay assembly is correctly oriented on the clean emission module bracket.

5. Tighten the bolts to a torque of 12 N·m (142 lb in).

6. Connect harness assembly (4) to harness assembly connection (5) for the clean emission module.

7. Install cable straps (3) to harness assembly (4).

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

8. Turn the battery disconnect switch to the ON position.

i04203729

Heated Nozzle - Remove and Install (Heated Nozzle Connection)

Removal Procedure

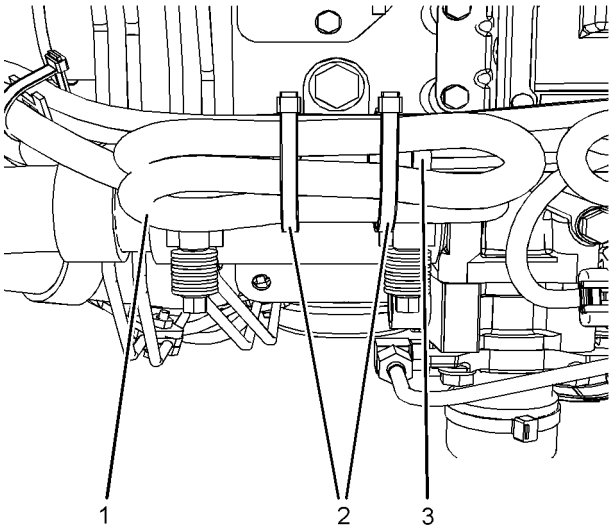


Illustration 148 g02029533

1. Cut cable straps (2) from harness assembly (1).

Note: Note position of cable straps.

2. Slide the locking tab for connection (3) into the unlocked position.

3. Disconnect harness assembly (1) from connection (3).

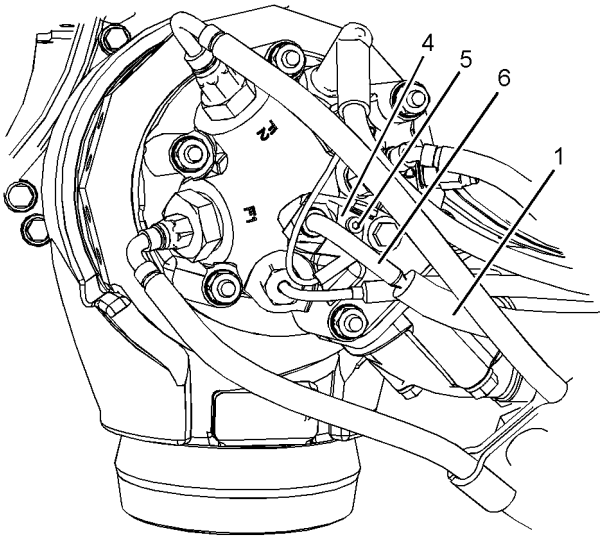


Illustration 149 g02029535

4. Make temporary marks on heated nozzle connection (6) and the combustion head for the ARD for installation purposes.

5. Remove allen head screw (5) and clamp (4).

6. Remove heated nozzle connection (6) from the combustion head for the ARD.

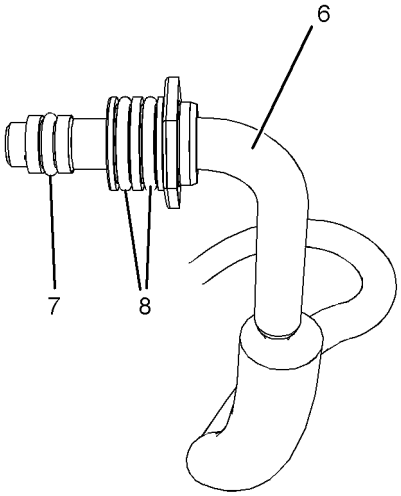


Illustration 150 g02029536

7. Remove O-ring seals (8) and O-ring seal (7) from the heated nozzle.

Installation Procedure

Table 24

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610296	Torque Wrench	1

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

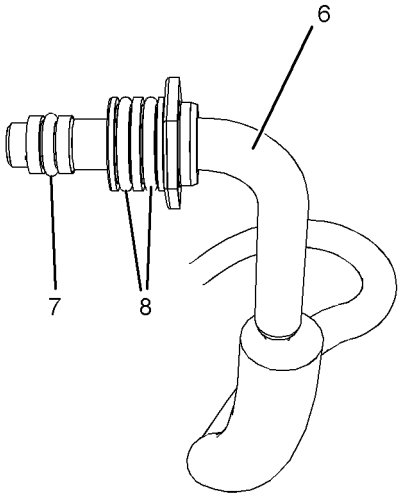


Illustration 151 g02029536

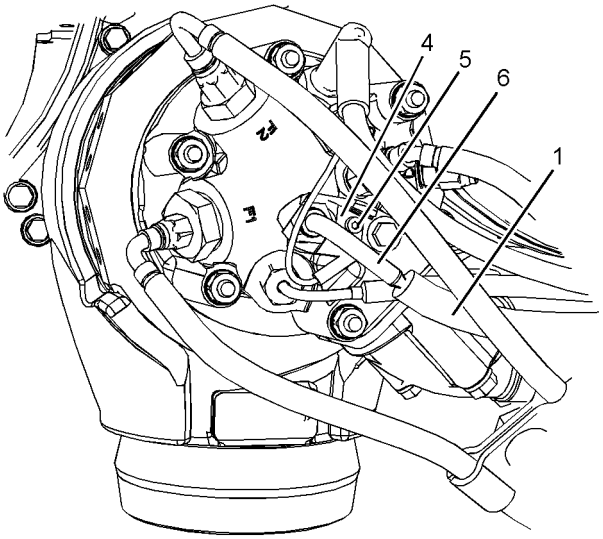


Illustration 152 g02029535

2. Install new O-ring seals (8) and O-ring seal (7) to heated nozzle connection (6).

3. Position harness assembly (1) and install heated nozzle connection (6) to the combustion head for the ARD.

Note: Ensure correct orientation of the heated nozzle connection.

4. Install clamp (4) and allen head screw (5).

5. Use Tooling (A) in order to tighten the allen head screw to a torque of 1.7 N·m (15 lb in).

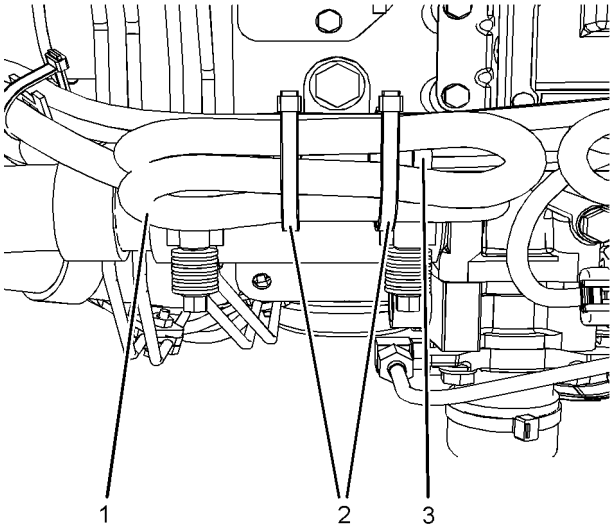


Illustration 153 g02029533

6. Connect harness assembly (1) to connection (3).

7. Slide the locking tab for connection (3) into the locked position.

8. Install new cable straps (2) to harness assembly (1).

Note: Ensure that cable straps meet the Original Equipment Manufacturers (OEM) specification.

i04224207

Exhaust Manifold - Remove

Removal Procedure

Start By:

a. Remove the first stage turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Remove (First Stage Turbocharger)” for the correct procedure.

Note: Plug or cap all open ports with new plugs or caps.

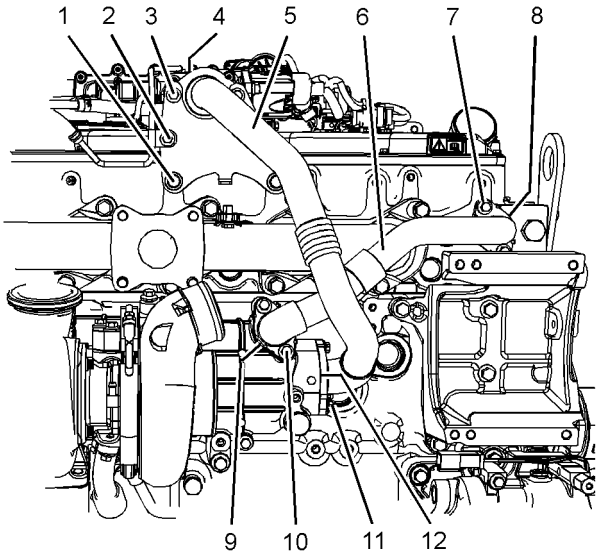


Illustration 154 g02177350

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

2. Loosen bolts (1) for the support bracket.

3. Remove bolt (2) from clip for tube assembly.

4. Remove bolts (3) and bolts (11). Remove tube assembly (5) from the exhaust cooler and induction mixer.

5. Remove gasket (4) (not shown) and gasket (12) (not shown).

6. Remove bolts (7) and bolts (10). Remove tube assembly (6) from the exhaust cooler and from the cylinder head.

7. Remove gasket (8) (not shown) and gasket (9) (not shown).

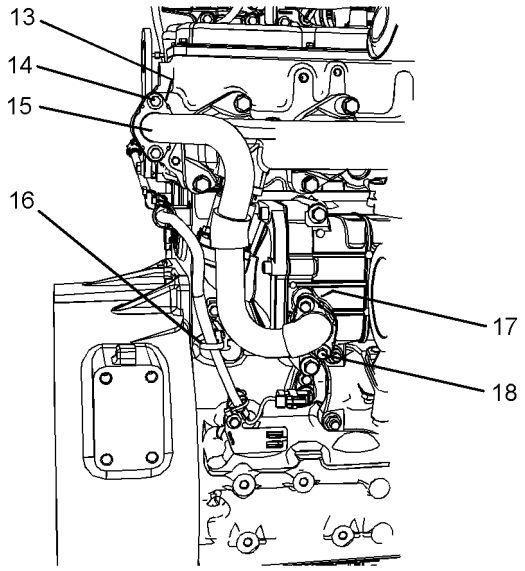


Illustration 155 g02177373

8. Cut cable straps (16).

9. Remove bolts (14) and bolts (18) from tube assembly (15). Remove the tube assembly (15) from the exhaust cooler.

10. Remove gasket (13) (not shown) and gasket (17) (not shown).

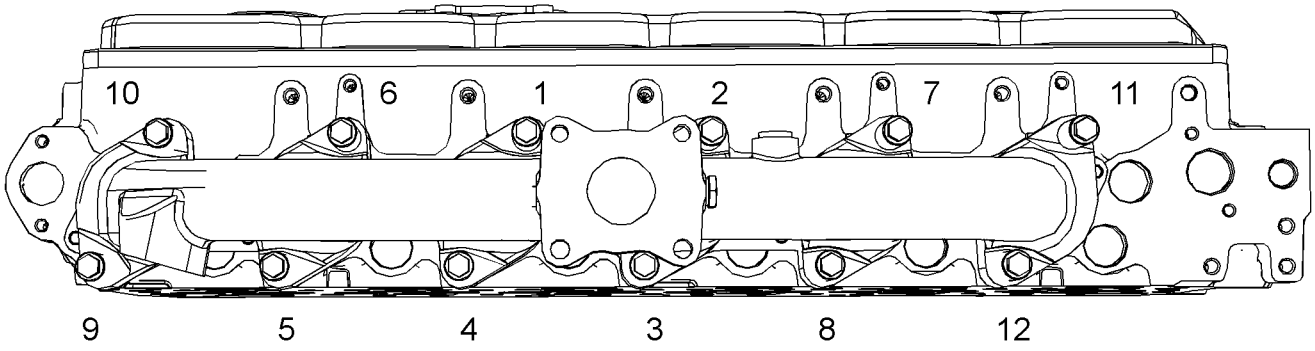


Illustration 156 g01977645

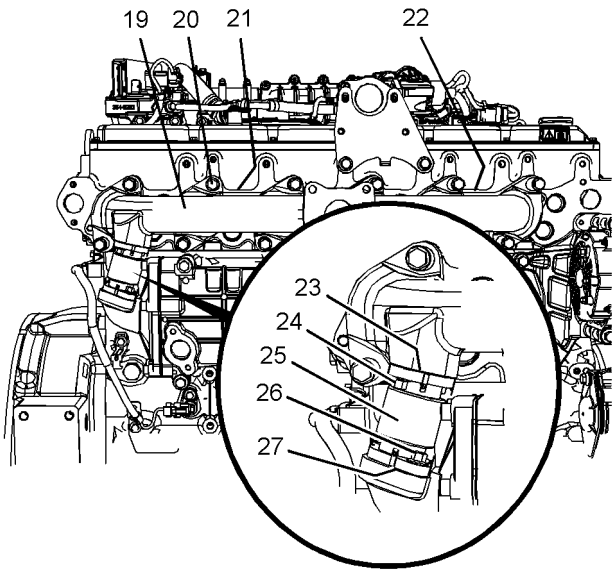


Illustration 157 g02367616

11. Prior to and during removal of bolts (24) and bolts (26) apply releasing fluid to the bolts. Remove bolts (24) and bolts (26) from tube assembly (25).

12. Loosen bolts (20) in reverse numerical order. Refer to Illustration 156.

Note: Loosening the bolts in reverse numerical order will help prevent distortion of the exhaust manifold.

13. Remove bolts (20) and the spacers from exhaust manifold (19).

Note: Support the manifold as the bolts are removed.

14. Remove exhaust manifold (19).

15. Remove exhaust manifold gaskets (21) (not shown) and exhaust manifold gaskets (22) (not shown).

16. Remove tube assembly (25). Remove gasket (23) (not shown) and gasket (27) (not shown).

i04224214

Exhaust Manifold - Install

Installation Procedure

Table 25

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400019	Alignment Pins	2
	T400020	Alignment Pins	2

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

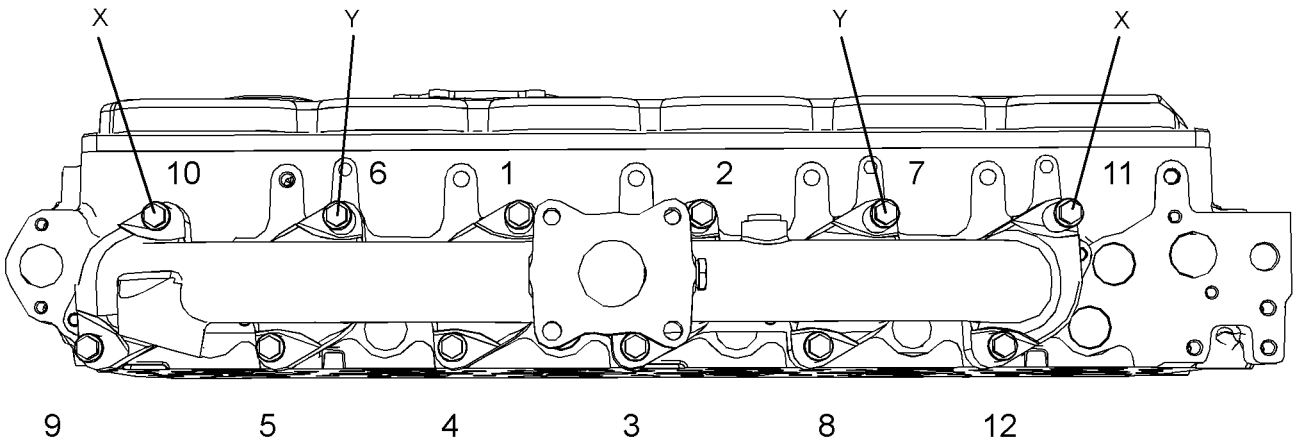


Illustration 158 g02177553

Two of Tooling (A) have threads on one end. This threaded end of Tooling (A) should be installed into Positions (Y).

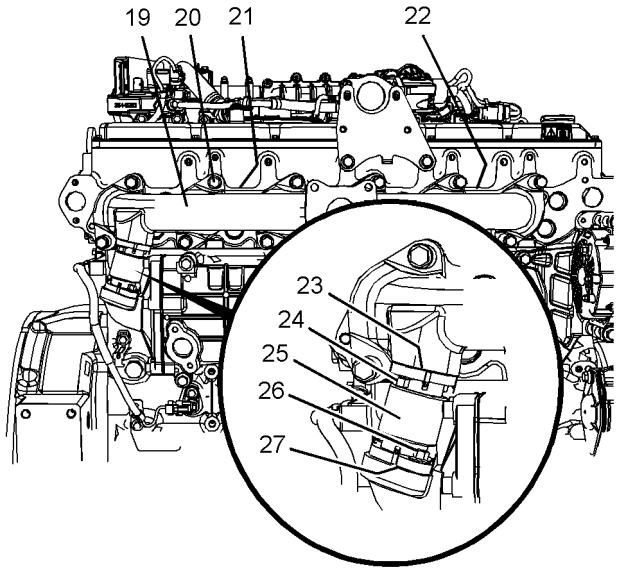


Illustration 159 g02367616

1. Ensure that exhaust manifold (19) is clean and free from damage. If necessary, replace the exhaust manifold. Clean the gasket surface of the cylinder head.

2. Position a new exhaust manifold gasket (21) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Positions (Y). Refer to Illustration 158.

Note: Ensure that the exhaust manifold gaskets are correctly oriented.

3. Position a new exhaust manifold gasket (22) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Positions (Y). Refer to Illustration 158.

Note: Ensure that the exhaust manifold gaskets are correctly oriented.

4. Position a new gasket (27) (not shown) onto a new tube assembly (25). Position tube assembly onto the NRS exhaust cooler and install new bolts (26) and tighten the bolts ensuring that the tube assembly can still move.

5. Position a new gasket (23) (not shown) onto tube assembly (25)

6. Align exhaust manifold (19) with Tooling (A). Install the exhaust manifold to the cylinder head.

7. Install bolts (24) for tube assembly (25) and tighten the bolts ensuring that the tube assembly can still move.

8. Install new bolts (20) and the spacers in the eight available position to exhaust manifold (19).

9. Tighten bolts (20) one to four to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 158.

10. Remove Tooling (A). Install remaining new bolts (20) and the spacers to exhaust manifold (19).

11. Tighten remaining bolts (20) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 158.

12. Tighten bolts (24) and bolts (26) for tube assembly (25) to a torque of 22 N·m (195 lb in).

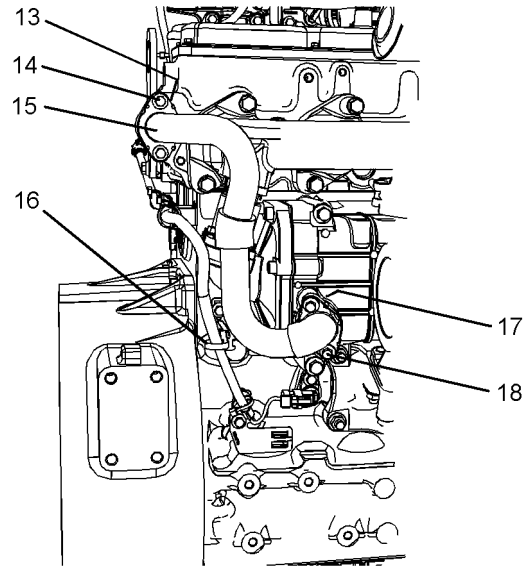


Illustration 160 g02177373

13. Position a new gasket (13) (not shown) and a new gasket (17) (not shown) onto tube assembly (15).

14. Position tube assembly (15) onto the exhaust cooler and the cylinder head.

15. Install bolts (14) and bolts (18). Tighten bolts hand tight.

16. Tighten bolts (14) to a torque of 22 N·m (195 lb in).

Tighten bolts (18) to a torque of 18 N·m (159 lb in).

17. Install new cable straps (16).

Note: Ensure that the cable straps meet Original Equipment Manufacturers (OEM) specifications.

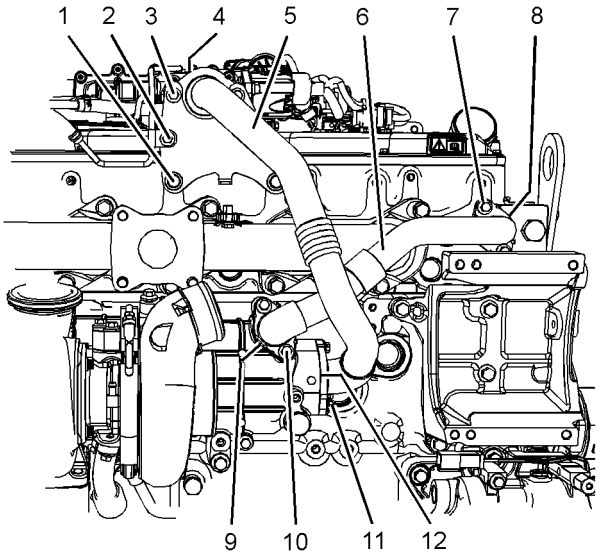


Illustration 161 g02177350

18. Position a new gasket (8) (not shown) and a new gasket (9) (not shown) onto tube assembly (6).

19. Position tube assembly (6) onto the exhaust cooler and the cylinder head. Install bolts (7) and bolts (10). Tighten bolts hand tight.

20. Tighten bolts (7) to a torque of 22 N·m (195 lb in).

Tighten bolts (10) to a torque of 18 N·m (159 lb in).

21. Ensure that tube assembly (6) is not stressed as the bolts are tightened.

22. Position a new gasket (4) (not shown) the induction mixer.

Note: Ensure that the gasket is correctly installed the locating pins on the induction mixer.

23. Position a new gasket (12) (not shown) onto tube assembly (5).

24. Position tube assembly (5) between the bracket and the induction mixer. Install bolts (3) finger tight.

25. Position tube assembly (5) onto the exhaust cooler. Install bolts (11) finger tight.

26. Tighten bolts (11) to a torque of 18 N·m (159 lb in).

27. Tighten bolts (3) to a torque of 22 N·m (195 lb in).

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

28. Install bolt (2) to clip for tube assembly. Tighten the bolt to a torque of 22 N·m (195 lb in).

29. Ensure that tube assembly (5) is not stressed as the bolts are tightened.

30. Install the first stage turbocharger. Refer to Disassembly and Assembly, “Turbocharger (First Stage Turbocharger) - Install” for the correct procedure.

31. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

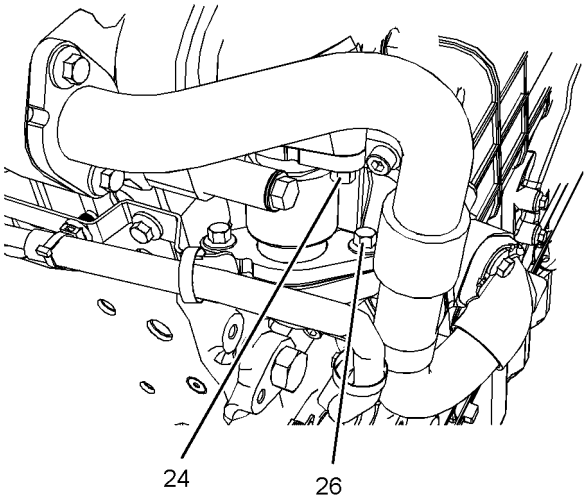


Illustration 162 g02177558

32. After the engine has been operated for 15 minutes, the engine should be stopped. Bolts (24) and bolts (26) should be checked for correct torque. Tighten bolts to a torque of 22 N·m (195 lb in).

i04203651

Catalyst - Remove and Install (Diesel Oxidation Catalyst (DOC))

Removal Procedure

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

⚠ WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

NOTICE

Do not strike any part of the assembly of the Diesel Oxidation Catalyst (DOC). Do not allow any object to contact the internal element of the DOC. If the internal element of the DOC becomes damaged, the assembly must be replaced.

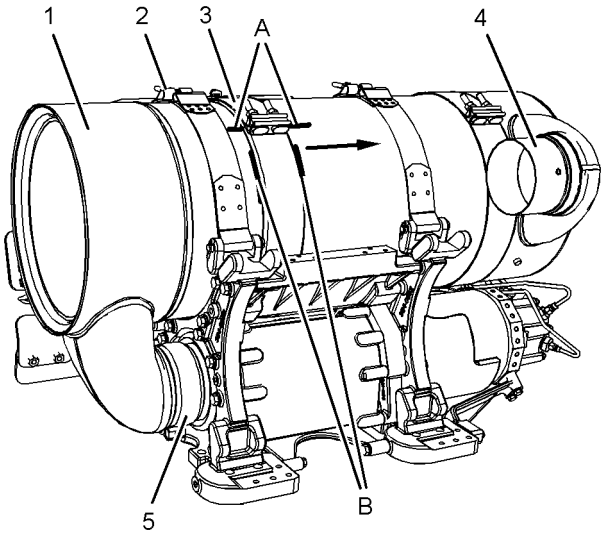


Illustration 163 g02360116

1. If necessary, remove the Original Equipment Manufacturers (OEM) exhaust system from outlet cannister (4) of the clean emission module.

2. Make temporary alignment marks on Torca clamp (3) in Position (A) and Position (B). Loosen the nuts for Torca clamp (3) and slide the Torca clamp along the Diesel Particulate Filter (DPF).

3. Sufficiently loosen the nuts on clamp (2) in order to allow the Diesel Oxidation Catalyst (DOC) (1) to be removed.

4. Loosen the bolt on ball clamp (5) in order to allow the removal of DOC (1).

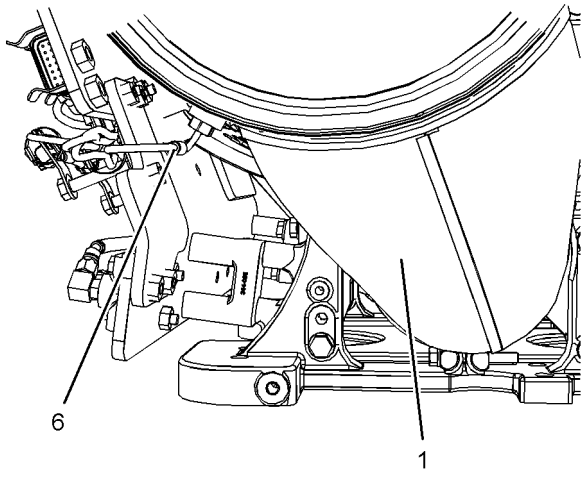


Illustration 164 g02360117

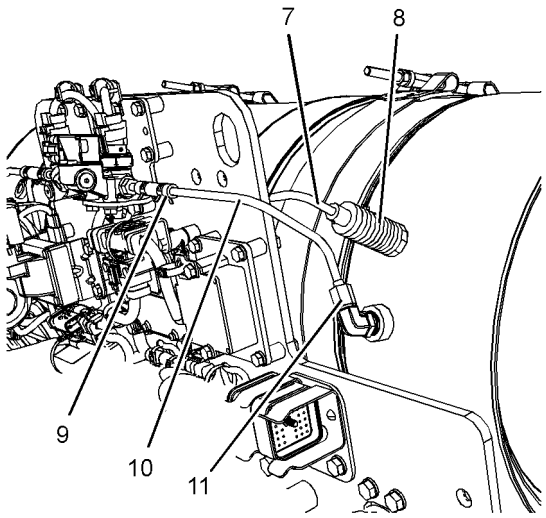


Illustration 165 g02360118

5. Disconnect harness assembly (7) from soot antenna (8).

6. Remove temperature sensor (6). Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

7. Remove soot antenna (8). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

8. Disconnect nut (11) for tube assembly (10).

9. Slide hose clamp (9) along the hose assembly. Remove tube assembly (10).

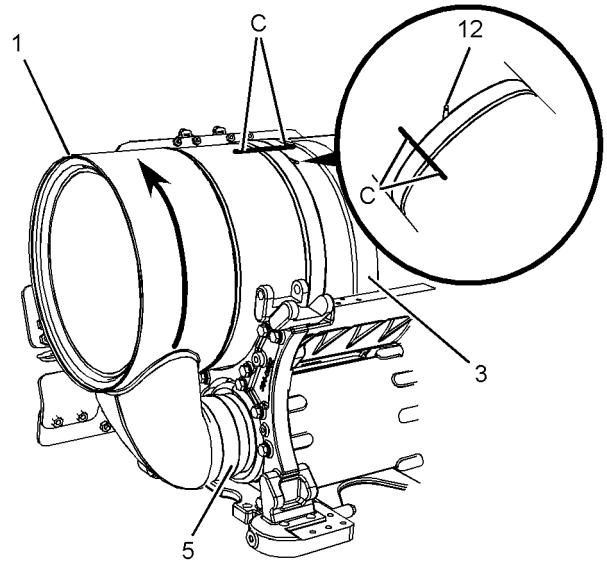


Illustration 166 g02360119

10. Make temporary alignment mark on DOC (1) and Diesel Particulate Filter (DPF) in Position (C).

11. Attach a suitable lifting device to DOC (1). The weight of the DOC is approximately 20 kg (44 lb).

12. Rotate the DOC in a counter clockwise direction in order to disengage pins and slots (12) from the DPF.

13. Use the suitable lifting device to remove DOC (1) from the clean emission module mounting bracket.

14. Remove Torca clamp (3).

15. Remove ball clamp (5).

Installation Procedure

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

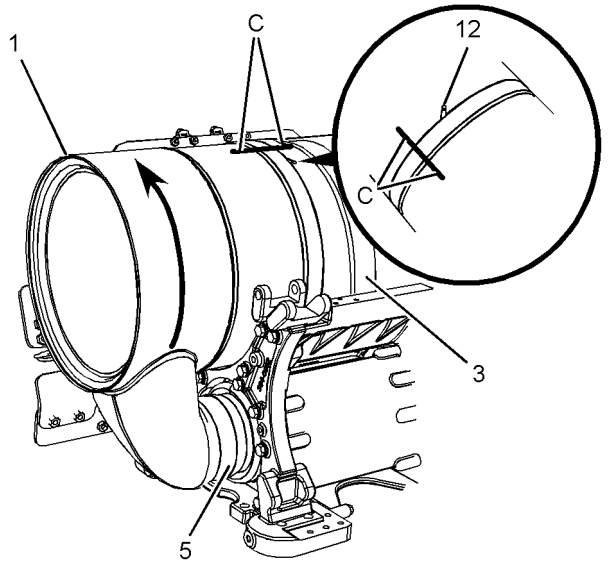


Illustration 167 g02360119

2. Position a new Torca clamp (3) onto the DPF. Ensure the correct orientation of the Torca clamp (3).

3. Position a new ball clamp (5) onto DOC (1). Ensure the correct orientation of ball clamp (5).

4. Attach a suitable lifting device to DOC (1). The weight of the DOC is approximately 20 kg (44 lb).

5. Use the suitable lifting device to position DOC (1) onto the clean emission module mounting bracket and align pins and slots (12).

6. Rotate DOC (1) in a clockwise direction in order to engage pins and slots (12) as in Position (C). Ensure that the pins and slots are fully engaged.

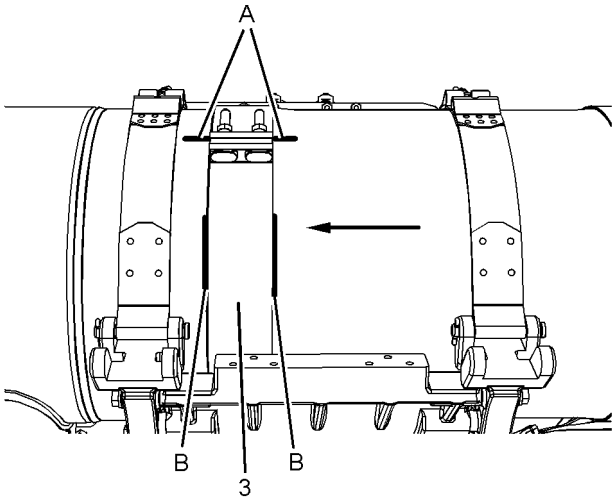


Illustration 168 g02328556

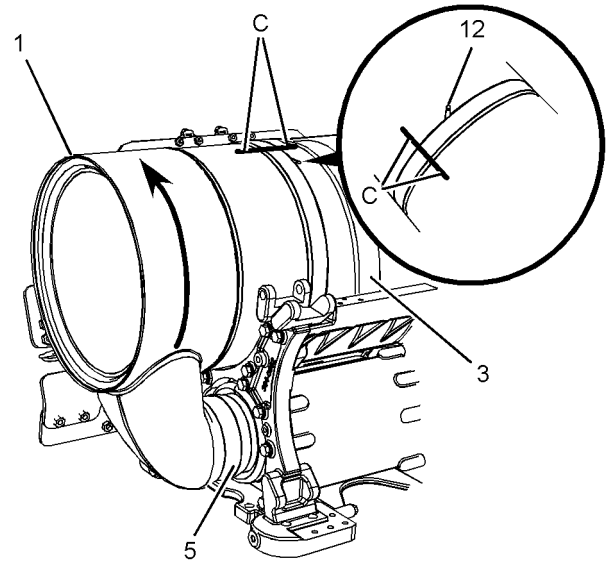


Illustration 169 g02360119

7. Position ball clamp (5) and hand tighten the bolt. Ensure that the ball clamp is correctly orientated.

8. Slide Torca clamp (3) along the DPF ensure that Torca clamp is correctly orientated.

9. Position the Torca clamp between Position (A) and Positions (B). Hand tighten the Torca clamp. Ensure that the Torca clamp is correctly aligned.

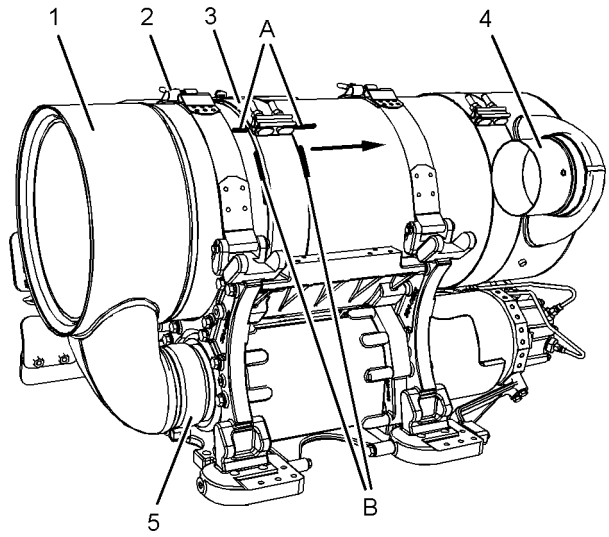


Illustration 170 g02360116

10. Tighten the nuts on clamp (2) for DOC (1) and the DPF hand tight.

11. Tighten nuts for Torca clamp (3) to a torque of 42 N·m (31 lb ft).

12. Tighten the nuts for clamp (2) to a torque of 18 N·m (159 lb in).

13. Tighten the bolt for clamp (5) to a torque of 18 N·m (159 lb in).

14. If necessary, install the OEM exhaust system to outlet cannister (4) of the clean emission module.

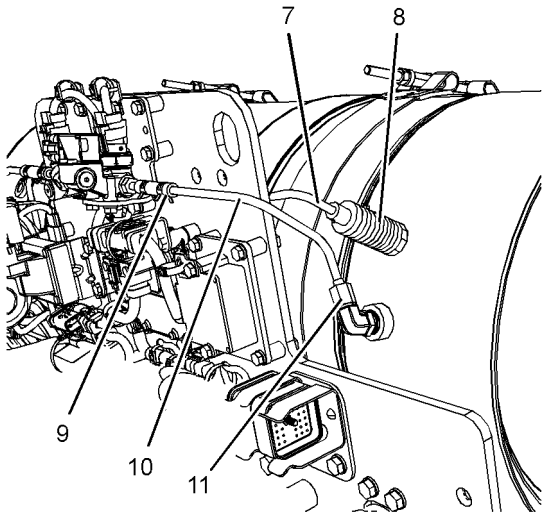


Illustration 171 g02360118

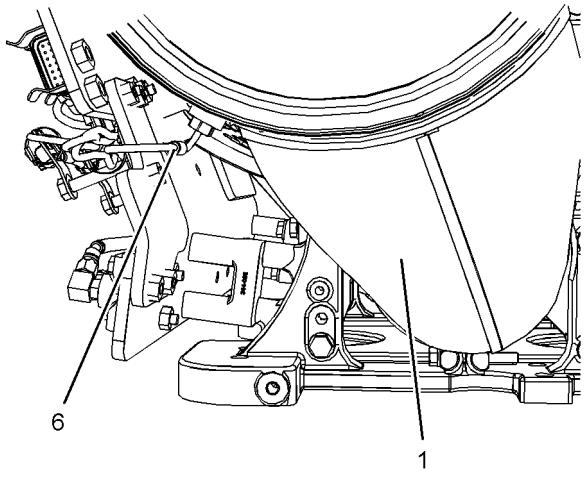


Illustration 172 g02360117

15. Install soot antenna (8). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

16. Connect harness assembly (7) to soot antenna (8). Tighten the harness assembly to a torque of 1.5 N·m (13 lb in).

17. Position tube assembly (10) onto the hose assembly and connection on DOC. Connect nut (11) finger tight.

18. Slide hose clamp (9) along the hose assembly. Ensure that the hose clamp is correctly positioned.

19. Tighten nut (11) to a torque of 16 N·m (142 lb in).

20. Install temperature sensor (6) in to DOC (1). Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

i04203698

Flexible Exhaust Pipe - Remove and Install

Removal Procedure for the Flexible Exhaust Pipe as an Assembly

⚠ CAUTION

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

NOTICE
The bellows must be supported at all times when the bellows are not installed in the application. Failure to support the bellows adequately could result in the failure of the bellows. Do not use power tools in order to disassemble or assemble any part of the flexible exhaust system.

The alignment of the bellows is important. Incorrect alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the uniformity of the spacing between the convolutions on the bellows.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. If there is any difficulty in installation after the repair, discard the bellows.

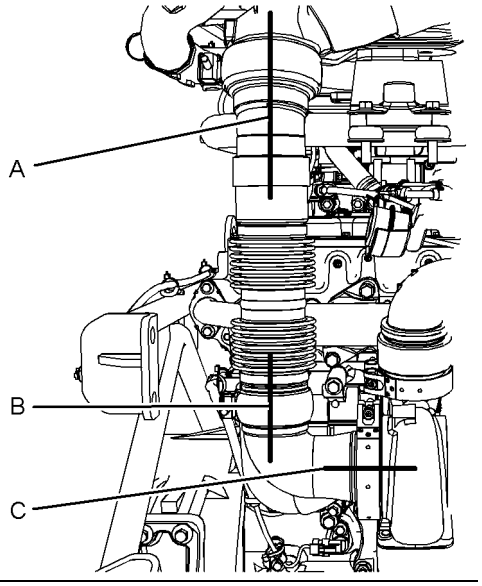


Illustration 173 g02354623

1. The lateral alignment of the bellows is critical. All the components must be assembled in the same alignment as prior to disassembly. The components that require correct lateral alignment are shown at Positions (A, B, and C).

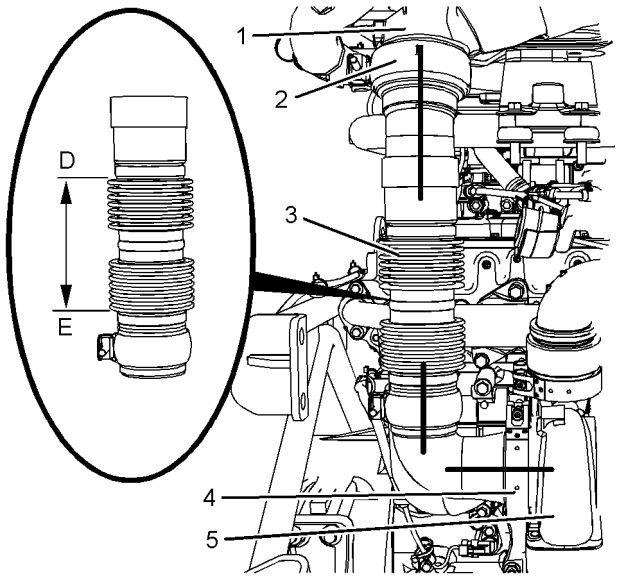


Illustration 174 g02354616

2. Follow Steps 2.a through Step 2.d in order to remove the flexible exhaust as an assembly from the Clean Emission Module (CEM) and the turbocharger.

a. Use suitable material in order to encase flexible exhaust pipe (3). Encasing the flexible exhaust pipe will prevent damage of the bellows. Encase bellows for the flexible exhaust pipe (3) between Position (D) and Position (E). Use cable straps in order to retain the suitable material.

Note: Ensure that the flexible exhaust pipe is supported at all times.

b. Loosen ball clamp (2) from the flexible exhaust pipe assembly.

c. Loosen the bolt for V-band clamp (4).

Note: If V-band clamp (4) remain tight on the flanges, apply releasing fluid on the V-band clamp. Lightly tap the bolt on the V-band clamp with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamp.**

d. Remove the assembly of the flexible exhaust pipe from the CEM (1) and the turbocharger (5).

Note: Ensure that the assembly of the flexible exhaust pipe is supported as the clamps are removed.

Disassembly Procedure for the Flexible Exhaust Pipe Assembly

1. If any part of the flexible exhaust pipe assembly is damaged. Refer to Special Instruction, REHS5014, “Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines” for more information.

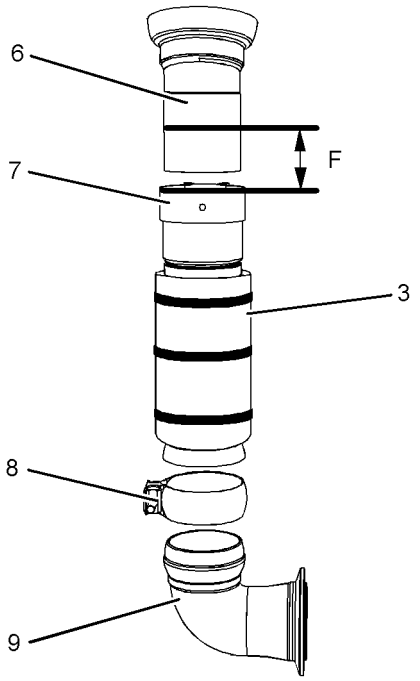


Illustration 175 g02354617

2. If necessary, follow Step 2.a through Step 2.d in order to disassemble the flexible exhaust pipe assembly.

a. Make temporary marks in Position (F) on all components of the bellows (3) and tube assembly (6) in order to show correct orientation and alignment.

Note: Do not scribe the components in order to mark the position of the flexible exhaust pipe assembly.

b. Loosen clamp (7) and remove tube assembly (6) from bellows (3).

c. Loosen ball clamp (8) and remove the ball clamp. Discard the ball clamp.

d. Remove bellows (3) from the elbow (9).

Note: Ensure that the flexible exhaust pipe bellows are not subjected to any undue stress.

Assembly Procedure for the Flexible Exhaust Pipe Assembly

1. Ensure that all components of the flexible exhaust pipe assembly are clean and free from wear and damage. If necessary, replace any components of the flexible exhaust pipe assembly that are worn or damaged. Refer to Special Instruction, REHS5014, “Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines” for more information.

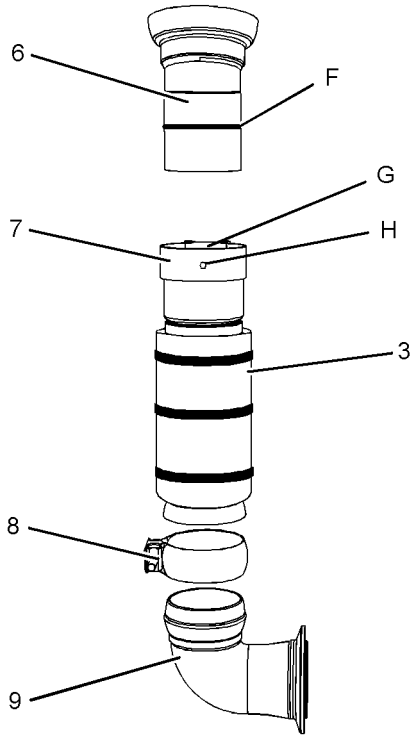


Illustration 176 g02354618

2. If the flexible exhaust pipe assembly was previously disassembled. Follow Step 2.a through Step 2.i in order to assemble the flexible exhaust pipe assembly.

NOTICE
Use the correct personal protective equipment when removing the clamp.

a. If original bellows are to be reinstalled, place the internal area in Position (G) of the bellows on a suitable support. Use a 3 mm (0.118 inch) in order to drill a pilot hole through the spot weld in Position (H) on clamp (7).

Note: Do not center punch the spot weld on clamp (7).

b. Use a 6.5 mm (0.256 inch) in order to drill out spot weld in Position (H) on clamp (7). Remove clamp (7) from the bellows.

c. Remove all burrs from the internal and external areas of bellows (3). **Ensure that debris does not enter bellows.**

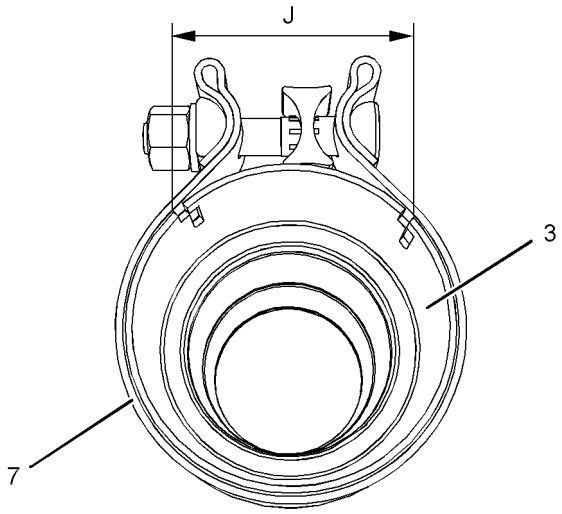


Illustration 177 g02354619

d. Position a new clamp (7) onto bellows (3). Hand tighten clamp (7). Ensure that the center of the clamp is central to Slots (J) on the bellows. The clamp must be flush with the end of the bellows (3).

Note: Ensure that the bellows are not subjected to any undue stress.

e. If new bellows (3) are installed, clamp (7) will be pre-installed to the bellows.

Note: Ensure that the bellows are not subjected to any undue stress.

f. Position a new ball clamp (8) onto elbow (9).

g. Position bellows (3) onto elbow (9). Align the bellows and the elbow with temporary marks.

h. Tighten ball clamp (8) hand tight.

Note: Ensure that the bellows are not subjected to any undue stress.

i. Install tube assembly (6), align the tube assembly with the temporary marks on the bellows. Tighten clamp (7) hand tight.

Installation Procedure for the Flexible Exhaust Pipe as an Assembly

NOTICE
Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. If there is any difficulty in installation after the repair, discard the bellows.

1. Check the flexible exhaust pipe assembly for damage. Refer to Special Instruction, REHS5014, “Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines” for more information.

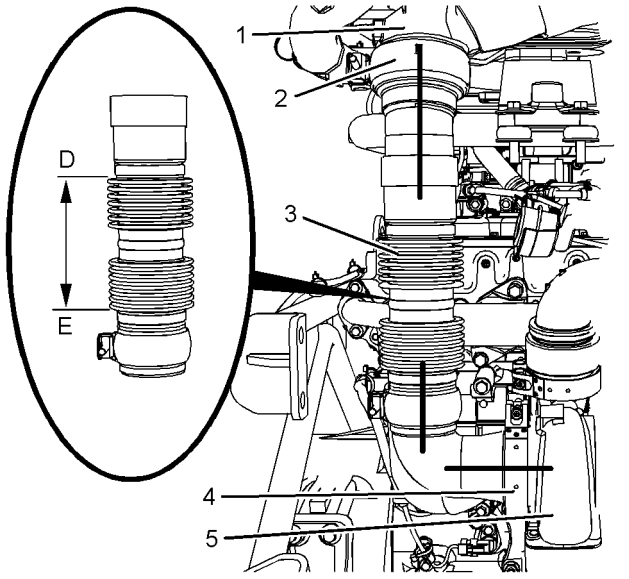


Illustration 178 g02354616

2. Position a new ball clamp (2) onto the flexible exhaust pipe assembly.

3. Install V-band clamp (4) onto turbocharger (5).

4. Install assembly of the flexible exhaust pipe onto CEM (1) and turbocharger (5).

Note: Ensure that the assembly of the flexible exhaust pipe is supported at all times.

5. Tighten V-band clamp (4) hand tight.

6. Tighten ball clamp (2) hand tight.

NOTICE
Failure to reinstall the bellows into the original position will result in a failure of the bellows and possible emissions failure.

7. Align the assembly of the flexible exhaust pipe with the temporary marks. Ensure that bellows (3) are not subjected to any undue stress.

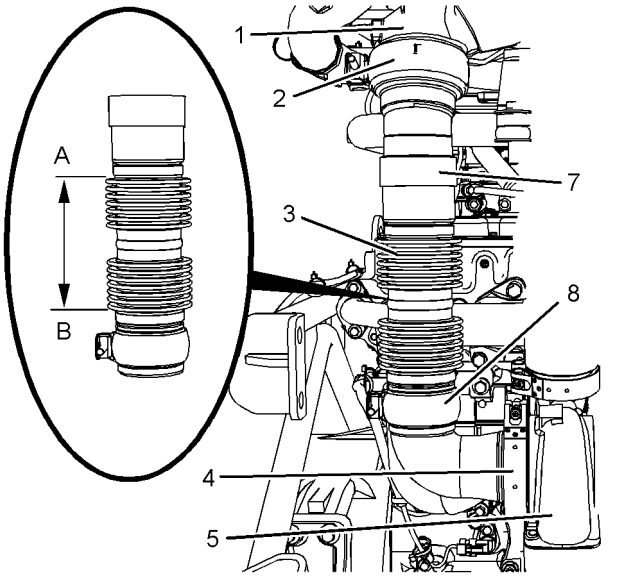


Illustration 179 g02250353

8. If a new bellows assembly has been installed, ensure that all components of the flexible exhaust pipe are not subjected to any undue stress and are correctly aligned.

9. Tighten ball clamp (2) to a torque of 35 N·m (26 lb ft).

10. Tighten clamp (7) to a torque of 55 N·m (40 lb ft).

11. Tighten ball clamp (8) to a torque of 35 N·m (26 lb ft).

12. Tighten V-band clamp (4) to a torque of 12 N·m (106 lb in).

13. Cut cable straps from the suitable material that was encasing the bellows (3) between Position (A) and Position (B). Remove the suitable material from bellows (3).

i04203674

Diesel Particulate Filter - Remove

Removal Procedure (Method 1)

Use Method 1 when removal of the DPF as an assembly is necessary.

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

⚠ WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

NOTICE
Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

1. Refer to System Operation, Testing and Adjusting , “Diesel Particulate Filter - Clean” before starting any maintenance procedures on the assembly of the Diesel Particulate Filter (DPF).

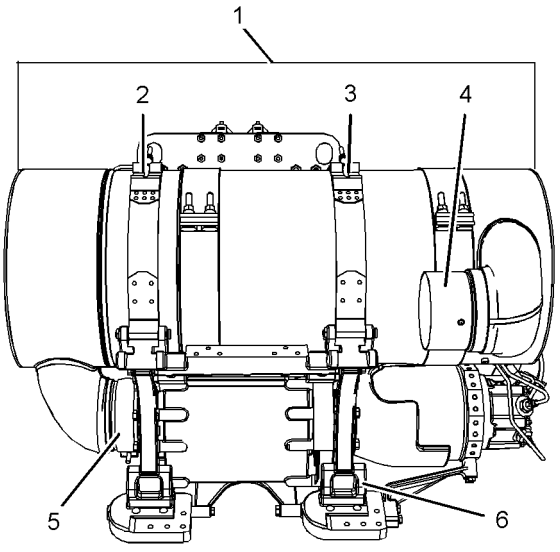


Illustration 180 g02330913

2. In certain applications, it will be necessary to remove the assembly of the DOC, DPF, and the outlet section as an assembly in order to allow the removal of the DPF.

3. Follow Step 3.a through Step 3.i in order to remove the DOC, DPF, and outlet section as an assembly (1).

   a. Remove the Original Equipment Manufacturers (OEM) exhaust system from outlet cannister (4).

   b. Remove the tube assemblies for the pressure sensor from the DPF assembly and outlet section (4). Refer to Disassembly and Assembly, “Pressure Sensor (DPF) - Remove and Install” for the correct procedure.

   c. Remove the soot antennas from the DPF assembly and outlet section (4). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

   d. Remove the temperature sensors from the DPF assembly. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

   e. Loosen the bolt on ball clamp (5) in order to allow the removal of DPF assembly (1).

   f. Remove the nuts on clamp (2) and clamp (3). Position clamp (2) and clamp (3) away from DPF assembly (1).

   g. Attach a suitable lifting device to DPF assembly (1). The weight of the DPF assembly is approximately 66 kg (145 lb).

   h. Use the suitable lifting device to remove DPF assembly (1) from the bracket for clean emission module (6).

   i. Remove the DPF. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Disassemble” for the correct procedure.

Removal Procedure (Method 2)

Use Method 2 when removal of either the Diesel Oxidation Catalyst (DOC) or the outlet section is necessary in order to remove the Diesel Particulate Filter (DPF).

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

⚠ WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

NOTICE

Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

1. Refer to System Operation, Testing and Adjusting , “Diesel Particulate Filter - Clean” before starting any maintenance procedures on the assembly of the Diesel Particulate Filter (DPF).

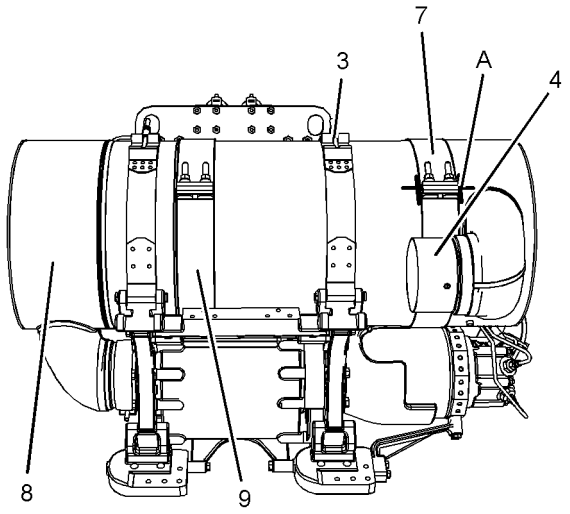


Illustration 181 g02331135

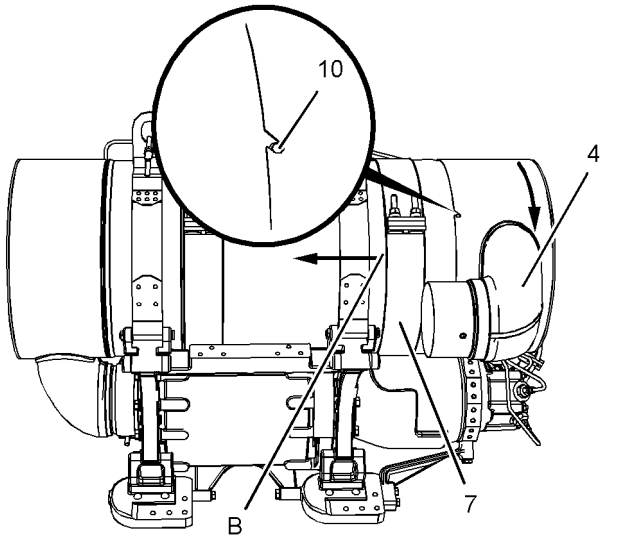


Illustration 182 g02332653

2. In certain applications, it will be necessary to remove outlet section (4) or the Diesel Oxidation Catalyst (DOC) (8) from the Diesel Particulate Filter (DPF) in order to allow the removal of the DPF.

3. If necessary, remove DOC (8). Refer to Disassembly and Assembly, “Catalyst (Diesel Oxidation Catalyst) - Remove and Install” for the correct procedure.

4. Remove the DPF. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Disassemble” for the correct procedure.

5. If necessary, remove the OEM exhaust tube assembly from outlet section (4).

6. Remove the tube assembly for the pressure sensor from outlet section (4). Refer to Disassembly and Assembly, “Pressure Sensor (DPF) - Remove and Install” for the correct procedure.

7. Remove the soot antenna from outlet section (4). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

8. Make temporary alignment marks on Torca clamp (7) in Position (A). Loosen the nuts on Torca clamp (7).

9. Slide Torca clamp along the DPF into Position (B).

10. Sufficiently loosen the nuts on clamp (3) in order to allow removal of outlet section (4).

11. Rotate the outlet section (4) in a counter clockwise direction in order to disengage the pins and slots (10).

12. Attach a suitable lifting device to outlet section (4). The weight of the outlet section is approximately 15 kg (33 lb).

13. Use the suitable lifting device to remove outlet section (4) from the DPF.

14. Remove Torca clamp (7) from the DPF.

15. Remove the DPF. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Disassemble” for the correct procedure.

i04203671

Diesel Particulate Filter - Disassemble

Disassembly Procedure

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

⚠ WARNING

The muffler, catalytic converter/muffler, and diesel particulate filter will become extremely hot during engine operation. A hot muffler, catalytic converter/muffler and diesel particulate filter can cause serious burns. Allow adequate cooling time before working on or near the muffler, catalytic converter/muffler and diesel particulate filter.

NOTICE

Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

1. Refer to System Operation, Testing and Adjusting , “Diesel Particulate Filter - Clean” before starting any maintenance procedures on the assembly of the Diesel Particulate Filter (DPF).

2. Remove the assembly of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), and the outlet section Clean Emission Module (CEM). Refer to Disassembly and Assembly, “Diesel Particulate Filter - Remove” for the correct procedure.

3. Place the assembly of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), and the outlet section onto a suitable stand.

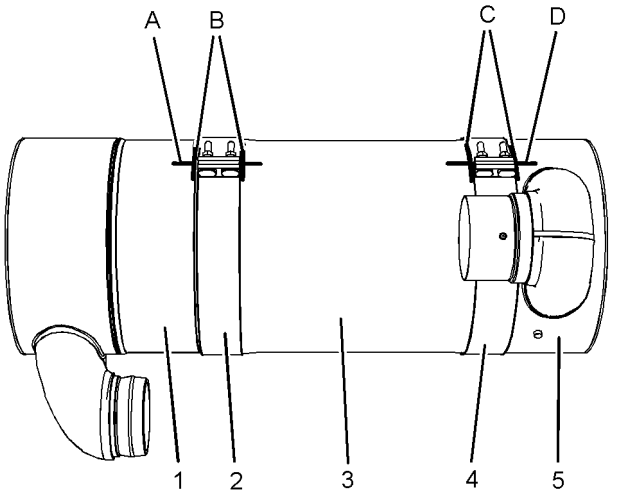


Illustration 183 g02335336

(1) Diesel Oxidation Catalyst (DOC)

(2) Torca clamp

(3) Diesel Particulate Filter (DPF)

(4) Torca clamp

(5) Outlet section

4. Make temporary alignment marks in Position (A) and Position (D) on DOC (1), DPF (3), and outlet section (5).

5. Make temporary alignment marks in Position (B) and Position (C) on Torca clamp (2) and Torca clamp (4) in order to identify the correct position for the Torca clamps.

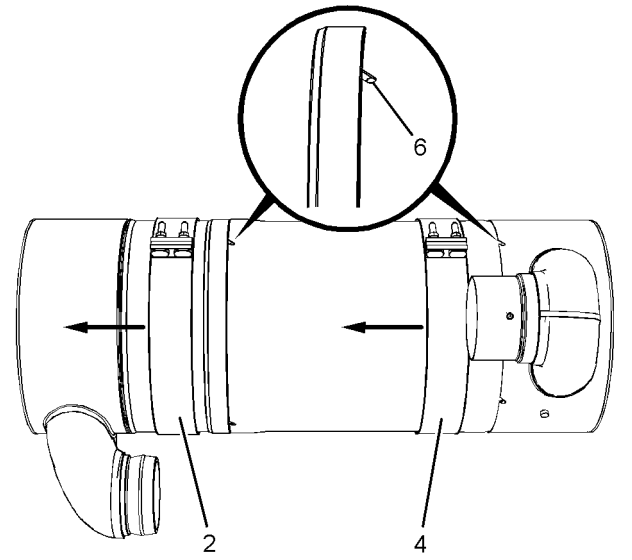


Illustration 184 g02335337

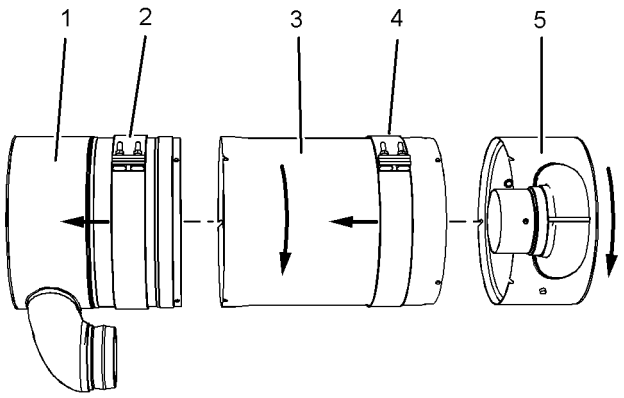


Illustration 185 g02335377

(1) Diesel Oxidation Catalyst (DOC)

(2) Torca clamp

(3) Diesel Particulate Filter (DPF)

(4) Torca clamp

(5) Outlet section

6. Loosen the nuts on Torca clamp (2) and Torca clamp (4) in order to allow Torca clamps to be moved.

7. Slide Torca clamp (2) and Torca clamp (4) along the DOC and the DPF.

8. Attach a suitable lifting device to outlet section (5). The weight of the outlet section is approximately 15 kg (33 lb).

9. Rotate outlet section (5) in a counter clockwise direction in order to disengage pins and slots (6).

10. Use the suitable lifting device to remove outlet section (5) from the DPF.

11. Remove Torca clamp (4) from DPF (3).

12. Attach a suitable lifting device to DPF assembly (3). The weight of the DPF assembly is approximately 66 kg (145 lb).

13. Rotate DPF (3) in a counter clockwise direction in order to disengage pins and slots (6).

14. Use the suitable lifting device to remove DPF (3) from DOC (1).

15. Remove Torca clamp (2) from DOC (1).

16. If necessary, clean the DPF. Refer to System Operation Testing and Adjustment, “Diesel Particulate Filter (DPF) - Clean” for the correct procedure.

i04203670

Diesel Particulate Filter - Assemble

Assembly Procedure

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

NOTICE

Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

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

2. Place the assembly of the Diesel Oxidation Catalyst (DOC) onto a suitable stand.

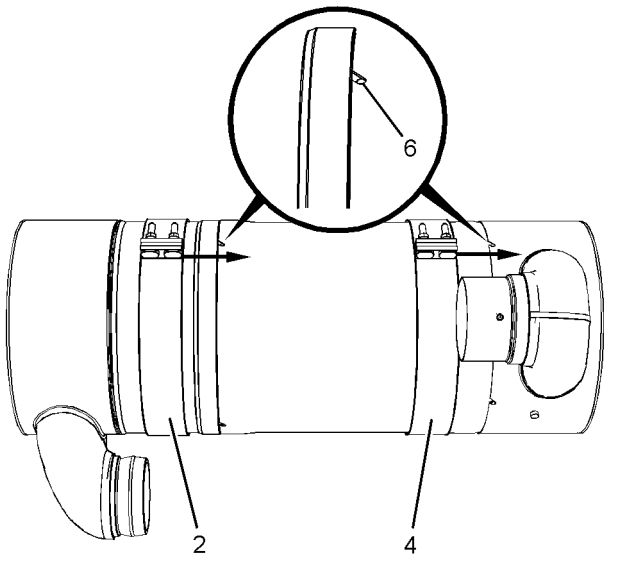


Illustration 186 g02337077

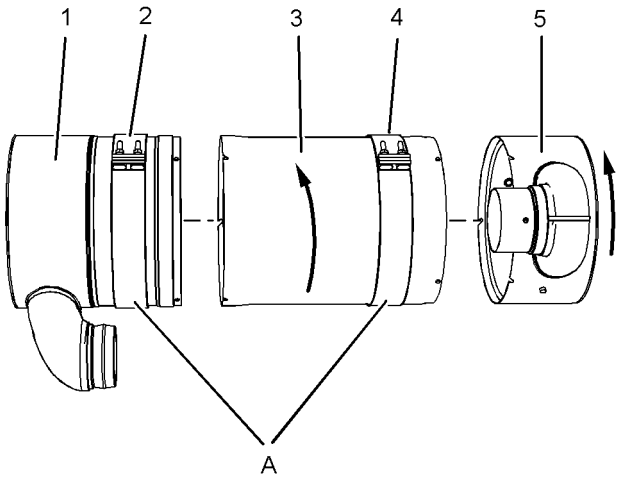


Illustration 187 g02337076

(1) Diesel Oxidation Catalyst (DOC)

(2) Torca clamp

(3) Diesel Particulate Filter (DPF)

(4) Torca clamp

(5) Outlet section

3. Install new Torca clamp (2) and Torca clamp (4) onto DOC (1) and DPF (3) as shown in Position (A). Ensure that the Torca clamps are correctly orientated.

4. Attach a suitable lifting device to DPF assembly (3). The weight of the DPF assembly is approximately 66 kg (145 lb).

5. Use the suitable lifting device to position DPF (3) onto DOC (1).

6. Rotate DPF (3) in a clockwise direction in order to engage pins and slots (6).

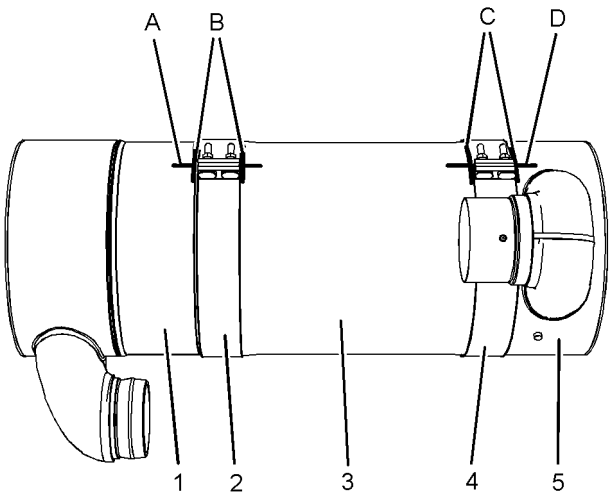
7. Slide Torca clamp (2) along the DOC onto the DPF. Alignment the Torca clamp with temporary marks. Tighten the nuts on the Torca clamp hand tight.

8. Attach a suitable lifting device to outlet section (5). The weight of the outlet section is approximately 15 kg (33 lb).

9. Use the suitable lifting device to position outlet section (5) onto the DPF.

10. Rotate outlet section (5) in a clockwise direction in order to engage pins and slots (6).

11. Slide Torca clamp (4) along the DPF onto the outlet section. Alignment the Torca clamp with temporary marks. Tighten the nuts on the Torca clamp hand tight.



g02335336

Illustration 188

(1) Diesel Oxidation Catalyst (DOC)

(2) Torca clamp

(3) Diesel Particulate Filter (DPF)

(4) Torca clamp

(5) Outlet section

12. Ensure that Torca clamp (2) and Torca clamp (4) are correctly aligned with temporary alignment marks in Position (B) and Position (C). If necessary, adjust the alignment of the Torca clamps.

13. Ensure that Torca clamp (2) and Torca clamp (4) are correctly aligned with temporary alignment marks in Position (A) and Position (D). If necessary, adjust the alignment of the Torca clamps.

14. Tighten nuts for Torca clamp (2) and Torca clamp (4) to a torque of 42 N·m (31 lb ft).

15. Install the assembly of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), and the outlet section Clean Emission Module (CEM). Refer to Disassembly and Assembly, “Diesel Particulate Filter - Install” for the correct procedure.

i04203672

Diesel Particulate Filter - Install

Installation Procedure (Method 1)

Use Method 1 when installation of the DPF as an assembly is necessary.

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

NOTICE

Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

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

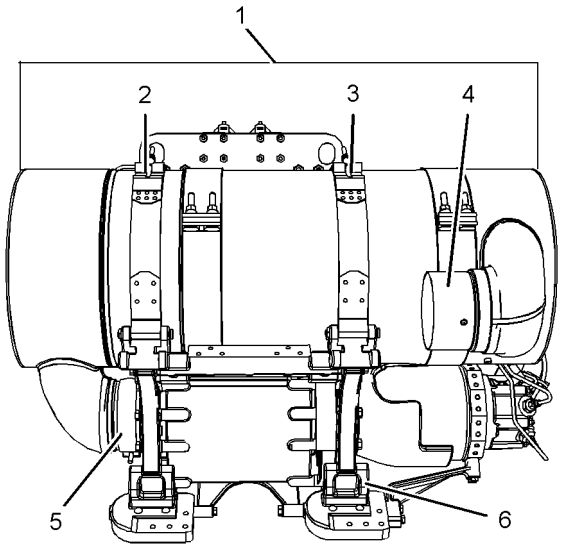


Illustration 189 g02330913

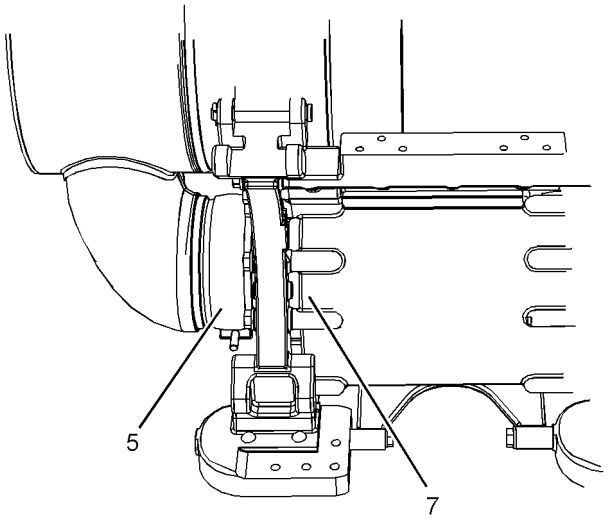


Illustration 190 g02332737

2. In certain applications, it will be necessary to install the assembly of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), and the outlet cannister as an assembly.

3. Follow Step 3.a through Step 3.l in order to install the DOC, DPF, and outlet cannister as an assembly (1).

   a. Position a new ball clamp (5) onto the inlet of DPF assembly (1).

   b. Attach a suitable lifting device to DPF assembly (1). The weight of the DPF assembly is approximately 66 kg (145 lb).

   c. Use the suitable lifting device to position DPF assembly (1) onto the bracket for clean emission module (6).

   d. Align DPF assembly (1) with flexible bellows (7).

   e. Install ball clamp (5) onto flexible bellows (7). Tighten the ball clamp finger tight.

   f. Position clamp (2) and clamp (3) onto DPF assembly (1). Install the nuts to clamp (2) and clamp (3).

Note: Ensure that the DPF assembly is correctly positioned on the bracket for clean emission module.

   g. Tighten bolt for ball clamp (6) to a torque of 18 N·m (159 lb in).

   h. Tighten nuts for clamp (2) and clamp (4) to a torque of 18 N·m (159 lb in).

   i. Install the tube assemblies for the pressure sensor to the DPF assembly. Refer to Disassembly and Assembly, “Pressure Sensor (DPF) - Remove and Install” for the correct procedure.

   j. Install the soot antennas to the DPF assembly. Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

   k. Install the temperature sensors to the DPF assembly. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

   l. If necessary, install the Original Equipment Manufacturers (OEM) exhaust system to outlet cannister (4) of the clean emission module.

4. After a replacement DPF has been installed, use the electronic service tool in order to reset the engine ash model. Refer to System Operation, Testing and Adjusting, “Diesel Particulate Filter - Clean”.

Installation Procedure (Method 2)

Use Method 2 when Installation of either the Diesel Oxidation Catalyst (DOC) or the outlet section is necessary in order to install the Diesel Particulate Filter (DPF).

⚠ WARNING

Wear goggles, gloves, protective clothing, and a National Institute for Occupational Safety and Health (NIOSH) approved P95 or N95 half-face respirator when handling a used Diesel Particulate Filter or Catalytic Converter Muffler. Failure to do so could result in personal injury.

NOTICE

Do not strike any part of the assembly of the Diesel Particulate Filter (DPF). Do not allow any object to contact the internal element of the DPF. If the internal element of the DPF becomes damaged, the assembly must be replaced.

Do not use power tools in order to disassemble or assemble any part of the Diesel Oxidation Catalyst (DOC), Diesel Particulate Filter (DPF), or the outlet section.

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

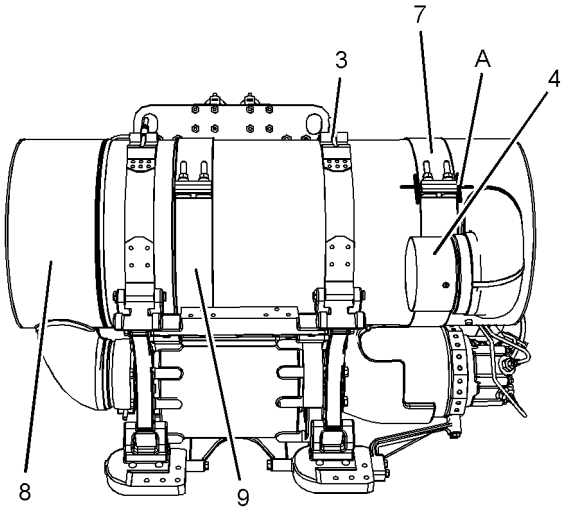


Illustration 191 g02331135

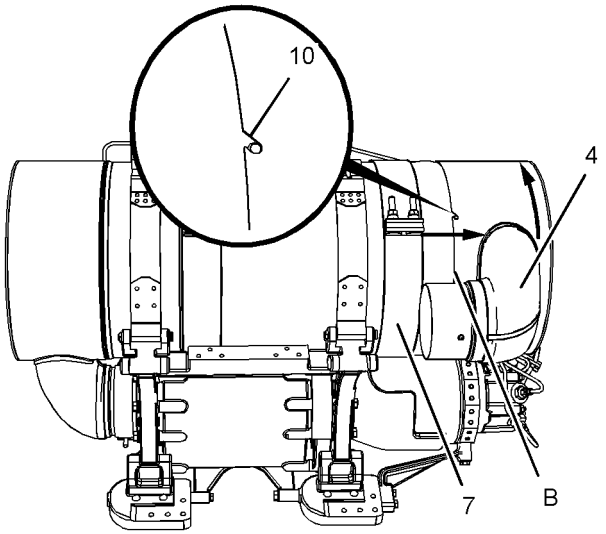


Illustration 192 g02334016

2. In certain applications, it will be necessary to install outlet section (4) or the Diesel Oxidation Catalyst (DOC) (8) after the Diesel Particulate Filter (DPF) has been installed.

   If necessary, install the DPF. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Assemble” for the correct procedure.

3. If necessary, install the DOC after the DPF has been installed. Refer to Disassembly and Assembly, “Catalyst (Diesel Oxidation Catalyst) - Remove and Install” for the correct procedure.

4. Position a new Torca clamp (7) in Position (B) onto the DPF. Ensure that the Torca clamp is correctly orientated.

5. Attach a suitable lifting device to outlet section (4). The weight of the outlet section is approximately 15 kg (33 lb).

6. Use the suitable lifting device to position outlet section (4) to the DPF.

7. Rotate outlet section (4) in a clockwise direction in order to engage the pins and slots (10).

8. If necessary, install the Original Equipment Manufacturers (OEM) exhaust tube assembly to outlet section (4). Ensure that the outlet section is correctly aligned.

9. Position Torca clamp (7) between DPF and the outlet section. Align the Torca clamp with the temporary marks in Position (A). Tighten the nuts on the Torca clamp hand tight.

10. Tighten the nut on clamp (3) hand tight.

11. Tighten nuts for Torca clamp (7) to a torque of 42 N·m (31 lb ft).

12. Tighten nut for clamp (3) to a torque of 18 N·m (159 lb in).

13. Install the soot antenna to outlet section (4). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

14. Install the tube assembly for the pressure sensor to outlet section (4). Refer to Disassembly and Assembly, “Pressure Sensor (DPF) - Remove and Install” for the correct procedure.

15. After a replacement DPF has been installed, use the electronic service tool in order to reset the engine ash model. Refer to System Operation, Testing and Adjusting, “Diesel Particulate Filter - Clean”.

i04203742

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 26

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1
B(1)	T400011	Crankshaft Turning Tool	1
B(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove” for the correct procedure.

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

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

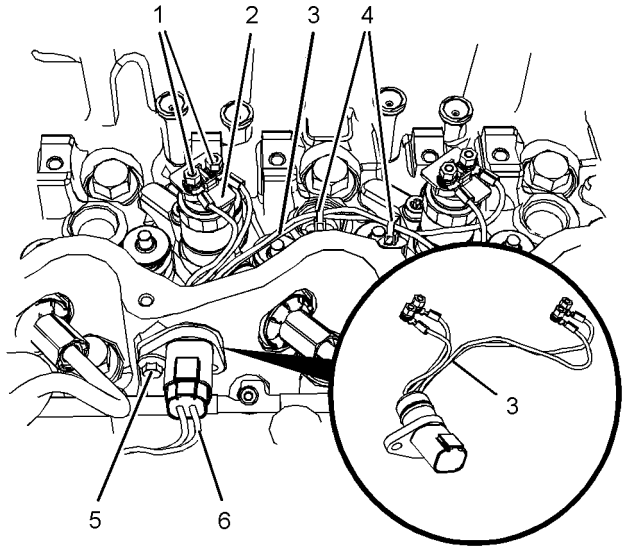


Illustration 193 g02313393

1. Follow Step 1.a through Step 1.f in order to remove the harness assembly for the electronic unit injectors.

a. Use a deep socket to remove connections (1) from electronic unit injectors (2).

b. Cut cable straps (4) and remove the remaining sections of the cable straps from the cylinder head.

c. Disconnect plug (6) from harness assembly (3).

d. Remove bolt (5) from harness assembly (3).

e. Withdraw harness assembly (3) from the cylinder head.

f. Repeat Step 1.a through Step 2 in order to remove the remaining harness assemblies.

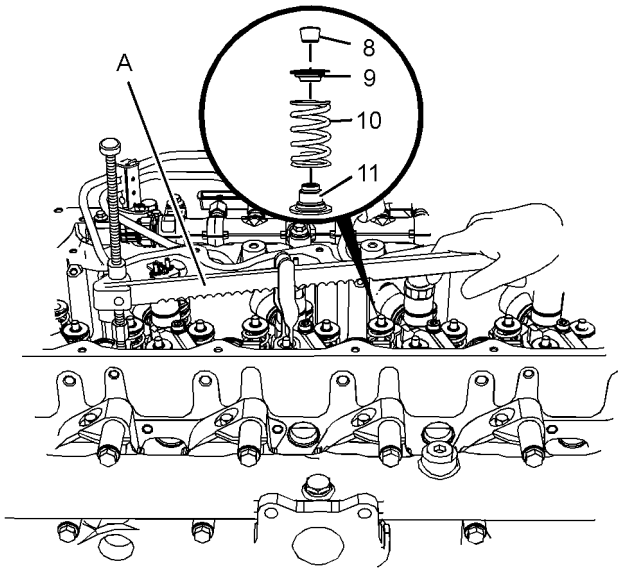


Illustration 194 g01978814

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

2. Follow Step 2.a through Step 2.d in order to position the appropriate piston at top dead center.

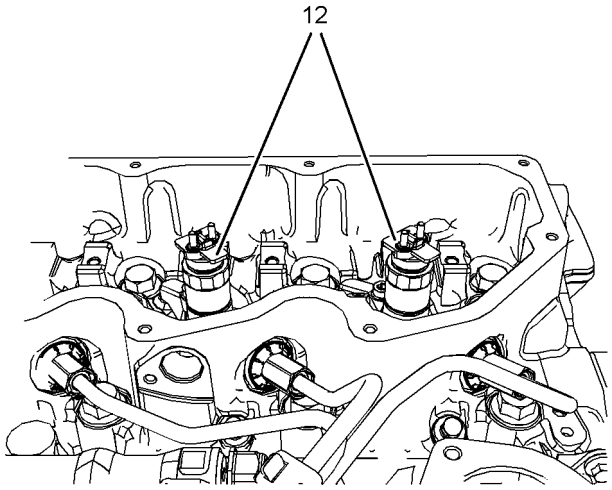


Illustration 195 g02202973

a. Install Tooling (A) in position on the cylinder head in order to compress a valve spring (10) for the appropriate cylinder.

Note: Ensure that the electronic unit injector label code (12) is not damaged when Tooling (A) is compressed.

b. Use Tooling (A) in order to compress valve spring (10) and open the valve slightly.

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

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

Note: Do not use excessive force to turn the crankshaft. The use of force can result in bent valve stems.

d. Continue to rotate the crankshaft and gradually release the pressure on Tooling (A) 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 (A) in order to allow removal of valve keepers (8).

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

4. Remove valve spring retainer (9).

5. Slowly release pressure on Tooling (A).

6. Remove valve spring retainer (9) and remove valve spring (10).

7. If necessary, remove valve stem seals (11).

8. Repeat Step 3 through Step 7 in order to remove the remaining valve springs from the appropriate cylinder.

9. Remove Tooling (A).

Installation Procedure

Table 27

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1
B(1)	T400011	Crankshaft Turning Tool	1
B(2)	27610291	Housing	1
	27610291	Engine Turning Tool	1
C	27610289	Torque Wrench	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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

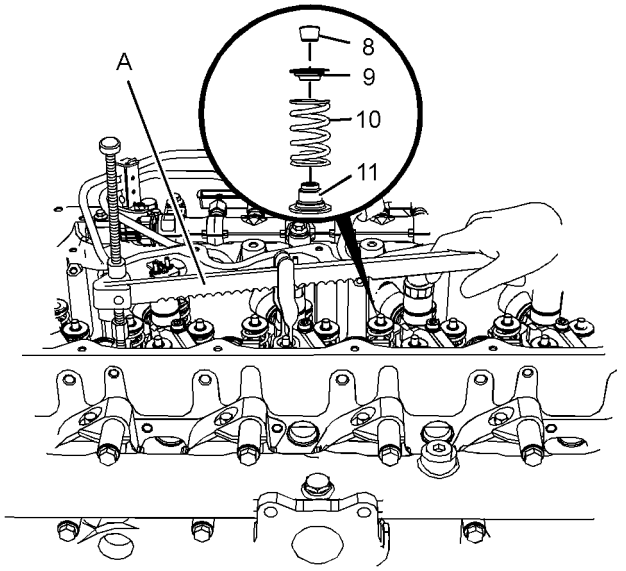


Illustration 196 g01978814

1. Inspect valve springs (10) for damage and for the correct length. Refer to Specifications, “Cylinder Head Valves ” for more information.

2. If necessary, install a new valve stem seal (11) onto the valve guide.

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

3. Install valve spring (10) onto the cylinder head. Position valve spring retainer (9) on valve spring (10).

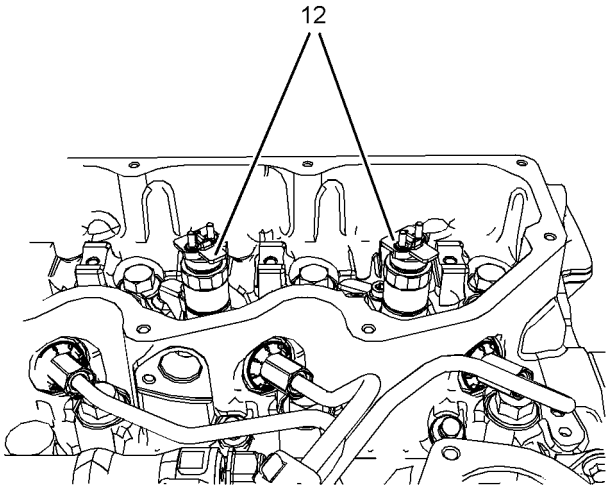


Illustration 197 g02202973

⚠ 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 (A) in the appropriate position on the cylinder head in order to compress valve spring (10).

Note: Ensure that the electronic unit injector label code (12) is not damaged when Tooling (A) is compressed.

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

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

6. Install valve spring keepers (8).

7. Carefully release the pressure on Tooling (A).

8. Repeat Step 2 through Step 7 for the remaining valve springs.

⚠ WARNING

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

9. Remove Tooling (A).

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.

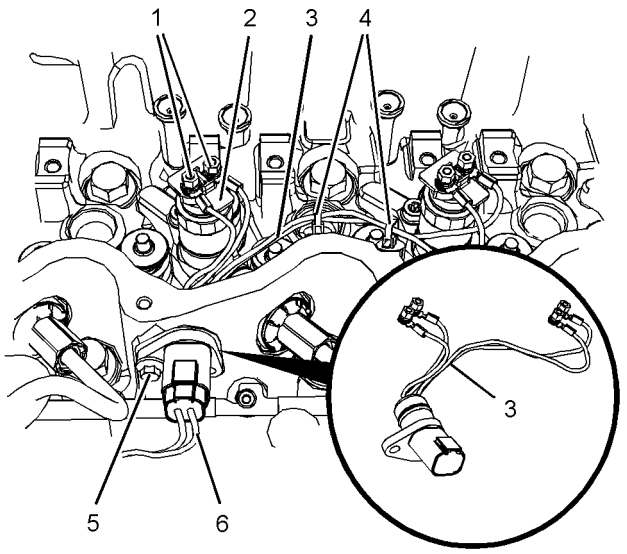


Illustration 198 g02313393

10. Follow Step 10.c through Step 10.f in order to install a new harness assembly (3) to electronic unit injectors (2).

a. Position a new harness assembly (3) into the cylinder head.

Note: Do not lubricate the O-ring seal.

b. Push harness assembly (3) into the cylinder head.

c. Install a new bolt (5) and tighten the bolt to a torque of 5.5 N·m (49 lb in).

d. Connect plug (6) to harness assembly (3).

e. Use a deep socket to install connections (1) to electronic unit injectors (2). Use Tooling (C) to tighten the connections to a torque of 2.0 N·m (18 lb in).

f. Install the cable straps (4) in to the cylinder head.

Note: Ensure that the assemblies of the cable straps are correctly installed into the cylinder head.

g. Repeat Step 10.c through Step 10.f for the remaining harness assemblies.

End By:

a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install” for the correct procedure.

i04203743

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 28

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

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bottom mating surface of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, “Cylinder Head Valves” for the correct dimensions.

2. Place a temporary identification mark on the heads of the valves in order to identify the correct position.

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

3. Use a suitable lifting device to position the cylinder head with the valve springs upward. The weight of the cylinder head is approximately 96 kg (212 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.

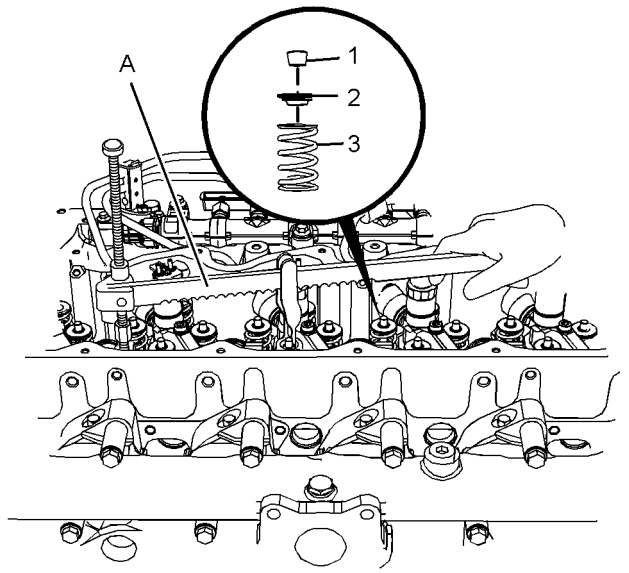


Illustration 199 g01978994

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

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

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

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

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

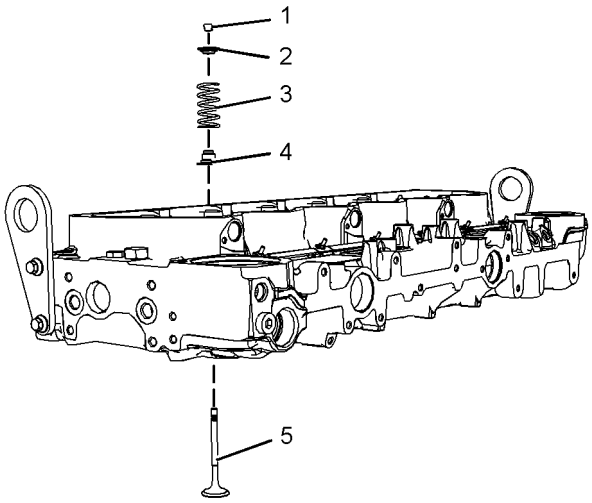


Illustration 200 g01978995

7. Place a temporary identification mark on valve spring (3) in order to identify the correct position.

8. Remove valve spring retainer (2). Remove valve spring (3).

9. Repeat Step 4 through Step 8 for the remaining valves.

10. Remove Tooling (A).

11. Remove valve stem seals (4).

12. Use a suitable lifting device to turn over the cylinder head.

13. Place a temporary identification mark on valves (5). Remove valves (5) from the cylinder head.

Installation Procedure

Table 29

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The valves have a hard surface finish. Grinding compound must not be used on the valves. Grinding compound will damage the hard surface finish of the valves.

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 Step 1.a through Step 1.e in order to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.

a. Inspect the cylinder head for wear and for damage. Refer to System Operation, Testing and Adjusting, “Cylinder Head Inspect” for the correct procedure.

b. Inspect the valve seats for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for more information.

c. Inspect the valve guides for wear and for damage. Refer to Specifications, “Cylinder Head Valves” and System Operation, Testing and Adjusting, “Valve Guide - Inspect” for more information.

d. Inspect the valves for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for more information.

e. Inspect the valve springs for damage and for the correct length. Refer to Specifications, “Cylinder Head Valves ” for more information.

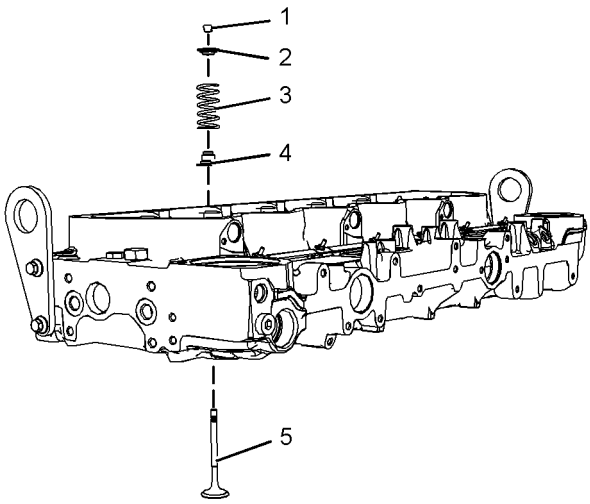


Illustration 201 g01978995

2. Lubricate the stems of valves (5) with clean engine oil. Install valves (5) in the appropriate positions in the cylinder head. Check the depth of the valves below the face of the cylinder head. Refer to System Operation, Testing and Adjusting, “Valve Depth - Inspect” for more information.

3. Use a suitable lifting device to turn over the cylinder head. The weight of the cylinder head is approximately 96 kg (212 lb).

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

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

Note: The outer face of the valve guides must be clean and dry before installing valve stem seals (4).

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

WARNING

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

Make sure to wear all necessary protective equipment.

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

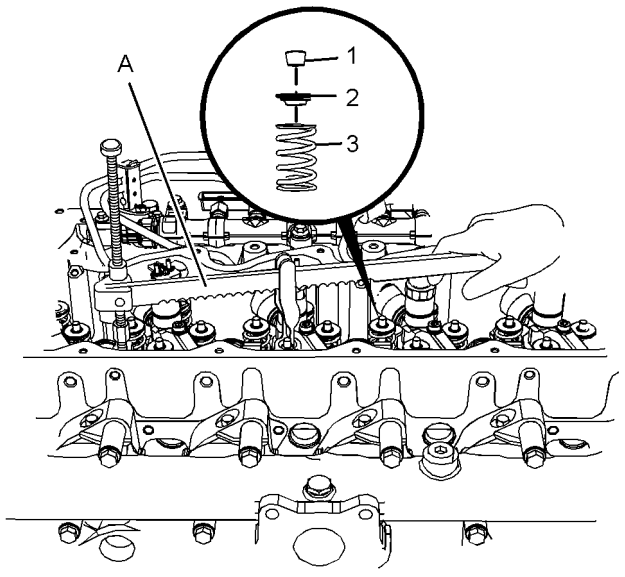


Illustration 202 g01978994

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

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

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

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

WARNING

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

8. Carefully release the pressure on Tooling (A).

9. Repeat Step 5 through Step 8 for the remaining valves.

10. Remove Tooling (A) from the cylinder head.

End By:

a. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i04203686

Engine Oil Filter Base - Remove and Install (Engine Oil Filter Base with Adapter)

Removal Procedure

Start By:

a. Remove the engine oil filter base. Refer to Disassembly and Assembly, “Engine Oil Filter Base - Removal and Install” 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.

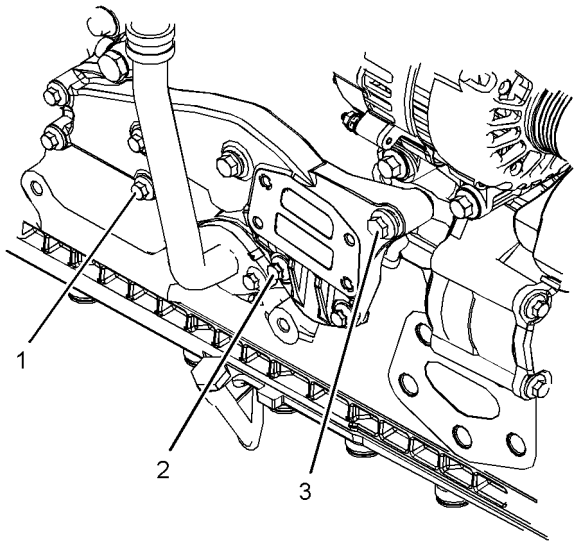


Illustration 203 g02047393
Typical example

1. Remove bolts (1), bolts (2) and bolts (3).

Note: Note the position of the bolts and the length of the bolts.

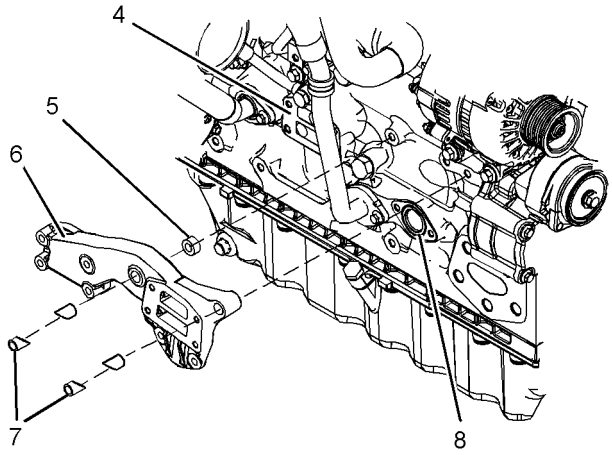


Illustration 204 g02047397
Typical example

2. Remove adapter (6) and spacer (5) from the cylinder block. Remove gasket (4) and gasket (8).

3. If necessary, remove split collars (7) from adapter (6).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the gasket surfaces of the adapter. Clean the gasket surfaces of the cylinder block.

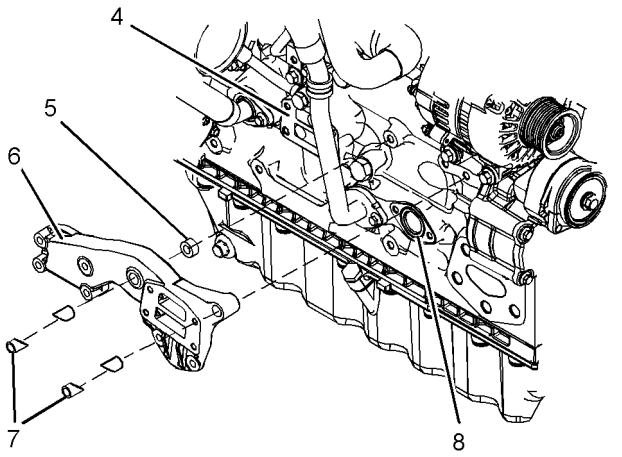


Illustration 205 g02047397
Typical example

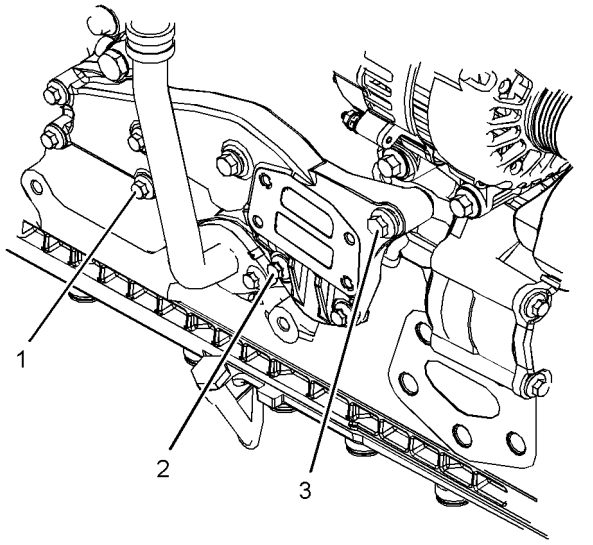


Illustration 206 g02047393
Typical example

2. Position new gasket (4) and gasket (8) onto adapter (6).

3. If necessary, install split collars (7) to adapter (6).

4. Install bolts (1), bolts (2) and bolts (3) to adapter (6). Install spacer (5) to applicable bolt (2).

5. Position adapter (6) to the cylinder block.

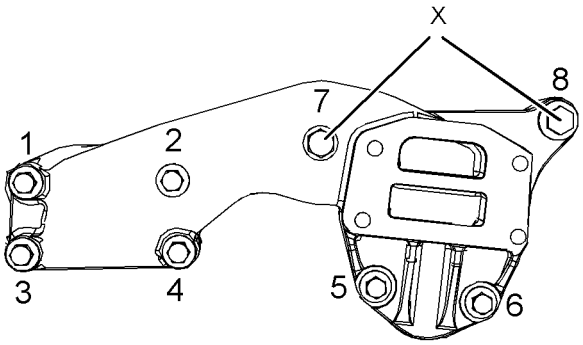


Illustration 207 g02047413

6. Tighten bolts (1) and bolts (2) to a torque of 22 N·m (195 lb in). Tighten the bolts in the sequence that is shown in Illustration 207.

Tighten bolts (3) in Position (X) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 207.

7. Install the oil filter base. Refer to Disassembly and Assembly, “Engine Oil Filter Base - Removal and Install” for the correct procedure.

i04203685

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 30

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Chain Wrench	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

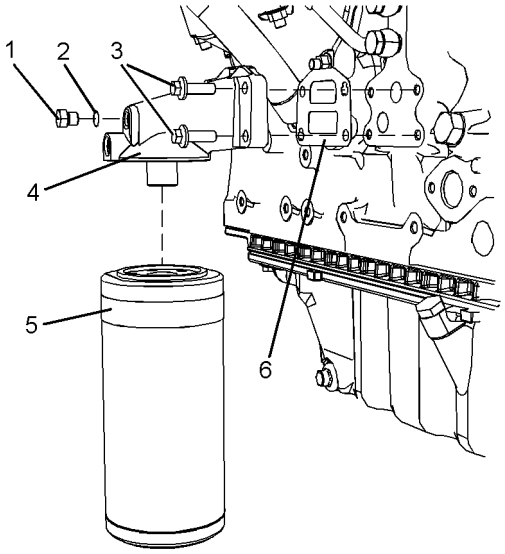


Illustration 208 g01980935

1. Place a suitable container below engine oil filter (5) in order to catch any oil that might be spilled.
2. Use Tooling (A) to remove engine oil filter (5). Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for the correct procedure.
3. Remove bolts (3).

Note: If bolts of different lengths are installed, identify the correct position of the bolts.

4. Remove engine oil filter base (4).
5. Remove gasket (6).
6. If necessary, remove plug (1) from engine oil filter base (4). Remove O-ring seal (2) from plug (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

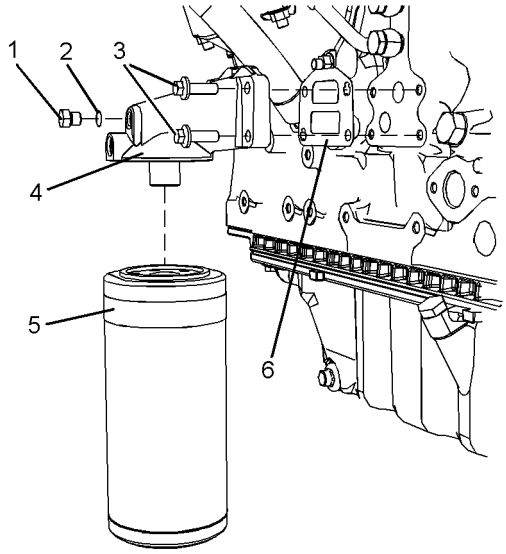


Illustration 209 g01980935

1. Clean engine oil filter base (4). Clean the gasket surfaces of the cylinder block or the engine oil cooler.
2. If necessary, install new O-ring seal (2) to plug (1). Install plugs (1) to engine oil filter base (4). Tighten the plug to a torque of 12 N·m (106 lb in).
3. Install bolts (3) to engine oil filter base (4).
4. Install a gasket (6) onto bolts (3). Install the assembly of the engine oil filter base to the cylinder block or the engine oil cooler.
5. Tighten bolts (3) to a torque of 22 N·m (195 lb in).
6. Install a new engine oil filter (5) and check the level of the engine lubricating oil. Refer to Operation and Maintenance Manual, “Engine Oil Level - Check” for the correct procedure.

i04203684

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

Removal Procedure

Start By:

a. Remove the mounting bracket for the Electronic Control Module (ECM) . Refer to Disassembly and Assembly, “ECM Mounting Bracket- Remove and Install” for the correct procedure.

NOTICE

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

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

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

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.

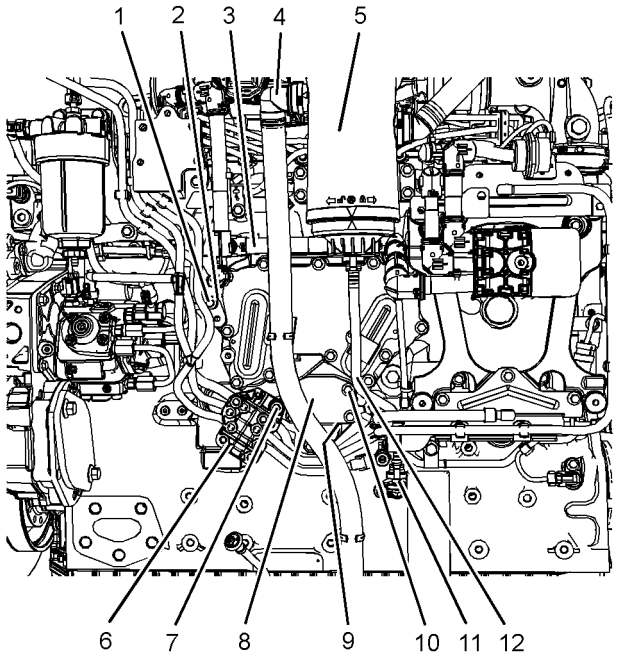


Illustration 210 g02191813

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

If the engine has a right-hand side oil filter, follow Step 2.a through Step 2.c in order to remove blanking plate (8).

a. Remove bolts (10).

b. Remove blanking plate (8).

c. Remove gasket (9) (not shown).

3. Remove bolt (1) from fuel injection line clamp (2). Position clamp (2) away from the engine oil cooler assembly.

4. Cut cable straps (3) from the engine wiring harness assembly.

5. Remove plastic tube assembly (4) from crankcase breather canister (5) and the plastic tube assembly clips. Refer to Disassembly and Assembly, "Crankcase Breather- Remove" for the correct procedure.

6. Remove plastic tube assembly (12) from crankcase breather canister (5) and crankcase breather valve (11). Refer to Disassembly and Assembly, "Crankcase Breather- Remove" for the correct procedure.

7. Remove bolt (7) from bracket (6). Position bracket (6) away from the engine oil cooler.

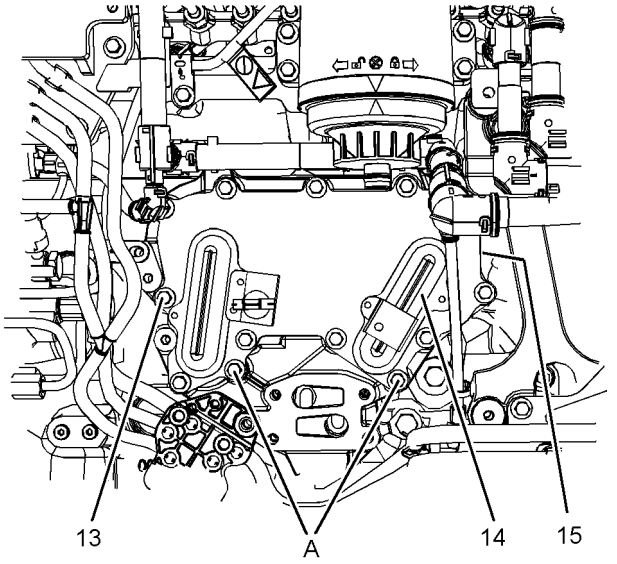


Illustration 211 g02191874

8. Do not remove bolts from Position (A).

9. Remove bolts (13) from engine oil cooler (14).

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

10. Remove engine oil cooler assembly (14) from the cylinder block.

11. Remove gasket (15) (not shown) from engine oil cooler (14).

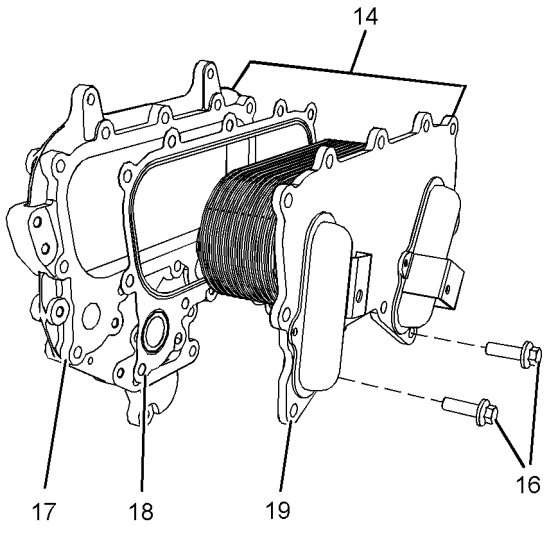


Illustration 212 g02191814

12. If necessary, follow Step 12.a through Step 12.c in order to disassembly the engine oil cooler.

a. Remove bolts (16) from engine oil cooler assembly (14).

b. Remove engine oil cooler matrix (19) from spacer plate (17).

c. Remove gasket (18).

i04203683

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

Removal Procedure

Start By:

a. Remove the mounting bracket for the Electronic Control Module (ECM) . Refer to Disassembly and Assembly, “ECM Mounting Bracket- Remove and Install” for the correct procedure.

NOTICE

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

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

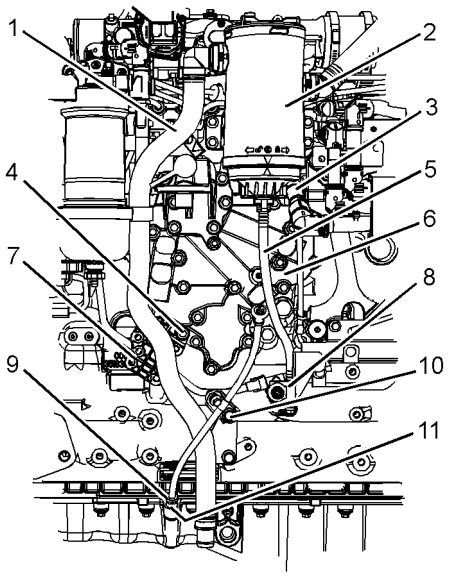


Illustration 213 g02193293

2. If the engine has a left-hand side oil filter, remove the oil filter base. Refer to Disassembly and Assembly, “Oil Filter Base - Remove and Install” for the correct procedure.

3. Disconnect plastic tube assembly (1) from crankcase breather (2) and remove the plastic tube assembly from the clips. Refer to Disassembly and Assembly, “Crankcase Breather- Remove” for the correct procedure.

4. Disconnect plastic tube assembly (5) from crankcase breather canister (2) and crankcase breather valve (8). Refer to Disassembly and Assembly, “Crankcase Breather- Remove” for the correct procedure.

5. Cut the cable straps for engine wiring harness (3) that secure the wiring harness assembly to engine oil cooler (6).

6. Remove bolt (4) and remove bracket (7) from engine oil cooler (6). Position the bracket away from the engine oil cooler

7. Remove bolt (10) from the bracket for the tube assembly. Loosen nut (9) and remove tube assembly.

8. Remove seal (11) (not shown) from the tube assembly.

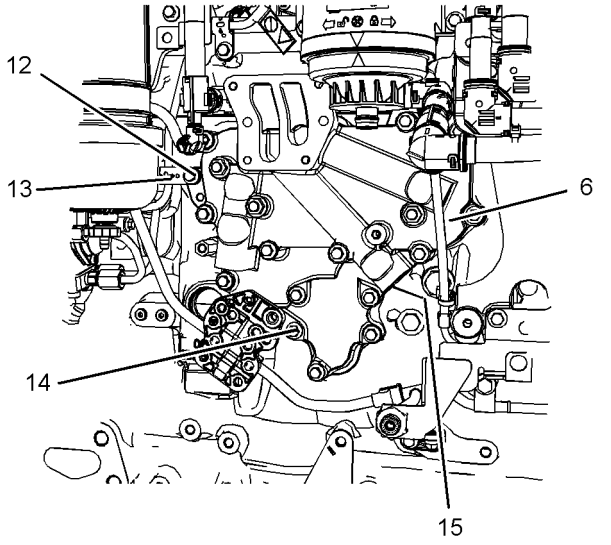


Illustration 214 g02194313

9. Remove bolt (12) from bracket (13). Position bracket (13) away from the engine oil cooler.

10. Remove bolts (14) from oil cooler (6).

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

11. Remove engine oil cooler assembly (6) from the cylinder block.

12. Remove gasket (15) (not shown).

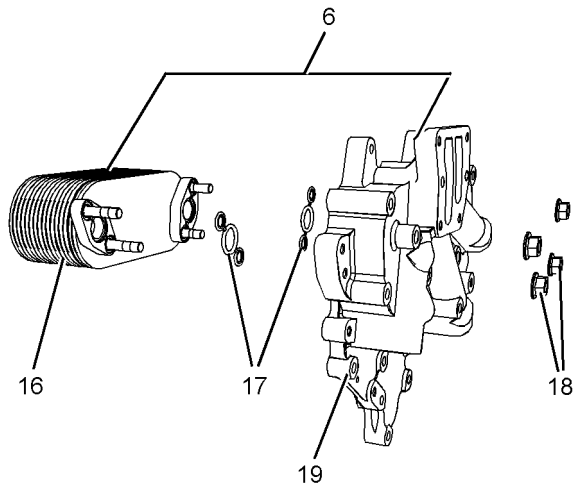


Illustration 215 g02193294

13. If necessary, follow Step 13.a through Step 13.c in order to disassemble the engine oil cooler.

a. Remove nuts (18) from the assembly of engine oil cooler (6).

b. Remove cooler matrix (16) from housing (19).

c. Remove gaskets (17).

i04203682

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

Assembly Procedure

Table 31

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 50 mm	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

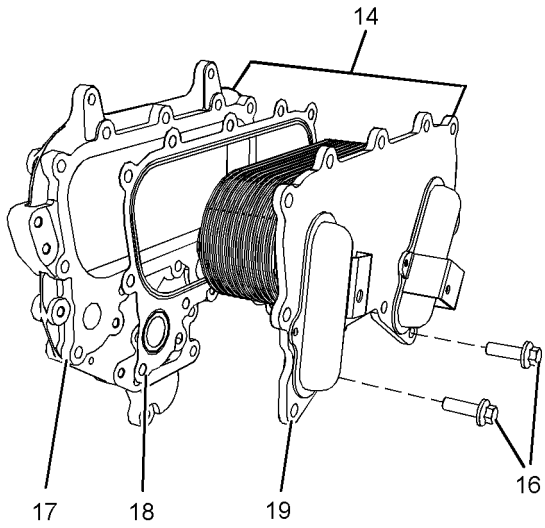


Illustration 216 g02191814

1. If necessary, follow Step 1.a through Step 1.d in order to assembly the engine oil cooler.

a. Ensure that engine oil cooler matrix (19) is clean, free from damage and restriction. Replace engine oil cooler matrix (19) if damaged or restricted.

b. Ensure that spacer plate (17) is clean and free from damage. Replace spacer plate (17) if damaged.

c. Position a new gasket (18) onto spacer plate (17). Install engine oil cooler matrix (19) to the spacer plate.

d. Install bolts (16) finger tight.

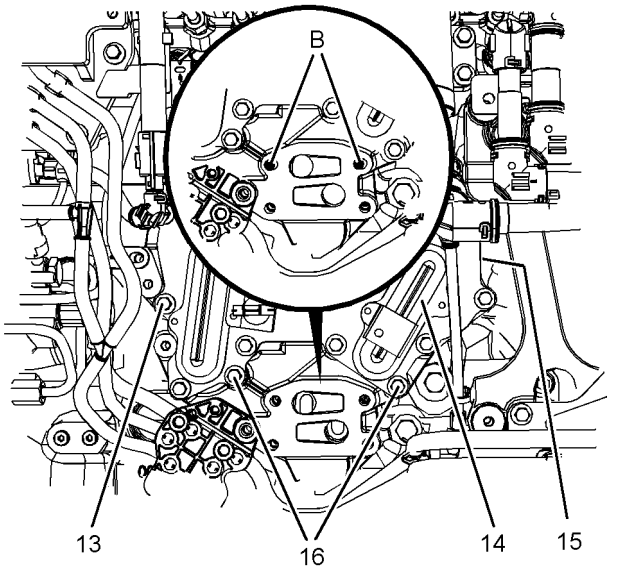


Illustration 217 g02192853

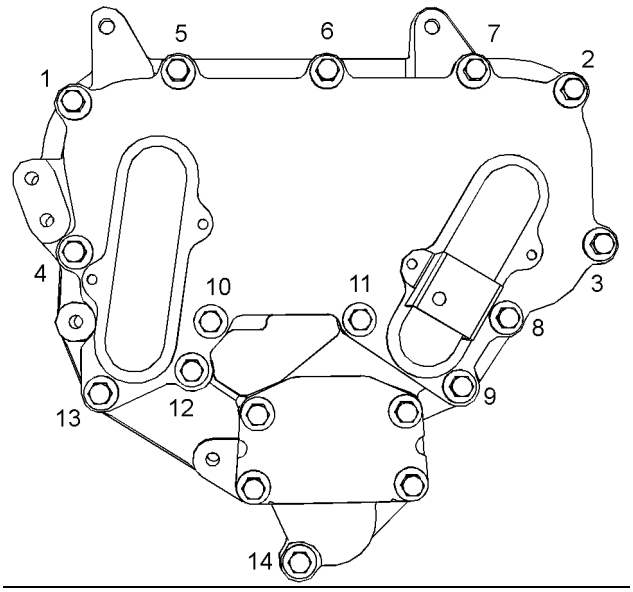


Illustration 218 g02192893

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

2. Clean the gasket surfaces of the cylinder block.

3. Install Tooling (A) into Position (B).

4. Position a new gasket (15) (not shown) onto Tooling (A).

5. Install the assembly of engine oil cooler (14) to the cylinder block.

6. Install bolts (13) to engine oil cooler (14).

Note: Ensure that the bolts of different lengths are installed in the correct position. Ensure that any brackets for the tube assemblies are location and correctly orientated.

7. Tighten bolts (13) and bolts (16) to a torque of 22 N·m (195 lb in) in the sequence that is shown in Illustration 218.

8. Remove Tooling (A).

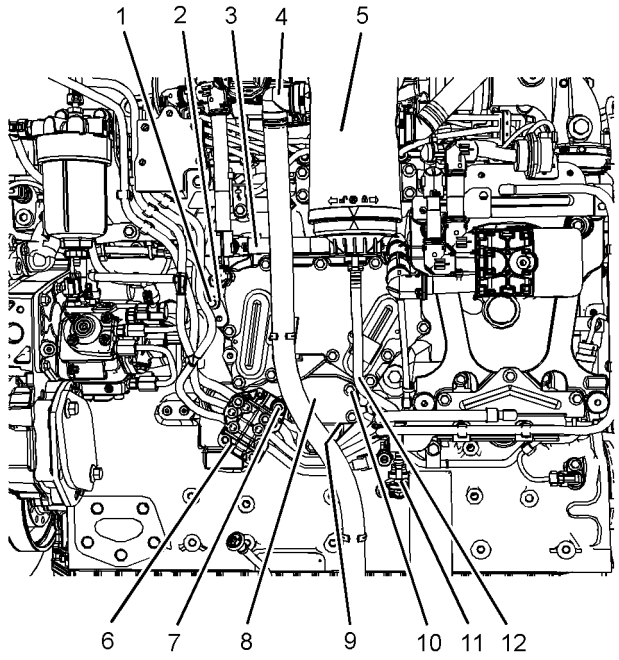


Illustration 219 g02191813

9. If the engine has a low mounted oil filter on the left-hand side, install the oil filter base. Refer to Disassembly and Assembly, “Oil Filter Base - Remove and Install” for the correct procedure.

If the engine has a right-hand side oil filter, follow Step 9.a through Step 9.d in order to install blanking plate (8).

a. Install bolts (10) to blanking plate (8).

b. Position a new gasket (9) (not shown) onto blanking plate (8).

c. Install the assembly of blanking plate (8) to the assembly of the engine oil cooler.

d. Tighten bolts (10) to a torque of 22 N·m (195 lb in).

10. Position bracket (6) onto engine oil cooler. Install bolt (7). Tighten bolts (7) to a torque of 22 N·m (195 lb in).

Note: Ensure that locating pin for the bracket is correctly located into the engine oil cooler.

11. Install bolt (1) to fuel injection line clamp (2). Tighten bolts (1) to a torque of 10 N·m (88 lb in).

12. Install new cable straps (3) to the engine wiring harness assembly.

13. Install plastic tube assembly (4) to crankcase breather canister (5) and to the plastic tube assembly clips. Refer to Disassembly and Assembly, “Crankcase Breather- Remove” for the correct procedure.

14. Install plastic tube assembly (12) to crankcase breather canister (5) and crankcase breather valve (11). Refer to Disassembly and Assembly, “Crankcase Breather- Remove” for the correct procedure.

15. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

16. 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 mounting bracket for the Electronic Control Module (ECM) . Refer to Disassembly and Assembly, “ECM Mounting Bracket- Remove and Install” for the correct procedure.

i04203681

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

Assembly Procedure

Table 32

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 50 mm	4
B	-	Loctite 575 Sealant	1

NOTICE

Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

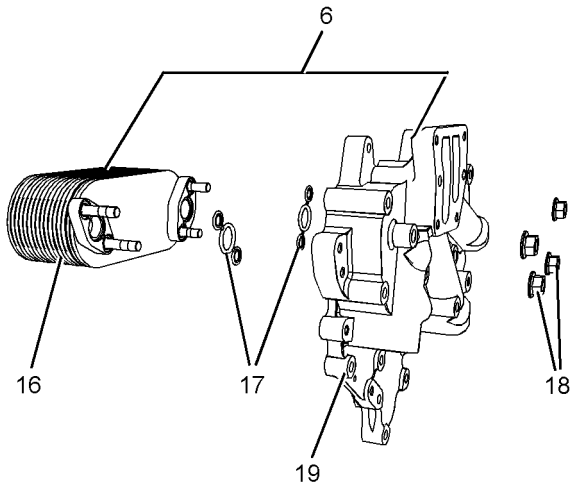


Illustration 220 g02193294

1. If necessary, follow Step 1.a through Step 1.d in order to assembly the engine oil cooler.

a. Ensure that engine oil cooler matrix (16) is clean, free from damage and restriction. Replace engine oil cooler matrix (16) if damaged or restricted.

b. Ensure that housing (19) is clean and free from damage. Replace spacer plate (19) if damaged.

c. Position new gaskets (17) onto engine oil cooler matrix (16). Install engine oil cooler matrix (16) to housing (19).

d. Install nuts (18) to the assembly of oil cooler (6). Tighten the nuts to a torque of 44 N·m (32 lb ft).

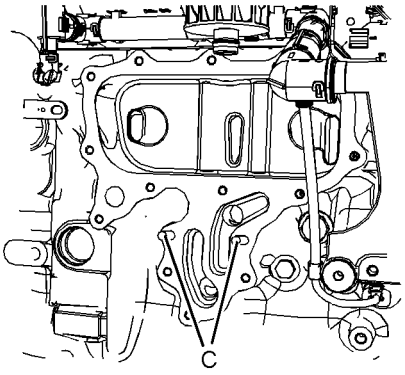


Illustration 221 g02194374

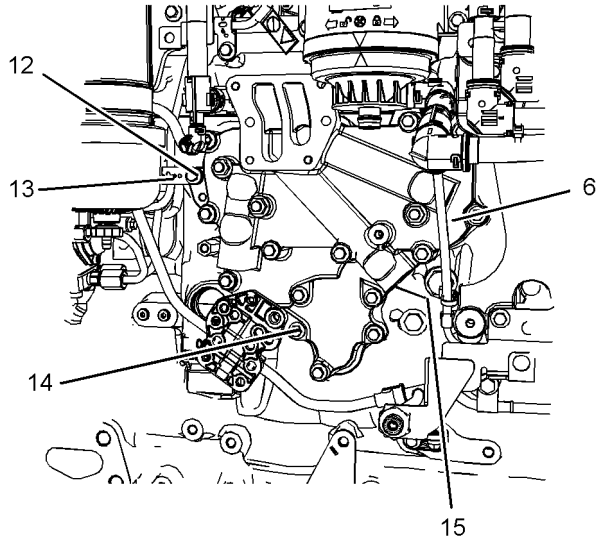


Illustration 222 g02194313

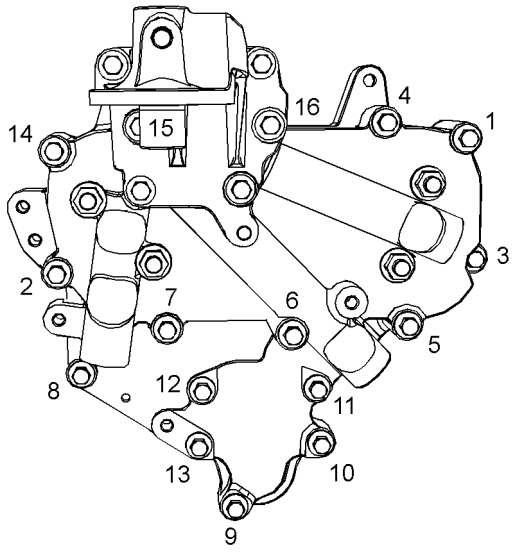


Illustration 223 g02194394

Tightening sequence for the oil cooler with the high mounted oil filter

2. Clean the gasket surfaces of the cylinder block.

3. Install Tooling (A) into Position (C).

4. Position a new gasket (15) (not shown) onto Tooling (A).

5. Install assembly of oil cooler (6) to cylinder block. Install bolts (14) to the assembly of oil cooler (6). Tighten bolts (14) finger tight.

Note: Ensure that the bolts of different lengths are installed in the correct position. Ensure that any brackets for the tube assemblies are location and correctly orientated.

6. Remove Tooling (A) and install remaining bolts (14).

7. Install oil filter base and install the bolts for the oil filter base finger tight. Refer to Illustration 223 and refer to Disassembly and Assembly, “Engine Oil Filter Base - Remove and Install” for the correct procedure.

8. Tighten bolts (14) to a torque of 22 N·m (195 lb in) in sequence that is shown in Illustration 223. Tighten the remaining bolts that secure oil filter base to a torque of 22 N·m (195 lb in).

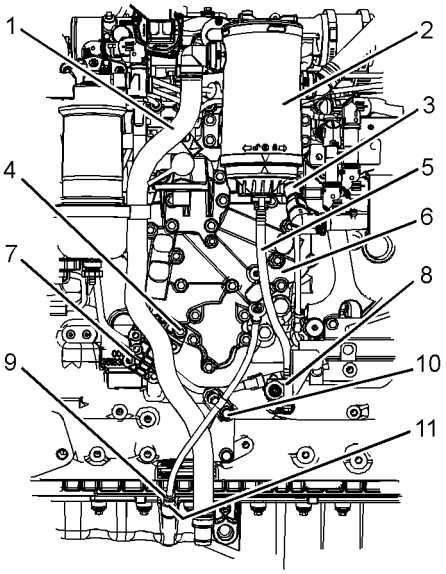


Illustration 224 g02193293

9. Install new cable straps to engine wiring harness (3) that secure the wiring harness assembly to engine oil cooler (6).

10. Connect plastic tube assembly (1) to crankcase breather (2). Install the plastic tube assembly to the clips. Refer to Disassembly and Assembly, “Crankcase Breather- Install” for the correct procedure.

11. Connect plastic tube assembly (5) to crankcase breather canister (2) and crankcase breather valve (8). Refer to Disassembly and Assembly, “Crankcase Breather- Install” for the correct procedure.

12. Position clamp (13) onto engine oil cooler (6). Install bolt (12) and tighten the bolt to a torque 10 N·m (88 lb in).

13. Position bracket (7) onto engine oil cooler (6) and install bolts (4). Tighten the bolt to a torque of 18 N·m (159 lb in).

Note: Ensure that locating pin for the bracket is correctly located into the engine oil cooler.

14. Install a new seal (11) (not shown) to the tube assembly. Apply a bead of Tooling (B) onto the threads of nut (9).

15. Install the tube assembly to the engine oil pan. Install bolt (10) to the bracket for tube assembly.

16. Tighten bolt (10) to a torque of 22 N·m (195 lb in).

17. Tighten nut (9) to a torque of 18 N·m (159 lb in).

18. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

19. Check 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 mounting bracket for the Electronic Control Module (ECM) . Refer to Disassembly and Assembly, “ECM Mounting Bracket- Remove and Install” for the correct procedure.

i04203692

Engine Oil Pump - Remove

Removal Procedure

Start By:

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

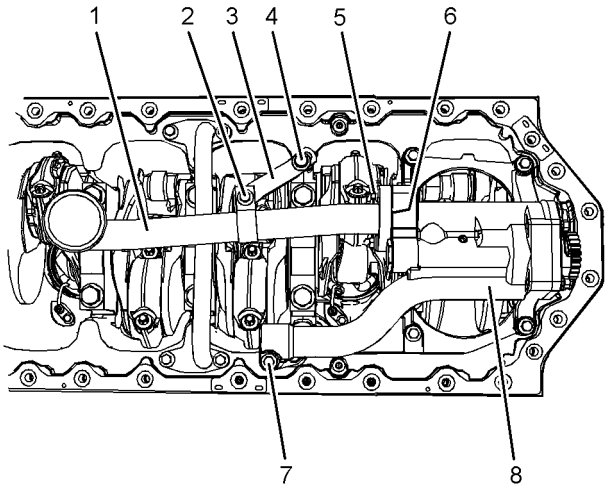


Illustration 225 g02367717

1. If suction pipe (1) has a support bracket, remove bolt (4) from bracket (3). Loosen bolt (2) for the retaining clip.

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

2. Remove bolts (5). Remove suction pipe (1) from oil pump (8).

3. Remove gasket (6) (not shown).

4. Remove bolts (7) and remove the assembly of engine oil pump (8) from the cylinder block.

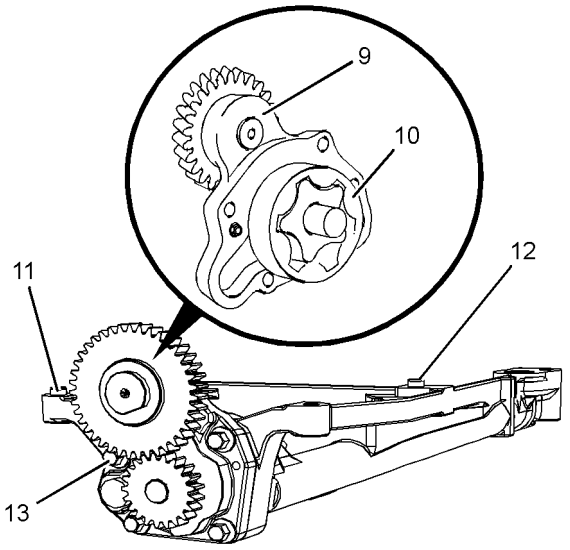


Illustration 226 g02367718

5. If necessary, remove bolts (13) and front cover assembly (9). Remove outer rotor (10) from the housing of the engine oil pump.

Note: Do not remove dowel (11) or dowel (12) from the housing of the engine oil pump unless the dowels are damaged.

i04203691

Engine Oil Pump - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

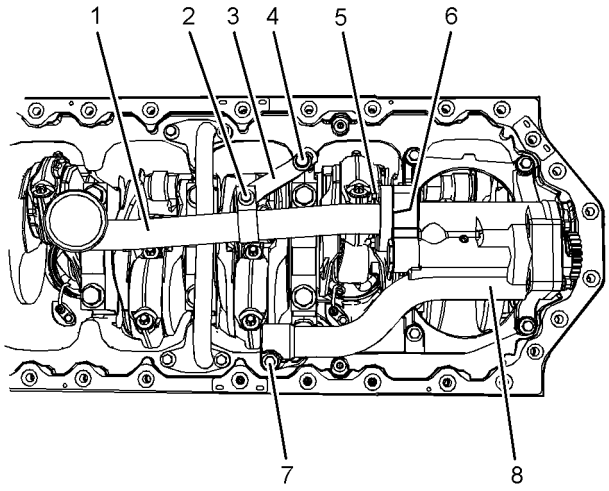


Illustration 227 g02367717

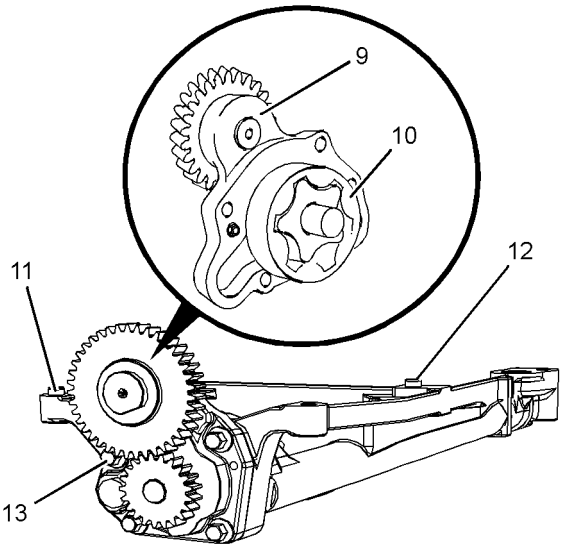


Illustration 228 g02367718

2. If necessary, lubricate the internal components for the assembly of the engine oil pump with clean engine oil. Install outer rotor (10) and front cover (9) to the housing of engine oil pump (8). Install bolts (13).

3. Tighten bolts (13) to a torque of 22 N·m (195 lb in).

4. Ensure that two dowel (11) and dowel (12) are correctly located in the housing of engine oil pump (8). Position the assembly of the engine oil pump onto the cylinder block.

Note: Ensure that the dowels in the housing of the engine oil pump are aligned with the holes in the cylinder block.

5. Install bolts (7). Tighten the bolts to a torque of 22 N·m (195 lb in).

6. Check the backlash between idler gear and the crankshaft gear. Refer to Specifications, “Gear Group (Front)” for more information.

7. Install suction pipe (1) and a new gasket (6) (not shown) to the assembly of engine oil pump (9).

8. Install bolts (5). Tighten the bolts to a torque to 22 N·m (195 lb in).

9. If suction pipe (1) has a support bracket, follow Step 9.a through Step 9.d.

a. Install the components of support bracket (3). Ensure the correct location and orientation of the bracket and the retaining clip.

b. Install bolt (4).

c. Tighten bolt (4) and bolt (2) finger tight in order to align the components of the support bracket.

d. Tighten bolt (2) to a torque of 22 N·m (195 lb in).

Tighten bolt (4) to a torque of 44 N·m (32 lb ft).

End By:

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

i04203794

Water Pump - Remove

Removal Procedure

Start By:

a. Remove the fan and the fan pulley. Refer to Disassembly and Assembly, “Fan - Remove and Install” 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. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

2. Loosen the hose clamps and remove the hose from the water pump inlet.

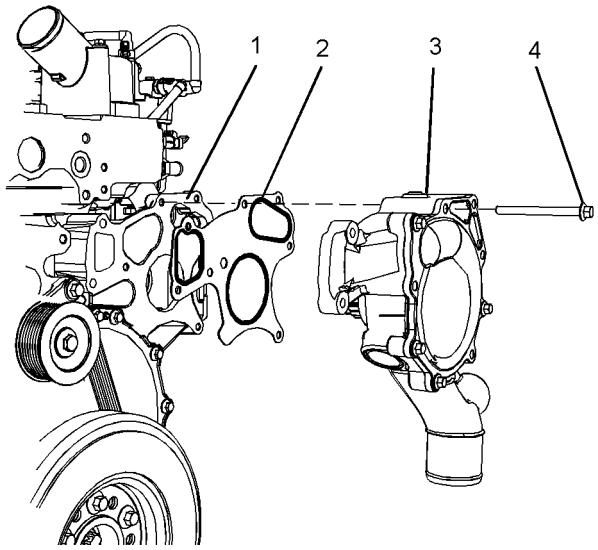


Illustration 229 g02164768

3. Remove bolts (4).

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

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

5. Remove gasket (2).

i04203793

Water Pump - Install

Installation Procedure

Table 33

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 90 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 and damage. If necessary, replace the water pump. Clean the gasket surface of the water pump.

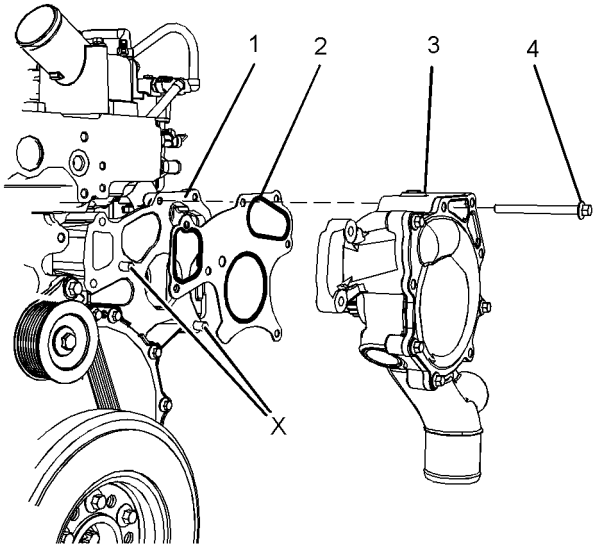


Illustration 230 g02164797

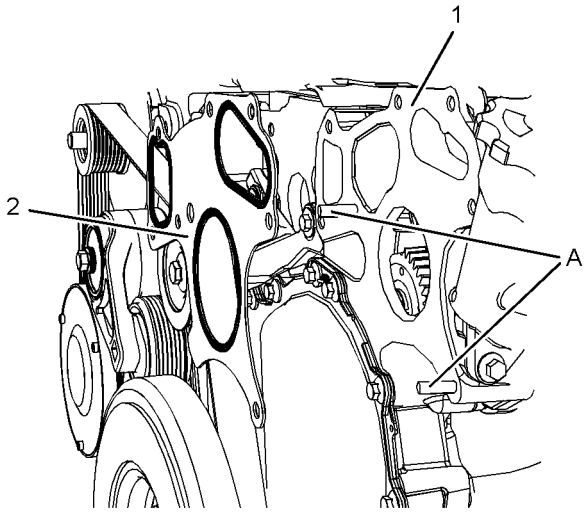


Illustration 231 g02164963

2. Clean the gasket surface of housing (1).

3. Install Tooling (A) in Position (X).

4. Use Tooling (A) in order to align new gasket (2) to housing (1). Install the gasket onto the housing.

5. Align water pump (3) to Tooling (A). Install the water pump to housing (1).

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

6. Install bolts (4). Refer to Illustration 230. Tighten the bolts finger tight.

7. Remove Tooling (A) and install remaining bolts (4).

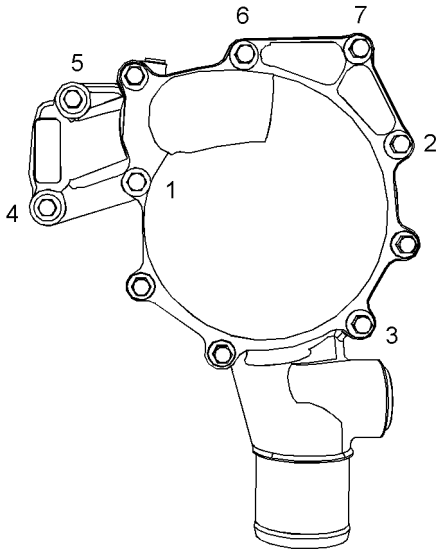


Illustration 232 g01985813

8. Tighten the bolts in the sequence that is shown in Illustration 232 to a torque of 22 N·m (195 lb in).

9. Install the hose to the water pump inlet. Tighten the hose clamps securely.

10. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.

End By:

a. Install the fan and the fan pulley. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04203796

Water Temperature Regulator - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system to a level below the water temperature regulator, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

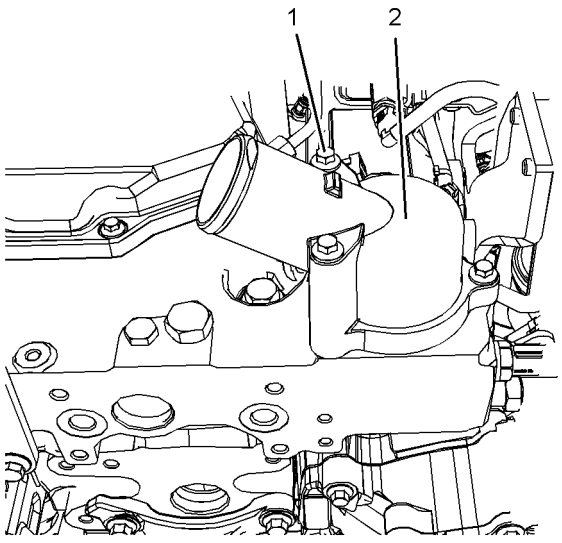


Illustration 233 g01985853
Typical example

2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from water temperature regulator housing (2).

3. Remove bolts (1) from water temperature regulator housing (2).

4. Remove water temperature regulator housing (2) from the cylinder head.

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

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

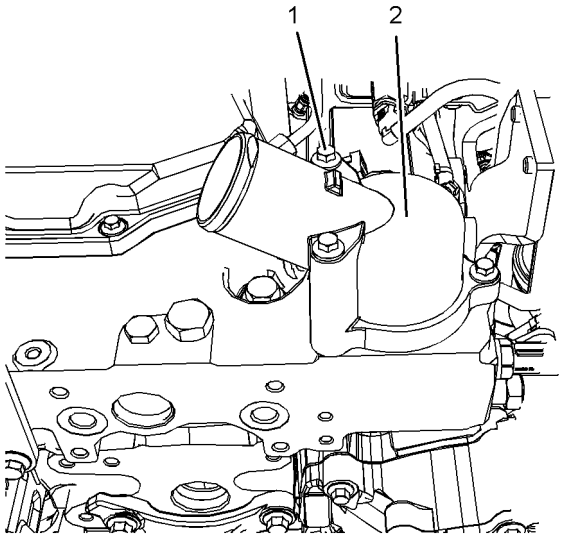


Illustration 234 g01985853
Typical example

1. Ensure that all components of water temperature regulator housing (2) are clean and free of wear and damage. If any components of the water temperature regulator housing are worn or damaged, the complete assembly must be replaced.

2. Check the water temperature regulator for correct operation. Refer to System Operation, Testing, and Adjusting, “Water Temperature Regulator - Test” for the procedure to test the water temperature regulator. If the water temperature regulator is no operating correctly, the complete assembly must be replaced.

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

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

4. Install bolts (1). Tighten the bolts to a torque of 22 N·m (195 lb in).

5. Connect the upper radiator hose and tighten the hose clamps securely.

6. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Check” and Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct filling procedure.

i04203704

Flywheel - Remove

Removal Procedure

Table 34

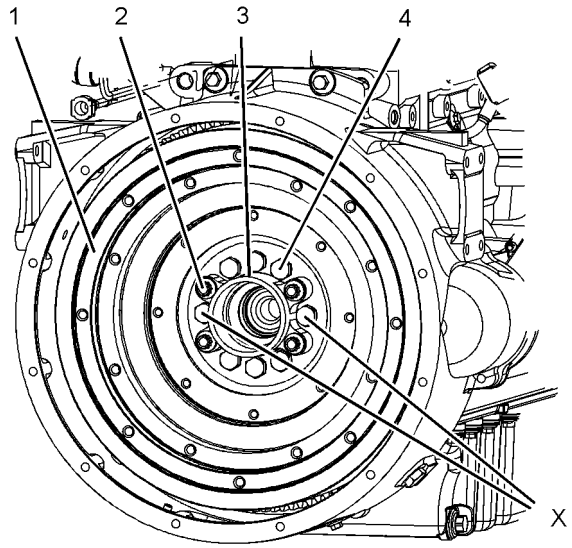
Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud 1/2 inch - UNF by 4 inch	2

Start By:

a. Remove the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

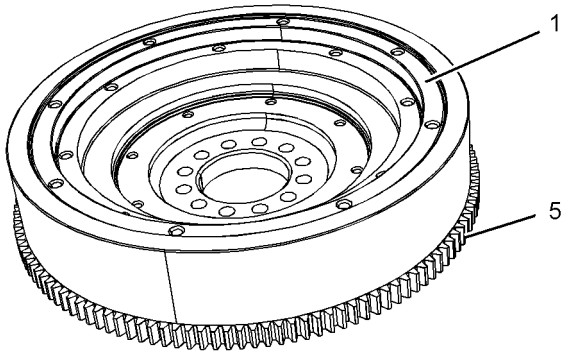


g01336668

Illustration 235

Typical example

1. Remove bolts from Position (X) from flywheel (1).
2. Install Tooling (A) in Position (X) to flywheel (1).
3. Install a suitable lifting device onto flywheel (1). Support the weight of the flywheel. The flywheel can weigh 71 kg (156 lb).
4. If necessary, remove bolts (2) that secure the housing for pilot bearing (3) to flywheel (1). Remove the housing for pilot bearing (3).
5. Remove remaining bolts (4).
6. Use the lifting device to remove the flywheel from the engine.



g01336669

Illustration 236

Typical example

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

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

i04203703

Flywheel - Remove (Equipped with Rear Power Take-Off)

Removal Procedure

Table 35

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud 1/2 inch - UNF by 4 inch	2

Start By:

a. Remove the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

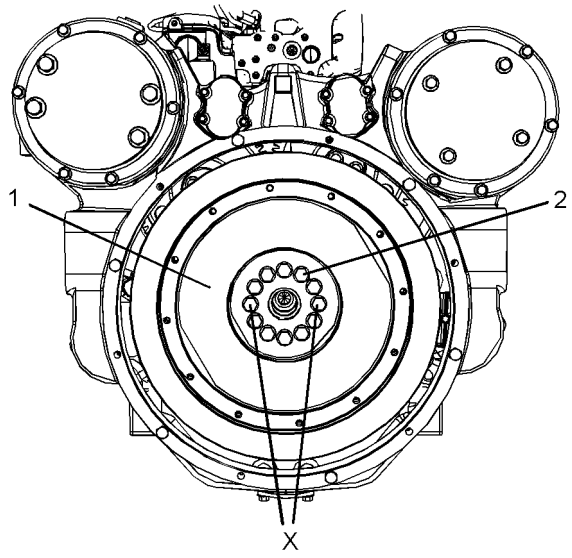


Illustration 237 g02062053

1. Remove bolts from Position (X) from flywheel (1).
2. Install Tooling (A) in Position (X) to flywheel (1).
3. Use a suitable lifting device to support the flywheel. The weight of flywheel (2) is approximately 68 kg (150 lb).
4. Remove remaining bolts (2).
5. Use the lifting device to remove flywheel (1) from the engine.
6. Remove Tooling (A).

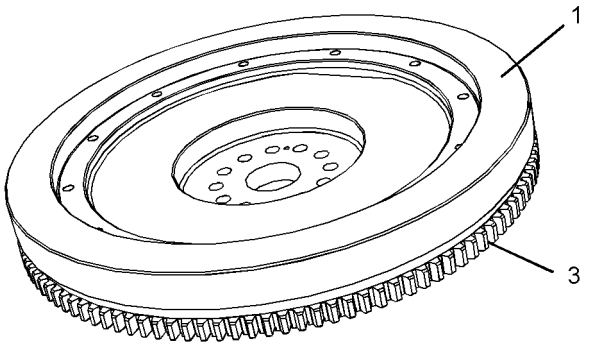


Illustration 238 g02062054

7. Inspect flywheel (1) and ring gear (3) for wear and damage. Replace any worn components or damaged components.
8. To remove flywheel ring gear (3), follow Step 8.a through Step8.b.
   a. Place the flywheel assembly on a suitable support.
   b. Use a hammer and a punch in order to remove ring gear (3) from flywheel (1).

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

i04203702

Flywheel - Install

Installation Procedure

Table 36

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud 1/2 inch - UNF by 4 inch	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

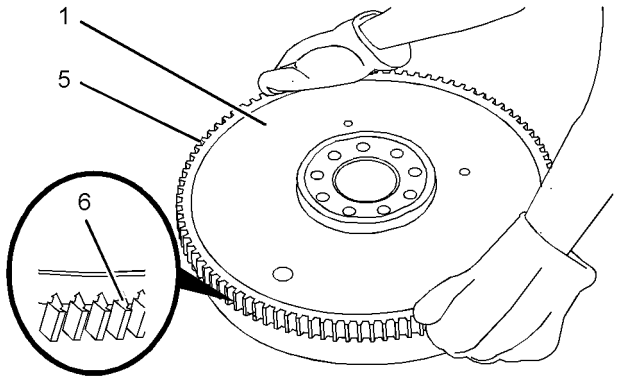


Illustration 239 g01336671
Typical example

WARNING

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

1. If the flywheel ring gear was removed, follow Step 1.a through Step 1.c in order to install ring gear (5) to flywheel (1).
   a. Identify the orientation of teeth (6) on new ring gear (5).

Note: The chamfered side of ring gear teeth (6) must face toward the starting motor when the flywheel is installed. The chamfered side of ring gear teeth ensures the correct engagement of the starting motor.

b. Heat flywheel ring gear (5) in an oven to a maximum temperature of 250 °C (482 °F) prior to installation.

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

c. Ensure that the orientation of ring gear (5) is correct and quickly install the ring gear onto flywheel (1).

2. Inspect the crankshaft rear seal for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

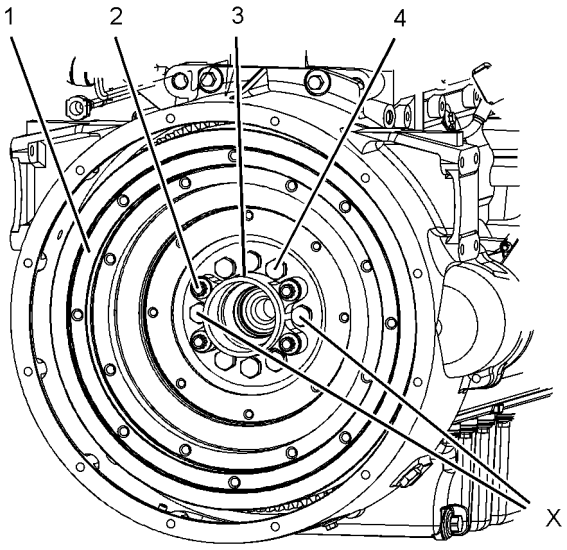


Illustration 240 g01336668
Typical example

3. Install a suitable lifting device onto flywheel (1). The flywheel can weigh 71 kg (156 lb).

4. Install Tooling (A) in Position (X) on the crankshaft.

5. Use the lifting device to position flywheel (1) onto Tooling (A).

6. If necessary, install pilot bearing (3) and bolts (2) to flywheel (1).

7. Install bolts (4) to flywheel (1).

8. Remove Tooling (A) and install remaining bolts (4) to flywheel (1).

9. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) and (4) to a torque of 140 N·m (103 lb ft).

10. Remove the lifting device from flywheel (1).

11. Check the run out of the flywheel. Refer to Specifications, “Flywheel” for further information.

End By:

a. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i04203701

Flywheel - Install (Equipped with Rear Power Take-Off)

Installation Procedure

Table 37

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud 1/2 inch - UNF by 4 inch	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

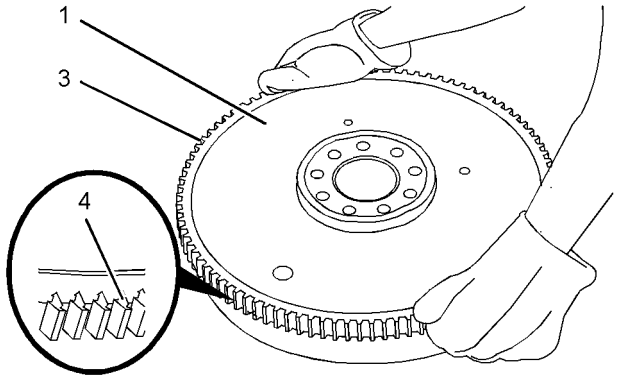


Illustration 241 g02062093

WARNING

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

1. If the flywheel ring gear was removed, follow Step 1.a through Step 1.c in order to install ring gear (3) to flywheel (1).

a. Identify the orientation of teeth (4) on new ring gear (3).

Note: The chamfered side of ring gear teeth (4) must face toward the starting motor when the flywheel is installed. The chamfered side of ring gear teeth ensures the correct engagement of the starting motor.

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

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

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

2. Inspect the crankshaft rear seal for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

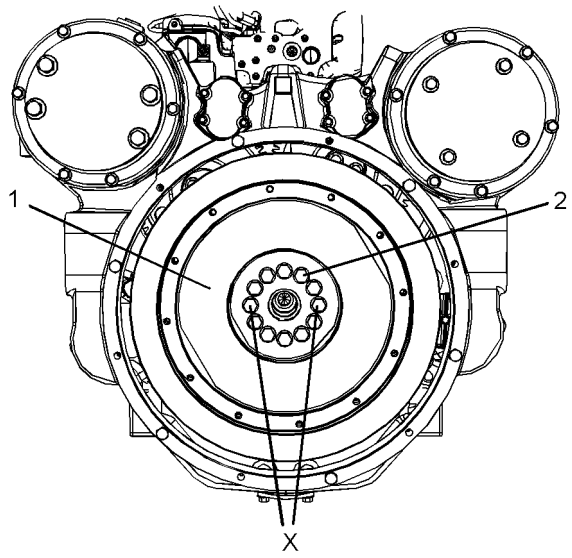


Illustration 242 g02062053

3. Install a suitable lifting device on flywheel (1). The flywheel can weigh 68 kg (150 lb).

4. Install Tooling (A) in Position (X) on the crankshaft.

5. Use the lifting device to position flywheel (1) onto Tooling (A).

6. Install bolts (2) to flywheel (1).

7. Remove Tooling (A) and install remaining bolts (2) to flywheel (1).

8. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) and (4) to a torque of 140 N·m (103 lb ft).

9. Remove the lifting device from flywheel (1).

10. Check the run out of the flywheel. Refer to Specifications, “Flywheel” for more information.

End By:

a. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i04203666

Crankshaft Rear Seal - Remove

Removal Procedure

Table 38

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	T40 Torx Socket	1
B	-	E10 Torx Socket	1

Start By:

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

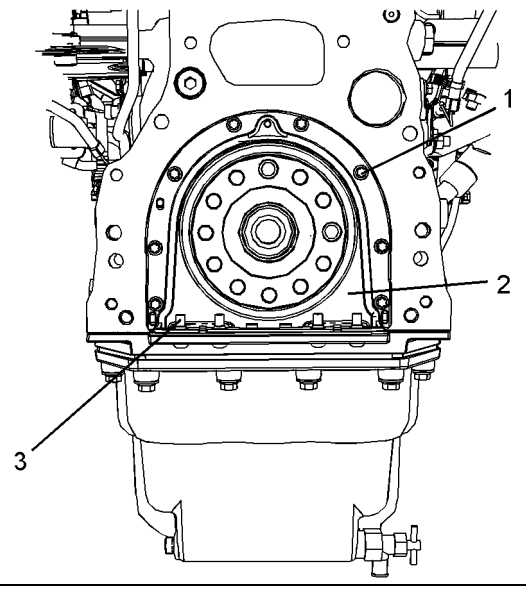


Illustration 243 g01985913

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

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

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

i04203665

Crankshaft Rear Seal - Install

Installation Procedure With Oil Pan in Position

Table 39

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	T40 Torx Socket	1
B	-	E10 Torx Socket	1

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

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

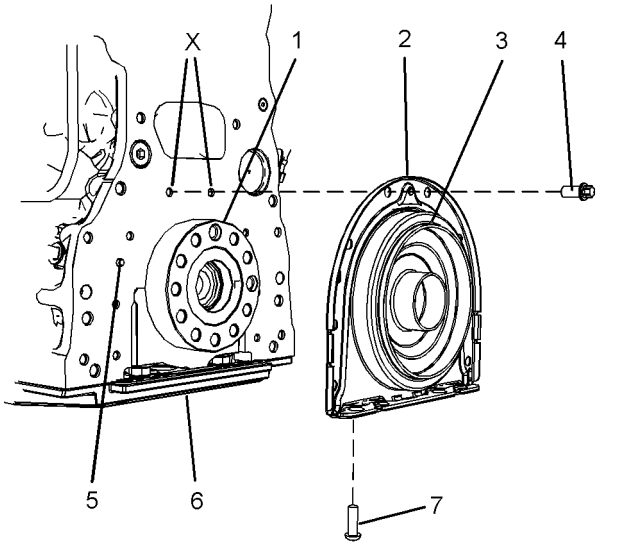


Illustration 244 g01986153

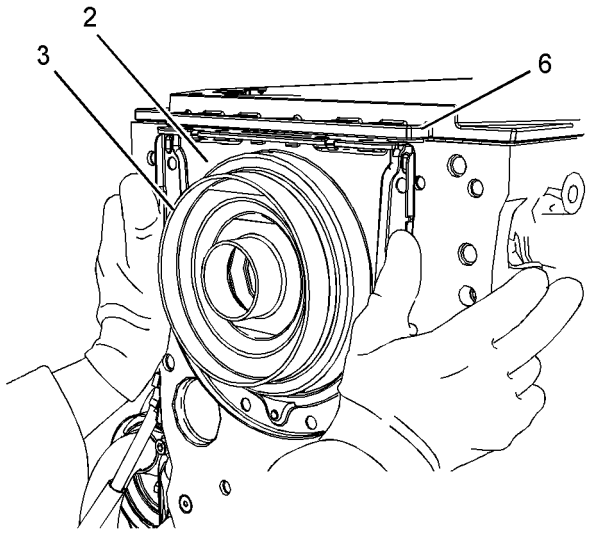


Illustration 245 g01986154

1. Ensure that crankshaft flange (1) is clean, dry, and free from damage.
2. Ensure that the gasket surface of the cylinder block is clean, free from damage, and dry. Ensure that the gasket surface of isolating frame (6) is clean and dry.

3. Ensure that plastic sleeve (3) is squarely installed within new crankshaft rear seal (2).

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

4. Place the assembly of crankshaft rear seal (2) over crankshaft flange (1). Align dowel (5) with the slot in crankshaft rear seal (2).

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

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

6. Use Tooling (A) in order to install two outer Torx bolts (7) at the base of crankshaft rear seal (2). Tighten Torx bolts (7) to a torque of 15 N·m (133 lb in).

7. Use Tooling (B) in order to install two Torx bolts (4) to crankshaft rear seal (2) at Position (X). Tighten Torx bolts (4) to a torque of 22 N·m (195 lb in).

8. Use Tooling (A) in order to unscrew Torx bolts (7) by one complete turn.

9. Use Tooling (A) in order to install remaining Torx bolts (7). Tighten all Torx bolts (7) to a torque of 22 N·m (195 lb in).

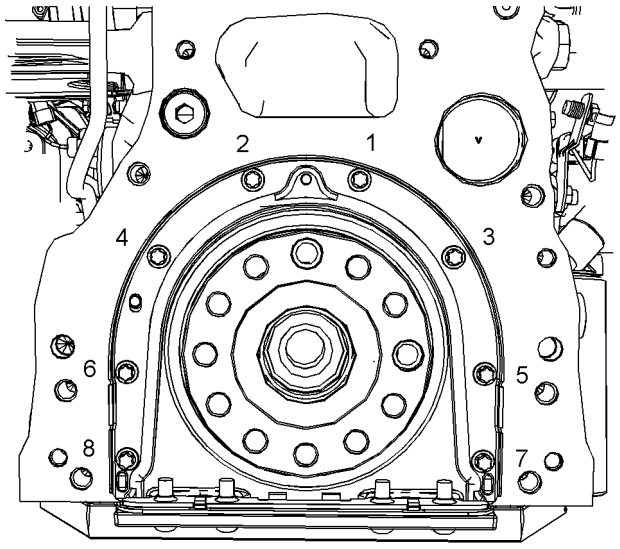


Illustration 246 g02047453

10. Tighten all Torx bolts (4) in the numerical sequence that is shown in Illustration 246. Tighten all Torx bolts (4) to a torque of 22 N·m (195 lb in).

End By:

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

Installation Procedure Without Isolating Frame for the Oil Pan

Table 40

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

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

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

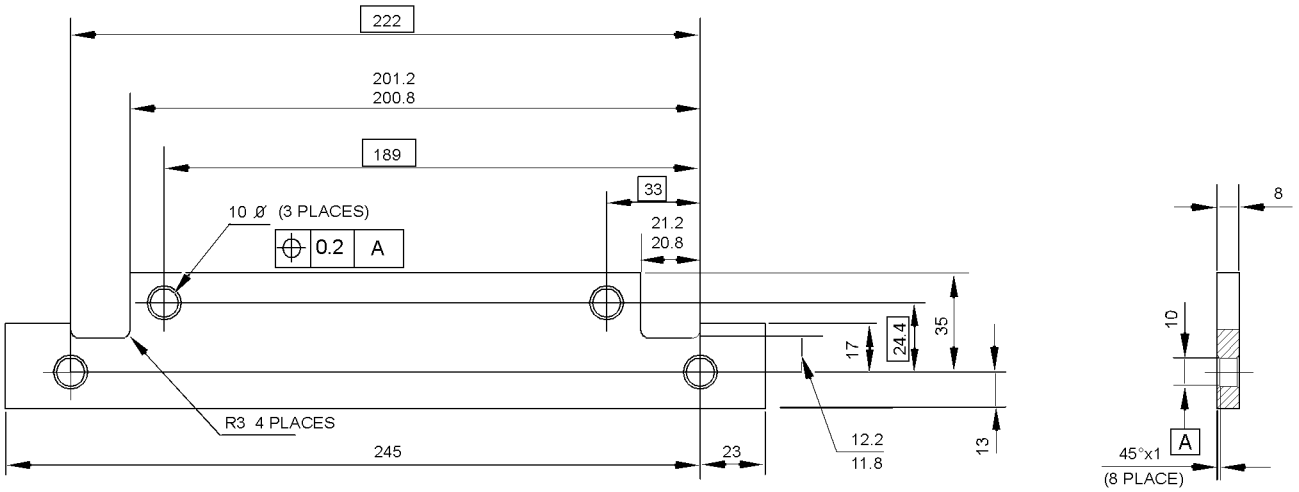


Illustration 247 g01279001

Alignment tool

1. To install the crankshaft rear seal without the isolating frame for the oil pan in position, Tooling (C) must be used. The tool should be fabricated from 8 mm (5/16 inch) steel stock. The dimensions for the tool are given in Illustration 247. All dimensions are shown in millimeters.

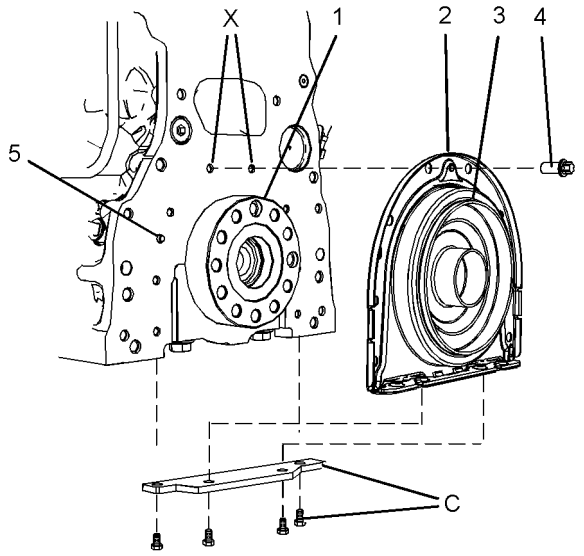


Illustration 248 g01988536

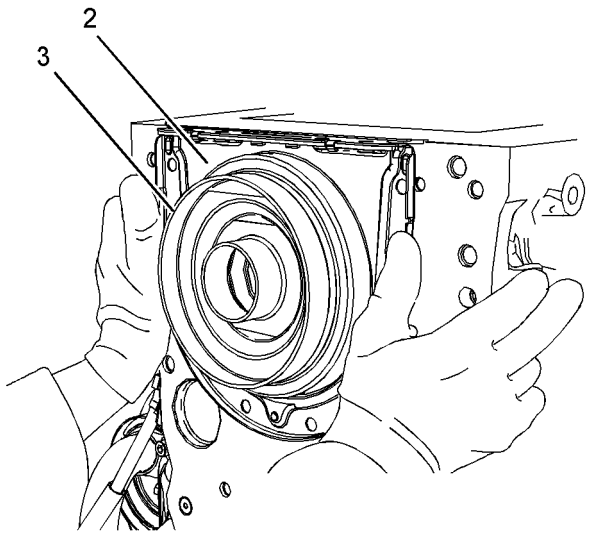


Illustration 249 g01988593

2. Ensure that crankshaft flange (1) is clean, dry, and free from damage.

3. Ensure that the gasket surface of the cylinder block is clean and dry.

4. Ensure that plastic sleeve (3) is squarely installed within new crankshaft rear seal (2).

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

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

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

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

7. Install Tooling (C) to the cylinder block and to crankshaft rear seal (2). Tighten the bolts to a torque of 15 N·m (133 lb in).

8. Use Tooling (A) in order to install two Torx bolts (4) to crankshaft rear seal (3) in Position (X). Tighten the two Torx bolts (4) to a torque of 22 N·m (195 lb in).

9. Use Tooling (A) in order to install remaining Torx bolts (4).

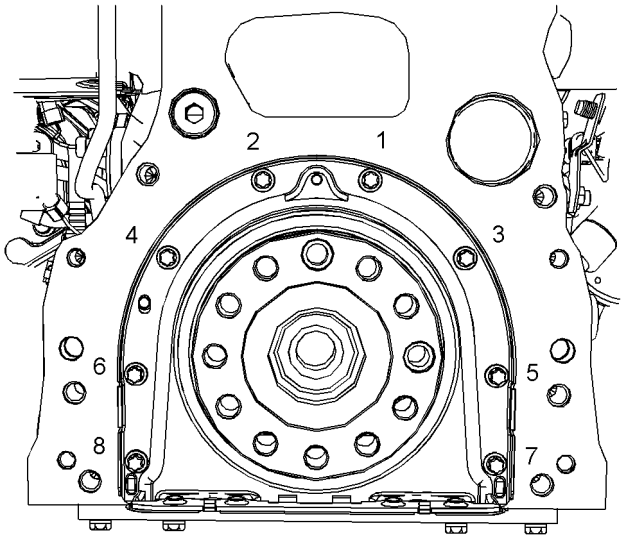


Illustration 250 g02047414

10. Tighten all Torx bolts (4) in the numerical sequence that is shown in Illustration 250. Tighten all Torx bolts (4) to a torque of 22 N·m (195 lb in).

11. Remove Tooling (C).

End By:

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

i04203707

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

Removal Procedure

Table 41

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

Start By:

a. Remove the flywheel. Refer to Disassembly and Assembly, “Flywheel - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The wet back-end flywheel housing may be installed on standard engines. When the wet back-end flywheel housing, is installed to a standard engine a seal will not be installed to the flywheel housing.

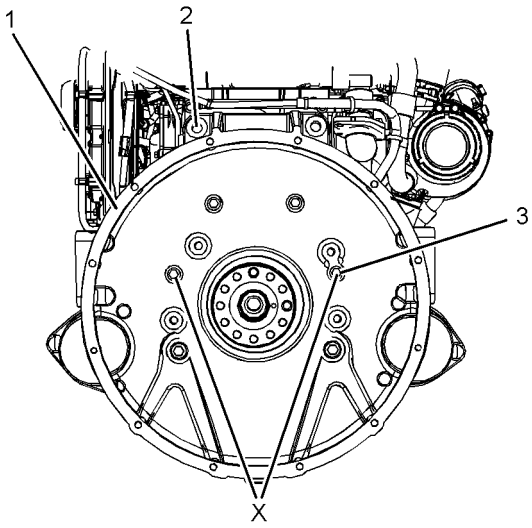


Illustration 251 g02227493
Typical example

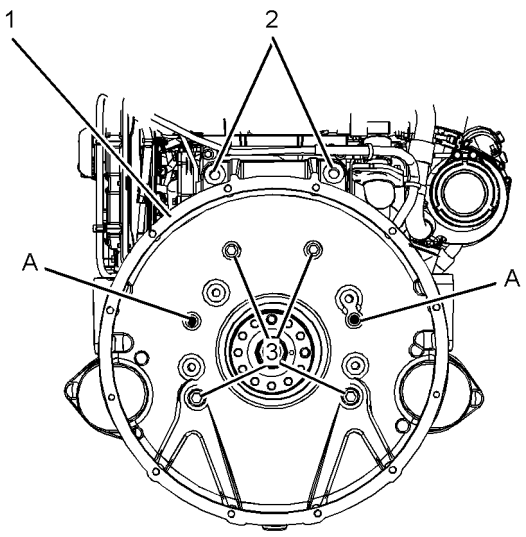


Illustration 252 g02227494
Typical example

1. Remove the bolts from Position (X) from flywheel housing (1).

2. Install Tooling (A) into Position (X) on flywheel housing (1).

3. Install a suitable lifting device onto the flywheel housing in order to support the flywheel housing. The weight of the flywheel housing is approximately 40 kg (88 lb).

4. Remove bolts (2) and remaining bolts (3) from flywheel housing (1).

5. Use the lifting device in order to remove flywheel housing (1) from the cylinder block.

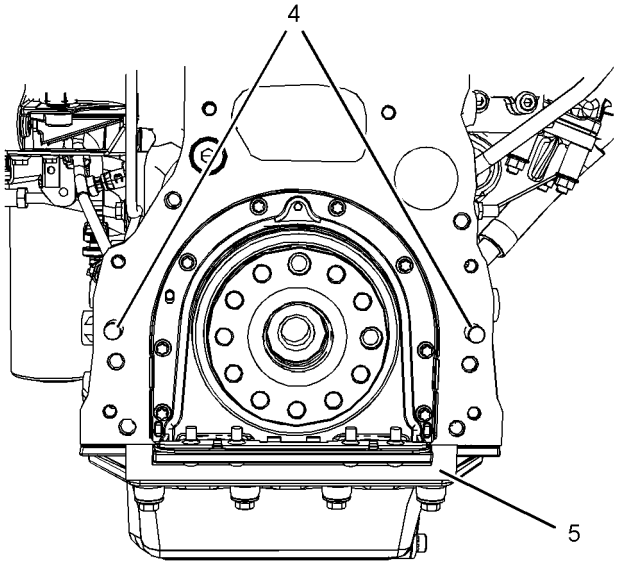


Illustration 253 g01988534
Typical example

6. Remove dust seal (5).

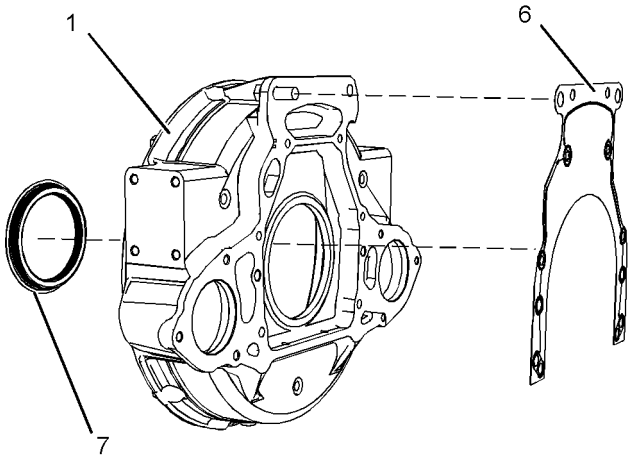


Illustration 254 g01988535
Typical example

7. Remove gasket (6).

8. If necessary, remove dowels (4) from the cylinder block.

9. Remove oil seal (7) from flywheel housing (1).

Installation Procedure (Wet Back End Housing)

Table 42

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

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.

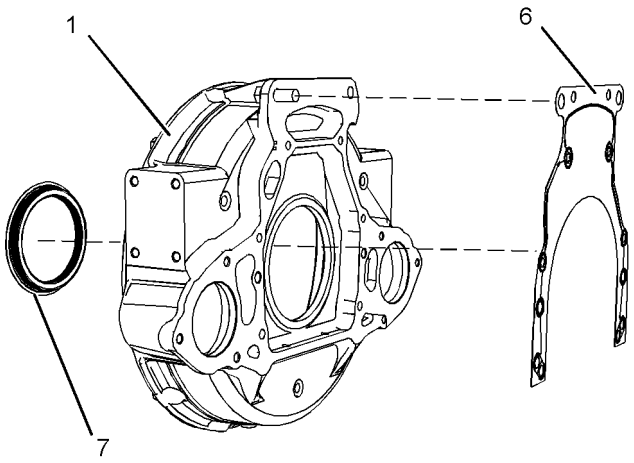


Illustration 255 g01988676
Typical example

2. Install a new oil seal (7) to flywheel housing (1).

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

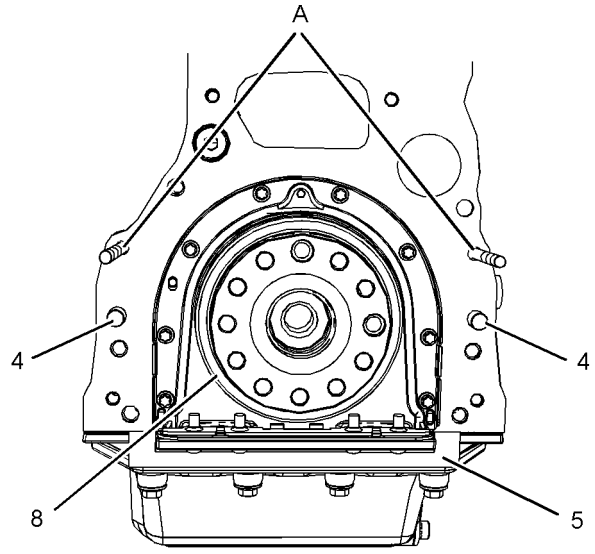


Illustration 256 g01988677
Typical example

3. Inspect crankshaft rear seal (8) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” and refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

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

5. Install Tooling (A) to the cylinder block.

6. Align a new gasket (6) with Tooling (A). Install the gasket to the cylinder block.

7. Install dust seal (5).

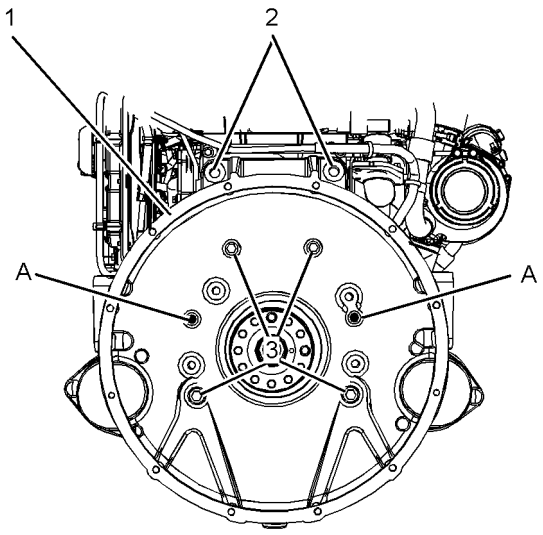


Illustration 257 g02227495
Typical example

8. Install a suitable lifting device onto the flywheel housing. The weight of the flywheel housing is approximately 40 kg (88 lb).

9. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.

10. Install bolts (2) and bolts (3).

11. Remove Tooling (A). Install remaining bolts (3).

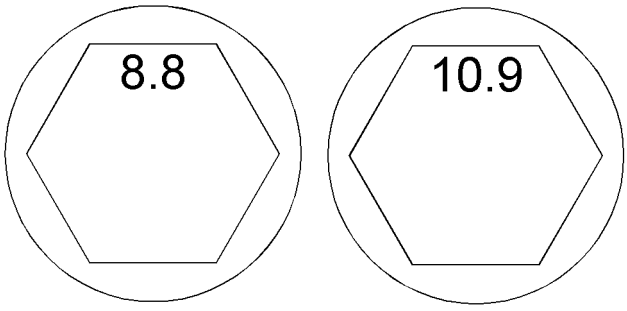


Illustration 258 g01984554
Identification of the bolt Grade.

12. When 8.8 Graded bolts are installed, follow Step 12.a through Step 12.b.

    a. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).

    b. Tighten bolts (2) to a torque of 78 N·m (58 lb ft).

13. When 10.9 Graded bolts are installed, follow Step 13.a through Step 13.b.

    a. Tighten bolts (3) to a torque of 115 N·m (85 lb ft).

    b. Tighten bolts (2) to a torque of 190 N·m (140 lb ft).

14. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, “Flywheel Housing - Inspect” for more information.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i04203705

Flywheel Housing - Remove and Install (Standard Housing)

Removal Procedure

Table 43

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

Start By:

a. Remove the flywheel. Refer to Disassembly and Assembly, “Flywheel - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

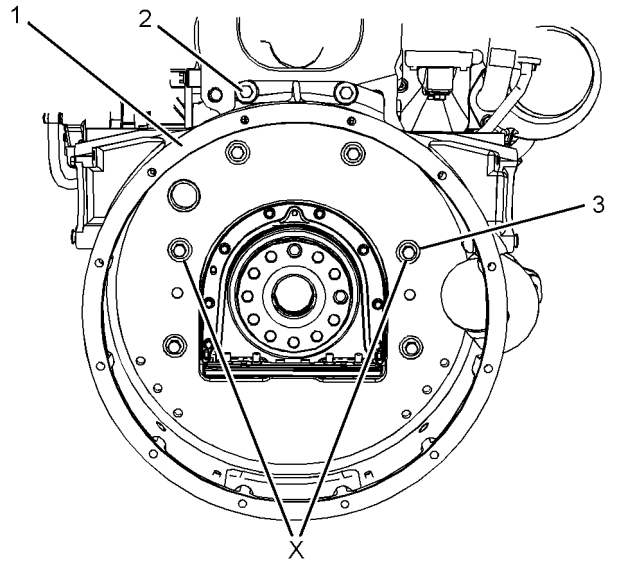


Illustration 259 g02227473

Typical example

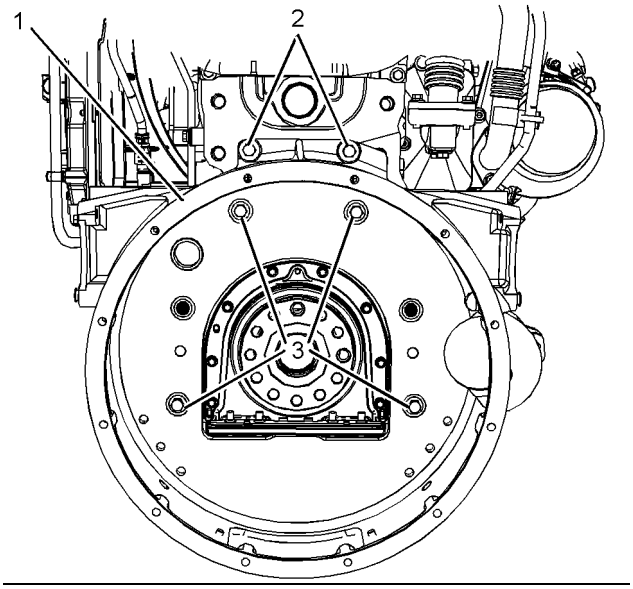


Illustration 260 g02227474

Typical example

1. Remove bolts (3) from Position (X) from flywheel housing (1).
2. Install Tooling (A) into Position (X) on flywheel housing (1).
3. Install a suitable lifting device onto the flywheel housing in order to support the flywheel housing. The weight of the flywheel housing is approximately 40 kg (88 lb).
4. Remove bolts (2) and remaining bolts (3) from flywheel housing (1).
5. Use a suitable lifting device in order to remove flywheel housing (1) from the cylinder block.

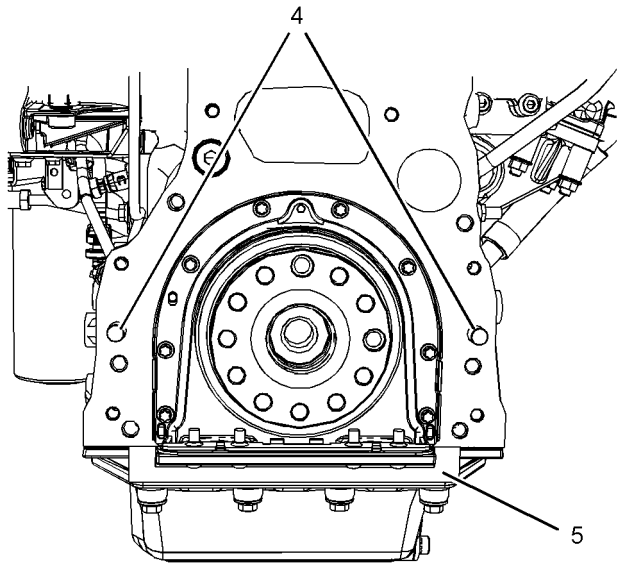


Illustration 261 g01983533

Typical example

6. Remove dust seal (5).
7. If necessary, remove dowels (4) from the cylinder block.

Installation Procedure (Standard Housing)

Table 44

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

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.

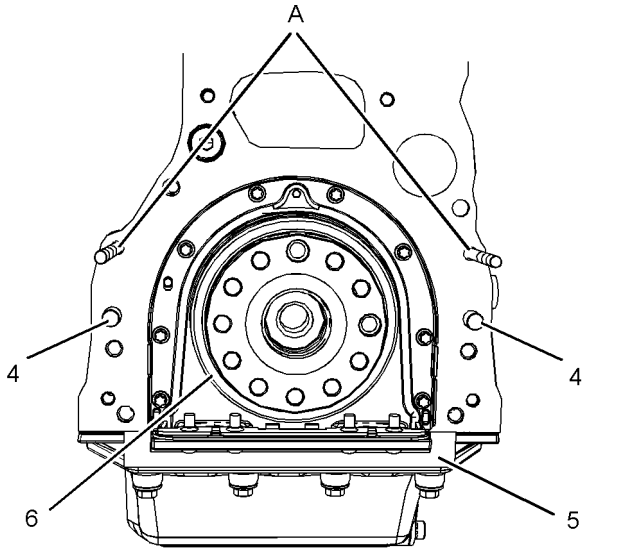


Illustration 262 g01983535

Typical example

2. Inspect crankshaft rear seal (6) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” and refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

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

4. Install Tooling (A) to the cylinder block.

5. Install dust seal (5).

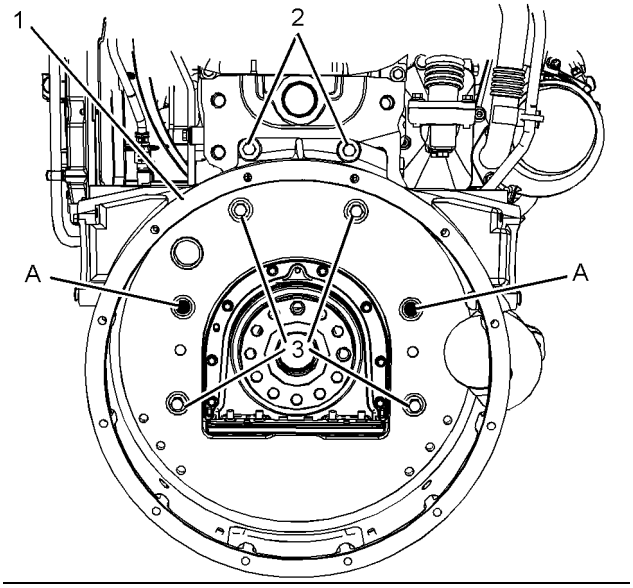


Illustration 263 g02227475

Typical example

6. Install a suitable lifting device onto the flywheel housing. The weight of the flywheel housing is approximately 40 kg (88 lb).

7. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.

8. Install bolts (2) and bolts (3).

9. Remove Tooling (A). Install remaining bolts (3).

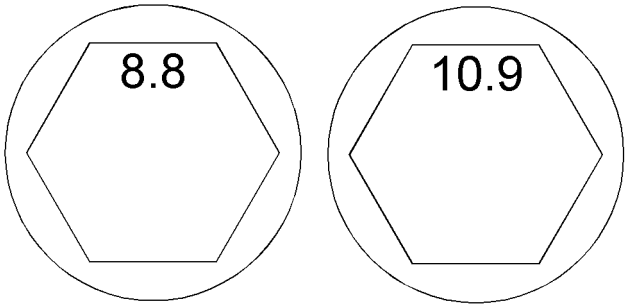


Illustration 264 g01984554

Identification of the bolt Grade.

10. When 8.8 Graded bolts are installed, follow Step 10.a through Step 10.b.

a. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).

b. Tighten bolts (2) to a torque of 78 N·m (58 lb ft).

11. When 10.9 Graded bolts are installed follow Step 11.a through Step 11.b.

a. Tighten bolts (3) to a torque of 115 N·m (85 lb ft).

b. Tighten bolts (2) to a torque of 190 N·m (140 lb ft).

12. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, “Flywheel Housing - Inspect” for more information.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i04203708

Flywheel Housing - Remove and Install (Flywheel Housing that is Equipped with Rear Power Take-Off)

Removal Procedure

Table 45

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Link Bracket	2
B	-	Guide Stud M10 by 100 mm	2

Start By:

a. Remove the Rear Power Take-Off (RPTO). Refer to Disassembly and Assembly, “Rear Power Take-Off (RPTO) - Remove” for the correct procedure.

b. Remove the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If necessary, remove engine mountings from the flywheel housing. Refer to Original Equipment Manufactures (OEM) for the correct procedure.

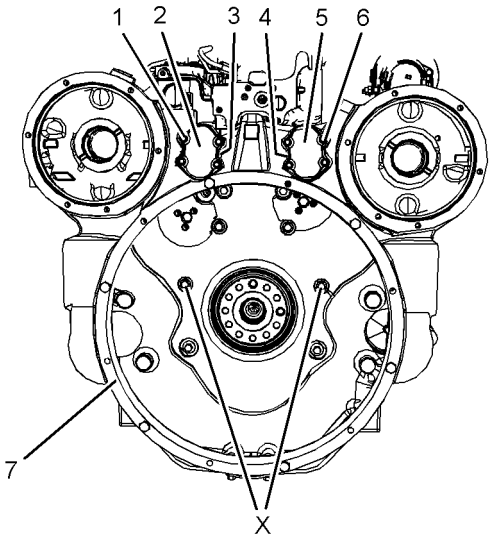


Illustration 265 g02062234

2. Remove bolts in Position (X) from flywheel housing (7).

3. Install Tooling (B) into Position (X) of flywheel housing (7).

4. Remove bolts (1) and bolts (6) from blanking plate (2) and blanking plate (5).

5. Remove blanking plate (2) and blanking plate (5) from the flywheel housing. Remove O-ring seal (3) (not shown) and O-ring seal (4) (not shown).

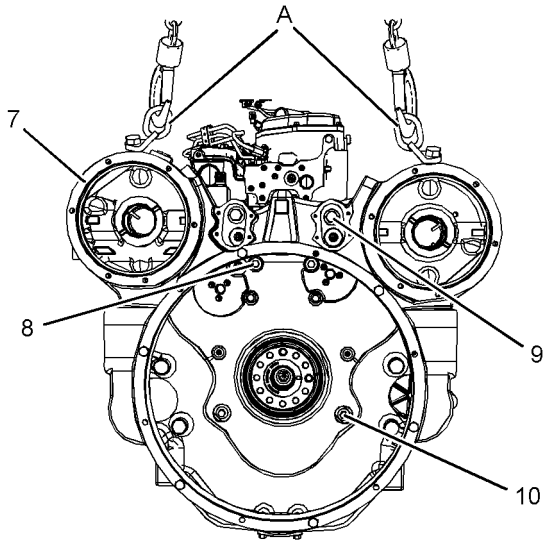


Illustration 266 g02063693

6. Install Tooling (A) and a suitable lifting device onto flywheel housing (7). The weight of flywheel housing (7) is approximately 134 kg (295 lb).

7. Remove bolts (8), bolts (9) and bolts (10) from flywheel housing (7).

8. Use the suitable lifting device in order to remove flywheel housing (7) from the cylinder block.

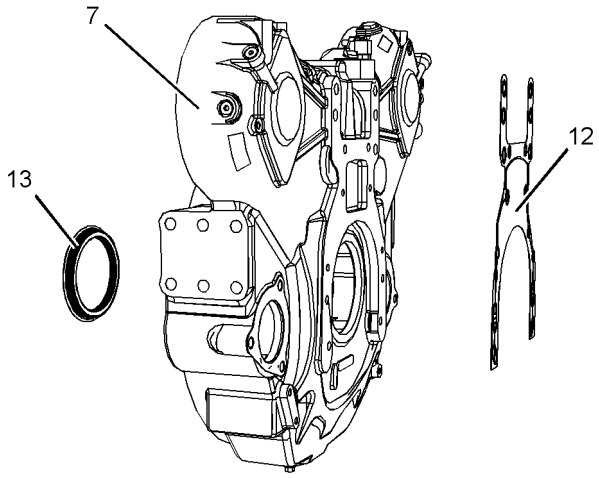


Illustration 267 g02062293

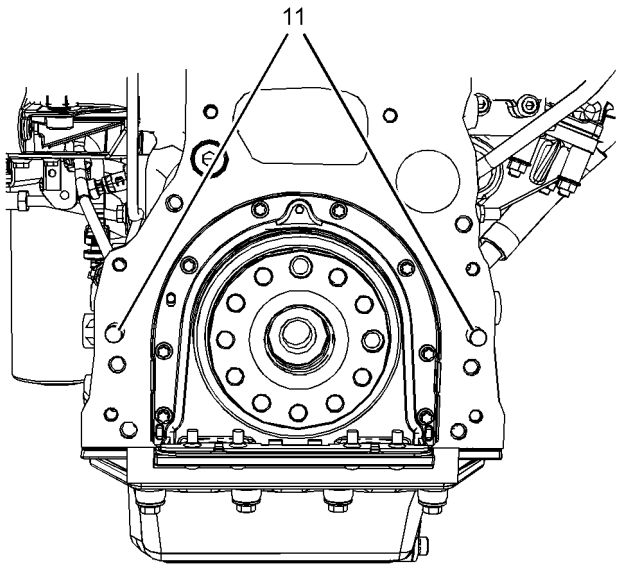


Illustration 268 g02062275

9. If necessary, remove dowels (11) from the cylinder block.

10. Remove gasket (12).

11. Remove oil seal (13) from flywheel housing (7).

Installation Procedure

Table 46

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Link Bracket	2
B	-	Guide Stud M10 by 100 mm	2
C	-	Loctite 5900 Flange Sealant	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.

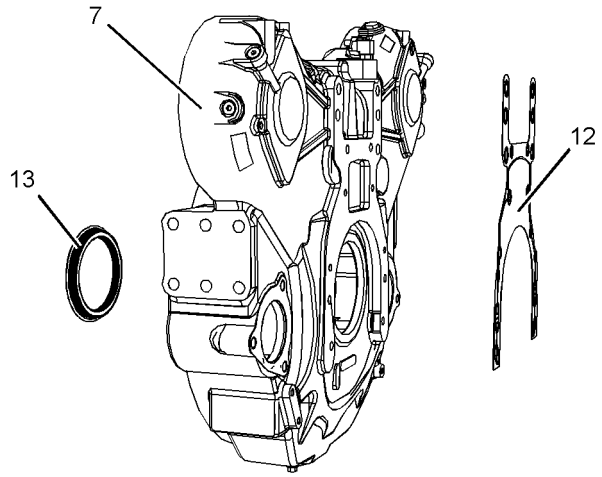


Illustration 269 g02062293

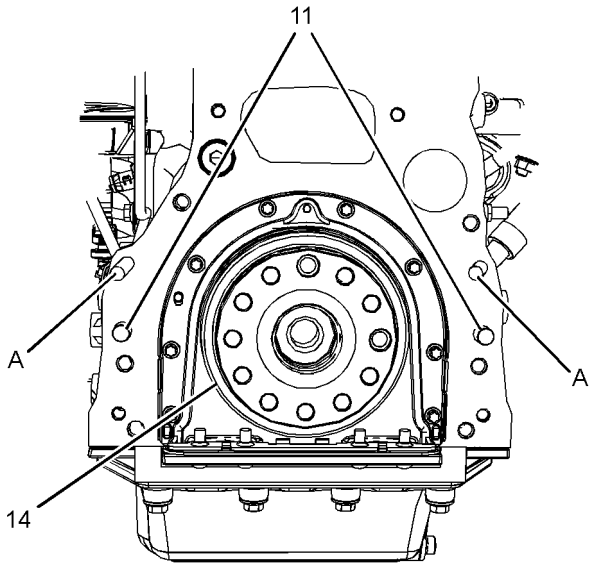


Illustration 270 g02063873

2. Install a new oil seal (13) to flywheel housing (7).

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 gasket surface of the flywheel housing.

3. Inspect crankshaft rear seal (14) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” and refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

4. Clean the rear face of the cylinder block. If necessary, install dowels (11) to the cylinder block.

5. Install Tooling (B) to the cylinder block.

6. Align a new gasket (12) with Tooling (B). Install the gasket to the cylinder block.

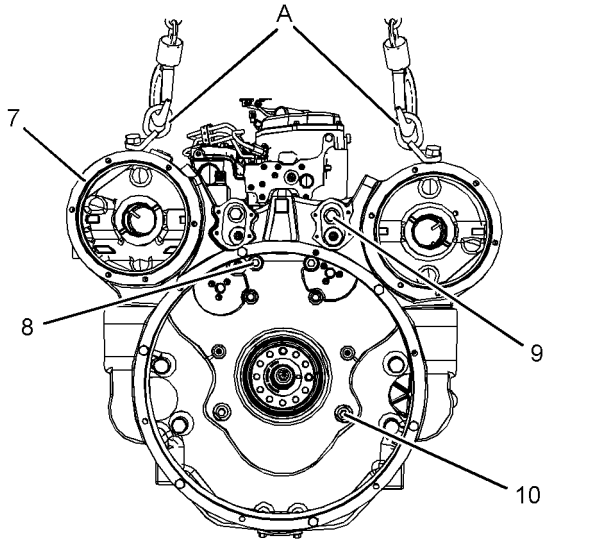


Illustration 271 g02063693

7. Install Tooling (A) and a suitable lifting device onto flywheel housing (7). The weight of the flywheel housing is approximately 134 kg (295 lb).

8. Apply Tooling (C) to the bottom of flywheel housing (7) in order to fill the space at the cylinder block, the flywheel housing, and the engine oil pan.

9. Position flywheel housing (7) on the cylinder block. Install bolts (8), bolts (9), and bolts (10) hand tight.

10. Remove Tooling (B) and install reaming bolts (10).

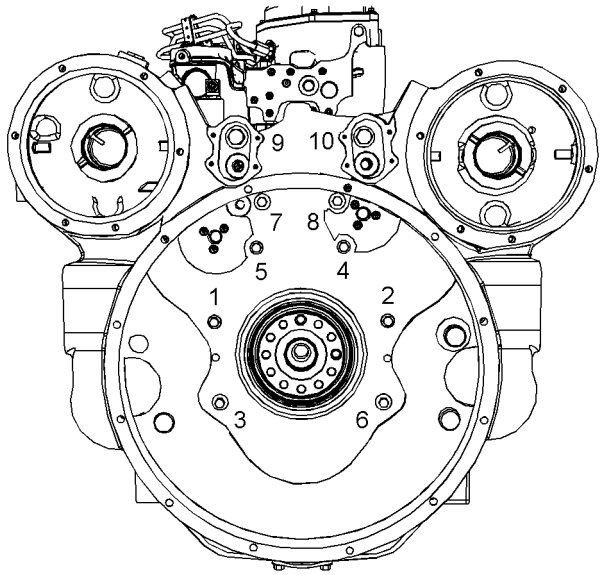


Illustration 272 g02063913

11. Follow Steps 11.a through Step 11.c in order to tighten bolts (8), bolts (9) and bolts (10). Tighten the bolts in the numerical sequence. Refer to Illustration 272.

a. Tighten bolt (10) to a torque of 55 N·m (41 lb ft).

b. Tighten bolt (8) to a torque of 100 N·m (74 lb ft).

c. Tighten bolt (9) to a torque of 240 N·m (177 lb ft).

12. Remove Tooling (A) from the flywheel housing.

13. Check the alignment of the flywheel housing with the crankshaft. Refer to System Operation, Testing and Adjusting, “Flywheel Housing - Inspect” for more information.

14. If necessary, install engine mountings from the flywheel housing. Refer to OEM for the correct procedure.

End By:

a. Install the Rear Power Take-Off (RPTO). Refer to Disassembly and Assembly, “Rear Power Take-Off (RPTO) - Install” for the correct procedure.

b. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install”for the correct procedure.

i04203754

Rear Power Take-Off (RPTO) - Remove

Removal Procedure

Table 47

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

Start By:

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If necessary, remove the OEM equipment from the rear power take-off (RPTO).

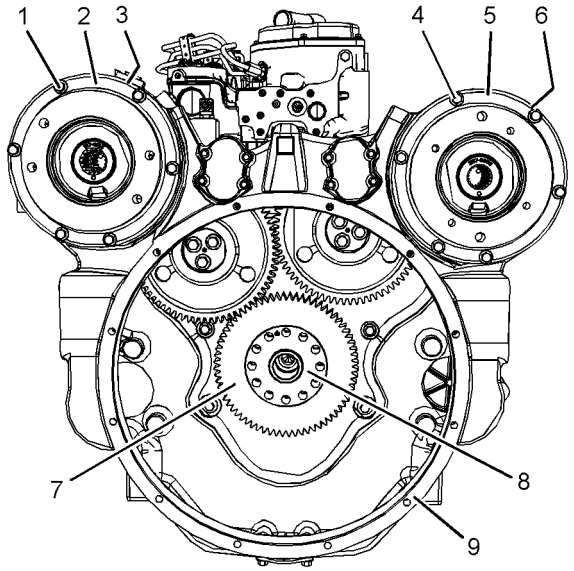


Illustration 273 g02069019

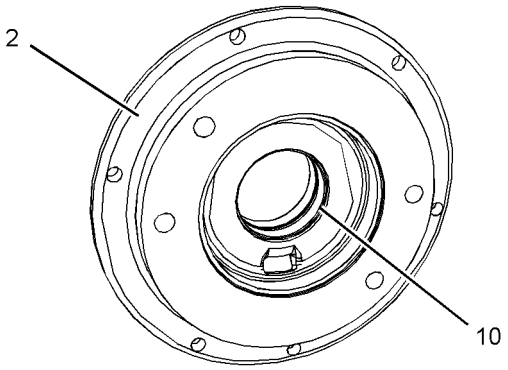


Illustration 274 g02069023

2. Remove bolts (1). Remove adapter (2) from flywheel housing (9). Remove O-ring seal (3) (not shown).

Note: Make a temporary mark on the adapter and the flywheel housing in order to show the correct orientation of the adapter.

3. Remove bolts (4). Remove adapter (5) from flywheel housing (9). Remove O-ring seal (6) (not shown).

Note: Make a temporary mark on the adapter and the flywheel housing in order to show the correct orientation of the adapter.

4. Remove gear (7) from crankshaft (8).

5. If necessary, follow Steps 9.a through Steps 9.c in order to remove the sleeve bearing from the adapter.

a. Place adapter (2) onto suitable support.

b. Use Tooling (A) and a suitable press in order to remove sleeve bearing (10) from adapter (2).

c. Repeat Steps 9.a through Step 9.b in order to remove the sleeve bearing from adapter (5).

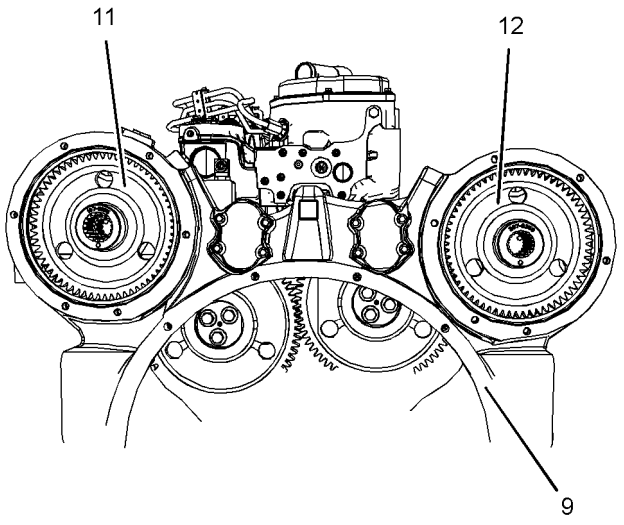


Illustration 275 g02069020

6. Remove gear assembly (11) and gear assembly (12) from flywheel housing (9).

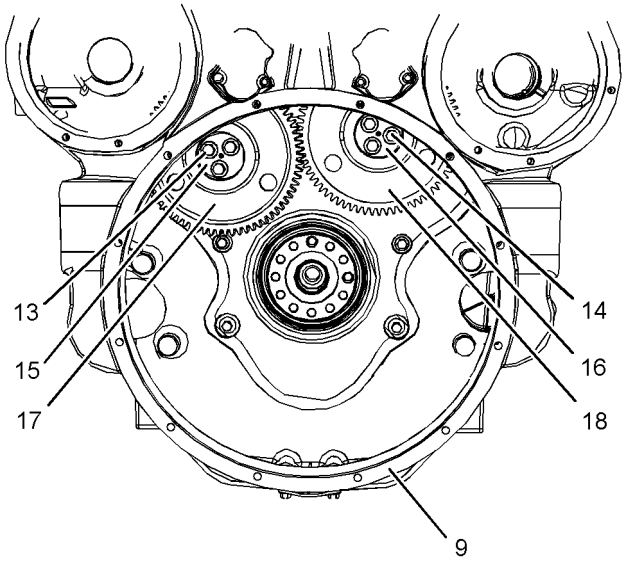


Illustration 276 g02069021

7. Remove bolts (13). Remove gear (17) and idler hub (15) from flywheel housing (9).

8. Remove bolts (14). Remove gear (18) and idler hub (16) from flywheel housing (9).

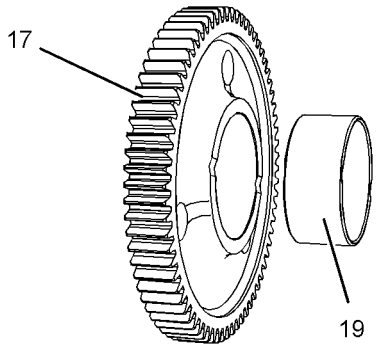


Illustration 277 g02069453

9. If necessary, follow Steps 9.a through Steps 9.c in order to remove the sleeve bearing from the gear.

a. Place gear (17) onto suitable support.

b. Use Tooling (A) and a suitable press in order to remove sleeve bearing (19) from gear (17).

c. Repeat Steps 9.a through Step 9.b in order to remove the sleeve bearing from the remaining gear.

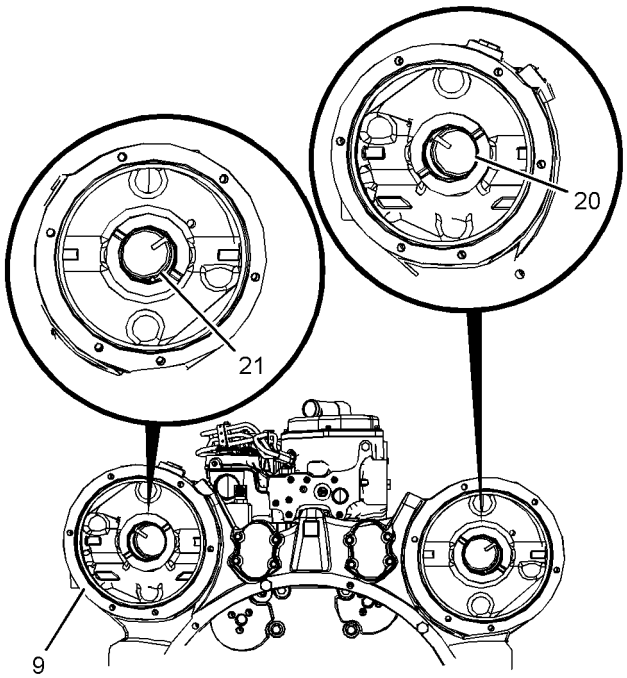


Illustration 278 g02069024

10. If necessary, follow Steps 10.a through Steps 10.b in order to remove the sleeve bearing from the flywheel housing.

a. Use a suitable tool in order to remove sleeve bearing (20) from flywheel housing (9).

b. Repeat Step 10.a in order to remove sleeve bearing (21) from flywheel housing (9).

i04203753

Rear Power Take-Off (RPTO) - Install

Installation Procedure

Table 48

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of the rear power take-off (RPTO) are clean and free from wear and damage.

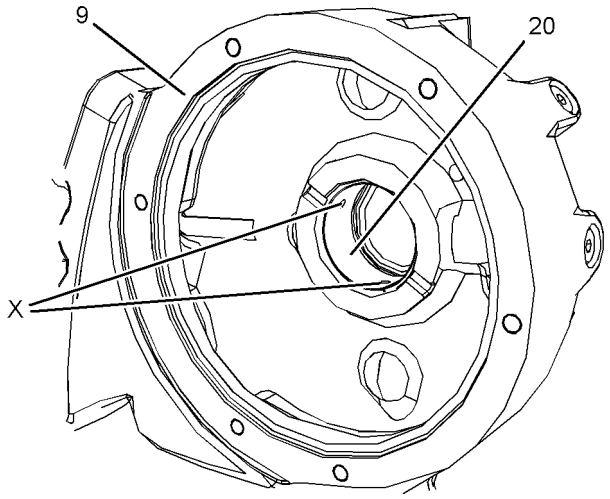


Illustration 279 g02070454

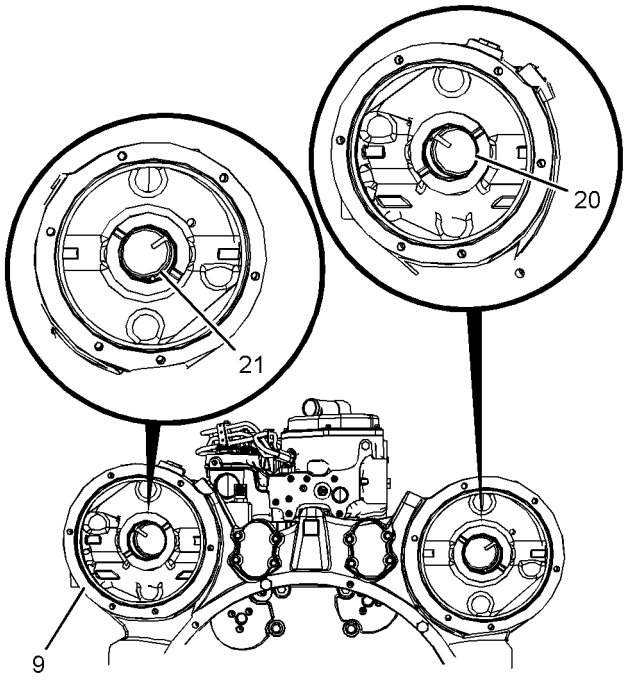


Illustration 280 g02069024

2. If necessary, follow Steps 2.a through Steps 2.c in order to install the sleeve bearing from the flywheel housing.

a. Accurately align oil Holes (X) in sleeve bearing (20) with the oil holes in flywheel housing (9).

b. Use Tooling (A) in order to install sleeve bearing (20) into flywheel housing (9).

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

c. Repeat Step 2.a through Steps 2.c in order to install sleeve bearing (21) to flywheel housing (9).

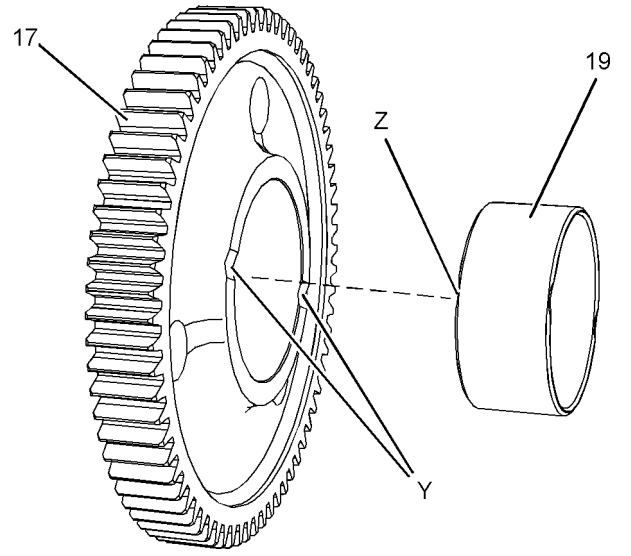


Illustration 281 g02070455

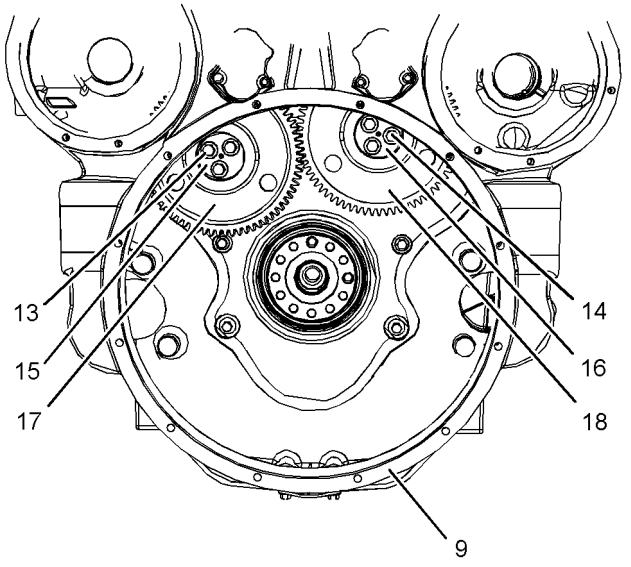


Illustration 282 g02069021

3. If necessary, follow Steps 3.a through Steps 3.d in order to install the sleeve bearing to the gears.

a. Place gear (17) onto suitable support.

b. Accurately align Grooves (Z) in sleeve bearing (20) with Grooves (Y) in gear (17).

c. Use Tooling (A) and a suitable press in order to install sleeve bearing (19) into gear (17).

d. Repeat Steps 3.a through Step 3.c in order to install the sleeve bearing to gear (18).

4. Lubricate idler hub (15) and gear (17) with clean oil. Install idler hub (15) to gear (17).

Note: Ensure that the gear and the idler hub are correctly oriented.

5. Install gear (17) and idler hub (15) assembly to flywheel housing (9).

Note: Ensure that the oil hole in the idler hub is correctly positioned.

6. Install bolts (13) to idler hub (15) and hand tighten bolts.

Note: Ensure that the idler hub is correctly aligned to the flywheel housing.

7. Repeat Steps 4 through Step 6 in order to install gear (18), idler hub (16) and bolts (14) to flywheel housing (9).

8. Tighten bolts (13) and bolts (14) to a torque of 100 N·m (74 lb ft).

9. Ensure that there is tactile backlash between gear (17) and gear (18). Ensure that there is end play between the idler hubs and the gears.

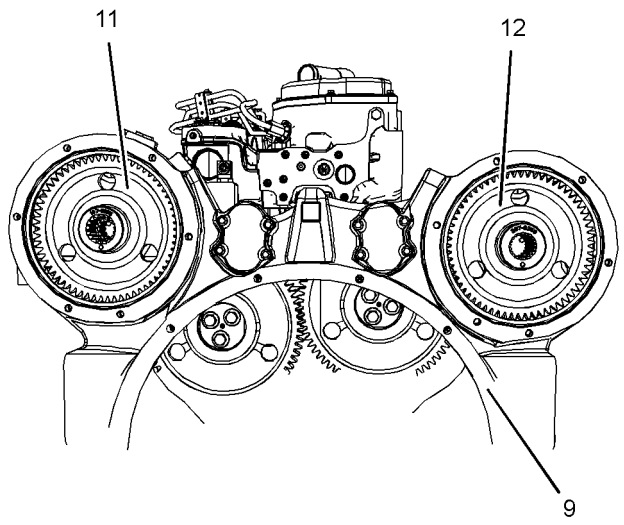


Illustration 283 g02069020

10. install gear assembly (11) and gear assembly (12) to flywheel housing (9).

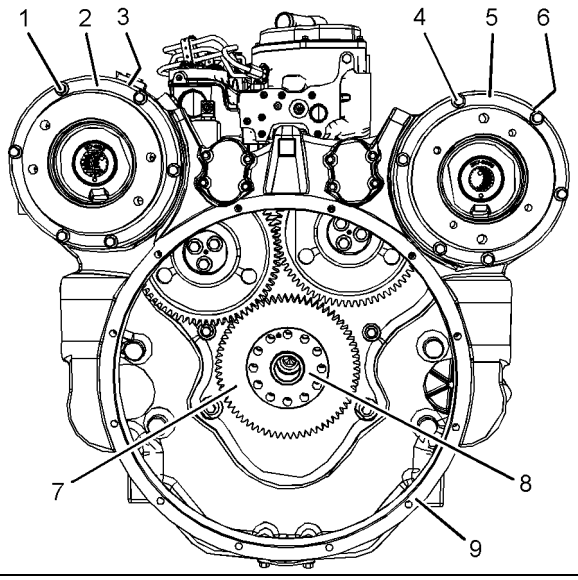


Illustration 284 g02069019

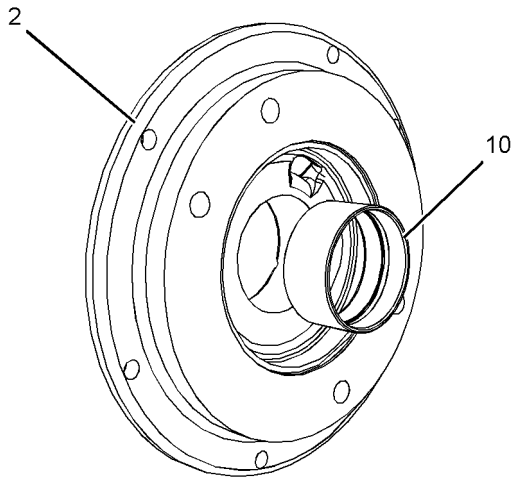


Illustration 285 g02070473

11. If necessary, follow Steps 11.a through Steps 11.c in order to install the sleeve bearing to the adapter.

a. Place adapter (2) onto suitable support.

b. Use Tooling (A) and a suitable press in order to install sleeve bearing (10) into adapter (2).

c. Repeat Steps 11.a through Step 11.b in order to install the sleeve bearing into adapter (5).

12. Install a new O-ring seal (3) (not shown) to adapter (2).

13. Install adapter (2) to flywheel housing (9).

Note: Ensure correct orientation of the adapter.

14. Install bolts (1) and tighten the bolts to a torque of 55 N·m (41 lb ft).

15. Install a new O-ring seal (6) (not shown) to adapter (5).

16. Install adapter (5) to flywheel housing (9).

Note: Ensure correct orientation of the adapter.

17. Install bolts (4) and tighten the bolts to a torque of 55 N·m (41 lb ft).

18. Ensure that there is tactile backlash between the gears. Ensure that there is end play between the gears and the flywheel housing and the adapters.

19. Install gear (7) to crankshaft (8).

20. If necessary, install the OEM equipment to the rear power take-off (RPTO).

End By:

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

i04203791

Vibration Damper and Pulley - Remove

Removal Procedure

Table 49

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M14 x 1.5 by 100 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” for the correct procedure.

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

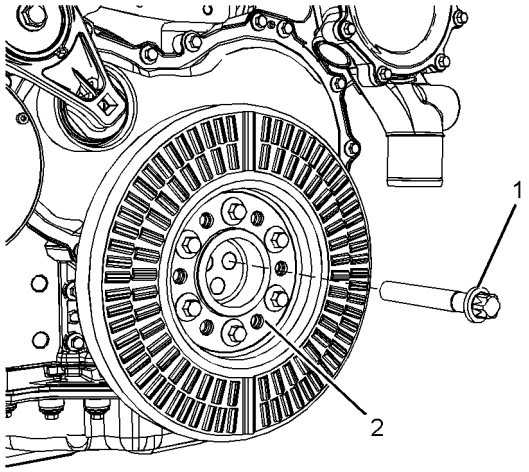


Illustration 286 g02368017

1. Use a suitable tool in order to prevent the crankshaft from rotating. Use Tooling (B) to remove one Torx screws (1) from crankshaft pulley assembly (2).
2. Install Tooling (A) into crankshaft pulley assembly (2).
3. Remove remaining Torx screws (1) from crankshaft pulley assembly (2).
4. Remove crankshaft pulley assembly (2).
5. Tooling (A).

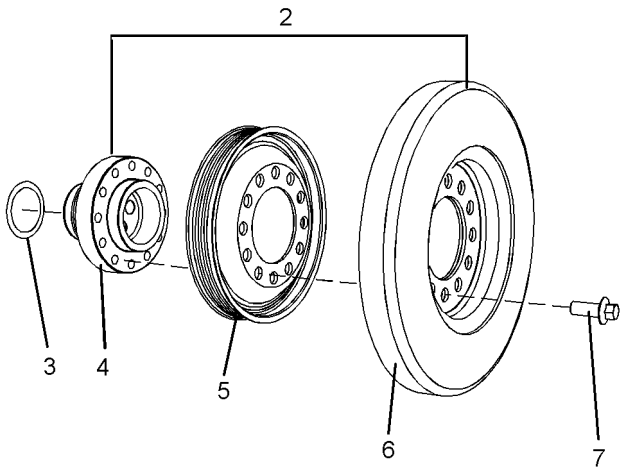


Illustration 287 g02368018

6. If necessary, follow Step 6.a through Step 6.b in order to remove friction shim (3) from the crankshaft.
   a. Remove the front seal from the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.
   b. Remove friction shim (3).
7. If necessary, follow Step 7.a through Step 7.c in order to disassemble vibration damper, crankshaft pulley from crankshaft adapter.
   a. Place the crankshaft pulley assembly onto a suitable support.
   b. Remove bolts (7) from crankshaft pulley assembly (2).
   c. Remove vibration damper (6) and crankshaft pulley (5) from adapter (4).

i04203790

Vibration Damper and Pulley - Install

Installation Procedure

Table 50

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M14 x1.5 by 100 mm	1
B	27610299	E18 Torx Socket	1
C	21825607	Degree Wheel	1
D	-	Guide Stud M12 x1.75 by 50 mm	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

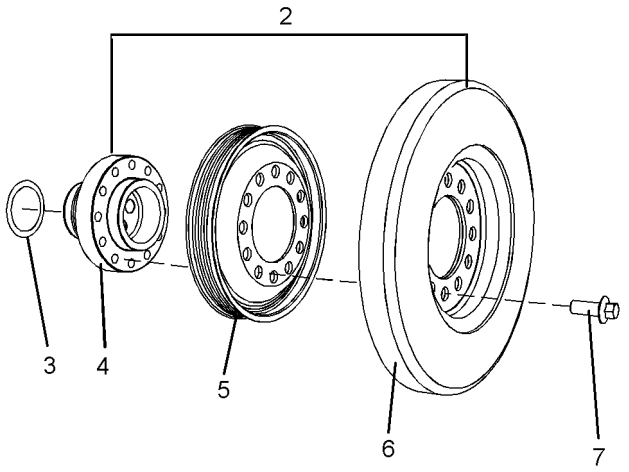


Illustration 288 g02368018

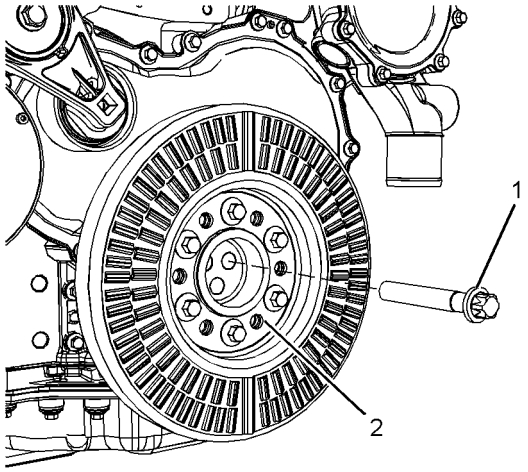


Illustration 289 g02368017

1. Ensure that the crankshaft adapter and the front of the crankshaft are clean and free from damage.
2. Inspect vibration damper (6) for damage. If necessary, replace the vibration damper.
3. If necessary, follow Step 3.a through Step 3.e in order to install vibration damper, crankshaft pulley to crankshaft adapter.
   a. Place crankshaft adapter (4) onto a suitable support.
   b. Install Tooling (D) crankshaft adapter (4).
   c. Install crankshaft pulley (5) and vibration damper (6) over Tooling (D).
   d. Install bolts (7) to the crankshaft pulley assembly.

Note: Evenly space bolts (7) around the crankshaft pulley assembly.

   e. Tighten bolts (7) to a torque of 115 N·m (85 lb ft).

4. If necessary, install friction shim (3). Follow Step 4.a through Step 4.b in order to install friction shim (3).
   a. Install friction shim (3).
   b. Install a new front seal to the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.
5. Install Tooling (A) to the crankshaft.
6. Install crankshaft pulley assembly (2) onto the crankshaft.

Note: Do not lubricate the front seal or the seal face of the crankshaft pulley assembly.

7. Install one Torx screws (1) to crankshaft pulley assembly (2) hand tighten.
8. Remove Tooling (A).
9. Install remaining Torx screws (1) to crankshaft pulley assembly (2).
10. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten Torx screws (1) to a torque of 40 N·m (29 lb ft).
11. Use Tooling (B) and Tooling (C) to turn Torx screws (1) through an additional 120 degrees.

End By:

a. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

i04203661

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 51

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400016	Oil Seal Removal & installer Tool	1

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

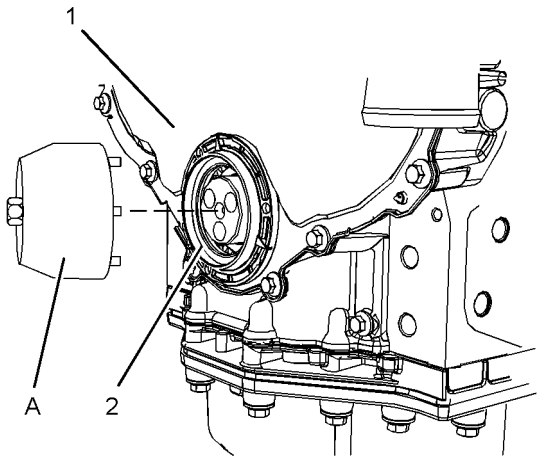


Illustration 290 g01989793

1. Position Tooling (A) onto crankshaft front seal (2).

2. Turn Tooling (A) in a counterclockwise direction and remove crankshaft front seal (2) from front cover (1).

Installation Procedure

Table 52

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400016	Oil Seal Removal & installer Tool	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the front cover is clean and free from damage.

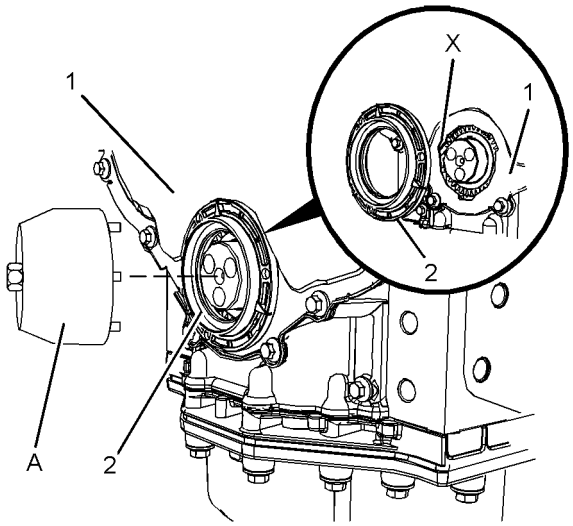


Illustration 291 g01990013

2. Correctly position a new crankshaft front seal (2) in Position (X) onto front cover (1).

3. Position Tooling (A) onto crankshaft front seal (2).

4. Use Tooling (A) in order to turn crankshaft front seal (2) in clockwise direction.

5. If it is necessary, to apply a torque greater than 50 N·m (37 lb ft) in order to install crankshaft front seal (2). Remove crankshaft front seal (2). Inspect the crankshaft front seal and the front cover for faults or damage.

6. If necessary repeat Step 2 through Step 5 in order to install crankshaft front seal (2).

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

i04203660

Crankshaft Front Seal - Remove and Install (Crankshaft Front Seal for Heavy Duty Front Cover)

Removal Procedure

Table 53

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, “Vibration Damper and Pulley - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

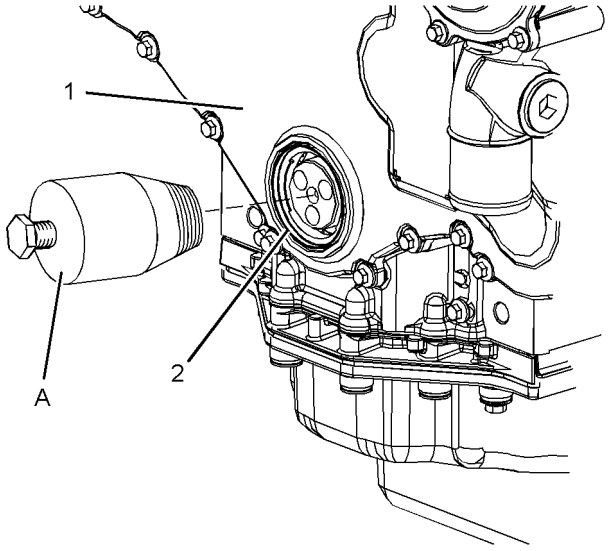


Illustration 292 g02048634

1. Position Tooling (A) on the nose of the crankshaft. Screw Tooling (A) into crankshaft front seal (2).

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

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

Installation Procedure

Table 54

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	21825577	Front Seal Installer	1
	27610284	Seal Installer Tool	1
	21825579	Sleeve	1
	T400029	Plate	1
	27610284	Installer	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

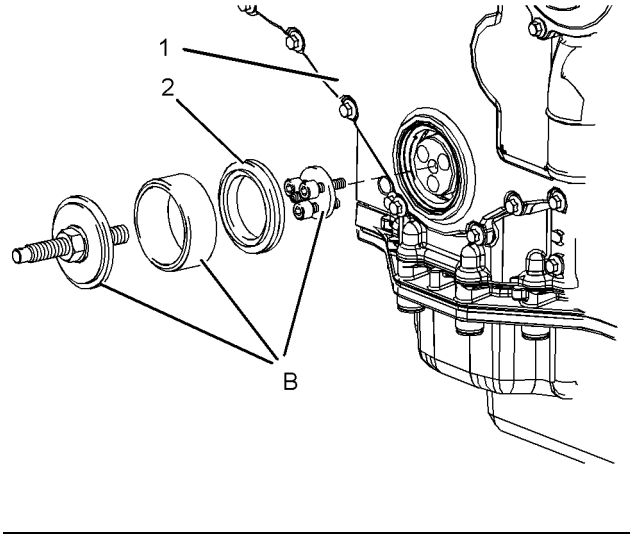


Illustration 293 g02048635

2. Assemble Tooling (B).

3. Correctly position a new crankshaft front seal (2) to front cover (1).

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

4. Use Tooling (B) to install crankshaft front seal (2) to front cover (1). Ensure that the front face of the crankshaft front seal is installed to a depth of 6.5 ± 0.2 mm (0.256 ± 0.008 inch).

5. Remove Tooling (B) from the crankshaft.

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

i04203710

Front Cover - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove” for the correct procedure.

b. If the engine is equipped with a fan, remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

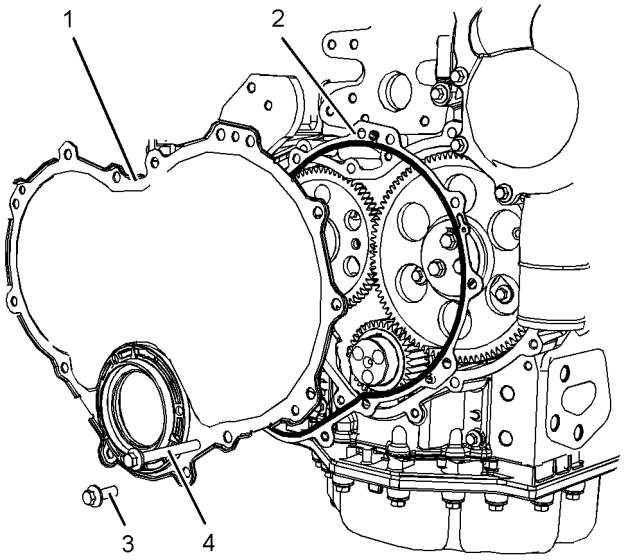


Illustration 294 g01992013

1. Remove the front seal from the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.

2. Remove bolts (3) and bolts (4). Identify the positions of bolts of different length.

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

4. Remove gasket (2) from front cover (1).

Installation Procedure

Table 55

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 70 mm	2
B	T400017	Front Cover Alignment Tool	1

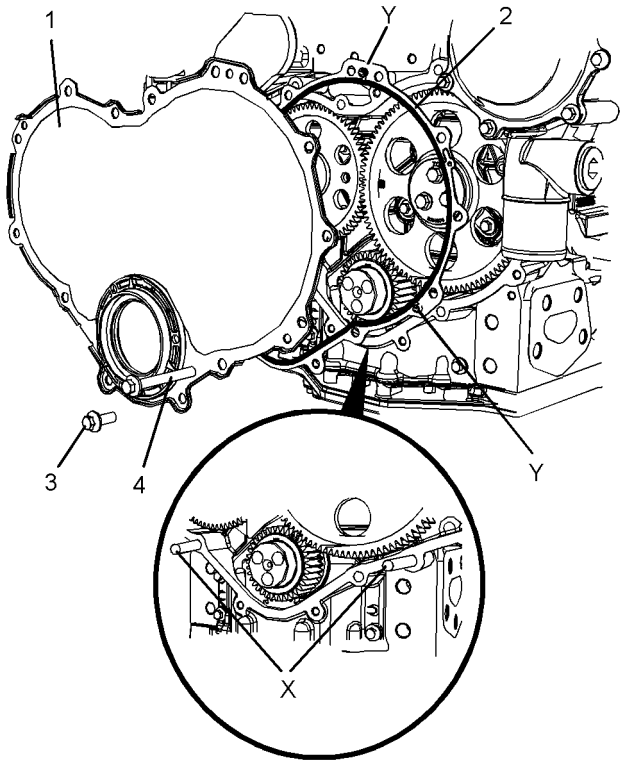


Illustration 295 g02190133

1. Thoroughly clean the gasket surface of the front housing.

2. If the original front cover is installed, follow Step 2.a through Step 2.b.

   a. Thoroughly clean front cover (1).

b. Install a new gasket (2) to front cover (1). Engage Locators (Y) into the holes in the front cover.

3. Install Tooling (A) into Holes (X) in the front housing.

4. Use Tooling (A) in order to position the front cover assembly onto the front housing.

5. Install bolts (3) and bolts (4) finger tight. Ensure that the bolts of different length are installed in the correct positions.

6. Install a new front seal to the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.

7. Use Tooling (B) in order to align the front cover.

8. Remove Tooling (A) and install remaining bolts (4).

9. Tighten bolts (3) and bolts (4) to a torque of 22 N·m (195 lb in).

10. Remove Tooling (B) from the front cover.

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

b. If the engine was equipped with a fan, install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04203709

Front Cover - Remove and Install (Heavy Duty Front Cover)

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove” for the correct procedure.

b. If the engine is equipped with a fan, remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

c. Remove the front seal. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.

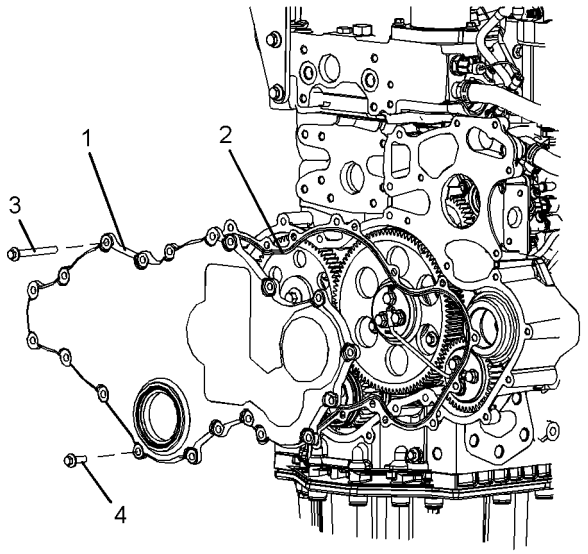


Illustration 296 g02048613

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

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

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

Installation Procedure

Table 56

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 70 mm	2
B	T400018	Front Cover Alignment Tool	1

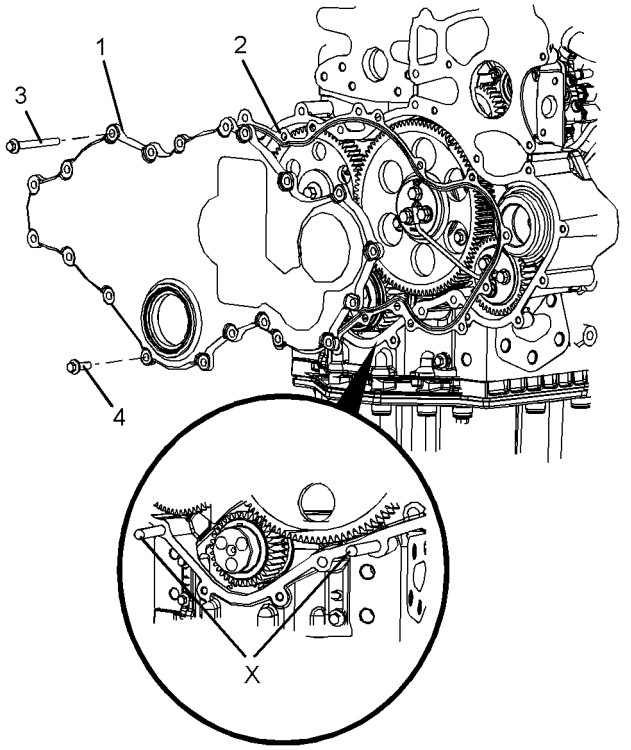


Illustration 297 g02190213

1. Ensure that all components are clean and free from damage. Replace any damaged components.
2. Thoroughly clean the gasket surface of the front housing.
3. Thoroughly clean front cover (1).
4. Install Tooling (A) into Holes (X) in the front housing.
5. Install a new gasket (2) onto Tooling (A).
6. Install front cover (1) onto Tooling (A).
7. Install bolts (3) and bolts (4) finger tight. Ensure that the bolts of different length are installed in the correct positions.
8. Use Tooling (B) to align the front cover assembly.
9. Remove Tooling (A) and install remaining bolts (4).
10. Tighten bolts (3) and bolts (4) to a torque of 22 N·m (195 lb in).
11. Remove Tooling (B).
12. Install a new front seal to the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

b. If the engine was equipped with a fan, install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04203726

Gear Group (Front) - Remove and Install

Removal Procedure

Table 57

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	T40 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

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

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.

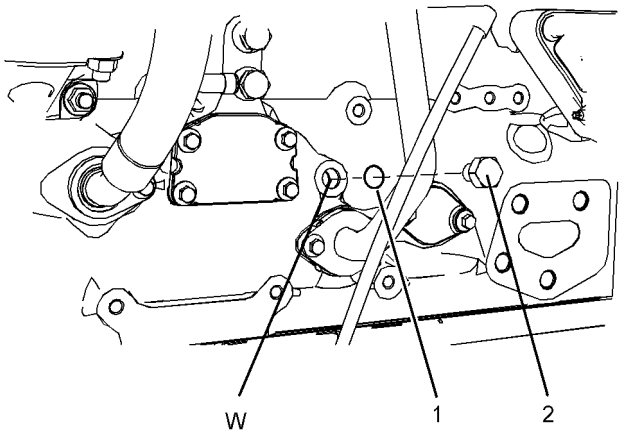


Illustration 298 g01992076

1. Remove plug (2) from the cylinder block. Remove O-ring seal (1) from the plug.

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

3. Install Tooling (D) through Hole (W) in order to lock the crankshaft.

4. Remove Tooling (D).

5. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

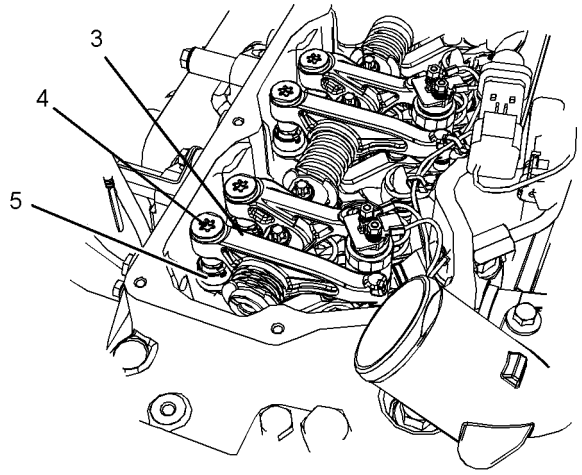


Illustration 299 g01992077

6. Use Tooling (E) in order to loosen threaded inserts (4) on all rocker arms (3). Unscrew threaded inserts (4) on all rocker arms (3) until all valves are fully closed. Ensure that guides (5) for the pushrods are left in position on threaded inserts (4).

Note: Ensure that ALL threaded inserts are fully unscrewed.

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

8. Install Tooling (D) through Hole (W) in order to lock the crankshaft. Refer to Illustration 298.

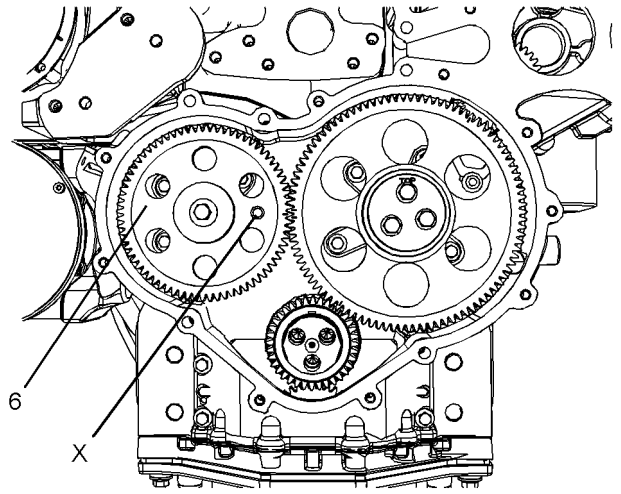


Illustration 300 g01992075

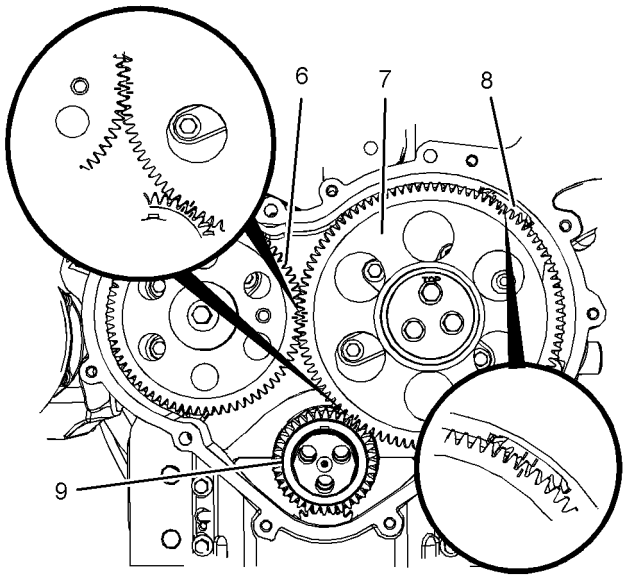


Illustration 301 g01992078

9. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

10. Install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

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

11. Use Tooling (C) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

12. Mark gear (6), gear (7), gear (8) and gear (9) in order to show alignment. Refer to Illustration 301.

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

13. Remove Tooling (B), Tooling (C), and Tooling (D).

14. Remove camshaft gear (6). Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

15. Remove idler gear (7). Refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for the correct procedure.

Installation Procedure

Table 58

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	T40 Torx Socket	1
F	21825496	Indicator Bracket	1
	21825617	Dial Indicator	1
	-	Indicator Contact Point	1
	-	Universal Attachment	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

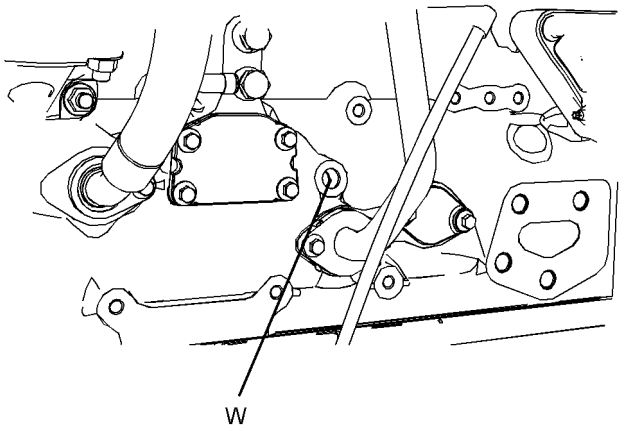


Illustration 302 g02085993

2. If necessary, install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

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

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

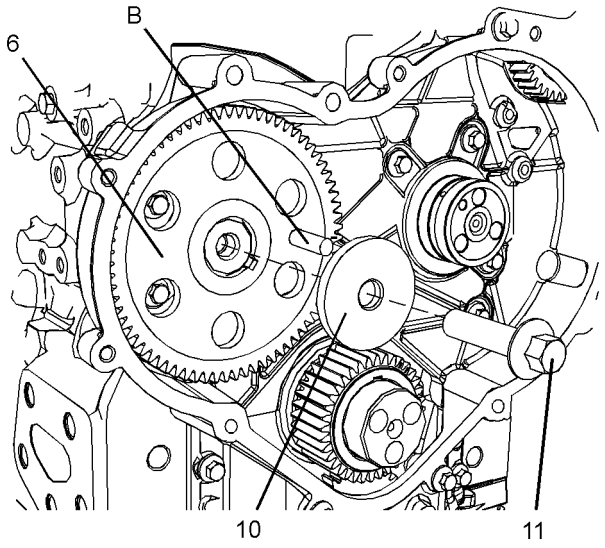


Illustration 303 g01992079

4. Install camshaft gear (6). Loosely install bolt (11) and washer (10) for the camshaft gear. Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

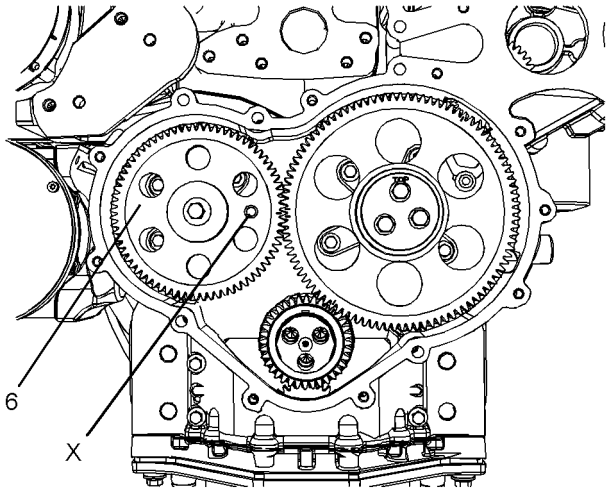


Illustration 304 g01993593

5. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing.

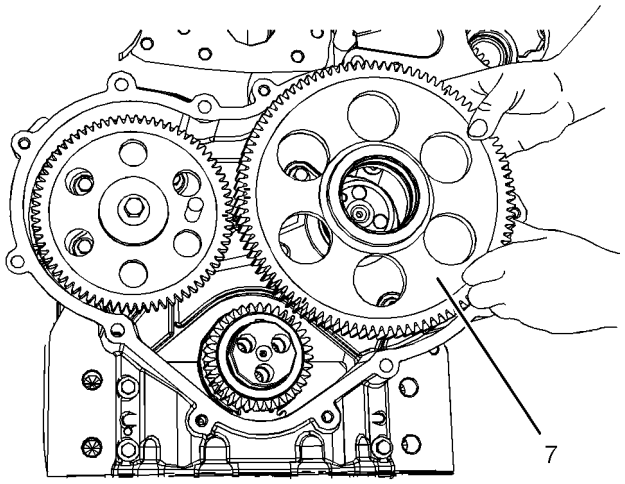


Illustration 305 g01993576

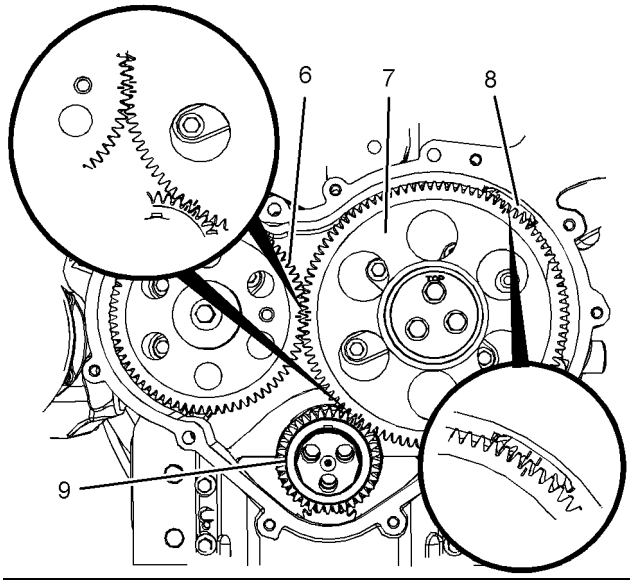


Illustration 306 g01992078

Alignment of timing marks

6. Install idler gear (7). Ensure that the timing marks on gear (6), gear (7), gear (8) and gear (9) are in alignment. Refer to Disassembly and Assembly, “Idler Gear - Remove and Install”. Check the end play of the idler gear. Refer to Specifications, “Gear Group (Front)” and refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for the correct procedure.

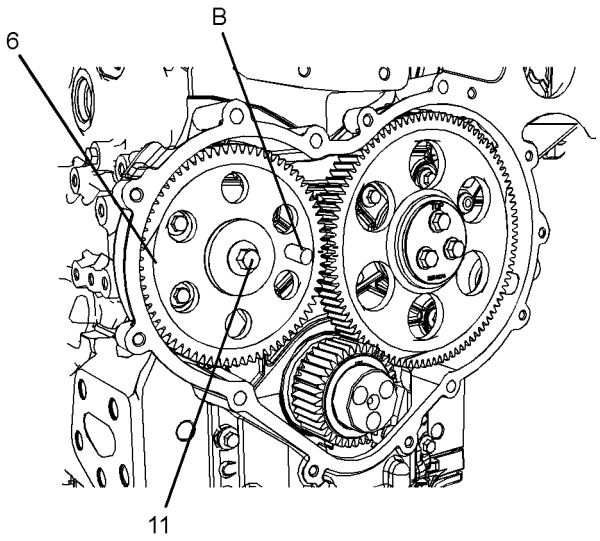


Illustration 307 g02086016

7. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install” for the correct procedure.

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

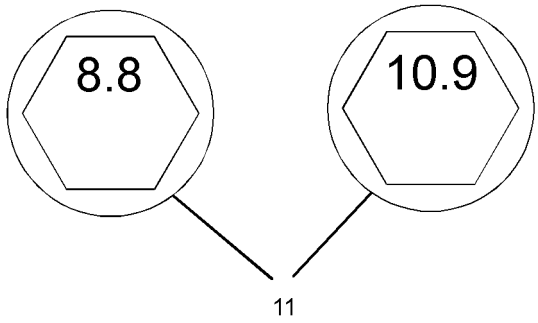


Illustration 308 g02353396

9. When a 8.8 Graded bolt (11) is installed. Tighten the bolt to a torque of 95 N·m (70 lb ft).

When a 10.9 Graded bolt (11) is installed. Tighten the bolt to a torque of 120 N·m (89 lb ft).

10. Check the end play of the camshaft gear. Refer to Specifications, “Camshaft” for more information.

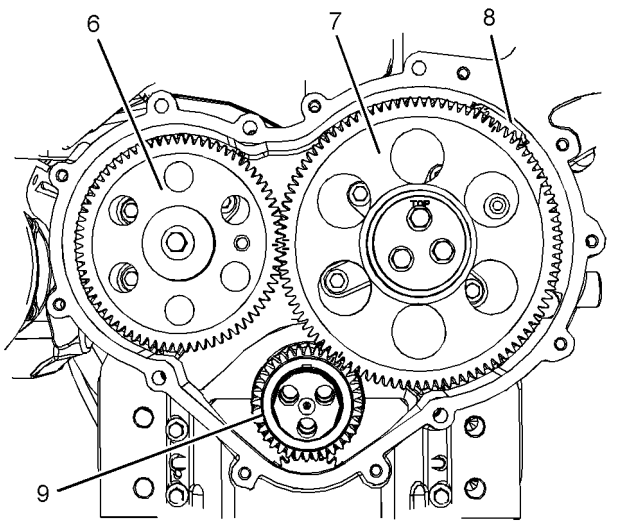


Illustration 309 g02086053

11. Use Tooling (F) in order to measure the backlash for gear (6), gear (7), gear (8) and gear (9). Refer to Specifications, “Gear Group (Front)” for more information.

12. Lubricate each gear with clean lubricating engine oil.

13. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure. If necessary, use Tooling (D) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.

14. Remove Tooling (D).

NOTICE
Failure to ensure that the crankshaft is positioned at 60 degrees after top dead center will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

15. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

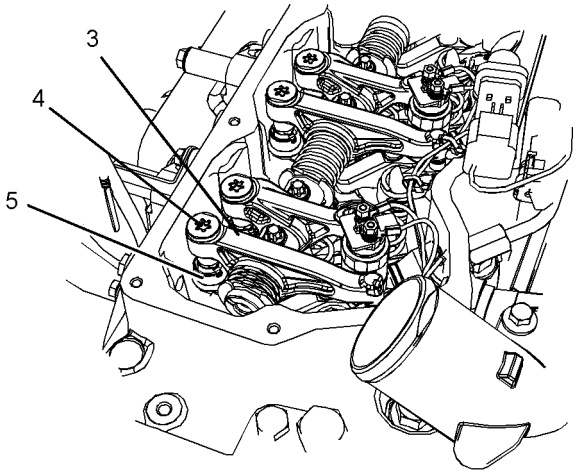


Illustration 310 g01992077

16. Ensure that guides (5) for the pushrods are correctly positioned on threaded inserts (4). Use Tooling (E) in order to tighten threaded inserts (4) on all rocker arms (3). Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly into the cup for the pushrod.

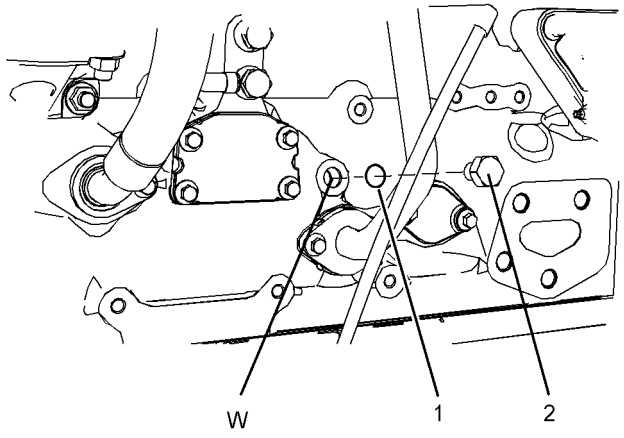


Illustration 311 g01992076

17. Install a new O-ring seal (1) to plug (2). Install the plug into Hole (W) in the cylinder block. Tighten plug (2) to a torque of 21 N·m (186 lb in).

18. The engine should not be operated for a period 30 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force from the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i04203725

Gear Group (Front) - Remove and Install (Heavy Duty Gear Group (Front))

Removal Procedure

Table 59

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1
D	27610286	Timing Pin (Crankshaft)	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

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

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. If the air compressor is equipped with a hydraulic pump, remove the hydraulic pump. Refer to Original Equipment Manufactures (OEM) for the correct procedure.

2. If the engine is equipped, with an air compressor remove the air compressor. Refer to Disassembly and Assembly, “Air Compressor - Remove” for the correct procedure.

3. If the engine is equipped with only a hydraulic pump, remove the hydraulic pump. Refer to the OEM for the correct procedure.

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

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

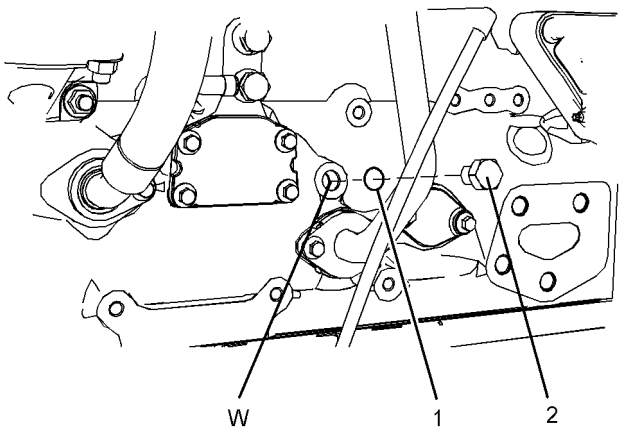


Illustration 312 g02048654

5. Remove plug (2) from the cylinder block. Remove O-ring seal (1) from the plug.

6. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft.

7. Remove Tooling (D).

8. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

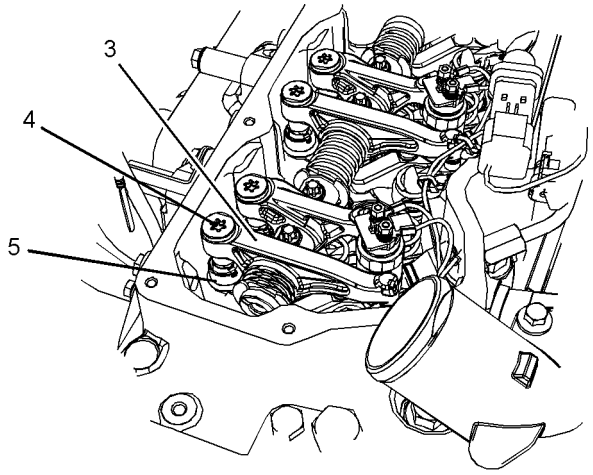


Illustration 313 g02048655

9. Loosen threaded inserts (4) on all rocker arms (3). Unscrew threaded inserts (4) on all rocker arms (3) until all valves are fully closed. Ensure that guides (5) for the pushrods are left in position on threaded inserts (4).

Note: Ensure that ALL threaded inserts are fully unscrewed.

10. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft. Refer to Illustration 312.

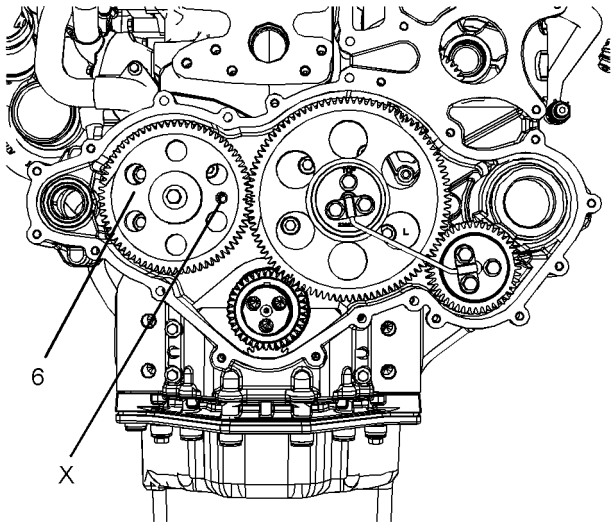


Illustration 314 g02048653

11. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

12. Use Tooling (C) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

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

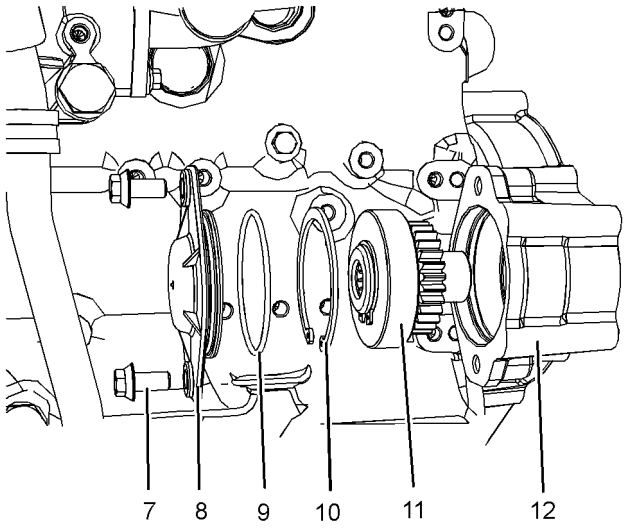


Illustration 315 g02052394

13. If the right-hand side of the engine is equipped, with a hydraulic pump remove the hydraulic pump. Refer to the OEM for the correct procedure.

14. If necessary, remove bolts (7) from plate (8). Remove plate (8) and remove O-ring seal (9).

15. Remove circlip (10) and remove gear assembly (11) from front housing (12).

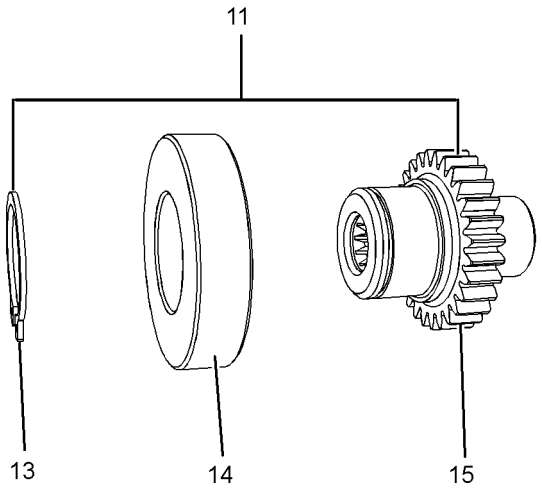


Illustration 316 g02053673

16. If necessary, follow Step 16.a through Step 16.b in order to disassemble gear assembly (11).

a. Remove circlip (13) from gear (15).

b. Place gear assembly (11) on a suitable support. Press bearing (14) from gear (15).

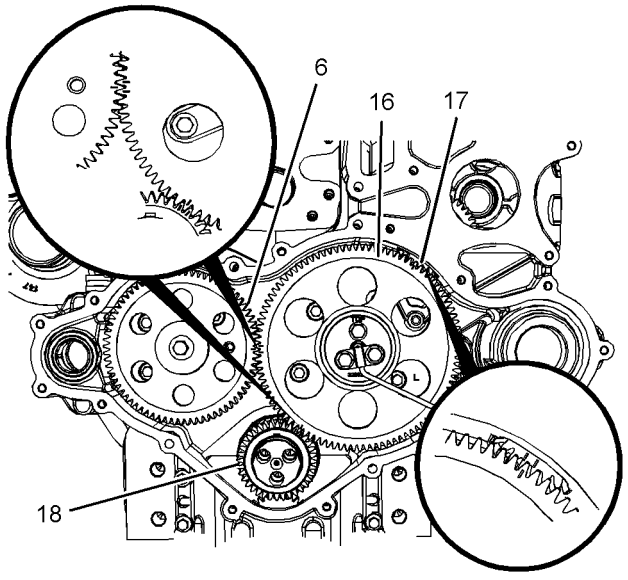


Illustration 317 g02048714

17. Mark gear (6), gear (16), gear (17) and gear (18) in order to show alignment. Refer to Illustration 317.

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

18. Remove camshaft gear (6). Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

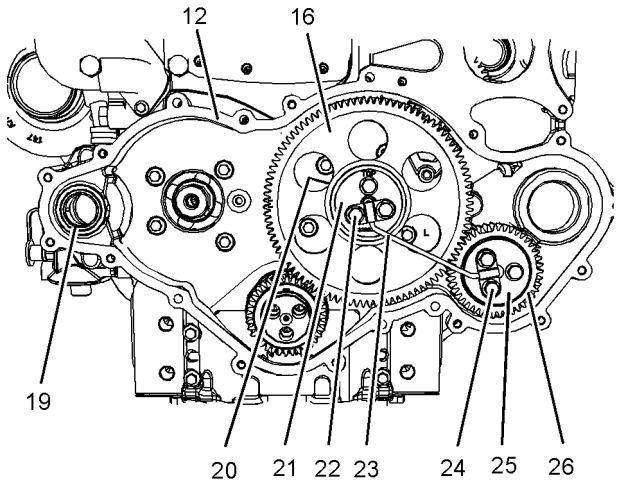


Illustration 318 g02053984

19. Remove bolts (22) and bolts (24).

20. Remove tube assembly (23) from idler gear (16) and idler gear (26).

21. Remove plate (21).

22. Remove idler gear (16) from front housing (12).

23. Remove idler gear (26) and idler gear hub (25) from front housing (12).

24. Remove hub (20) (not shown) from front housing (12).

25. If necessary, remove bearing (19) from front housing (12). Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

Installation Procedure

Table 60

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Fuel Injection Pump Timing Pin	1
D	27610286	Timing Pin (Crankshaft)	1
E	21825496	Indicator Bracket	1
	21825617	Dial Indicator	1
	-	Indicator Contact Point	1
	-	Universal Attachment	1
F	-	Loctite 609 Bearing Mount Compound	1
G	-	Dephi Lockheed Rubber Grease	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

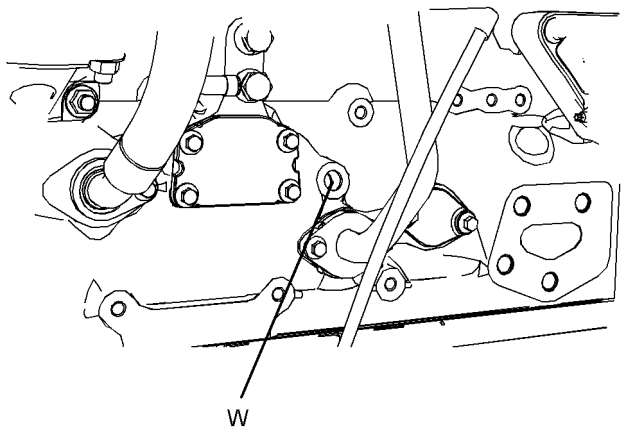


Illustration 319 g02048656

2. If necessary, install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston”.

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

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

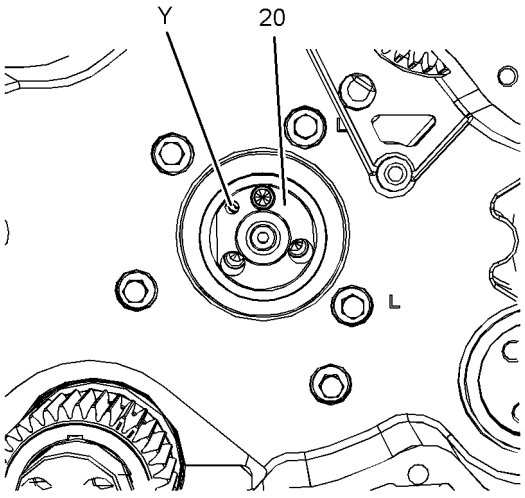


Illustration 320 g02048660

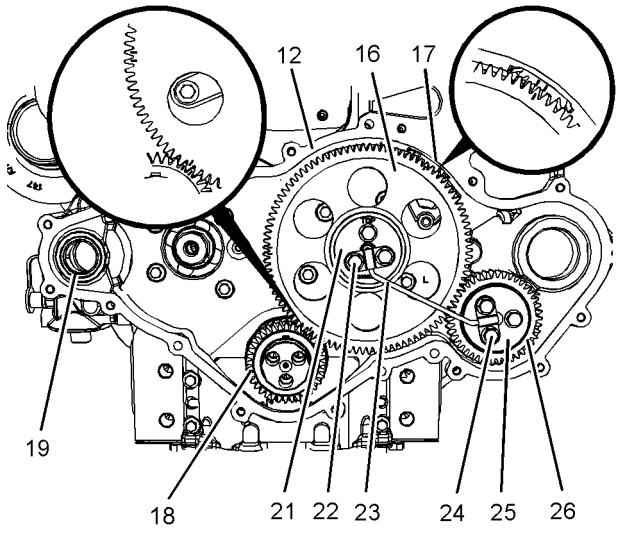


Illustration 321 g02053693

4. If necessary, install bearing (19) to front housing (12). Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

5. Install hub (20) to the recess of front housing (12). Ensure that oil Hole (Y) is to the top of the hub.

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

7. Lubricate idler hub (20) with clean engine lubricating oil. Install idler gear (16) to the idler hub. Ensure that the timing marks are toward the front of the idler gear. Align timing marks on idler gear (16) with gear (17) and gear (18).

8. Lubricate idler gear hub (25) with clean engine lubricating oil and install idler gear (26) to the idler gear hub. Install the assembly for idler gear (26) to front housing (12).

Note: Ensure that the idler gear hub and the idler gear are correctly aligned.

9. Position plate (21) onto idler gear (16).

Note: Ensure that the identification mark TOP is upward.

10. Position tube assembly (23) onto idler gear (16) and idler gear (26). Install bolts (22) and bolts (24).

Note: Ensure that the tube is correctly positioned on the hubs of the idler gears.

11. Tighten bolts (22) and bolts (24) to a torque of 44 N·m (32 lb ft).

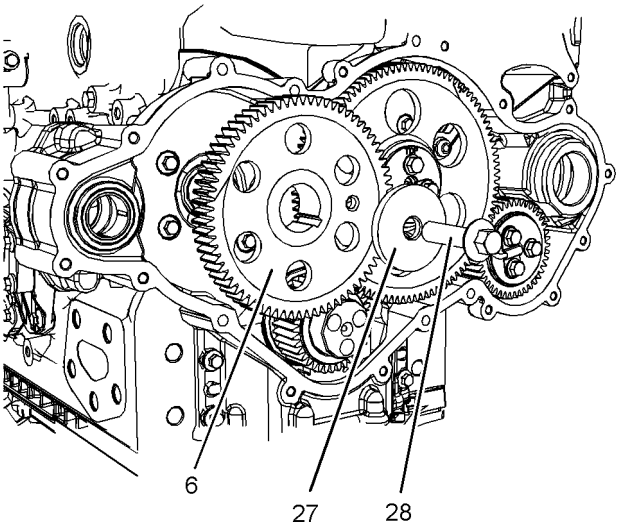


Illustration 322 g02048659

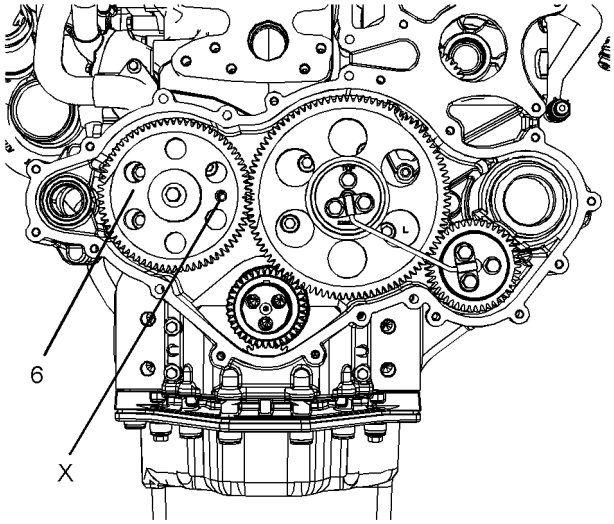


Illustration 323 g02048653

12. Install camshaft gear (6). Loosely install bolt (28) and washer (27) for the camshaft gear. Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

13. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing.

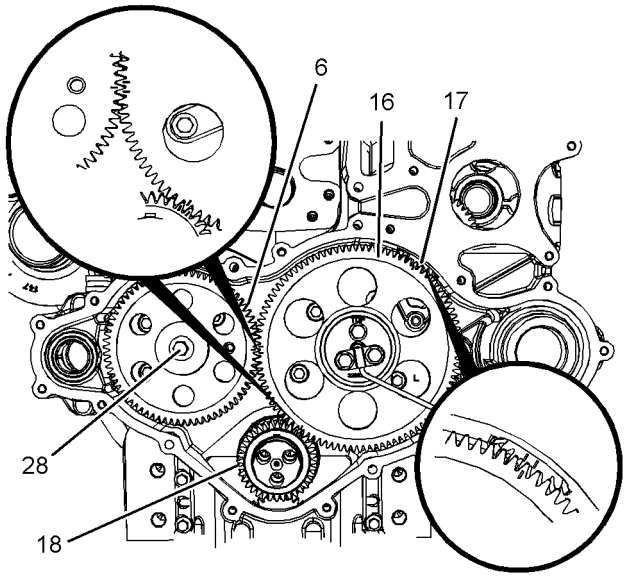


Illustration 324 g02353398

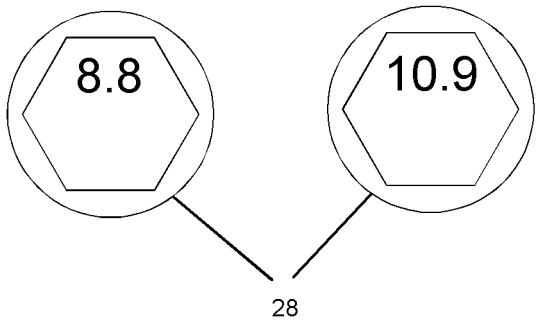


Illustration 325 g02353397

14. Ensure that the timing marks on gear (6), gear (16), gear(17) and gear (18) are in alignment.

15. Remove Tooling (B), Tooling (C), and Tooling (D).

16. When a 8.8 Graded bolt (28) is installed. Tighten the bolt to a torque of 95 N·m (70 lb ft).

When a 10.9 Graded bolt (28) is installed. Tighten the bolt to a torque of 120 N·m (89 lb ft).

17. Use Tooling (E) in order to check the end play of the camshaft gear. Refer to Specifications, “Camshaft” for more information.

18. Use Tooling (E) in order to check the end play of the idler gears. Refer to Specifications, “Gear Group (Front)” and refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for more information.

19. Use Tooling (E) in order to measure the backlash for gear (6), gear (16), gear (17) and gear (18). Refer to Specifications, “Gear Group (Front)” for more information.

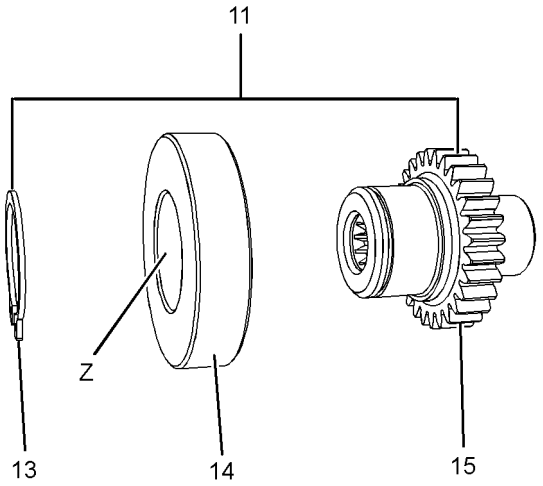


Illustration 326 g02058193

20. If necessary, follow Step 20.a through Step 20.c in order to assemble gear assembly (11).

a. Apply a small continuous bead of Tooling (F) to inner Surface (Z) of bearing (14). Place the inner race of bearing (14) onto a suitable support. Press the shaft of gear (15) into bearing (14) until the shoulder of the gear is against the bearing. Remove any excess bearing mount compound.

b. Install circlip (13) to gear (15).

c. Lightly lubricate bearing (14) and gear (15) with clean engine oil.

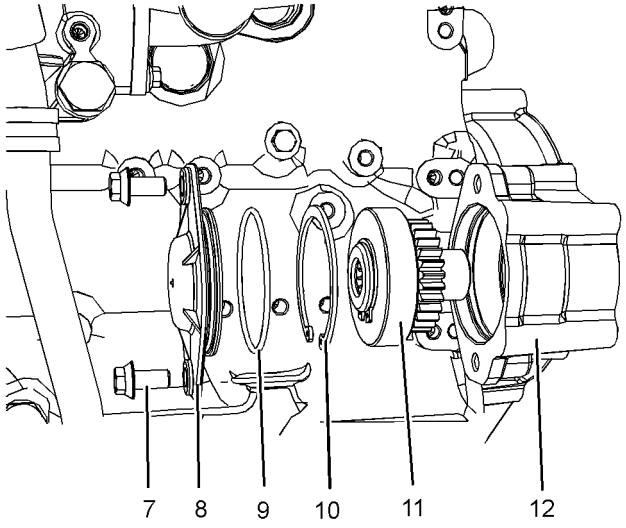


Illustration 327 g02052394

21. Install gear assembly (11) to front housing (12). Ensure that the shaft of gear assembly (11) is correctly aligned with the bearing in front housing (12).

22. Install circlip (10) to front housing (12).

Note: Ensure that the circlip is correctly located in the front housing.

23. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

24. If the right-hand side of the engine is equipped, with a hydraulic pump install the hydraulic pump. Refer to the OEM for the correct procedure.

25. Lightly lubricate a new O-ring seal (9) with Tooling (G). Install new O-ring seal (9) to plate (8). Install plate (8) to front housing (12).

26. Install bolts (7) to plate (8). Tighten the bolts to a torque of 16 N·m (142 lb in).

27. Lubricate each gear with clean engine oil.

NOTICE
Failure to ensure that the crankshaft is positioned at 60 degrees after top dead center will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

28. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

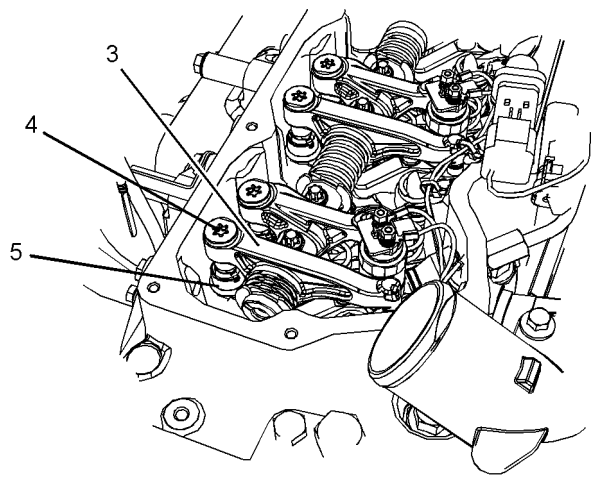


Illustration 328 g02048655

29. Ensure that guides (5) for the pushrods are correctly positioned on threaded inserts (4). Tighten threaded inserts (4) on all rocker arms (3). Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly into the cup for the pushrod.

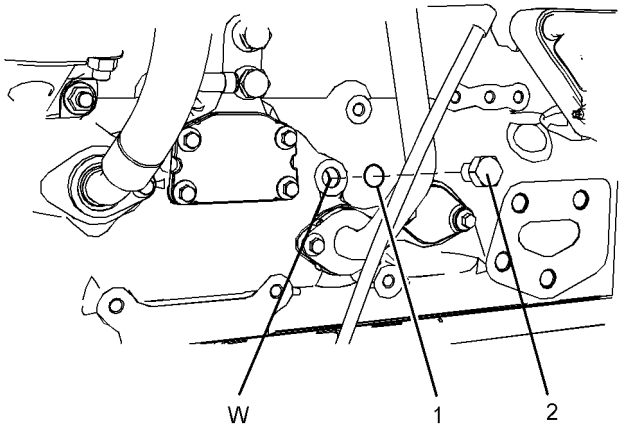


Illustration 329 g02048654

30. Install a new O-ring seal (1) to plug (2). Install the plug into Hole (W) in the cylinder block. Tighten plug (2) to a torque of 21 N·m (186 lb in).

31. If the engine is equipped, with an air compressor install the air compressor. Refer to Disassembly and Assembly, “Air Compressor - Install” for the correct procedure.

32. If the air compressor is equipped with a hydraulic pump, install the hydraulic pump. Refer to the OEM for the correct procedure.

33. If the engine is equipped only with a hydraulic pump, install the hydraulic pump. Refer to the OEM for the correct procedure.

34. The engine should not be operated for a period 30 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force from the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i04203736

Idler Gear - Remove

Removal Procedure

Table 61

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400015	Fuel Injection Pump Timing Pin	1
B	27610212	Timing Pin (Camshaft)	1
C	27610286	Timing Pin (Crankshaft)	1
D	-	T40 Torx Socket	1

Start By:

a. Remove the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

b. Remove the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the idler 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.

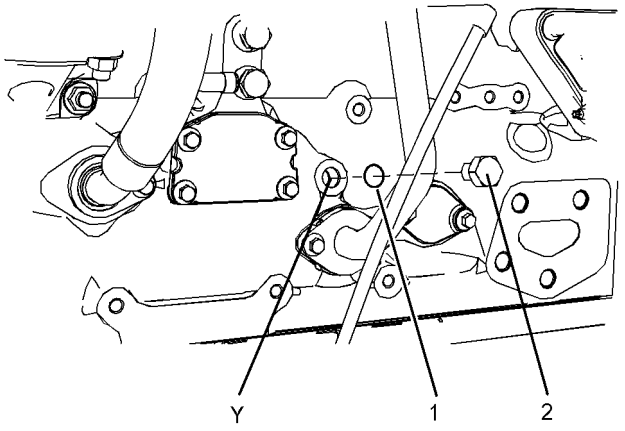


Illustration 330 g01994555

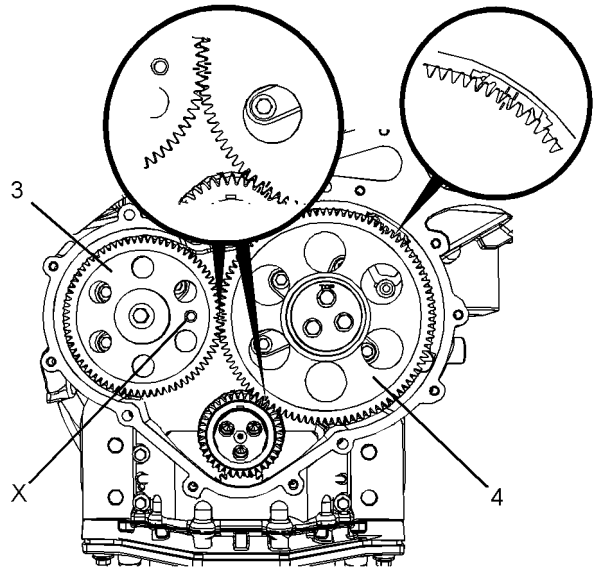


Illustration 331 g01994553

1. Rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.
2. Remove plug (2) from the cylinder block and remove O-ring seal (1) from the plug.
3. 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.
4. Ensure that Tooling (B) is installed into Hole (X) in camshaft gear (3). Use Tooling (B) 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 331.

5. Use Tooling (A) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

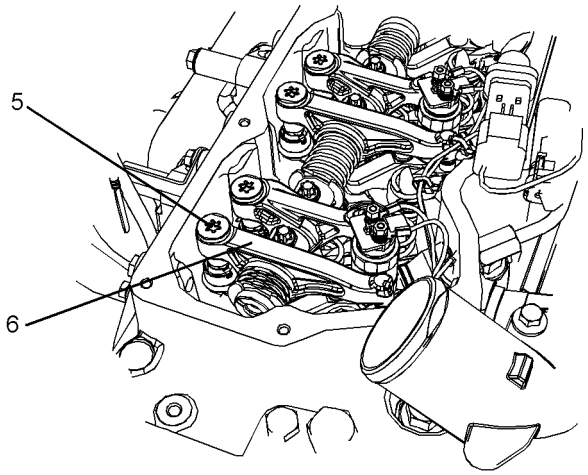


Illustration 332 g01994556

6. Use Tooling (D) in order to loosen threaded inserts (5) on all rocker arms (6). Unscrew threaded inserts (5) on all rocker arms (6) until all valves are fully closed.

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

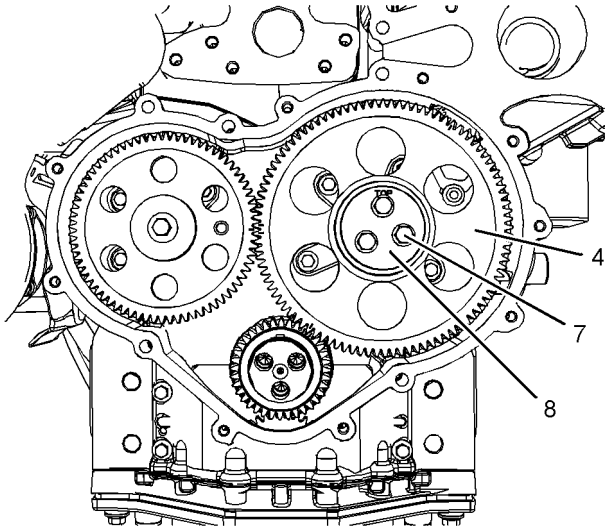


Illustration 333 g01994576

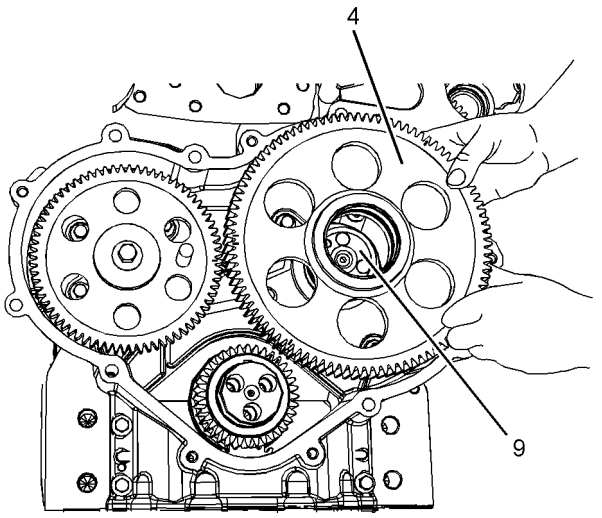


Illustration 334 g01994557

7. Mark plate (8) in order to show orientation.

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

8. Remove bolts (7).

9. Remove plate (8).

10. Remove the assembly of idler gear (4).

11. Remove hub (9) from the recess in the front housing.

i04203735

Idler Gear - Install

Installation Procedure

Table 62

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400015	Fuel Injection Pump Timing Pin	1
B	27610212	Timing Pin (Camshaft)	1
C	27610286	Timing Pin (Crankshaft)	1
D	-	T40 Torx Socket	1
E	21835496	Indicator Bracket	1
	21825617	Dial Indicator	1
	-	Indicator Contact Point	1
	-	Universal Attachment	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

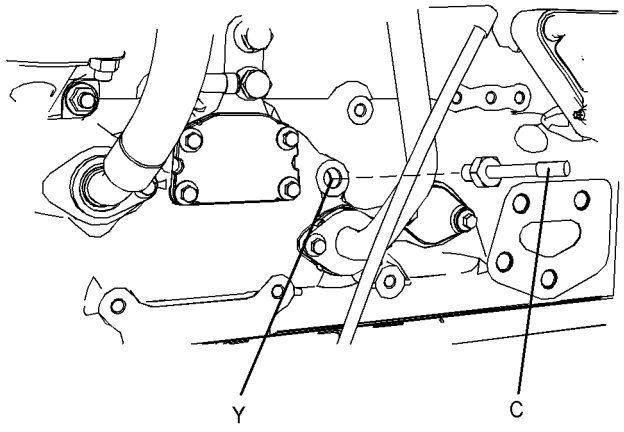


Illustration 335 g01996476

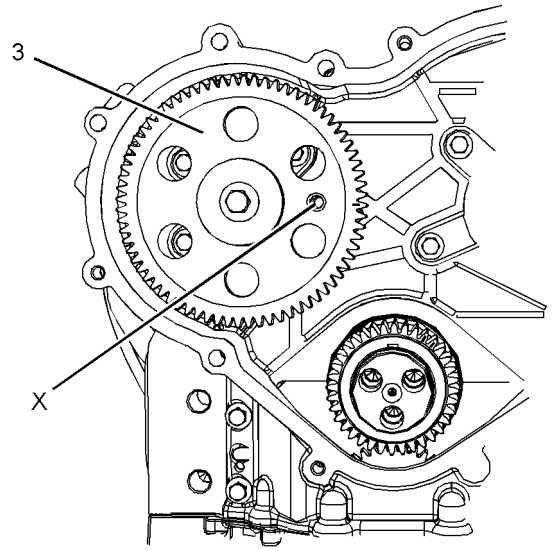


Illustration 336 g01996475

1. Ensure that Tooling (C) is installed in Hole (Y) in the cylinder block. Use Tooling (C) in order to lock the crankshaft in the correct Position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

2. Ensure that Tooling (B) is installed into Hole (X) in camshaft gear (3).

3. Use Tooling (A) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

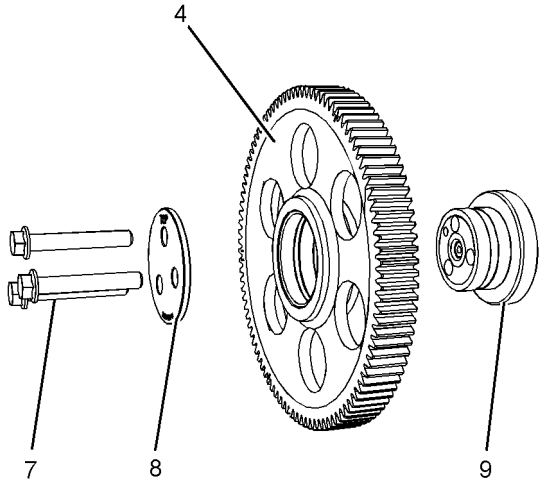


Illustration 337 g01996477

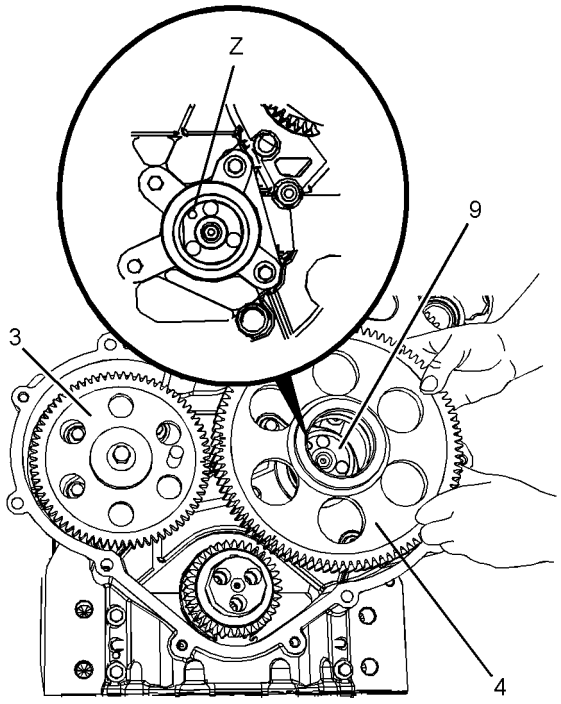


Illustration 338 g02196594

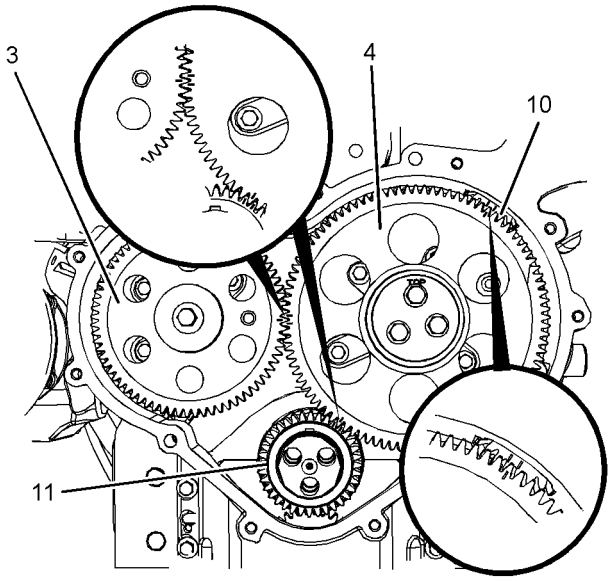


Illustration 339 g01996576

4. Clean idler gear (4) and inspect the idler gear for wear and damage. Refer to Specifications, “Gear Group (Front)” for more information. If necessary, replace the idler gear.

5. Clean hub (9) and inspect the hub for wear and damage. Refer to Specifications, “Gear Group (Front)” for more information. If necessary, replace the hub.

6. Lubricate hub (9) with clean engine oil. Install hub (9) into the recess in the front housing. Ensure that oil Hole (Z) is position as shown in the Illustration 338.

7. Install idler gear (4) onto hub (9). Ensure that the timing marks are toward the front of the idler gear.

8. Align the timing mark on idler gear (4) with the timing mark on camshaft gear (3), fuel injection pump gear (10) and crankshaft gear (11). Refer to the Illustration 339. Install the assembly of idler gear (4) to hub (9).

9. Clean plate (8) and inspect the plate for wear and damage. If necessary, replace the plate.

10. Lubricate plate (8) with clean engine oil. Align the holes in plate (8) with the holes in hub (9). Install the plate in the original orientation.

Note: Ensure that the identification mark TOP is upward.

11. Install bolts (7). Tighten the bolts to a torque of 44 N·m (32 lb ft).

12. Remove Tooling (A), Tooling (B), and Tooling (C).

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

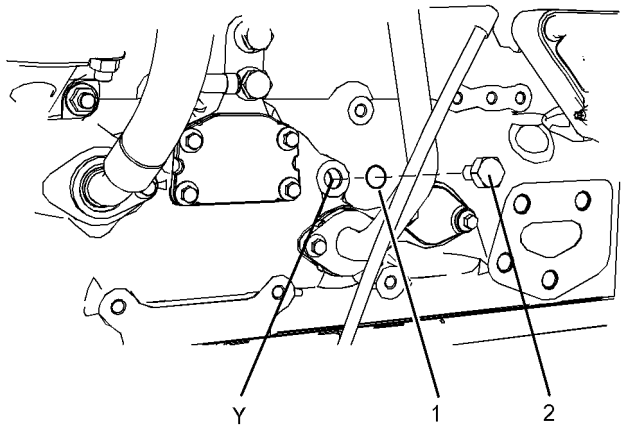


Illustration 340 g01996554

13. Position a new O-ring seal (1) onto plug (2). Install the plug to the cylinder block and tighten the plug to a torque of 21 N·m (186 lb in).

14. Use Tooling (E) in order to check the end play for the idler gear. Refer to Specifications, “Gear Group (Front)” for more information.

15. Use Tooling (E) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, “Gear Group (Front)” for more information.

16. Use Tooling (E) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, “Gear Group (Front)” for more information.

17. Use Tooling (E) in order to check the backlash between the idler gear and the fuel injection pump gear. Refer to Specifications, “Gear Group (Front)” for more information.

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

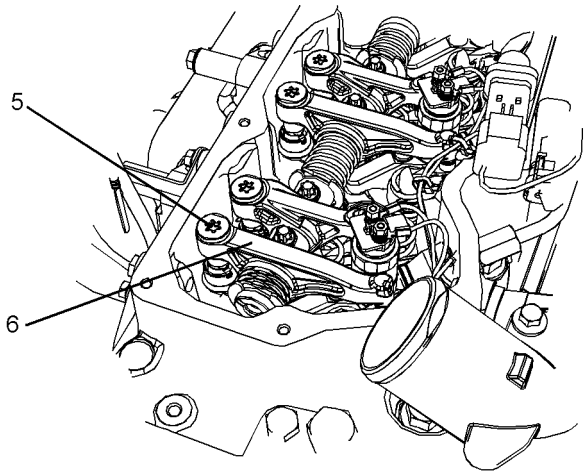


Illustration 341 g01994556

19. Rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

20. Use Tooling (D) in order to tighten threaded inserts (4) on all rocker arms (5). Tighten the threaded inserts to a torque of 30 N·m (266 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly into the cup for the pushrod.

21. The engine should not be operated for a period 30 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force from the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i04203734

Housing (Front) - Remove

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

b. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove” for the correct procedure.

c. Remove the engine oil pan plate. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove” for the correct procedure.

d. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.

e. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove” for the correct procedure.

f. Remove the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Remove and Install” for the correct procedure.

g. Remove the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” 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.

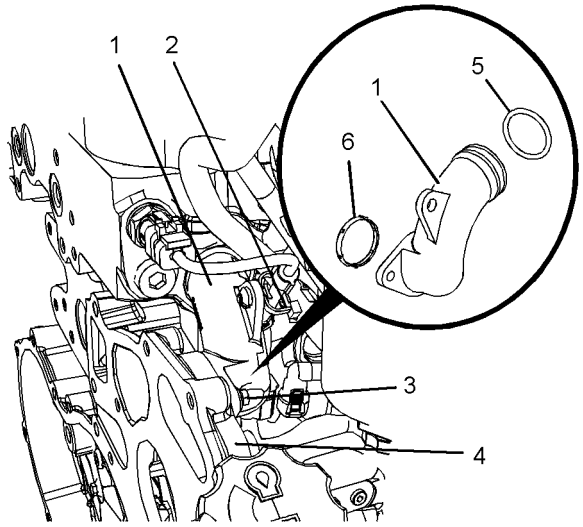


Illustration 342 g02198874

1. Cut cable strap (2) from wiring harness assembly.

2. Remove bolts (3) that secure bypass tube (1) to front housing (4).

3. Remove bypass tube (1) from the cylinder head. Remove O-ring (5) and O-ring (6) from bypass tube (1).

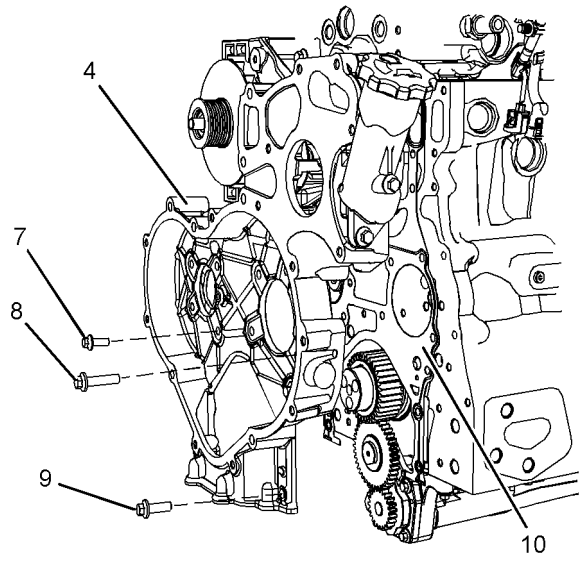


Illustration 343 g02198875

4. Remove bolts (7), bolts (8) and bolts (9) from front housing (4).

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

5. Remove front housing (4) from the cylinder block.

6. Remove gasket (10).

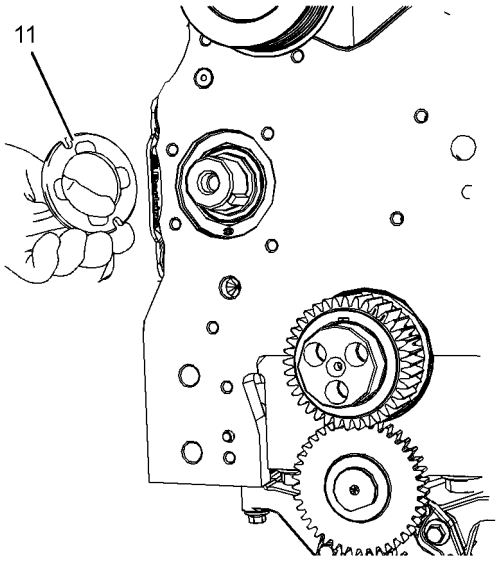


Illustration 344 g02198876

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

i04203733

Housing (Front) - Remove (Heavy Duty Housing (Front))

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

b. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Remove” for the correct procedure.

c. Remove the engine oil pan plate. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove” for the correct procedure.

d. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.

e. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove” for the correct procedure.

f. Remove the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Remove and Install” for the correct procedure.

g. Remove the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” 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.

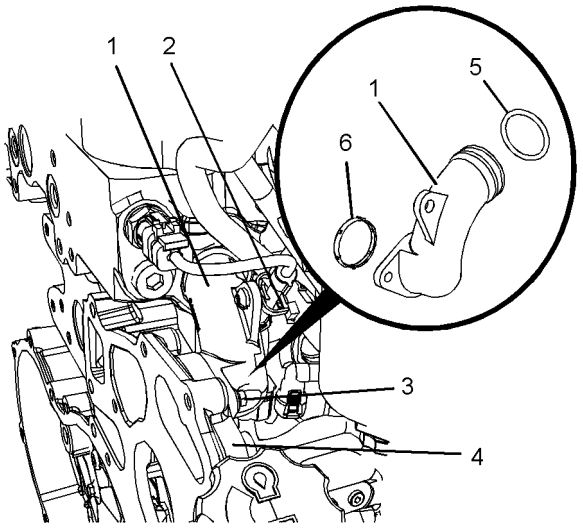


Illustration 345 g02198874

1. Cut cable strap (2) from wiring harness assembly.
2. Remove bolts (3) that secure bypass tube (1) to front housing (4).
3. Remove bypass tube (1) from the cylinder head. Remove O-ring (5) and O-ring (6) from bypass tube (1).

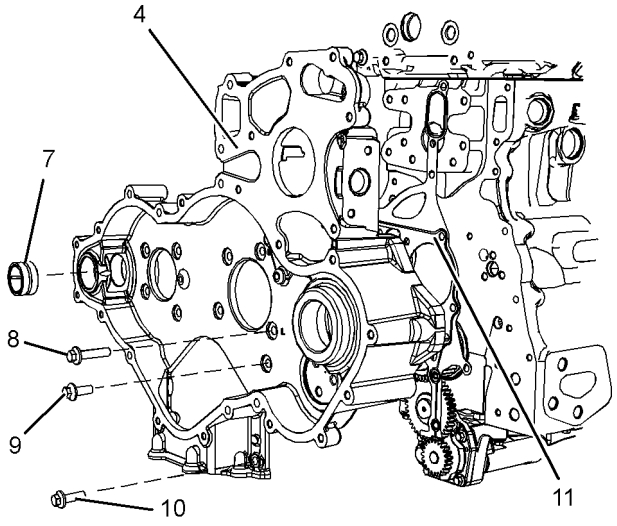


Illustration 346 g02201095

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

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

5. Remove front housing (4) from the cylinder block.
6. Remove gasket (11).
7. If necessary, follow Step 7.a through Step 7.b in order to remove bearing (7) from housing (3).
   a. Place housing (4) onto a suitable support.
   b. Use a suitable tool in order to press bearing (7) out of housing (4).

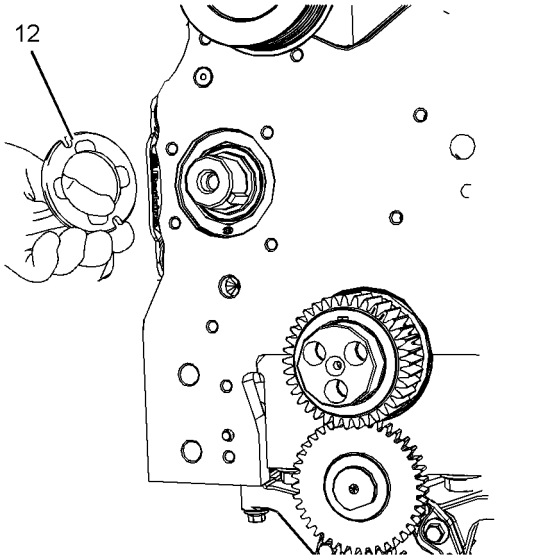


Illustration 347 g02201096

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

i04203731

Housing (Front) - Install

Installation Procedure

Table 63

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 575 Sealant	1
B	-	Guide Bolt M8 by 40 mm	2
C	27610216	Alignment Tool	1
	-	Bolts M10 by 50 mm	3
D	-	Dephi Lockheed Rubber Grease	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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

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

2. Clean all the gasket surfaces of the cylinder block.

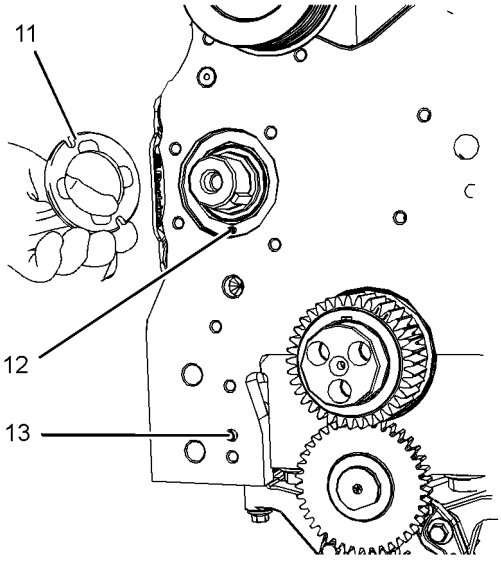


Illustration 348 g02198913

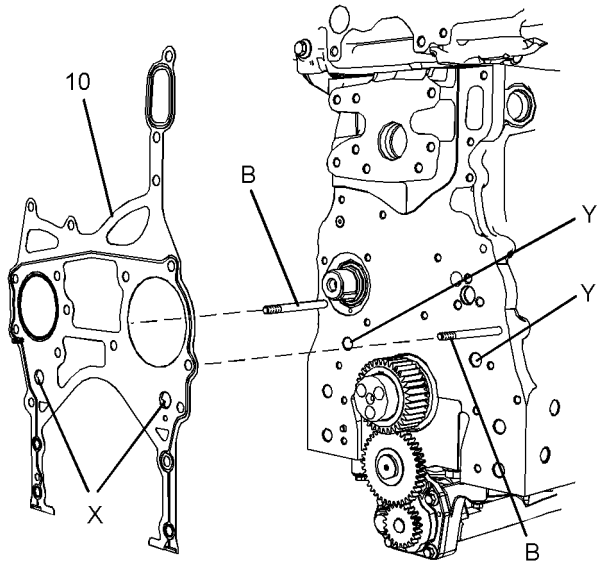


Illustration 349 g02198914

3. Inspect dowel (12) and dowel (13) for damage. If necessary, replace the dowels in the cylinder block.

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

5. Install Tooling (B) to the cylinder block. Refer to Illustration 349.

6. Align a new gasket (10) with Tooling (B). Install the gasket to the cylinder block.

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in the cylinder block. Ensure that dowel (12) in the cylinder block is engaged on the gasket.

7. Install Tooling (C) to the cylinder block.

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

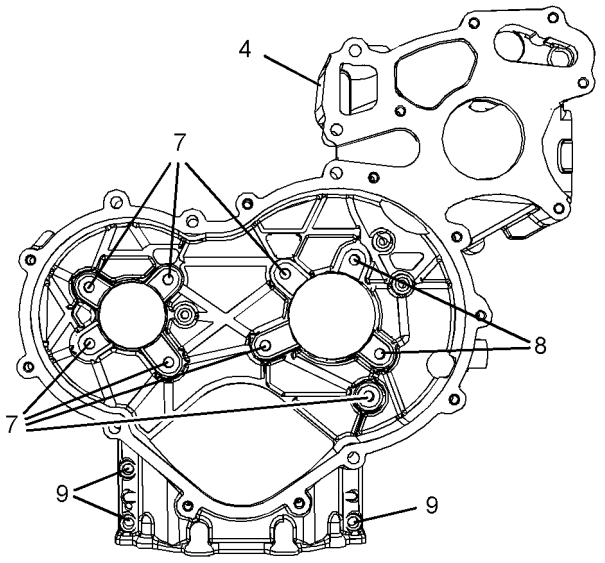


Illustration 350 g02198915

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

9. Install new bolts (9) to front housing (4) hand tight.

10. Remove Tooling (B).

11. Loosely install bolts (7) and bolts (8) finger tight. Refer to Illustration 350 for the correct position of the bolts.

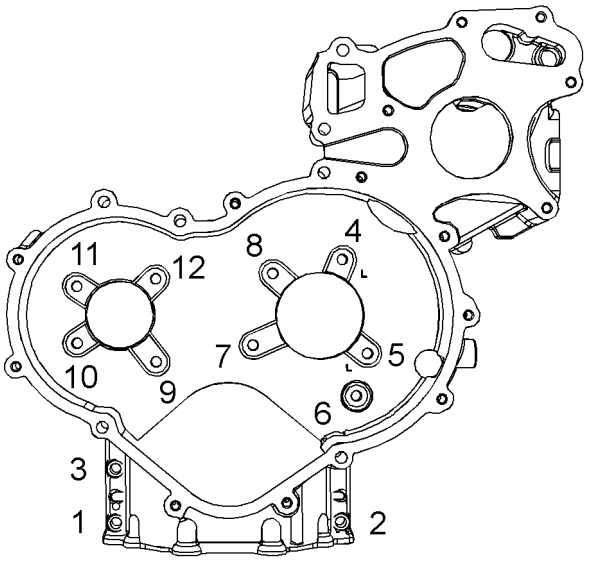


Illustration 351 g01998054

12. Tighten bolts (7), bolts (8) and bolts (9) in the sequence that is shown in Illustration 351 to a torque of 28 N·m (248 lb in).

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

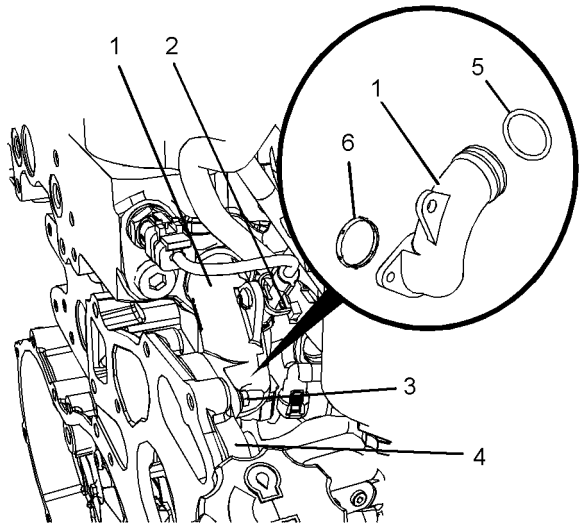


Illustration 352 g02198874

14. Install new O-ring seal (5) and O-ring seal (6) to bypass tube (1). Use Tooling (D) in order to lubricate the O-ring seals.

15. Install bypass tube (1) to the cylinder head. Install bolts (3). Tighten the bolts to a torque of 9 N·m (80 lb in)

16. Install a new cable strap (2) to the wiring harness assembly.

End By:

a. Install the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install” for the correct procedure.

b. Install the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Install” for the correct procedure.

c. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.

d. Install the engine oil pan plate. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove” for the correct procedure.

e. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

f. Install the water pump. Refer to Disassembly and Assembly, “Water Pump - Install” for the correct procedure.

g. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

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

i04203730

Housing (Front) - Install (Heavy Duty Housing (Front))

Installation Procedure

Table 64

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 575 Sealant	1
B	-	Guide Bolt M8 by 40 mm	2
C	27610216	Alignment Tool	1
	-	Bolts M10 by 50 mm	3
D	-	Dephi Lockheed Rubber Grease	1
E	-	Loctite 609 Bearing Mount Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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

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

2. Clean all the gasket surfaces of the cylinder block.

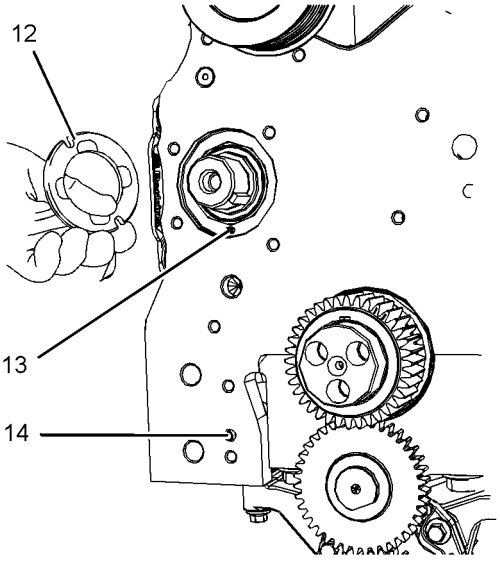


Illustration 353 g02201113

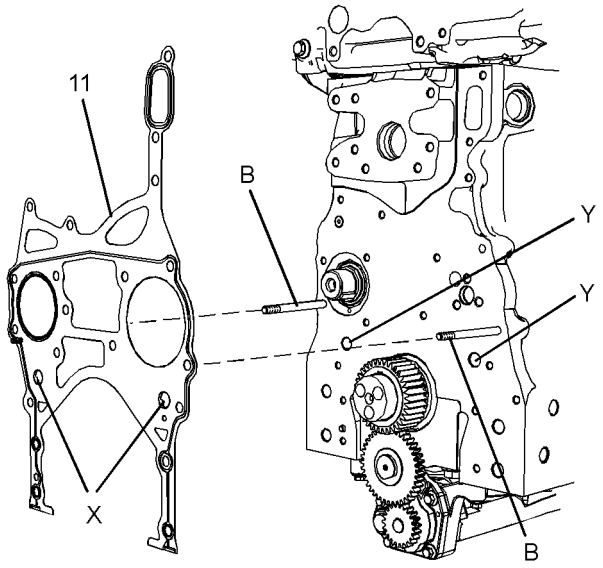


Illustration 354 g02201114

3. Inspect dowel (13) and dowel (14) for damage. If necessary, replace the dowels in the cylinder block.

4. Install thrust washer (12) into the recess in the cylinder block. Refer to Disassembly and Assembly, “Camshaft - Install” for more information.

5. Install Tooling (B) to the cylinder block. Refer to Illustration 354.

6. Align a new gasket (11) with Tooling (B). Install the gasket to the cylinder block.

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in the cylinder block. Ensure that dowel (14) in the cylinder block is engaged on the gasket.

7. Install Tooling (C) to the cylinder block.

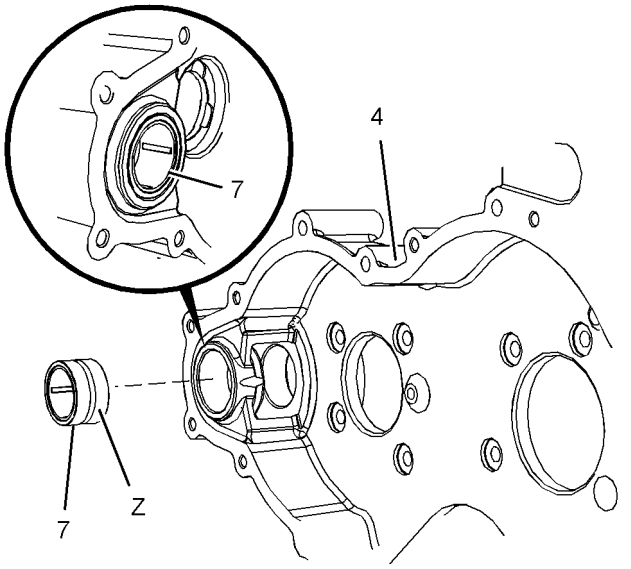


Illustration 355 g02201115

8. If necessary, follow Step 8.a through Step 8.c in order to install bearing (7) to housing (4).

a. Apply a small continuous bead of Tooling (E) to outer Surface (Z) of bearing (7).

b. Place housing (4) onto a suitable support.

c. Use a suitable tool in order to press bearing (7) into housing (3) until the bearing is in the correct position within the housing. Remove any excess bearing mount compound.

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

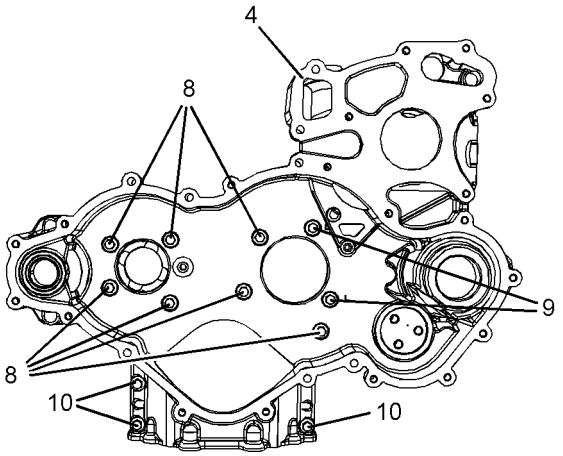


Illustration 356 g02201116

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

10. Install new bolts (10) to front housing (3) hand tight.

11. Remove Tooling (B).

12. Loosely install bolts (8) and bolts (9) finger tight. Refer to Illustration 356 for the correct position of the bolts.

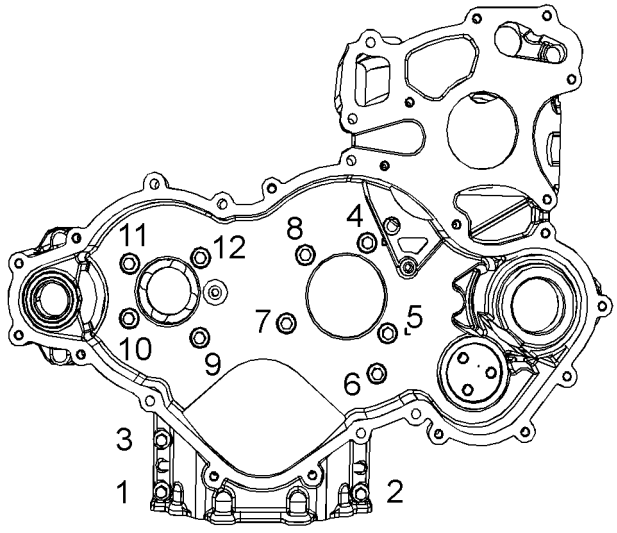


Illustration 357 g02058297

13. Tighten bolts (8), bolts (9) and bolts (10) in the sequence that is shown in Illustration 357 to a torque of 28 N·m (248 lb in).

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

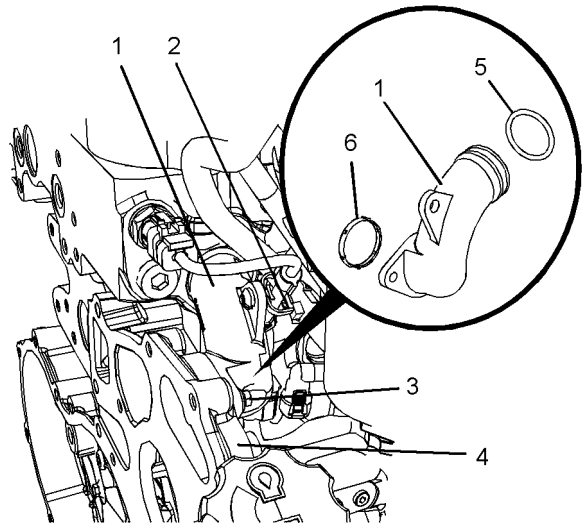


Illustration 358 g02198874

15. Install new O-ring seal (5) and O-ring seal (6) to bypass tube (1). Use Tooling (D) in order to lubricate the O-ring seals.

16. Install bypass tube (1) to the cylinder head. Install bolts (1). Tighten the bolts to a torque of 9 N·m (80 lb in).

17. Install a new cable strap (2) to wiring harness assembly.

End By:

a. Install the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install” for the correct procedure.

b. Install the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Install” for the correct procedure.

c. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.

d. Install the engine oil pan plate. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove” for the correct procedure.

e. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Vibration Damper and Pulley - Install” for the correct procedure.

f. Install the water pump. Refer to Disassembly and Assembly, “Water Pump - Install” for the correct procedure.

g. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

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

i04203634

Accessory Drive - Remove and Install (Accessory Drive SAE "B")

Removal Procedure

Table 65

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. Remove the auxiliary equipment from the accessory drive housing. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

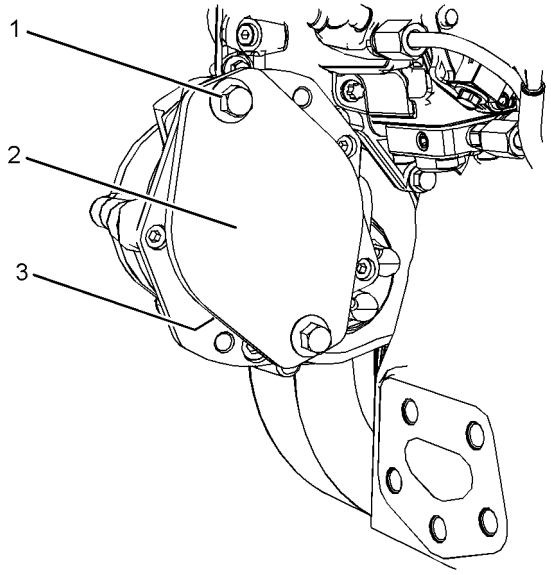


Illustration 359 g02186453

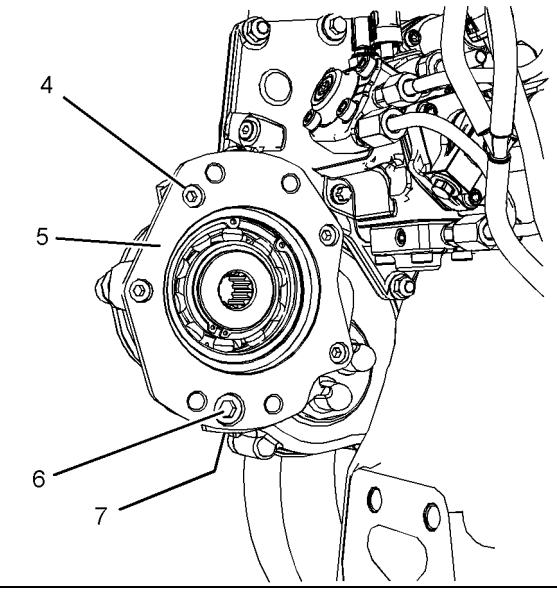


Illustration 360 g02374996

2. If the OEM driven equipment has not been installed to the auxiliary drive, remove bolts (1). Remove cover plate (2) and remove gasket (3) (not shown).

3. Remove allen head screws (4) from accessory drive housing (5). Remove allen head screw (6) from accessory drive housing (5).

4. Remove accessory drive housing (5) from the front housing.

5. Remove gasket (7) from accessory drive housing (5).

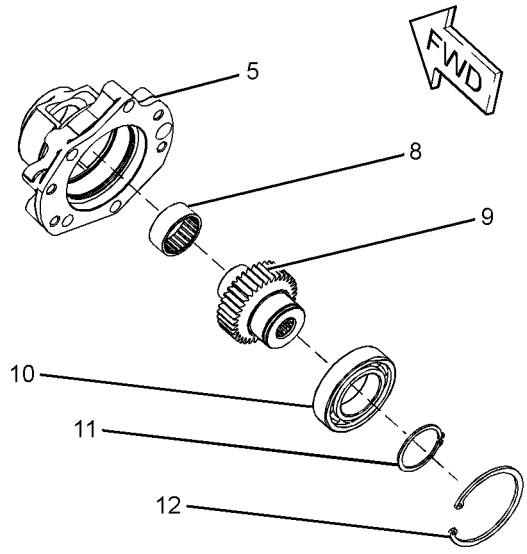


Illustration 361 g02374997

6. If necessary, follow Step 6.a through Step 6.d in order to disassemble the accessory drive.

a. Remove circlip (11) from gear (9).

b. Remove circlip (12) from accessory drive housing (5).

c. Place accessory drive housing (5) onto a suitable support. Press the assembly of gear (9) and bearing (10) out of accessory drive housing (5). Use Tooling (A) in order to remove bearing (10) from gear (9).

Note: Note the position of the bearing in the accessory drive housing before removal.

d. Press bearing (8) out of accessory drive housing (5).

Installation Procedure

Table 66

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	Loctite 603 Retaining Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

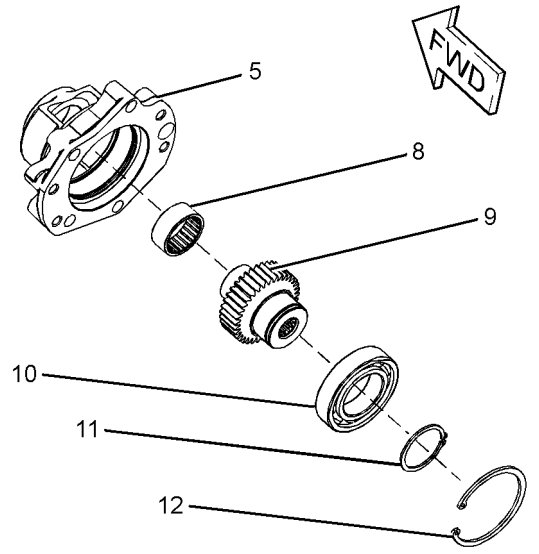


Illustration 362 g02374997

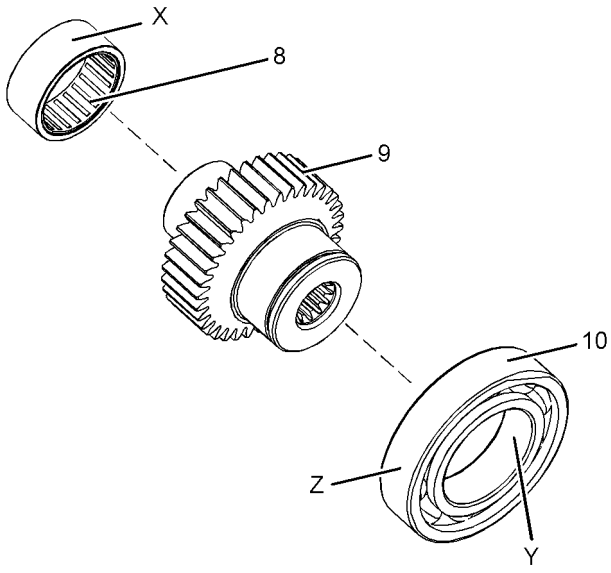


Illustration 363 g02052174

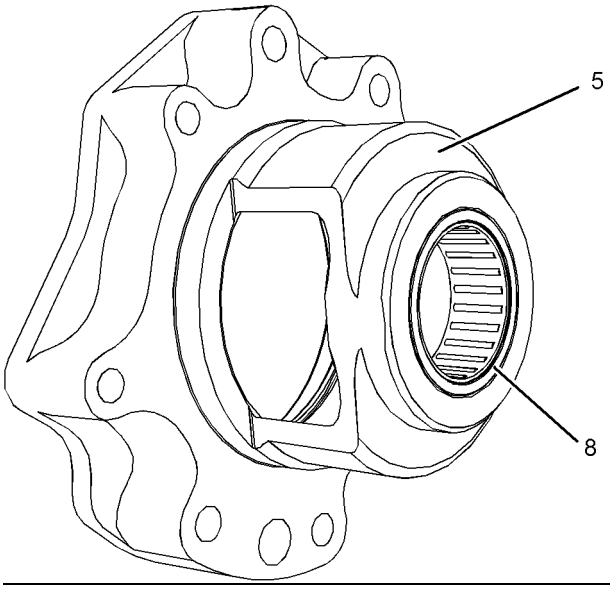


Illustration 364 g02052273

1. If necessary, follow Step 1.a through Step 1.f in order to assemble the accessory drive.

a. Inspect the condition of the teeth and the splines of gear (9) for wear and damage. Inspect bearing (8), bearing (10), circlip (11) and circlip (12). Inspect the front housing for wear and damage. Replace any components that are worn or damaged.

b. Apply a small continuous bead of Tooling (B) to outer Surface (X) of bearing (8). Place the accessory drive housing on a suitable support. Press on the outer race of bearing (8) until the bearing is in the correct position within accessory drive housing (5). Remove any excess bearing mount compound.

c. Apply a small continuous bead of Tooling (B) to inner Surface (Y) of bearing (10). Place the inner race of bearing (10) onto a suitable support. Press the shaft of gear (9) into bearing (10) until the shoulder of the gear is against the bearing. Remove any excess bearing mount compound.

d. Install circlip (11) into the groove in gear (9).

e. Apply a small continuous bead of Tooling (B) to the outer Surface (Z) of bearing (10). Place accessory drive housing (5) on a suitable support. Ensure that the shaft of gear (9) is correctly aligned with bearing (8). Press the assembly of the gear into the accessory drive housing. Remove any excess bearing mount compound.

f. Install circlip (12) into the groove in accessory drive housing (5). Ensure that circlip (12) is correctly positioned in the groove.

2. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” and Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

3. Lightly lubricate bearing (8), bearing (10), and gear (9) with clean engine oil.

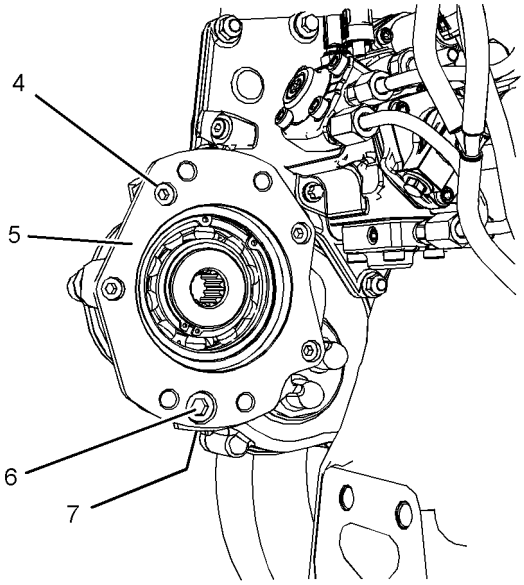


Illustration 365 g02374996

4. Install new gasket (7) to accessory drive assembly (5). Install the assembly of the accessory drive to the front housing.

5. Install new M8 allen head screws (4) to accessory drive housing (5).

6. Install a new M12 allen head screw (6) to accessory drive housing (5).

7. Tighten new M8 allen head screws (4) to a torque of 22 N·m (195 lb in).

8. Tighten M12 allen head screw (6) to a torque of 78 N·m (58 lb ft).

9. Repeat Step 7 to ensure correct torque of M8 allen head screws (4).

10. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

11. Install the auxiliary equipment to the accessory drive housing. Refer to the OEM for the correct procedure.

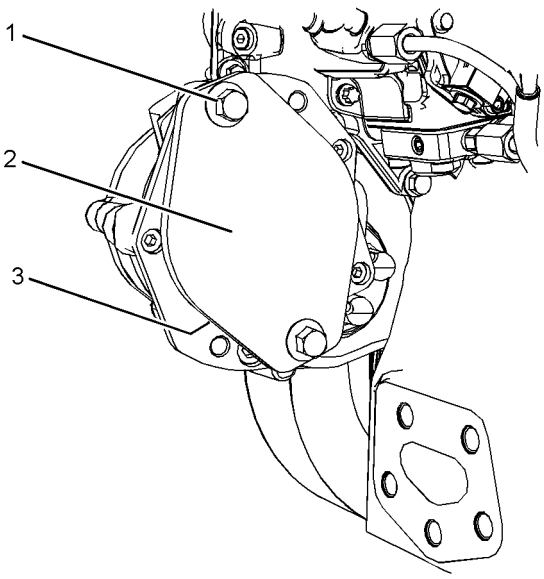


Illustration 366 g02186453

12. If the OEM driven equipment is not being installed to the auxiliary drive. Install a new gasket (3) (not shown) and cover plate (2). Install bolts (1) and tighten the bolts to a torque of 44 N·m (33 lb ft).

i04203633

Accessory Drive - Remove and Install (Accessory Drive SAE "A")

Removal Procedure

Table 67

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

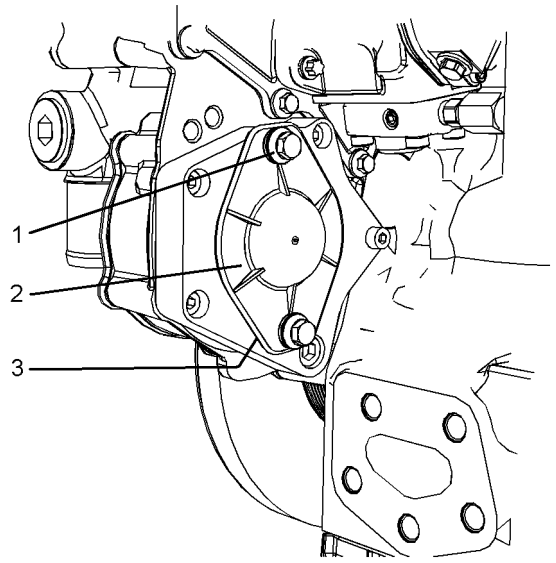


Illustration 367 g02186413

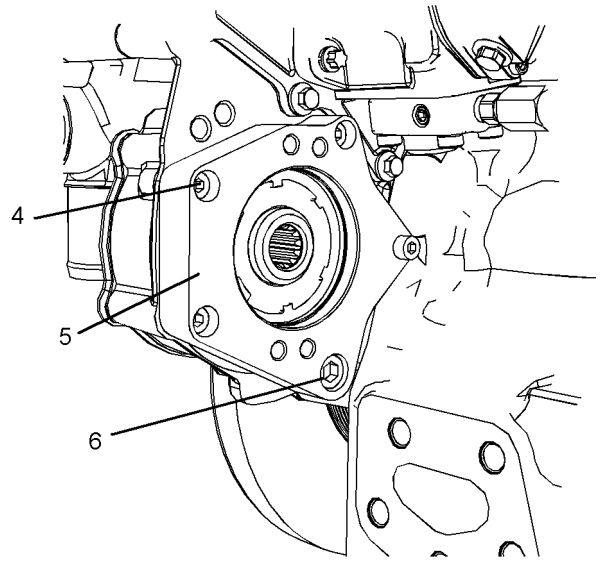


Illustration 368 g02186414

1. If necessary, remove Original Equipment Manufactures (OEM) driven equipment from auxiliary drive (5). Refer to the OEM for the correct procedure.
2. If the OEM driven equipment was not installed onto auxiliary drive (5). Remove cover plate (2) and remove O-ring seal (3) (not shown).
3. Remove allen head screws (4) and allen head screw (6) from accessory drive housing (5).
4. Remove accessory drive housing (5) from the front housing.

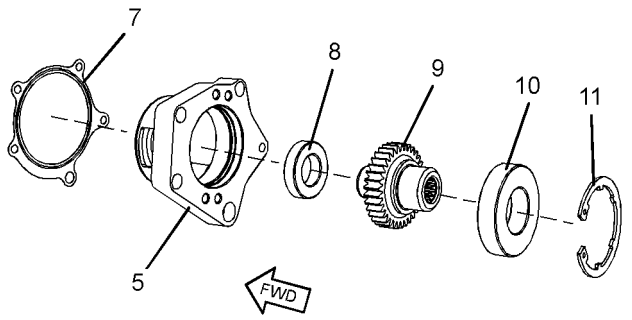


Illustration 369 g02183295

5. Remove gasket (7) from accessory drive housing (5).
6. If necessary, follow Step 6.a through Step 6.d in order to disassemble the accessory drive.
   a. Remove circlip (11) from accessory drive housing (5).
   b. Place accessory drive housing (5) onto a suitable support. Press the assembly of gear (9), bearing (10) and bearing (8) out of accessory drive housing (5).
   c. Use Tooling (A) in order to remove bearing (10) from gear (9).
   d. Use Tooling (A) in order to remove bearing (8) from gear (9).

Installation Procedure

Table 68

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	Loctite 603 Retaining Compound	1
C	-	Dephi Lockheed Rubber Grease	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

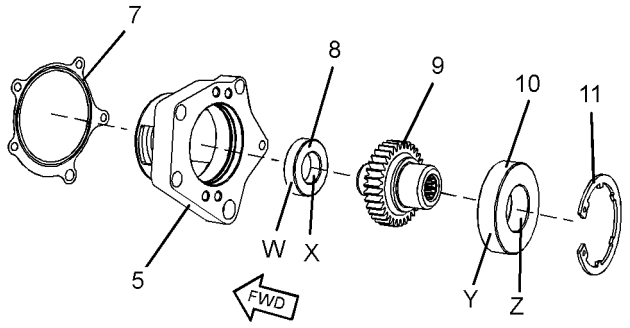


Illustration 370 g02183296

1. If necessary, follow Step 1.a through Step 1.e in order to assemble the accessory drive.

a. Inspect the condition of the teeth and the splines of gear (9) for wear and damage. Inspect bearing (10), bearing (8), and circlip (11). Inspect accessory drive housing (5) for wear and damage. Replace any components that are worn or damaged.

b. Apply a small continuous bead of Tooling (B) to inner Surface (X) of bearing (8). Place the inner race of bearing (8) onto a suitable support. Press the shaft of gear (9) into bearing (8) until the shoulder of the gear is against the bearing. Remove any excess compound.

c. Apply a small continuous bead of Tooling (B) to inner Surface (Z) of bearing (10). Place the inner race of bearing (10) onto a suitable support. Press the shaft of gear (9) into bearing (10) until the shoulder of the gear is against the bearing. Remove any excess compound.

d. Apply a small continuous bead of Tooling (B) to the outer Surface (W) and the outer Surface (Y) of bearing (8) and bearing (10). Place accessory drive housing (5) on a suitable support. Press the assembly of gear (9) into the accessory drive housing. Ensure that bearing (10) and bearing (8) are against the front face of the recesses in accessory drive housing (5). Remove any excess compound.

e. Install circlip (11) into the groove in accessory drive housing (5). Ensure that circlip (11) is correctly positioned in the groove.

2. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” and Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

3. Position a new gasket (7) to accessory drive housing (5).

4. Lightly lubricate bearing (10), bearing (8), and gear (9) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing. Ensure that the flange on the accessory drive housing is flush with the front housing.

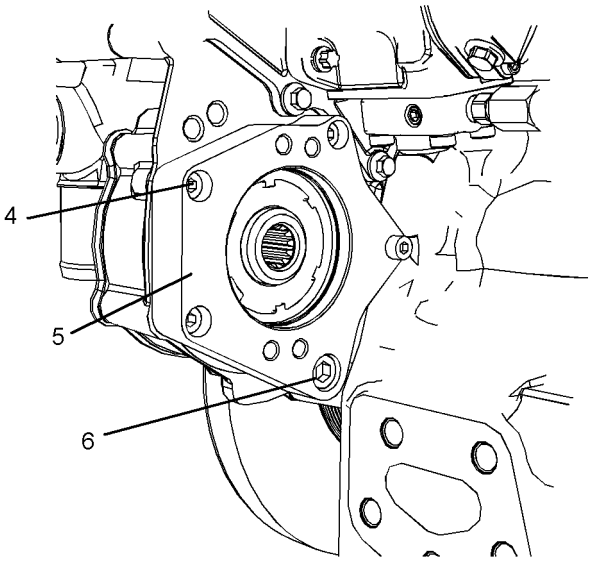


Illustration 371 g02186414

5. Install new M8 allen head screws (4) to accessory drive housing (5).

6. Install new M12 allen head screw (6) to accessory drive housing (5).

7. Tighten M8 allen head screws to a torque of 22 N·m (195 lb in).

8. Tighten M12 allen head screw to a torque of 78 N·m (58 lb ft).

9. Repeat Step 7 to ensure correct torque of M8 allen head screws (4).

10. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

11. If necessary, install the OEM driven equipment to auxiliary drive (5). Refer to the OEM for the correct procedure.

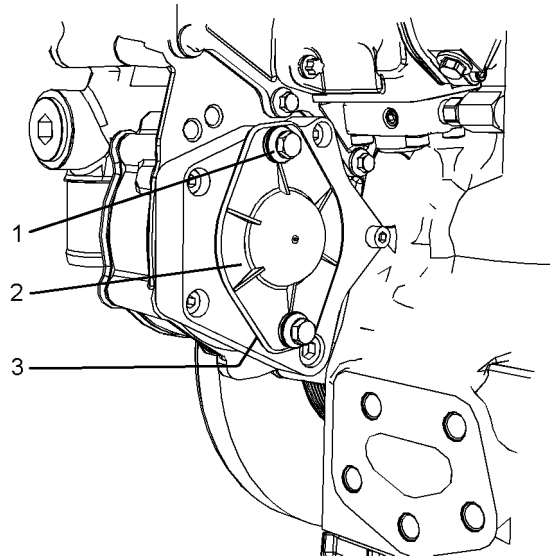


Illustration 372 g02186413

12. If the OEM driven equipment is not being installed to the auxiliary drive. Use Tooling (C) in order to lubricate a new O-ring seal (3). Install O-ring seal (3) (not shown) to cover plate (2) install the cover assembly to the auxiliary drive and install bolts (1).

13. Tighten bolts (1) to a torque of 16 N·m (142 lb in).

i04203657

Crankcase Breather - Remove

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
When disconnecting and connecting the plastic tube assemblies for the crankcase breather system, the plastic tube assemblies should not be twisted. Twisting of the plastic tube assemblies will result in the seals being damaged. Damaged to seals will result in leakage.

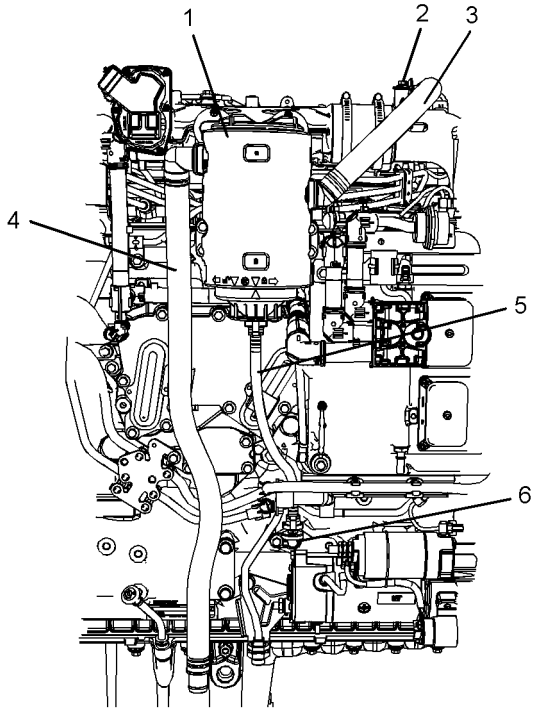


Illustration 373 g02163113

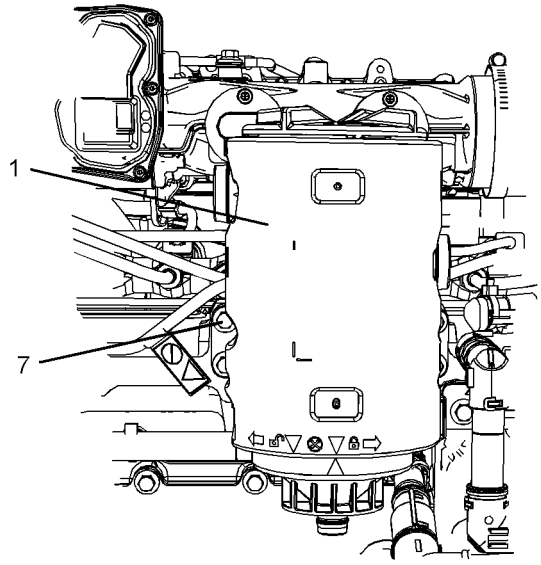


Illustration 374 g02163114

1. Cut cable strap (2) from plastic tube assembly (3).

2. Remove plastic tube assembly (3) from breather canister (1) and the valve mechanism cover.

3. If necessary, cut cable straps in order to remove plastic tube assembly (4) from breather canister (1).

4. Remove plastic tube assembly (5) from breather canister (1) and adapter (6) in the cylinder block.

5. Remove bolts (7) and remove breather canister (1) from the cylinder head.

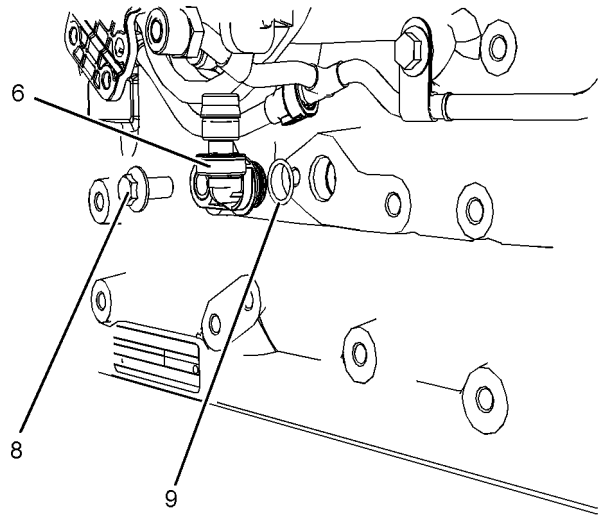


Illustration 375 g02163115

6. Remove bolt (8) and remove valve (6) from the cylinder block.

7. Remove O-ring seal (9) from valve (6).

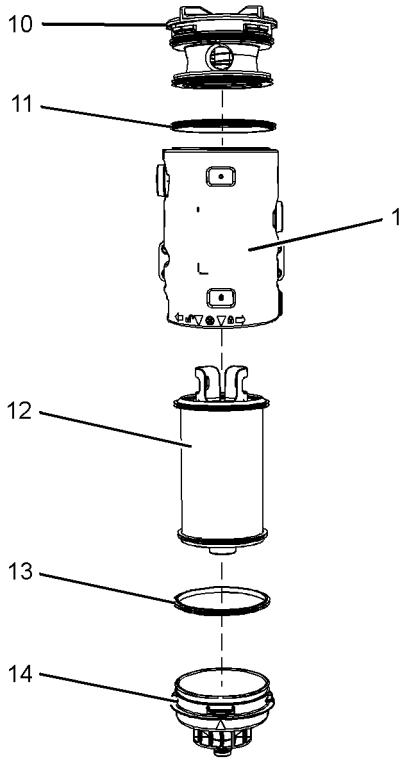


Illustration 376 g02163116

8. If necessary, follow Step 8.a through Step 8.e in order to disassemble the breather canister.

a. Remove bottom cap (14) from breather canister (1).

b. Remove seal (13) from bottom cap (14).

c. Remove filter element (12) from breather canister (1). Refer to Operation and Maintenance Manual, “Engine Crankcase Breather Element - Replace” for the correct procedure.

d. Remove top cap (10) from breather canister (1).

e. Remove seal (11) from top cap (10).

i04203656

Crankcase Breather - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
When disconnecting and connecting the plastic tube assemblies for the crankcase breather system, the plastic tube assemblies should not be twisted. Twisting of the plastic tube assemblies will result in the seals being damaged. Damaged to seals will result in leakage.

1. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.

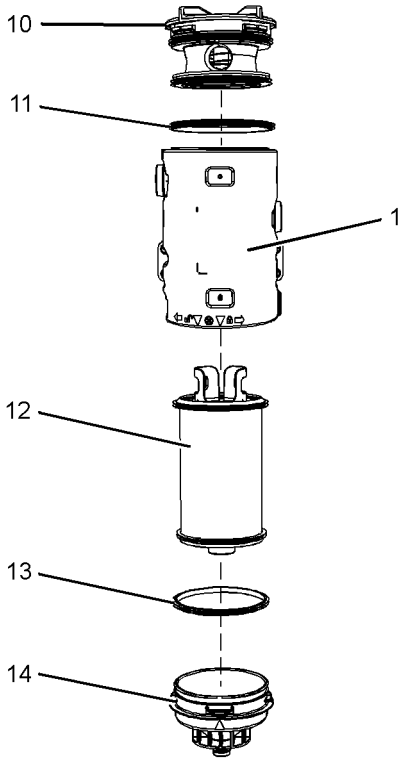


Illustration 377 g02163116

2. If necessary, follow Step 2.a through Step 2.e in order to assemble the breather canister.

a. Install a new seal (13) to bottom cap (14).

b. Install bottom cap (14) onto breather canister (1).

c. Install a new filter element (12) to breather canister (1). Refer to Operation and Maintenance Manual, “Engine Crankcase Breather Element - Replace” for the correct procedure.

d. Install a new seal (11) to top cap (10).

e. Install top cap (10) onto breather canister (1).

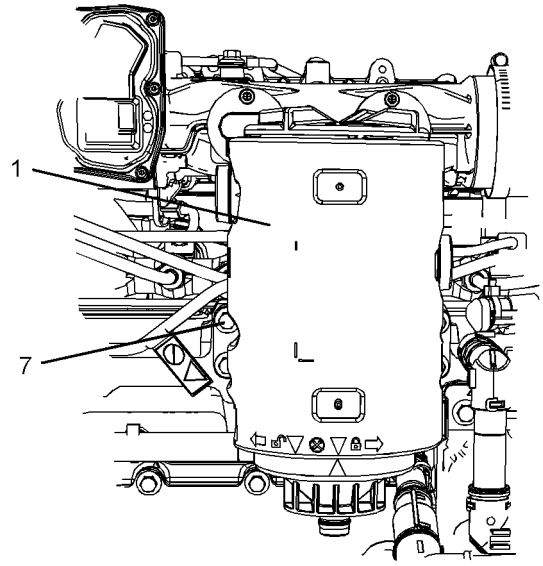


Illustration 378 g02163114

3. Position breather canister (1) onto the cylinder head and install bolts (7). Tighten the bolts to a torque of 22 N·m (195 lb in).

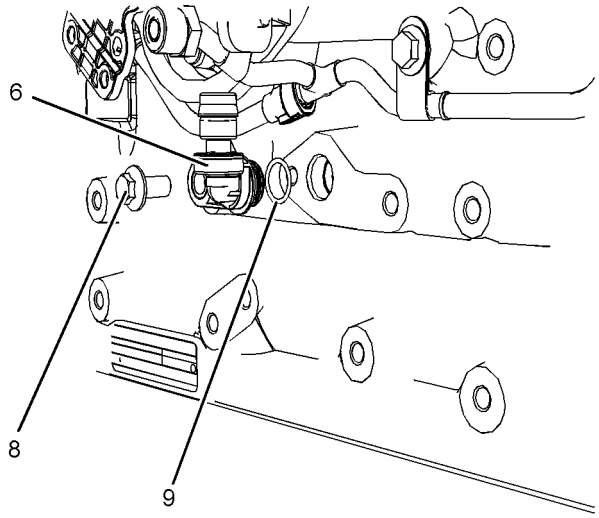


Illustration 379 g02163115

4. Install a new O-ring seal (9) to valve (6).

Note: Do not lubricate the O-ring seal.

5. Install valve (6) into the cylinder block. Install bolt (8) and tighten the bolt to a torque of 22 N·m (195 lb in).

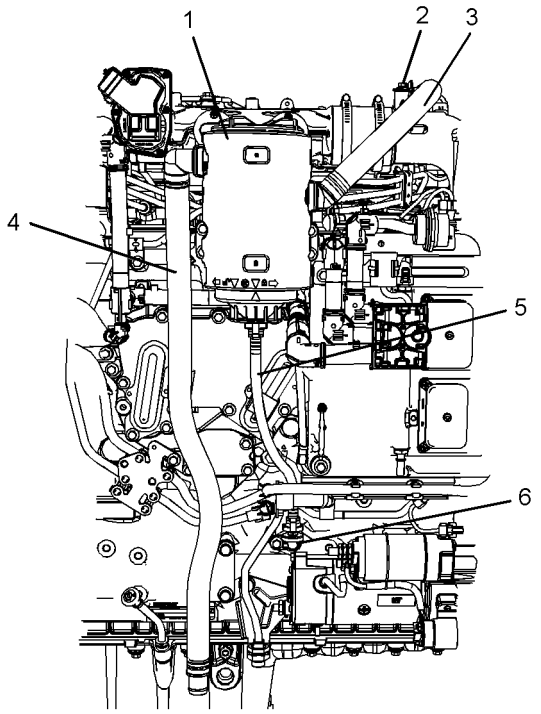


Illustration 380 g02163113

6. Ensure that plastic tube assembly (3), plastic tube assembly (4), and plastic tube assembly (5) are clean and free from restriction.

7. Connect plastic tube assembly (5) to breather canister (1) and valve (6) in the cylinder block.

8. Connect plastic tube assembly (4) to breather canister (1). Ensure that plastic tube assembly (4) is correctly locked into the outlet of crankcase breather cannister (1).

9. Ensure that plastic tube assembly (4) is correctly positioned onto clips. If necessary, install new cable straps.

Note: Ensure that the cable straps meet the Original Equipment Manufacturers (OEM) specification.

10. Connect plastic tube assembly (3) to breather canister (1) and the valve mechanism cover. Ensure that plastic tube assembly (3) is correctly locked into the inlet of crankcase breather cannister (1).

11. Install a new cable strap (2) to plastic tube assembly (3).

Note: Ensure that the cable straps meet the OEM specification.

i04203789

Valve Mechanism Cover - Remove and Install

Removal Procedure

Start By:

a. Remove the inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

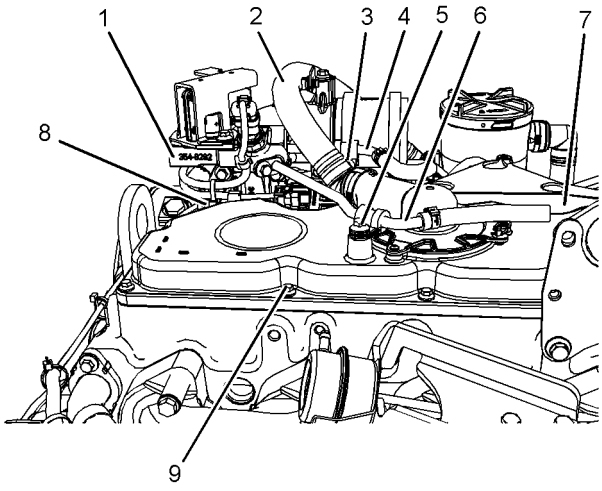


Illustration 381 g02173456

1. Disconnect plastic tube assembly (2) from the crankcase breather on valve mechanism cover (7). Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

2. Remove bolt (3) from clip for tube assembly (4).

3. Remove bolt (5) from clip for tube assembly (6).

4. Remove bolt (8) and position pressure sensor manifold (1) away from valve mechanism cover (7).

5. Remove bolts (9) from valve mechanism cover (7).

6. Remove valve mechanism cover (7) from the cylinder head.

Note: Remove the valve mechanism cover vertically in order to avoid damage to the electronic unit injectors.

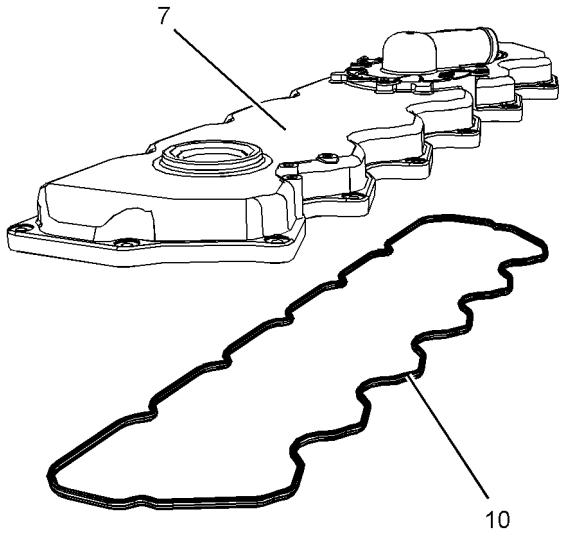


Illustration 382 g02173457

7. Remove gasket (10) from valve mechanism cover (7).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

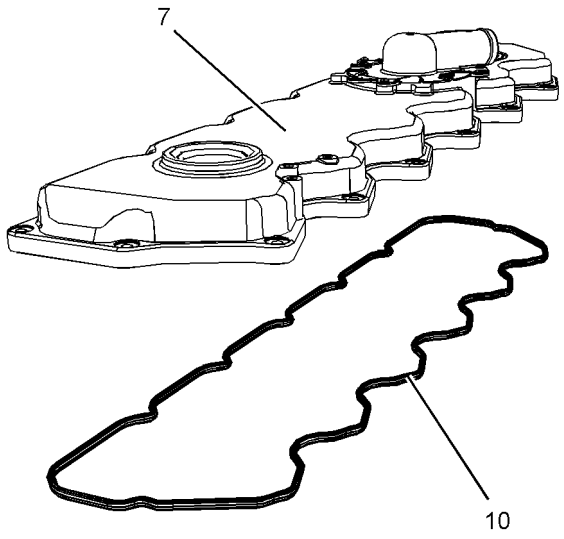


Illustration 383 g02173457

1. Thoroughly clean all gasket surfaces of valve mechanism cover (7). Clean the gasket surfaces of the cylinder head.

2. Inspect gasket (10) for damage. If necessary, install a new gasket to valve mechanism cover (7).

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

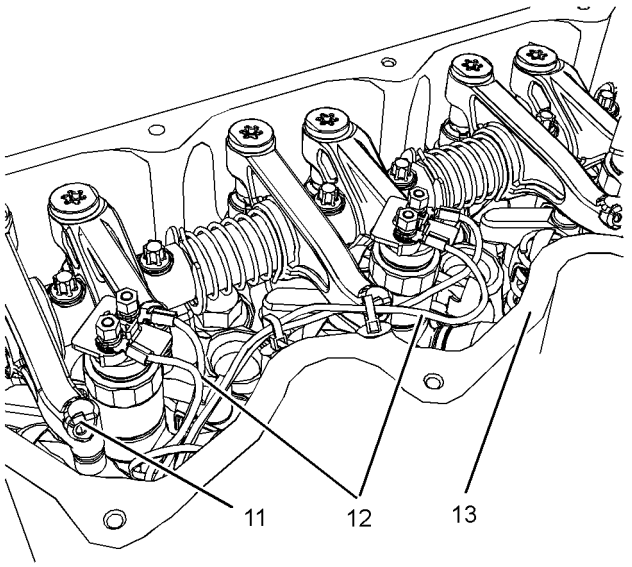


Illustration 384 g02173458

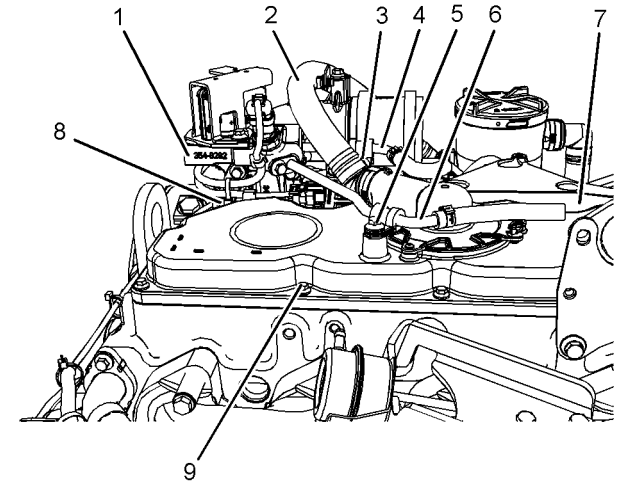


Illustration 385 g02173456

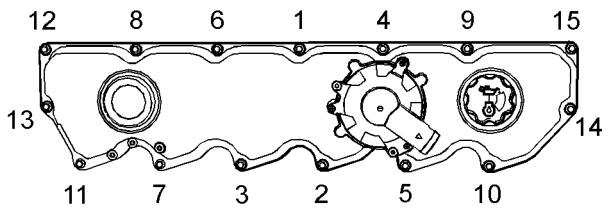


Illustration 386 g02002834

3. Ensure that harness assemblies (12) are not in contact with rocker arms (11) or cylinder head (13).

Note: Install the valve mechanism cover vertically in order to avoid damage to the electronic unit injectors.

4. Position valve mechanism cover (7) onto cylinder head (13). Ensure that harness assemblies (12) are not trapped during the assembly procedure.

5. Install bolts (9).

6. Tighten bolts (9) in the numerical sequence that is shown in Illustration 386. Tighten the bolts to a torque of 9 N·m (79 lb in).

Repeat Step 6 in order to ensure correct torque.

7. Position pressure sensor manifold (1) onto inlet elbow. Loosely install bolt (8).

8. Install bolt (3) to clip for tube assembly (4).

9. Install bolt (5) to clip for tube assembly (6).

10. Tighten bolt (8) to a torque of 22 N·m (195 lb in).

11. Tighten bolt (3) and bolt (5) to a torque of 22 N·m (195 lb in).

12. Connect plastic tube assembly (2) to the crankcase breather on valve mechanism cover (7). Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

End By:

a. Install the inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Install” for the correct procedure.

i04203761

Rocker Shaft and Pushrod - Remove

Removal Procedure

Table 69

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	-	E10 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

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) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

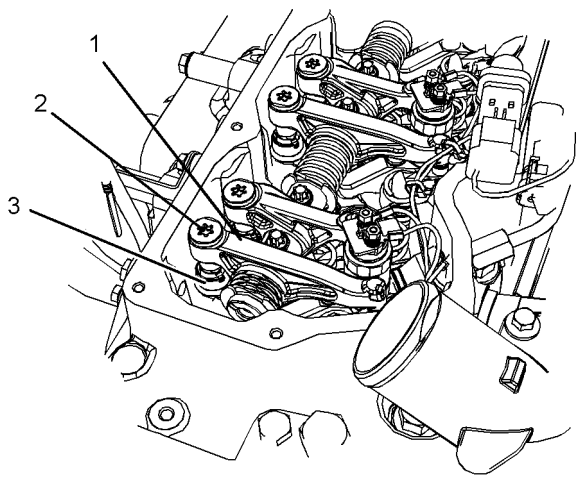


Illustration 387 g02409496

2. Use Tooling (B) in order to loosen threaded inserts (2) on all rocker arms (1). Unscrew threaded inserts (2) on all rocker arms (1) until all valves are fully closed. Ensure that guides (3) for the pushrods are left in position on threaded inserts (2).

Note: Ensure that ALL threaded inserts are fully unscrewed.

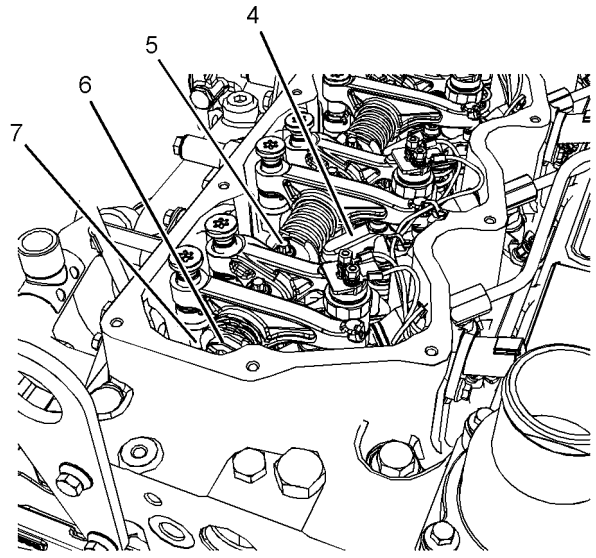


Illustration 388 g02409498

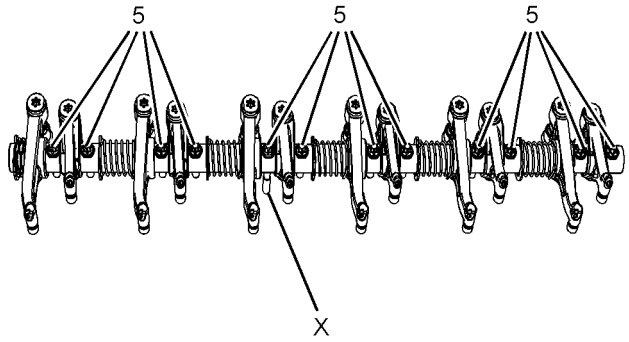


Illustration 389 g02409500

3. Use Tooling (C) to loosen Torx screws (5). Begin at the ends of rocker shaft assembly (6) and work toward the center.

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

4. Remove Torx screws (5) from rocker shaft assembly (6).

Note: Different length Torx screw in Position (X).

5. Remove rocker shaft assembly (6) from the cylinder head.

6. Place an identification mark on pushrods (7) 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.

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

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

i04203759

Rocker Shaft - Disassemble

Disassembly Procedure

Start By:

a. Remove the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove” for the correct procedure.

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.

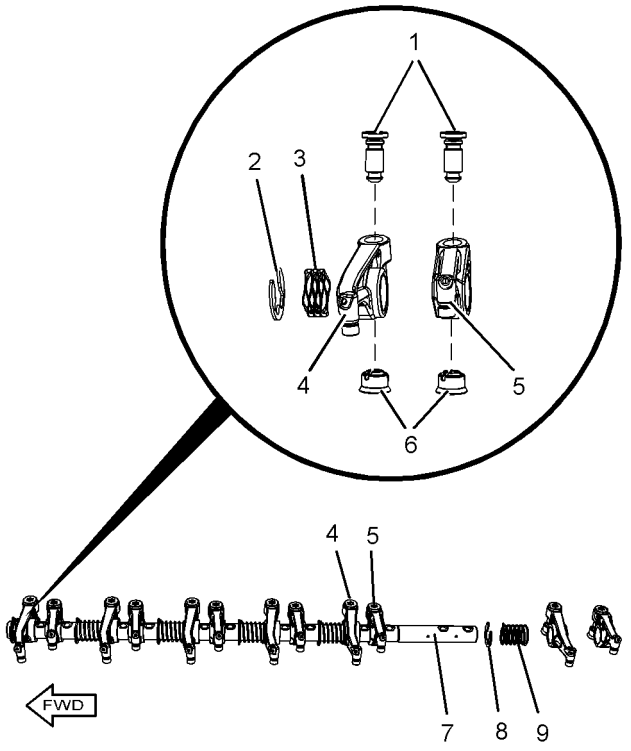


Illustration 390 g02179054

2. Remove rocker arm assembly (5) for the exhaust valve from rocker shaft (7). Remove rocker arm assembly (4) for the inlet valve from rocker shaft (7).

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

3. Remove spring (9) from the rocker shaft. Remove retaining clip (8) from rocker shaft (7).

4. Repeat Step 2 through Step 3 in order to remove the remaining rocker arms from rocker shaft (7).

5. If necessary, remove retaining clip (2) and spring (3) from the rocker shaft.

6. If necessary, follow Step 6.a through Step 6.c in order to remove threaded inserts (1) from the rocker arms.

a. Make a temporary identification mark on each threaded inserts (1) in order to show the location.

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

b. Remove guide (6) from threaded inserts (10).

c. Remove threaded inserts (10) from the rocker arms.

i04203758

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 and damage. Refer to Specifications, “Rocker Shaft” for more information. If necessary, replace any components that are worn or damaged.

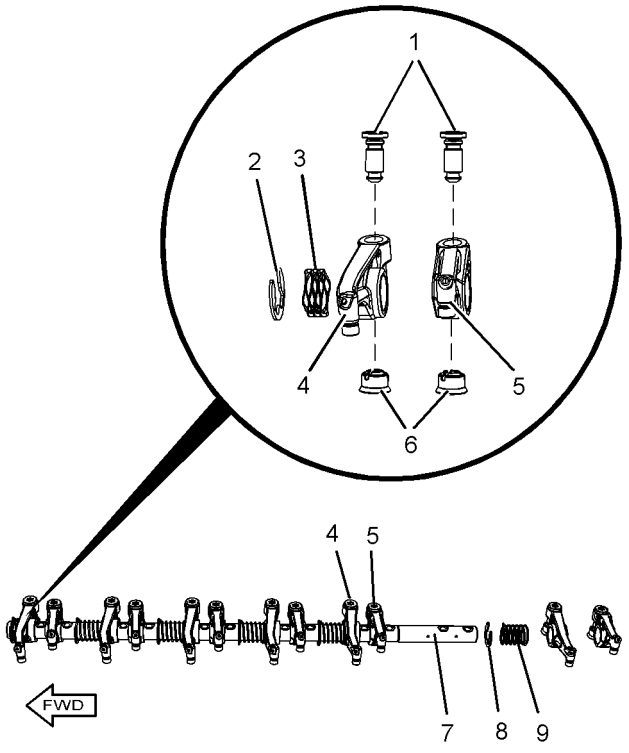


Illustration 391 g02179054

2. If necessary, follow Step 2.a through Step 2.b in order to install threaded inserts (1) to the rocker arms.

a. Loosely install threaded inserts (1) to rocker arm assembly (4) and rocker arm assembly (5).

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

b. Install guide (6) onto threaded inserts (1).

Note: Ensure that ALL threaded inserts are fully unscrewed after the installation of the guide .

3. Lubricate the bore of rocker arm assemblies (4) for the inlet valve with clean engine oil.

4. Lubricate the bore of rocker arm assemblies (5) for the exhaust valve with clean engine oil.

5. Lubricate rocker shaft (7) with clean engine oil.

6. If necessary, install retaining clip (2) and spring (3) to the front end of rocker shaft (7).

7. Install rocker arm assembly (4) for number 1 inlet valve to the rocker shaft. Install rocker arm assembly (5) for number 1 exhaust valve to rocker shaft (7).

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.

⚠ 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.

8. Install retaining clip (8) to rocker shaft (7).

9. Install spring (9) to rocker shaft (7).

10. Install rocker arm assembly (4) for number 2 inlet valve to the rocker shaft. Install rocker arm assembly (5) for number 2 exhaust valve to rocker shaft (7).

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.

11. Repeat Step 8 through Step 10 in order to assemble the remaining components to rocker shaft (7).

End By:

a. Install the rocker shaft assembly. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install” for the correct procedure.

i04203760

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 70

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	-	E10 Torx Socket	1
D	T400027	Rocker Arm Spacer	6

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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.

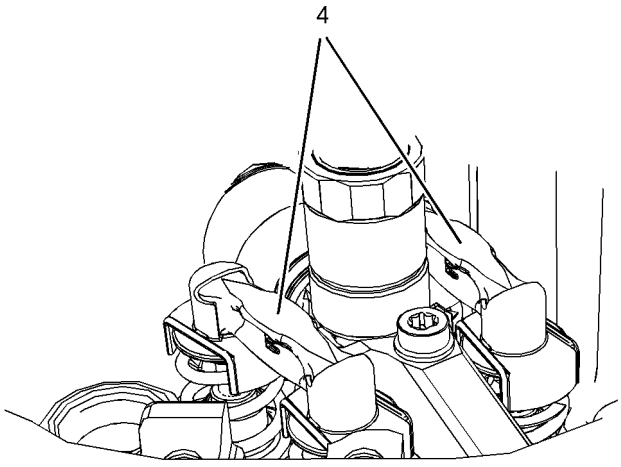


Illustration 392 g02409697

The correct location of valve bridges on valve stems is shown.

1. Clean valve bridges (4). Inspect the valve bridges for wear and damage. Replace any valve bridges that are worn or damaged.

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

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

3. Install valve bridges (4) to the valve stems.

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.

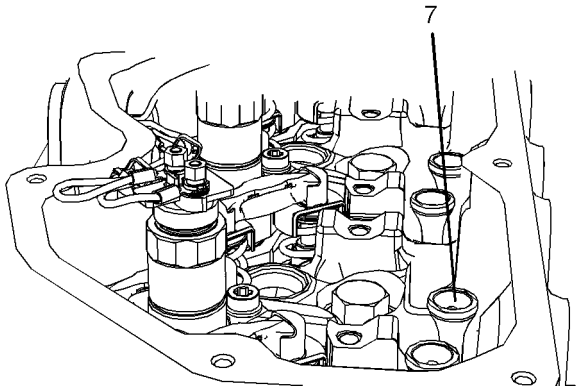


Illustration 393 g02409699

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

5. Apply clean engine lubricating oil to both ends of pushrods (7). Install the pushrods to the engine with the cup upward.

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

NOTICE
Failure to ensure that the crankshaft is positioned at 60 degrees after top dead center will result in interference between the pistons and the valves. Failure to ensure that the crankshaft is positioned at 60 degrees after top dead center will result in damage to the engine.

6. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at 60 degrees after top dead center. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure

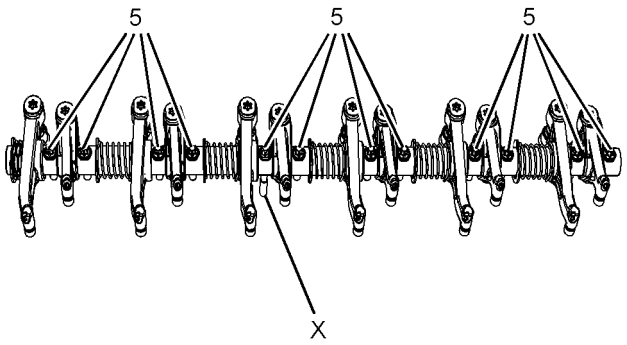


Illustration 394 g02409500

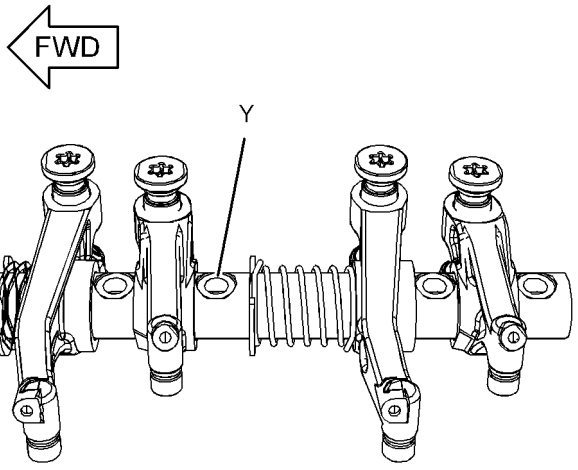


Illustration 395 g02307257

7. Ensure that the rocker shaft assembly is clean and free from wear and damage.

8. Position the rockershaft assembly with Spotfaces (Y) for Torx screws (5) in the up ward position.

9. Install Tooling (D) to rocker shaft assembly.

10. Install Torx screws (5) to the rocker shaft.

Note: Ensure that the correct Torx screw is installed to Position (X).

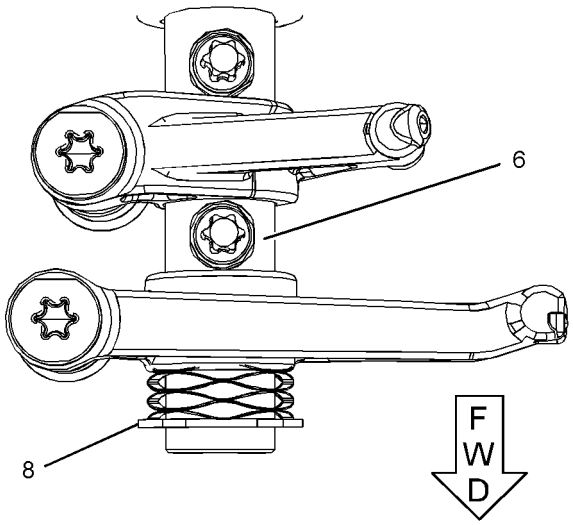


Illustration 396 g02409700

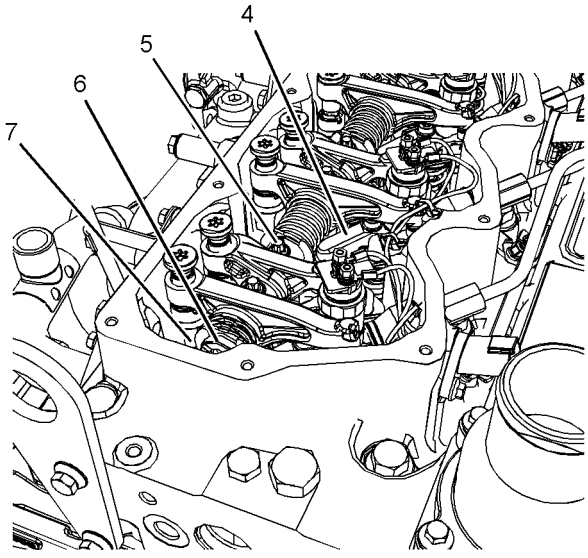


Illustration 397 g02409498

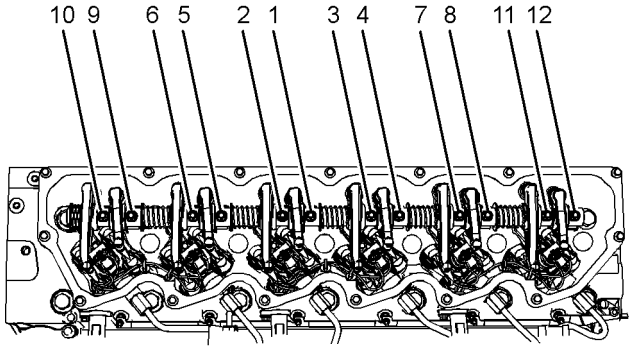


Illustration 398 g02047334

11. Ensure that ALL threaded inserts are fully unscrewed. Position rocker shaft assembly (6) onto the cylinder head. The retaining clip (8) should face the front of the engine.

Note: Ensure that the threaded inserts are correctly seated in ends of pushrods (7).

12. Use Tooling (C) in order to tighten Torx screws (5) hand tight.

13. Remove Tooling (D) from the rocker shaft. Install the remaining Torx screws (5) to the rocker shaft. Tighten the Torx screws (5) hand tight.

14. Tighten the Torx screws to a torque of 35 N·m (26 lb ft) in the numerical sequence that is shown in Illustration 398.

15. Ensure that valve bridges (4) are correctly located on the valve stems.

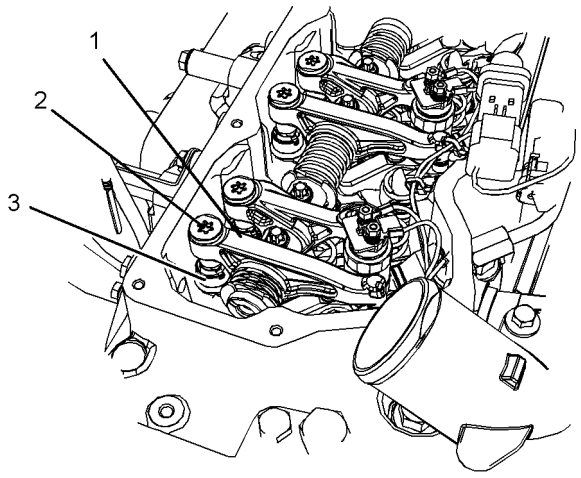


Illustration 399 g02409496

16. Ensure that guides (3) for the pushrods are correctly positioned on threaded inserts (2). Use Tooling (B) in order to tighten threaded inserts (2) on all the rocker arms. Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must seat correctly into the cup for the pushrod.

17. The engine should not be operated for a period 30 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force of the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

a. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i04203669

Cylinder Head - Remove

Removal Procedure

Table 71

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

Start By:

a. If necessary, remove the secondary fuel filter and the fuel filter base. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.

b. If necessary, remove the water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

c. Remove the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.

d. Remove the crankcase breather cannister and plastic tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

e. Remove the fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (Rail) - Remove and Install” for the correct procedure.

f. Remove the electronic unit injectors. Refer to Disassembly and Assembly, “Electronic Unit Injector - Remove” for the correct procedure.

g. Remove the mounting bracket for the electronic control module. Refer to Disassembly and Assembly, “E.C.M. Mounting Bracket - Remove and Install” for the correct procedure.

h. Remove the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install” 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. 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.

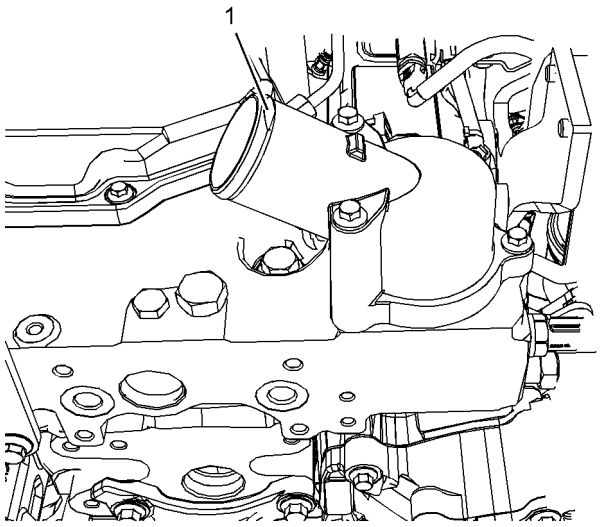


Illustration 400 g02005213

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

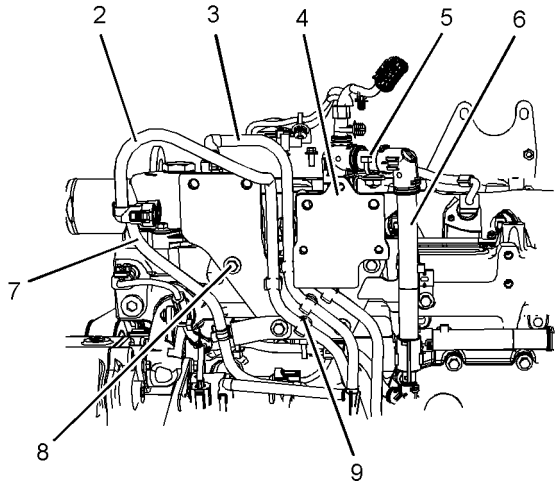


Illustration 401 g02206193

3. Remove plastic tube assembly (2), plastic tube assembly (3), and plastic tube assembly (7) from clips (9).

4. Cut all cable straps (5) from engine wiring harness assembly (6). Position engine wiring harness assembly away from the engine.

Note: Ensure that all cable straps are removed from the engine wiring harness.

5. Remove bolts (8) and remove bracket (4) from the cylinder head.

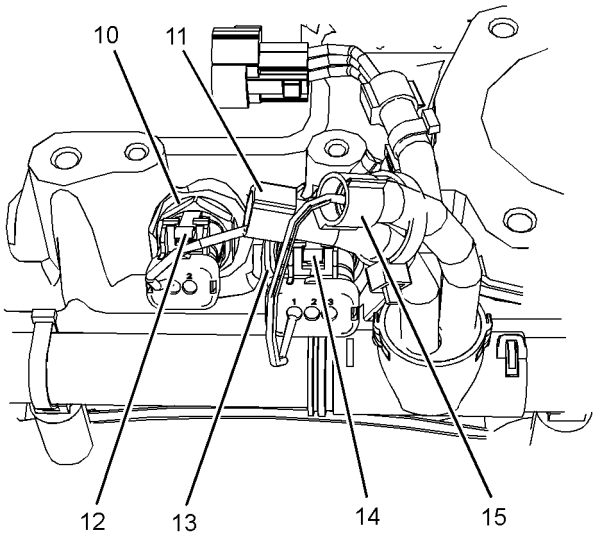


Illustration 402 g02206194

6. Follow Step 6.a through Step 6.b in order to disconnect harness assembly (15) from boost pressure sensor (13).

a. Slide locking tab (14) into the unlocked position.

b. Disconnect harness assembly (15) from boost pressure sensor (13).

7. Follow Step 7.a through Step 7.b in order to disconnect harness assembly (11) from inlet air temperature sensor (10).

a. Slide locking tab (12) into the unlocked position.

b. Disconnect harness assembly (11) from inlet air temperature sensor (10).

8. Remove all cable straps that secure the harness assembly to the cylinder head. The harness assembly should be positioned away from the cylinder head in order to avoid causing an obstruction during the removal of the cylinder head.

9. On some application there is an engine wiring harness support bracket on the rear of the cylinder head. if necessary, cut the cable straps and remove the engine wiring harness from the support bracket. Remove the support bracket from the cylinder head before removal the cylinder head assembly.

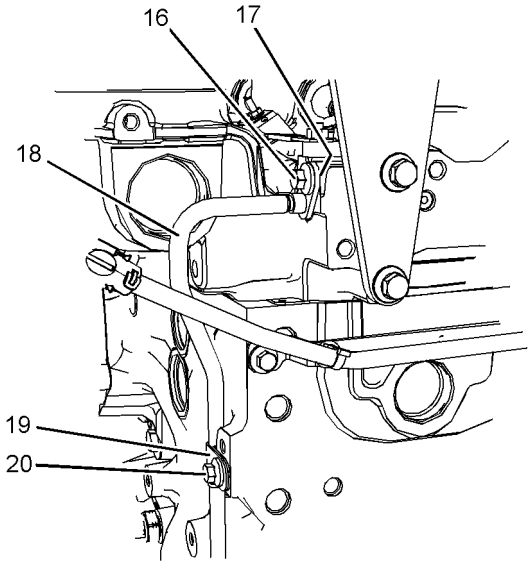


Illustration 403 g02206213

10. Remove bolt (16) from tube assembly (18). Remove bolt (20) from tube clip (19).

11. Remove tube assembly (18) from the cylinder head. Remove O-ring seal (17) (not shown) from the tube assembly. Use Tooling (A) to plug the port in the cylinder head with a new plug. Use Tooling (A) to cap the tube assembly with new cap.

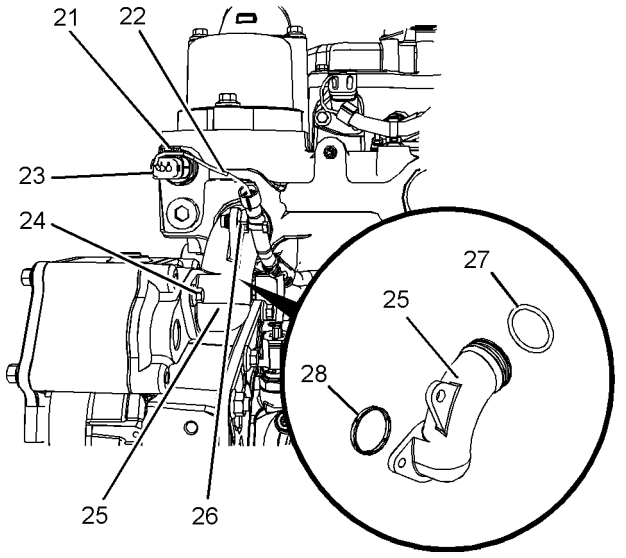


Illustration 404 g02206214

12. Follow Step 12.a through Step 12.c in order to disconnect harness assembly (22) from coolant temperature sensor (23).

a. Slide locking tab (21) into the unlocked position.

b. Disconnect harness assembly (22) from coolant temperature sensor (23).

c. Cut cable strap (26) and remove harness assembly (22) from bypass tube (25).

13. Remove bolts (24).

14. Remove bypass tube (25) from the cylinder head. Remove O-ring seal (27) and O-ring seal (28) from bypass tube (25).

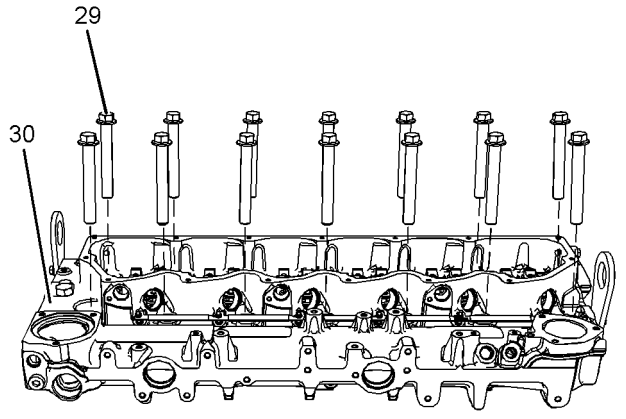


Illustration 405 g02206215

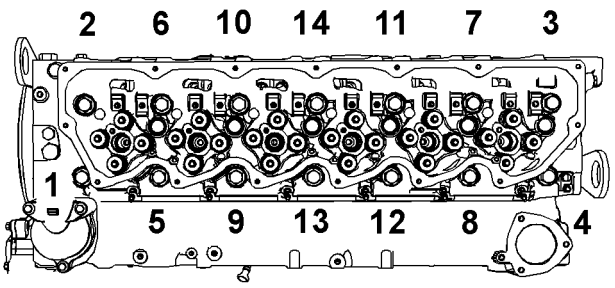


Illustration 406 g02206216

Sequence for tightening the bolts for the cylinder head

15. Gradually loosen bolts (29) in the reverse numerical order to the tightening sequence. Refer to the Illustration 406.

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

16. Remove bolts (29) from cylinder head (30).

17. Attach a suitable lifting device to cylinder head (30). Support the weight of the cylinder head. The weight of the cylinder head is approximately 96 kg (212 lb).

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

18. Use the suitable lifting device to lift cylinder head (30) 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.

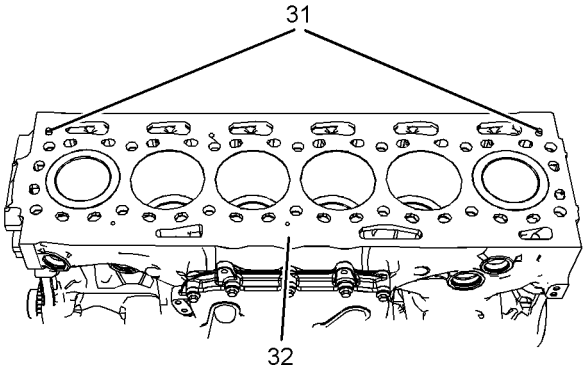


Illustration 407 g02206217

19. Remove cylinder head gasket (32).

20. Note the position of dowels (31) in the cylinder block.

21. If necessary, remove the water temperature regulator from the cylinder head. Refer to Disassembly and Assembly, “Water Temperature Regulator - Remove and Install” for the correct procedure.

i04203668

Cylinder Head - Install

Installation Procedure

Table 72

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	Guide Bolt M16 by 115mm	2
C	21825607	Degree Wheel	1
D	-	Dephi Lockheed Rubber Grease	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

1. Thoroughly clean the gasket surfaces of the cylinder head and the cylinder block. Do not damage the gasket surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.

2. Inspect the gasket surface of the cylinder head for distortion. Refer to Specifications, “Cylinder Head” for more information. If the gasket surface of the cylinder head is distorted beyond maximum permitted limits, replace the cylinder head.

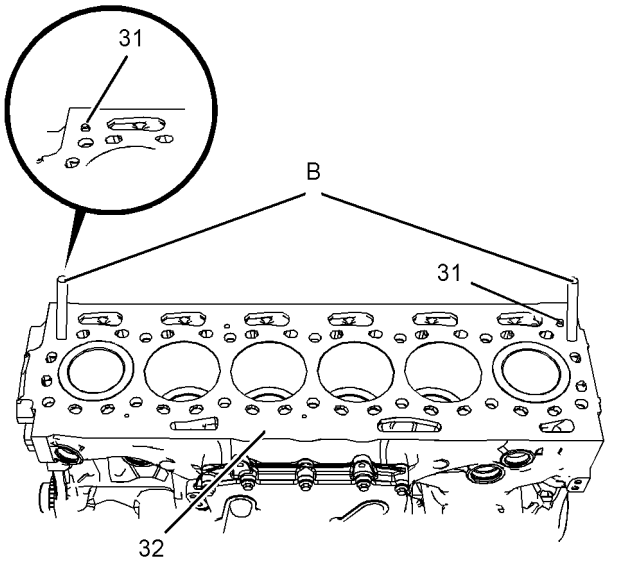


Illustration 408 g02411639

3. Inspect dowels (31) for damage. If necessary, replace the dowels in the cylinder block.

4. Align a new cylinder head gasket (32) with dowels (31). Install the new cylinder head gasket (32) onto the cylinder block.

5. Install Tooling (B) to the cylinder block.

6. Use a suitable lifting device to lift cylinder head. The weight of the cylinder head is approximately 96 kg (212 lb).

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

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

Note: Ensure that the cylinder head is correctly positioned on dowels (31).

8. Remove Tooling (B).

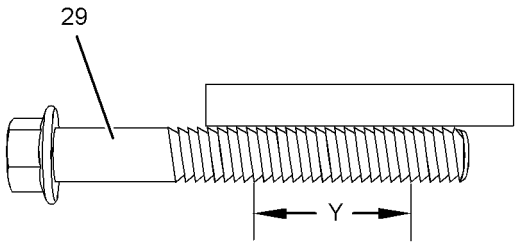


Illustration 409 g02216034

9. Clean bolts (29). Follow Step 9.a for the procedure to inspect the bolts.

   a. Use a straight edge to check the threads of the bolts. Refer to Illustration 409. Replace any bolts that show visual reduction in the diameter of the thread over Length (Y).

10. Lubricate the threads and the shoulder of bolts (29) with clean engine oil.

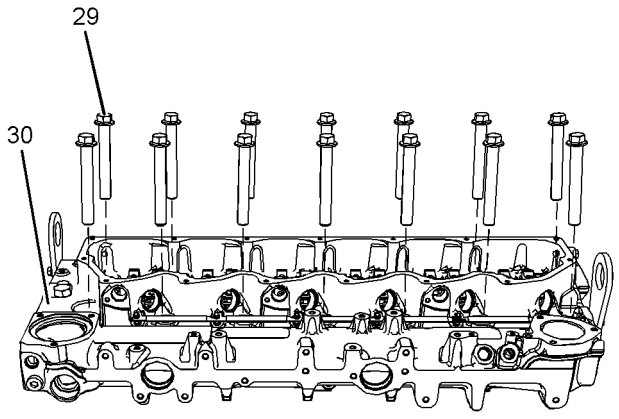


Illustration 410 g02206215

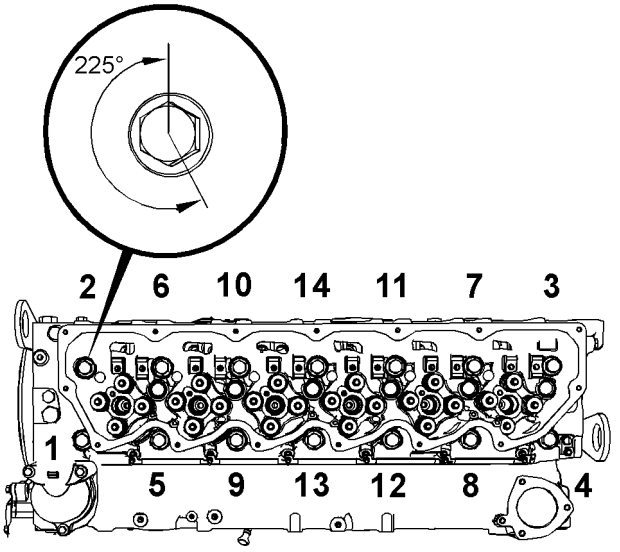


Illustration 411 g02007814

11. Install bolts (29) to cylinder head (30).

12. Tighten the bolts to a torque of 50 N·m (37 lb ft) in the numerical sequence that is shown in Illustration 411.

13. Tighten the bolts to a torque of 100 N·m (74 lb ft) in the numerical sequence that is shown in Illustration 411.

14. Use Tooling (C) in order to turn the bolts through an additional 225 degrees in the numerical sequence that is shown in Illustration 411.

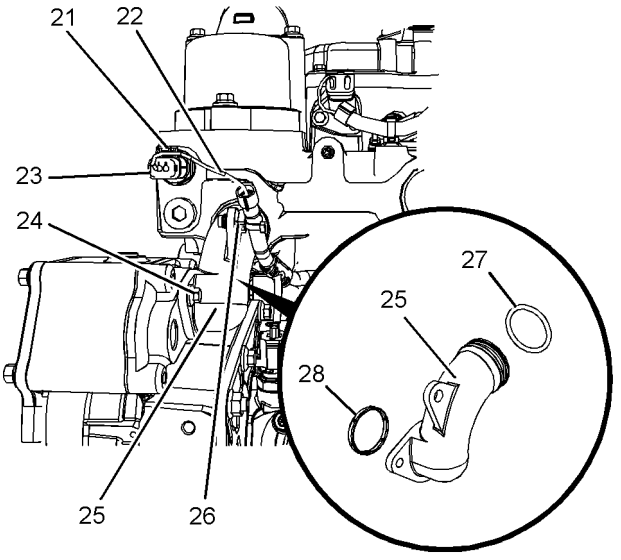


Illustration 412 g02206214

15. Use Tooling (D) in order to lubricate the O-ring seals. Install new O-ring seal (27) and O-ring seal (28) to bypass tube (25). Install the bypass tube in the cylinder head. Install bolts (24). Tighten the bolts to a torque of 9 N·m (80 lb in).

16. Follow Step 16.a through Step 16.c in order to connect harness assembly (22) to coolant temperature sensor (23).

a. Connect harness assembly (22) to coolant temperature sensor (23).

b. Slide locking tab (21) into the locked position.

c. Position harness assembly (22) onto the bypass tube and install a new cable strap (26).

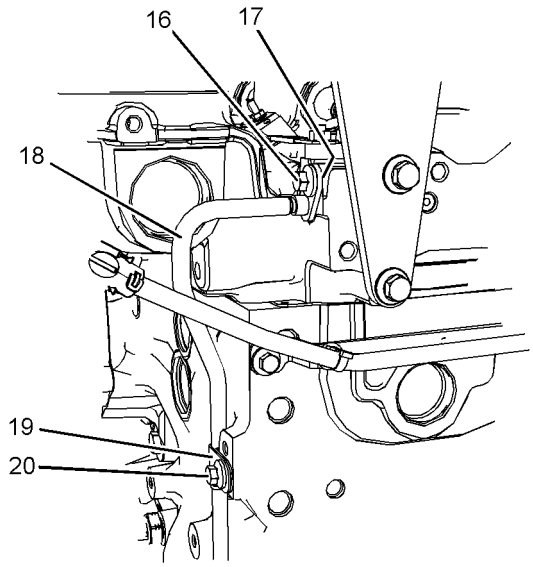


Illustration 413 g02206213

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

18. Use Tooling (C) in order to lubricate new O-ring seals (17) (not shown). Install the O-ring seal to tube assembly (18) for the fuel return from the cylinder head.

19. Install tube assembly (18) to the cylinder head.

20. Install bolt (16) finger tight.

21. Install bolt (20) to tube clip (19) finger tight.

22. Tighten bolt (16) and bolt (20) to a torque of 22 N·m (195 lb in).

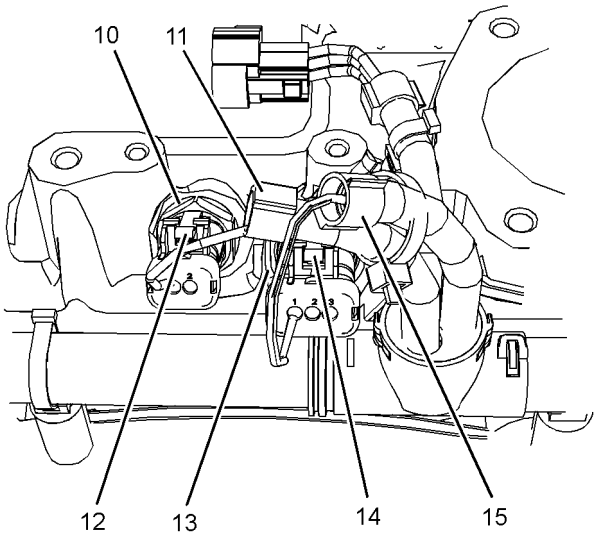


Illustration 414 g02206194

23. Follow Step 23.a through Step 23.b in order to connect harness assembly (11) to inlet air temperature sensor (10).

a. Connect harness assembly (11) to inlet air temperature sensor (10).

b. Slide locking tab (12) into the locked position.

24. Follow Step 24.a through Step 24.b in order to connect harness assembly (15) to boost pressure sensor (13).

a. Connect harness assembly (15) to boost pressure sensor (13).

b. Slide locking tab (14) into the locked position.

25. Position the harness assembly onto the cylinder head. Use new cable straps in order to secure the harness assembly to the cylinder head. Ensure that the harness assembly is not strained.

26. On some applications there is an engine wiring harness support bracket on the rear of the cylinder head. If necessary, install the support bracket for the engine wiring harness to the cylinder head assembly. Use new cable straps in order to secure the engine harness assembly to the support bracket.

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

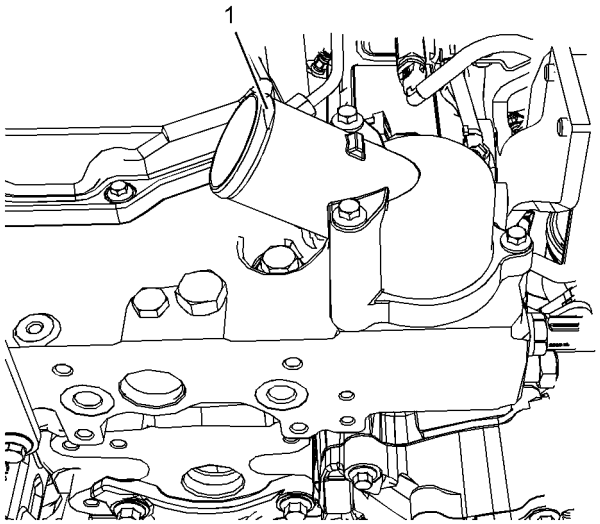


Illustration 415 g02005213
Typical example

27. If necessary, install water temperature regulator housing (1) to the cylinder head. Refer to Disassembly and Assembly, “Water Temperature Regulator Housing - Remove and Install” for the correct procedure.

28. Connect the upper radiator hose to water temperature regulator housing (1) on the cylinder head. Tighten hose clamp securely.

29. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct filling procedure.

30. 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” for the correct procedure.

End By:

a. Install the electronic unit injectors. Refer to Disassembly and Assembly, “Electronic Unit Injector - Remove” for the correct procedure.

b. Install the rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrods - Install” for the correct procedure.

c. Install the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.

d. Install the fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (rail) - Remove and Install” for the correct procedure.

e. Install the mounting bracket for the electronic control module. Refer to Disassembly and Assembly, “E. C.M. Mounting Bracket - Remove and Install” for the correct procedure.

f. If necessary, install the fuel filter base and the secondary fuel filter. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.

g. If necessary, install the water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

h. Install the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.

i04203745

Lifter Group - Remove and Install (Hydraulic Lifter Group)

Removal Procedure

Table 73

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

Start By:

a. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

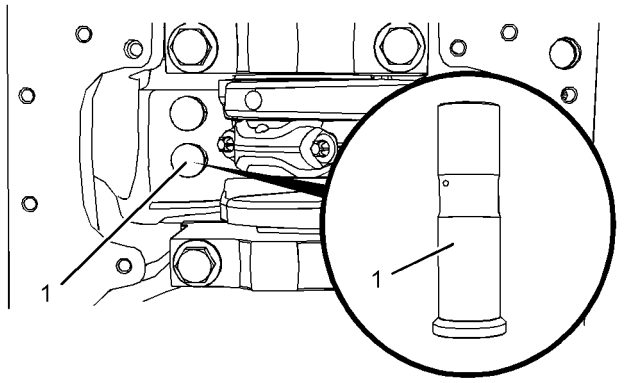


Illustration 416 g02008013

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

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

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

3. Repeat Step 1 through Step 2 in order to remove the remaining lifters.

Installation Procedure

Table 74

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Replace all lifters when a new camshaft is installed.

1. Clean the lifters. Follow Step 1.a through Step 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 and damage.

b. Inspect the shank of the lifter for wear and damage. Refer to Specifications, “Lifter Group” for more information.

c. Inspect the face of the lifter that runs on the camshaft for visual wear and damage.

2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft to allow access to the cylinder block for the installation of the appropriate lifters (1).

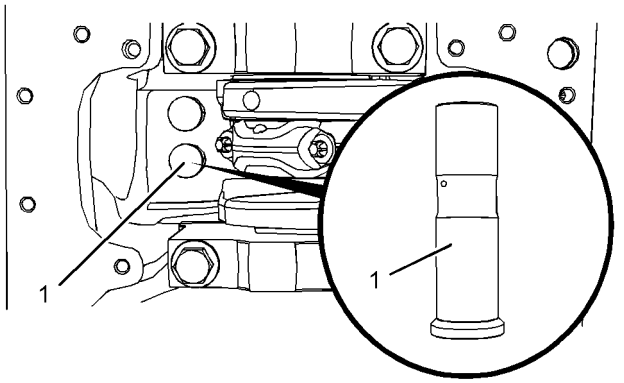


Illustration 417 g02008013

3. Lubricate lifters (1) with clean engine oil.

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

Note: The lifters should be free to rotate.

5. Repeat Step 1 through Step 4 in order to install the remaining lifters.

End By:

a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.

i04203647

Camshaft - Remove and Install

Removal Procedure

Start By:

a. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove” for the correct procedure.

b. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

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.

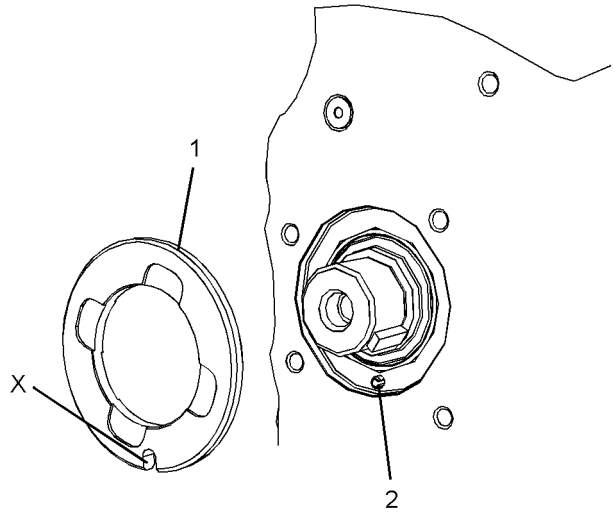


Illustration 418 g02311154

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

Note: The thrust washer has one Slots (X).

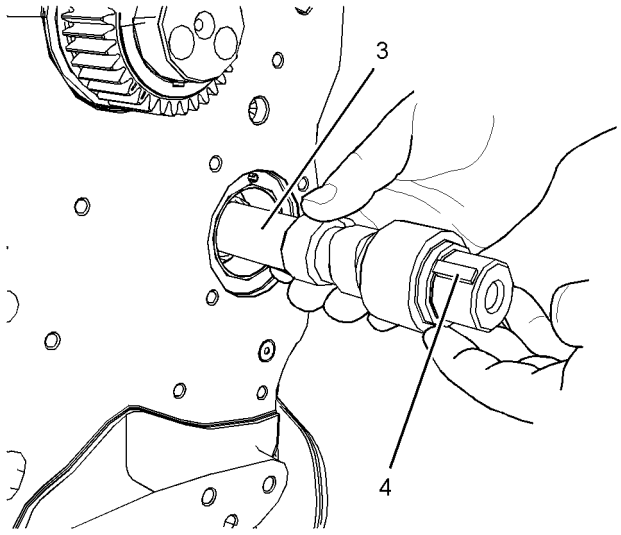


Illustration 419 g02009035

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

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

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

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the camshaft and the thrust washer. Inspect the camshaft and the thrust washer for wear and for damage. Refer to Specifications, “Camshaft” for more information. Replace any components that are worn or damaged.

2. Clean the camshaft bearing in the cylinder block. Inspect the camshaft bearing for wear and for damage. Refer to Specifications, “Camshaft Bearings” for more information. If necessary, replace the camshaft bearing. Refer to Disassembly and Assembly, “Camshaft Bearing - Remove and Install”.

NOTICE
Replace all lifters when a new camshaft is installed.

3. Inspect the lifters for wear and for damage. Refer to Specifications, “Lifter Group” for more information. Replace any lifters that are worn or damaged. Refer to Disassembly and Assembly, “Lifter Group - Remove and install” for the correct procedure.

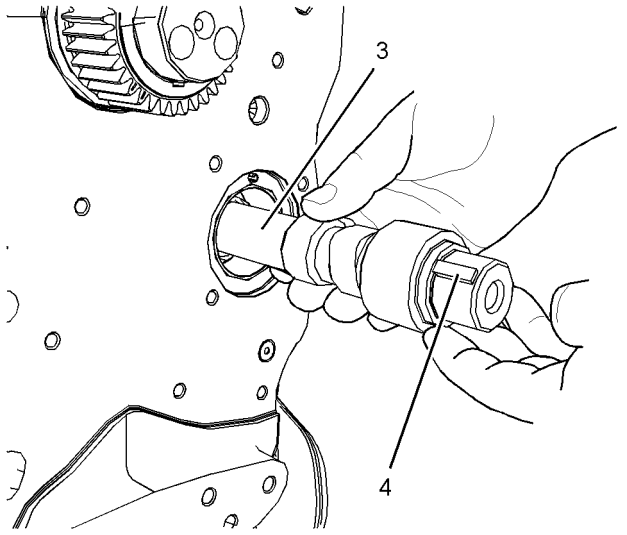


Illustration 420 g02009035

4. If necessary, install a new key (4) into camshaft (3).

5. Lubricate the bearing surfaces of camshaft (3) and lubricate the lobes of the camshaft with clean engine oil.

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

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

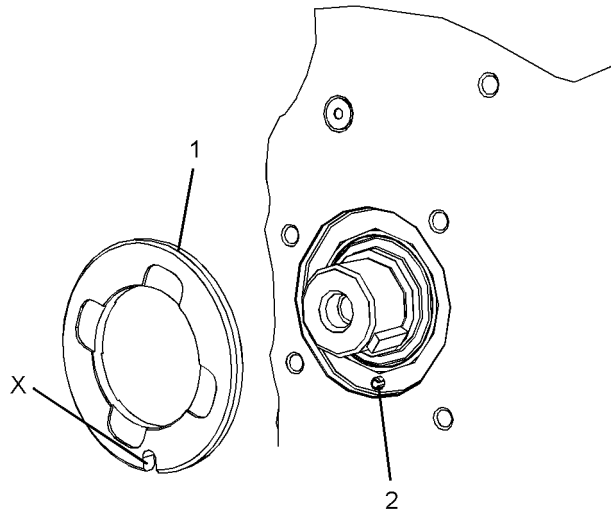


Illustration 421 g02311154

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

Note: The thrust washer has one Slots (X).

End By:

a. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

b. Install the rockershaft and pushrods. Refer to Disassembly and Assembly, “Rocker shaft and Pushrod - Install” for the correct procedure.

i04203649

Camshaft Gear - Remove and Install

Removal Procedure

Table 75

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T40-0015	Fuel Injection Pump Timing Pin	1
E	27610286	Timing Pin (Crankshaft)	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

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

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

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

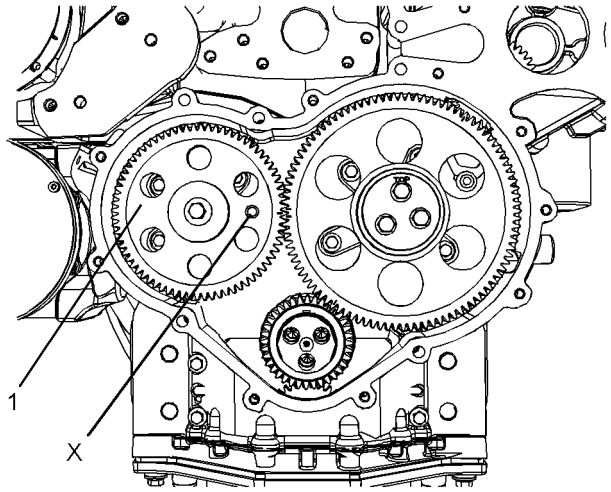


Illustration 422 g02009113

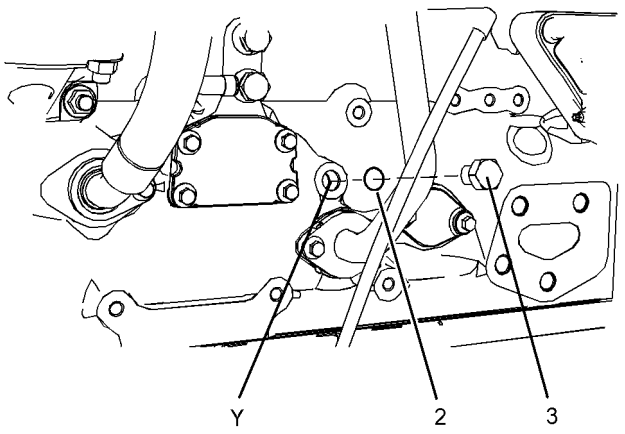


Illustration 423 g02009114

2. Install Tooling (C) through Hole (X) in camshaft gear (1) into the front housing. Use Tooling (C) in order to locate the camshaft in the correct position.

3. Remove plug (3) from the cylinder block. Remove O-ring seal (2) from the plug.

4. Install Tooling (E) into Hole (Y) in the cylinder block. Use Tooling (E) in order to lock the crankshaft in the correct position.

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

5. Use Tooling (D) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

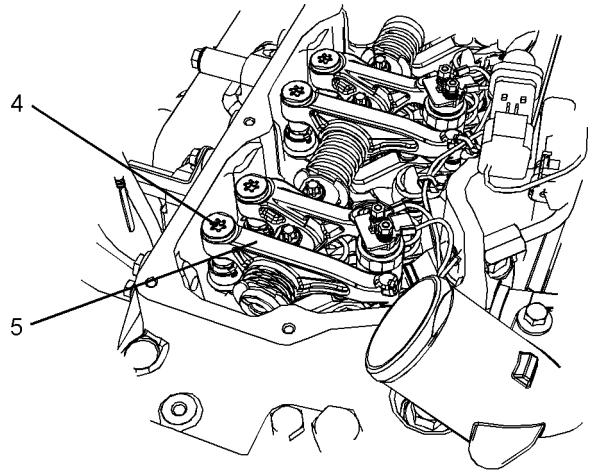


Illustration 424 g02009115

6. Use Tooling (B) in order to loosen threaded inserts (4) on all rocker arms (5). Unscrew threaded inserts (4) on all rocker arms (5) until all valves are fully closed.

Note: Ensure that all threaded inserts are fully unscrewed.

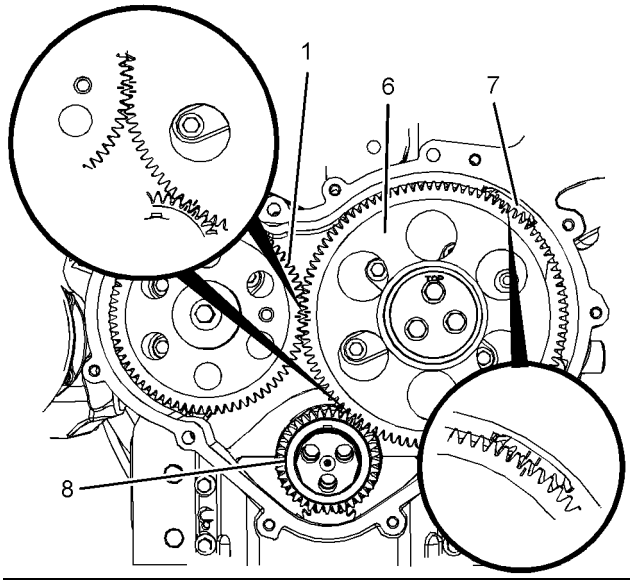


Illustration 425 g02009116

Alignment of timing marks

7. Mark gear (1), gear (6), gear (7) and gear (8) in order to show alignment. Refer to Illustration 425.

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

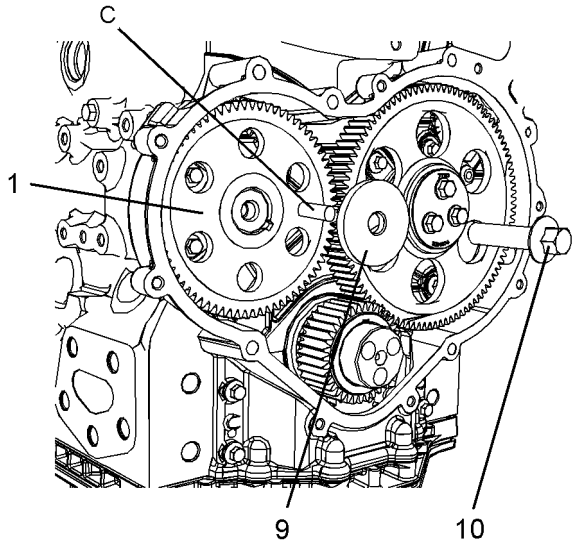


Illustration 426 g02009117

8. Remove Tooling (C), Tooling (D), and Tooling (E).

9. Remove bolt (10) and washer (9) from camshaft gear (1)

10. Remove camshaft gear (1) from the camshaft.

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

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

Installation Procedure

Table 76

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T400015	Fuel Injection Pump Timing Pin	1
E	27610286	Timing Pin (Crankshaft)	1
F	21825496	Indicator Bracket	1
	21825617	Dial Indicator	1
	-	Indicator Contact Point	1
	-	Universal Attachment	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

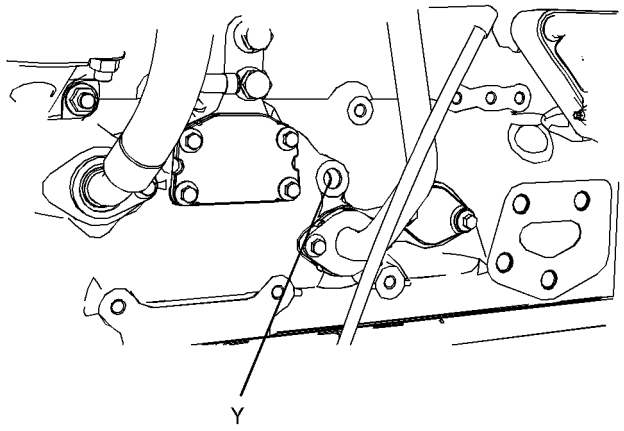


Illustration 427 g02009353

2. Ensure that Tooling (E) is installed in Hole (Y) in the cylinder block. Use Tooling (E) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

3. Use Tooling (D) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, “Fuel Injection Pump - Install” for the correct procedure.

4. Ensure that the camshaft gear and the key are clean and free from wear and damage.

5. If necessary, install the key into the nose of the camshaft.

Note: Ensure that the key is squarely seated.

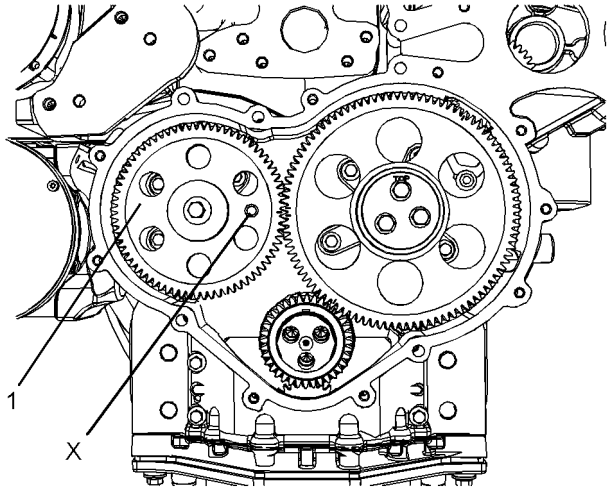


Illustration 428 g02009113

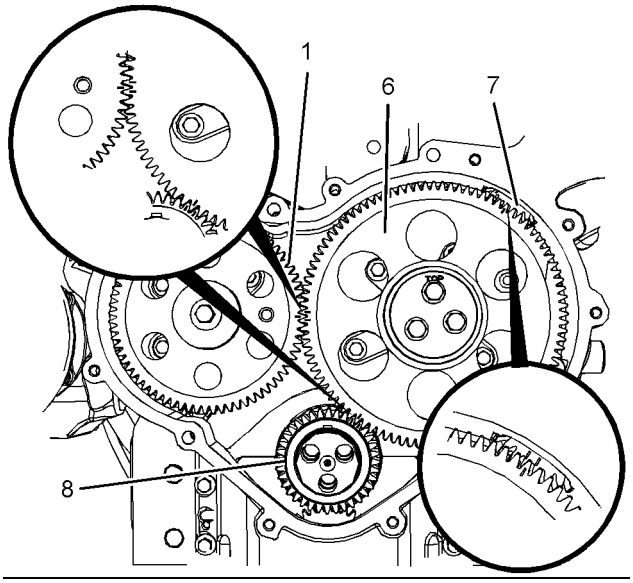


Illustration 429 g02009116

Alignment of timing marks

6. Align the keyway in camshaft gear (1) with the key in the camshaft. Install the camshaft gear onto the camshaft. Ensure that the timing marks on gear (1), gear (6), gear (7) and gear (8) are in alignment. Refer to Illustration 429.

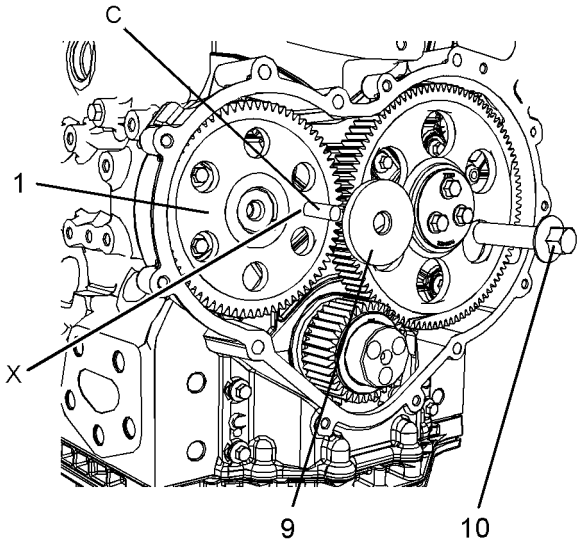


Illustration 430 g02352702

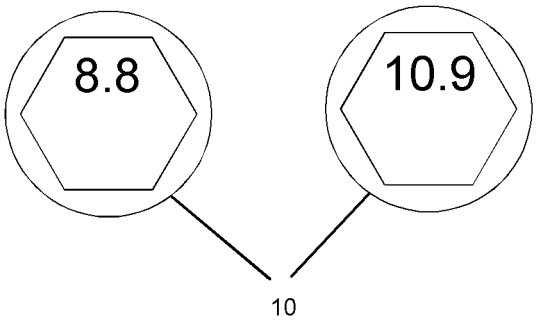


Illustration 431 g02352694

7. Install Tooling (C) through Hole (X) in the camshaft gear into the front housing.

8. Install washer (9) and bolt (10) to camshaft gear (1).

9. Remove Tooling (E), Tooling (D), and Tooling (C).

10. When a 8.8 Graded bolt (10) is installed. Tighten the bolt to a torque of 95 N·m (70 lb ft).

When a 10.9 Graded bolt (10) is installed. Tighten the bolt to a torque of 120 N·m (89 lb ft).

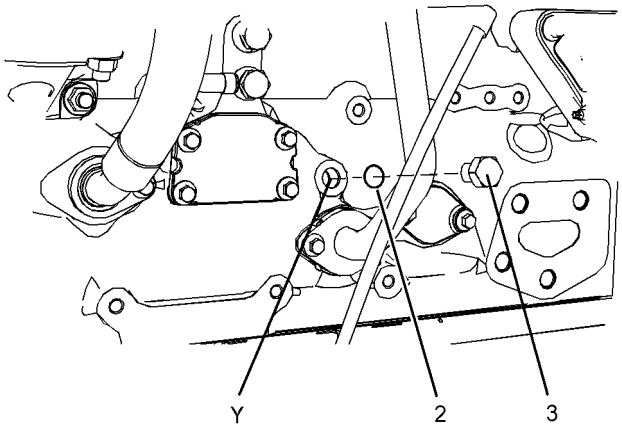


Illustration 432 g02009114

11. Install a new O-ring seal (2) to plug (3). Install the plug into Hole (Y) in the cylinder block. Refer to Illustration 432. Tighten plug (3) to a torque of 21 N·m (186 lb in).

12. Use Tooling (F) in order to measure the backlash for gear (1), gear (6), gear (7) and gear (8). Refer to Specifications, “Gear Group (Front)” for further information.

13. Use Tooling (F) in order to measure the end play of camshaft gear (1). Refer to Specifications, “Camshaft” for further information.

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

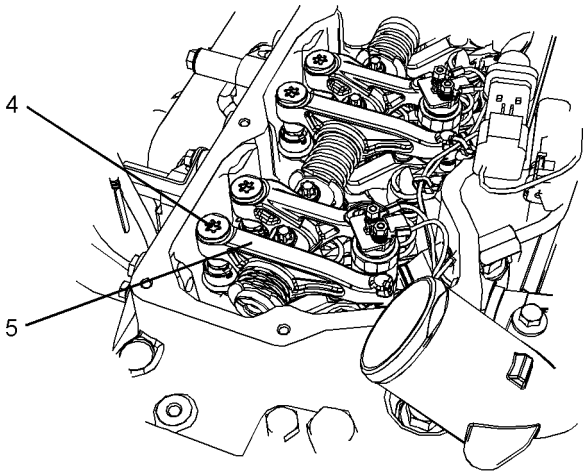


Illustration 433 g02009115

15. Use Tooling (B) in order to tighten threaded inserts (4) on all rocker arms (5). Tighten the threaded inserts to a torque of 30 N·m (266 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly into the cup for the pushrod.

End By:

a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.

b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i04203648

Camshaft Bearings - Remove and Install

Removal Procedure

Table 77

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

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

b. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

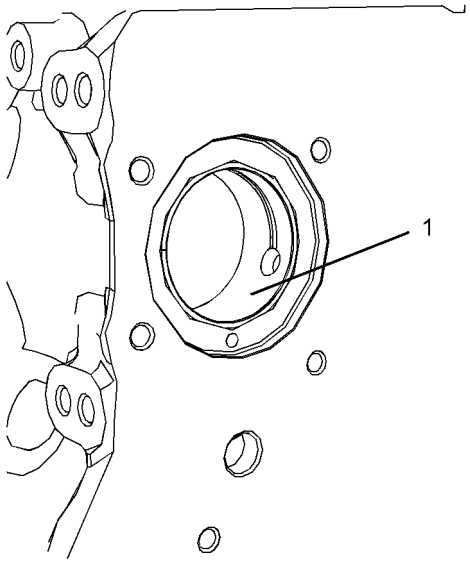


Illustration 434 g02010213

1. Inspect camshaft bearing (1). Refer to Specifications, “Camshaft Bearings” for more information.

2. If camshaft bearing (1) is worn or damaged, use Tooling (A) in order to remove the camshaft bearing from the cylinder block.

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

Installation Procedure

Table 78

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

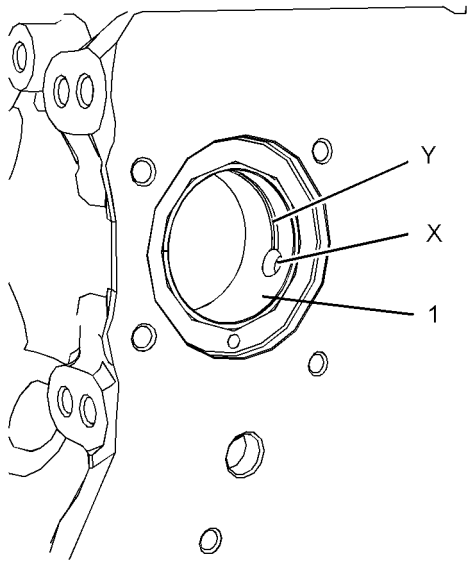


Illustration 435 g02010216

2. Lubricate the bearing housing in the cylinder block with clean engine oil.

3. Accurately align large oil Hole (X) in camshaft bearing (1) with the oil hole in the cylinder block.

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

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

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

End By:

a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.

i04203688

Engine Oil Pan - Remove (Aluminum Oil Pan)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

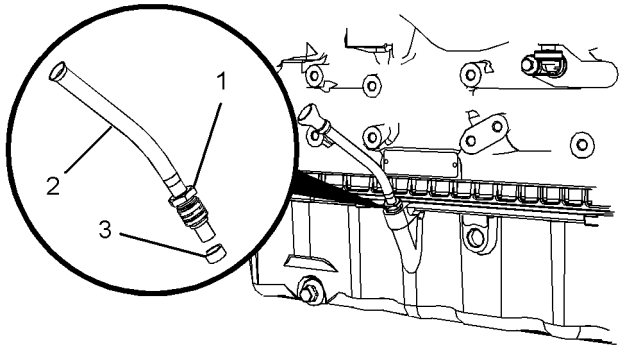


Illustration 436 g02010294

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

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

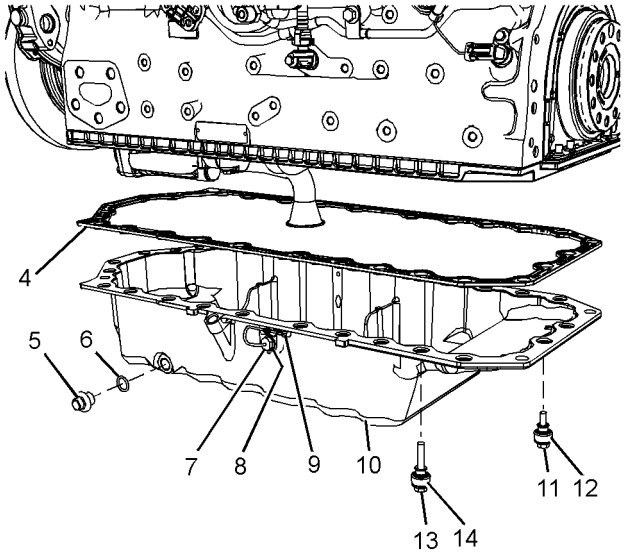


Illustration 437 g02352666

2. Place a suitable container below engine oil pan (10). Remove drain plug (5) and drain the engine oil. Refer to the Operation and Maintenance Manual, “Engine Oil and Filter - Change” for the correct procedure.

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

4. Remove the cable strap that retains wiring harness assembly (9).

5. Disconnect the Original Equipment Manufactures (OEM) wiring harness assembly from wiring harness assembly (9) for oil level switch (7).

6. If necessary, remove oil level switch (7) from engine oil pan (10). Remove O-ring seal (8) from oil level switch (7).

7. Support the assembly of engine oil pan (10). Remove bolts (13) and bolts (11) from the assembly of the engine oil pan.

8. Remove the assembly of engine oil pan (10) from the engine.

9. Remove isolators (14) and isolators (12) from the engine oil pan.

Note: The isolators are held captive by gasket (4).

10. If necessary, remove the plate for the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove and Install” for the correct procedure.

i04203687

Engine Oil Pan - Install (Aluminum Oil Pan)

Installation Procedure

Table 79

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 100 mm	4
B	-	Loctite 575 Sealant	-

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. If necessary, install the plate for the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan Plate - Remove and Install” for the correct procedure.

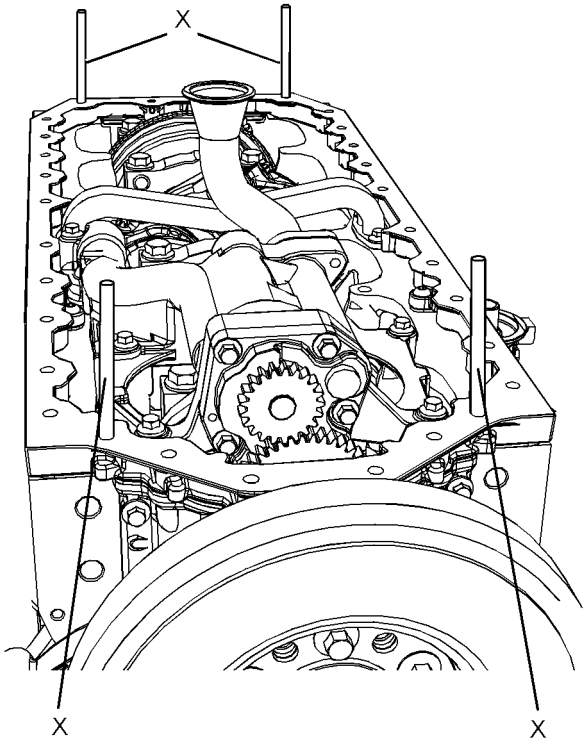


Illustration 438 g02010373

2. Install Tooling (A) to Positions (X) in the cylinder block.

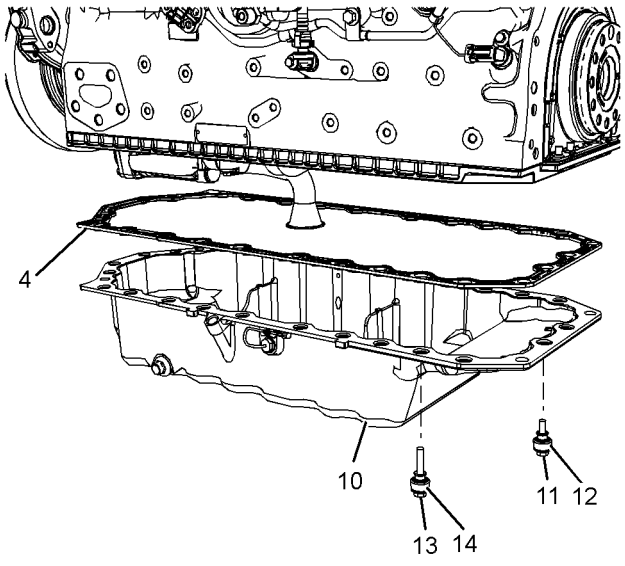


Illustration 439 g02383016

3. Ensure that engine oil pan (10) is clean and free from damage.

4. Position a new gasket (4) onto engine oil pan (10).

5. Install new isolators (14) and isolators (12) to the engine oil pan. Do not install the isolators (12) in Positions (X). Refer to Illustration 438.

Note: The isolators are held captive by the gasket.

6. Ensure that the gasket surface of the isolating frame is clean and from damage.

7. Align the assembly of the engine oil pan with Tooling (A). Install the assembly of the engine oil pan to the isolating frame.

8. Install bolts (13) and bolts (11) to the isolators finger tight.

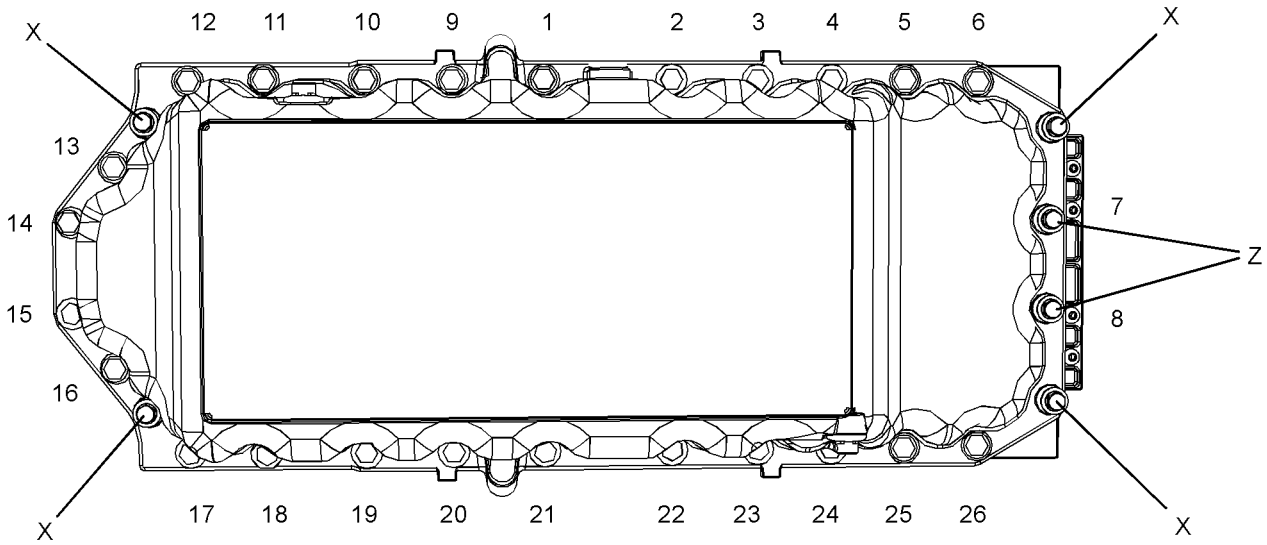


Illustration 440 g02010374

(X) Position of guide studs.

(Z) Position of short bolts.

Sequence for tightening the bolts

9. Tighten bolts (13) and bolts (11) to a torque of 22 N·m (195 lb in). Tighten the bolts in the sequence that is shown in Illustration 440.

10. Remove Tooling (A).

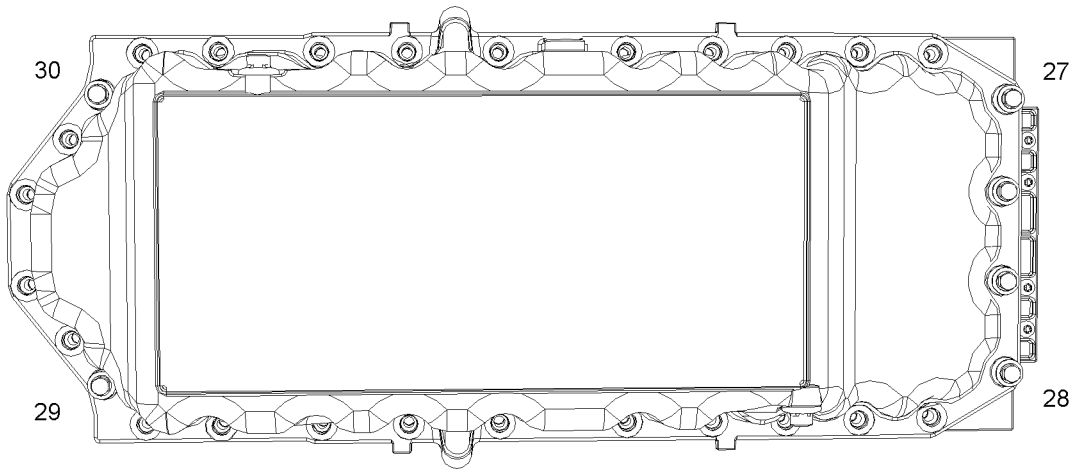


Illustration 441 g02010375

Sequence for tightening the bolts

11. Install the four remaining bolts (11). Tighten the isolating screws to a torque of 22 N·m (195 lb in). Tighten the bolts in the sequence that is shown in Illustration 441.

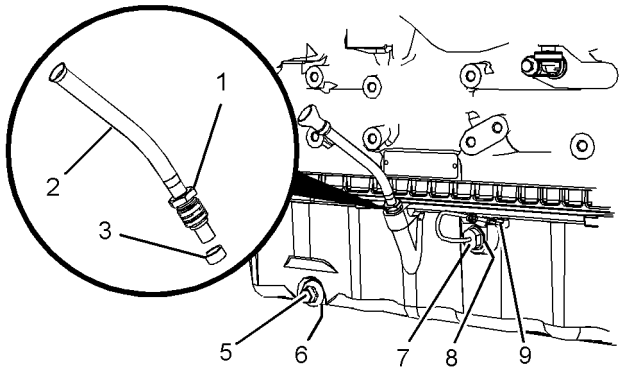


Illustration 442 g02382976

12. Install a new O-ring seal (6) (not shown) to drain plug (5). Install drain plug (5) to engine oil pan (7). Refer to Illustration 439. Tighten the oil drain plug to a torque of 34 N·m (301 lb in).

13. If necessary, follow Step 13.a through Step 13.c in order to install the assembly of the dipstick tube.

a. Install a new seal (3) to tube assembly (2).

b. Apply Tooling (B) to nut (1). Install the tube assembly to the engine oil pan.

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

c. Tighten nut (1) to a torque of 18 N·m (159 lb in).

14. If necessary, follow Step 14.a through Step 14.c in order to install oil level switch (7) to engine oil pan (10).

a. Install a new O-ring seal (8) (not shown) to oil level switch (7).

b. Install oil level switch (7) to engine oil pan (10). Tighten the oil level switch to a torque of 34 N·m (301 lb in).

c. Connect the Original Equipment Manufactures (OEM) wiring harness to wiring harness assembly (9) for oil level switch (7). Install a new cable strap to the wiring harness assembly.

Note: Ensure that the cable strap meets the OEM specification.

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

i04203689

Engine Oil Pan Plate - Remove and Install (Aluminum Oil Pan)

Removal Procedure

Table 80

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

Start By:

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

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

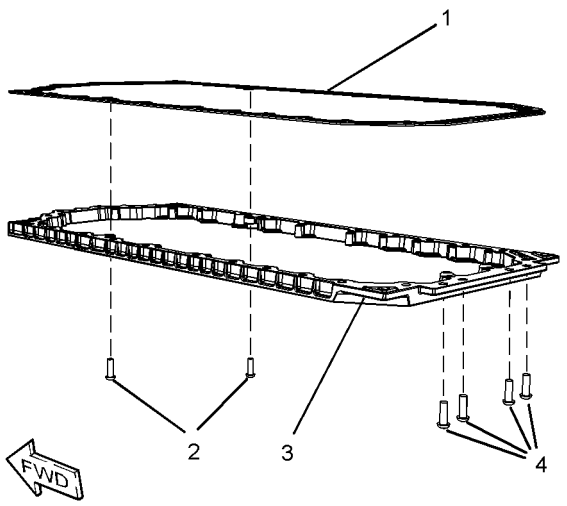


Illustration 443 g02011517

1. Support isolating frame (3). Use Tooling (A) to remove Torx screws (2) and Torx screws (4).

2. Remove isolating frame (3) from the cylinder block.

3. Remove gasket (1).

Installation Procedure

Table 81

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	T40 Torx Socket	1
B	-	Guide Stud M8 by 100 mm	4

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.

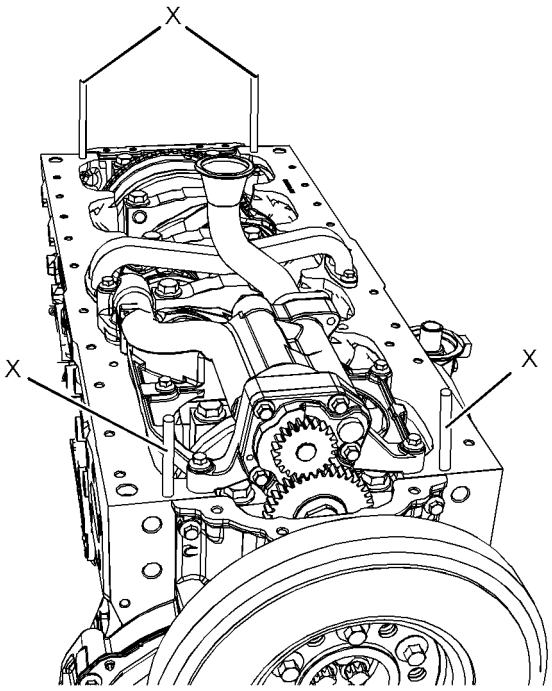


Illustration 444 g02011518

1. Ensure that the gasket surface of the cylinder block is clean and free from damage.
2. Install Tooling (B) to Positions (X) in the cylinder block.
3. Ensure that the isolating frame is clean and free from damage. If necessary, replace the isolating frame.

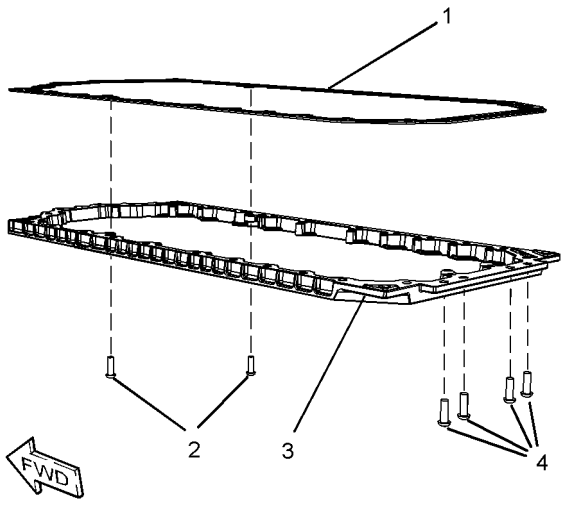


Illustration 445 g02011517

4. Position a new gasket (1) onto isolating frame (3).
5. Align isolating frame (3) with Tooling (B). Install the isolating frame to the cylinder block.
6. Use Tooling (A) to install Torx screws (2) and Torx screws (4) to the isolating frame finger tight.
7. Tighten Torx screws (2) and Torx screws (4) to a torque of 22 N·m (195 lb in).

End By:

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

b. Install the flywheel housing. Refer to Disassembly and Assembly, “Flywheel Housing - Remove and Install” for the correct procedure.

i04203746

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 82

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

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.

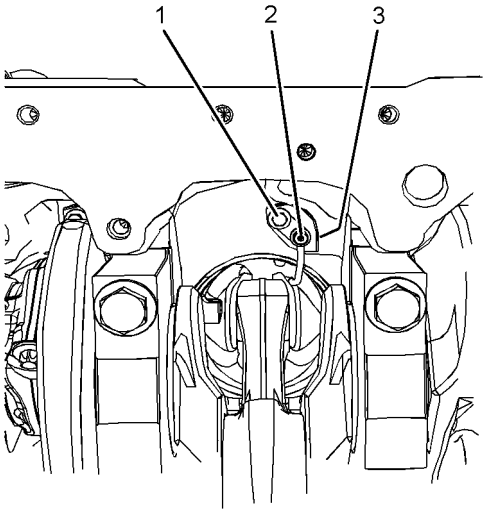


Illustration 446 g02011713

2. Remove bolt (1) and piston cooling jet (2) from the cylinder block. Remove O-ring seal (3) (not shown).

3. Repeat Step 1 through Step 2 in order to remove the remaining piston cooling jets.

Installation Procedure

Table 83

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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.

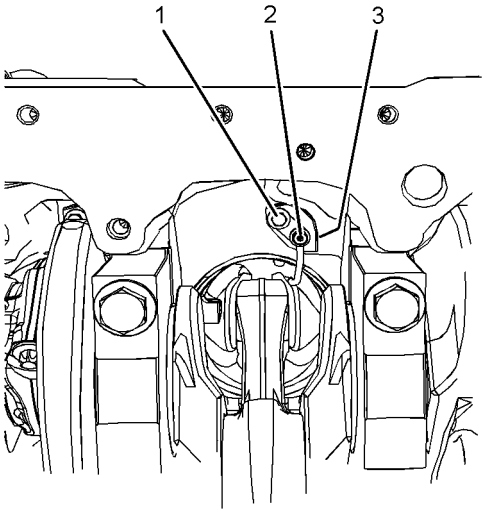


Illustration 447 g02011713

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 that the alignment of the piston cooling jets is described in Specifications, “Piston Cooling Jet Alignment” for more information.

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. Install a new O-ring seal (3) (not shown) onto piston cooling jet (2).

4. Install piston cooling jet (2) into the oil passage in the cylinder block.

Note: Ensure that the piston cooling jet is correctly installed into the oil passage in the cylinder block before tightening the bolt.

5. Install bolt (1). Tighten the bolt to a torque of 9 N·m (80 lb in).

6. Repeat Step 2 through Step 4 in order to install the remaining piston cooling jets.

End By:

a. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04203750

Pistons and Connecting Rods - Remove

Removal Procedure

Table 84

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610274	Ridge Reamer	1
C	-	E12 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

b. Remove the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install” for the correct procedure.

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.

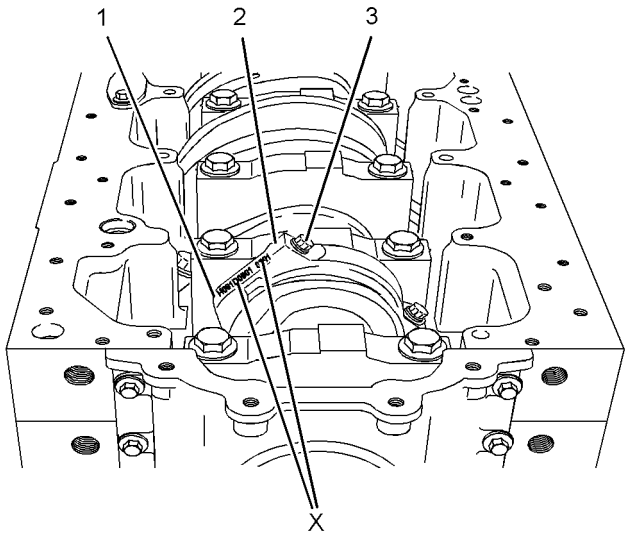


Illustration 448 g02411576

3. The connecting rod and the connecting rod cap should have an etched number in Position (X) on the side. The number on the connecting rod and the connecting rod cap must match. Ensure that connecting rod (1) and connecting rod cap (2) are marked for the correct location. If necessary, make a temporary mark on the connecting rod and the connecting rod cap in order to identify the cylinder number.

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

4. Use Tooling (C) to remove bolts (3). Remove connecting rod cap (2) from connecting rod (1).

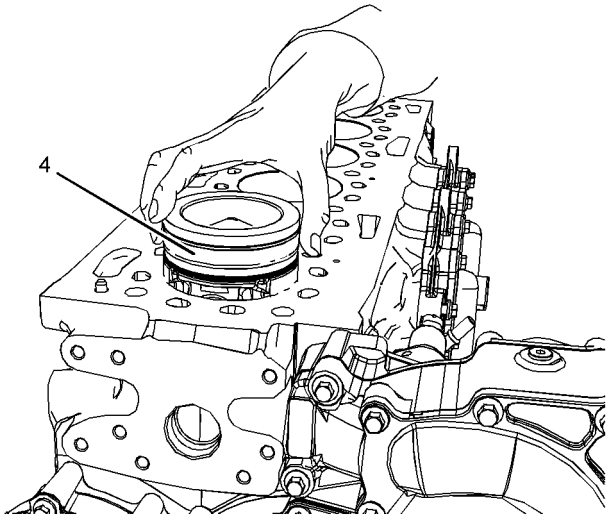


Illustration 449 g02013134

5. Carefully push piston (4) and the connecting rod out of the cylinder bore. Lift piston (4) out of the top of the cylinder block.

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

6. Repeat Step 1 through Step 5 for the remaining pistons and connecting rods.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. Temporarily install connecting rod cap (2) and bolts (3) to connecting rod (1) when the assembly is out of the engine. Ensure that the etched number on connecting rod cap matches the etched number on connecting rod . Ensure the correct orientation of the connecting rod cap . The locating tab for the upper bearing shell and the lower bearing shell should be on the same side. Tighten bolts (3) to a torque of 20 N·m (177 lb in).

i04203748

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 85

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Retaining Ring Pliers	1
B	-	Ring Expander	1

Start By:

a. Remove the pistons and the connecting rods. Refer to Disassembly and Assembly, “Piston and Connecting Rods - Remove” for the correct procedure.

Note: Make a temporary mark on the components of the piston and connecting rod assembly. Making temporary marks 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.

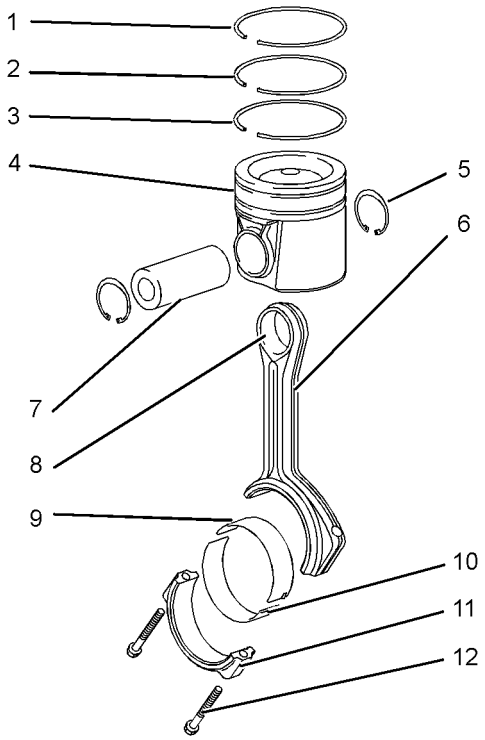


Illustration 450 g01341306

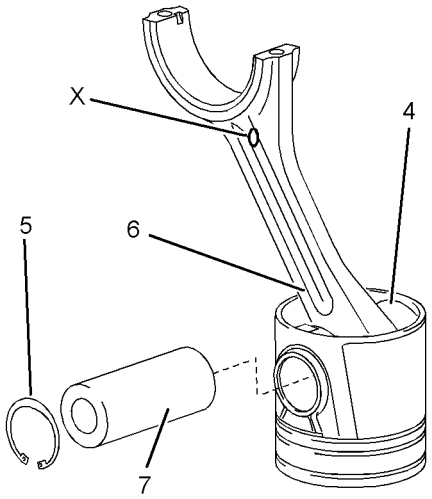


Illustration 451 g02383077

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

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

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

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

Note: Note the position of forged Mark (X). The forged mark is for the purposes of correct orientation of the connecting rod assembly and piston assembly.

4. Remove piston pin (7) and connecting rod (6) from piston (4).

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of 45 ± 5 °C (113 ± 9 °F). Do not use a torch to heat the piston. Note the orientation of connecting rod (6) and piston (4).

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

Note: Make temporary identification marks to Identify the position and orientation of compression ring (1) and compression ring (2), and oil control ring (3).

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.

6. Inspect the connecting rod for wear and damage. If necessary, replace connecting rod (6) or replace bushing (8) for piston pin (7).

Note: If the connecting rod or the bushing for the piston pin are replaced, refer to Specifications, “Connecting Rods” for more information.

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

i04203747

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 86

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Retaining Ring Pliers	1
B	-	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 and damage. If necessary, replace any components that are worn or damaged.

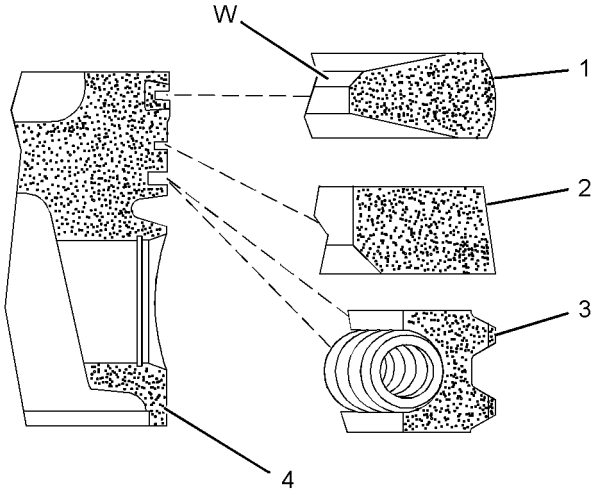


Illustration 452 g02319675

2. If the original piston is assembled, follow Step 2.a through Step 2.e in order to install the piston rings.

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

b. Position the oil control ring with the word “TOP” in the upward position. Use Tooling (B) to install oil control ring (3) over the piston and the spring.

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

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

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

Note: Ensure that the top compression ring is installed with Chamfer (W) in the upward position.

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

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

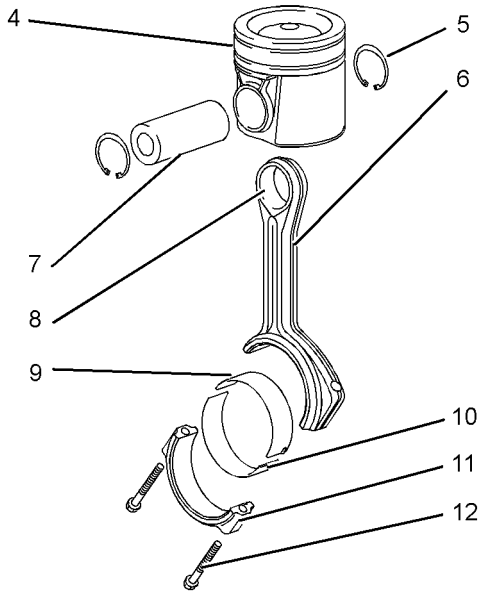


Illustration 453 g02210673

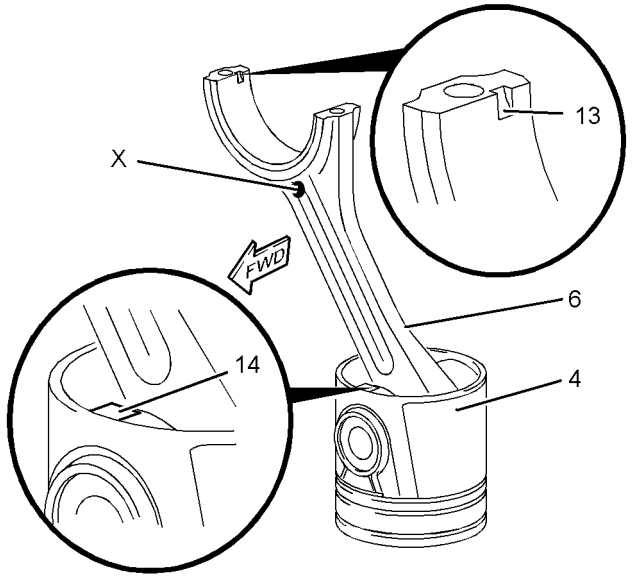


Illustration 454 g02090053

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.

3. If connecting rod assembly (6), bushing (8), and piston pin (7) are replaced, refer to Specifications, “Connecting Rods” for more information.

4. Lubricate bushing (8) for piston pin (7) in the connecting rod with clean engine oil. Lubricate the bore for the piston pin in piston (4) with clean engine oil.

5. Place piston (4) on a suitable surface with the crown downward. Position connecting rod (6) with forged Mark (X) to the square boss (14) on the piston. Ensure that slot (13) on the connecting rod is in the correct position. See Illustration 454.

6. Install piston pin (7) to piston (4).

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of 45° ± 5°C (113° ± 9°F).

7. Use Tooling (A) in order to install circlips (5) to the piston pin bore in piston (4).

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

8. Install upper bearing shell (9) into connecting rod (6). Ensure that the locating tab for the upper bearing shell is correctly seated in slot (13) in the connecting rod.

9. Install lower bearing shell (10) into connecting rod cap (11). Ensure that the locating tab for the lower bearing shell is correctly seated in the slot in the connecting rod cap.

10. Fracture split connecting rods should not be left without the connecting rod caps installed. Temporarily install connecting rod cap (11) and bolts (12) to connecting rod (6) when the assembly is out of the engine. Ensure that the etched number on connecting rod cap matches the etched number on connecting rod. Ensure the correct orientation of the connecting rod cap. The locating tab for the upper bearing shell and the lower bearing shell should be on the same side. Tighten bolts (12) to a torque of 20 N·m (177 lb in).

11. Repeat Step 2 through Step 10 for the remaining piston and connecting rod assemblies.

End By:

a. Install the pistons and the connecting rods. Refer to Disassembly and Assembly, “Piston and Connecting Rods - Install” for the correct procedure.

i04203749

Pistons and Connecting Rods - Install

Installation Procedure

Table 87

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825491	Piston Ring Compressor	1
C	-	E12 Torx Socket	1
D	21825607	Degree Wheel	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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, piston rings, outer surface of the piston, and the bearing shells for the connecting rod.

Note: Install the bearing shells for the connecting rods dry when clearance checks are performed. Refer to Disassembly and Assembly, “Bearing Clearance - Check” for the correct procedure. 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 are 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.

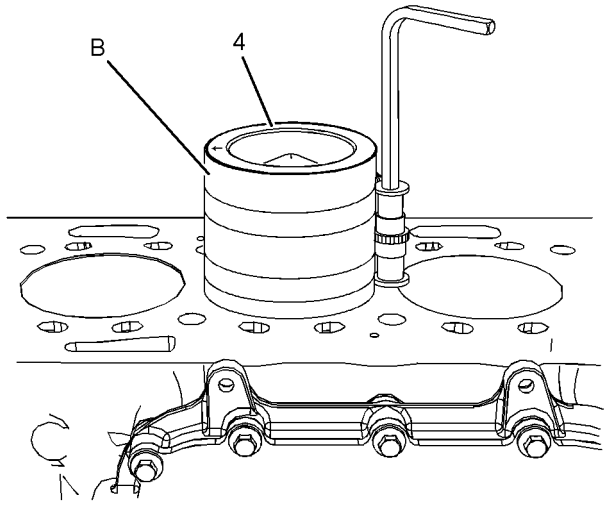


Illustration 455 g02013213

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

Note: Ensure that Tooling (B) is installed correctly and that piston (4) can easily slide from the tool.

Note: The arrow on the top of the piston must be toward the front of the engine. The locating tab for the bearing shell of the connecting rod must be on the same side of the engine as the piston cooling jet.

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

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

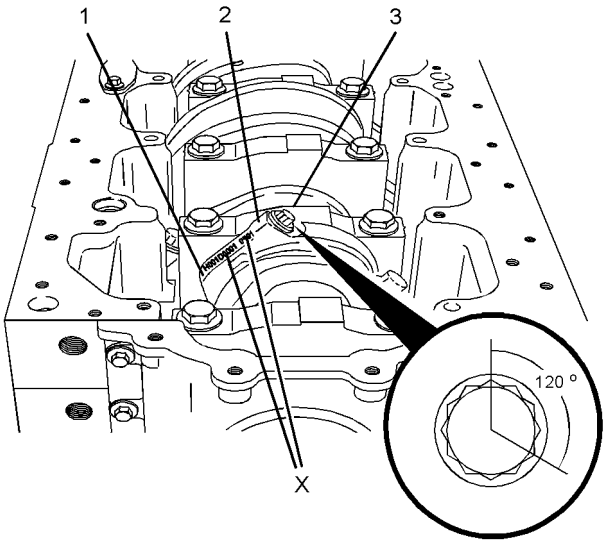


Illustration 456 g02383096

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

Note: Ensure that etched number in Position (X) on connecting rod cap (2) matches etched number in Position (X) on connecting rod (1). Ensure the correct orientation of connecting rod cap (2). The locating tab for the upper bearing shell and the lower bearing shell should be on the same side.

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

7. Install new bolts (3) to connecting rod (1). Use Tooling (C) in order to tighten the bolts evenly to a torque of 40 N·m (30 lb ft).

8. Turn the bolts for an additional 120 degrees in a clockwise direction. Use Tooling (C) and Tooling (D) to achieve the correct final torque.

9. Ensure that the installed connecting rod assembly has tactile side play. Rotate the crankshaft in order to ensure that there is no binding.

10. Repeat Step 2 through Step 9 in order to install the remaining pistons and connecting rods.

End By:

a. Install the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install” for the correct procedure.

b. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i04203654

Connecting Rod Bearings - Remove (Connecting rods in position)

Removal Procedure

Table 88

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	E12 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Discard all used Connecting Rod fasteners.

Note: If all connecting rod bearings require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 6, 2 with 5, and 3 with 4. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders**. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

1. Use Tooling (A) to rotate the crankshaft until the crankshaft pins are at the bottom center position.

If necessary, remove the glow plugs. Ref to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.

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

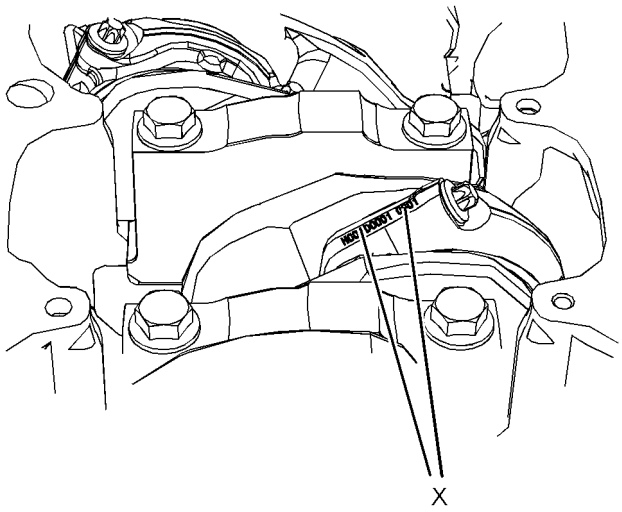


Illustration 457 g02319916
Etched number in Position (X)

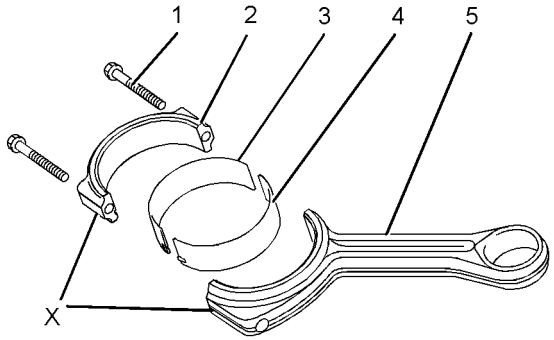


Illustration 458 g01341322

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

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

3. Use Tooling (B) in order to remove bolts (1). **Discard bolts** (1).

4. Remove connecting rod cap (2) from connecting rod (5).

5. Remove lower bearing shell (3) from connecting rod cap (2). Keep the bearing shell and the connecting rod cap together.

6. Carefully push connecting rod (5) into the cylinder bore until connecting rod (5) is clear of the crankshaft. Remove upper bearing shell (4) from the connecting rod. Keep the bearing shells together.

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

7. Repeat Step 1 through Step 6 in order to remove the remaining bearing shells.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the bearing shells is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

i04203653

Connecting Rod Bearings - Install (Connecting rods in position)

Installation Procedure

Table 89

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	E12 Torx Socket	1
C	21825607	Degree Wheel	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Discard all used Connecting Rod fasteners.

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

Note: If the bearing shells are replaced, check whether oversize bearing shells were previously installed.

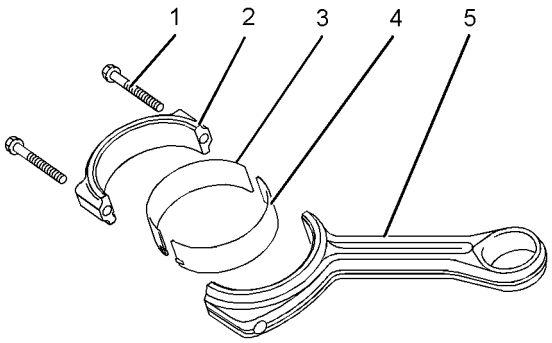


Illustration 459 g02015553

2. Install upper bearing shell (4) into connecting rod (5). Ensure that the locating tab for the upper bearing shell is correctly seated in the slot in the connecting rod.

Note: The ends of the upper bearing shell must be centered in the connecting rod. The ends of the upper bearing shell must be equally positioned in relation to the mating faces of the connecting rod.

3. Lubricate upper bearing shell (4) with clean engine oil.

4. Use Tooling (A) to rotate the crankshaft until the crankshaft pins is at the bottom dead center position.

5. Carefully pull connecting rod (5) against the crankshaft pin.

Note: Do not allow the connecting rod to contact the piston cooling jet.

6. Clean connecting rod cap (2). Install lower bearing shell (3) into connecting rod cap (2). Ensure that the locating tab for the lower bearing shell is correctly seated in the slot in the connecting rod cap.

7. Lubricate the pin of the crankshaft and lubricate lower bearing shell (3) with clean engine oil.

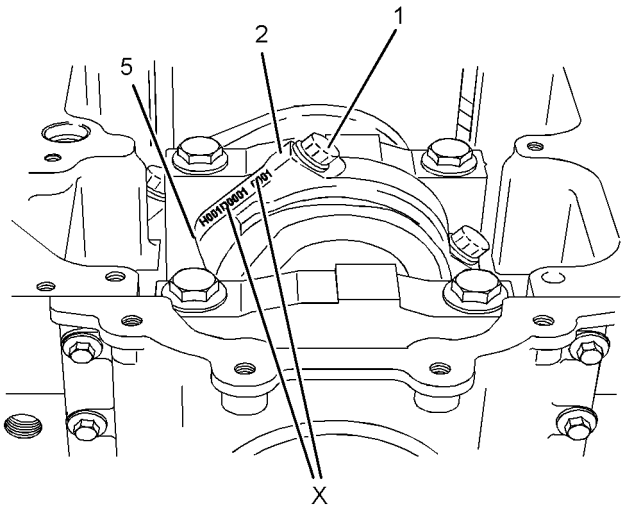


Illustration 460 g02411597
Etched number in Position (X)

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

Note: Ensure that etched number in Position (X) on connecting rod cap (2) matches etched number in Position (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.

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

9. Use Tooling (B) in order to install new bolts (1) to the connecting rod. Tighten the bolts evenly to a torque of 40 N·m (30 lb ft).

10. Turn the bolts through an additional 120 degrees in a clockwise direction. Use Tooling (B) and Tooling (C) to achieve the correct final torque.

11. Ensure that the installed connecting rod assembly has tactile side play. Rotate the crankshaft in order to ensure that there is no binding.

12. Repeat Step 2 through Step 11 in order to install the remaining connecting rod bearings.

Note: If all connecting rod bearings require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 6, 2 with 5, and 3 with 4. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders**. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

13. If the glow plugs were removed, install the glow plugs. Ref to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.

End By:

a. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04203663

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

Removal Procedure

Table 90

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400011	Crankshaft Turning Tool	1

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

b. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” for the correct procedure.

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.

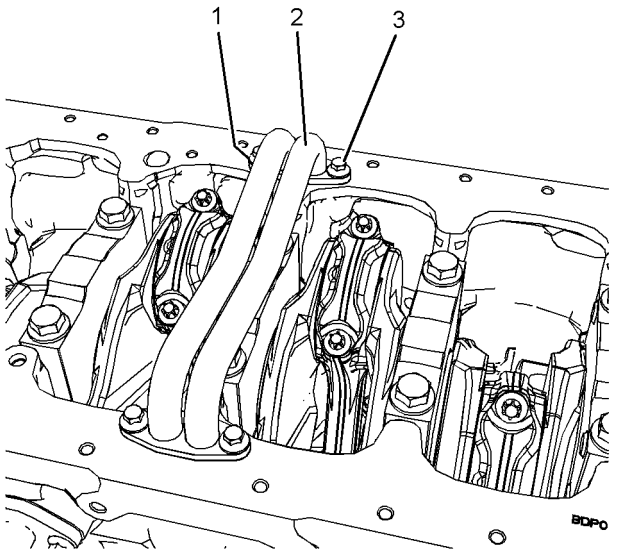


Illustration 461 g02204377

2. Remove bolts (3) from tube assembly (2).

3. Remove tube assembly (2) from the cylinder block.

4. Remove gaskets (1) (not shown).

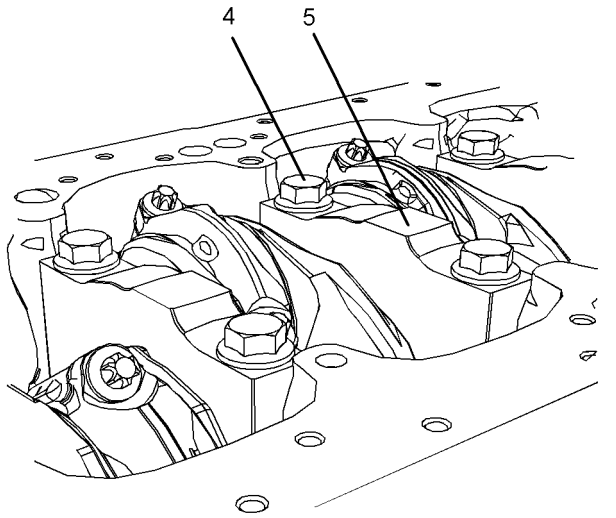


Illustration 462 g02204373

5. Remove bolts (4) and remove main bearing cap (5) from the cylinder block.

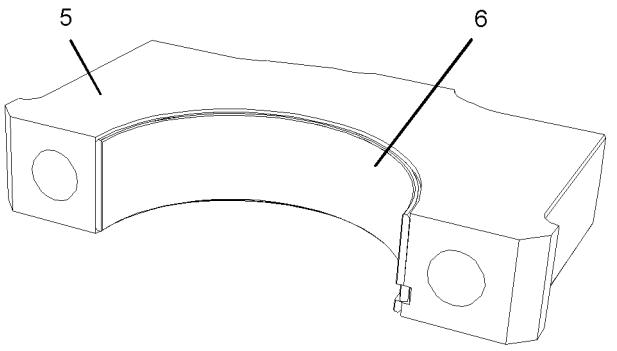


Illustration 463 g02204374

6. Remove lower main bearing shell (6) from main bearing cap (5). 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.

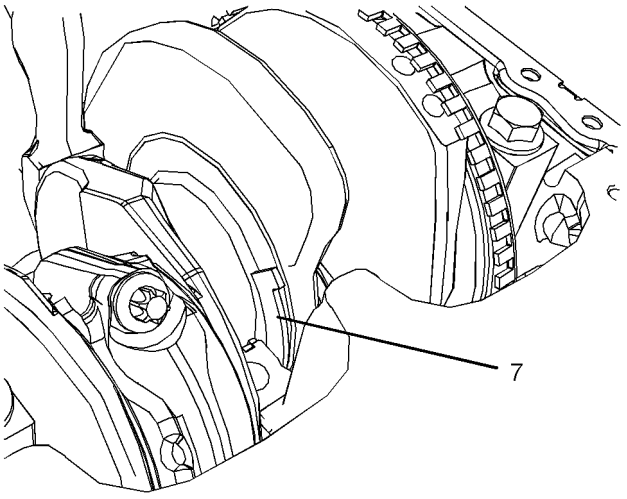


Illustration 464 g02204375

7. For number six main bearing, remove two thrust washers (7) from the cylinder block. In order to remove thrust washers (7), 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.

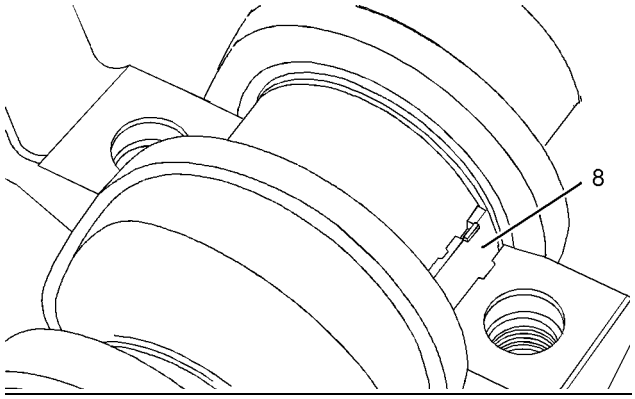


Illustration 465 g02204376

8. Push out upper main bearing shell (8) with a suitable tool from the side opposite the locating tab. Carefully rotate the crankshaft while you push on the bearing shell. Remove upper main bearing shell (8) 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 91

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	21825607	Degree Wheel	1
C	21825617	Dial Indicator	1
	21825496	Dial Indicator	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 and damage. If necessary, replace the main bearing shells.

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.

2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

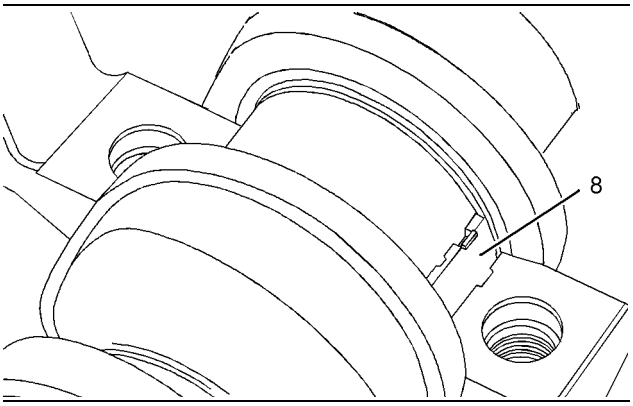


Illustration 466 g02204376

3. Lubricate the crankshaft journal and upper main bearing shell (8) with clean engine oil. Slide upper main bearing shell (8) 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.

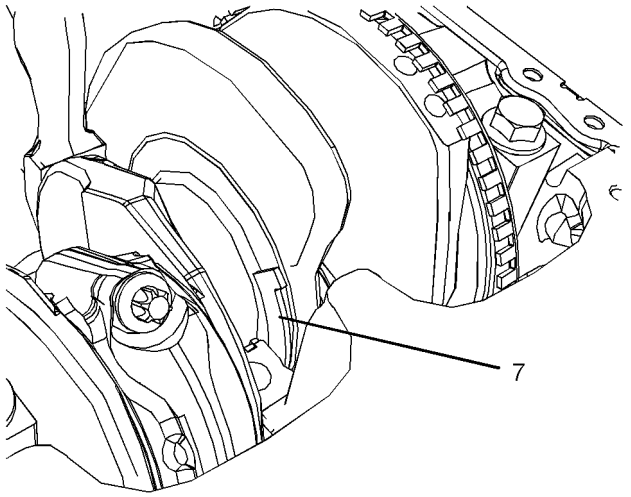


Illustration 467 g02204375

4. For number six main bearing, ensure that two thrust washers (7) are clean and free from wear and damage. If necessary, replace the thrust washers. Lubricate thrust washers (7) with clean engine oil. Slide thrust washers (7) into position between the crankshaft and the cylinder block. Ensure that the locating tab is correctly seated in the cylinder block.

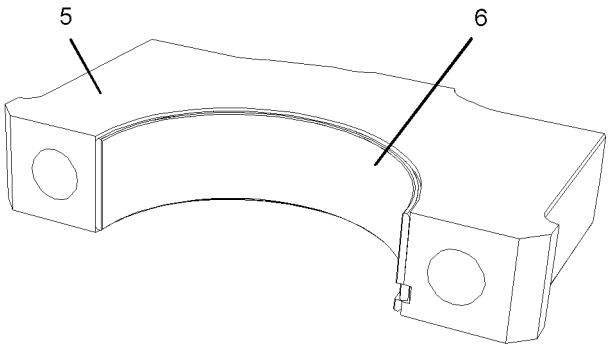


Illustration 468 g02204374

5. Install lower main bearing shell (6) into main bearing cap (5). 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.

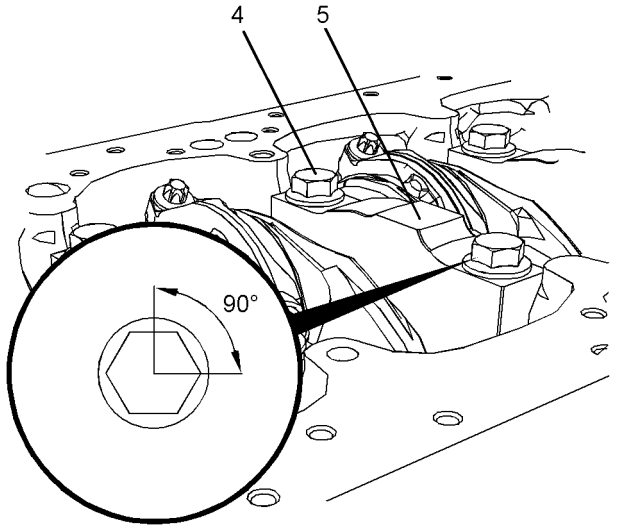


Illustration 469 g02204393

6. Lubricate the crankshaft journal and the lower main bearing shell with clean engine oil. Install main bearing cap (5) to the cylinder block.

Note: Ensure the correct orientation of the main bearing cap. The locating tab for the upper and the lower bearing should be on the same side of the engine.

7. Lubricate the threads of bolts (4) with clean engine oil. Lubricate the underside of the heads of bolts (4) with clean engine oil.

8. Install bolts (4) to main bearing cap (5). Evenly tighten the bolts in order to pull cap (5) into position. Ensure that the cap is correctly seated.

Note: Do not tap the main bearing cap into position as the bearing shell may be dislodged.

9. Tighten bolts (4) to a torque of 80 N·m (59 lb ft).

Turn bolts (4) through an additional 90 degrees. Use Tooling B to achieve the correct final torque.

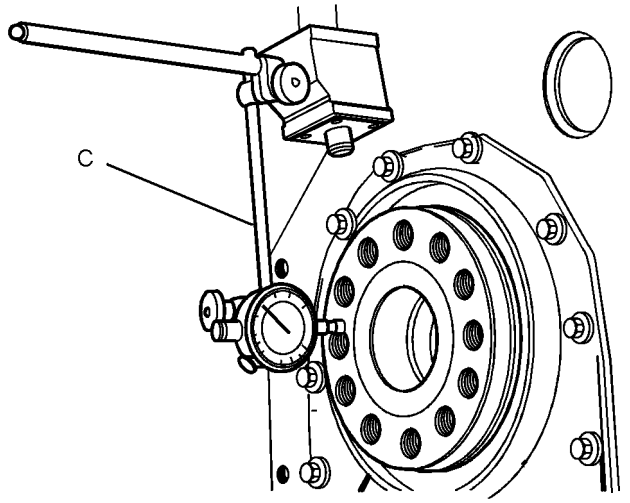


Illustration 470 g01341329

10. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (C) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (C) to measure the crankshaft end play. The permissible crankshaft end play is 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).

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

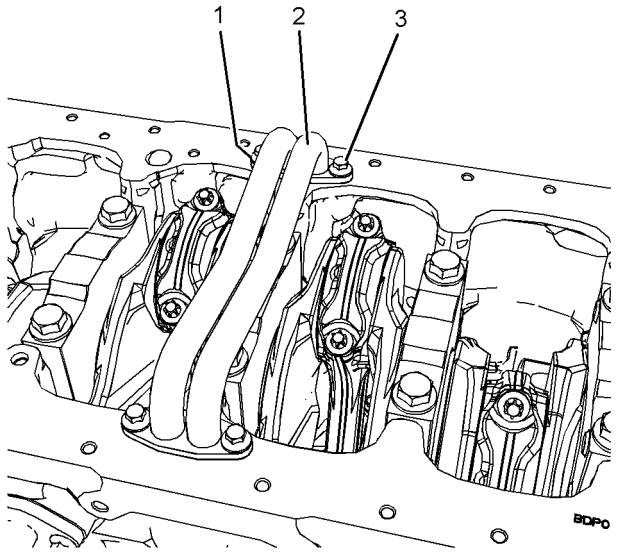


Illustration 471 g02204377

12. Position new gaskets (1) (not shown) onto the cylinder block.

13. Position tube assembly (2) onto the cylinder block.

14. Install bolts (3) to tube assembly (2).

15. Tighten bolts (3) to a torque of 22 N·m (195 lb in).

End By:

a. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

b. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04203659

Crankshaft - Remove

Removal Procedure

Table 92

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Sling	2

Start By:

a. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

b. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” for the correct procedure.

d. If necessary, remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

e. If necessary, remove the pistons and connecting rods. Refer to Disassembly and Assembly, “Pistons and Connecting Rods - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

2. If the cylinder head, the pistons and the connecting rods have not been removed already, remove the connecting rod bearings. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Remove” for the correct procedure.

3. Ensure that the main bearing caps are marked for the location and orientation.

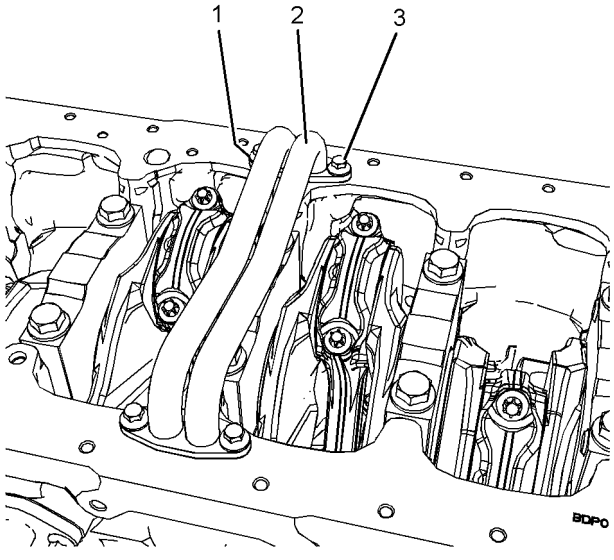


Illustration 472 g02204377

4. Remove bolts (3) from tube assembly (2).

5. Remove tube assembly (2) from the cylinder block.

6. Remove gaskets (1) (not shown).

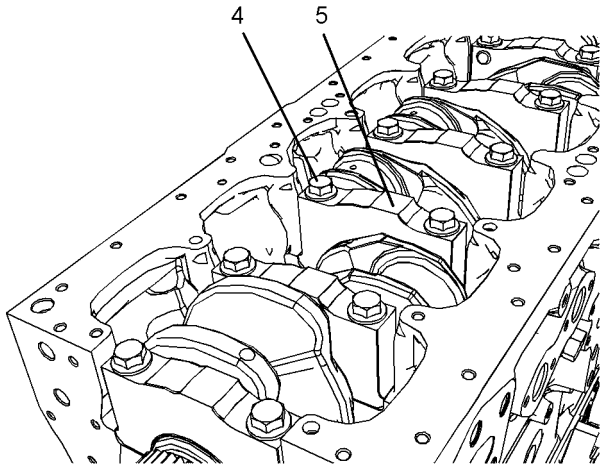


Illustration 473 g02212653

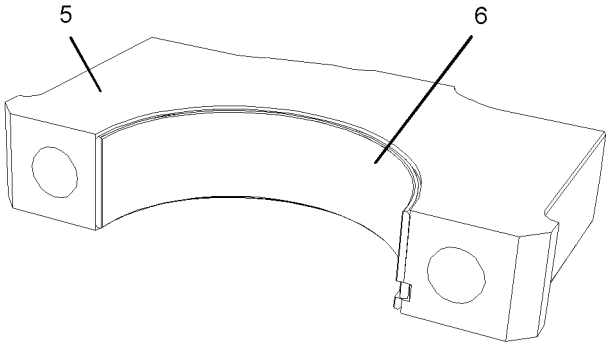


Illustration 474 g02212654

7. Remove bolts (4) and main bearing caps (5) from the cylinder block.

8. Remove lower main bearing shells (6) from main bearing caps (5). 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.

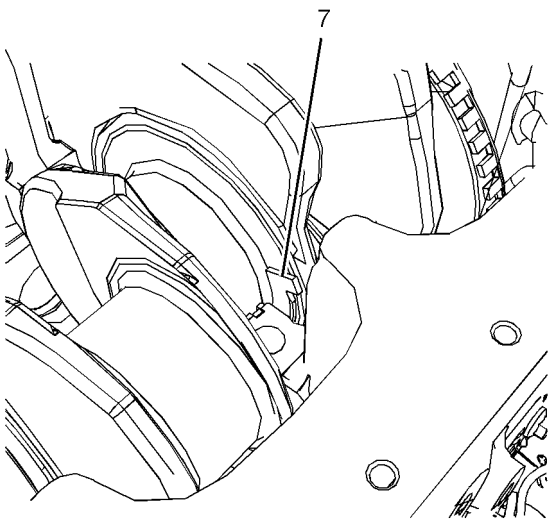


Illustration 475 g02212693

9. For number six main bearing, remove two thrust washers (7) from the cylinder block. In order to remove thrust washers (7), rotate the crankshaft in the correct direction. If necessary, push the crankshaft toward the front of the engine while you rotate the crankshaft, in order to aid removal. If necessary, 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.

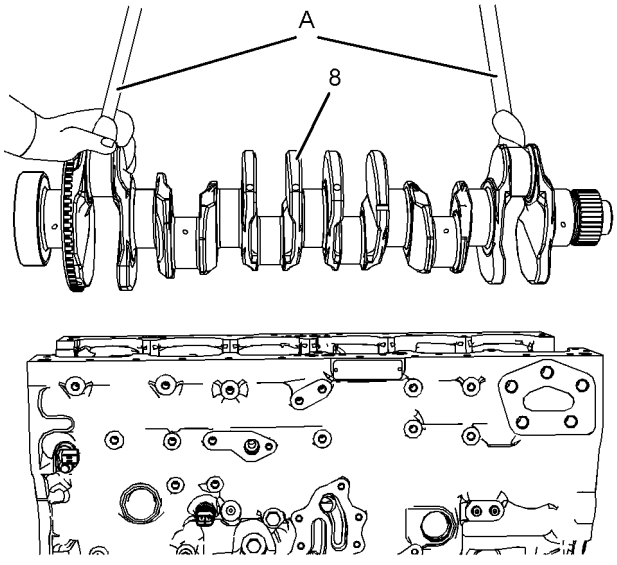


Illustration 476 g02212655

10. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Lift crankshaft (8) out of the cylinder block. The weight of the crankshaft is approximately 61 kg (134 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.

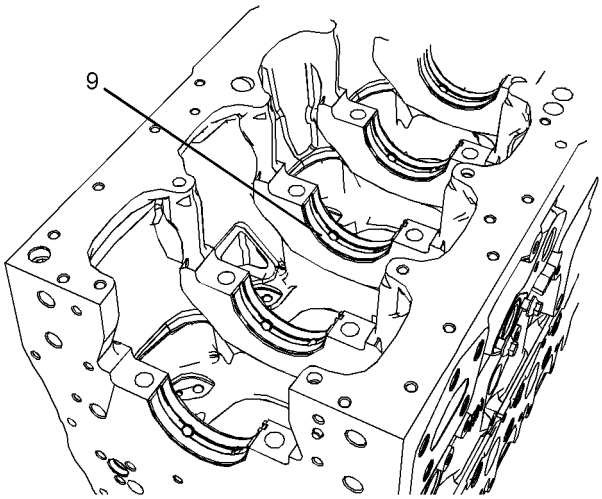


Illustration 477 g02212656

11. Remove upper main bearing shells (9) 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.

12. If necessary, remove the crankshaft timing ring. Refer to Disassembly and Assembly, “Crankshaft Timing Ring - Remove and Install” for the correct procedure.

13. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, “Crankshaft Gear - Remove and Install” for the correct procedure.

i04203658

Crankshaft - Install

Installation Procedure

Table 93

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Sling	2
B	21825607	Degree Wheel	1
C	21825617	Dial Indicator	1
	21825496	Indicator Bracket	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the crankshaft and inspect the crankshaft for wear and damage. Refer to Specifications, “Crankshaft” for more information. If necessary, replace the crankshaft or recondition the crankshaft.

2. If necessary, install the crankshaft gear. Refer to Disassembly and Assembly, “Crankshaft Gear - Remove and Install” for the correct procedure.

3. If necessary, install a new crankshaft timing ring. Refer to Disassembly and Assembly, “Crankshaft Timing Ring - Remove and Install” for the correct procedure.

4. Ensure that parent bores for bearing shells in the cylinder block are clean. Ensure that the threads for the main bearing bolts in the cylinder block are clean and free from damage.

5. Clean the main bearing shells and the thrust washers. Inspect the main bearing shells and the thrust washers for wear and 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.

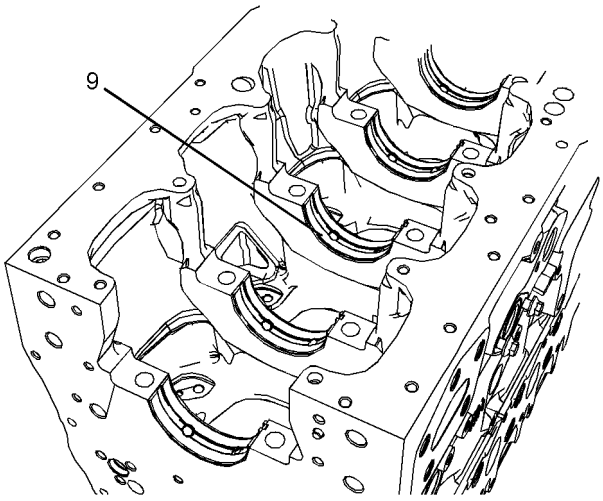


Illustration 478 g02212656

6. Install upper main bearing shells (9) to the cylinder block. Ensure that the locating tabs for the upper main bearing shells are seated in the slots in the cylinder block.

Note: The upper main bearing shells have a groove and two oil holes.

7. Lubricate upper main bearing shells (9) with clean engine oil.

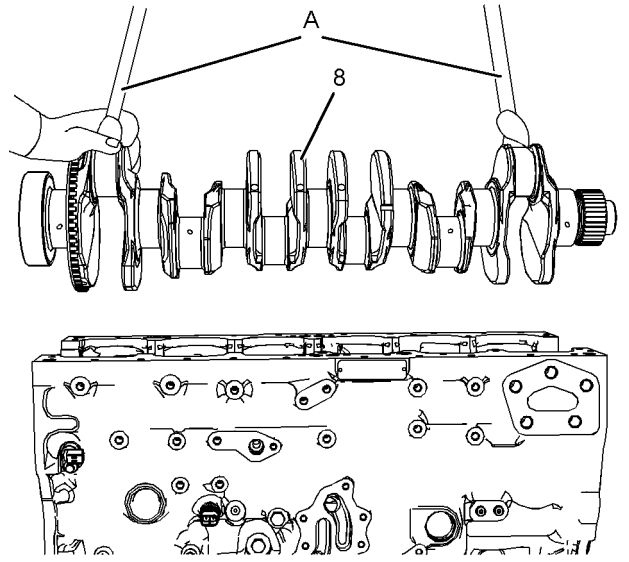


Illustration 479 g02212655

8. Attach Tooling (A) and a suitable lifting device to crankshaft (8). Lift crankshaft (8) into the cylinder block. The weight of the crankshaft is approximately 61 kg (134 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. Do not damage the main bearing shells.

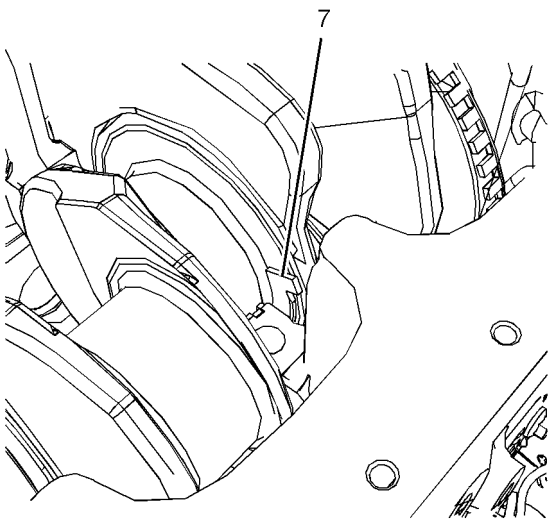


Illustration 480 g02212693

9. Lubricate thrust washers (7) with clean engine oil. Install thrust washers (7) into number six main bearing in the cylinder block.

Note: The grooves in the thrust washers must be located against the crankshaft. The thrust washers have a locating tab at one end. Ensure that the locating tabs are correctly seated in the cylinder block.

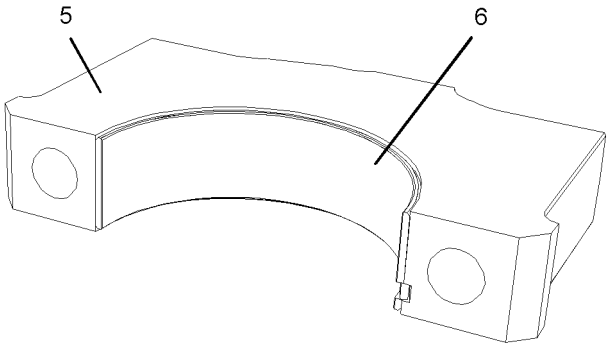


Illustration 481 g02212654

10. Install lower main bearing shells (6) into main bearing caps (5). Ensure that the locating tabs for the lower main bearing shells are correctly seated into the slots in the bearing caps.

Note: The lower main bearing shells are plain bearings that do not have oil holes.

11. Lubricate lower main bearing shells (6) and lubricate the journals of the crankshaft with clean engine oil. Install main bearing caps (5) to the cylinder block.

Note: Ensure the correct location and orientation of main bearing caps (5). The locating tabs for the upper and the lower main bearing shells should be on the same side of the engine.

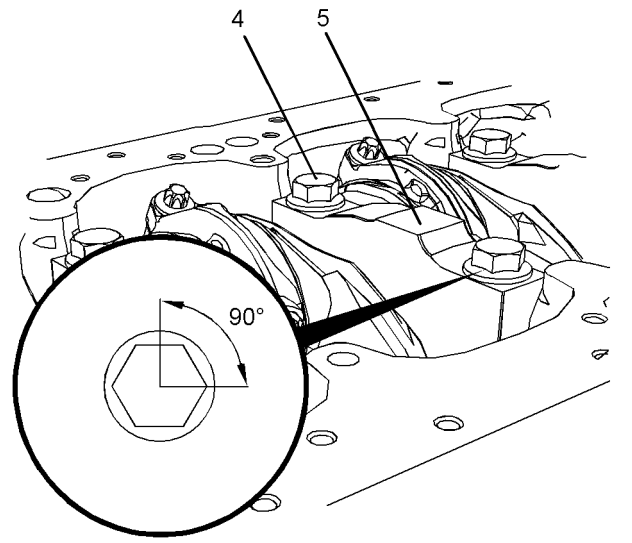


Illustration 482 g02214093

12. Lubricate the threads of bolts (4) with clean engine oil. Lubricate the underside of the heads of bolts (4) with clean engine oil.

13. Install bolts (4) to main bearing caps (5). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.

Note: Do not tap the main bearing caps into position as the bearing shells may be dislodged.

14. Tighten bolts (4) to a torque of 80 N·m (59 lb ft).

Turn bolts (4) through an additional 90 degrees. Use Tooling (B) to achieve the final torque.

15. Rotate the crankshaft in order to ensure that there is no binding.

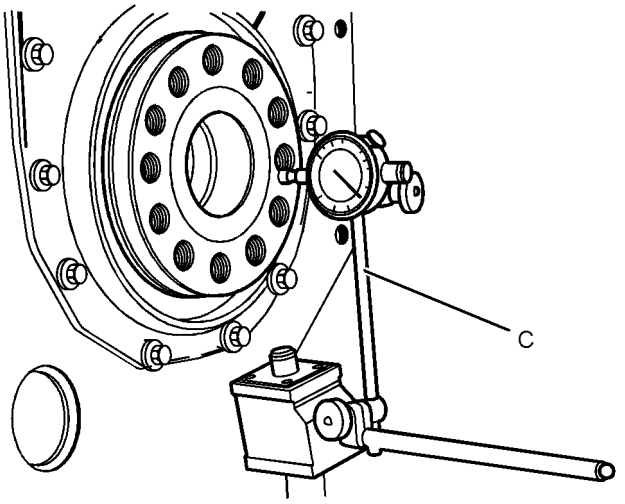


Illustration 483 g01399694

16. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (C) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (C) to measure the crankshaft end play. The permissible crankshaft end play is 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).

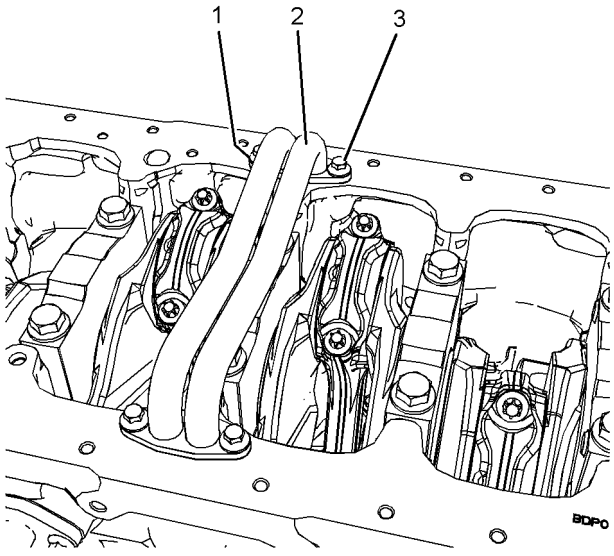


Illustration 484 g02204377

17. Position new gaskets (1) (not shown) onto cylinder block.

18. Position tube assembly (2) onto the cylinder block.

19. Install bolts (3) to tube assembly (2).

20. Tighten bolts (3) to a torque of 22 N·m (195 lb in).

21. If the crankshaft has not been replaced or the crankshaft has not been reconditioned, install the connecting rod bearings. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

End By:

a. If necessary, install the pistons and connecting rods. Refer to Disassembly and Assembly, “Pistons and Connecting Rods - Install” for the correct procedure.

b. If necessary, install the cylinder head. Refer to Disassembly and Assembly, “Cylinder head - Install” for the correct procedure.

c. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

d. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

e. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04203667

Crankshaft Timing Ring - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove ” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

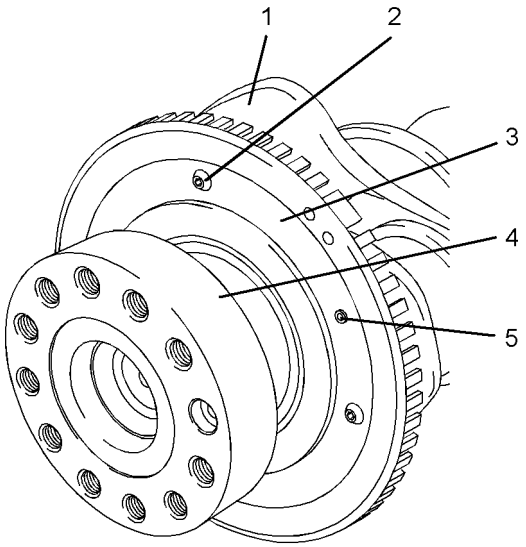


Illustration 485 g01341462

1. Support crankshaft (1) on a suitable stand.

2. Remove allen head screws (2) from crankshaft timing ring (3). Do not reuse the allen head screws.

3. Carefully remove crankshaft timing ring (3) from crankshaft (1). Do not reuse the crankshaft timing ring.

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

Note: Do not remove dowel (5) from crankshaft (1) unless the dowel is damaged.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the flange for the crankshaft timing ring on the crankshaft is clean and free from damage.

2. Support crankshaft (1) on a suitable stand.

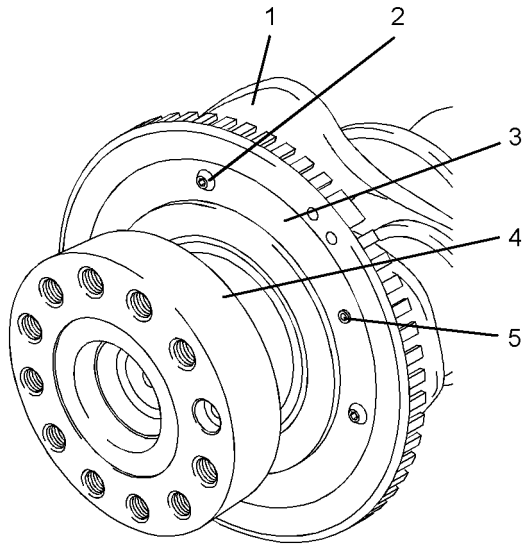


Illustration 486 g01341462

3. If dowel (5) was removed, install a new dowel to crankshaft (1).

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

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

5. Install new allen head screws (2). Tighten the allen head screws to a torque of 9 N·m (80 lb in).

End By:

a. Install the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Install ” for the correct procedure.

i04203662

Crankshaft Gear - Remove and Install

Removal Procedure

Table 94

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

Start By:

a. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

b. Remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

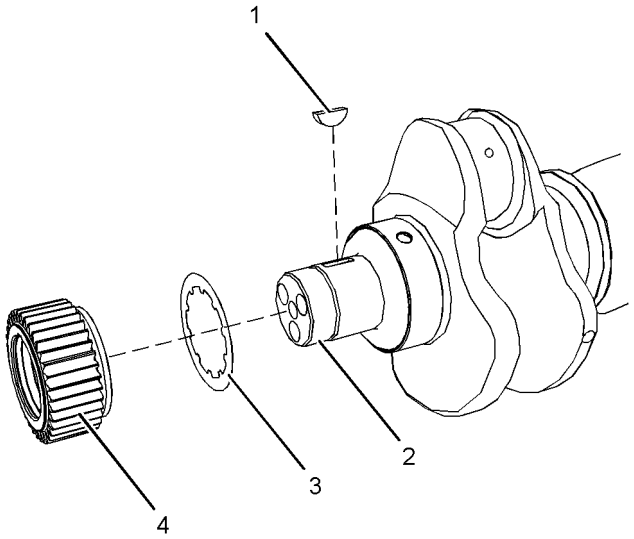


Illustration 487 g02048917

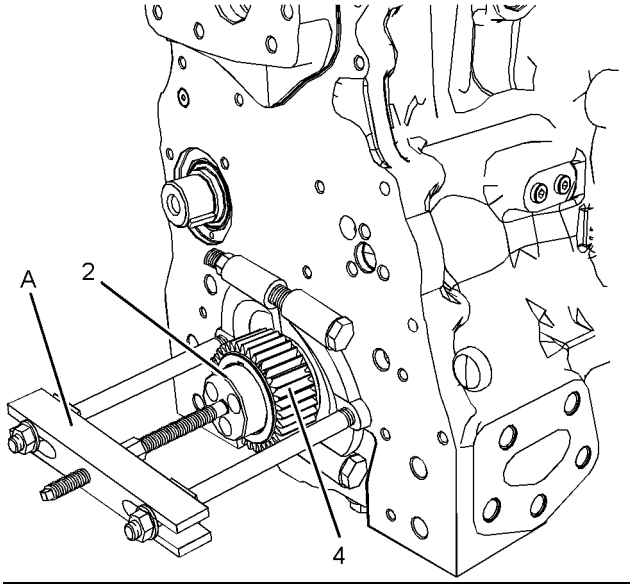


Illustration 488 g02049073

1. Use Tooling (A) in order to remove crankshaft gear (4) from crankshaft (2).

2. If necessary, remove key (1) and remove friction shim (3) from crankshaft (2).

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

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

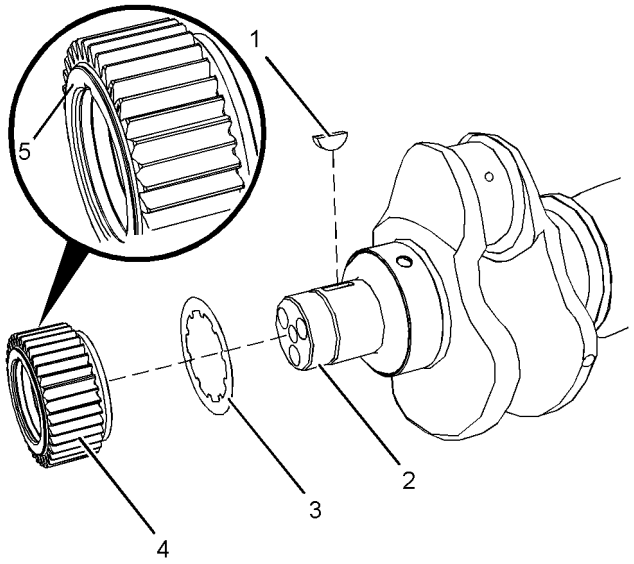


Illustration 489 g02052055

2. If necessary, install a new friction shim (3) to crankshaft (2).

3. If necessary, install a new key (1) to crankshaft (2).

⚠ 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.

4. Heat crankshaft gear (4) in an oven to 150° ± 50°C (302° ± 90°F). Align the keyway on crankshaft gear (4) with key (1) in the crankshaft. Install crankshaft gear (4) to crankshaft (2). Ensure that shoulder (5) of crankshaft gear (4) is toward the front of the engine.

End By:

a. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

b. Install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i02748526

Bearing Clearance - Check

Measurement Procedure

Table 95

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

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

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

- Ensure that the backs of the bearings and the bores are clean and dry.

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

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

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

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

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

3. Carefully remove the cap, but do not remove Tooling (A). Measure the width of Tooling (A) while Tooling (A) is in the bearing cap or on the crankshaft journal. Refer to Illustration 490.

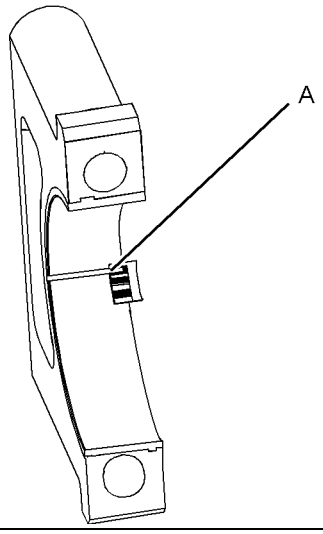


Illustration 490 g01152855
Typical Example

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

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

i04203755

Refrigerant Compressor - Remove and Install

Removal Procedure

Note: Cleanliness is an important factor. Cleaning of the exterior of the component before the disassembly procedure is carried out will help to prevent dirt from entering the internal mechanism.

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

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

Dispose of all fluids according to local regulations and mandates.

⚠ WARNING

Personal injury can result from contact with refrigerant.

Contact with refrigerant can cause frost bite. Keep face and hands away to help prevent injury.

Protective goggles must always be worn when refrigerant lines are opened, even if the gauges indicate the system is empty of refrigerant.

Always use precaution when a fitting is removed. Slowly loosen the fitting. If the system is still under pressure, release it slowly in a well ventilated area.

Personal injury or death can result from inhaling refrigerant through a lit cigarette.

Inhaling air conditioner refrigerant gas through a lit cigarette or other smoking method or inhaling fumes released from a flame contacting air conditioner refrigerant gas, can cause bodily harm or death.

Do not smoke when servicing air conditioners or wherever refrigerant gas may be present.

Use a certified recovery and recycling cart to properly remove the refrigerant from the air conditioning system.

Note: Put identification marks on all lines, on all hoses, on all wires, and on all tubes for installation purposes. Plug all lines, hoses, and tubes. Plugging all lines helps to prevent fluid loss and helps to keep contaminants from entering the system.

1. Turn the battery disconnect switch to the OFF position.
2. Refer to Service Manual, SENR5664, “Air Conditioning and Heating Systems with R-134a Refrigerant” for the correct procedure.

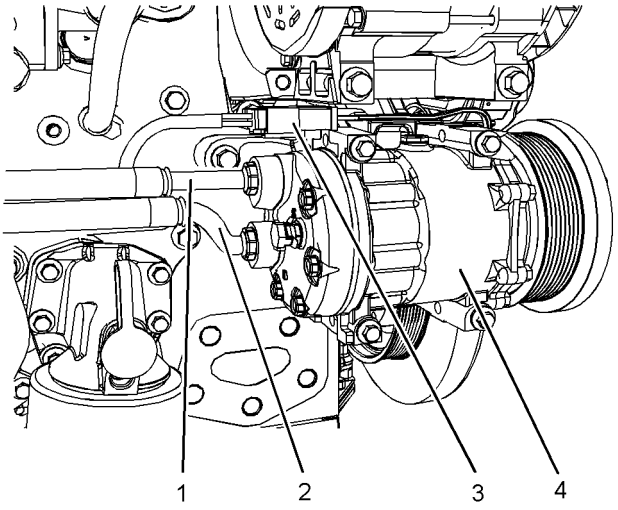


Illustration 491 g02321153

Typical example of a refrigerant compressor (ports may vary)

3. Disconnect hose assembly (1) and hose assembly (2) from refrigerant compressor (4). Refer to the Original Equipment Manufacture (OEM) for the correct procedure.

Note: Cap the hose assemblies with new caps. Plugs the ports in the refrigerant compressor with new plugs.

4. Disconnect harness assembly (3) from refrigerant compressor (4).

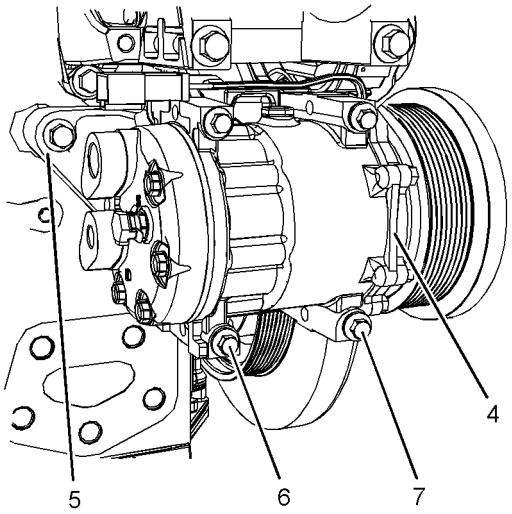


Illustration 492 g02321154

5. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belts - Remove and Install” for the correct procedure.

6. Remove bolts (6) and bolts (7) from refrigerant compressor (4).

Note: Support the weight of the refrigerant compressor on removal of the bolts.

7. Remove refrigerant compressor (4) from bracket (5).

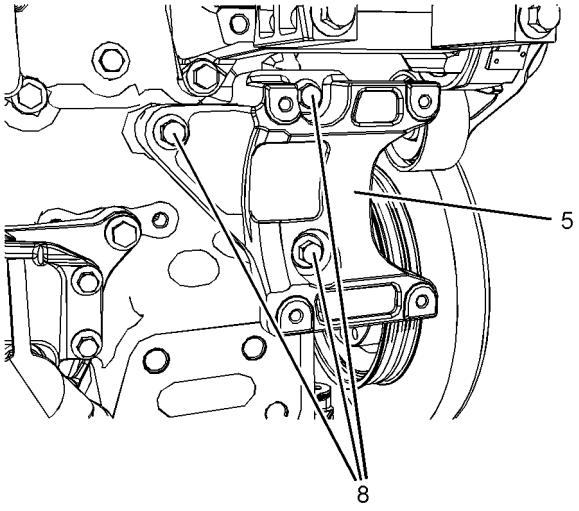


Illustration 493 g02100040

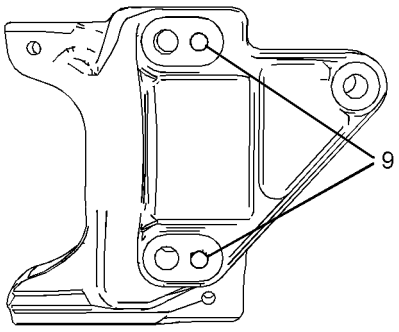


Illustration 494 g02100041

8. If necessary, follow Step 8.a through Step 8.c in order to remove bracket (5) for the refrigerant compressor from the cylinder block.

a. Remove bolts (8) from bracket (5).

b. Remove bracket (5) from the cylinder block.

c. Note the position of dowels (9) in bracket (5).

Installation Procedure

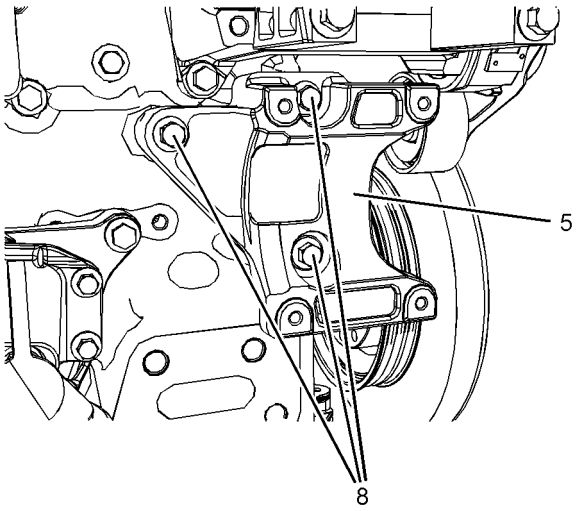


Illustration 495 g02100040

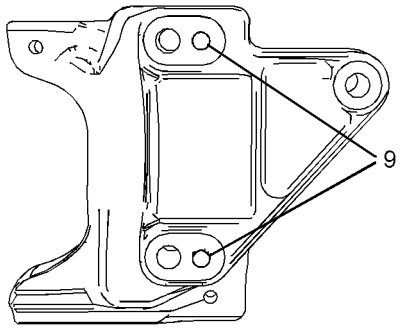


Illustration 496 g02100041

1. If necessary, follow Step 1.a through Step 1.d in order to install bracket (5) for the refrigerant compressor to the cylinder block.

a. Ensure that bracket (5) is clean and free from wear and damage. If necessary, replace the bracket.

b. Ensure that dowels (9) are free from wear and damage. If necessary, replace the dowels.

c. Position bracket (5) onto the cylinder block. Install bolts (8) and hand tighten the bolts.

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

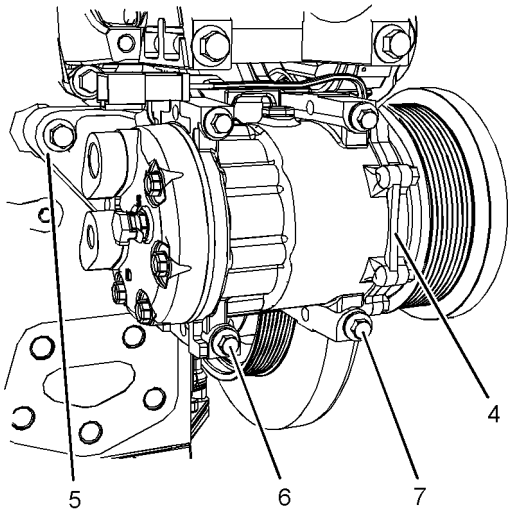


Illustration 497 g02321154

2. Position refrigerant compressor (4) onto bracket (5).

Note: Support the weight of the refrigerant compressor.

3. Install bolts (6) and bolts (7) to refrigerant compressor (4).

4. Tighten bolts (6) and bolts (7) to a torque of 22 N·m (195 lb in).

5. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belts - Remove and Install” for the correct procedure.

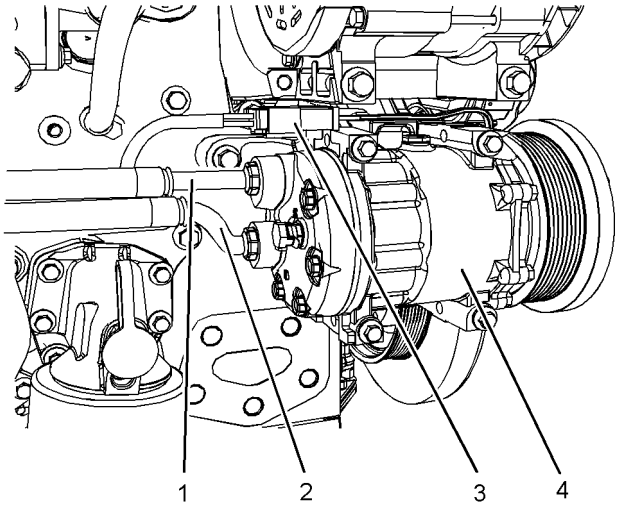


Illustration 498 g02321153

Typical example of a refrigerant compressor (ports may vary)

6. Connect harness assembly (3) to refrigerant compressor (4).

7. Remove the caps from hose assemblies and remove the plugs from the ports of the refrigerant compressor. Connect hose assembly (1) and hose assembly (2) to refrigerant compressor (4). Refer to the OEM for the correct procedure.

8. Refer to Service Manual, SENR5664, “Air Conditioning and Heating Systems with R-134a Refrigerant” for the correct charging procedures.

9. Turn the battery disconnect switch to the ON position.

i04203644

Atmospheric Pressure Sensor - Remove and Install

Removal Procedure

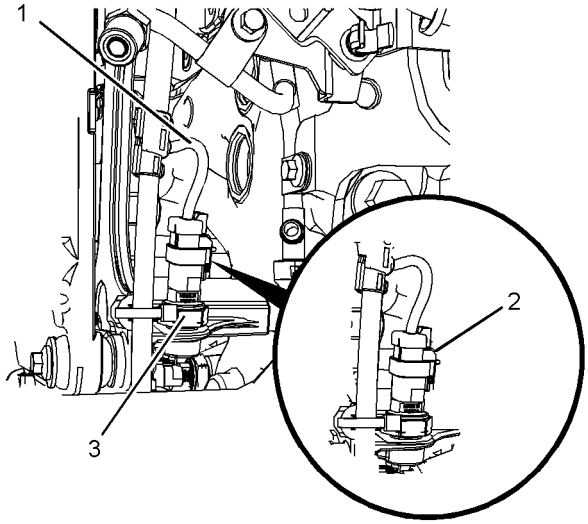


Illustration 499 g02315313

1. Removal of the Electronic Control Module (ECM) may be necessary in order to remove the atmospheric pressure sensor. If necessary, remove the electronic control module. Refer to Disassembly and Assembly, “Electronic Control Module - Remove and Install” for the correct procedure.

2. Slide locking tab (2) into the unlocked position. Disconnect harness assembly (1).

3. Remove atmospheric pressure sensor (3) from the bracket for the ECM.

Installation Procedure

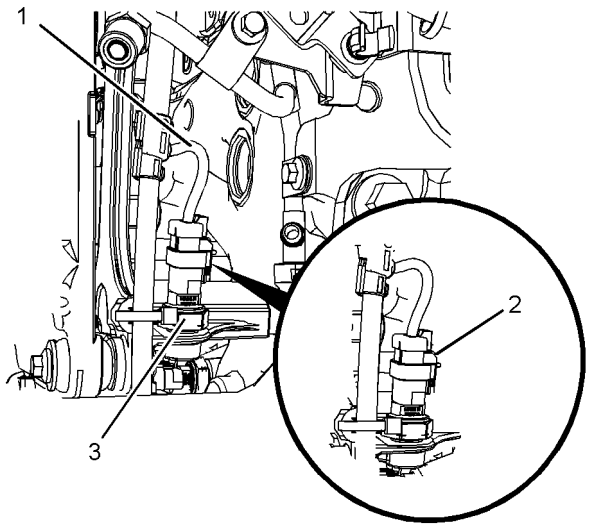


Illustration 500 g02315313

1. Install atmospheric pressure sensor (3) to the bracket for the ECM. Tighten atmospheric pressure sensor (3) to a torque of 10 N·m (89 lb in).

Note: The atmospheric pressure sensor should not be installed with an O-ring seal.

2. Connect harness assembly (1) to atmospheric pressure sensor (3). Slide locking tab (2) into the locked position.

3. If removal of the ECM was necessary, install the ECM. Refer to Disassembly and Assembly, “Electronic Control Module - Remove and Install” for the correct procedure.

i04203650

Camshaft Position Sensor - Remove and Install

Removal Procedure

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

Dispose of all fluids according to local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

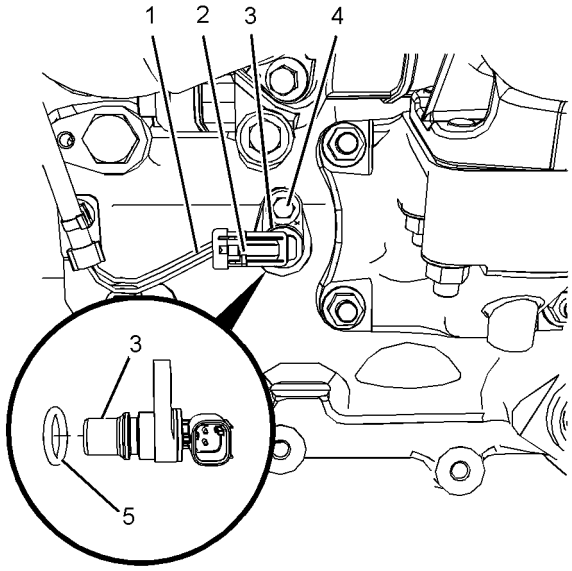


Illustration 501 g02022992

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

2. Remove bolt (4). Carefully remove camshaft position sensor (3) from the cylinder block.

Note: Do not use a lever to remove the camshaft position sensor.

3. Remove O-ring seal (5) from camshaft position sensor (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

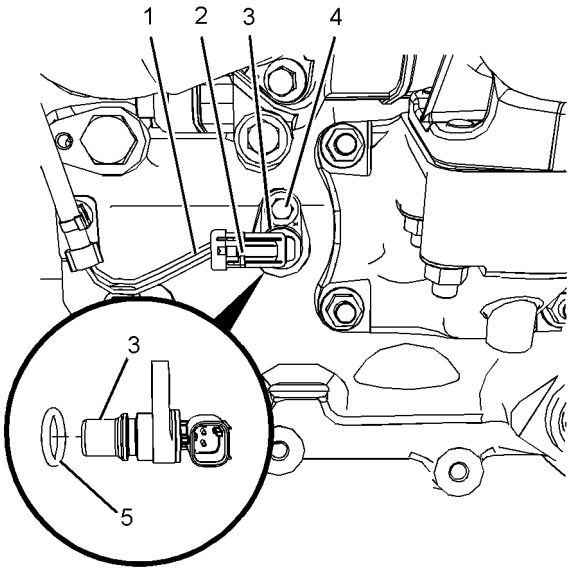


Illustration 502 g02022992

1. Install a new O-ring seal (5) to camshaft position sensor (3).

Note: Do not lubricate the O-ring seal.

2. Install camshaft position sensor (3) to the cylinder block. Install bolt (4) and tighten the bolt to a torque of 14 N·m (124 lb in).

3. Connect harness assembly (1) to camshaft position sensor (3). Slide locking tab (2) into the locked position.

i04203664

Crankshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

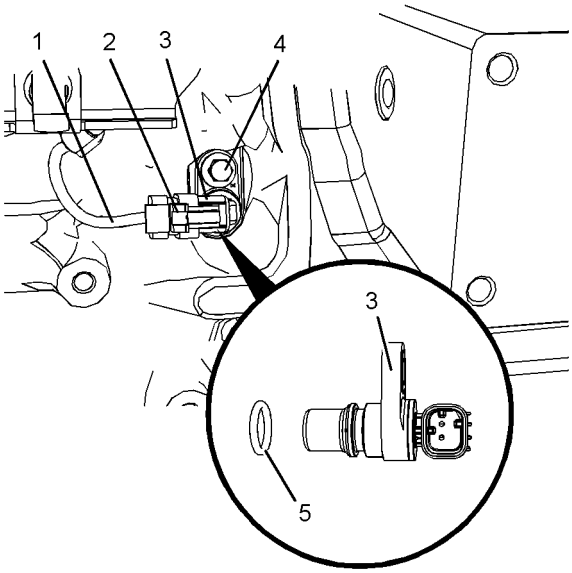


Illustration 503 g02315333

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

2. Remove bolt (4) from the cylinder block.

3. Carefully remove crankshaft position sensor (3) from the cylinder block.

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

4. Remove O-ring seal (5) from crankshaft position sensor (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

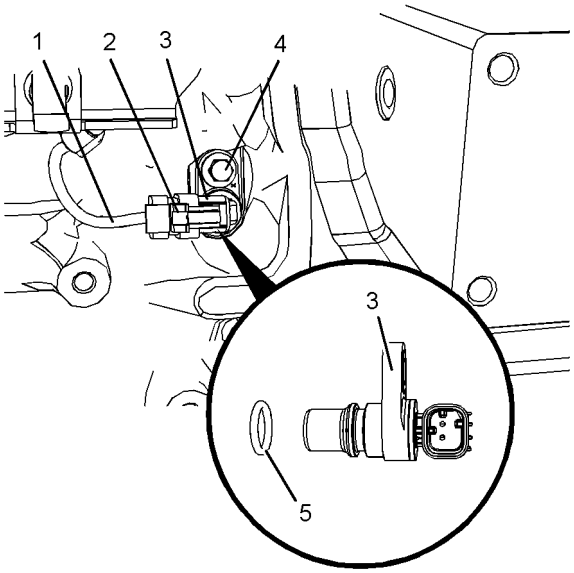


Illustration 504 g02315333

1. Install a new O-ring seal (5) to crankshaft position sensor (3).

Note: Do not lubricate the O-ring seal.

2. Install crankshaft position sensor (3) to the cylinder block. Install bolt (4) and tighten the bolt to a torque of 14 N·m (124 lb in).

3. Connect harness assembly (1) to crankshaft position sensor (3). Slide locking tab (2) into the locked position.

i04203655

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. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

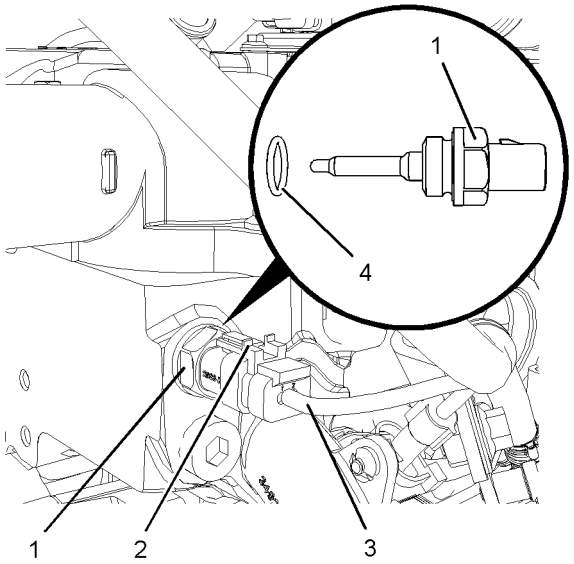


Illustration 505 g02315373

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

3. Use a deep socket in order to remove coolant temperature sensor (1) from the cylinder head.

4. Remove O-ring seal (4) from coolant temperature sensor (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

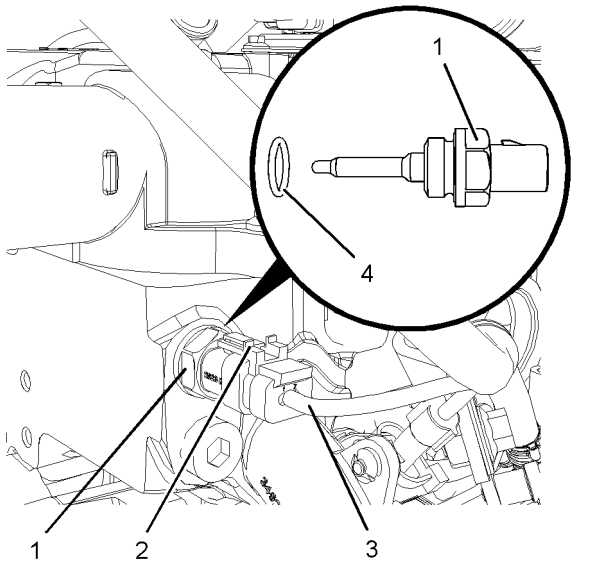


Illustration 506 g02315373

1. Install a new O-ring seal (4) onto coolant temperature sensor (1).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket in order to install coolant temperature sensor (1) to the cylinder head. Tighten the coolant temperature sensor to a torque of 20 N·m (177 lb in).

3. Connect harness assembly (3) to coolant temperature sensor (1). Slide locking tab (2) into the locked position.

4. 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 procedures.

i04203690

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.

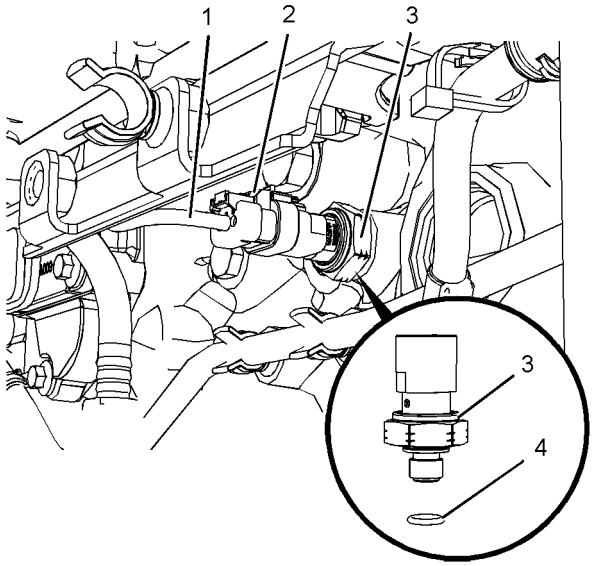


Illustration 507 g02315394

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

2. Use a deep socket to remove engine oil pressure sensor (3) from the cylinder block.

3. Remove O-ring seal (4) from engine oil pressure sensor (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

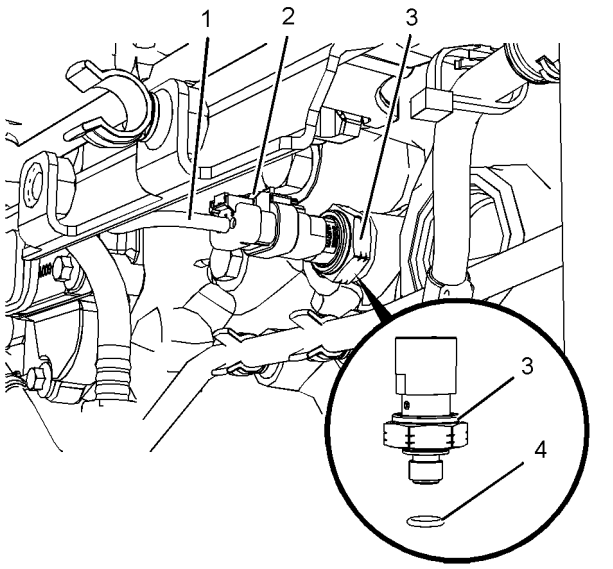


Illustration 508 g02315394

1. Install a new O-ring seal (4) onto engine oil pressure sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install engine oil pressure sensor (3) to the cylinder block. Tighten the engine oil pressure sensor to a torque of 10 N·m (89 lb in).

3. Connect harness assembly (1) to engine oil pressure sensor (3).

4. Slide locking tab (2) 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” for the correct procedure.

i04203724

Fuel Temperature Sensor - Remove and Install

Removal Procedure

Table 96

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping 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 authorized personnel that have the correct training.

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Turn the fuel supply to the OFF position.

2. Turn the battery disconnect switch to the OFF position.

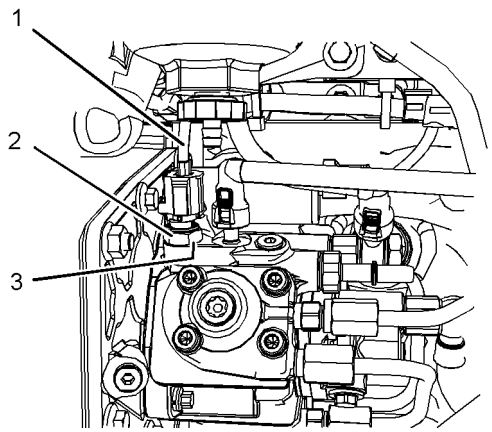


Illustration 509 g02210488

3. Disconnect harness assembly (1) from fuel temperature sensor (2).

4. Use a deep socket in order to remove fuel temperature sensor (2) from the fuel injection pump.

5. Use Tooling (A) to plug the open port of the fuel injection pump.

6. Remove O-ring seal (3) (not shown) from fuel temperature sensor (2).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are free from wear and damage. Replace any components that are worn or damaged.

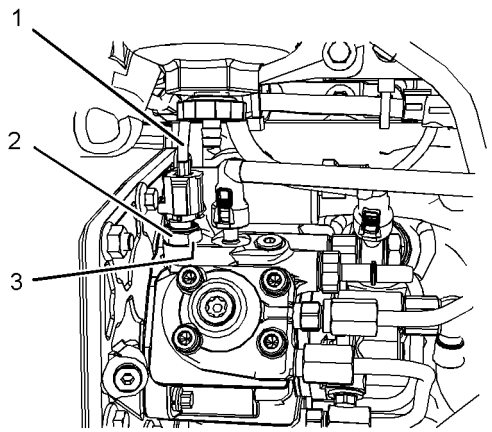


Illustration 510 g02210488

2. Ensure that the new O-ring seal (3) (not shown) on the fuel temperature sensor (2) is free from damage.

3. Remove the plug from the fuel injection pump.

4. Install fuel temperature sensor (2) to the fuel injection pump. Use a deep socket to tighten the fuel temperature sensor to a torque of 22 N·m (195 lb in).

5. Connect harness assembly (1) to fuel temperature sensor (2).

6. Turn the fuel supply to the ON position.

7. Turn the battery disconnect switch to the ON position.

i04203697

Flame Detection Temperature Sensor - Remove and Install (Flame Detection Temperature Sensor for the ARD)

Removal Procedure

Table 97

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400006	Crowfoot Wrench	1

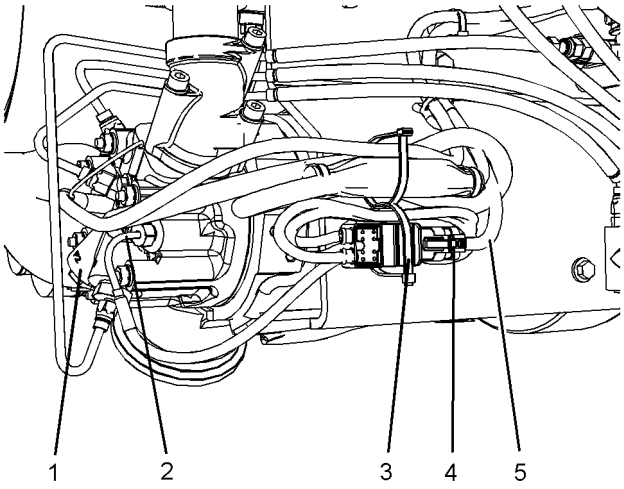


Illustration 511 g02157877

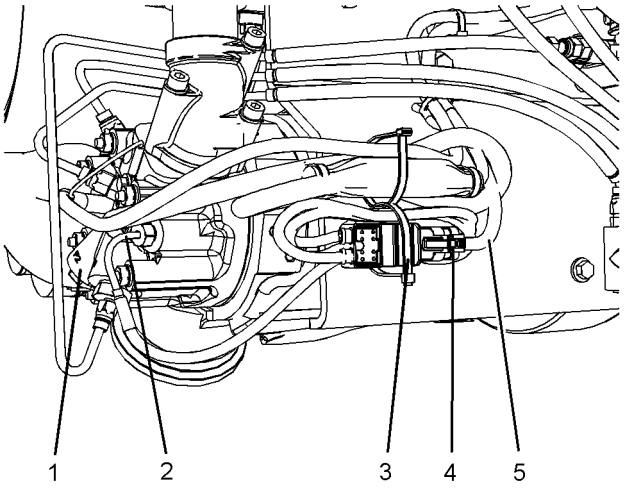


Illustration 512 g02157877

1. Cut cable straps (3) from harness assembly (5).

Note: Ensure that all cable straps are removed from the harness assemblies.

2. Slide locking tab (4) into the unlocked position. Disconnect harness assembly (5) from harness assembly for flame detection temperature sensor (2).

3. Use Tooling (A) in order to remove flame detection temperature sensor (2) from ARD head (1).

4. If necessary, remove temperature sensor (DPF) for the Diesel Particulate Filter (DPF). Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

Installation Procedure

Table 98

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400006	Crowfoot Wrench	1
B	-	Bostik Pure Nickel Anti-Seize Compound	1

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

2. If necessary, install temperature sensor for the DPF. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

3. Use Tooling (B) in order to lubricate the threads of flame detection temperature sensor (2).

4. Install flame detection temperature sensor (2) to ARD head (1).

5. Use Tooling (A) in order to tighten flame detection temperature sensor (2) to a torque of 45 N·m (33 lb ft).

6. Connect harness assembly (5) to harness assembly for flame detection temperature sensor (2). Slide locking tab (4) into the locked position.

7. Install new cable strap (4) to harness assembly (5).

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

i04203762

Soot Antenna - Remove and Install

Removal Procedure

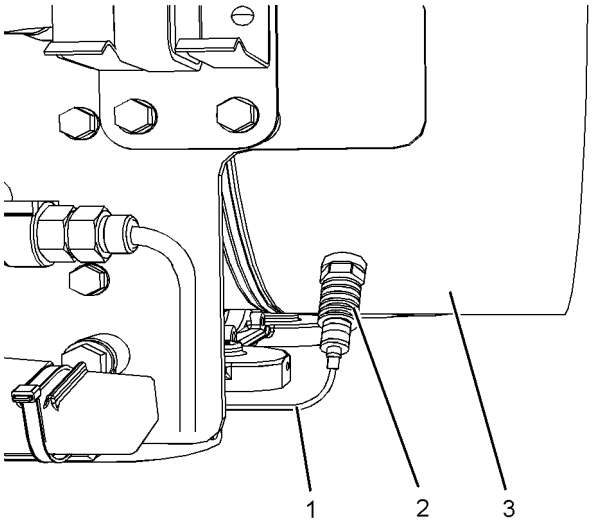


Illustration 513 g02034774

1. Disconnect harness assembly (1) from soot antenna (2).
2. Repeat Step 1 in order to disconnect the remaining harness assembly from the remaining soot antenna.
3. Remove soot antenna (2) from the assembly of the Diesel Particulate Filter (DPF) (3).
4. Repeat Step 3 In order to remove the remaining soot antenna.

Installation Procedure

Table 99

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Bostik Pure Nickel Anti-Seize Compound	1

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

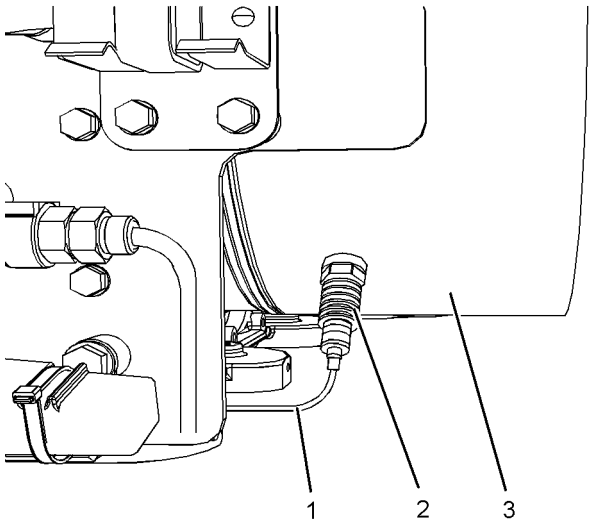


Illustration 514 g02034774

2. Lightly lubricate the thread of soot antenna (2) with Tooling (A). Install soot antenna (2) to DPF (3). Tighten the soot antenna to a torque of 45 N·m (33 lb ft).
3. Repeat Step 2 in order to install the remaining soot antenna.
4. Connect harness assembly (1) to soot antenna (2). Tighten the harness assembly to a torque of 1.2 N·m (11 lb in).
5. Repeat Step 4 in order to connect the remaining harness assembly.

i04203763

Temperature Sensor (DPF) - Remove and Install (Temperature Sensor (DPF) and Flame Detection Sensor)

Removal Procedure

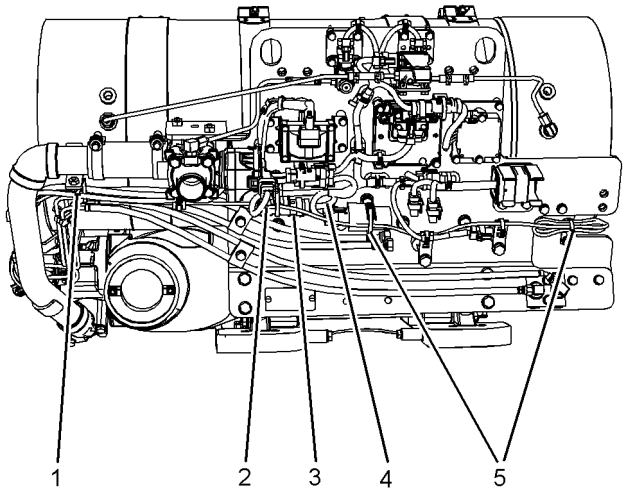


Illustration 515 g02360136

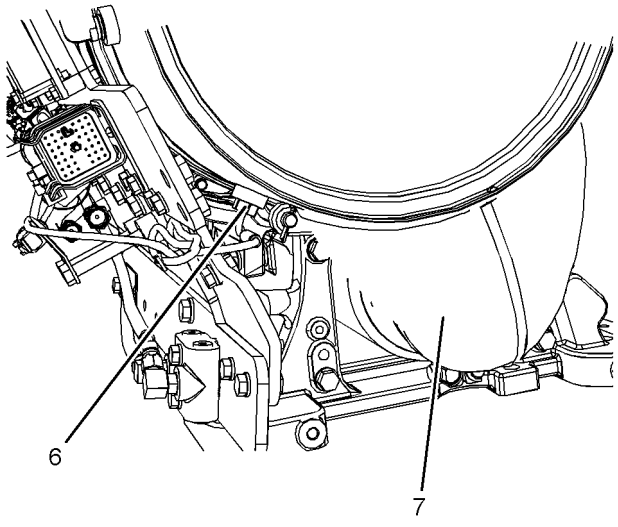


Illustration 516 g02360156

1. Cut cable strap (1) and cable straps (5) from harness assembly (2).

Note: Ensure that all cable straps are removed for the harness assembly.

2. Slide locking tab (3) into the unlocked position. Disconnect harness assembly (2) from harness assembly (4).

3. Make temporary marks on temperature sensor (6) for installation purpose. Remove temperature sensor (6) from the Diesel Oxidation Catalyst (DOC) (7).

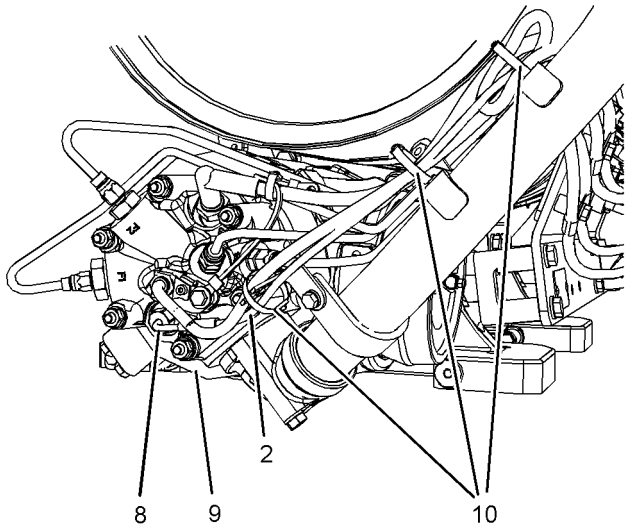


Illustration 517 g02360176

4. Cut cable straps (10) from harness assembly (2).

Note: Ensure that all cable straps are removed for the harness assembly.

5. Make temporary marks on flame detection sensor (8) for installation purpose. Remove flame detection sensor (8) from ARD combustion head (9).

6. Remove harness assembly (2) Clean Emission Module (CEM).

Installation Procedure

Table 100

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Bostik Pure Nickel Anti-Seize Compound	1
B	T400030	Crowfoot Wrench	1

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

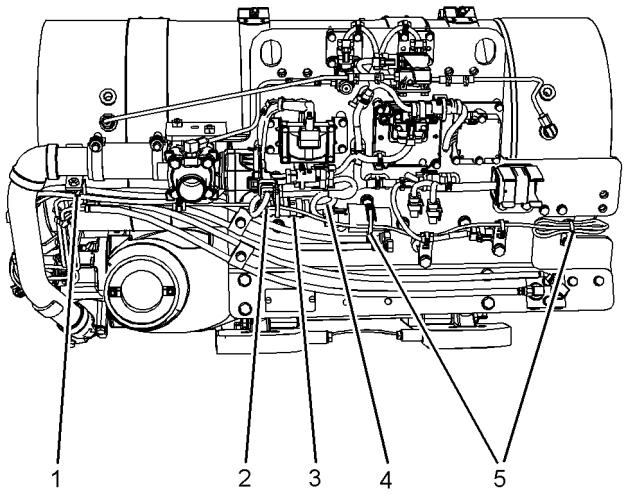


Illustration 518 g02360136

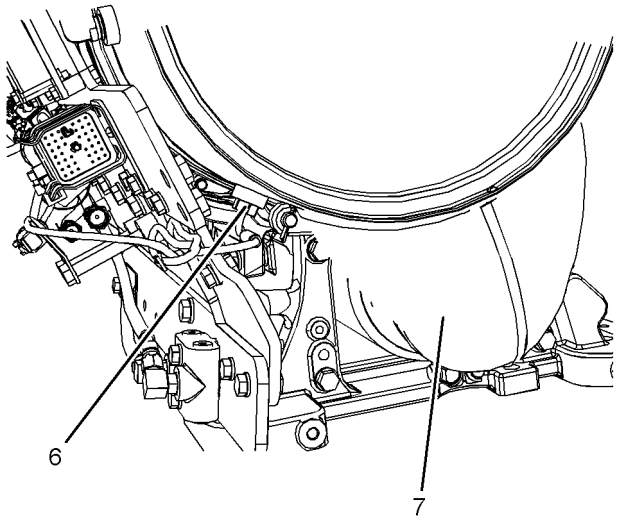


Illustration 519 g02360156

2. Position harness assembly (2) onto the bracket for the CEM.

3. Use tooling (A) in order to lubricate the thread of temperature sensor (6).

4. Install temperature sensor (6) to the DOC.

Note: Ensure correct positioning of temperature sensor.

5. Use tooling (B) in order to tighten temperature sensors (6) to a torque of 45 N·m (33 lb ft).

6. Connect harness assembly (2) to harness assembly (4). Slide locking tab (3) into the locked position.

7. Install new cable strap (1) and cable strap (5) to harness assembly (2).

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

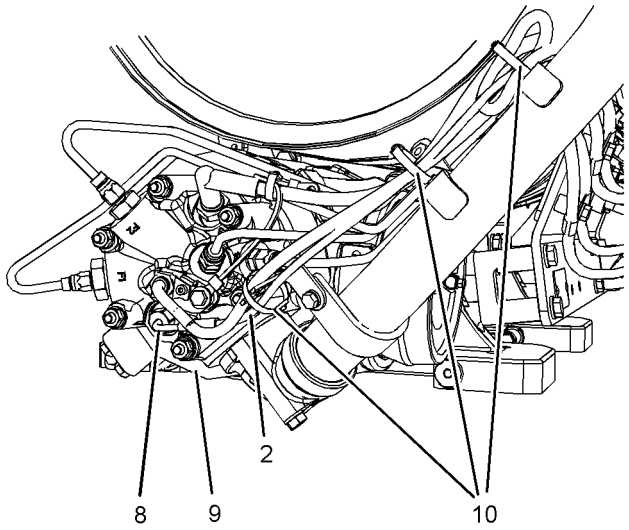


Illustration 520 g02360176

8. Use tooling (A) in order to lubricate the thread of flame detection sensor (8).

9. Install flame detection sensor (8) to the ARD combustion head (9).

Note: Ensure correct positioning of the temperature sensor.

10. Use tooling (B) in order to tighten flame detection sensor (8) to a torque of 45 N·m (33 lb ft).

11. Install new cable straps (10) to harness assembly (2).

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

i04203751

Pressure Sensor (DPF) - Remove and Install (Clean Emissions Module)

Removal Procedure

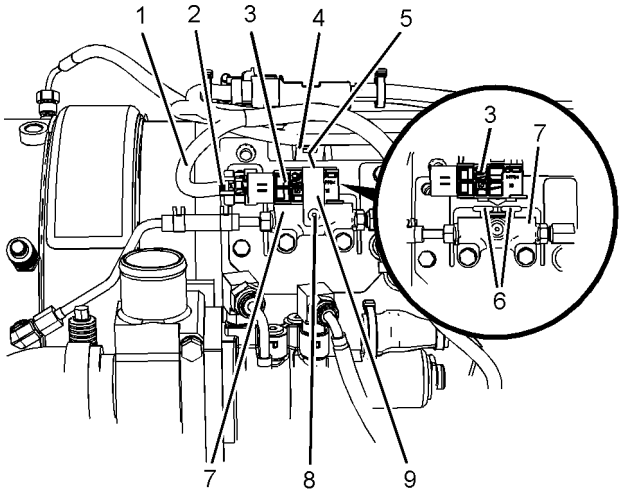


Illustration 521 g02157893

1. Slide locking tab (2) into the unlocked position.
2. Disconnect harness assembly (1) from pressure sensor (3).
3. Remove the bolt from bracket (4) and position the bracket away from pressure sensor (3).
4. Remove bolt (5) (not shown) and allen head bolt (8).
5. Remove bracket (9) from pressure sensor (3).
6. Remove pressure sensor (3) from manifold (7). Remove O-ring seals (6).

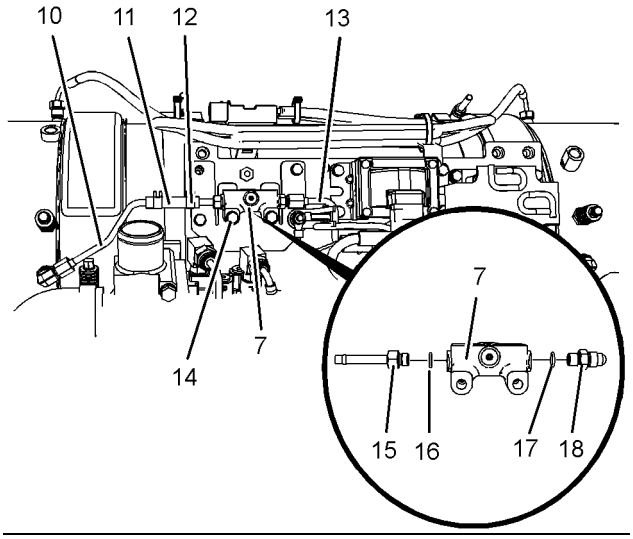


Illustration 522 g02157894

7. If necessary, follow Step 7.a through Step 7.f in order to remove manifold (7) from mounting bracket.
   a. Slide hose clamp (12) along hose (11).
   b. Remove tube assembly (10) from manifold (7) and the outlet section of the Diesel Particulate Filter (DPF).
   c. Remove tube assembly (13) from manifold (7) and the inlet section of the Diesel Oxidation Catalyst (DOC).
   d. Remove bolts (14) from manifold (7). Remove the manifold from the mounting bracket.
   e. If necessary, remove connection (15) from manifold (7). Remove O-ring seal (16).
   f. If necessary, remove connection (17) from manifold (7). Remove O-ring seal (18).

Installation Procedure

1. If necessary, follow Step 1.a through Step 1.h in order to install manifold (4) for the pressure sensor.

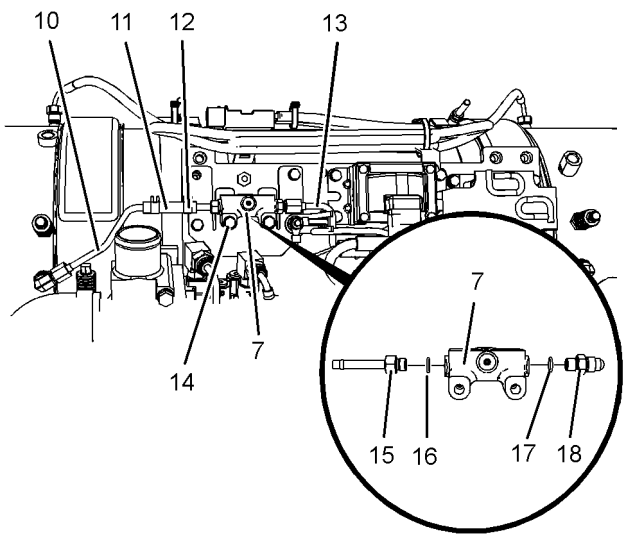


Illustration 523 g02157894

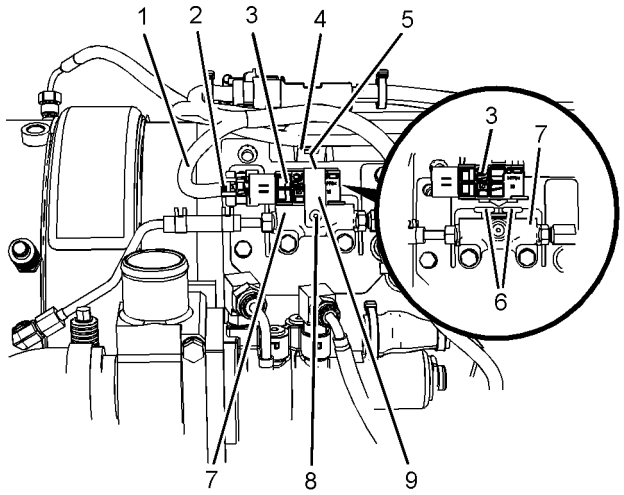


Illustration 524 g02157893

a. If necessary, install connection (15) to manifold (7). Install a new O-ring seal (16) to connection (15). Install the connection to manifold (7). Tighten the connection to a torque of 10 N·m (89 lb in).

b. If necessary, install connection (18) to manifold (7). Install a new O-ring seal (17) to connection (18). Install the connection to manifold (7). Tighten the connection to a torque of 10 N·m (89 lb in).

c. Position manifold (7) onto mounting bracket. Loosely install bolts (14).

d. Install tube assembly (13) to manifold (7) and the inlet section of the Diesel Oxidation Catalyst (DOC). Loosely tighten tube assembly.

e. Install tube assembly (12) to manifold (7) and the outlet section of the Diesel Particulate Filter (DPF). Loosely tighten tube assembly.

f. Tighten bolts (14) to a torque of 12 N·m (106 lb in).

g. Securely tighten tube assembly (10) and tube assembly (13).

h. Slide hose clamp (12) along hose (11).

2. Install new O-ring seals (6) to manifold (7).

3. Position pressure sensor (3) onto manifold (7). Position bracket (9) onto pressure sensor (3).

Note: Ensure the correct orientation of the pressure sensor.

4. Install allen head bolt (8) and bolt (5) (not shown) to bracket (9). Hand tighten bolt (5) (not shown) and allen head bolt (8).

Note: Ensure that the pressure sensor is correctly seated onto the manifold.

5. Tighten allen head bolt (8) to a torque of 2 N·m (17 lb in).

Tighten bolt (5) (not shown) to a torque of 12 N·m (106 lb in).

6. Position the bracket and install the bolt for bracket (4). Tighten the bolt to a torque of 12 N·m (106 lb in).

7. Connect harness assembly (1) to pressure sensor (3). Slide locking tab (2) into the locked position.

i04203764

Temperature Sensor (Cooled Exhaust Gas) - Remove and Install

Removal Procedure

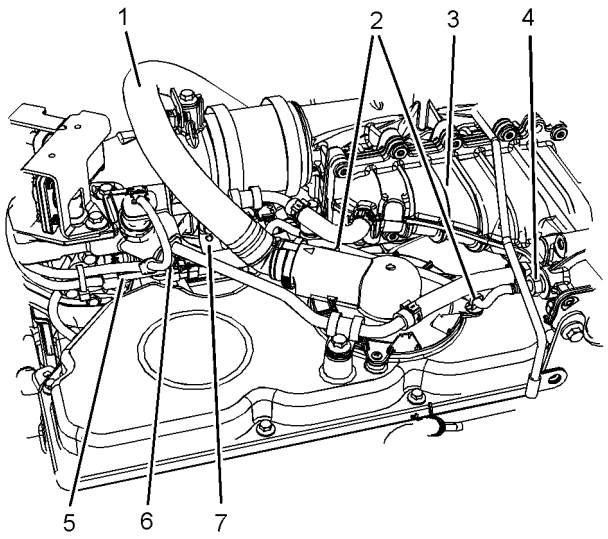


Illustration 525 g02168393

1. Disconnect plastic tube assembly (1) for the crankcase breather from valve mechanism cover.
2. Slide the locking tab into the unlocked position. Disconnect engine wiring harness assembly (5) from wiring harness assembly (6). Slide connection for wiring harness assembly (6) from bracket (7).
3. Cut cable straps (2).
4. Remove temperature sensor (4) from NOx Reduction System (NRS) inlet air control (3).

Installation Procedure

Table 101

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Bostik Pure Nickel Anti-Seize Compound	1

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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

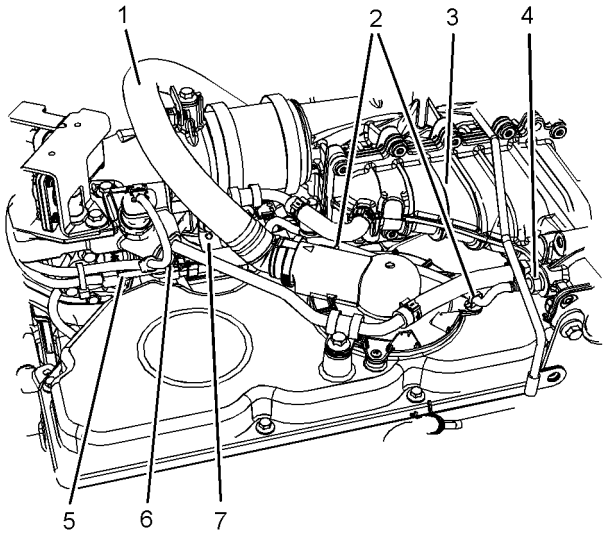


Illustration 526 g02168393

2. Lightly lubricate the thread of temperature sensor (4) with Tooling (A). Install temperature sensor (4) to NRS inlet air control (3).
3. Tighten temperature sensors (4) to a torque of 24 N·m (212 lb in).
4. Slide connection for wiring harness assembly (6) onto bracket (7). Connect engine wiring harness assembly (5) to wiring harness assembly (6). Slide the locking tab into the locked position.
5. Install new cable straps (2) to harness assembly (6).

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

6. Connect plastic tube assembly (1) for crankcase breather to valve mechanism cover.

i04203752

Pressure Sensor (Cooled Exhaust Gas) - Remove and Install (Differential Pressure Sensor)

Removal Procedure

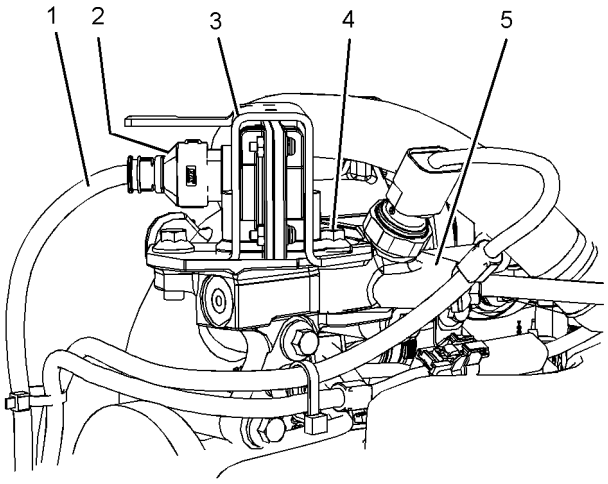


Illustration 527 g02160475

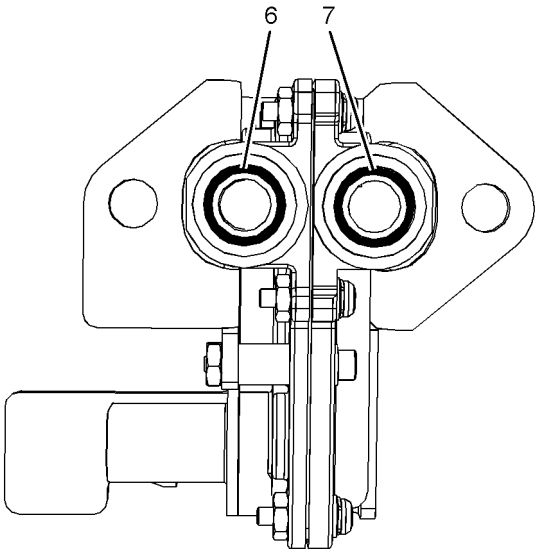


Illustration 528 g02160476

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

2. Remove bolts (4). Remove differential pressure sensor (3) from manifold (5).

3. Remove O-ring seal (6) and O-ring seal (7).

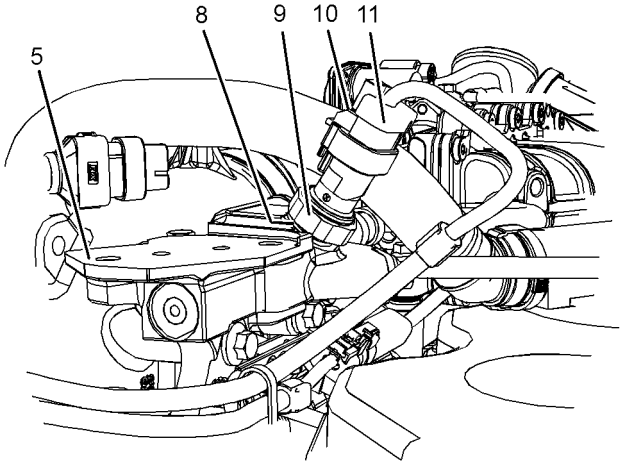


Illustration 529 g02160477

4. Slide locking tab (10) into the unlocked position. Disconnect harness assembly (11) from absolute pressure sensor (9).

5. Use a deep socket to remove absolute pressure sensor (9) from sensor manifold (5).

6. Remove O-ring seal (8) (not shown) from pressure sensor (9).

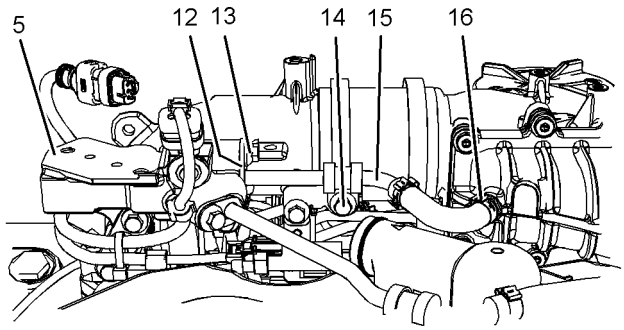


Illustration 530 g02160478

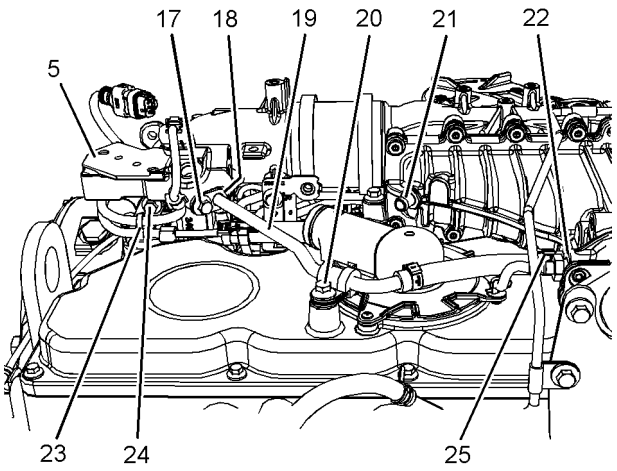


Illustration 531 g02160482

7. If necessary, follow Step 7.a through Step 7.g in order to remove manifold (5) and tube assemblies from the NOx reduction system (NRS) manifold.

a. Remove plastic breather tube from the crankcase breather cannister and the valve mechanism cover. Refer to Disassembly and Assembly, “Crankcase Breather- Remove” for the correct procedure.

b. Remove bolt (13) from tube assembly (15). Remove bolt (14) from clip for the tube assembly. Loosen hose clamp (16) from the hose for tube assembly (15).

c. Remove tube assembly (15) from manifold (5) and the NRS manifold. Remove O-ring seal (12) (not shown).

d. Remove bolt (17) from tube assembly (19). Remove bolt (20) from clip for the tube assembly. Loosen hose clamp (25) from hose for tube assembly (19).

e. Remove tube assembly (19) from manifold (5) and the NRS manifold. Remove O-ring seal (18) (not shown).

f. If necessary, remove connection (21) and connection (25) from the NRS manifold.

g. Cut cable strap (23) from harness assemblies. Remove bolts (24) from manifold (5). Remove manifold (5) from the inlet elbow.

Installation Procedure

NOTICE
Ensure that the wiring harness assembly is correctly routed and the cable straps are not over tightened. Over tightening of the cable straps will damage the wiring harness convoluting.

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

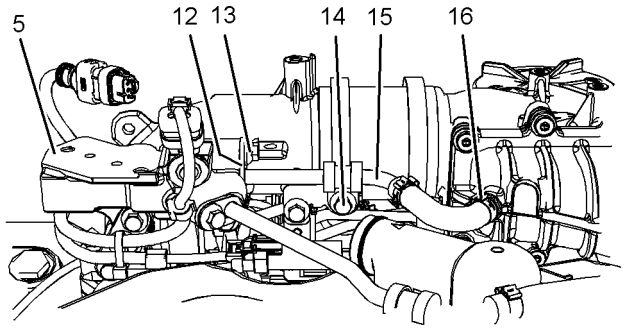


Illustration 532 g02160478

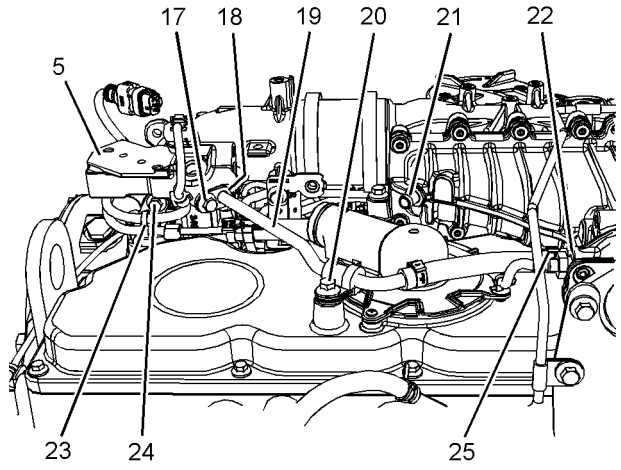


Illustration 533 g02160482

2. If necessary, follow Step 2.a through Step 2.j in order to install manifold (5) and tube assemblies to the NOx reduction system (NRS) manifold.

a. If necessary, install connection (21) and connection (22) NRS manifold. Tighten connections to a torque of 9 N·m (80 lb in).

b. Position manifold (5) onto the inlet elbow. Install bolts (24). Tighten the bolts to a torque of 22 N·m (195 lb in).

c. Install a new O-ring seal (10) (not shown) onto tube assembly (19). Install tube assembly (19) into manifold (5) and install bolt (17).

d. Install hose for tube assembly (19) onto connection (25). Install bolt (20) for the clip for tube assembly (19).

e. Tighten bolt (20) and bolt (17) to a torque of 22 N·m (195 lb in). Securely tighten hose clamp (25).

f. Install a new O-ring seal (12) (not shown) onto tube assembly (15). Install tube assembly (15) into manifold (5) and install bolt (13).

g. Install hose for tube assembly (15) onto connection (21). Install bolt (14) for the clip for tube assembly (15).

h. Tighten bolt (13) and bolt (14) to a torque of 22 N·m (195 lb in). Securely tighten hose clamp (16).

i. Install plastic breather tube to the crankcase breather cannister and the valve mechanism cover. Refer to Disassembly and Assembly, “Crankcase Breather- Install” for the correct procedure.

j. Install a new cable strap (23) to harness assemblies.

Note: Ensure that cable straps meet the Original Equipment Manufactures (OEM) specification.

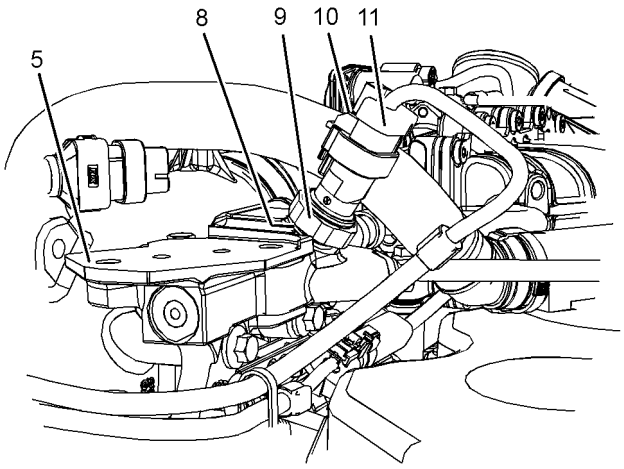


Illustration 534 g02160477

3. Install a new O-ring seal (8) (not shown) to pressure sensor (9).

4. Use a deep socket to install absolute pressure sensor (9) to manifold (5). Tighten pressure sensor (9) to a torque of 10 N·m (89 lb in).

5. Connect harness assembly (11) to absolute pressure sensor (8). Slide locking tab (10) into the locked position.

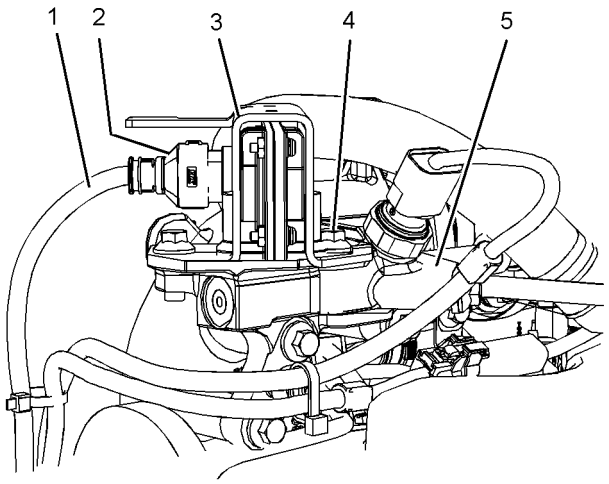


Illustration 535 g02160475

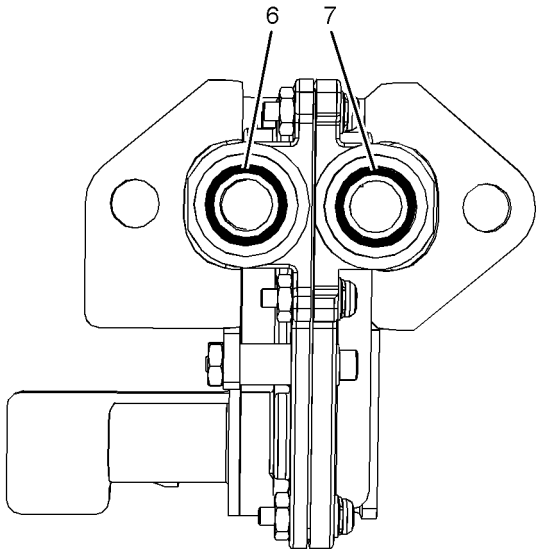


Illustration 536 g02160476

6. Install new O-ring seal (6) and O-ring seal (7) to differential pressure sensor (3).

Note: Ensure that the O-ring seals are correctly seated into the differential pressure sensor.

7. Position differential pressure sensor (3) onto manifold (5).

8. Install bolts (4). Tighten bolts to a torque of 22 N·m (195 lb in).

9. Connect harness assembly (1) to differential pressure sensor (3). Slide locking tab (2) (not shown) into the locked position.

i04203646

Boost Pressure Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

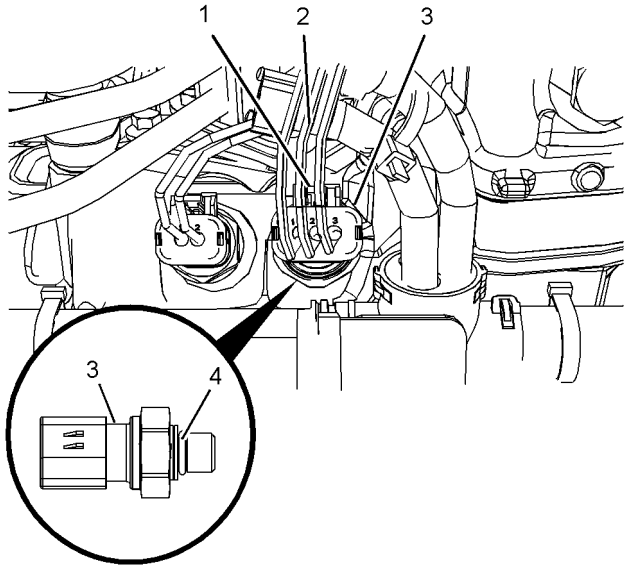


Illustration 537 g02383202

1. Slide locking tab (1) into the unlocked position.

2. Disconnect harness assembly (2) from boost pressure sensor (3).

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

3. Use a deep socket to remove boost pressure sensor (3) from the inlet manifold.

4. Remove O-ring seal (4) from the boost pressure sensor (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

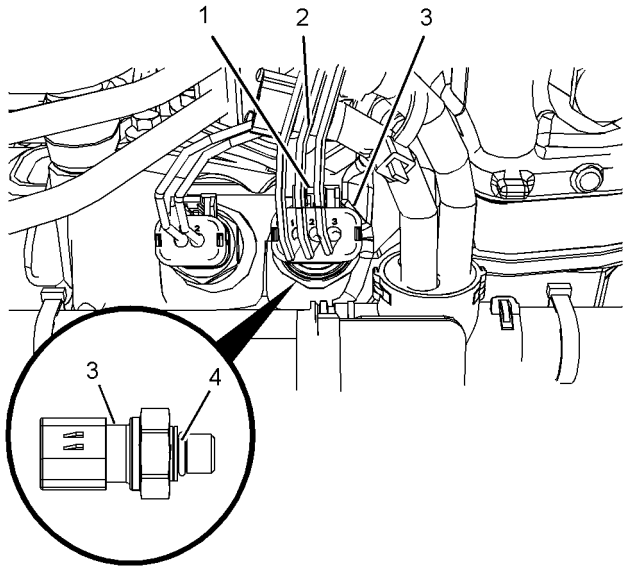


Illustration 538 g02383202

1. Install a new O-ring seal (4) onto boost pressure sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install boost pressure sensor (3) to the inlet manifold. Tighten the boost pressure sensor to a torque of 10 N·m (89 lb in).

3. Connect harness assembly (2) to boost pressure sensor (3).

4. Slide locking tab (1) into the locked position.

i04203744

Inlet Manifold Temperature Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

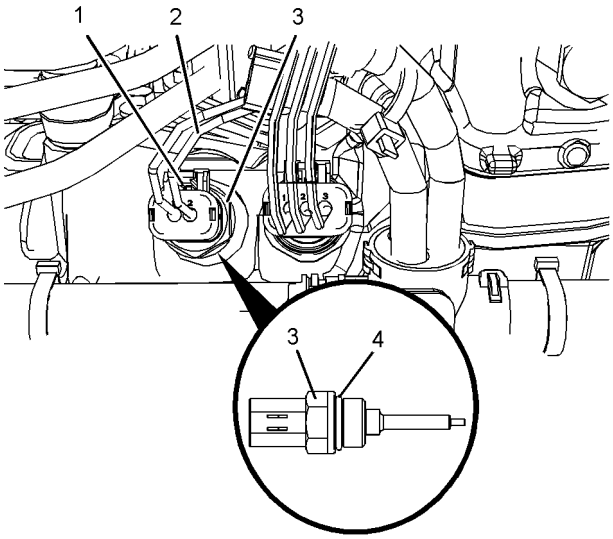


Illustration 539 g02022990

1. Slide locking tab (1) into the unlocked position.

2. Disconnect harness assembly (2) from inlet manifold temperature sensor (3).

Note: The inlet manifold temperature sensor has a two-wire plug.

3. Use a deep socket to remove inlet manifold temperature sensor (3) from the inlet manifold.

4. Remove O-ring seal (4) from the inlet manifold temperature sensor (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

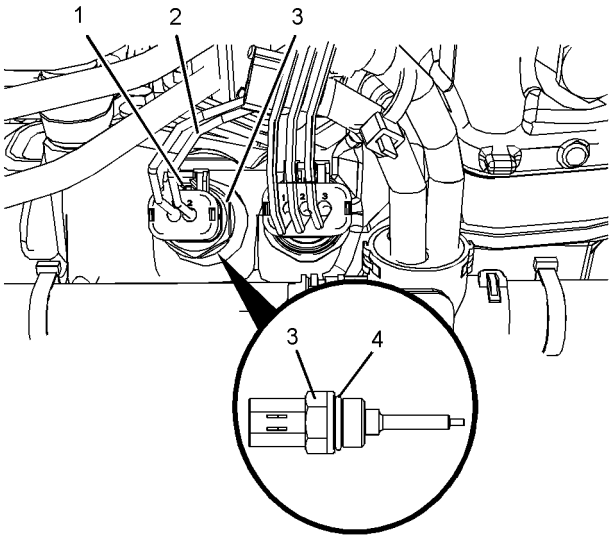


Illustration 540 g02022990

1. Install a new O-ring seal (4) to inlet manifold temperature sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install inlet manifold temperature sensor (3) to the inlet manifold. Tighten the inlet manifold temperature sensor to a torque of 20 N·m (177 lb in).

3. Connect harness assembly (2) to inlet manifold temperature sensor (3).

4. Slide locking tab (1) into the locked position.

i04203727

Glow Plugs - Remove and Install

Removal Procedure

Start By:

a. Remove the inlet elbow and inlet air control (NOx Reduction System (NRS) Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Turn the battery disconnect switch to the OFF position.

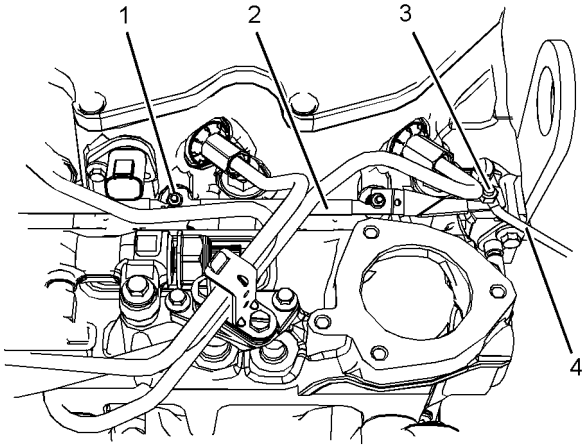


Illustration 541 g02025312

2. Remove nut (3) from the terminal insulator.
3. Disconnect wire (4) from the terminal insulator.
4. Remove nuts (1) that secure busbar (2) to the glow plugs.
5. Remove busbar (1) from glow plugs (4).

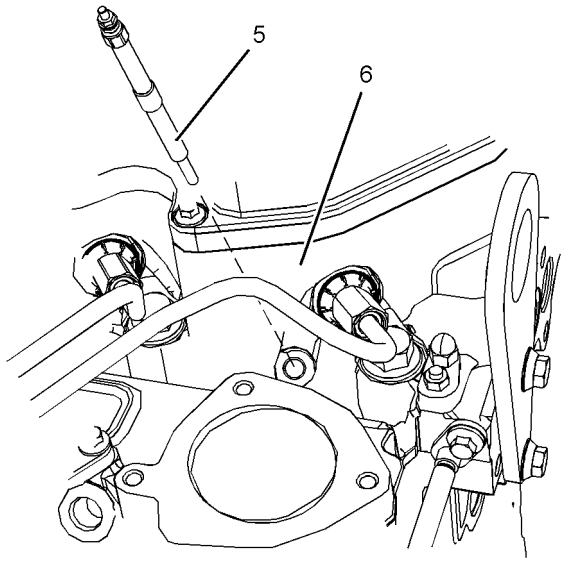


Illustration 542 g02025313

6. Clean the area around glow plugs (5). Ensure that the area is free from contamination before removal of the glow plugs.
7. Remove glow plugs (5) from cylinder head (6).

Installation Procedure

Table 102

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

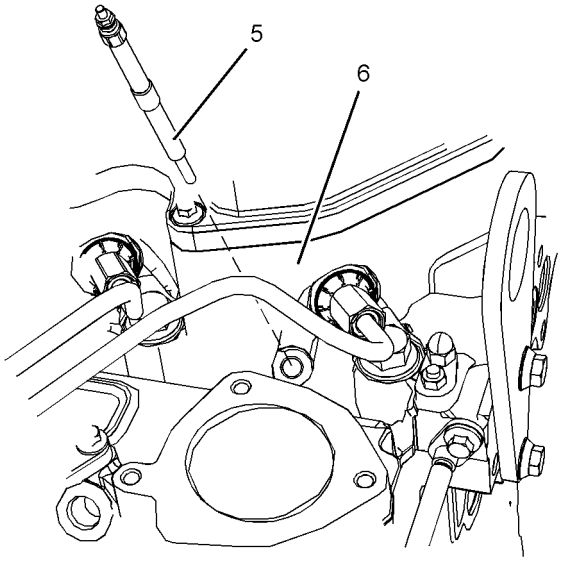


Illustration 543 g02025313

1. Before installing glow plugs (5), ensure that the glow plugs are operating correctly. Ref to Trouble Shooting, “Glow Plug Starting Aid - Test” “Check the Operation of the Glow Plugs” for the correct procedure.
2. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.
3. Install glow plugs (5) into cylinder head (6). Tighten the glow plugs to a torque of 15 N·m (132 lb in).

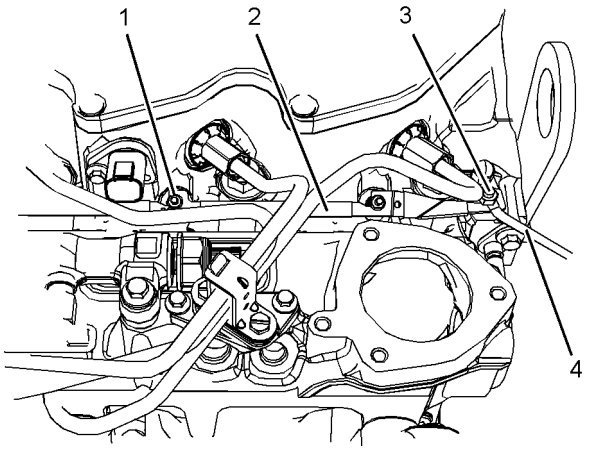


Illustration 544 g02025312

4. Position busbar (2) onto the glow plugs. Install nuts (1) onto the glow plugs.

5. Use Tooling (A) to tighten nuts (1) to a torque of 2 N·m (17 lb in).

6. Connect wire (4) to the stud on the terminal insulator.

7. Install nut (3) to the stud on the terminal insulator. Tighten the nut to a torque of 6 N·m (53 lb in).

8. Turn the battery disconnect switch to the ON position.

End By:

a. Install the inlet elbow and inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Install” for the correct procedure.

i04203642

Alternator Belt - Remove and Install

Removal Procedure

Table 103

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Locking Pin 8 mm (0.31 inch) Ø by 85 mm (3.35 inch)	1

1. If the engine has guards, remove the guards. Refer to the Original Equipment Manufacture (OEM) for the correct procedure.

Note: Mark the direction of rotation of the alternator belt if the belt will be reused.

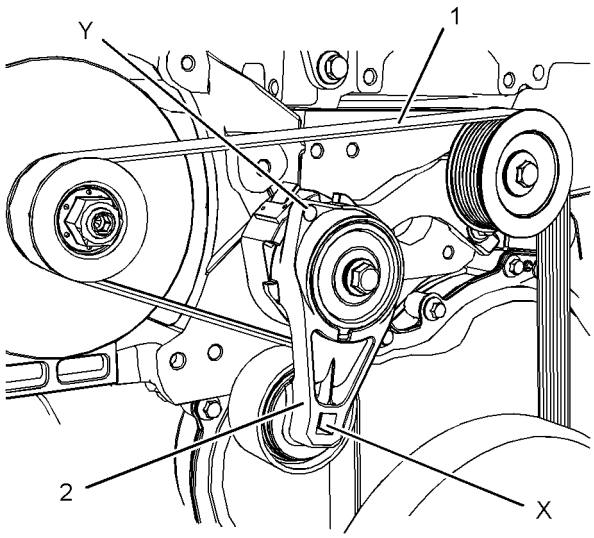


Illustration 545 g02017213

Typical example

2. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction.

3. Insert Tooling (A) into Hole (Y).

4. Remove alternator belt (1).

5. If necessary, Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction and remove Tooling (A) from Hole (Y).

6. Release the pressure on the 1/2" square drive tool and remove the 1/2" square drive tool from Hole (X).

Installation Procedure

Table 104

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Locking Pin 8 mm (0.31 inch) Ø by 85 mm (3.35 inch)	1

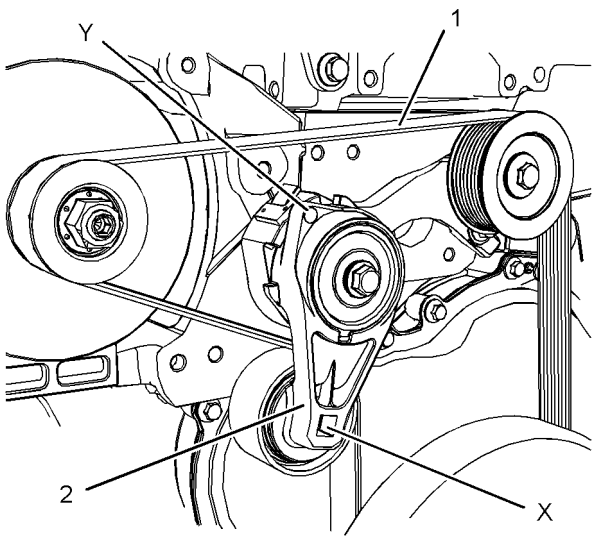


Illustration 546 g02017213
Typical example

1. If necessary, follow Step 1.a through Step 1.c in order to position the tensioner correctly.

   a. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction.

   b. Insert Tooling (A) into Hole (Y).

   c. Release the pressure on the 1/2" square drive tool and remove the 1/2" square drive tool from Hole (X).

2. Ensure that the belt tensioner, pulleys, and all guide rollers are clean. Ensure that the pulleys and guide rollers are free from dirt and build up from the old belt.

3. Ensure that all components of the belt tensioner, pulleys, and guide rollers are clean and free from wear and damage. If necessary, replace any components that are worn or damaged.

   Refer to Disassembly and Assembly, “Belt Tensioner - Remove and Install” for the correct procedure.

   Refer to Disassembly and Assembly, “Idler Pulley (Flat Idler Pulley) - Remove and Install” for the correct procedure.

   Refer to Disassembly and Assembly, “Idler Pulley (Grooved Idler Pulley) - Remove and Install” for the correct procedure.

4. Position alternator belt (1). Ensure that the alternator belt is centered on all pulleys. 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 grooves of all pulleys.

5. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction. Remove Tooling (A) from Hole (Y).

6. Release the pressure on the 1/2" square drive tool until the alternator belt is tensioned. Remove the 1/2" square drive tool from Hole (X).

   Note: The tensioner should be at the nominal position.

7. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i04203738

Idler Pulley - Remove and Install (Grooved Idler Pulley)

Removal Procedure

Start By:

a. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

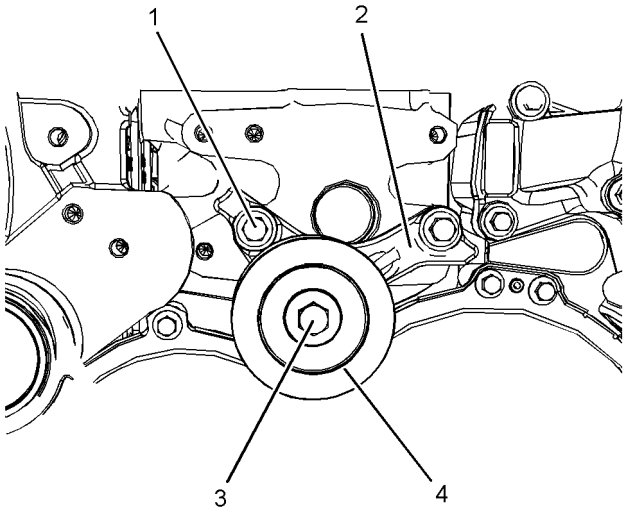


Illustration 547 g02058760
Typical example

1. Make a temporary mark on idler pulley (4) in order to identify the correct orientation and the position.
2. Loosen bolt (3) and remove idler pulley (4).
3. If necessary, follow Step 3.a through Step 3.c in order to remove bracket (2) for the idler pulley.
   a. Make a temporary mark on bracket (2) in order to identify the correct orientation and the position.
   b. Remove bolts (1) from bracket (2).
   c. Remove bracket (2) from the cylinder block.

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 idler pulley are clean and free from wear and damage. If necessary, replace any components that are worn or damaged.

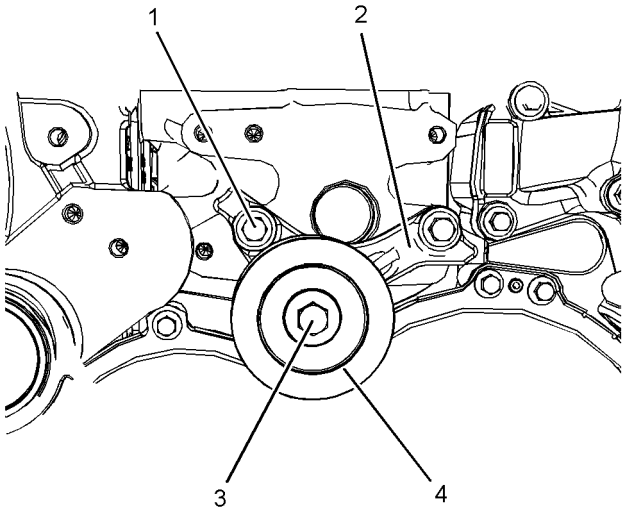


Illustration 548 g02058760
Typical example

2. If necessary, follow Step 2.a through Step 2.c in order to install bracket (2) for the idler pulley to the cylinder block.
   a. Position bracket (2) onto the cylinder block.

Note: Ensure that the bracket is correctly oriented.

   b. Install bolts (1) to bracket (2).
   c. Tighten bolts (1) to a torque of 44 N·m (32 lb ft).
3. Position idler pulley (4) onto bracket (2). Tighten bolt (3) hand tight.
4. Tighten bolt (3) to a torque of 44 N·m (32 lb ft).

End By:

a. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

i04203737

Idler Pulley - Remove and Install (Flat Idler Pulley)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

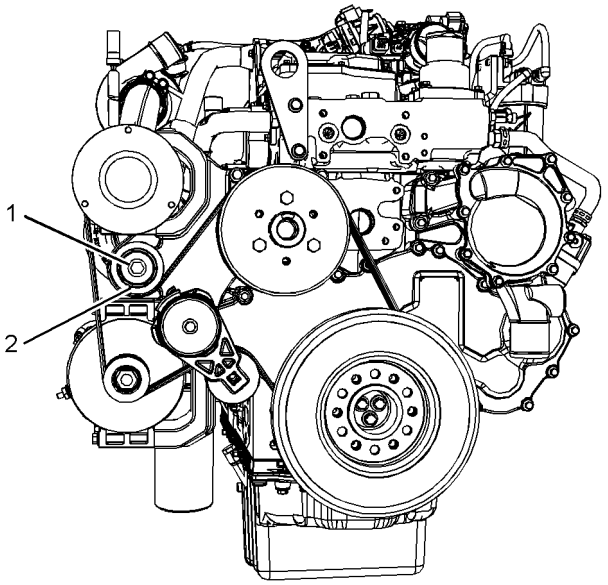


Illustration 549 g02048773
Typical example

2. Make a temporary mark on idler pulley (2) in order to identify the correct orientation and the position.

3. Loosen bolt (1) and remove idler pulley (2) from bracket.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

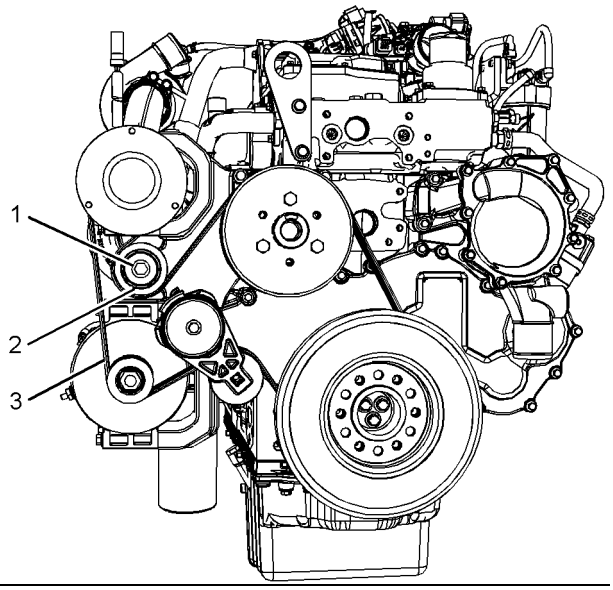


Illustration 550 g02048794
Typical example

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

2. Position idler pulley (2) on the bracket. Tighten bolt (1) hand tight.

3. Tighten the bolt to a torque of 44 N·m (32 lb ft).

4. Install alternator belt (3). Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

i04203645

Belt Tensioner - Remove and Install

Removal Procedure

1. If the engine has guards, remove the guards. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

2. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install.” for the correct procedure.

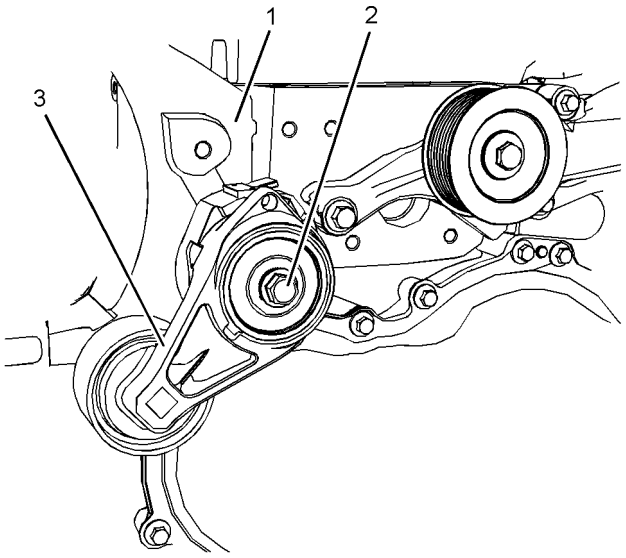


Illustration 551 g02019713

3. Make a temporary mark on belt tensioner (3) in order to identify the correct orientation and the position.

4. Loosen bolt (2) sufficiently in order to remove belt tensioner (3) from mounting bracket (1).

5. Remove belt tensioner (3) from mounting bracket (1).

Installation Procedure

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

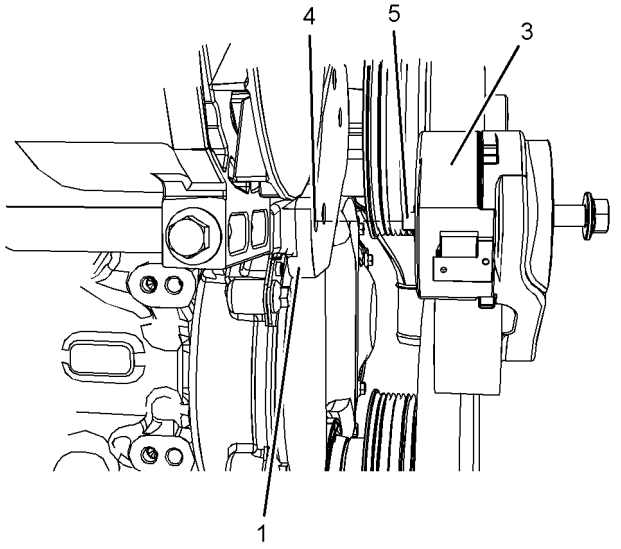


Illustration 552 g02093515

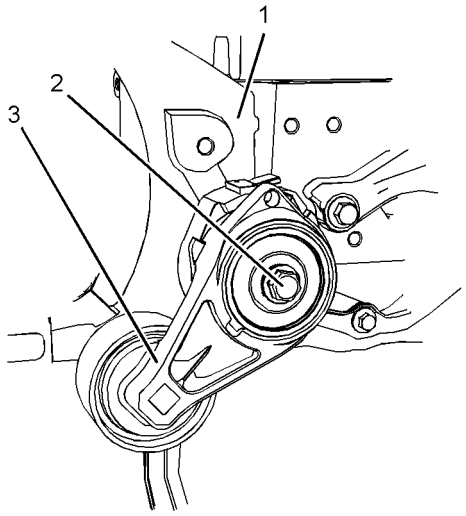


Illustration 553 g02092593

2. Position belt tensioner (3) with locating pin (5) in locating hole (4) on mounting bracket (1). Tighten bolt (2) finger tight.

3. Tighten bolt (2) to a torque of 45 N·m (33 lb ft).

4. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install.” for the correct procedure.

5. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i04203695

Fan - Remove and Install

Removal Procedure

Start By:

a. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

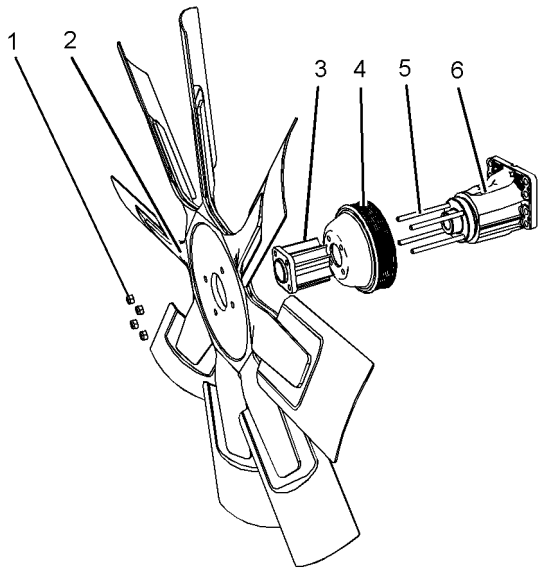


Illustration 554 g02320097

1. Remove locking nuts (1).

2. Remove fan (2).

Note: Note the orientation of the fan.

3. Remove fan adapter (3).

4. Remove fan pulley (4).

5. If necessary, remove studs (5) from fan drive (6).

Installation Procedure

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

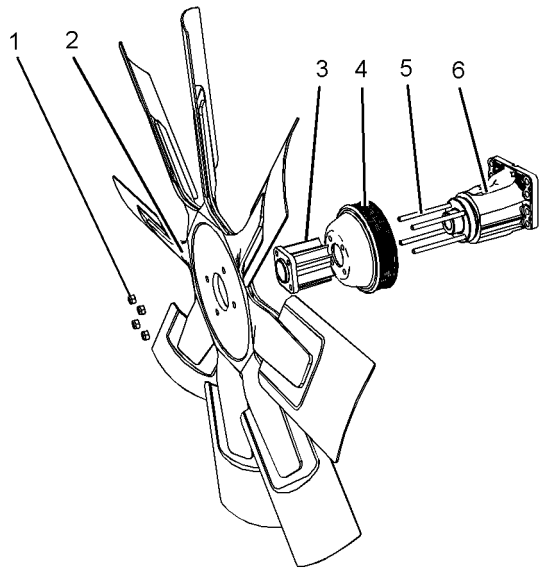


Illustration 555 g02320097

Typical example

2. If necessary, install studs (5) to fan drive (6). Tighten studs (5) to a torque of 11 N·m (97 lb in).

3. If studs (5) have not been previously removed from fan drive (6). It will be necessary to check for the correct installation of the studs to the fan drive. Tighten studs (5) to a torque of 11 N·m (97 lb in).

4. Install fan pulley (4).

5. Install fan adapter (3).

6. Install fan (2).

Note: Ensure that the fan is correctly oriented.

7. Inspect the condition of locking nuts (1). If necessary, replace the locking nuts. Install locking nuts (1). Tighten locking nuts (1) to a torque of 22 N·m (195 lb in).

End By:

a. Install the Alternator Belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

i04203696

Fan Drive - Remove and Install

Removal Procedure

Start By:

a. Remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

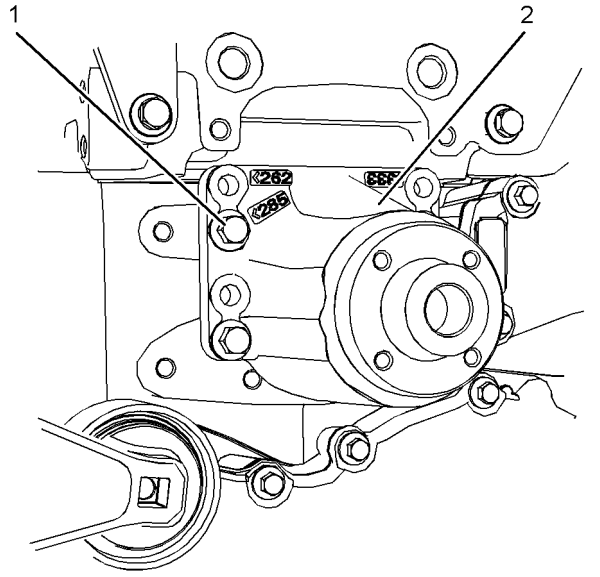


Illustration 556 g02014594
Typical example

1. Make a temporary mark on fan drive assembly (2) in order to identify the orientation and the position.

2. Remove bolts (1) from fan drive assembly (2).

3. Remove fan drive assembly (2).

Installation Procedure

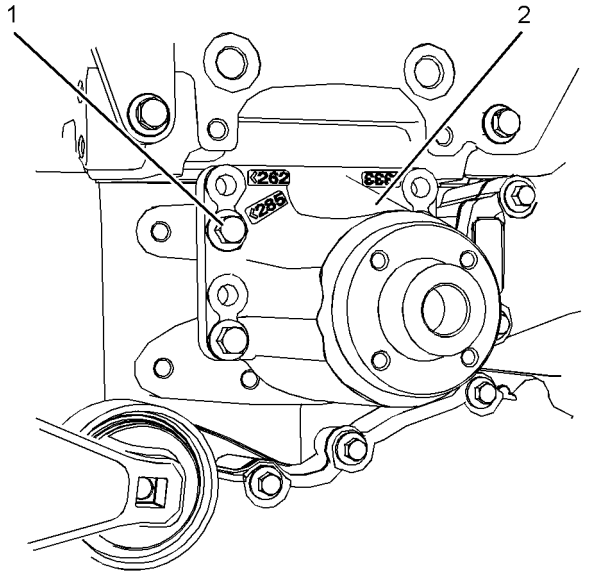


Illustration 557 g02014594
Typical example

1. Check the fan drive for wear and damage. If the fan drive is worn or damaged, replace the fan drive.

2. Install fan drive assembly (2).

Note: Ensure that the fan drive is correctly oriented.

3. Install bolts (1) finger tight to fan drive assembly (2). Tighten the bolts to a torque of 44 N·m (32 lb ft).

End By:

a. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04203678

Electronic Control Module - Remove and Install (Electronic Control Module With Banjo Bolt Connections)

Removal Procedure

Table 105

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

NOTICE

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

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

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

1. Turn the battery disconnect switch to the OFF position.

2. Turn the fuel supply to the OFF position.

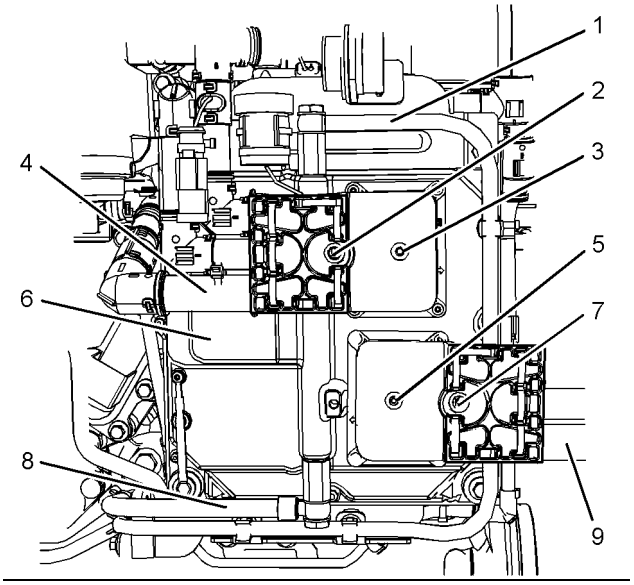


Illustration 558 g02163193

Typical example

3. Cut all cable straps that attach the wiring harness assemblies to electronic control module (6).

Note: Note position of cable straps that attach the wiring harness assemblies to the electronic control module.

4. Remove bolt (2). Loosen allen head bolts (3) that secures engine wiring harness assembly (4) to electronic control module (6). Disconnect the engine wiring harness assembly from the electronic control module.

5. Remove bolt (7). Loosen allen head bolts (5) that secures engine wiring harness assembly (9) to electronic control module (6). Disconnect the Original Equipment Manufactures (OEM) wiring harness assembly from the electronic control module.

6. Position harness assembly (9) and harness assembly (4) away from electronic control module (6).

7. Make temporary identification marks on fuel line (1) and fuel line (8) in order to show the correct position of the fuel lines.

8. Place a suitable container below electronic control module (6) in order to catch any fuel that might be spilled.

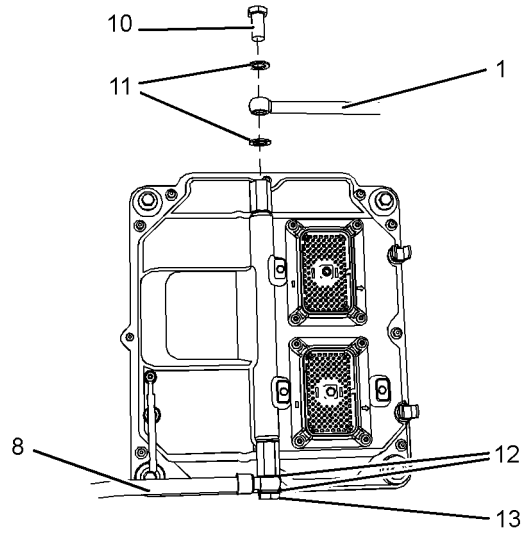


Illustration 559 g02163197

Typical example

9. Loosen banjo bolt (10) and banjo bolt (13) in order to drain the fuel from the electronic control module.

10. Remove banjo bolt (10) from fuel line (1). Remove sealing washers (11) from banjo bolt (10).

11. Remove fuel line (1) from fuel line clips. Position the fuel line away from the electronic control module.

12. Use Tooling (A) to cap fuel line (1) and plug the connection on the electronic control module.

13. Remove banjo bolt (13) from fuel line (8). Remove sealing washers (12) from banjo bolt (13).

14. Use Tooling (A) to cap fuel line (8) and plug the connection on the electronic control module.

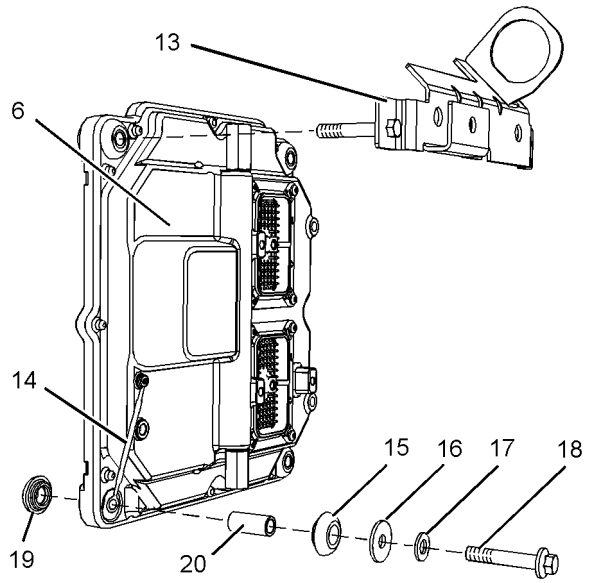


Illustration 560 g02163198

Typical example

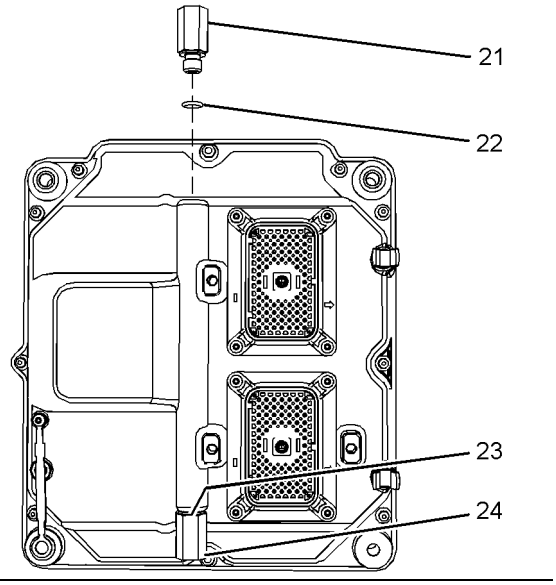


Illustration 561 g02163199

Typical example

15. Loosen bolts (18) for electronic control module (6).

16. Remove bolts (18) and remove washers (16) and washer (17). Take care to prevent damage to ground connection (14).

Note: Support the weight of the electronic control module as the remaining bolts are removed.

17. Remove bracket (13) and remove electronic control module (6) from mounting bracket for the electronic control module.

Note: Note the orientation of the electronic control module.

18. If necessary, follow Step 18.a through Step 18.c in order to disassemble the electronic control module.

a. Remove connection (21) and O-ring seal (22). Use Tooling (A) to plug the electronic control module and cap the connection.

b. Remove connection (24) and O-ring seal (23) (not shown). Use Tooling (A) to plug the electronic control module and cap the connection.

c. Remove isolation mounts (15), isolation mounts (19), and limit sleeves (20) from electronic control module (6).

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.

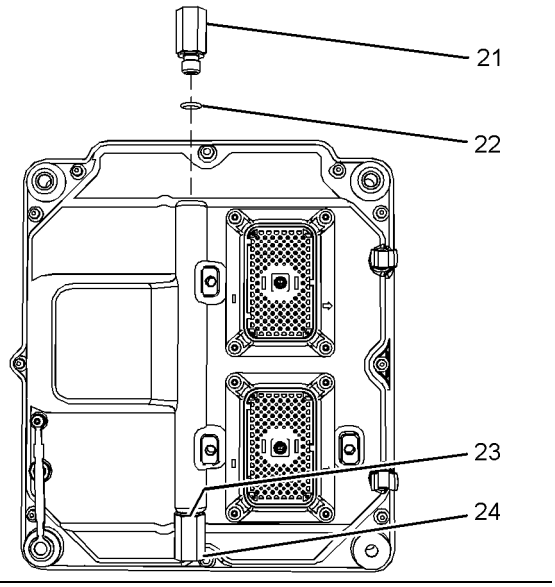


Illustration 562 g02163199

Typical example

3. If necessary, follow Step 3.a through Step 3.d in order to assemble electronic control module (6).

a. Remove the cap from connection (21). Install a new O-ring seal (22) to the connection.

b. Remove the cap from connection (24). Install a new O-ring seal (23) (not shown) to the connection.

c. Remove the plugs from electronic control module (6).

d. Install connector (21) and connector (24) to electronic control module (6). Tighten the connections to a torque of 18 N·m (159 lb in).

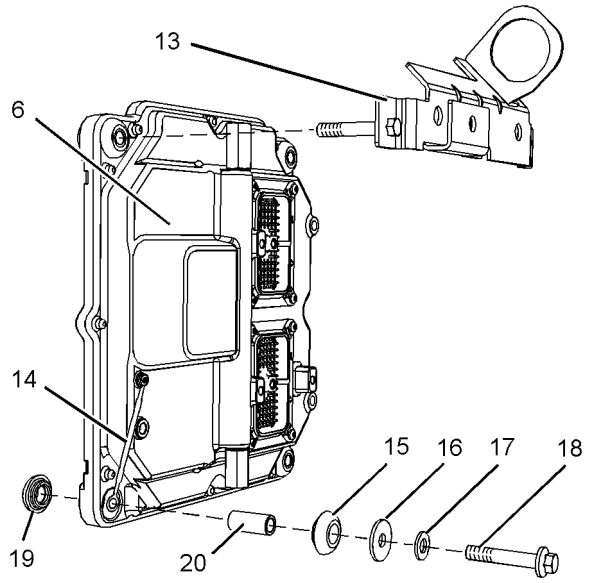


Illustration 563 g02163198
Typical example

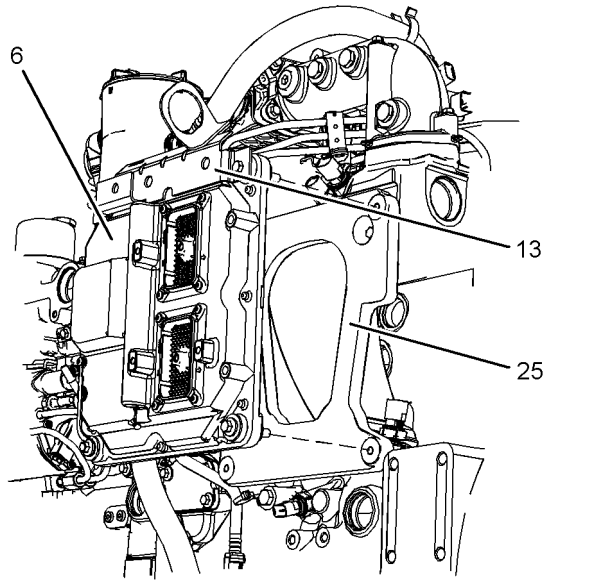


Illustration 564 g02163646
Typical example

4. Install isolation mounts (15), isolation mounts (19), and limit sleeves (20) to electronic control module (6).

5. Install washers (16) and washer (17) to bolts (18) to the lower isolation mounts.

Note: Ensure that ground strap (14) for the electronic control module is clamped between washer (16) and washer (17).

6. Position electronic control module (6) on mounting bracket (25) for the electronic control module. Loosely install bolts (18).

Note: Ensure that the electronic control module is correctly oriented.

7. Position bracket (13) onto electronic control module (6). Install remaining bolts (18) to bracket (13).

8. Tighten bolts (18) to a torque of 22 N·m (195 lb in).

Note: Ensure that the ground strap is not strained as the bolt is tightened.

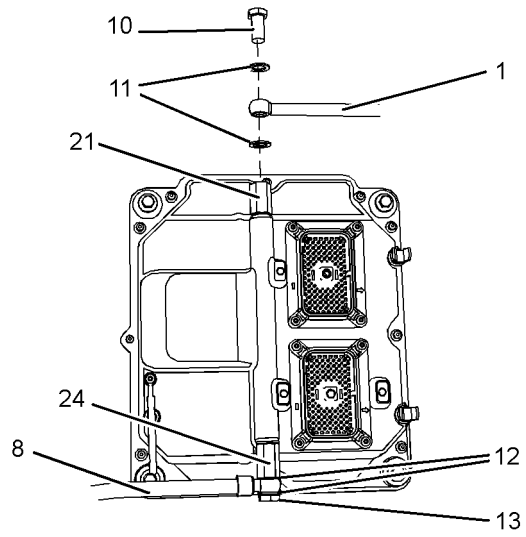


Illustration 565 g02163660
Typical example

9. Install a new sealing washer (12) to banjo bolt (13).

10. Remove the plug from fuel line (8) and remove the plug from connection (24) on the electronic control module.

11. Install banjo bolt (13) to fuel line (8) and install remaining new washer (12) to banjo bolt (13). Position fuel line assembly (8) onto connection (24) and hand tighten banjo bolt.

12. Tighten banjo bolt (13) to a torque of 18 N·m (159 lb in).

Note: Ensure that the fuel line is not strained as the banjo bolt is tightened.

13. Install a new sealing washer (11) to banjo bolt (10).

14. Remove the plug from fuel line (1) and remove the plug from connection (21) on the electronic control module.

15. Install banjo bolt (10) to fuel line (1) and install remaining new washer (11) to banjo bolt (10). Position fuel line assembly (1) onto connection (21) and hand tighten banjo bolt.

16. Install fuel line (1) to fuel line clips.

17. Tighten banjo bolt (10) to a torque of 18 N·m (159 lb in).

Note: Ensure that the fuel line is not strained as the banjo bolt is tightened.

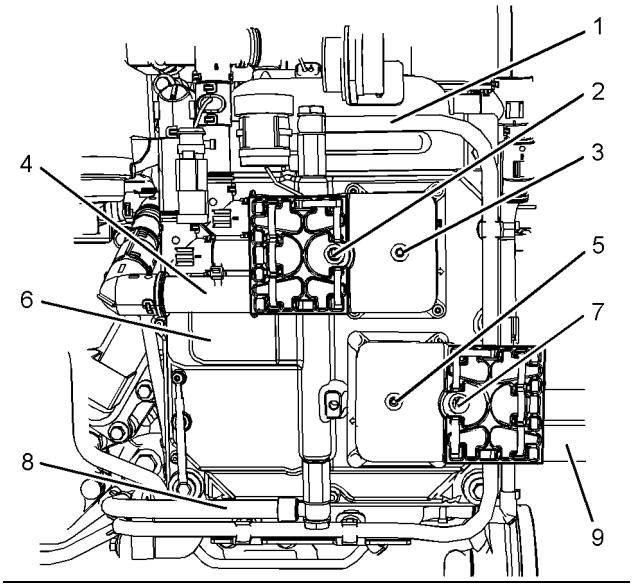


Illustration 566 g02163193

Typical example

18. Connect engine wiring harness assembly (4) to electronic control module (6). Tighten allen head bolt (3) to a torque of 6 N·m (53 lb in).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the wiring harness assembly.

19. Install bolt (2) and tighten the bolt to a torque of 6.5 N·m (58 lb in).

20. Connect OEM wiring harness assembly (9) to electronic control module (6). Tighten allen head bolt (5) to a torque of 6 N·m (53 lb in).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness assembly.

21. Install bolt (7) and tighten the bolt to a torque of 6.5 N·m (58 lb in).

22. Install new cable straps to the wiring harness assemblies.

Note: Ensure that the cable straps meet the Original Equipment Manufactures (OEM) specifications.

23. Turn the fuel supply to the ON position.

24. Turn the battery disconnect switch to the ON position.

25. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203677

Electronic Control Module - Remove and Install (Electronic Control Module With Quick Coupler Connections)

Removal Procedure

Table 106

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T410437	Capping Kit	1

NOTICE

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

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

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

1. Turn the battery disconnect switch to the OFF position.

2. Turn the fuel supply to the OFF position.

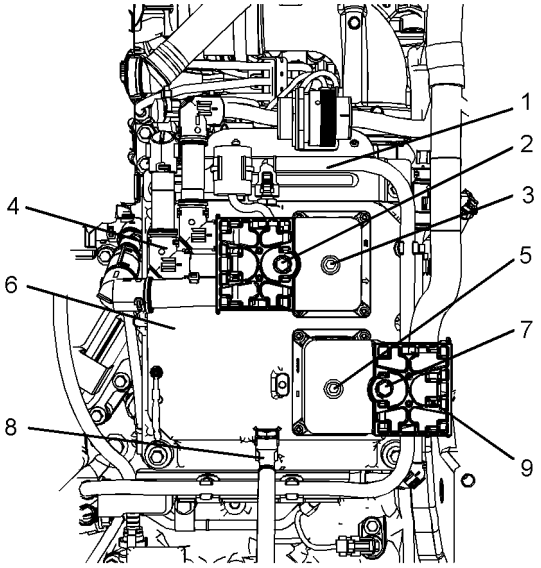


Illustration 567 g02163730
Typical example

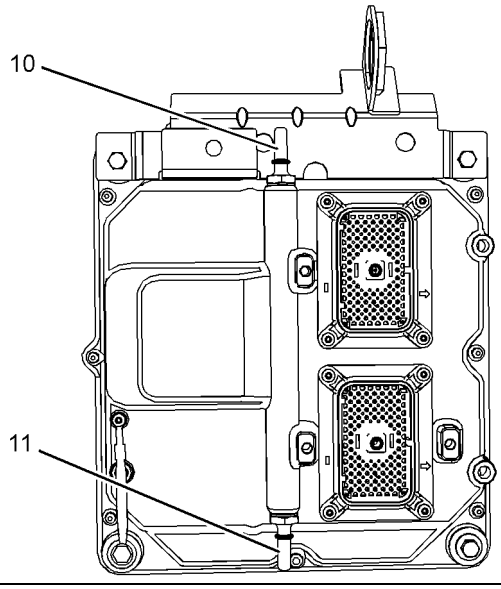


Illustration 568 g02163733
Typical example

3. Cut all cable straps that attach the wiring harness assemblies to electronic control module (6).

Note: Note position of cable straps that attach the wiring harness assemblies to the electronic control module.

4. Remove bolt (2). Loosen allen head bolt (3) that secures engine wiring harness assembly (4) to electronic control module (6). Disconnect the engine wiring harness assembly from the electronic control module.

5. Remove bolt (7). Loosen allen head bolt (5) that secures engine wiring harness assembly (9) to electronic control module (6). Disconnect the Original Equipment Manufactures (OEM) wiring harness assembly from the electronic control module.

6. Position harness assembly (9) and harness assembly (4) away from electronic control module (6).

7. Make temporary identification marks on fuel line (1) and fuel line (8) in order to show the correct position of the fuel lines.

8. Place a suitable container below electronic control module (6) in order to catch any fuel that might be spilled.

9. Disconnect fuel line (1) and remove the fuel line from fuel line clips. Use Tooling (A) to plug fuel lines (1). Position the fuel line away from the electronic control module.

10. Use Tooling (A) to cap connection (10) on the electronic control module.

11. Remove fuel line (8) and drain the fuel from electronic control module (6). Use Tooling (A) to plug fuel lines (8).

12. Use Tooling (A) to cap connection (11) on the electronic control module.

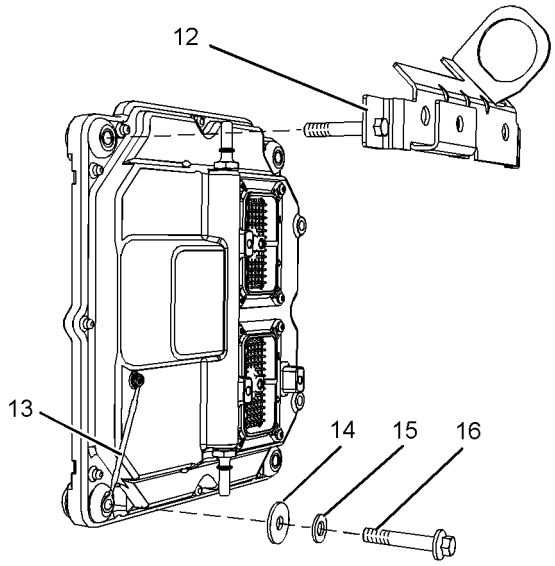


Illustration 569 g02163734
Typical example

13. Loosen bolts (16) for electronic control module (6).

14. Remove bolts (16) and remove washers (14) and washer (15). Take care to prevent damage to ground connection (13).

Note: Support the weight of the electronic control module as the remaining bolts are removed.

15. Remove bracket (12) and remove electronic control module (6) from mounting bracket for the electronic control module.

Note: Note the orientation of the electronic control module.

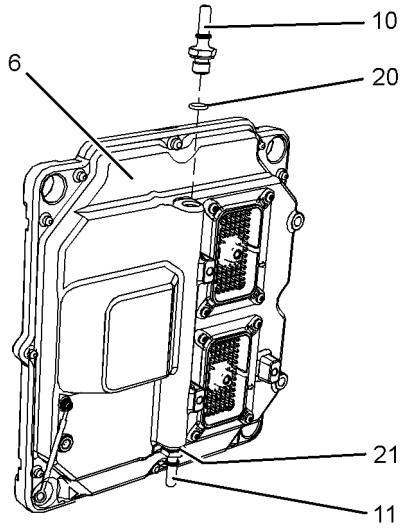


Illustration 570 g02163736

Typical example

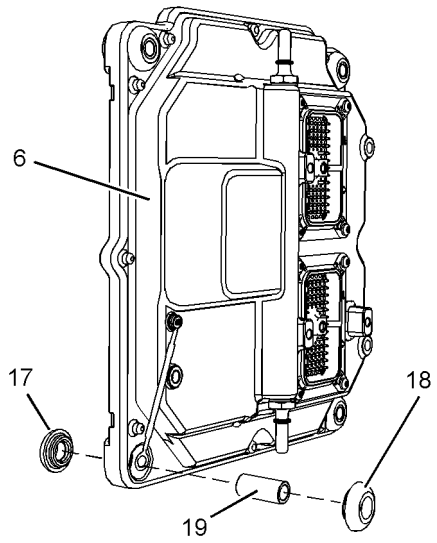


Illustration 571 g02163735

Typical example

16. If necessary, follow Step 16.a through Step 16.c in order to disassemble electronic control module (6).

a. Remove connection (10) and remove O-ring seal (20). Use Tooling (A) to cap connection (10) and plug electronic control module (6).

b. Remove connection (11) and remove O-ring seal (21) (not shown). Use Tooling (A) to cap connection (11) and plug electronic control module (6).

c. Remove isolation mounts (17), isolation mounts (18), and limit sleeves (19) from electronic control module (6).

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.

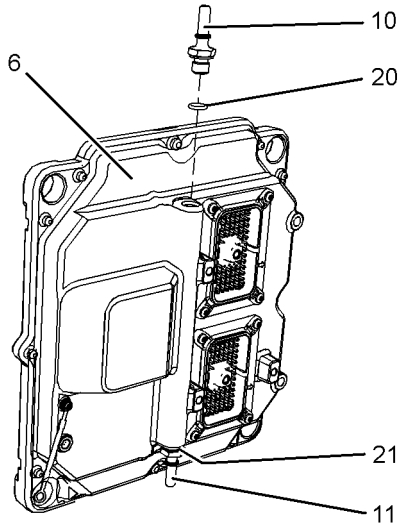


Illustration 572 g02163736

Typical example

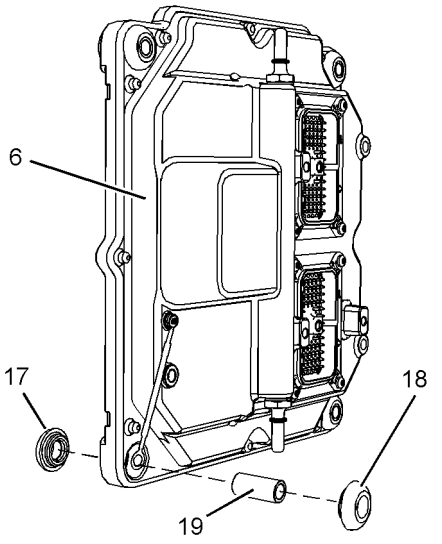


Illustration 573 g02163735
Typical example

3. If necessary, follow Step 3.a through Step 3.e in order to assemble electronic control module (6).

a. Remove the cap from connection (10). Install a new O-ring seal (20) to the connection.

b. Remove the cap from connection (11). Install a new O-ring seal (21) (not shown) to the connection.

c. Remove the plugs from electronic control module (6).

d. Install connection (10) and connection (11) to electronic control module (6). Tighten the connections to a torque of 18 N·m (159 lb in).

e. Install isolation mounts (17), isolation mounts (18), and limit sleeves (19) to electronic control module (6).

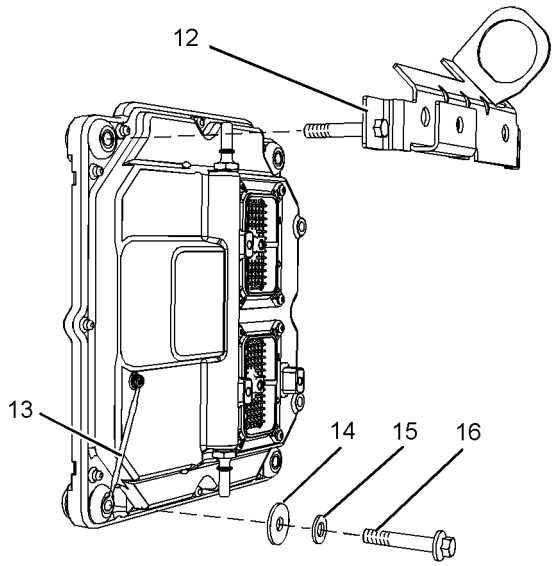


Illustration 574 g02163734
Typical example

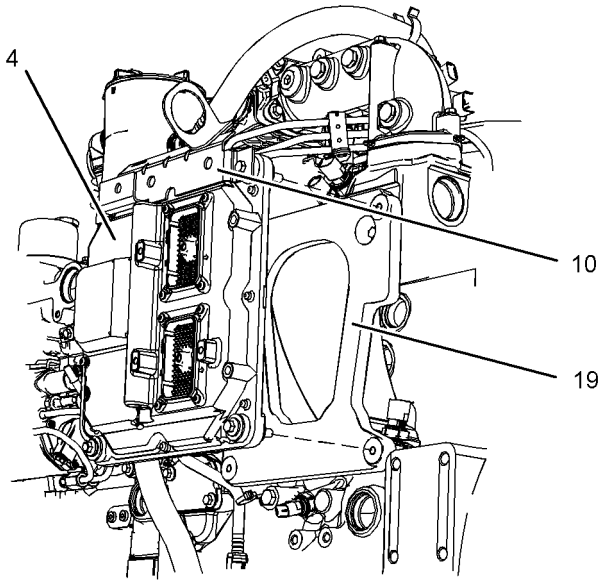


Illustration 575 g02163737

4. Install washers (14) and washers (15) to bolts (16).

Note: Ensure that ground strap (13) for the electronic control module is clamped between washer (15) and washer (14).

5. Position electronic control module (6) on mounting bracket (19) for the electronic control module. Loosely install bolts (16) to the lower isolator mounts.

Note: Ensure that the electronic control module is correctly oriented.

6. Position bracket (12) onto electronic control module (6). Install remaining bolts (16) to bracket (12).

7. Tighten bolts (16) to a torque of 22 N·m (195 lb in).

Note: Ensure that the ground strap is not strained as the bolt is tightened.

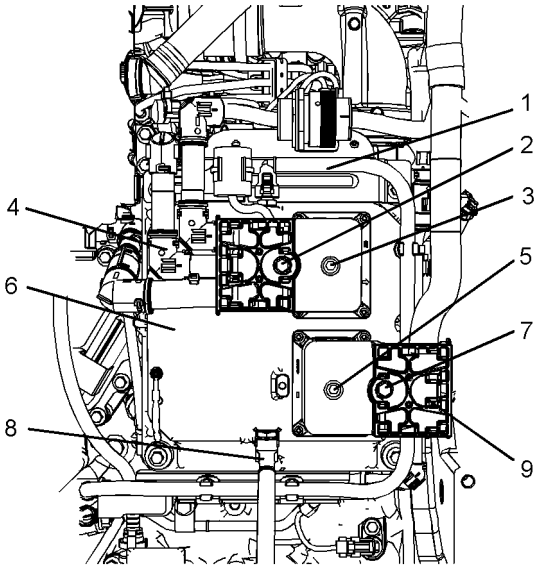


Illustration 576 g02163730

Typical example

8. Remove the plugs from fuel line (1) and fuel line (8).

9. Remove caps from connection on electronic control module (6) for fuel line (1) and fuel line (8).

10. Connect fuel line (1) and fuel line (6) to electronic control module (6).

11. Install fuel line (1) to fuel line clips.

12. Connect engine wiring harness assembly (4) to electronic control module (6). Tighten allen head bolt (3) to a torque of 6 N·m (53 lb in).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness.

13. Install bolt (2) and tighten the bolt to a torque of 6.5 N·m (58 lb in).

14. Connect OEM wiring harness assembly (9) to electronic control module (6). Tighten allen head bolt (5) to a torque of 6 N·m (53 lb in).

15. Install bolt (7) and tighten the bolt to a torque of 6.5 N·m (58 lb in).

16. Install new cable straps to the wiring harness assemblies.

Note: Ensure that the cable straps meet the Original Equipment Manufactures (OEM) specifications.

17. Turn the fuel supply to the ON position.

18. Turn the battery disconnect switch to the ON position.

19. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, “Fuel System - Prime” for the correct procedure.

i04203675

ECM Mounting Bracket - Remove and Install

Removal Procedure

Start By:

a. Remove the Electronic Control Module (ECM). Refer to Disassembly and Assembly, “Electronic Control Module - Remove and Install” for the correct procedure.

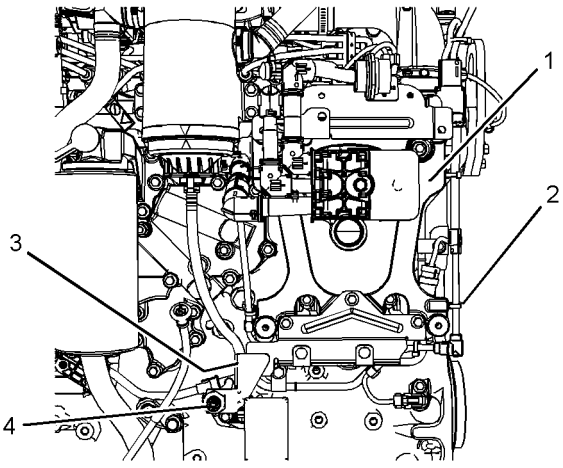


Illustration 577 g02164253

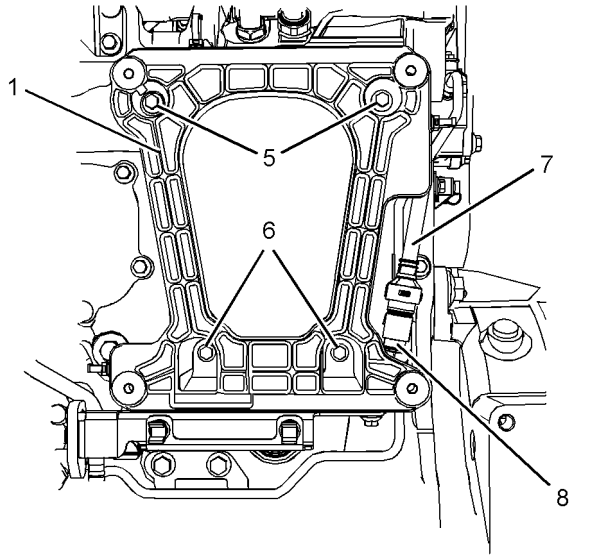


Illustration 578 g02164254

1. Cut cable straps (2) from wiring harness assembly.

Note: Note the position of cable straps that attach the wiring harness assembly to the ECM mounting bracket.

2. Remove bolt (3) (not shown) from clip for tube assembly (4).

3. Remove the fuel line from clips on the ECM mounting bracket.

4. Slide locking tab into the unlocked position. Disconnect wiring harness (7) from atmospheric pressure sensor (8).

5. Remove bolts (5) and loosen bolts (6) sufficiently to the allow ECM mounting bracket to be removed. Remove ECM mounting bracket (1) from the cylinder block.

6. If necessary, remove atmospheric pressure sensor (8) from the ECM mounting bracket. Refer to Disassembly and Assembly, “Atmospheric Pressure Sensor - Remove and Install” for the correct procedure.

Installation Procedure

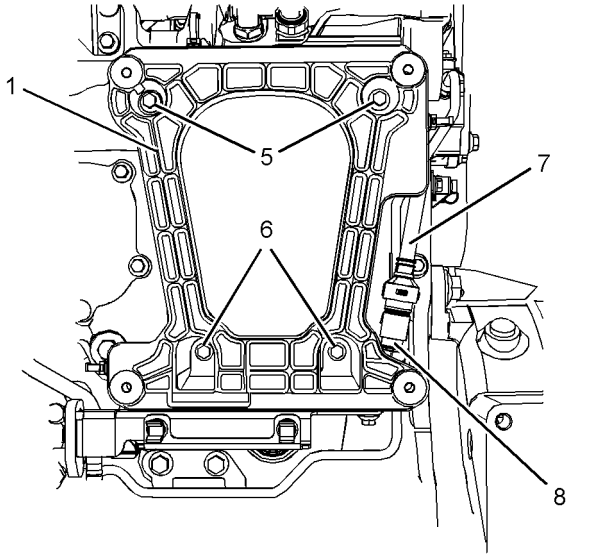


Illustration 579 g02164254

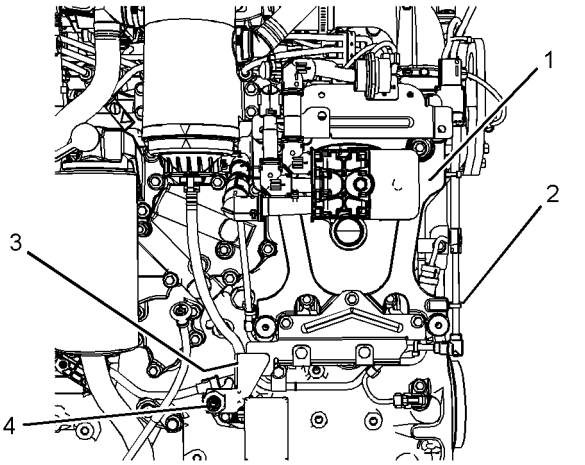


Illustration 580 g02164253

1. Ensure that ECM mounting bracket (1) for the electronic control module is clean and free from damage. If the mounting bracket is damaged, replace the bracket.

2. If necessary, install atmospheric pressure sensor (8) to ECM mounting bracket (1). Tighten the atmospheric pressure sensor to a torque of 10 N·m (89 lb in). Refer to Disassembly and Assembly, “Atmospheric Pressure Sensor - Remove and Install” for the correct procedure.

3. Position mounting bracket (1) onto bolts (6).

4. Install remaining bolts (5) to mounting bracket (1).

5. Tighten bolts (5) and bolts (6) to a torque of 22 N·m (195 lb in).

6. Connect harness assembly (7) to atmospheric pressure sensor (8). Slide the locking tab into the locked position.

7. Install fuel line to clips onto the ECM mounting bracket.

8. Install bolt (3) (not shown) to clip for tube assembly (4). Tighten the bolt to a torque of 22 N·m (195 lb in).

9. Position the wiring harness assemblies onto the ECM mounting bracket. Install new cable straps to the wiring harness assemblies.

Note: Ensure that the cable straps meet the Original Equipment Manufactures (OEM) specifications.

End By:

a. Install the electronic control module. Refer to Disassembly and Assembly, “Electronic Control Module - Remove and Install” for the correct procedure.

i04203641

Alternator - Remove

Removal Procedure

Table 107

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	-	1/2 Inch Drive T50 Torx Bit	1
	-	1/2 Inch Drive x 8 mm Hex Drive	1

(1) Either tool may be necessary in order to remove the alternator pulley.

Start By:

a. Remove the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

1. Turn the battery disconnect switch to the OFF position.

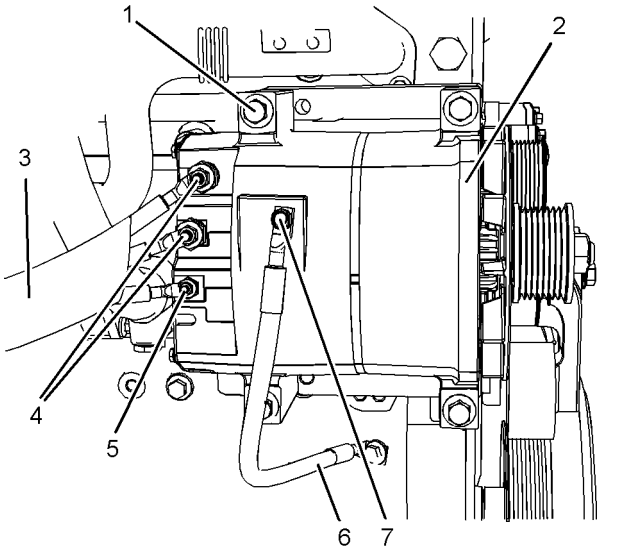


Illustration 581 g02020053

2. Place identification marks on all wiring harness connections (3). Remove nuts (4) and nut (5).

3. Remove harness assembly (3) from alternator (2).

4. Remove bolt (7) from alternator (2). Disconnect grounding strap (6) from alternator (2).

5. Support the weight of the alternator and remove bolts (1). Remove alternator (2) from the alternator bracket.

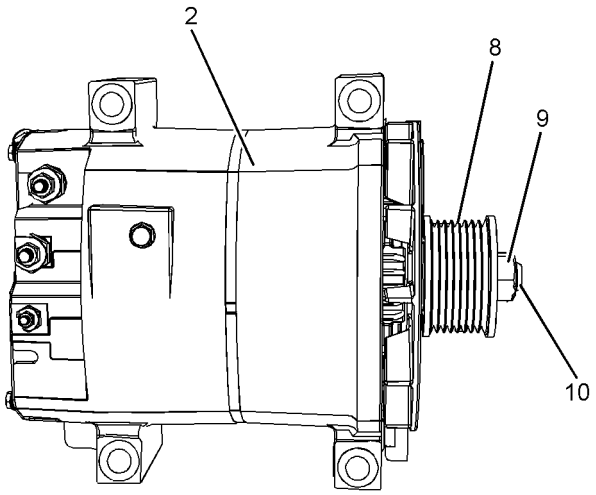


Illustration 582 g02022400

6. If necessary, follow Step 6.a through Step 6.d in order to remove pulley (8) from alternator (2).

Note: Either of Tooling (A) may be required in order to carry out the removal of the alternator pulley.

a. Place alternator (2) in a suitable support.

b. Hold shaft (10) of alternator (2) with Tooling (A). Use a cranked ring spanner to loosen nut (9).

c. Make a temporary mark on pulley (8) in order to show the correct orientation.

d. Remove nut (9) and pulley (8) from shaft (10).

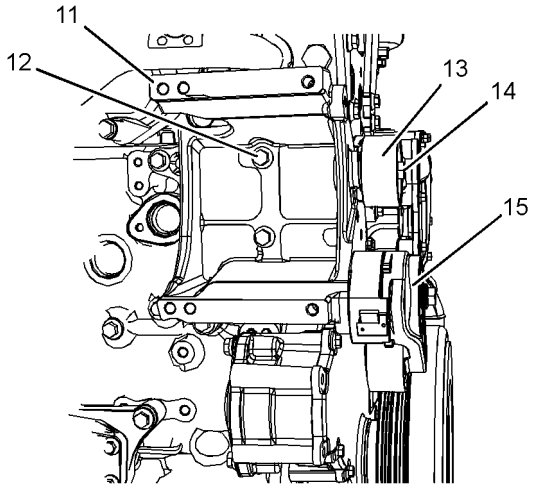


Illustration 583 g02022403

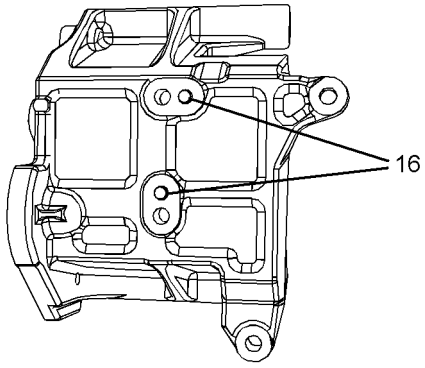


Illustration 584 g02022404

7. If necessary, follow Step 7.a through Step 7.d in order to remove alternator bracket (11) from the cylinder block.

a. If necessary, remove bolt (14) and remove flat idler pulley (13) from alternator bracket (11).

b. If necessary, remove belt tensioner (15) from alternator bracket (11). Refer to Disassembly and Assembly, “Belt Tensioner - Remove and Install” for the correct procedure.

c. Remove bolts (12) from alternator bracket (11). Remove the alternator bracket from the cylinder block.

Note: Support the weight of the alternator bracket as the bolts are removed.

d. Note the position of dowels (16) in alternator bracket (11).

Alternator Bracket for Hydraulic Excavator

1. If necessary, follow Step 1.a through Step 1.d in order to remove the alternator bracket for the hydraulic excavator from the cylinder block.

a. Remove the refrigerant compressor. Refer to Disassembly and Assembly, “Refrigerant Compressor - Remove and Install” for the correct procedures.

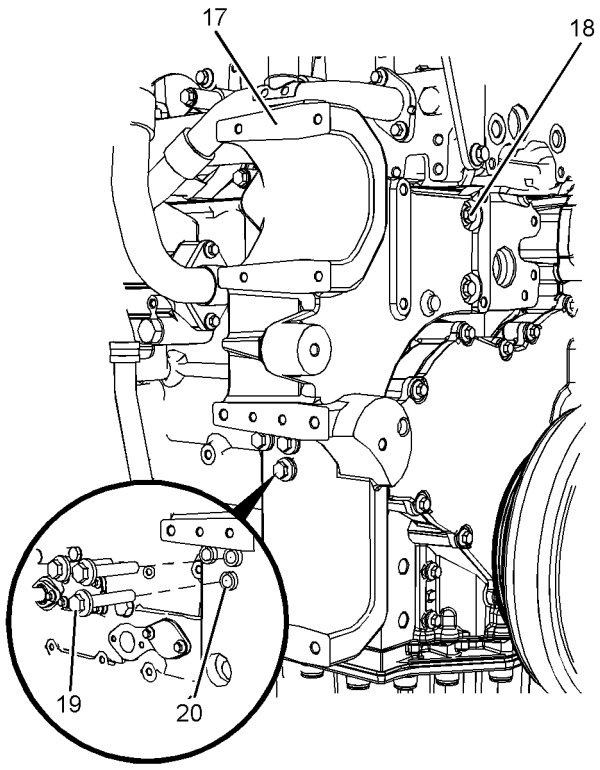


Illustration 585 g02320154

b. Remove bolts (19). Note the position of spacers (20) in bracket (17).

c. Remove bolts (18) from bracket (17).

Note: Support the weight of the bracket as the bolts are removed. The bracket can weight 19 kg (42 lb).

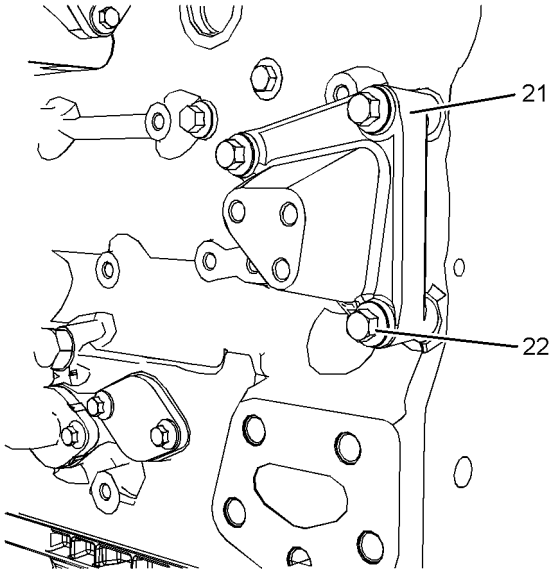


Illustration 586 g02320156

d. Remove bolts (22) and remove bracket (21) from the cylinder block.

i04203676

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. Turn the battery disconnect switch to the OFF position.

2. Place identification marks on the harness assembly that is connected to the electric starting motor and the solenoid.

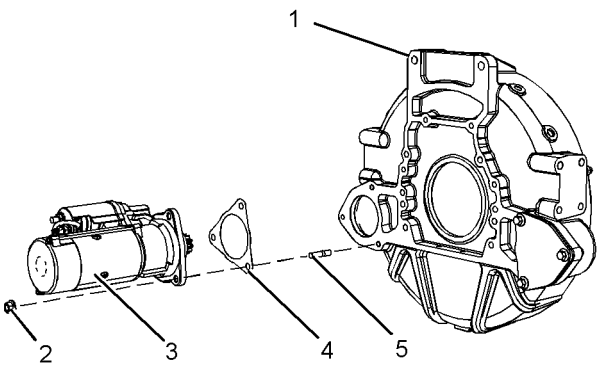


Illustration 587 g01973073

Typical example

3. Disconnect the harness assembly from the electric starting motor and the solenoid.

4. Support electric starting motor (3).

5. Remove nuts or bolts (2).

6. Remove electric starting motor (3).

7. If a gasket is installed, remove gasket (4).

8. If necessary, remove studs (5) from flywheel housing (1).

Installation Procedure

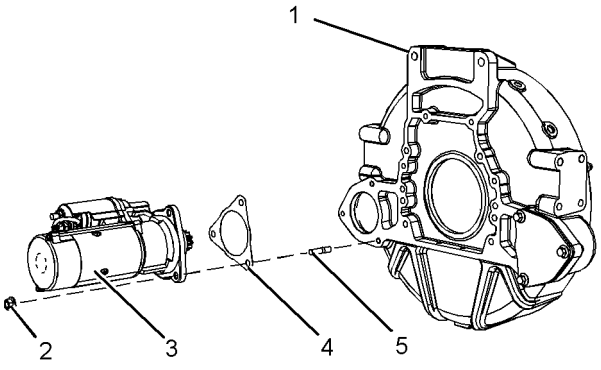


Illustration 588 g01973073

Typical example

1. If necessary, install studs (5) into flywheel housing (1).

Tighten M10 studs to a torque of 18 N·m (159 lb in).

Tighten M12 studs to a torque of 25 N·m (221 lb in).

2. If necessary, install a new gasket (4) onto the studs in flywheel housing (1).

3. Position electric starting motor (3) onto the studs in flywheel housing (1).

4. Install nuts or bolts (2).

Tighten M10 nuts to a torque of 44 N·m (33 lb ft).

Tighten M12 nuts to a torque of 78 N·m (58 lb ft).

Tighten M16 bolts to a torque of 240 N·m (177 lb ft).

5. Connect the harness assembly to the electric starting motor and the solenoid.

6. Turn the battery disconnect switch to the ON position.

i04203640

Alternator - Install

Alternator Bracket for Hydraulic Excavator

Table 108

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	-	1/2 Inch Drive T50 Torx Bit	1
	-	1/2 Inch Drive x 8 mm Hex Drive	1
B	-	Guide Studs M10 by 80 mm	2
C	-	Guide Studs M10 by 130 mm	2

(1) Either tool may be necessary in order to install the alternator pulley.

1. If necessary, follow Step 1.a through Step 1.k in order to install the alternator bracket to the cylinder block of the hydraulic excavator.

a. Ensure that all of the components of the alternator bracket are clean and free from wear and damage. Replace all components that are worn or damaged.

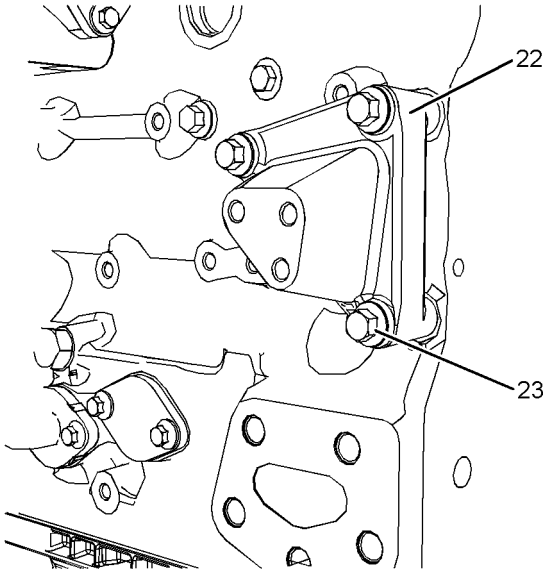


Illustration 589 g02095234

b. Position bracket (22) onto the cylinder block. Ensure that the bracket is correctly oriented.

c. Install bolts (23) and tighten the bolts to a torque of 44 N·m (32 lb ft).

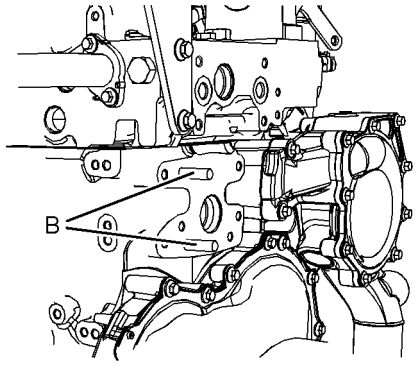


Illustration 590 g02165614

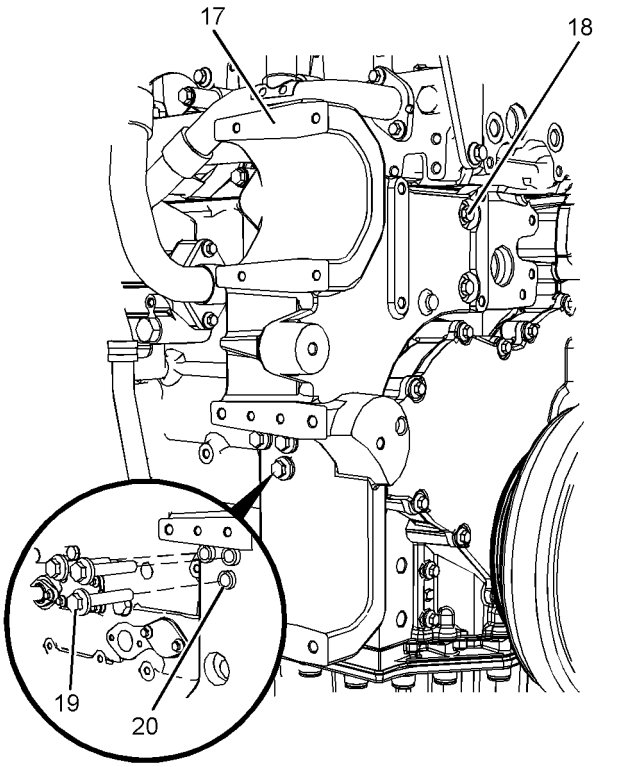


Illustration 591 g02352949

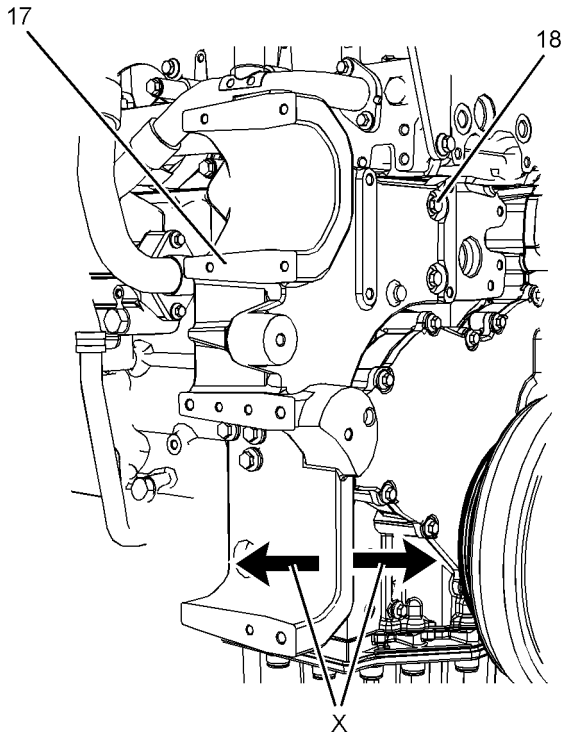


Illustration 592 g02165494

d. Install Tooling (B) to the cylinder block.

e. Position alternator bracket (17) onto Tooling (B). Install bolts (18) to the alternator bracket and hand tighten the bolts.

Note: Support the alternator bracket as the bolts are installed. The weight of the bracket is approximately 19 kg (42 lb).

f. Remove Tooling (B) and install the remaining bolts (18) to the alternator bracket and hand tighten the bolts.

g. Ensure that spacers (20) are correctly installed to alternator bracket (17).

h. Install bolts (19) to alternator bracket (17) and hand tighten the bolts.

i. Tighten bolts (18) to a torque of 44 N·m (32 lb ft).

j. Tighten bolts (19) to a torque of 44 N·m (32 lb ft).

Note: Ensure that Position (X) on alternator bracket (17) does not move in either direction.

k. Install the refrigerant compressor. Refer to Disassembly and Assembly, “Refrigerant Compressor - Remove and Install” for the correct procedure.

Installation Procedure

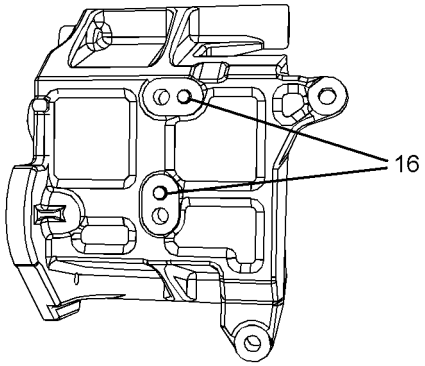


Illustration 593 g02022404

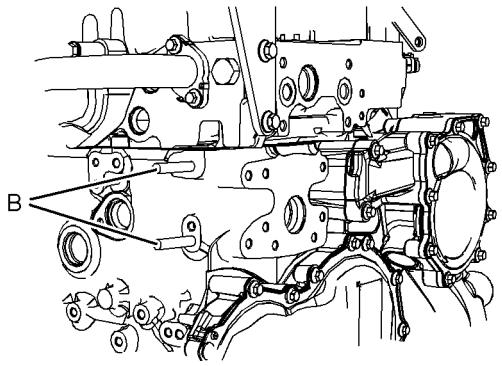


Illustration 594 g02165615

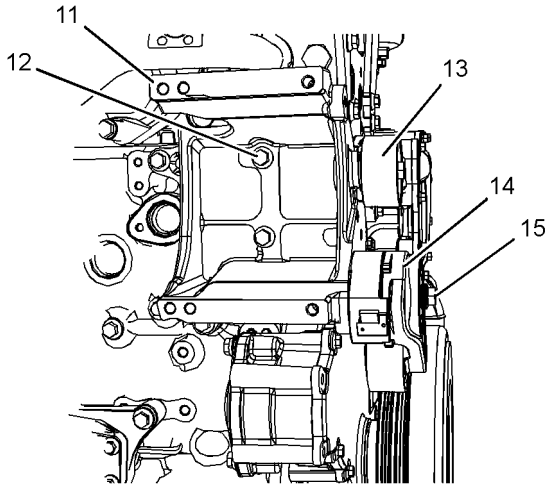


Illustration 595 g02352950

1. If necessary, follow Step 1.a through Step 1.h in order to install alternator bracket (11) onto the cylinder block.

a. Ensure that alternator bracket (11) is clean and free from wear and damage. If necessary, replace the alternator bracket.

b. Ensure that dowels (16) are free from wear and damage. If necessary, replace the dowels.

c. Install Tooling (B) to the cylinder block.

d. Position alternator bracket (11) onto Tooling (B). Install bolts (12) hand tight.

e. Remove Tooling (B) and install remaining bolts (12) hand tight.

f. Tighten bolts (12) to a torque of 44 N·m (32 lb ft).

g. If necessary, install belt tensioner (14) onto alternator bracket (11) and tighten bolt (15). Refer to Disassembly and Assembly, “Belt Tensioner - Install” for the correct procedure.

h. If necessary, install flat idler pulley (13) onto alternator bracket (11). Refer to Disassembly and Assembly, “Idler Pulley (Flat Idler Pulley) - Remove and Install” for the correct procedure.

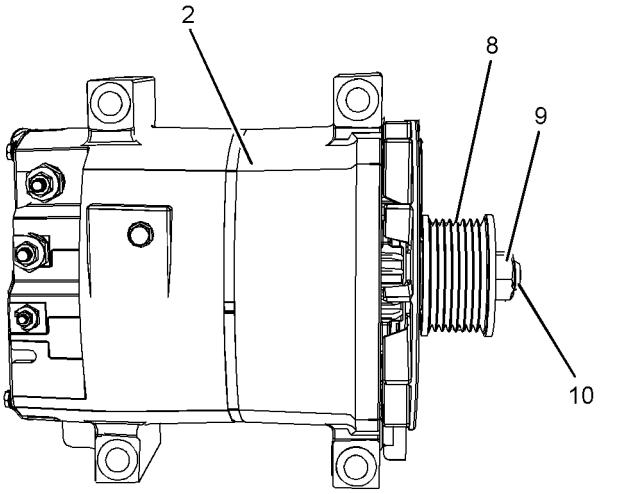


Illustration 596 g02019754

Typical example

2. If necessary, follow Step 2.a through Step 2.d in order to install pulley (8) to alternator (2).

Note: Either of Tooling (A) may be required in order to carry out the installation of the alternator pulley.

a. Place alternator (2) in a suitable support.

b. Ensure that pulley (8) is correctly oriented.

c. Install pulley (8) and a new nut (9) to alternator shaft (10).

d. Position a cranked ring spanner onto nut (9) and use a suitable tool in order to prevent the cranked ring spanner from turning. Use Tooling (A) in order to turn the shaft of the alternator in a counterclockwise direction. Tighten the nut to the correct torque. Refer to Specifications, “Alternator” for the correct torque.

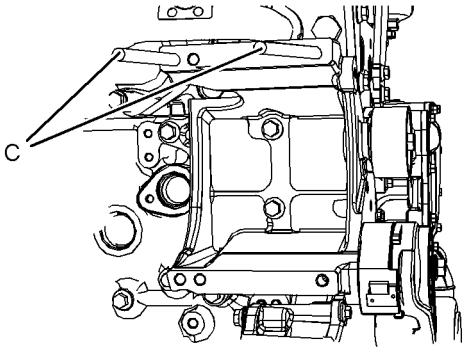


Illustration 597 g02166913

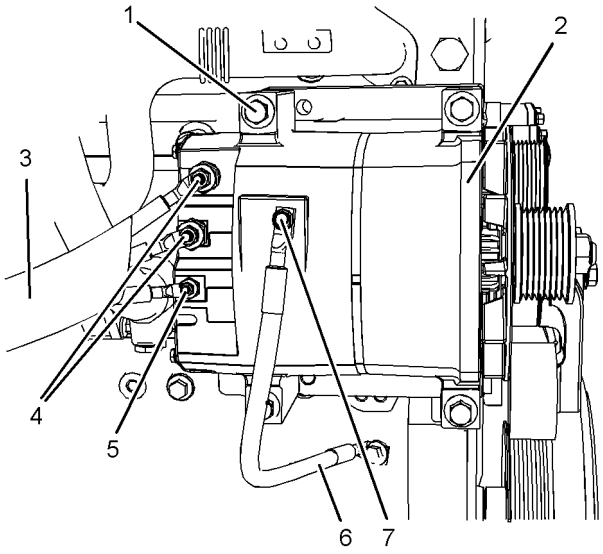


Illustration 598 g02014454
Typical example

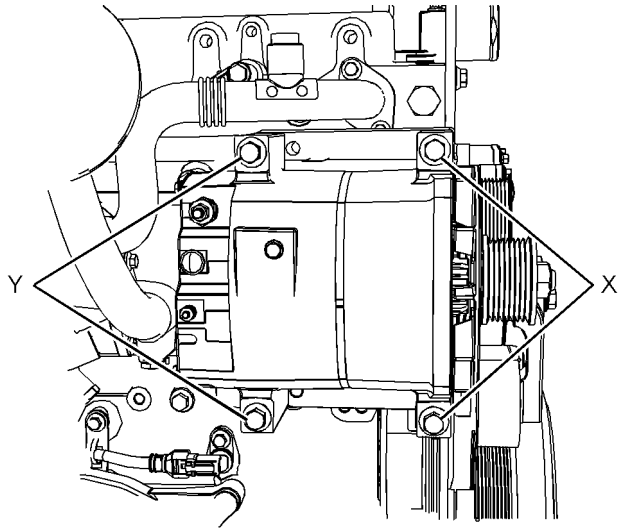


Illustration 599 g02014413
Typical example

3. Install Tooling (C) to the alternator bracket.
4. Install alternator (2) onto Tooling (C). Install bolts (1) and tighten the bolts hand tight.
5. Remove Tooling (C) and install remaining bolts (1) and tighten the bolts hand tight.
6. Tighten the bolts in Position (X) to a torque of 50 N·m (37 lb ft).
7. Tighten the bolts in Position (Y) to a torque of 50 N·m (37 lb ft).
8. Connect wiring harness assembly (3) to alternator (2). Install nuts (4) and nut (5) and tighten the nuts to the correct torque. Refer to Specifications, “Alternator” for the correct torque.
9. Connect grounding strap (6) to alternator (2). Install bolt (7) and tighten the bolt to the correct torque. Refer to Specifications, “Alternator” for the correct torque.
10. Install the alternator belt. Refer to Disassembly and Assembly , “Alternator Belt - Remove and Install” for the correct procedure.
11. Turn the battery disconnect switch to the ON position.

i04203638

Air Compressor - Remove and Install (Twin Cylinder Compressor)

Removal Procedure

Table 109

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	T400014	Timing Pin	1
C	-	Combination Puller	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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

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

Dispose of all fluids according to local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

3. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump. Refer to the OEM for the correct procedure.

4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to System Operation, Testing and Adjusting, “Fuel Injection Timing - Check” for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

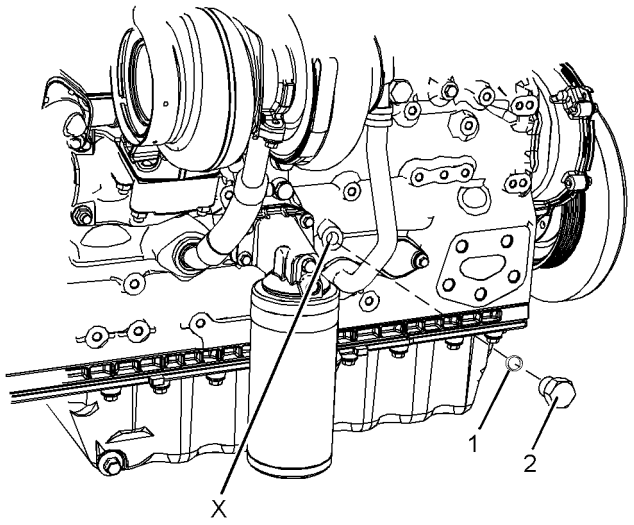


Illustration 600 g01966313
Typical example

5. Remove plug (2) from the cylinder block. Remove O-ring seal (1) from the plug.

6. Install Tooling (B) into Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

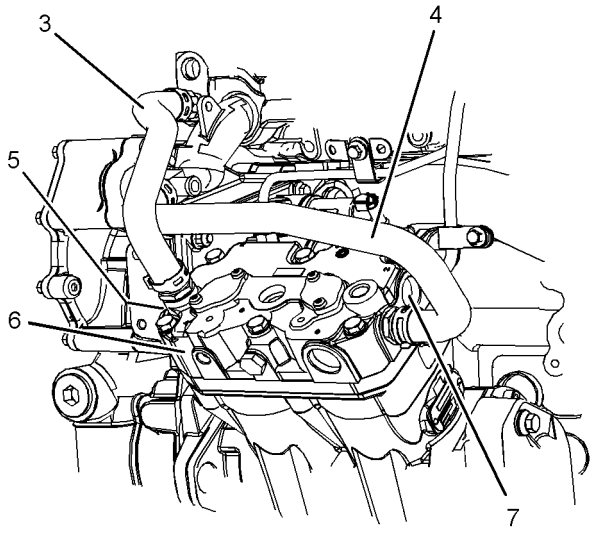


Illustration 601 g01969655
Typical example

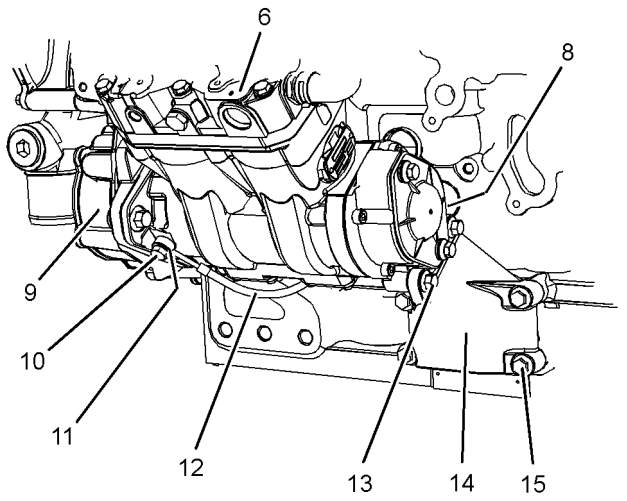


Illustration 602 g02022020

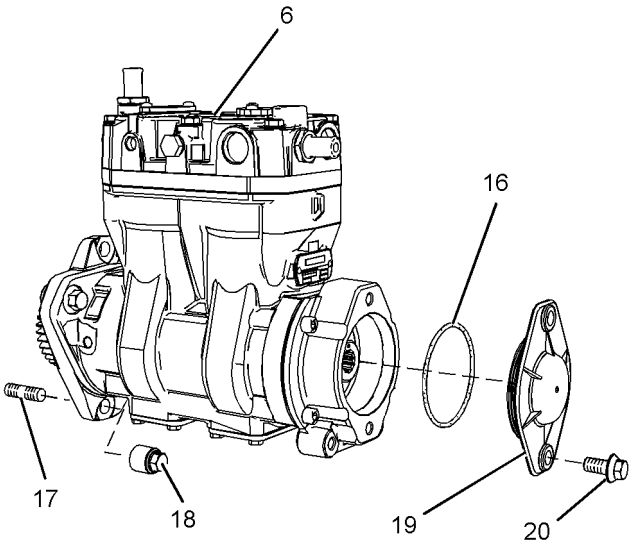


Illustration 603 g01969454
Typical example

7. Slide hose clamps along coolant hose (3) and coolant hose (4). Disconnect coolant hose (3) and coolant hose (4) from air compressor (6).

8. Disconnect the air line from port (5) (not shown) and air line from port (7). Ref to OEM for the correct procedure.

9. Remove banjo bolt (10) and remove sealing washers (11) (not shown).

10. Remove bolt (13) and bolt (15) from support bracket (14). Remove support bracket (14) from compressor (6) and the cylinder block.

11. Support air compressor (6). Remove nuts (18) and remove the air compressor from front housing (9).

Note: Note the position of tube assembly (12) before removal.

12. If necessary, disconnect nut (8) (not shown) and remove tube assembly (12) from the union on the cylinder block.

13. If necessary, remove studs (17) from front housing (9).

14. If necessary, remove bolts (20) and remove plate (19). Remove O-ring seal (16) from plate (19). Refer to Illustration 603.

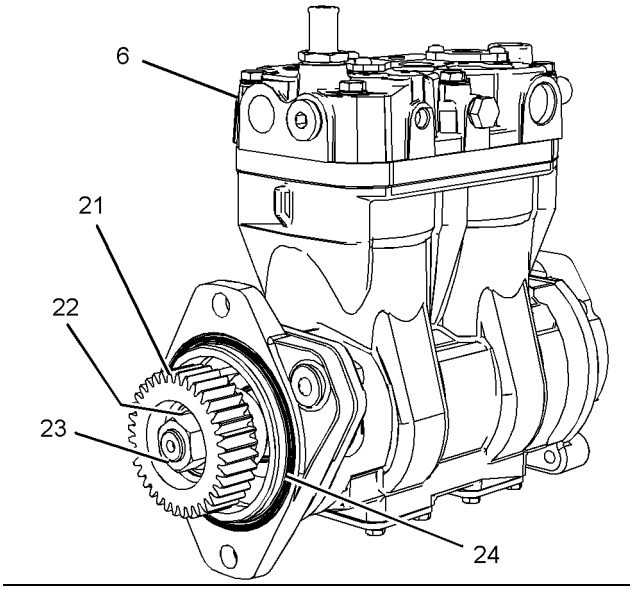


Illustration 604 g01969515
Typical example

15. Remove O-ring seal (24) from air compressor (6).

16. If necessary, follow Step 16.a through Step 16.b in order to remove gear (21) from the crankshaft of the air compressor.

a. Use a suitable tool in order to prevent the shaft of the compressor from rotating. Remove nut (23) and remove spring washer (22) (not shown).

b. Use Tooling (C) in order to remove gear (21) from the crankshaft of the air compressor.

Installation Procedure

Table 110

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
D	-	Loctite 638 High Strength Retaining	1
E	-	Dephi Lockheed Rubber Grease	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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.

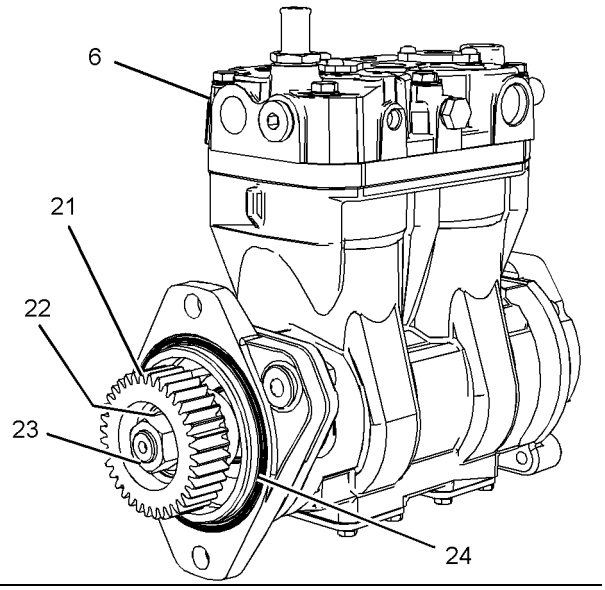


Illustration 605 g01969515
Typical example

1. If necessary, follow Step 1.a through Step 1.d in order to install gear (21) to air compressor (6).
   a. Ensure that the shaft of air the compressor is clean, free from damage, and dry. Ensure that the gear is clean, free from damage, and dry.
   b. Install gear (21) and a new spring washer (22) (not shown) to the shaft of the air compressor.
   c. Apply Tooling (D) to the threads of the shaft of the air compressor. Install nut (23) to the shaft of the air compressor.
   d. Use a suitable tool in order to prevent the shaft of the air compressor from rotating. Tighten nut (23) to a torque of 190 N·m (140 lb ft).
2. Use Tooling (E) in order to lubricate a new O-ring seal (24). Install the O-ring seal to air compressor (6).
3. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to System Operation, Testing and Adjusting, “Fuel Injection Timing - Check” for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

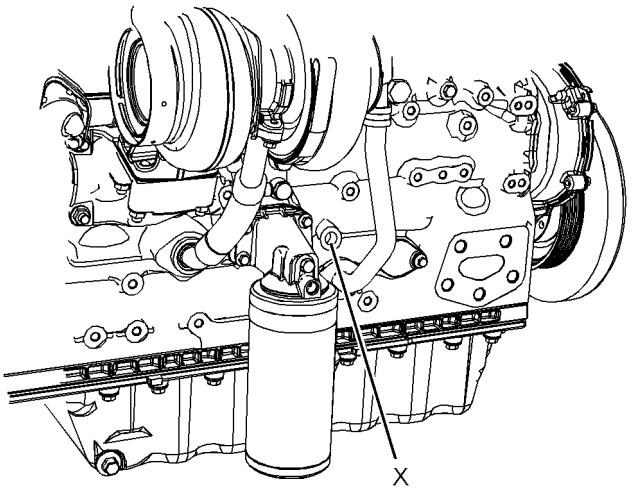


Illustration 606 g02021419

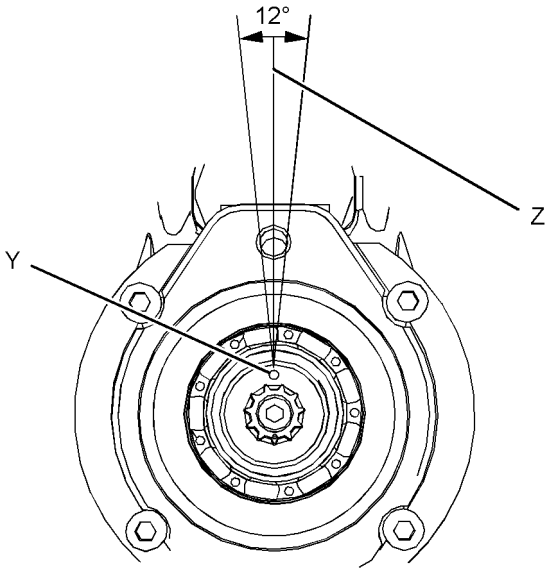


Illustration 607 g01970516
Typical example

4. Ensure that Tooling (B) is installed in Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

5. Rotate the crankshaft of the air compressor until timing Mark (Y) is within (+ / -) 6 degrees of Position (Z).

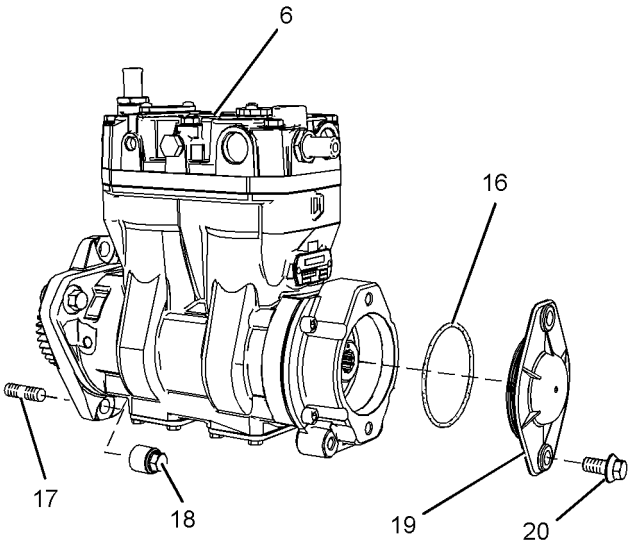


Illustration 608 g01969454
Typical example

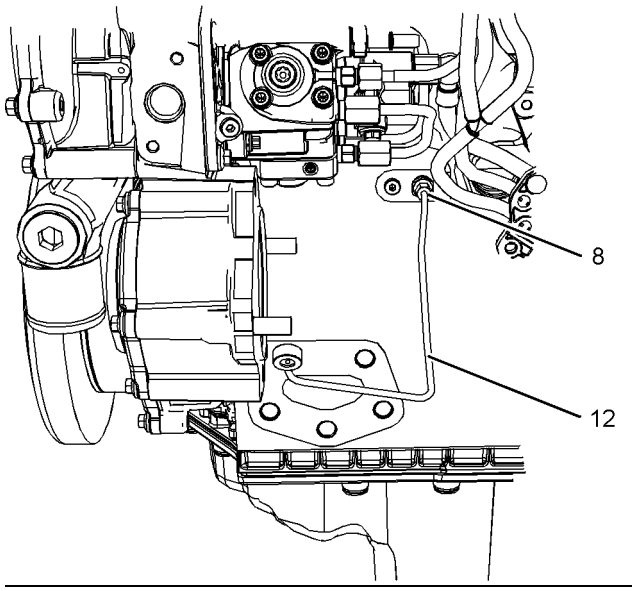


Illustration 609 g02087758
Compressor oil feed tube assembly

6. If necessary, install studs (17) to the front housing. Tighten the studs to a torque of 25 N·m (221 lb in).

7. If necessary, loosely install tube assembly (12) to the connection on the cylinder block. Tighten nut (8) finger tight.

8. Align air compressor (6) with studs (17). Install the air compressor to the front housing. If necessary, rotate the crankshaft of the air compressor in order to allow the gears to align.

Note: Ensure that timing Mark (Y) is aligned with timing Marks (Z). Refer to Illustration 607 for the correct position of timing marks.

9. Install nuts (18). Tighten the nuts to a torque of 78 N·m (58 lb ft).

10. If necessary, follow Step 10.a through Step 10.c in order to install cover (19).

a. Use Tooling (E) in order to lubricate a new O-ring seal (16). Install the O-ring seal to cover (19).

b. Install cover (19) to air compressor (6).

c. Install bolts (20). Tighten the bolts to a torque of 16 N·m (142 lb in).

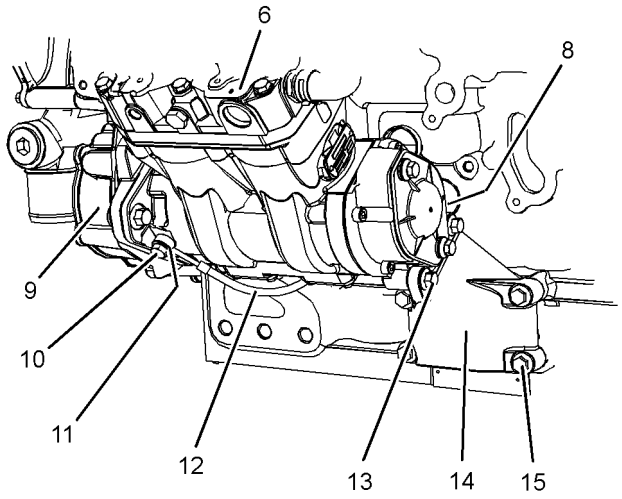


Illustration 610 g02022020

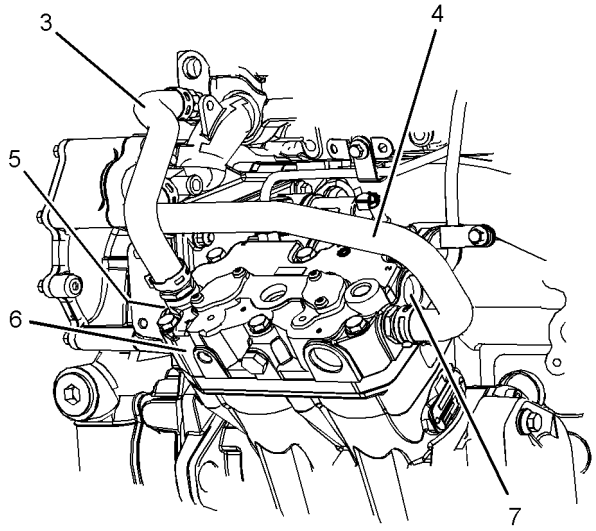


Illustration 611 g01969655

Typical example

11. Position support bracket (14) onto air compressor (6). Install bolts (13) finger tight.

12. Install bolts (15) finger tight.

13. Tighten bolts (15) to a torque of 44 N·m (32 lb ft).

14. Tighten bolts (13) to a torque of 22 N·m (195 lb in).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

15. Connect the air line to port (5) (not shown) and the air line to port (7) in the air compressor. Ref to (OEM) for the correct procedure.

16. Connect coolant hose (3) and coolant hose (4) to the air compressor. Slide hose clamps along coolant hose assemblies into the correct position.

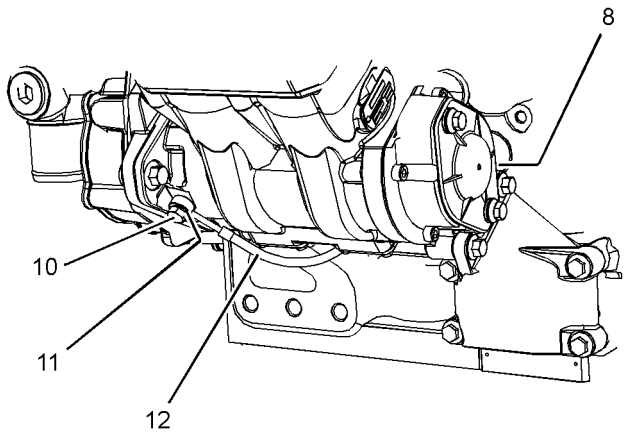


Illustration 612 g01970813

17. Install new sealing washer (11) (not shown) onto banjo bolt (10). Position the banjo bolt onto tube assembly (12) and install remaining sealing washer (11). Install tube assembly (12) and tighten banjo bolt (10) finger tight.

18. Tighten banjo bolt (10) to a torque of 9 N·m (80 lb in).

Note: Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.

19. Securely tighten nut (8) (not shown) for tube assembly (12).

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

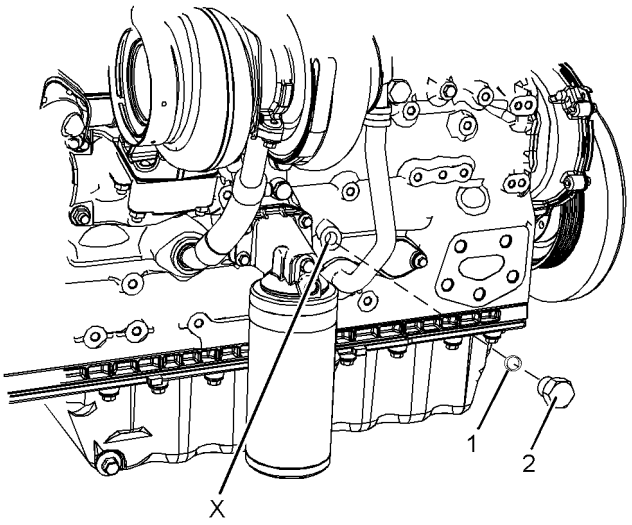


Illustration 613 g01966313
Typical example

20. Remove Tooling (B) from Hole (X) in the cylinder block.

21. Install a new O-ring seal (1) to plug (2). Install the plug to the cylinder block. Tighten the plug to a torque of 21 N·m (186 lb in).

22. If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump. Refer to the OEM for the correct procedure.

23. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Refill Capacities” and Operation and Maintenance Manual, “Cooling System Coolant Level - Check” for the correct procedure.

i04203637

Air Compressor - Remove and Install (Single Cylinder)

Removal Procedure

Table 111

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
C	-	Combination Puller	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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

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

Dispose of all fluids according to local regulations and mandates.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

3. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump. Refer to the OEM for the correct procedure.

4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to System Operation, Testing and Adjusting, “Fuel Injection Timing - Check” for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

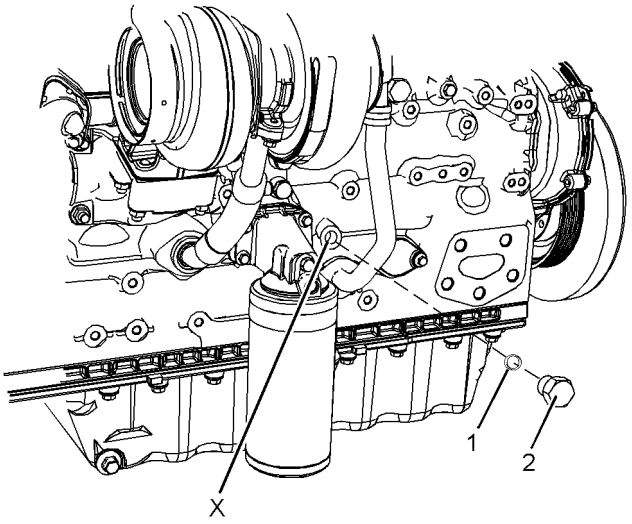


Illustration 614 g01966313

Typical example

5. Remove plug (2) from the cylinder block. Remove O-ring seal (1) from the plug.

6. Install Tooling (B) into Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

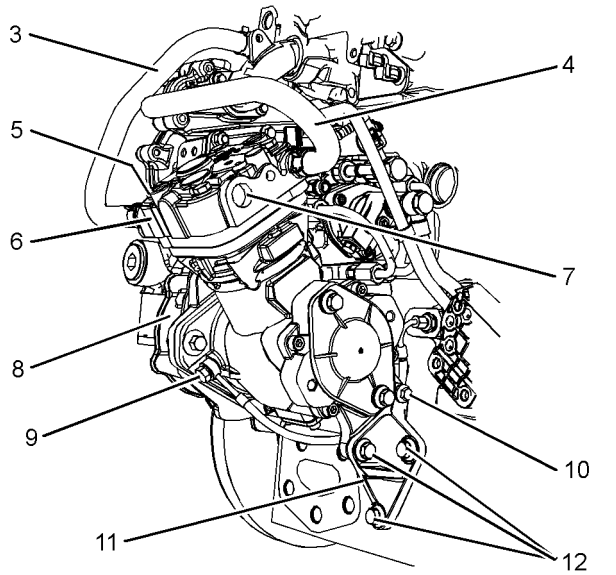


Illustration 615 g01964836

Typical example

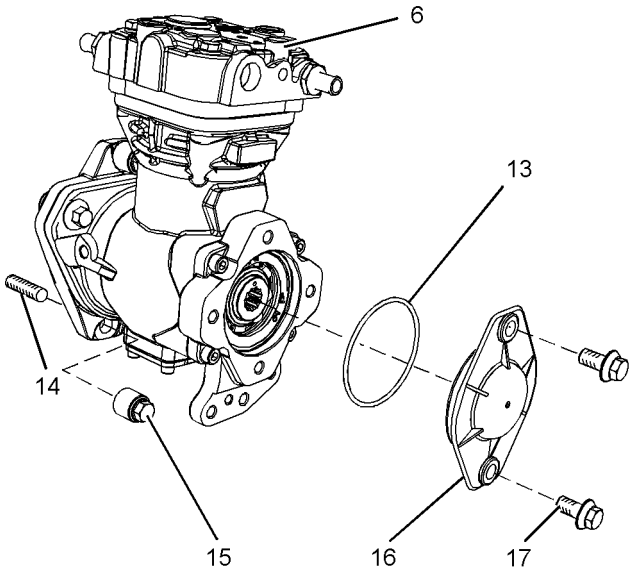


Illustration 616 g01965121

Typical example

7. Slide hose clamps along coolant hose (3) and coolant hose (4). Disconnect coolant hose (3) and coolant hose (4) from air compressor (6).

8. Disconnect the air lines from port (5) (not shown) and air lines from port (7). Refer to the OEM for the correct procedure.

9. Remove banjo bolt (9) and sealing washers from air compressor (6).

10. Remove bolt (10) and bolt (12) from support bracket (11) and remove the support bracket.

11. Support air compressor (6) and remove nuts (15). Remove the air compressor from front housing (8).

12. If necessary, remove studs (14) from front housing (8).

13. If necessary, remove bolts (17) and remove plate (16). Remove O-ring seal (13) from plate (16).

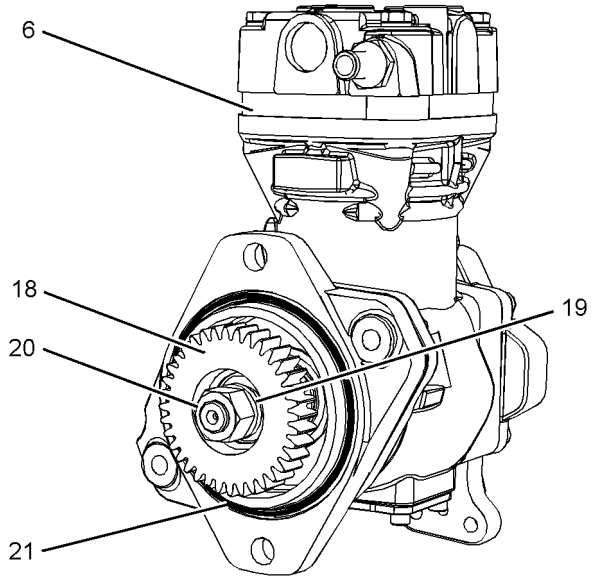


Illustration 617 g01964860

Typical example

14. Remove O-ring seal (21) from air compressor (6).

15. If necessary, follow Step 15.a through Step 15.b in order to remove gear (18) from the crankshaft of the air compressor.

a. Use a suitable tool in order to prevent the shaft of the compressor from rotating. Remove nut (20) and remove spring washer (19).

b. Use Tooling (C) in order to remove gear (18) from the crankshaft of the air compressor.

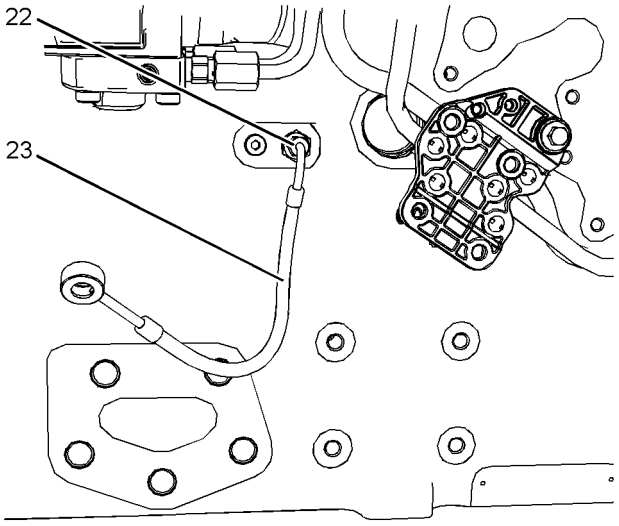


Illustration 618 g02091596

16. If necessary, follow Step 16.a through Step 16.b in order to remove the hose assembly.

a. Make a temporary mark in order to identify the position of hose assembly (23).

b. Disconnect nut (22) and remove hose assembly (23).

Installation Procedure

Table 112

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	T400011	Crankshaft Turning Tool	1
A(2)	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin	1
D	-	Loctite 638 High Strength Retaining	1
E	-	Dephi Lockheed Rubber Grease	1

(1) The Crankshaft Turning Tool is used on the front pulley.
(2) This Tool is used in the aperture for the electric starting motor.

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.

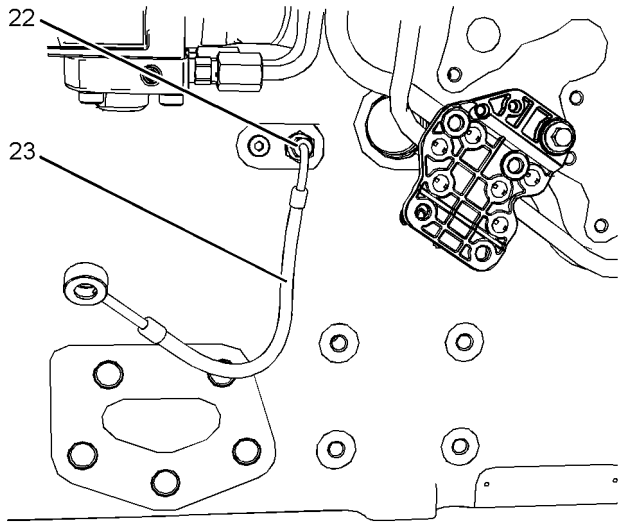


Illustration 619 g02091596

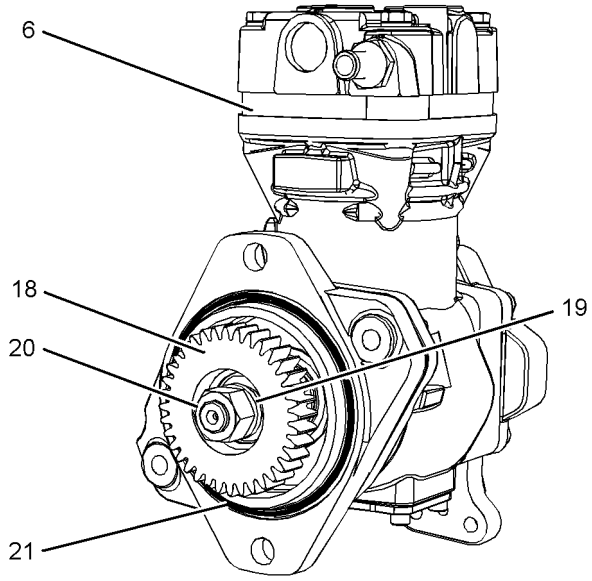


Illustration 620 g01964860
Typical example

1. If necessary, follow Step 1.a through Step 1.d in order to install gear (18) to the air compressor.

a. Ensure that the shaft of air compressor (6) is clean, free from damage, and dry. Ensure that gear (18) is clean and free from damage and dry.

b. Install gear (18) and a new spring washer (19) to the shaft of the air compressor.

c. Apply Tooling (D) to the threads of the shaft. Install nut (20) to the shaft of air compressor (6).

d. Use a suitable tool in order to prevent the shaft of the compressor from rotating. Tighten nut (20) to a torque of 9 N·m (80 lb in).

2. If necessary, install hose assembly (23) to the connection on the cylinder block. Align hose assembly with the temporary marks. Tighten nut (22) to a torque of 120 N·m (89 lb ft).

3. Use Tooling (E) in order to lubricate a new O-ring seal (21). Install the O-ring seal to air compressor (6).

4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to System Operation, Testing and Adjusting, “Fuel Injection Timing - Check” for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

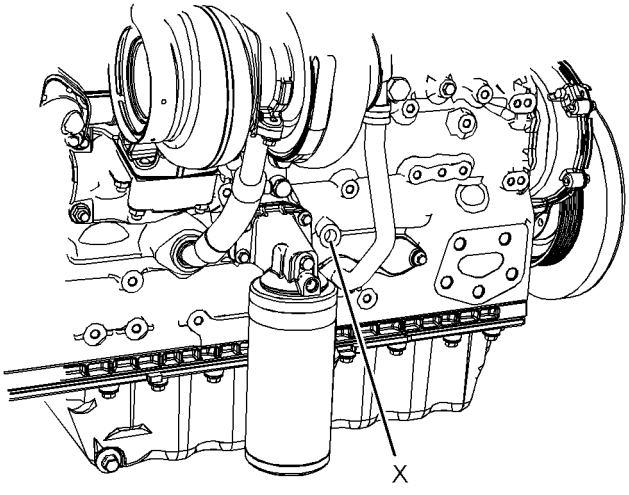


Illustration 621 g02021419

5. Ensure that Tooling (B) is installed in Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

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

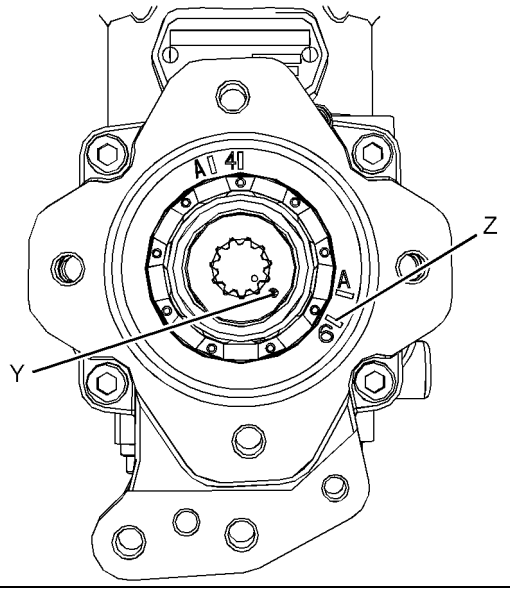


Illustration 622 g02358916

Typical example

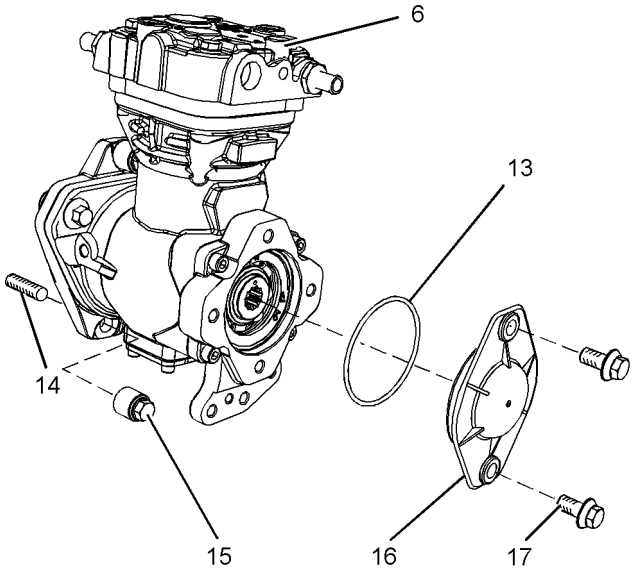


Illustration 623 g01965121

Typical example

6. Rotate the crankshaft of the air compressor until timing Mark (Y) is aligned with timing Mark (Z) on the rear face of the air compressor.

7. If necessary, install studs (14) to the front housing. Tighten the studs to a torque of 25 N·m (221 lb in).

8. Align air compressor (6) with studs (14). Install the air compressor to the front housing. If necessary, rotate the crankshaft of the air compressor in order to allow the gears to align.

9. Install nuts (15). Tighten the nuts to a torque of 78 N·m (58 lb ft).

10. If necessary, follow Step 10.a through Step 10.c in order to install cover (16).

a. Use Tooling (E) in order to lubricate a new O-ring seal (13). Install the O-ring seal to cover (16).

b. Install plate (16) to the air compressor.

c. Install bolts (17). Tighten the bolts to a torque of 16 N·m (142 lb in).

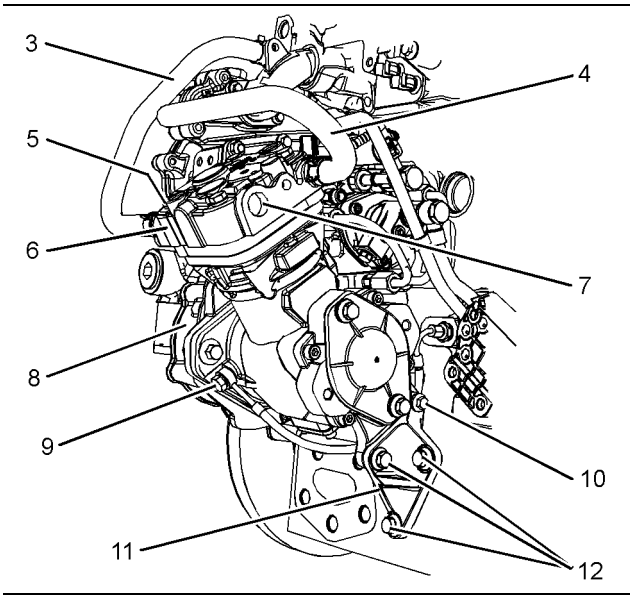


Illustration 624 g01964836

11. Position support bracket (11) onto air compressor (6). Install bolts (10) finger tight.

12. Install bolts (12) finger tight.

13. Tighten bolts (10) to a torque of 22 N·m (195 lb in).

14. Tighten bolts (12) to a torque 44 N·m (32 lb ft).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

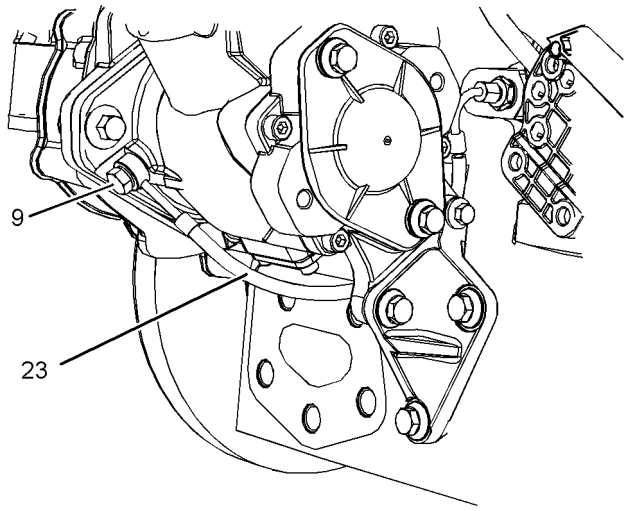


Illustration 625 g02091646
Typical example

15. Install a new sealing washer to banjo bolt (9). Position the banjo bolt onto hose assembly (23) and install the remaining new sealing washer to the banjo bolt.

16. Connect hose assembly (23) onto the air compressor. Tighten the banjo bolt to a torque of 9 N·m (80 lb in).

Note: Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.

17. Connect the air lines to port (5) (not shown) and port (7) in the air compressor. Refer to the OEM for the correct procedure.

18. Connect coolant hose (3) and coolant hose (4) to the air compressor. Slide hose clamps along coolant hose assemblies into the correct position.

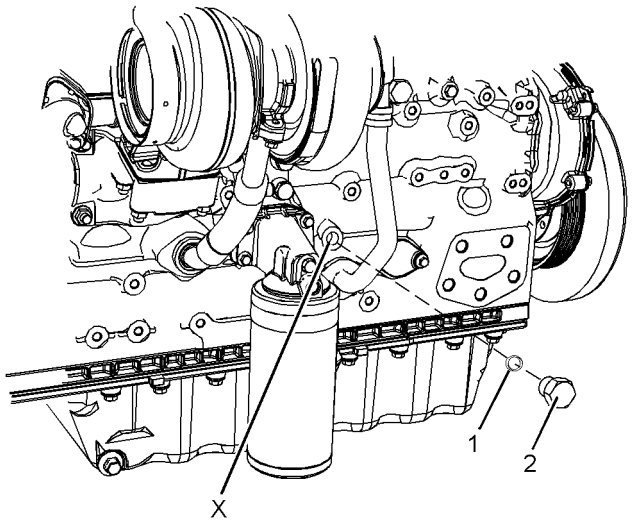


Illustration 626 g01966313
Typical example

19. Remove Tooling (B) from Hole (X) in the cylinder block.

20. Install a new O-ring seal (1) to plug (2). Install the plug to the cylinder block. Refer to Illustration 626. Tighten the plug to a torque of 21 N·m (186 lb in).

21. If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump. Refer to the OEM for the correct procedure.

22. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Refill Capacities” and Operation and Maintenance Manual, “Cooling System Coolant Level - Check” for the correct fill procedure.

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