KENR9125
August 2011

Disassembly and Assembly

1204E-E44TA and 1204E-E44TTA Industrial Engines

MK (Engine)
ML (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

i04485873

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.

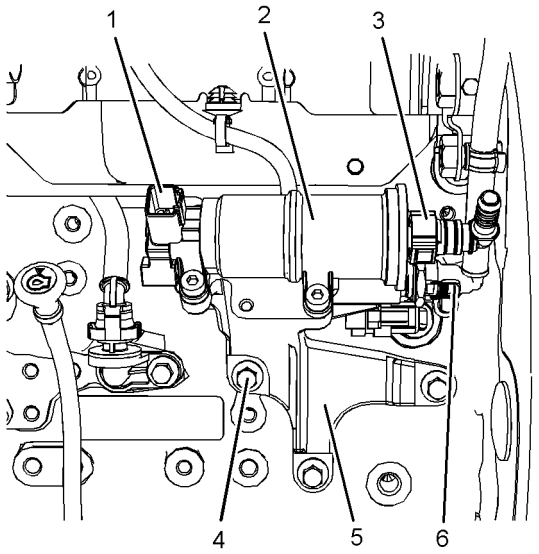

Illustration 1 g02485837

3. Make a temporary identification mark on plastic tube assemblies in order to show the correct position of the tube assemblies.
4. Disconnect plastic tube assembly (3) and plastic tube assembly (6) from fuel priming pump (2).
5. Use Tooling (A) in order to plug the plastic tube assemblies. Use Tooling (A) in order to cap the connections for plastic tube assemblies on the fuel priming pump.
6. Disconnect Original Equipment Manufactures (OEM) wiring harness assembly (1) from fuel priming pump (2).
7. Remove bolts (4) from bracket (5).

Note: Support the bracket as the bolts are removed.

8. Remove fuel priming pump (3) and bracket (5) as an assembly from the cylinder block.

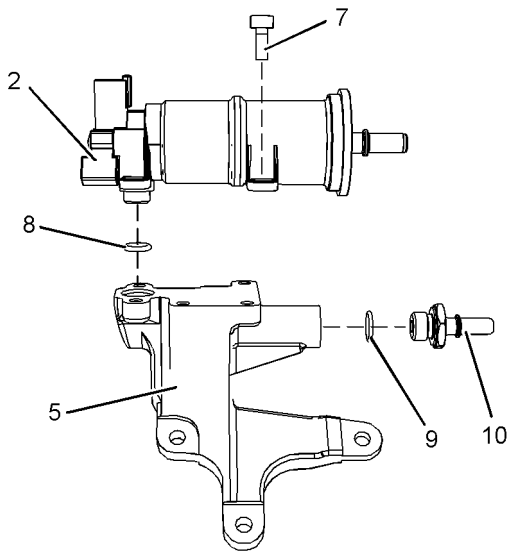

Illustration 2 g02485838

9. If necessary, follow Step 9.a through Step 9.d in order to remove fuel priming pump (2) from bracket (5).

a. Remove allen head screws (7) from fuel priming pump (2).

b. Remove fuel priming pump (2) from bracket (5).

c. Remove O-ring seal (8).

d. If necessary, remove connection (10) from bracket (5). Remove O-ring seal (9) from connection (10).

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.

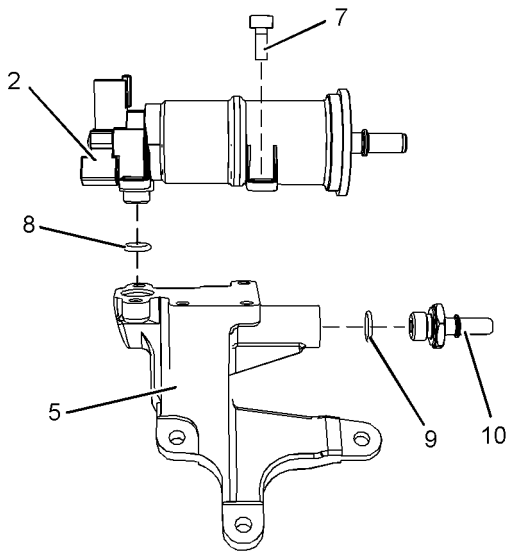

Illustration 3 g02485838

2. If necessary, follow Step 2.a through Step 2.d in order to install fuel priming pump (2) from bracket (5).

a. If necessary, install a new O-ring seal (9) to connection (10). Install connection (10) to bracket (5). Tighten the connection to a torque of 20 N·m (177 lb in).

b. Install a new O-ring seal (8) to fuel priming pump (2).

c. Position fuel priming pump (2) onto bracket (5).

Note: Ensure that the fuel priming pump is correctly located onto the bracket.

d. Install new allen head screws (7). Tighten the allen head screws to a torque of 9 N·m (80 lb in).

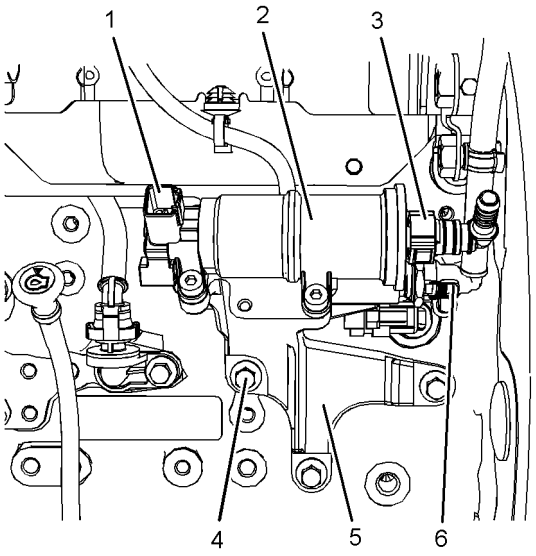

Illustration 4 g02485837

3. Position fuel priming pump (3) and bracket (5) as an assembly onto the cylinder block.

4. Install bolt (4) to bracket (5). Tighten the bolt to a torque of 22 N·m (195 lb in).

5. Remove plugs from plastic tube assembly (3) and plastic tube assembly (5). Remove cap from connections on fuel priming pump (2).

6. Connect plastic tube assembly (3) and plastic tube assembly (5) to fuel priming pump (2).

7. Connect (OEM) wiring harness assembly (1) to fuel priming pump (2).

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.

i04485856

Flow Control Valve - Remove and Install

Removal Procedure

Start By:

a. Remove the crankcase breather. Refer to Disassemble and Assemble, “Crankcase Breather - 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.

1. Turn the fuel supply to the OFF position.

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

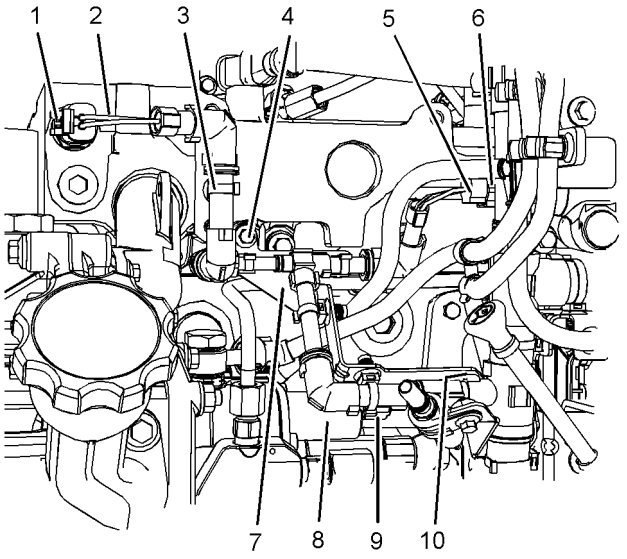

Illustration 5 g02596577

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

4. Cut cable strap (3).

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

6. Disconnect assembly (9) from flow control valve (8).

7. Remove bolt (4) and bolt (10) (not shown) from bracket (7).

8. Position bracket (7) and the harness assembly away from the fuel injection pump.

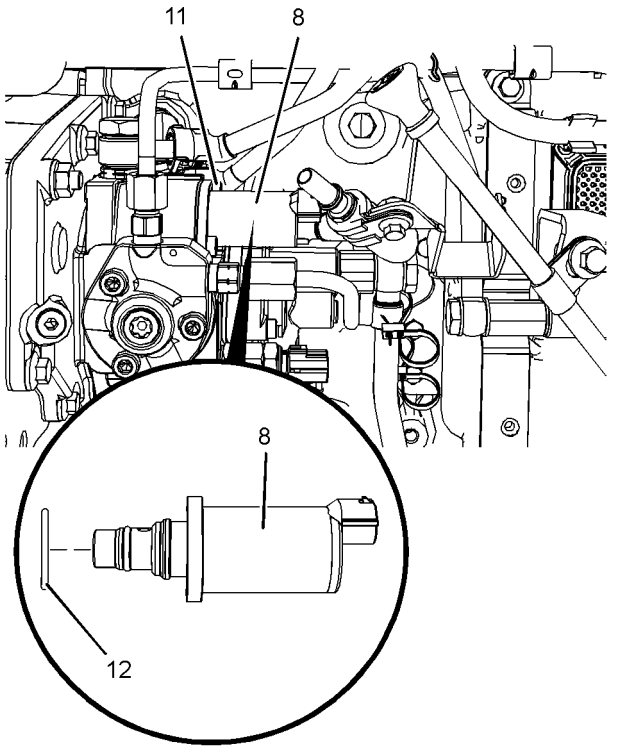

Illustration 6 g02596676

9. Clean the area around flow control valve (8) and fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.

10. Make temporary marks on flow control valve (8) and the fuel injection pump for installation purpose.

11. Remove allen heads screws (11) from flow control valve (8).

12. Remove flow control valve (8) from the fuel injection pump. Remove O-ring seal (12).

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.

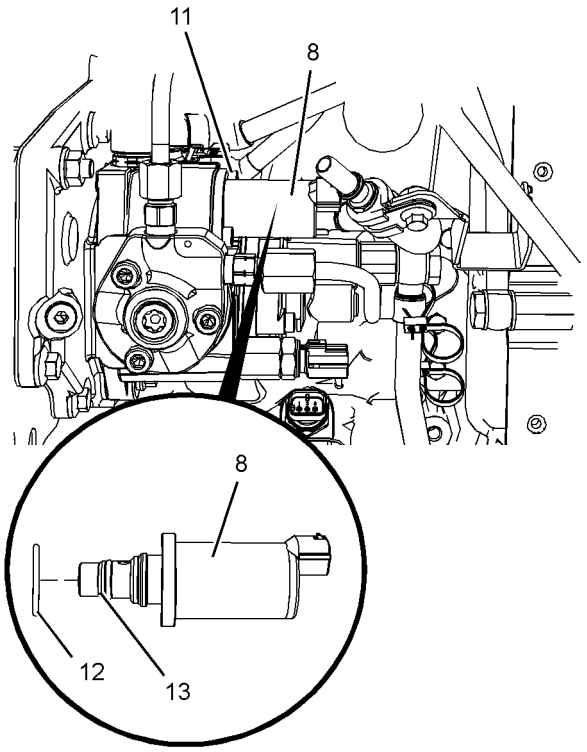

Illustration 7 g02596658

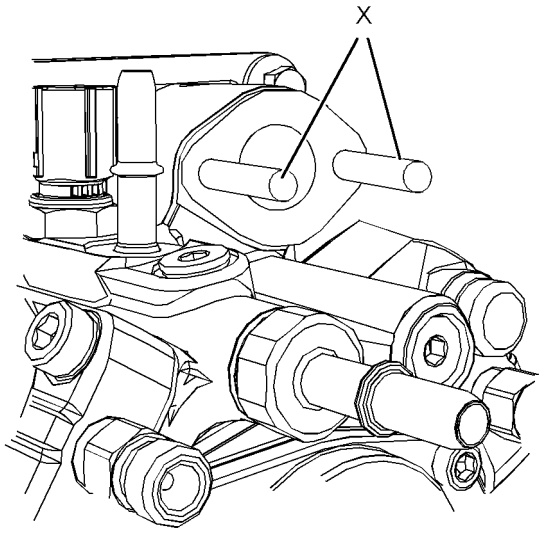

Illustration 8 g02306933

Flow control valve guide pins

2. Position a new O-ring seal (12) onto the fuel injection pump.

Note: Ensure that the O-ring seal is correctly seated into the recess of the fuel injection pump.

3. Check O-ring seal (13) is correctly positioned. Ensure that O-ring seal (13) is not damaged.

Note: If the O-ring seal 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 (13) with clean fuel.

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

6. Position flow control valve (8) onto guide pins.

Note: Ensure that the flow control valve is correctly orientated

7. Install flow control valve (8) to the fuel injection pump.

8. Remove guide pins from the fuel injection pump.

9. Install allen head screws (11).

10. Tighten allen head screws (11) equally until the flow control valve is seated correctly onto the fuel injection pump.

Note: Ensure that the allen head screws are tightened equally. Failure to ensure that the allen head 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).

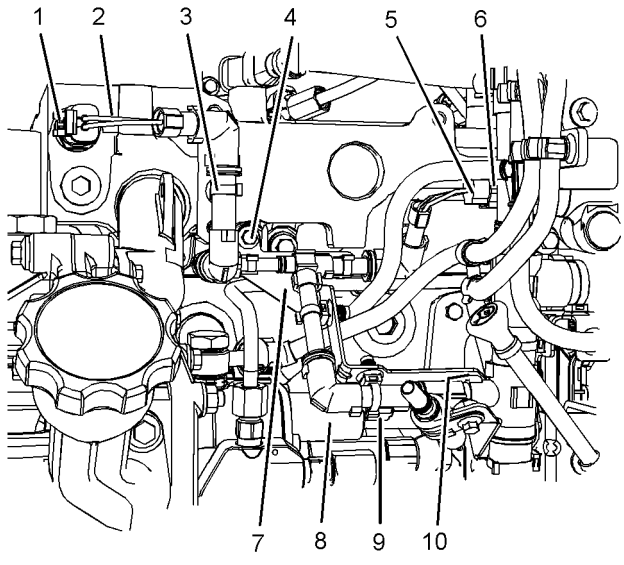

Illustration 9 g02596577

12. Position bracket (7) and harness assembly onto fuel injection pump.

13. Install bolt (4) and bolt (10) (not shown) to bracket (7). Tighten the bolts to a torque of 9 N·m (80 lb in).

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

15. Connect harness assembly (9) to flow control valve (8).

16. Connect harness assembly (2) to the coolant temperature sensor. Slide locking tab (1) into the locked position.

17. Install a new cable strap (3).

Note: Ensure that the cable strap meets the Original Equipment Manufactures (OEM) specification.

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

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

20. Turn the fuel supply to the ON position.

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

22. Install the crankcase breather. Refer to Disassemble and Assemble, “Crankcase Breather - Install” for the correct procedure.

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

24. After replacement of the flow control valve, the fuel injection pump must be calibrated. Use the electronic service tool to perform “High Pressure Fuel Pump Calibration”.

i04485864

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

Removal Procedure

Table 2

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.

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

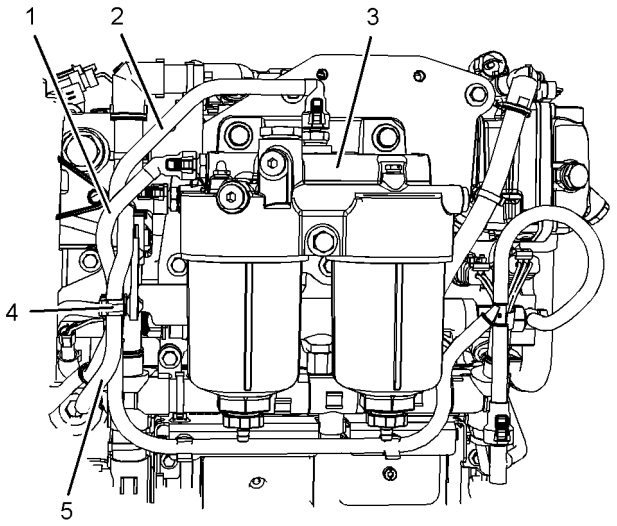

Illustration 10 g02597024

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 (1), plastic tube assembly (2), and plastic tube assembly (5) from fuel filter base (3).

7. Remove plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from clips (4).

8. 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.

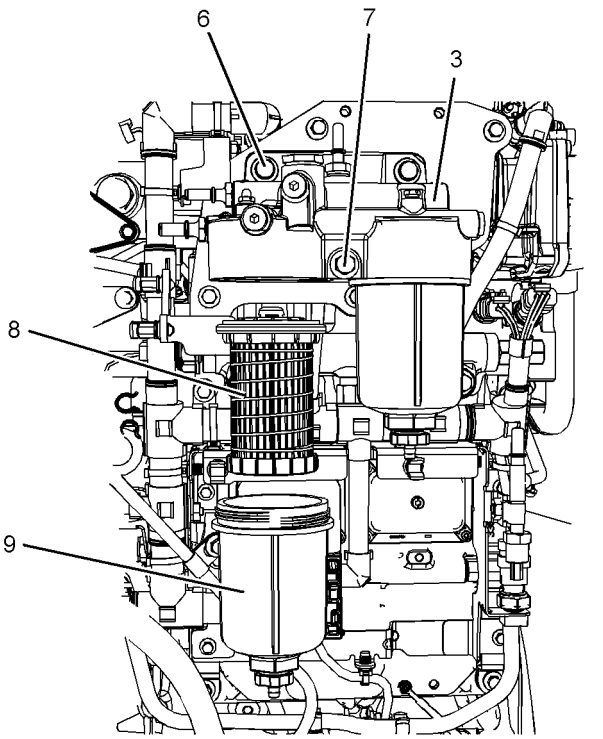

Illustration 11 g02597038

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

10. Remove bolts (6) and bolts (7) from fuel filter base (3). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

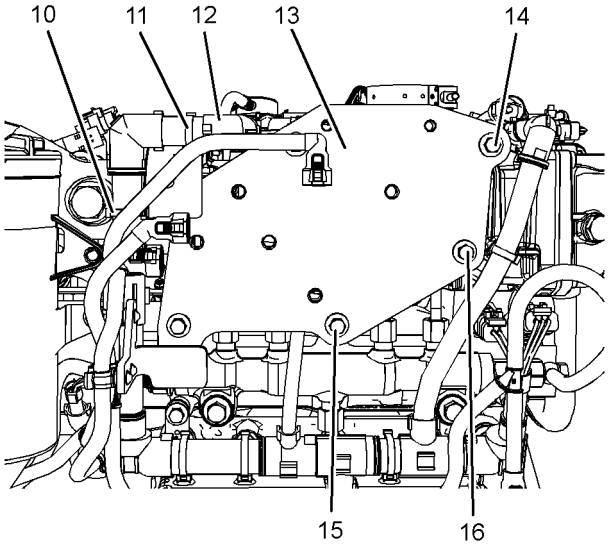

Illustration 12 g02597063

11. If necessary, follow Step 11.a through Step 11.c in order to remove the bracket for secondary fuel filter.

a. Cut cable strap (10) and cable strap (11) from harness assembly (12).

b. Remove bolts (11), bolts (12) and bolt (16) from fuel filter bracket (10).

Note: Note position of different length bolts.

c. Remove fuel filter bracket (10) from the NRS induction mixer assembly.

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.

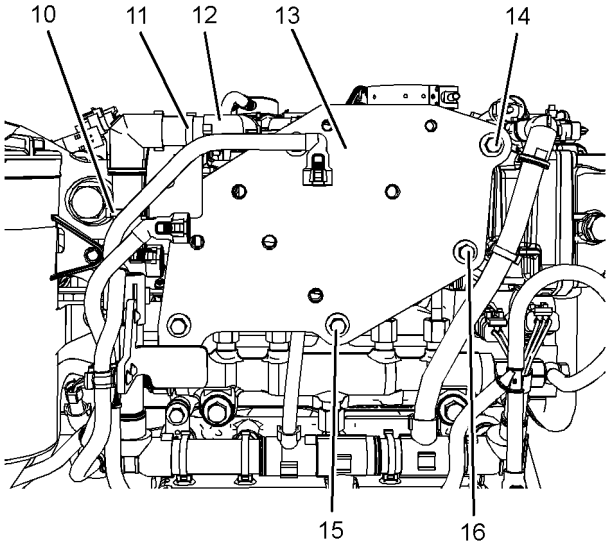

Illustration 13 g02597063

1. If necessary, follow Step 1.a through Step 1.d in order to install the bracket for secondary fuel filter.

a. Position fuel filter bracket (10) onto the NRS induction mixer assembly.

b. Install bolts (11), bolts (12) and bolt (16) to fuel filter bracket (10).

c. Tighten bolts (11), bolts (12) and bolt (16) to a torque of 22 N·m (195 lb in).

d. Install new cable strap (10) and cable strap (11) to harness assembly (12).

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

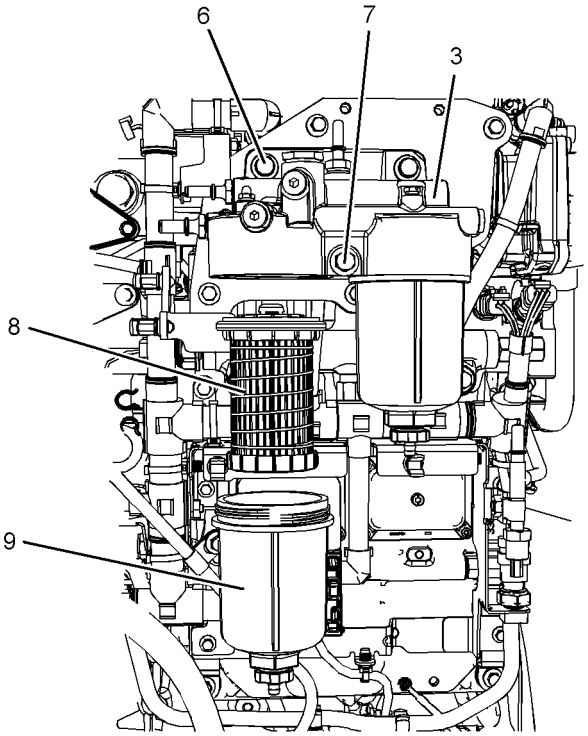

Illustration 14 g02597038

2. Ensure that fuel filter base (3) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.

3. Position fuel filter base (3) on the mounting bracket. Install bolts (6) and bolts (7). Tighten the bolts to a torque of 44 N·m (32 lb ft).

4. If necessary, install new fuel filters (8) to canisters (9). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

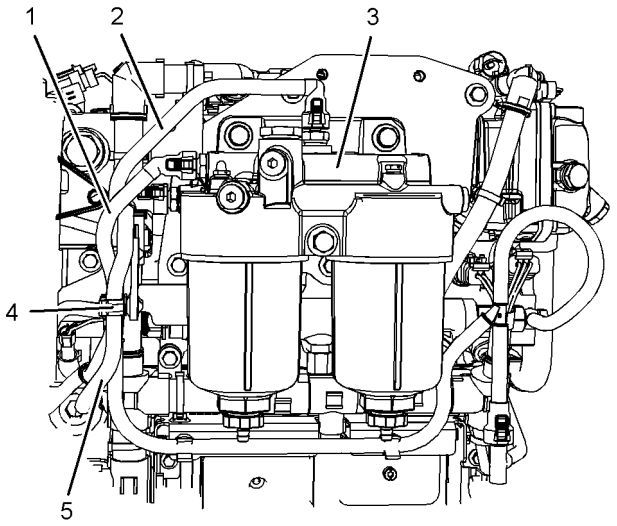

Illustration 15 g02597024

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 (5) to fuel filter base (3).

7. Install plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to clips (4).

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.

i04485863

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

Removal Procedure

Table 3

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

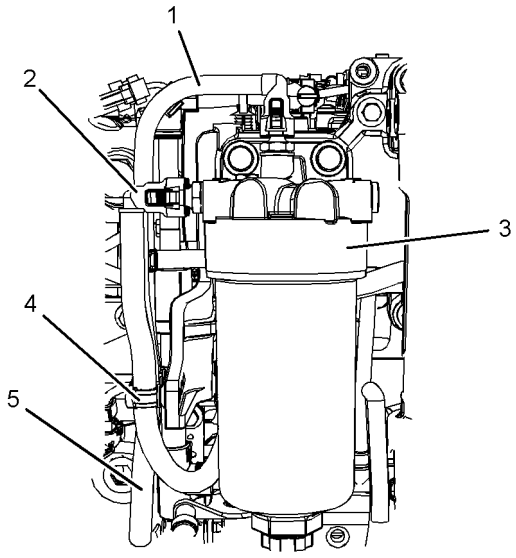

Illustration 16 g02526916

3. Make temporary identification marks on plastic tube assemblies in order to show the correct position of the 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 (1), plastic tube assembly (2), and plastic tube assembly (5) from the fuel filter base.

6. Remove plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from clips (4).

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 single secondary fuel filter with new caps.

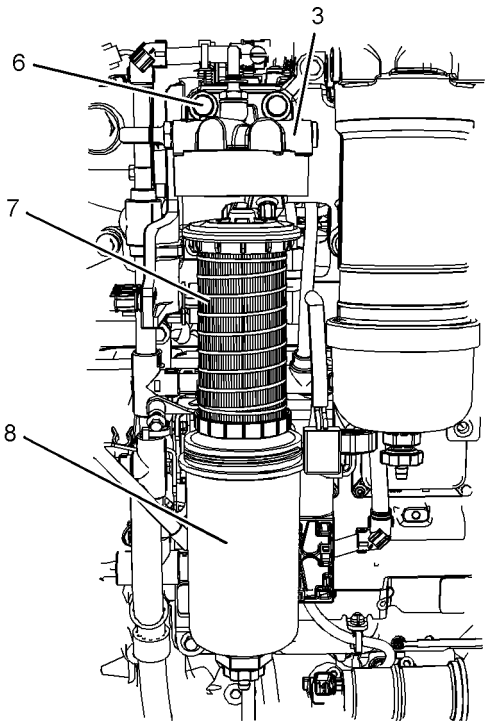

Illustration 17 g02526918

8. Remove canister (8) from fuel filter base (3). Remove secondary filter (7). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

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

Note: Do not disassemble the fuel filter base.

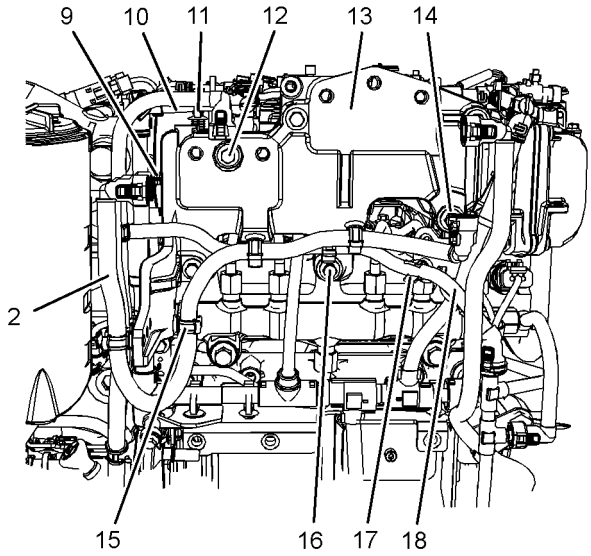

Illustration 18 g02599177

10. If necessary, follow Step 1.f through Step 10.e in order to remove the bracket for secondary fuel filter.

a. Cut cable strap (9) and cable strap (11) from harness assembly (10).

b. Remove plastic tube assembly (2) from clips (15).

c. Remove plastic tube assembly (18) from clips (17).

d. Remove bolts (12), bolts (14) and bolt (16) from fuel filter bracket (13).

Note: Note position of different length bolts.

e. Remove fuel filter bracket (13) from the NRS induction mixer assembly.

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.

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 and the convoluting.

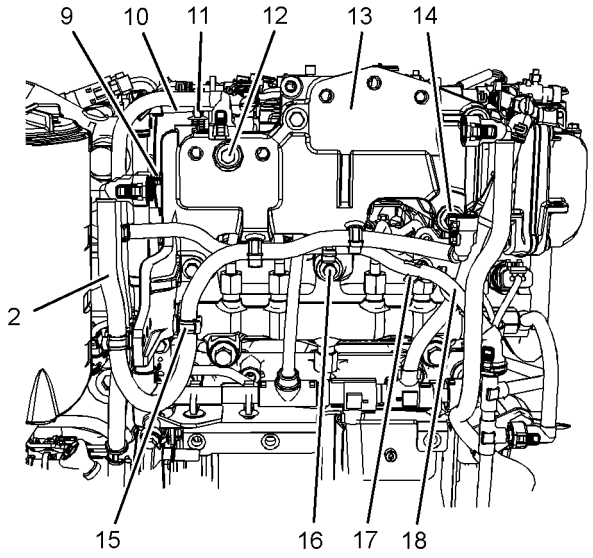

Illustration 19 g02599177

1. If necessary, follow Step 1.a through Step 1.f in order to install the bracket for secondary fuel filter.

a. Position fuel filter bracket (13) onto the NRS induction mixer assembly.

b. Install bolts (12), bolts (14) and bolt (16) to fuel filter bracket (13).

c. Tighten bolts (12), bolts (14) and bolt (16) to a torque of 22 N·m (195 lb in).

d. Install plastic tube assembly (2) to clips (15).

e. Install plastic tube assembly (18) to clips (17).

f. Install new cable strap (9) and cable strap (11) to harness assembly (10).

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

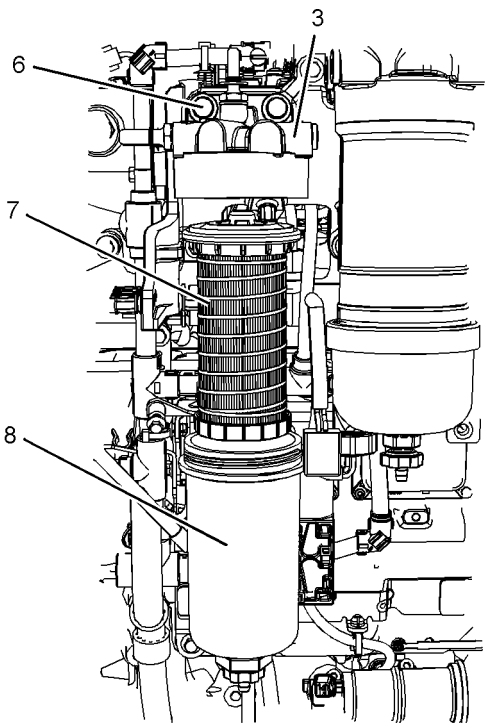

Illustration 20 g02526918

2. Ensure that fuel filter base (3) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.

3. Position fuel filter base (3) on the mounting bracket. Install bolts (6). 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). Install canister (8) to fuel filter base (3). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

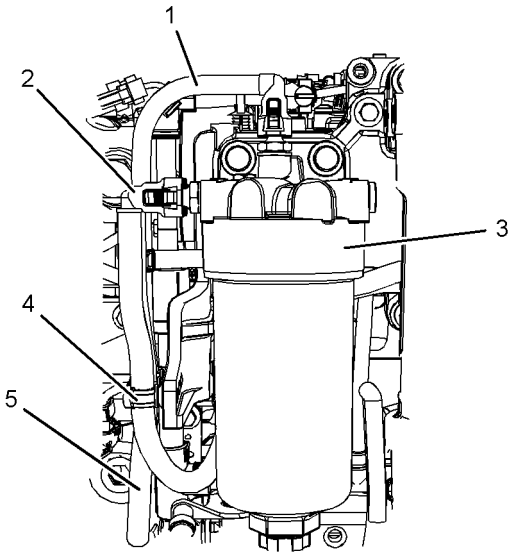

Illustration 21 g02526916

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. Allowing contamination to enter the fuel system will cause serious damage to the engine.

6. Connect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to the fuel filter base.

7. Install plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to clips (4).

8. Turn the fuel supply 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.

i04485918

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

Removal Procedure

Table 4

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.

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

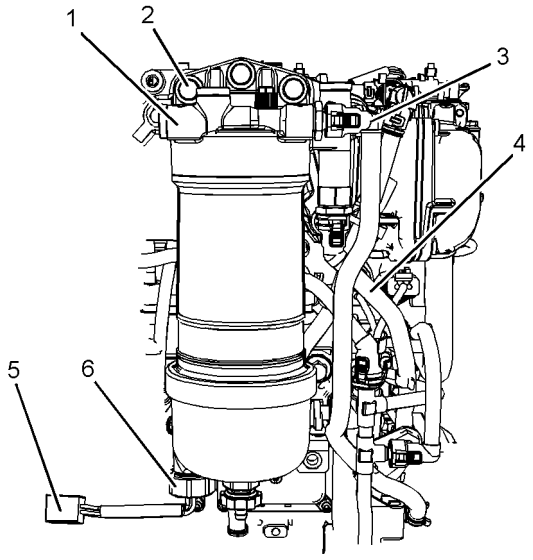

Illustration 22 g02524979

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 (3) and plastic tube assembly (4) from the assembly of primary fuel filter (1). 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 primary fuel filter with new caps.
6. Disconnect the Original Equipment Manufactures (OEM) harness assembly from the connection on harness assembly (5) for water in fuel sensor (6).
7. Remove bolts (2) and remove the assembly of primary fuel filter (1) from the mounting bracket.

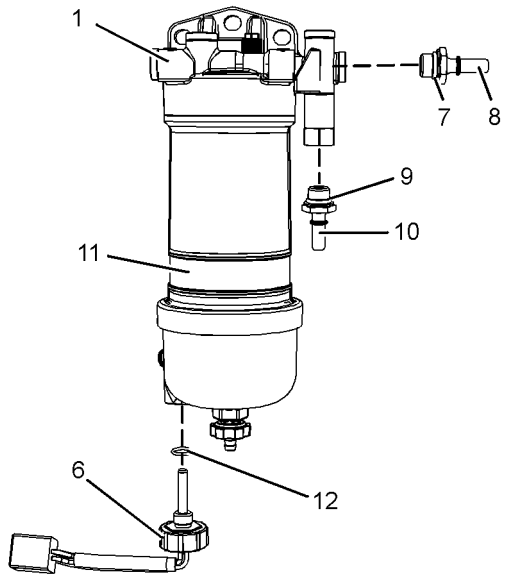

Illustration 23 g02524997

8. If necessary, follow Step 8.a through Step 8.d in order to disassembly the assembly of primary fuel filter (1).
   a. Remove connection (7) and remove O-ring seal (8). Use Tooling (A) in order to plug the primary fuel filter (1) with new plug. Use Tooling (A) in order to cap connection (7) with new caps.
   b. Remove connection (10) and remove O-ring seal (9). Use Tooling (A) in order to plug the primary fuel filter (1) with new plug. Use Tooling (A) in order to cap connection (10) with new caps.
   c. Remove water in fuel sensor (6) and remove O-ring seal (12).

d. Remove the filter element from fuel filter canister (11). 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.

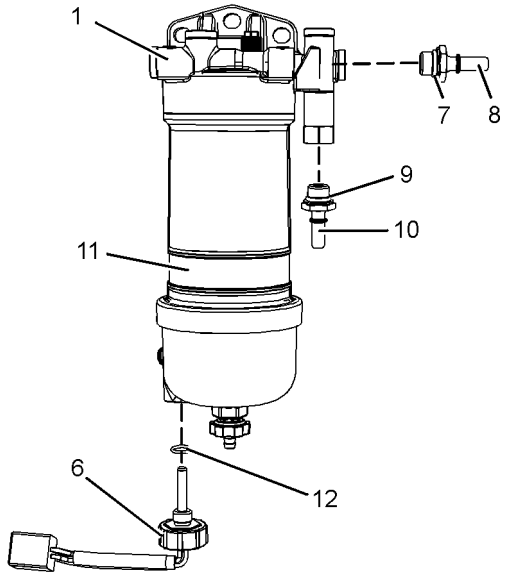

Illustration 24 g02524997

2. If necessary, follow Step 2.a through Step 2.f in order to assembly primary fuel filter (1).

a. Install a new filter element to fuel filter canister (11). Refer to Operation and Maintenance Manual, “Fuel System Primary Filter (Water Separator) Element - Replace” for the correct procedure.

b. Remove caps from connection (7). Install a new O-ring seal (8) to connection (7).

c. Remove cap from primary fuel filter (1). Install connection (7) to primary fuel filter (1). Tighten the connection to a torque of 20 N·m (177 lb in).

d. Remove caps from connection (10). Install a new O-ring seal (9) to connection (10).

e. Remove cap from primary fuel filter (1). Install connection (10) to primary fuel filter (1). Tighten the connection to a torque of 20 N·m (177 lb in).

f. Install a new O-ring seal (12) to water in fuel sensor (6). Install water in fuel sensor (6) to primary fuel filter (1). Tighten water in fuel sensor (6) hand tight.

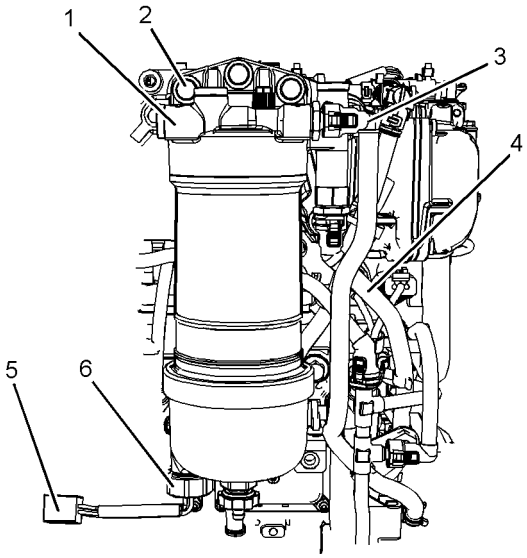

Illustration 25 g02524979

3. Position the assembly of primary fuel filter (1) onto the mounting bracket.

4. Install bolts (2) to the assembly of primary fuel filter (1). 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 connections on the primary fuel filter.

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 (3) and plastic tube assembly (4) to primary fuel filter (1).

7. Connect the OEM harness assembly to the connection on harness assembly (5) for water in fuel sensor (6).

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.

i04485872

Fuel Manifold (Rail) - Remove and Install

Removal Procedure

Table 5

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

Start By:

a. 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.

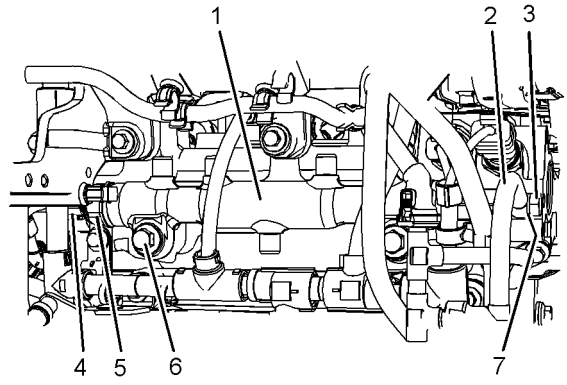

Illustration 26 g02484242

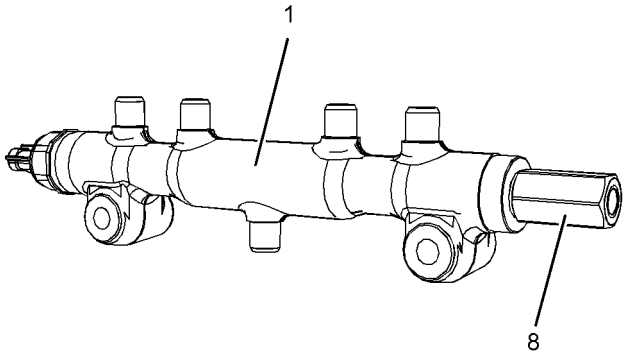

Illustration 27 g02484286

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

2. Disconnect harness assembly (4) from fuel pressure sensor (5).

3. Remove banjo bolt (3) from plastic tube assembly (2). Use Tooling (A) to plug the plastic tube assembly Remove sealing washers (7) (not shown). Use Tooling (A) to plug fuel manifold (1).

4. Remove bolts (6).

5. Remove fuel manifold (1) from the cylinder block.

6. If necessary, remove fuel pressure relief valve (8) from fuel manifold (1). 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.

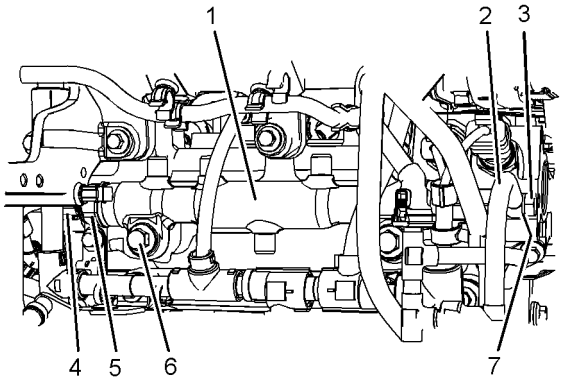

Illustration 28 g02484242

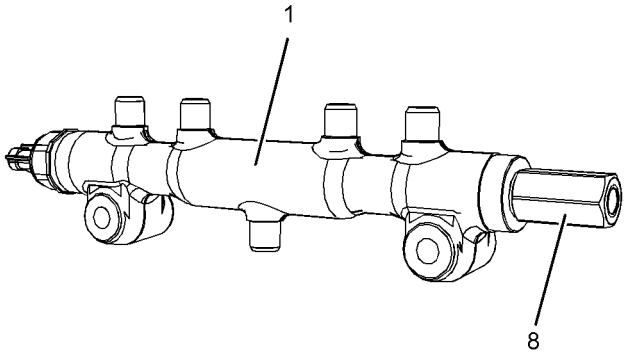

Illustration 29 g02484286

2. If necessary, install fuel pressure relief valve (8) to fuel manifold (1). Ref to Disassembly and Assembly, “Relief Valve (Fuel) - Remove and Install” for the correct procedure.

3. Position fuel manifold (1) onto the cylinder block. Install bolts (6) to fuel manifold (1) finger tight.

4. Install a new set of seals to the electronic unit injectors and a new set of fuel injection lines. Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

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

6. Install a new sealing washer (7) (not shown) to banjo bolt (3).

7. Remove plug from plastic tube assembly (2). Install assembly of banjo bolt (3) to plastic tube assembly (2). Install remaining new sealing washer (7) (not shown) to banjo bolt (3).

8. Install banjo bolt (3) and plastic tube assembly (2) to pressure relief valve (8) finger tight.

9. Tighten banjo bolts (3) to a torque of 15 N·m (133 lb in).

10. Connect harness assembly (4) to fuel pressure sensor (5).

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

i04494469

Relief Valve (Fuel) - Remove and Install

Removal Procedure

Table 6

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

⚠ WARNING

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

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by 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.

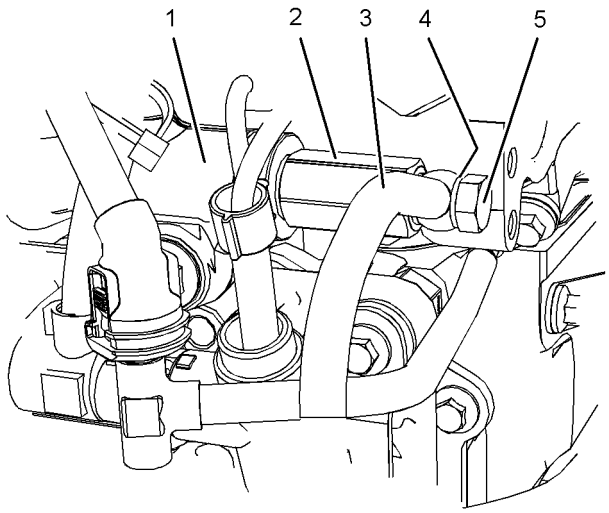

Illustration 30 g02673936

Typical example

1. Thoroughly clean the area around fuel manifold (1) and fuel pressure relief valve (2).
2. Remove banjo bolt (5) and remove sealing washers (4) (not shown).
3. Position plastic tube assembly (3) away from fuel pressure relief valve (2). Use Tooling (A) in order to immediately cap the open port in fuel pressure relief valve (2) with a new cap. Tooling (A) in order to immediately plug the open end of plastic tube assembly (3) with a new plug.
4. Follow Step 4.a through Step 4.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 (2) and fuel manifold (1) is still thoroughly clean.
   b. Use a deep socket in order to remove the fuel pressure relief valve (2) from fuel manifold (1).
   c. Use Tooling (A) in order to immediately plug the open port in fuel manifold (1). Use Tooling (A) in order to immediately cap the fuel pressure relief valve (2).

Installation Procedure

Table 7

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	21825607	Degree Wheel	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.

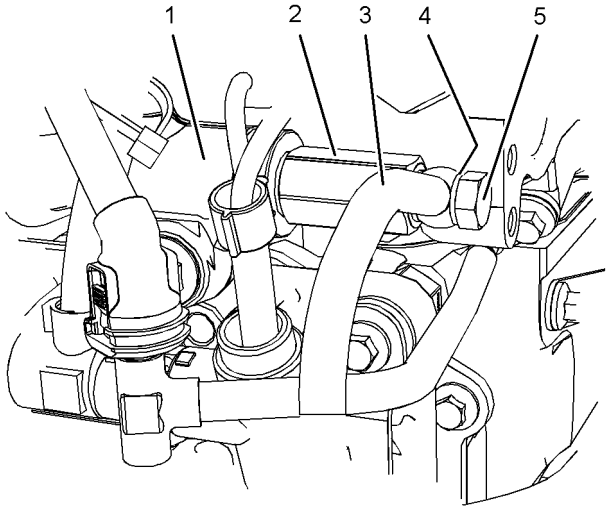

Illustration 31 g02673936

Typical example

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

a. Remove the plug from the port in fuel manifold (1).

b. Immediately clean the threads in fuel manifold (1) for fuel pressure relief valve (2). 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 (1) with a new cap after cleaning and inspection.

d. Remove the cap from the threaded end of fuel pressure relief valve (2). lubricate the thread of the pressure relief valve with clean fuel.

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

f. Tighten fuel pressure relief valve (2) to a snug torque of 30 N·m (266 lb in). Use Tooling (B) in order to rotate the fuel pressure relief valve in a clockwise direction for an additional 24 degrees in order to achieve the final torque.

2. Remove the plug from plastic tube assembly (3).

3. Install a new sealing washer (4) (not shown) onto banjo bolt (5). Position banjo bolt (5) onto plastic tube assembly (3) and install remaining new sealing washer (4) (not shown) onto the banjo bolt.

4. Remove the plug from fuel pressure relief valve (2).

5. Position plastic tube assembly (3) onto fuel pressure relief valve (2). Tighten banjo bolt (5) hand tight.

6. Tighten banjo bolt (5) to a torque of 15 N·m (133 lb in).

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

i04485866

Fuel Injection Lines - Remove

Removal Procedure

Start By:

a. Remove crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.

b. Remove secondary fuel filter assembly. Refer to Disassembly and Assembly, "Fuel Filter Base (Single Secondary Fuel Filter) - Remove and Install" for the correct procedure.

c. Remove water separator and fuel filter (Primary). Refer to Disassembly and Assembly, "Water Separator and Fuel Filter (Primary) - Remove and Install" for the correct procedure.

d. Remove the Inlet Air Control (NRS Induction Mixer). Refer to Disassembly and Assembly, "Inlet Air Control (NRS Induction Mixer) - Remove" for the correct procedure.

Table 8

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

⚠ WARNING

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

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by 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 and capping 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.

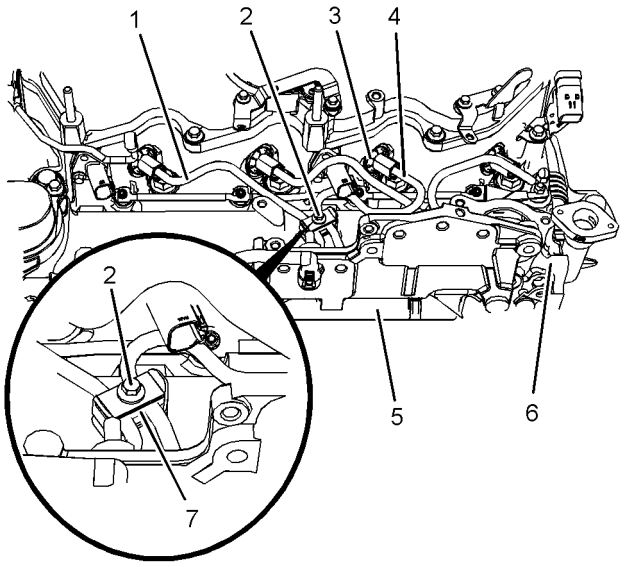

Illustration 32 g02481081

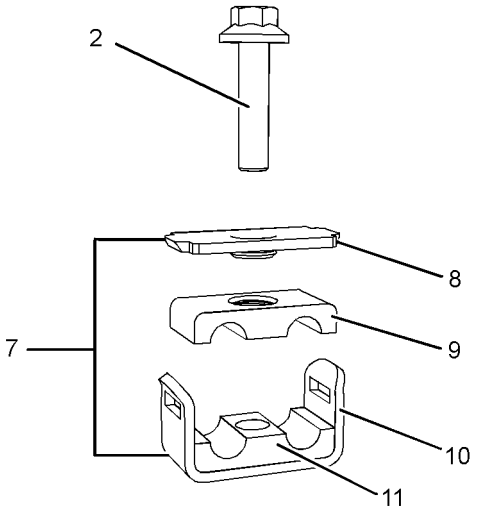

Illustration 33 g02625722

3. Remove bolt (2) from tube clamp (7). Remove clamp plate (8) and isolator (9) from fuel injection line (1) and fuel injection line (4).
4. Clean the area around the nuts for the fuel injection line (1) and fuel injection line (4). Ensure that the area is free from contamination before beginning disassembly.
5. Disconnect fuel injection line (1) and fuel injection line (4) from the electronic unit injector.
6. Disconnect fuel injection line (1) and fuel injection line (4) from fuel manifold (5).
7. Use Tooling (A) in order to plug the open port in the electronic unit injector immediately.

8. Remove fuel injection line (1) and fuel injection line (4). **Discard the fuel injection lines.**

9. Remove bracket (10) and isolator (11).

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

11. Remove seal (3) from the electronic unit injector and cylinder head (6).

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

13. Repeat Step 5 through Step 12 in order to remove the remaining fuel injection lines from the fuel manifold to the electronic unit injectors.

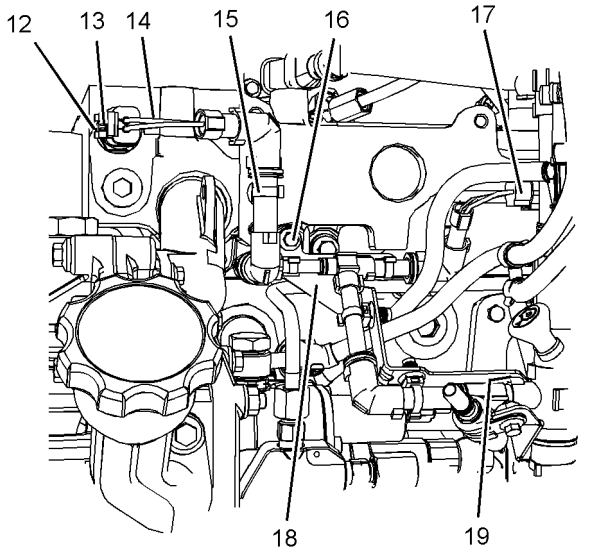

Illustration 34 g02625818

14. Slide locking tab (13) into the unlocked position. Disconnect harness assembly (14) from coolant temperature sensor (12).

15. Disconnect harness assembly (17) from fuel pressure sensor.

16. Cut cable strap (15).

17. Remove bolt (16) and bolt (19) (not shown) from bracket (18).

18. Position bracket (18) and the harness assembly away from the fuel injection pump.

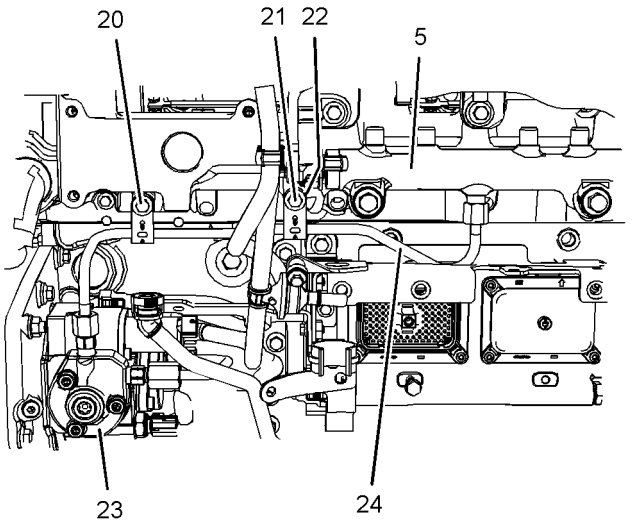

Illustration 35 g02481080

19. Remove bolt (20) from the tube clip.

20. Remove bolt (21) and spacer (22) (not shown) from the tube clip.

21. Disconnect fuel injection line (24) at fuel injection pump (23).

22. Disconnect fuel injection line (24) at fuel manifold (5).

23. Remove fuel injection line (24). **Discard the fuel injection lines.**

24. Use Tooling (A) in order to plug all open ports immediately in fuel manifold (5) and in fuel injection pump (23).

i04485865

Fuel Injection Lines - Install

Installation Procedure

Table 9

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	27610294	Injector Pipe Nut Tool	1
C	T40-0030	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.

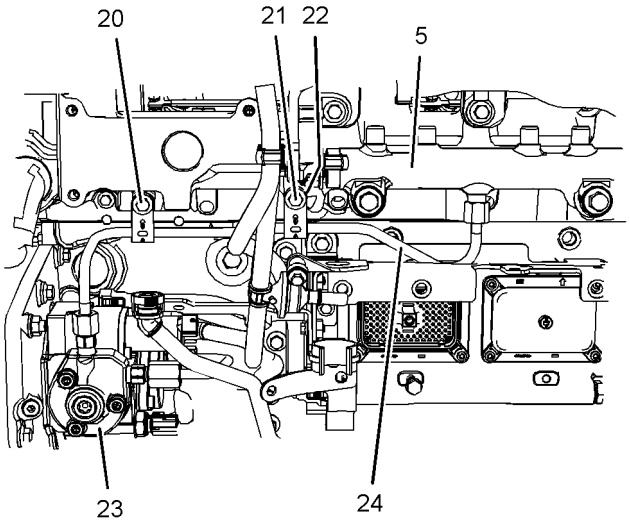

Illustration 36 g02481080

1. Remove plugs from fuel manifold (5) and fuel injection pump (23).
2. Remove the caps from new fuel injection line (24).
3. Position fuel injection line (24) onto fuel injection pump (23) and fuel manifold (5). Loosely install nuts for the fuel injection line onto the fuel manifold and the fuel injection pump.
4. Install bolt (20) to the tube clip finger tight.
5. Install bolt (21) and spacer (22) to the tube clip finger tight.
6. Use Tooling (C) to tighten the nuts on fuel injection line (24) to a torque of 40 N·m (30 lb ft).
7. Tighten bolt (20) and bolt (21) to a torque of 10 N·m (89 lb in).

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

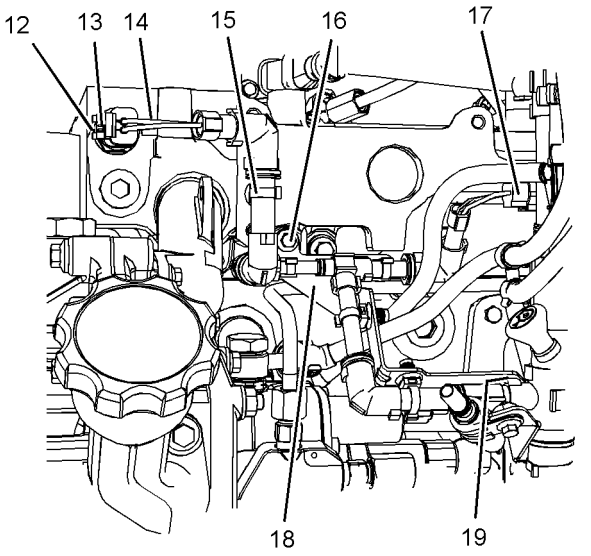

Illustration 37 g02625818

8. Position bracket (18) and the harness assembly onto the fuel injection pump.
9. Install bolt (16) and bolt (19) (not shown) to bracket (18). Tighten the bolt to a torque of 9 N·m (80 lb in).
10. Connect harness assembly (14) to coolant temperature sensor (12). Slide locking tab (13) into the locked position.
11. Connect harness assembly (17) to fuel pressure sensor.
12. Install new cable strap (15).

Note: Ensure that the cable strap meets Original Equipment Manufactures (OEM) specification.

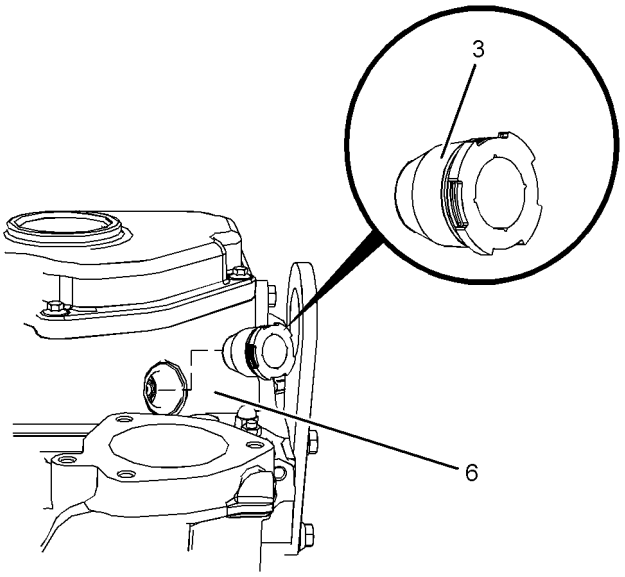

Illustration 38 g02481216

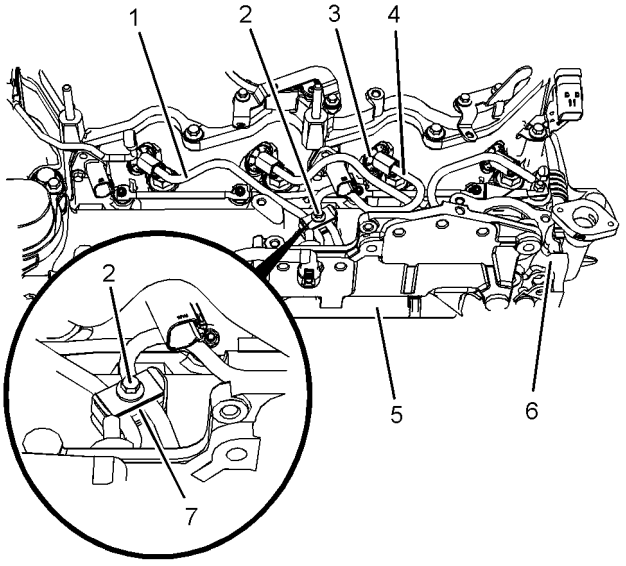

Illustration 39 g02481081

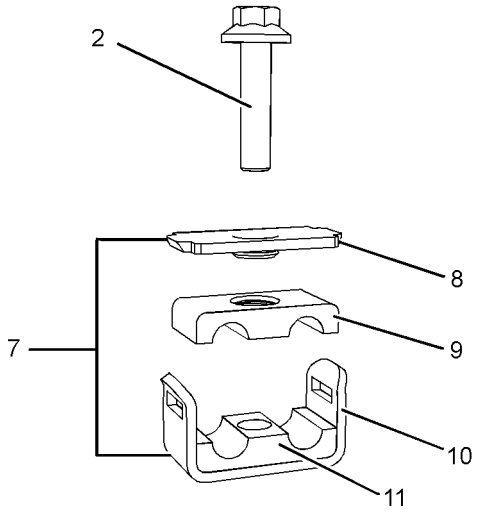

Illustration 40 g02625722

13. Install new seals (3) to the electronic unit injector and cylinder head (6). Ensure that the flange on the seal is flush with the cylinder head.

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

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

16. Install bracket (10) and isolator (11). Position isolator (9) and clamp plate (8).

17. Use a suitable tool in order to install clamp plate (8) to bracket (10).

18. Install bolt (2) finger tight.

19. Use Tooling (B) to tighten the nuts on fuel injection line (1) and fuel injection line (4) to a torque of 40 N·m (30 lb ft). Ensure that the dust seal is seated correctly against the seal.

20. Tighten bolt (2) to a torque of 10 N·m (89 lb in).

21. Follow Step 13 through Step 20 in order to install the remaining fuel injection lines.

22. Turn the fuel supply to the ON position.

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

24. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, “Fuel System - Prime” 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.

b. Install secondary fuel filter assembly. Refer to Disassembly and Assembly, “Fuel Filter Base (Single Secondary Fuel Filter) - Remove and Install” for the correct procedure.

c. Install water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

d. Install crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

i04485848

Exhaust Cooler (NRS) - Remove and Install (Top mounted Turbocharger)

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.

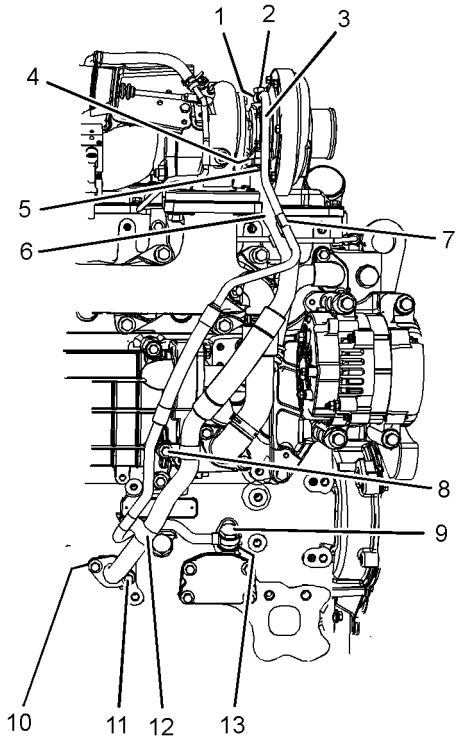

Illustration 41 g02619678

1. Remove clip (7) and clip (12) from tube assembly (3) and tube assembly (6).

2. Remove banjo bolt (2) from tube assembly (3). Remove sealing washers (1) (not shown).

3. Remove banjo bolt (9) from tube assembly (6). Remove sealing washers (13) (not shown).

4. Remove tube assembly (6).

5. remove bolt (8) from clip for tube assembly (6).

6. Remove bolts (5) and bolts (11) from tube assembly (6).

7. Remove tube assembly (6) from the turbo charger and the cylinder block.

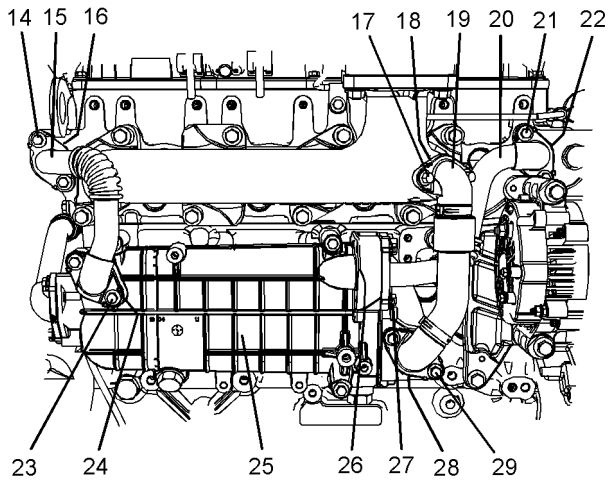

Illustration 42 g02619657

8. 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.

9. Remove bolts (14) and bolts (23) from tube assembly (15).

10. Remove tube assembly (15) from exhaust cooler (25) and the cylinder head.

11. Remove gaskets (16) (not shown) and gasket (24) (not shown) from tube assembly (15).

12. Prior to and during removal of bolts (17) and bolts (29) apply releasing fluid to the bolts. Remove bolts (17) and bolts (29) from tube assembly (19).

13. Remove tube assembly (19) from exhaust cooler (25) and the exhaust manifold.

14. Remove gaskets (18) (not shown) and gasket (28) (not shown) from tube assembly (19).

15. Remove bolts (21) and bolts (27) from tube assembly (20).

16. Remove tube assembly (20) from exhaust cooler (25) and the cylinder head.

17. Remove gasket (22) (not shown) and gasket (26) (not shown) from tube assembly (20).

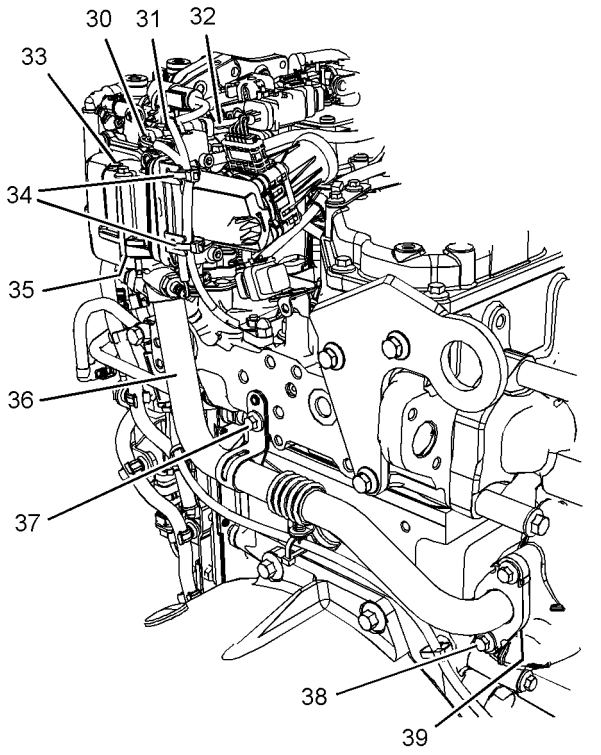

Illustration 43 g02619659

18. Cut cable straps (34) for wiring harness assembly (30). Ensure that all the cable straps are removed from all harness assemblies.

19. Slide locking tab (31) into the unlocked position. Disconnect wiring harness assembly (30) from engine wiring harness assembly (32).

20. Remove bolts (33) from tube assembly (36).

21. Remove bolt (37) from clamp on tube assembly (36).

22. Remove bolts (38) from tube assembly (36).

23. Remove tube assembly (36). Remove gasket (35) (not shown) and gasket (39) (not shown) from tube assembly (36).

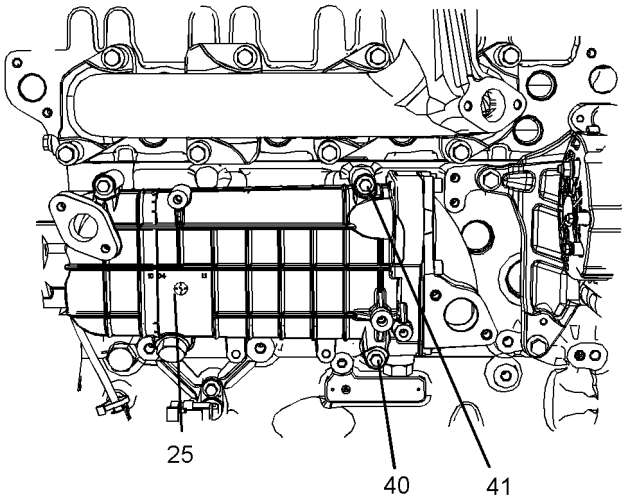

Illustration 44 g02619660

24. Remove bolt (40) and bolts (41) from exhaust cooler (25).

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

25. Remove exhaust cooler (25) from the cylinder block.

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 and the convoluting.

1. Ensure that the exhaust cooler is clean and free from restriction. Ensure that the exhaust cooler is 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.

2. Ensure that all tube assemblies are free from restriction and damage.

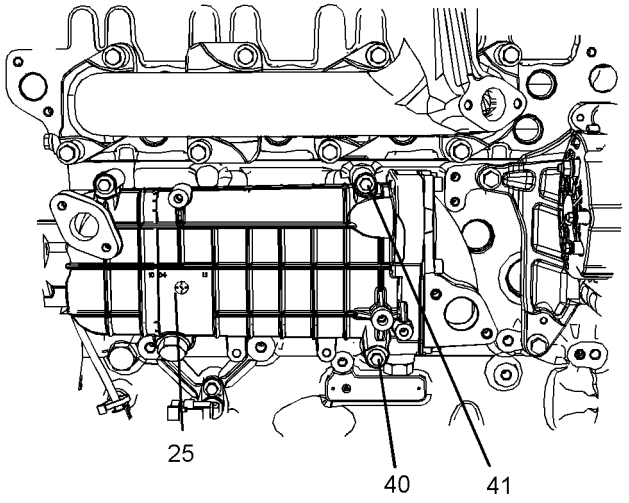

Illustration 45 g02619660

3. Position exhaust cooler (25) onto the cylinder block. Install bolt (40) and bolts (41) to exhaust cooler (25). Hand tighten bolt (40) and bolts (41).

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

4. Tighten bolt (40) and bolts (41) to a torque of 22 N·m (195 lb in).

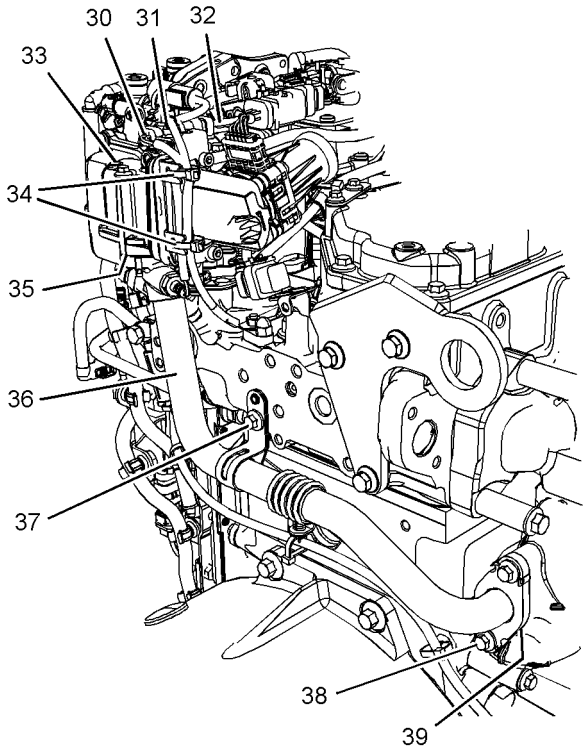

Illustration 46 g02619659

5. Position a new gasket (35) (not shown) and a new gasket (39) (not shown) onto tube assembly (36).

6. Position tube assembly (36) onto the exhaust cooler and the inlet air control. Install bolts (33) and bolts (38) to tube assembly (36).

7. Install bolt (37) to clamp on tube assembly (36).

8. Tighten bolts (33) to a torque of 9 N·m (80 lb in).

Tighten bolts (38) to a torque of 18 N·m (159 lb in).

Tighten bolt (37) to a torque of 22 N·m (195 lb in).

9. Connect wiring harness assembly (30) to engine wiring harness assembly (32). Slide locking tab (31) into the locked position.

10. Install new cable straps (34) to wiring harness assembly (30).

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

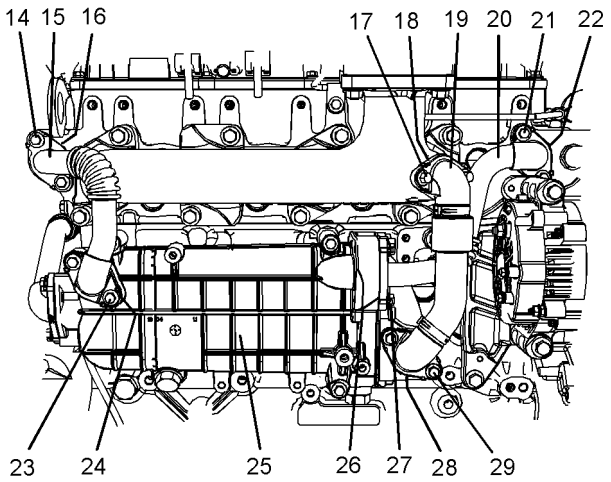

Illustration 47 g02619657

11. Position a new gasket (16) (not shown) and a new gasket (24) (not shown) onto tube assembly (15).

12. Install tube assembly (15) to exhaust cooler (25) and the cylinder head.

13. Install bolts (14) and bolts (23) to tube assembly (15).

14. Tighten bolts (23) to a torque of 18 N·m (159 lb in).

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

15. Position a new gasket (22) (not shown) and install a new gasket (26) (not shown) onto tube assembly (20).

16. Position tube assembly (20) onto exhaust cooler (25) and the cylinder head. Install bolts (21) and bolts (27) to tube assembly (20). Ensure that the tube assembly is correctly positioned into the exhaust cooler.

17. Tighten bolt (21) and bolts (27) to a torque of 22 N·m (195 lb in).

18. Position a new gasket (18) (not shown) and a new gasket (28) (not shown) onto tube assembly (19).

19. Position tube assembly (19) onto exhaust cooler (25) and the exhaust manifold.

20. Install new bolts (17) and new bolts (29) to tube assembly (19).

21. Tighten bolts (17) and bolts (29) to a torque of 22 N·m (195 lb in).

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

i04485847

Exhaust Cooler (NRS) - Remove and Install (Side mounted Turbocharger)

Removal Procedure

Start By:

a. Remove the turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Remove (Side Mounted Turbocharger)” 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.

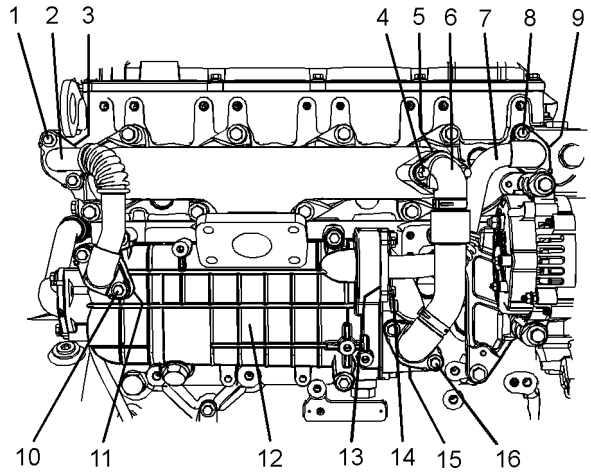

Illustration 48 g02619576

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. Remove bolts (1) and bolts (10) from tube assembly (2).

3. Remove tube assembly (2) from exhaust cooler (12) and the cylinder head.

4. Remove gaskets (3) (not shown) and gasket (11) (not shown) from tube assembly (2).

5. Prior to and during removal of bolts (4) and bolts (16) apply releasing fluid to the bolts. Remove bolts (4) and bolts (16) from tube assembly (6).

6. Remove tube assembly (6) from exhaust cooler (12) and the exhaust manifold.

7. Remove gaskets (5) (not shown) and gasket (15) (not shown) from tube assembly (6).

8. Remove bolts (8) and bolts (14) from tube assembly (7).

9. Remove tube assembly (7) from exhaust cooler (12) and the cylinder head.

10. Remove gasket (9) (not shown) and gasket (13) (not shown) from tube assembly (7).

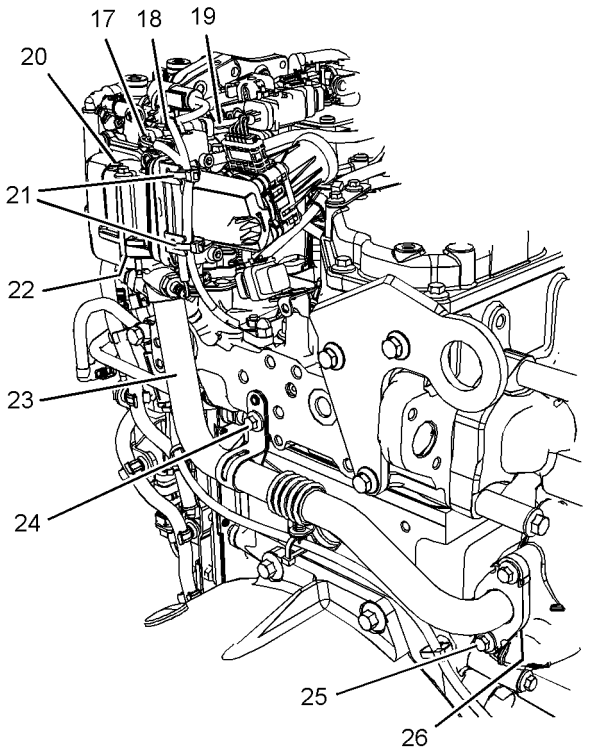

Illustration 49 g02619577

11. Cut cable straps (21) for wiring harness assembly (17). Ensure that all the cable straps are removed from all harness assemblies.

12. Slide locking tab (18) into the unlocked position. Disconnect wiring harness assembly (17) from engine wiring harness assembly (19).

13. Remove bolts (20) from tube assembly (23).

14. Remove bolt (24) from clamp on tube assembly (23).

15. Remove bolts (25) from tube assembly (23).

16. Remove tube assembly (23). Remove gasket (26) (not shown) and gasket (22) (not shown) from tube assembly (23).

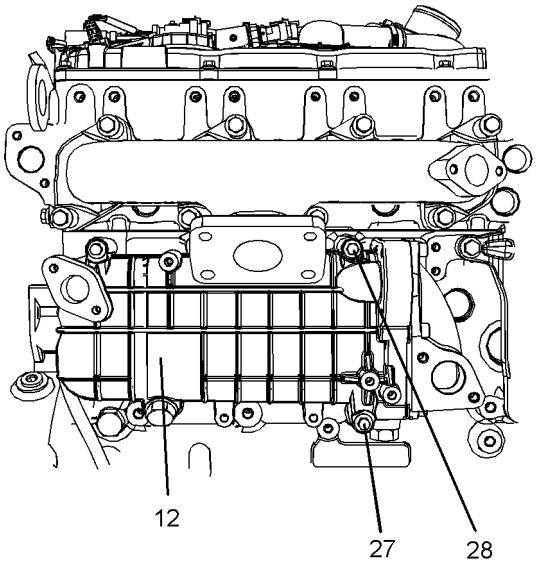

Illustration 50 g02619578

17. Remove bolt (27) and bolts (28) from exhaust cooler (12).

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

18. Remove exhaust cooler (12) from the cylinder block.

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 and the convoluting.

1. Ensure that the exhaust cooler is clean and free from restriction. Ensure that the exhaust cooler is 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.

2. Ensure that all tube assemblies are free from restriction and damage.

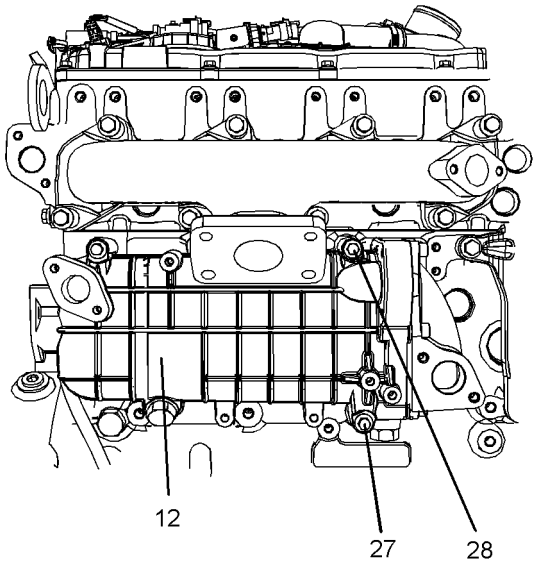

Illustration 51 g02619578

3. Position exhaust cooler (12) onto the cylinder block. Install bolt (27) and bolts (28) to exhaust cooler (12). Hand tighten bolt (27) and bolts (28).

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

4. Tighten bolt (27) and bolts (28) to a torque of 22 N·m (195 lb in).

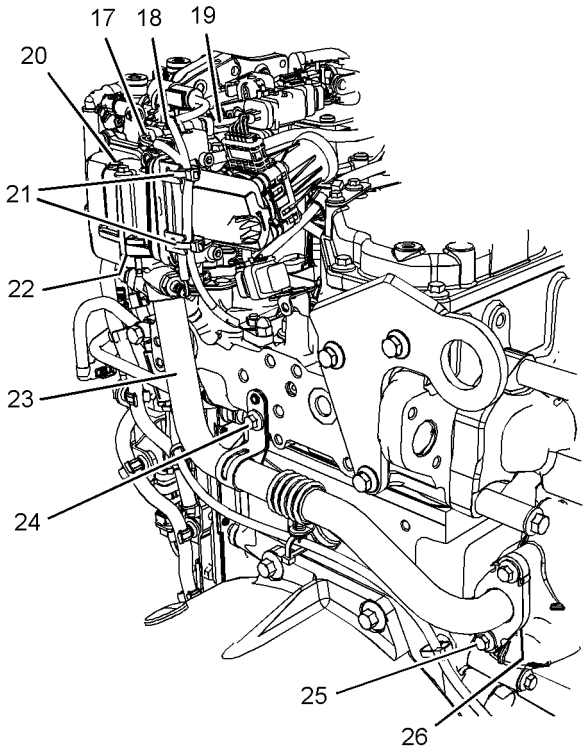

Illustration 52 g02619577

5. Position a new gasket (22) (not shown) and a new gasket (26) (not shown) onto tube assembly (23).

6. Position tube assembly (23) onto the exhaust cooler and the inlet air control. Install bolts (20) and bolts (25) to tube assembly (23).

7. Install bolt (24) to clamp on tube assembly (23).

8. Tighten bolts (20) to a torque of 9 N·m (80 lb in).

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

   Tighten bolt (24) to a torque of 22 N·m (195 lb in).

9. Connect wiring harness assembly (17) to engine wiring harness assembly (19). Slide locking tab (18) into the locked position.

10. Install new cable straps (21) to wiring harness assembly (17).

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

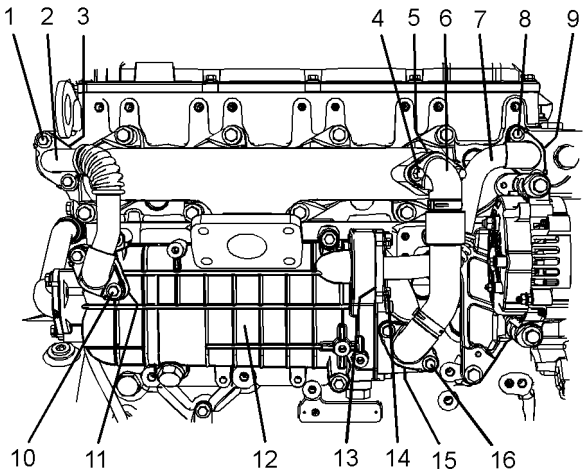

Illustration 53 g02619576

11. Position a new gasket (3) (not shown) and a new gasket (11) (not shown) onto tube assembly (2).

12. Install tube assembly (2) to exhaust cooler (12) and the cylinder head.

13. Install bolts (1) and bolts (10) to tube assembly (2).

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

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

15. Position a new gasket (9) (not shown) and install a new gasket (13) (not shown) onto tube assembly (7).

16. Position tube assembly (7) onto exhaust cooler (12) and the cylinder head. Install bolts (8) and bolts (14) to tube assembly (7). Ensure that the tube assembly is correctly positioned into the exhaust cooler.

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

18. Position a new gasket (5) (not shown) and a new gasket (15) (not shown) onto tube assembly (6).

19. Position tube assembly (6) onto exhaust cooler (12) and the exhaust manifold.

20. Install new bolts (4) and new bolts (16) to tube assembly (6).

21. Tighten bolts (4) and bolts (16) to a torque of 22 N·m (195 lb in).

22. 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 turbocharger. Refer to Disassembly and Assembly, “Turbocharger - Install (Side Mounted Turbocharger)” for the correct procedure.

i04485846

Exhaust Cooler (NRS) - Remove and Install (Twin Turbocharger)

Removal Procedure

Start By:

a. Remove the first stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger - Remove (First Stage Turbocharger)” for the correct procedure.

b. Remove the second stage turbocharger for twin turbocharged engine. 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.

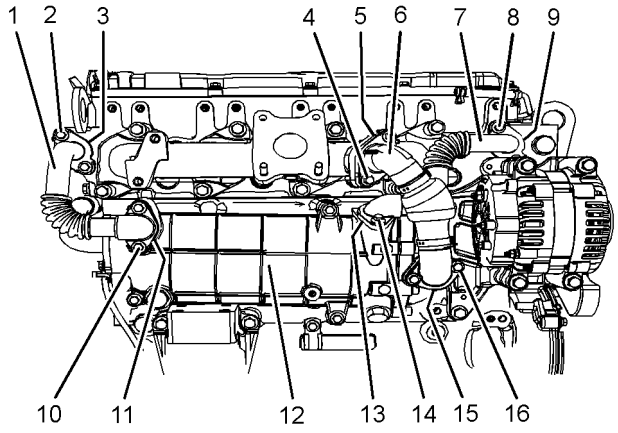

Illustration 54 g02477077

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. Remove bolts (2) and bolts (10) from tube assembly (1).

3. Remove tube assembly (1) from exhaust cooler (12) and the cylinder head.

4. Remove gaskets (3) (not shown) and gasket (11) (not shown) from tube assembly (1).

5. Prior to and during removal of bolts (4) and bolts (16) apply releasing fluid to the bolts. Remove bolts (4) and bolts (16) from tube assembly (6).

6. Remove tube assembly (6) from exhaust cooler (12) and the exhaust manifold.

7. Remove gaskets (5) (not shown) and gasket (15) (not shown) from tube assembly (6).

8. Remove bolts (8) and bolt (14) from tube assembly (7).

9. Remove tube assembly (7) from exhaust cooler (12) and the cylinder head.

10. Remove gasket (9) (not shown) and O-ring seal (13) (not shown) from tube assembly (7).

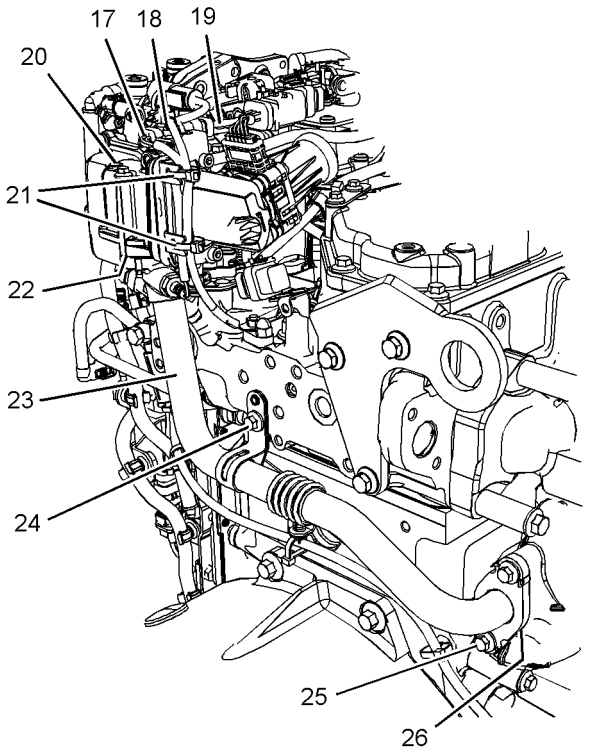

Illustration 55 g02477065

11. Cut cable straps (21) for wiring harness assembly (17). Ensure that all the cable straps are removed from all harness assemblies.

12. Slide locking tab (18) into the unlocked position. Disconnect wiring harness assembly (17) from engine wiring harness assembly (19).

13. Remove bolts (20) from tube assembly (23).

14. Remove bolt (24) from clamp on tube assembly (23).

15. Remove bolts (25) from tube assembly (23).

16. Remove tube assembly (23). Remove gasket (26) (not shown) and gasket (22) (not shown) from tube assembly (23).

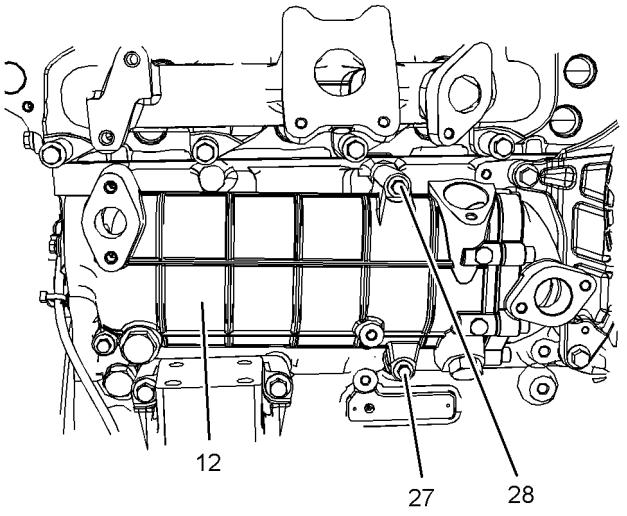

Illustration 56 g02477067

17. Remove bolt (27) and bolts (28) from exhaust cooler (12).

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

18. Remove exhaust cooler (12) from the cylinder block.

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 and the convoluting.

1. Ensure that the exhaust cooler is clean and free from restriction. Ensure that the exhaust cooler is 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.

2. Ensure that all tube assemblies are free from restriction and damage.

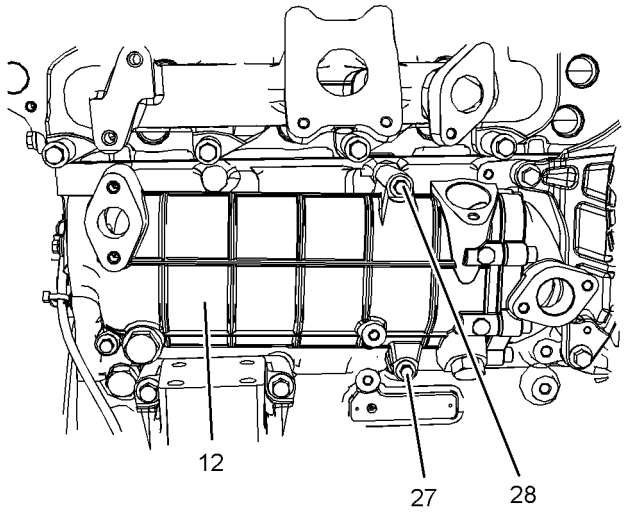

Illustration 57 g02477067

3. Position exhaust cooler (12) onto the cylinder block. Install bolt (27) and bolts (28) to exhaust cooler (12). Hand tighten bolt (27) and bolts (28).

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

4. Tighten bolt (27) and bolts (28) to a torque of 22 N·m (195 lb in).

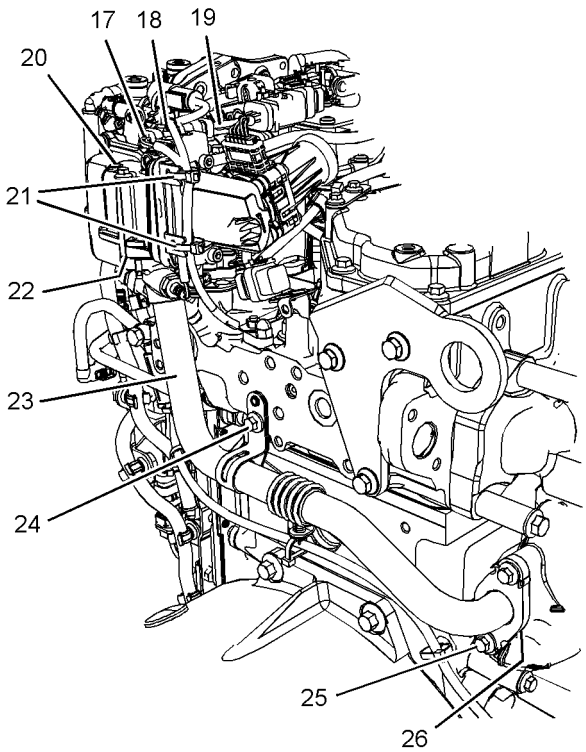

Illustration 58 g02477065

5. Position a new gasket (22) (not shown) and a new gasket (26) (not shown) onto tube assembly (23).

6. Position tube assembly (23) onto the exhaust cooler and the inlet air control. Install bolts (20) and bolts (25) to tube assembly (23).

7. Install bolt (24) to clamp on tube assembly (23).

8. Tighten bolts (20) to a torque of 9 N·m (80 lb in).

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

Tighten bolt (24) to a torque of 22 N·m (195 lb in).

9. Connect wiring harness assembly (17) to engine wiring harness assembly (19). Slide locking tab (18) into the locked position.

10. Install new cable straps (21) to wiring harness assembly (17).

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

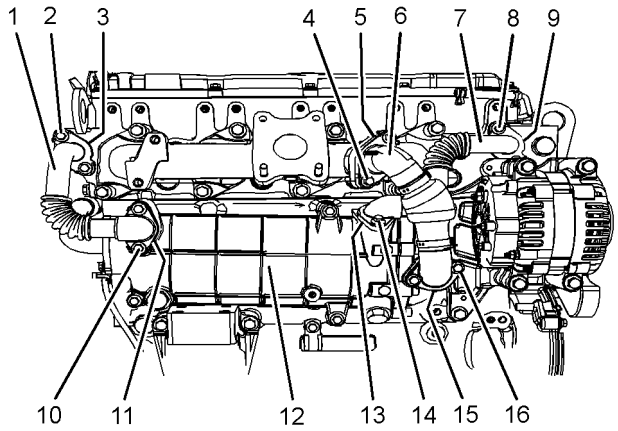

Illustration 59 g02477077

11. Position a new gasket (3) (not shown) and a new gasket (11) (not shown) onto tube assembly (1).

12. Install tube assembly (1) to exhaust cooler (12) and the cylinder head.

13. Install bolts (2) and bolts (10) to tube assembly (1).

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

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

15. Position a new gasket (9) (not shown) and install a new O-ring seal (13) (not shown) onto tube assembly (7).

Note: Do not lubricate the O-ring seal.

16. Position tube assembly (7) onto exhaust cooler (12) and the cylinder head. Install bolts (8) and bolt (14) to tube assembly (7). Ensure that the tube assembly is correctly positioned into the exhaust cooler.

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

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

18. Position a new gasket (5) (not shown) and a new gasket (15) (not shown) onto tube assembly (6).

19. Position tube assembly (6) onto exhaust cooler (12) and the exhaust manifold.

20. Install new bolts (4) and new bolts (16) to tube assembly (6).

21. Tighten bolts (4) and bolts (16) to a torque of 22 N·m (195 lb in).

22. 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 first stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (First Stage Turbocharger) - Install” for the correct procedure.

b. Install the second stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Second Stage Turbocharger) - Install” for the correct procedure.

i04485887

Inlet Air Control - Remove (NRS Induction 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.

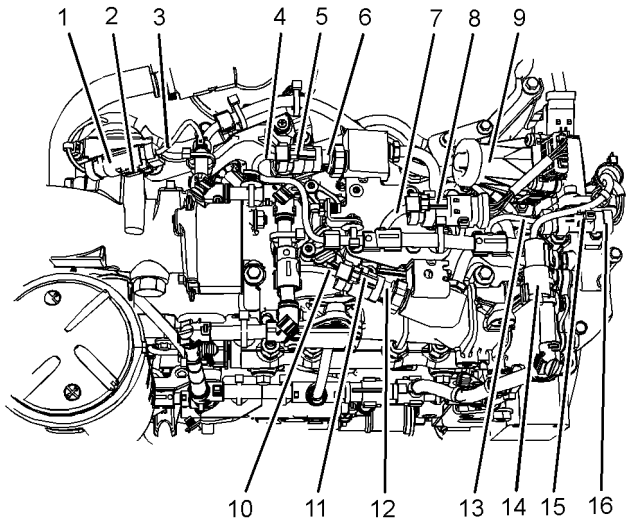

Illustration 60 g02503476

1. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, removal of the DPF assembly will be necessary in order to access the NRS induction mixer. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Remove” for the correct procedure.
2. If necessary, remove secondary fuel filter base and bracket. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
3. If necessary, remove water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
4. Slide locking tab (2) into the unlocked position. Disconnect wiring harness assembly (3) from wiring harness assembly (3) for the wastegate solenoid.
5. Slide locking tab (5) into the unlocked position. Disconnect wiring harness assembly (4) from outlet pressure sensor (6).
6. Slide locking tab (11) into the unlocked position. Disconnect wiring harness assembly (10) from inlet pressure sensor (12).
7. Slide locking tab (15) into the unlocked position. Disconnect harness assembly (13) from temperature sensor (16) for the NRS induction mixer. Cut cable the straps from temperature sensor (16) and position the temperature sensor away from the NRS induction mixer.
8. Slide locking tab (8) into the unlocked position. Disconnect harness assembly (7) from NRS valve (9).
9. If necessary, disconnect harness assembly (14) for the glow plug.
10. Make temporary marks on engine wiring harness to show location of all cable straps that retain the engine wiring harness. Cut all cable straps that retain the engine wiring harness, ensure that all cable straps are removed.

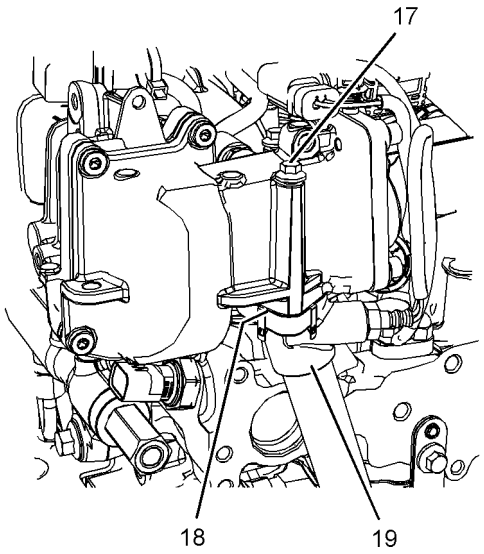

Illustration 61 g02503497

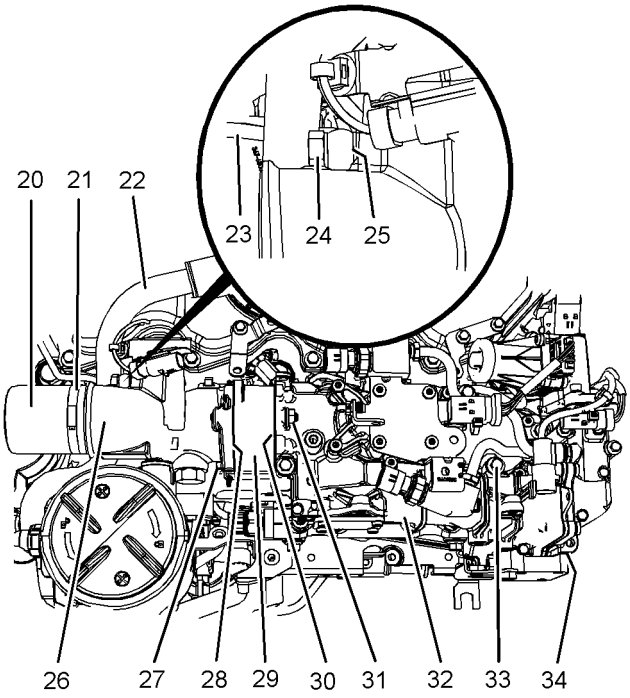

Illustration 62 g02503496

11. Remove bolt (17) from tube assembly (18).

12. Loosen hose clamp (21) on hose assembly (20). Remove hose assembly (20) from the connection of inlet connection (26).

13. Disconnect plastic tube assembly (22) from the valve mechanism cover and the crankcase breather canister. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

14. Remove bolt from tube assembly (23). Remove banjo bolt (24) and remove sealing washers (25) (not shown).

15. Remove bolts (27) and nut (31) from inlet connection (26).

16. Remove inlet connection (26) and spacer (29). Remove gasket (28) (not shown) and gasket (30) (not shown).

17. Remove bolts (33). Remove the assembly of NRS induction mixer (32) from the cylinder head.

18. Remove gasket (18) from tube assembly (19).

19. Remove gasket (34) (not shown) from assembly of NRS induction mixer (32).

i04485886

Inlet Air Control - Install (NRS Induction Mixer)

Installation Procedure

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

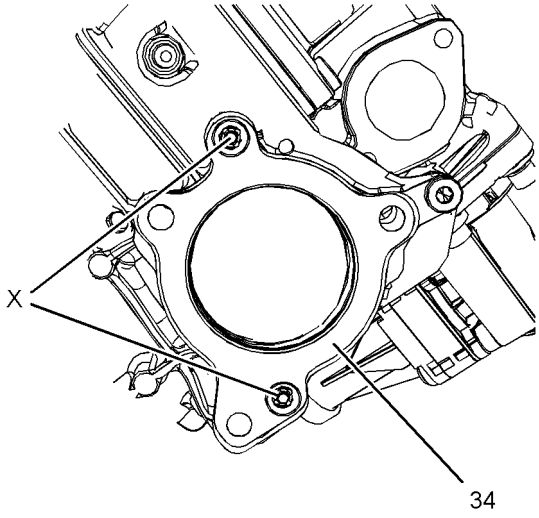

Illustration 63 g02509136

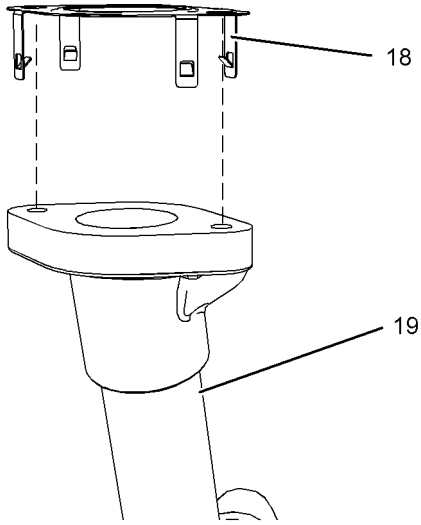

Illustration 64 g02509196

2. Position a new gasket (34) onto locating Pins (X). Ensure that the gasket is correctly orientated onto the NRS induction mixer.

3. Position a new gasket (18) onto tube assembly (19).

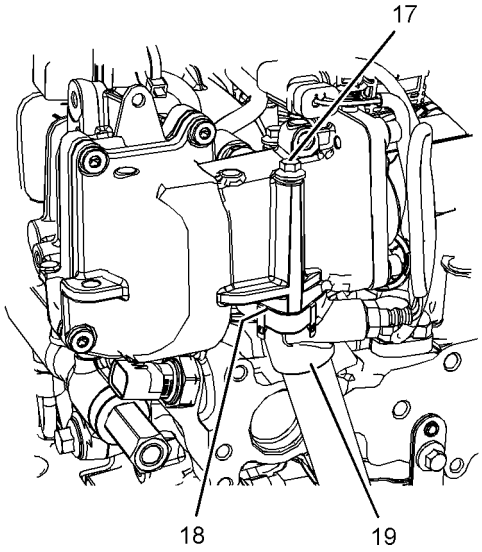

Illustration 65 g02503497

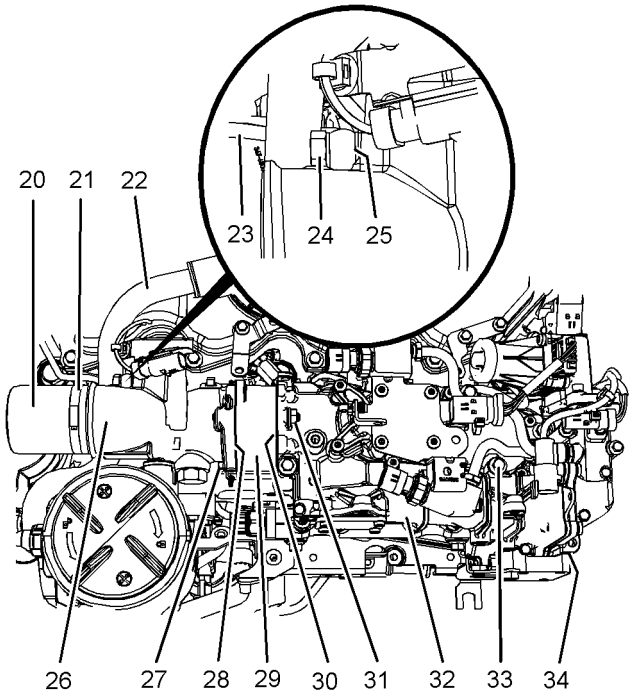

Illustration 66 g02503496

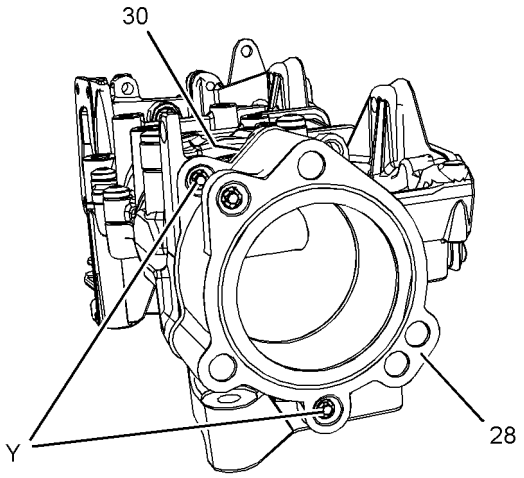

Illustration 67 g02614076

4. Position the assembly of NRS induction mixer (32) onto the cylinder head.

5. Loosely install bolts (33) to the assembly of NRS induction mixer (32).

6. Loosely install bolts (17) to tube assembly (18). Ensure that gasket (18) is still correctly located on tube assembly (18).

7. Tighten bolts (33) to a torque of 22 N·m (195 lb in).

8. Tighten bolts (17) to a torque of 9 N·m (80 lb in).

9. Position a new gasket (30) onto NRS induction mixer ensure that the gasket is correctly located onto Pins (Y).

10. Position a new gasket (28) onto the spacer ensure that the gasket is correctly located onto Pins (Y).

11. Position spacer (29) onto inlet connection (26).

Note: Ensure that the spacer is correctly orientated.

12. Install assembly of inlet connection (26). Install bolts (27) and nut (31).

Note: Ensure that the inlet connection is correctly orientated.

13. Tighten bolts (27) and nut (31) to a torque of 22 N·m (195 lb in).

14. Position a new sealing washer (25) (not shown) onto banjo bolt (24). Install the banjo bolt onto tube assembly (23) and install the remaining new sealing washer (25) (not shown).

15. Tighten banjo bolt (24) to a torque of 15 N·m (133 lb in).

16. Install the bolt for tube assembly (23). Tighten bolts to a torque of 22 N·m (195 lb in).

17. Position hose assembly (20) onto the inlet connection (26). Tighten hose clamp (21) securely.

18. Connect plastic tube assembly (22) to the valve mechanism cover and the crankcase breather canister. Refer to Disassembly and Assembly, “Crankcase Breather - Install” for the correct procedure.

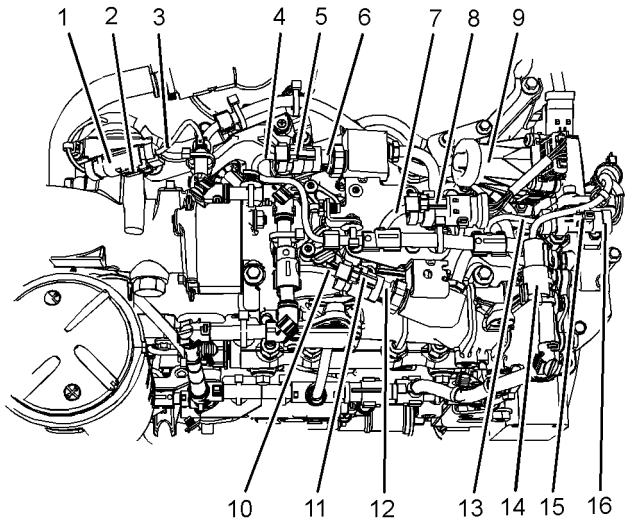

Illustration 68 g02503476

19. If necessary, connect harness assembly (14) for the glow plug.

20. Position engine harness assembly onto NRS induction mixer. Ensure that the engine harness assembly is correctly routed.

21. Connect harness assembly (13) to temperature sensor (16) for the NRS induction mixer. Slide locking tab (15) into the locked position.

22. Install new cable the straps to temperature sensor (16).

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

23. Connect wiring harness assembly (10) to inlet pressure sensor (12). Slide locking tab (11) into the locked position.

24. Connect wiring harness assembly (4) to outlet pressure sensor (6). Slide locking tab (5) into the locked position.

25. Connect wiring harness assembly (3) to wiring harness assembly (1) for the wastegate solenoid. Slide locking tab (2) into the locked position.

26. Connect harness assembly (7) to NRS valve (9). Slide locking tab (8) into the locked position.

27. Install new cable straps to the engine wiring harness. Ensure that the engine wiring harness is correctly routed and that all cable straps are correctly positioned.

Note: Ensure that the cable straps meet OEM specifications.

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

29. If necessary, install water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

30. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, installation of the DPF assembly will be necessary after the NRS induction mixer has been installed. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Install” for the correct procedure.

i04485869

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	Timing Pin (Fuel Injection Pump)	1
D	T410437	Cap 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. Remove crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - 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.

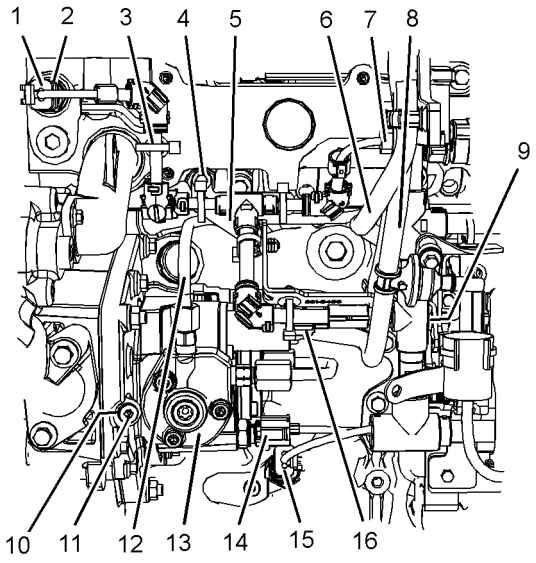

Illustration 69 g02482036

3. Remove plug (11) and remove O-ring seal (10) (not shown).

4. Install Tooling (C) to fuel injection pump (13).

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

6. Use Tooling (B) in order to ensure that the crankshaft is locked with number one piston at top dead center.

7. Cut cable strap (3) from harness assembly (1).

8. Disconnected harness assembly (1) from coolant temperature sensor (2). Refer to Disassembly and Assembly, “Coolant Temperature Sensor - Remove and Install” for the correct procedure.

9. Disconnected harness assembly (7) from the pressure sensor in the fuel manifold.

10. Disconnected harness assembly (16) from the flow control valve.

11. Disconnected harness assembly (14) from the fuel temperature sensor.

12. Disconnected harness assembly (15) from the engine oil pressure sensor. Refer to Disassembly and Assembly, “Engine Oil Pressure Sensor - Remove and Install” for the correct procedure.

13. Remove bolt (4) and bolt (9) (not shown) from bracket (5). Remove the bracket and position away from the fuel injection pump.

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

14. Clean fuel injection pump (13) and the area around the fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.

15. Place a suitable container below fuel injection pump (13) in order to catch any fuel that might be spilled.

16. Disconnect plastic tube assembly (6) and plastic tube assembly (8) from fuel injection pump (13). Use Tooling (D) in order to plug the plastic tube assemblies. Cap the connections for plastic tube assemblies on the fuel injection pump.

17. Remove fuel injection line (12) that connects fuel injection pump (13) to the fuel manifold. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove” for the correct procedure.

18. Use Tooling (D) in order to plug the open ports in the fuel injection pump and in the fuel manifold. **Discard the fuel injection line.**

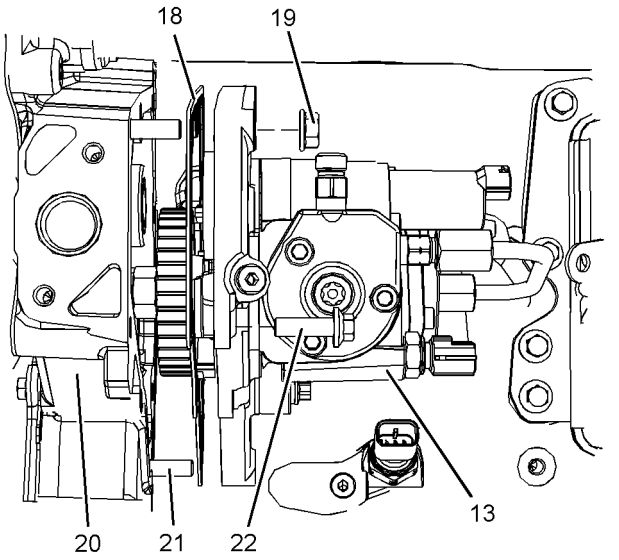

Illustration 70 g02482038

19. Remove nuts (19) and bolts (22) from fuel injection pump (13). Note position of the different length bolts.

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

20. Carefully remove fuel injection pump (13) from front housing (20). Ensure that the bore in front housing (20) is not damaged as the fuel injection pump is removed.

21. Remove gasket (18).

22. If necessary, remove studs (21) from front housing (20).

i04485867

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	Timing Pin (Fuel Injection Pump)	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.

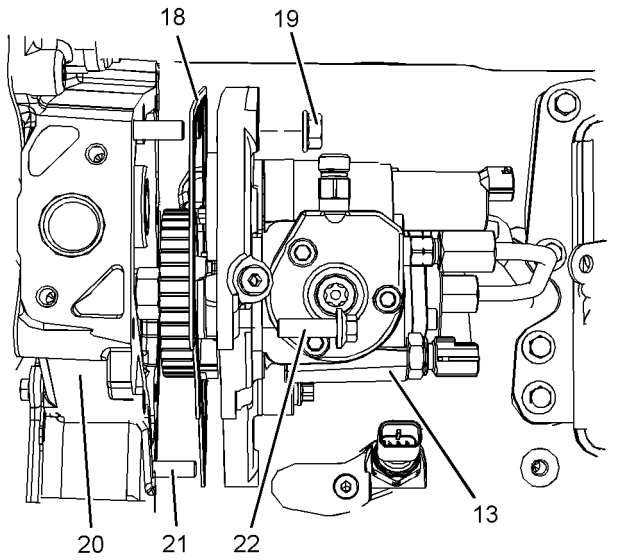

Illustration 71 g02482038

1. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.
2. Use Tooling (B) in order to lock the crankshaft so that number one piston is at top dead center.
3. Use Tooling (C) in order to lock fuel injection pump (13) in the correct position. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.
4. If necessary, install studs (21) from front housing (20). Tighten the studs to a torque of 11 N·m (97 lb in).
5. Position a new gasket (18) onto front housing (20).
6. Carefully install fuel injection pump (13) to front housing (20). Ensure that front housing (20) is not damaged as the fuel injection pump is installed.

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

7. Install nuts (19) to fuel injection pump (13) finger tight.
8. Install new bolts (22) to fuel injection pump (13). Ensure that the different length bolts are installed in to the correct position.
9. Tighten bolts (22) to a torque of 22 N·m (195 lb in).

   Tighten nut (19) to a torque of 22 N·m (195 lb in).

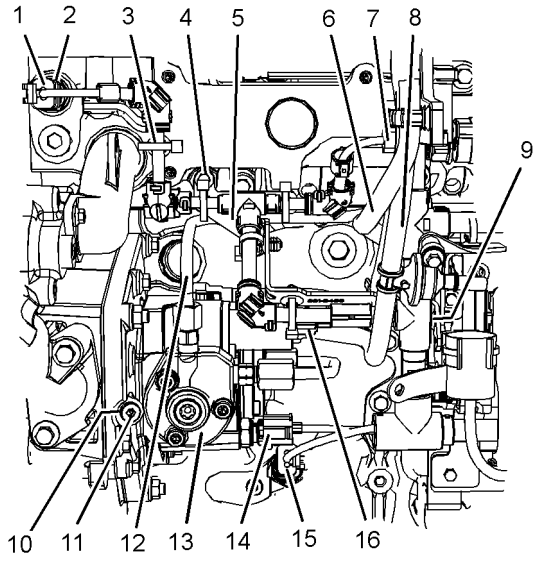

Illustration 72 g02482036

10. Remove Tooling (C) from fuel injection pump (9). Install a new O-ring seal (7) (not shown) to plug (8).

11. Install plug (8) to fuel injection pump (9). Tighten the plug to a torque of 14 N·m (124 lb in).

12. Remove the appropriate caps in order to install fuel injection line (1). Install a new fuel injection line (1) to the fuel injection pump and to the fuel manifold. Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

13. Position harness assembly (1) and bracket (5) onto the cylinder head. Loosely install bolt (4) and bolt (9) (not shown) to bracket (5).

14. Connected harness assembly (1) to coolant temperature sensor (2). Refer to Disassembly and Assembly, “Coolant Temperature Sensor - Remove and Install” for the correct procedure.

15. Install a new cable strap (3) to harness assembly (1).

Note: Ensure that the new cable strap meets Original Equipment Manufactures (OEM) specifications.

16. Connected harness assembly (7) to the pressure sensor in the fuel manifold.

17. Connected harness assembly (16) to the flow control valve.

18. Connected harness assembly (14) to the fuel temperature sensor. Refer to Disassembly and Assembly, “Fuel Temperature Sensor - Remove and Install” for the correct procedure.

19. Connected harness assembly (15) to the engine oil pressure sensor. Refer to Disassembly and Assembly, “Engine Oil Pressure Sensor - Remove and Install” for the correct procedure.

20. Tighten bolt (4) and bolt (9) (not shown) to a torque of 9 N·m (80 lb in).

21. Remove caps from connections for the plastic tube assemblies on fuel injection pump (13). Remove plugs from plastic tube assembly (6) and plastic tube assembly (8).

22. Connect plastic tube assembly (6) and plastic tube assembly (8) to fuel injection pump (13).

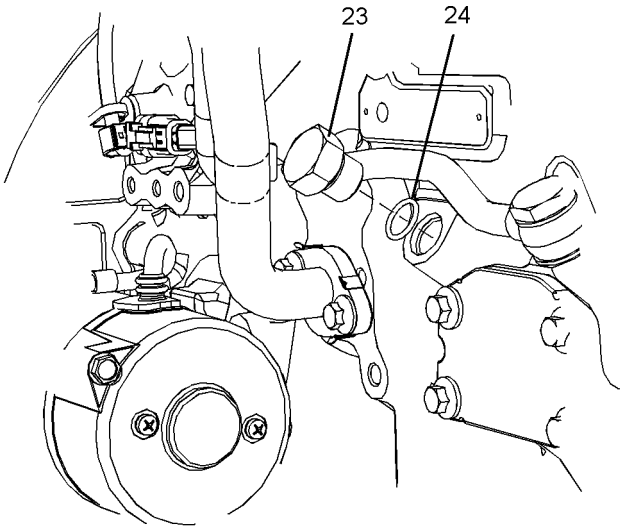

Illustration 73 g02612176

23. Remove Tooling (B) from the cylinder block.

24. Install a new O-ring seal (24) to plug (23). Install the plug into the cylinder block. Tighten plug (23) to a torque of 21 N·m (186 lb in).

25. Turn the fuel supply to the ON position.

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

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

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

29. After replacement of the fuel injection pump, the fuel injection pump must be calibrated. Use the electronic service tool to perform “High Pressure Fuel Pump Calibration”.

i04485871

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 12

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Puller (Two Leg)	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.

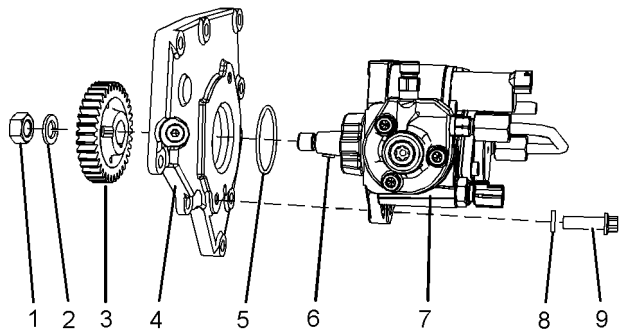

Illustration 74 g02483636

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. Remove bolts (9) and washers (8). Remove adapter plate (4) from fuel injection pump (7).

6. Remove O-ring seal (5).

i04485870

Fuel Injection Pump Gear - Install

Installation Procedure

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 of damage.

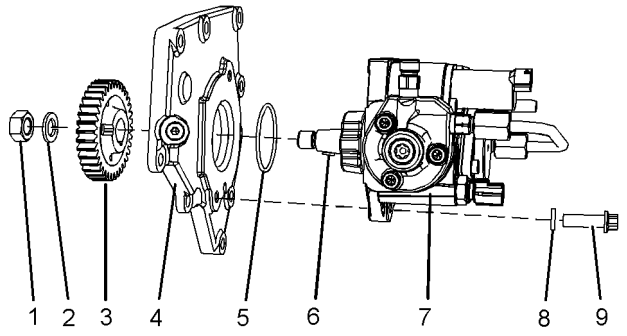

Illustration 75 g02483636

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 bolts (9) and washer (8). Tighten the bolts to a torque of 22 N·m (195 lb in).

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

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

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

8. 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.

9. 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.

i04485833

Electronic Unit Injector - Remove

Removal Procedure

Table 13

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

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

⚠ WARNING

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

NOTICE

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

Before 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: Put identification marks on all hoses, on all hose assemblies, on wires and on all tube assemblies for installation purposes. Plug all hose assemblies and tube assemblies. That helps to prevent fluid loss and this 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.

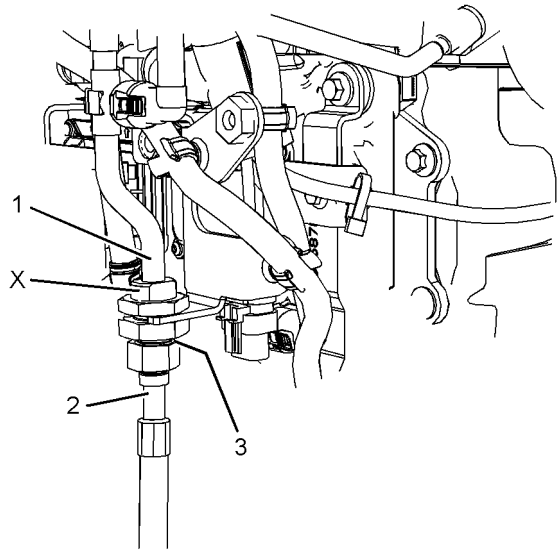

Illustration 76 g02475251

3. Place a suitable container below tube assembly (1) in order to catch any fuel that might be spilled.
4. Use a suitable tool in Position (X) in order to hold tube assembly (1) as nut on hose assembly(2) is loosened.
5. Loosen the nut on hose assembly (2) in order to allow the fuel to drain from tube assembly (1).
6. Remove hose assembly (2) from tube assembly (1). Remove O-ring seal (3) (not shown).
7. Use Tooling (C) in order to cap the hose assembly immediately. Use Tooling (C) in order to plug the tube assembly immediately.

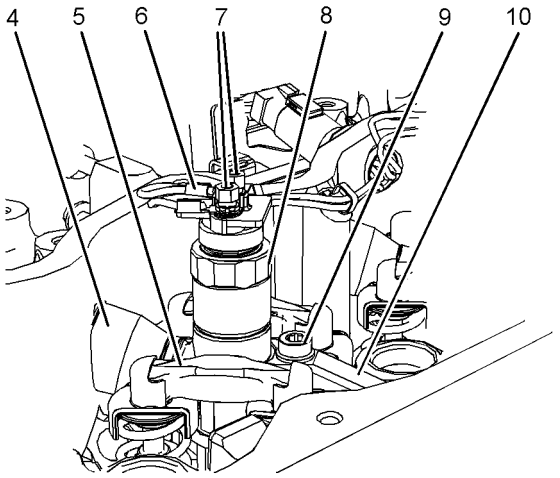

Illustration 77 g01971773

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

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

9. Remove seal (4) from the cylinder head and electronic unit injector (8).
10. Make a temporary mark on wiring harness assembly (6) in order to show the location and orientation.
11. Use a deep socket to remove connections (7) from electronic unit injector (8).
12. Use Tooling (A) in order to remove Torx screw (9) from clamp (10). Discard the Torx screw.

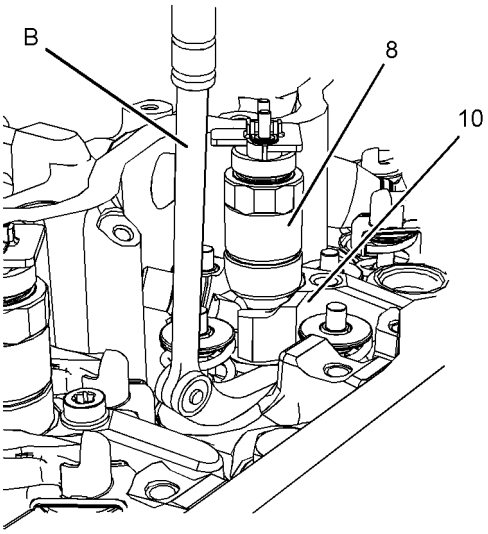

Illustration 78 g01971775

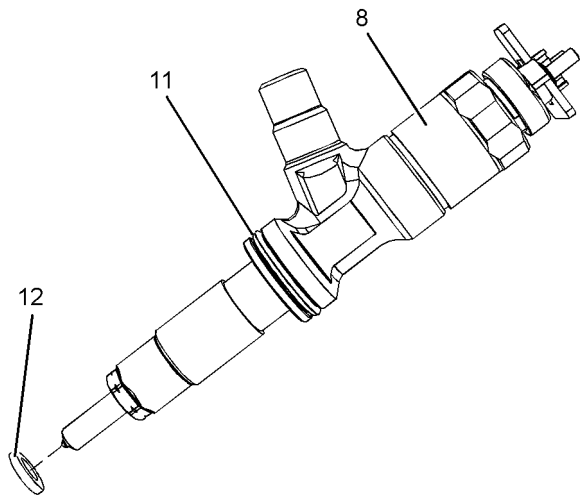

Illustration 79 g01972153

13. 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.

14. 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.

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

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

17. If necessary, repeat Step 8 through Step 16 in order to remove the remaining electronic unit injector.

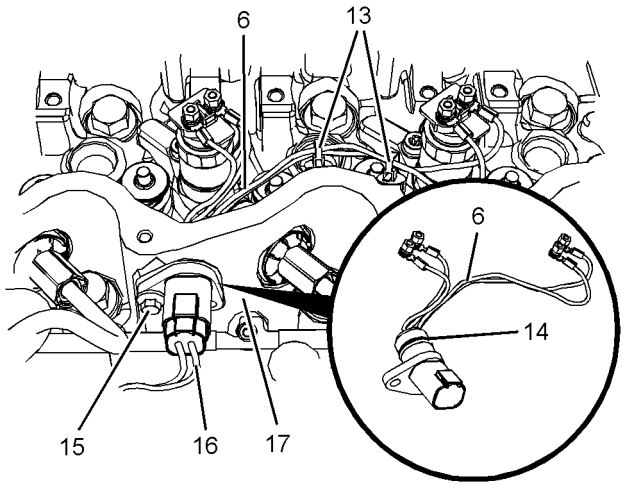

Illustration 80 g02047333

18. If necessary, follow Steps 18.a through 18.f in order to remove harness assemblies (6) from cylinder head (17).

a. Place a temporary identification mark on harness assembly (6) for the electronic unit injectors.

b. Cut cable straps (13) and remove the remaining sections of the cable straps from the cylinder head.

c. Disconnect harness assembly (16) from harness assembly (6).

d. Remove bolt (15) for harness assembly (6).

e. Withdraw harness assembly (6) from cylinder head (17).

f. Remove O-ring seal (14) from harness assembly (6).

g. If necessary, repeat Step 18.a through Step 18.f in order to remove the remaining harness assemblies from the cylinder head.

i04485832

Electronic Unit Injector - Install

Installation Procedure

Table 14

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

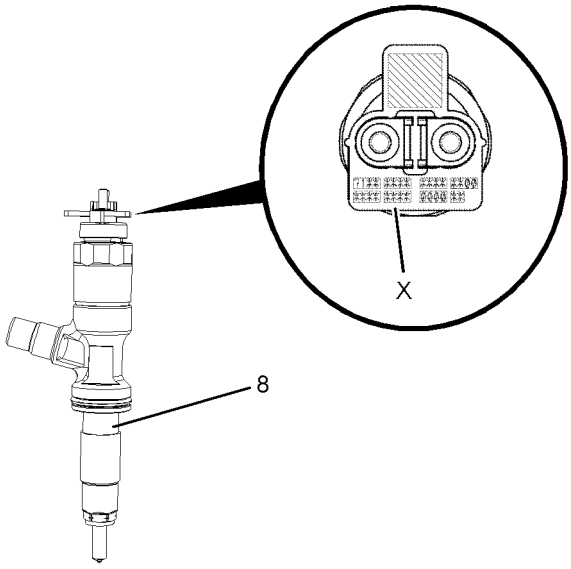

Illustration 81 g01973053

Injector code

1. 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 the correct procedure. The code that is required to obtain the injector code is located at Position (X).

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

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

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

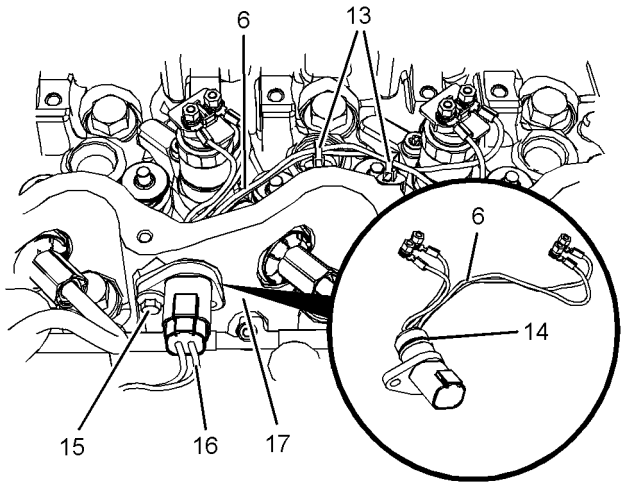

Illustration 82 g02047333

3. If necessary, follow Step 3.a through Step 3.e in order to install harness assemblies (6) to cylinder head (17).

   a. Install a new O-ring seal (14) to harness assembly (6).

Note: Do not lubricate the O-ring seal.

   b. Install harness assembly (6) to cylinder head (17).

   c. Install a new bolt (15) to harness assembly (6). Tighten the bolt to a torque of 5.5 N·m (49 lb in).

   d. Install new assemblies of the cable strap (13) to harness assembly (6).

Note: Ensure that the cable straps meet the Original Equipment Manufactures (OEM) specification. Ensure that the assemblies of the cable strap are correctly installed into the cylinder head.

   e. Connect harness assembly (16) to harness assembly (6).

   f. If necessary, repeat Step 3.a through Step 3.f in order to install the remaining harness assemblies to the cylinder head.

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

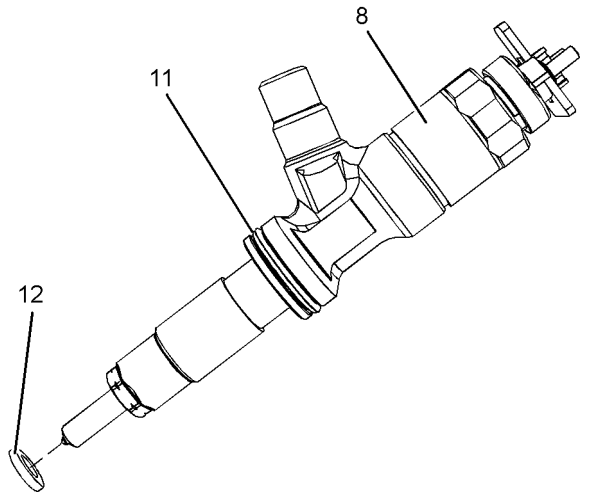

Illustration 83 g01972153

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

Note: Do not lubricate the O-ring seal.

6. 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.

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

Note: Do not lubricate the O-ring seal.

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

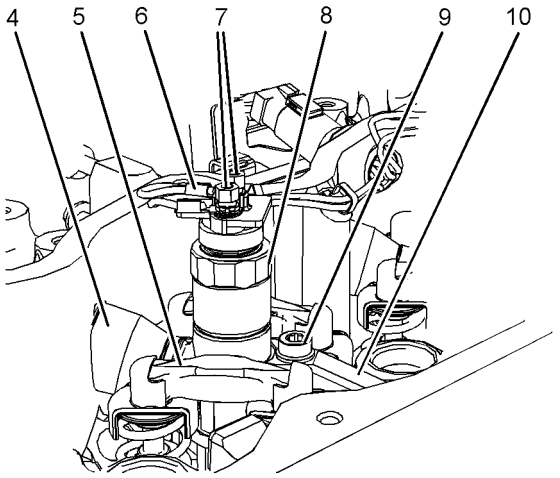

Illustration 84 g01971773

9. Position clamp (10) between the valve springs. Align electronic unit injector (8) to the bore for the electronic unit injector in the cylinder head. Install the clamp to the electronic unit injector. Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head.

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

11. 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.

12. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line. 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 in the electronic unit injector and the fuel manifold. Tighten the nuts finger tight.

13. Use Tooling (A) to tighten Torx screw (12) to a torque of 27 N·m (239 lb in).

14. Use Tooling (E) to tighten the fuel injection line to a torque of 40 N·m (30 lb ft). Refer to Disassembly and Assembly, “Fuel Injection Lines - Install” for the correct procedure.

15. 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).

16. If necessary, repeat Step 1 through Step 15 in order to install the remaining electronic unit injector.

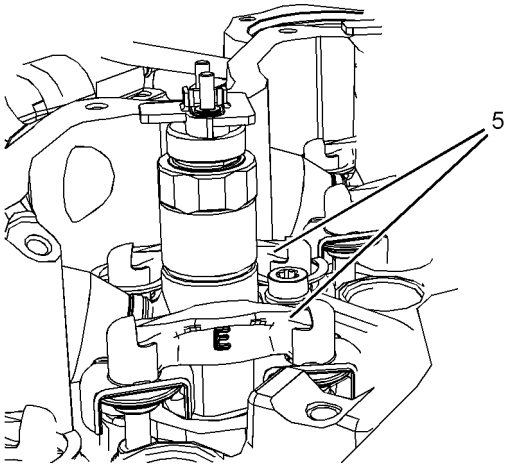

Illustration 85 g01973093

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.

17. 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.

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

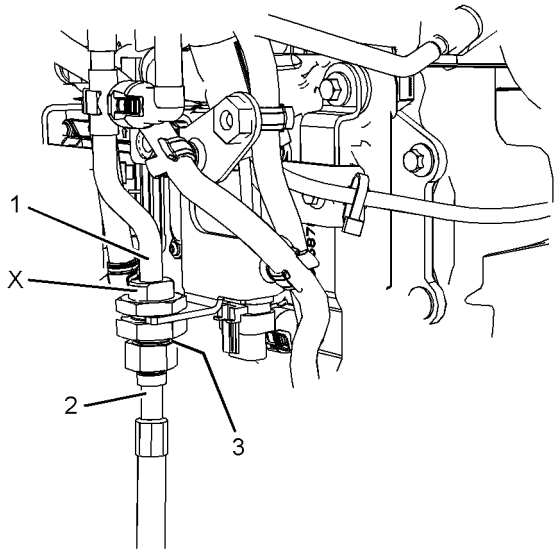

Illustration 86 g02475251

19. Remove cap from tube assembly (1). Install a new O-ring seal (3) (not shown) to tube assembly (1).

20. Remove cap from hose assembly (2). Install hose assembly (2) to tube assembly (1).

21. Use a suitable tool in order to hold tube assembly (1) in Position (X). Tighten nut for hose assembly(2) to a torque of 43 N·m (32 lb ft).

22. Turn the fuel supply to the ON position.

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

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

i04485906

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.

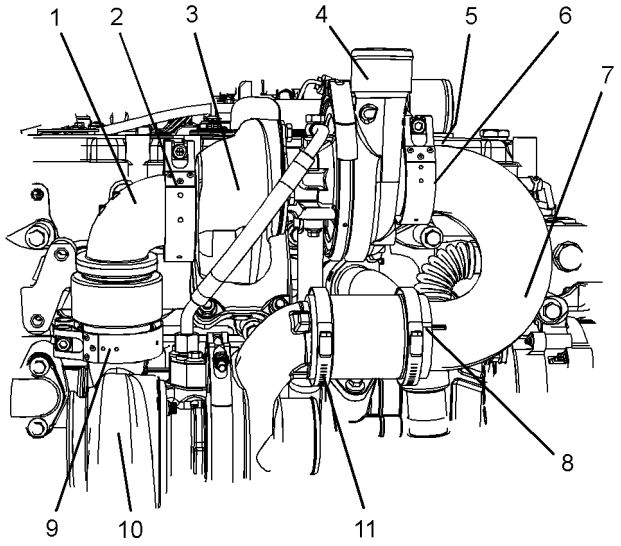

Illustration 87 g02526997

1. Loosen the hose clamp and disconnect hose assembly from air outlet (4) from turbocharger (3).

2. Slide hose clamp along hose assembly (5). Disconnect hose assembly (5) from the wastegate actuator.

3. Loosen the allen head bolt on V-band clamp (2) and loosen the allen head bolt on V-band clamp (9) from elbow (1). Remove the V-band clamps from the elbow.

Note: If the V-band clamps remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the allen head 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.**

4. Remove elbow (1) from turbocharger (3) and turbocharger (10).

5. Loosen allen head bolt on V-band clamp (6) on air duct (7) and loosen hose clamps (11).

Note: If the V-band clamp remains tight on the flange, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the allen head 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.**

6. Remove hose assembly (8) and air duct (7) from the outlet of turbocharger (10) and turbocharger (3).

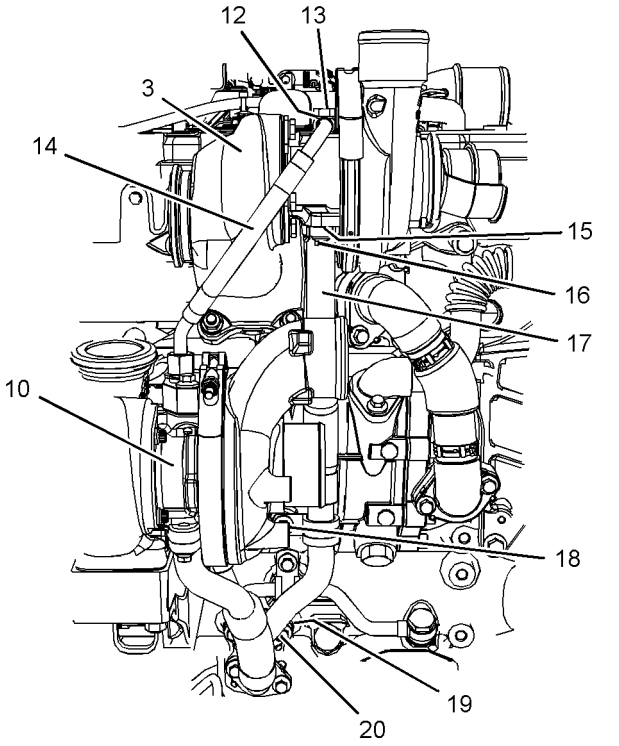

Illustration 88 g02526998

7. Remove banjo bolt (13) from hose assembly (14).

8. Remove sealing washers (12) (not shown).

9. Disconnect hose assembly (14) from the connection on turbocharger (10). Plug and cap the turbocharger. Plug and cap the hose assembly.

10. Remove hose assembly (14).

11. Remove bolt (18) from the clip for tube assembly (17).

12. Remove bolts (16) and bolts (20) from tube assembly (17).

13. Remove tube assembly (17) from turbocharger (3) and the cylinder block.

14. Remove gasket (15) (not shown) and gasket (19) (not shown) from tube assembly (17).

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

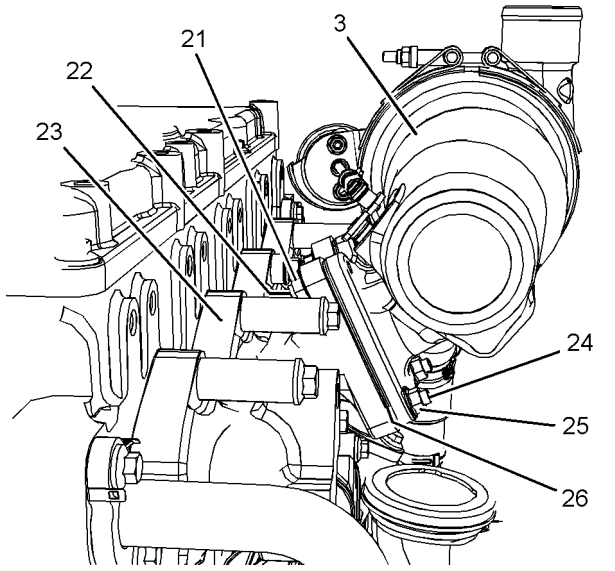

Illustration 89 g02526999

15. Remove nuts (21) and nuts (25) from turbocharger (3).

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

16. Remove turbocharger (3) from exhaust manifold (23).

17. Remove gasket (26) (not shown).

18. If necessary, remove studs (22) (not shown) from turbocharger (3).

19. If necessary, remove studs (24) from exhaust manifold (23).

i04485911

Turbocharger - Remove (Top Mounted Turbocharger)

Removal Procedure

Start By:

a. Remove the exhaust elbow from the turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - 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: Plug and cap all open ports and tube assemblies.

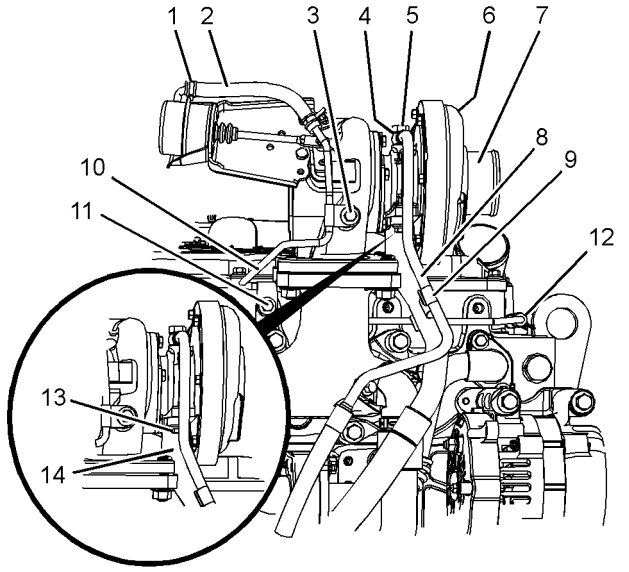

Illustration 90 g02568360

1. Loosen hose clamps and disconnect the hose assemblies from turbocharger inlet (7) and from turbocharger outlet (6) (not shown).

2. Remove banjo bolt (5) from tube assembly (8). Remove sealing washers (4) (not shown).

3. Remove clip (9) from tube assembly (8) and tube assembly (14).

4. Slide hose clamp (1) along hose assembly (2). Disconnect hose assembly (2) from the wastegate actuator.

5. Remove bolt (3) and bolt (11) for tube assembly (10).

6. Slide hose clamp (12) along the hose assembly. Remove tube assembly (10).

7. Remove bolts (13) tube assembly (14).

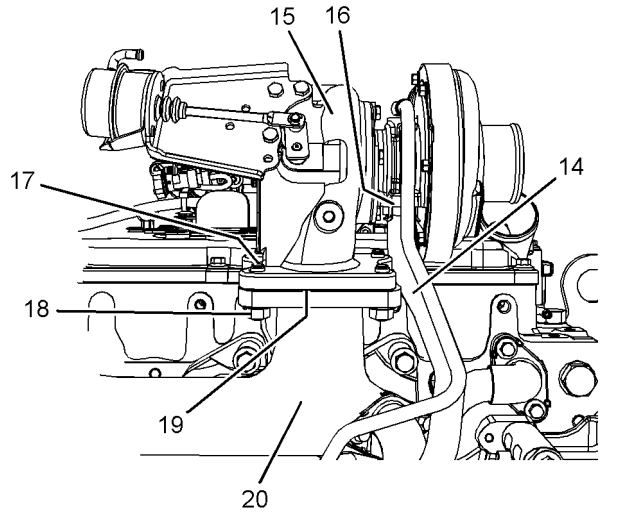

Illustration 91 g02568359

8. Remove nuts (18). Remove turbocharger (15) from exhaust manifold (20).

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

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

10. Remove gasket (16) (not shown) from tube assembly (14).

11. If necessary, remove the studs (17) (not shown) from turbocharger (15).

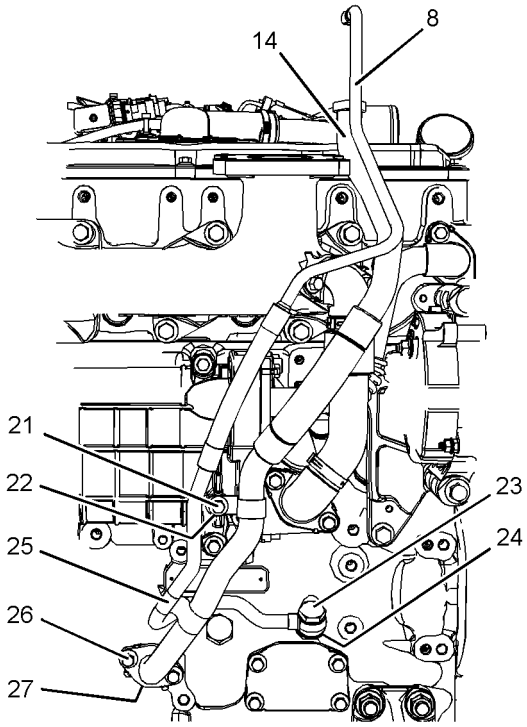

Illustration 92 g02570158

12. If necessary, follow Step 12.a through Step 12.f in order to remove tube assembly (8) and tube assembly (14).

a. Remove clip (25) from tube assembly (8) and tube assembly (14).

b. Remove banjo bolt (23) from tube assembly (8). Remove sealing washers (24) (not shown).

c. Remove bolts (21) and spacer (22) (not shown).

d. Remove tube assembly (8).

e. Remove bolts (26) and remove tube assembly (14).

f. Remove gasket (27) (not shown).

i04485910

Turbocharger - Remove (Side Mounted Turbochargers)

Removal Procedure

Start By:

a. Remove the exhaust elbow from the turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - 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.

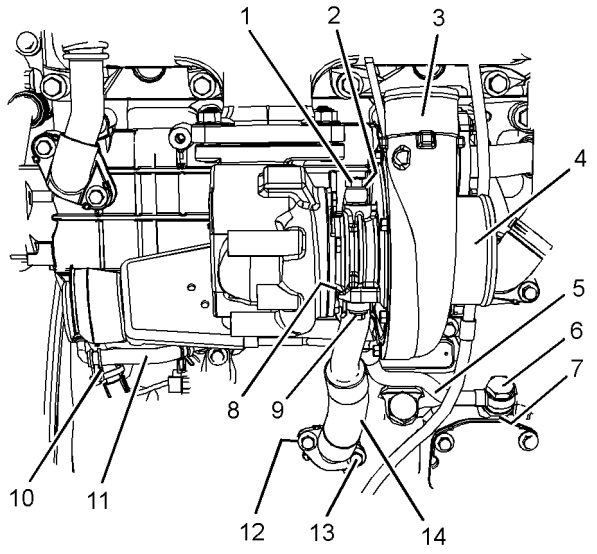

Illustration 93 g02530062

1. Loosen hose clamps and disconnect the hose assemblies from turbocharger inlet (4) and from turbocharger outlet (3).

2. Remove banjo bolt (1) from tube assembly (5). Remove sealing washers (2) (not shown).

3. Remove banjo bolt (6) from tube assembly (5). Remove sealing washers (7) (not shown).

4. Remove tube assembly (5) from the turbocharger and the cylinder block.

5. Slide hose clamp (10) along hose assembly (11). Disconnect hose assembly (6) from the wastegate actuator.

6. Remove bolts (13) and bolts (9). Remove tube assembly (14) from the turbocharger.

7. Remove gasket (8) (not shown) and gasket (12) (not shown).

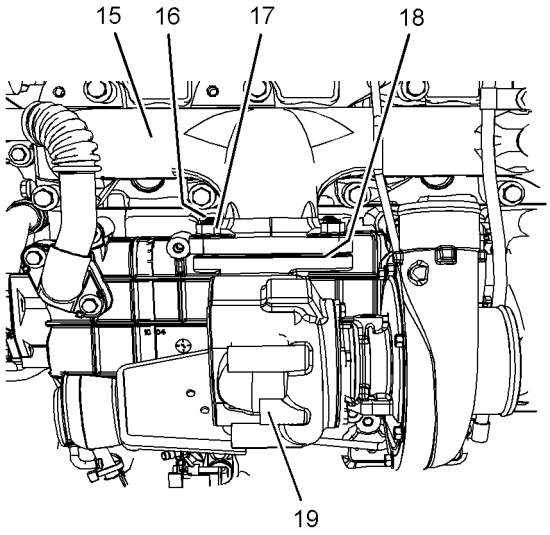

Illustration 94 g02530138

8. Remove nuts (17). Remove turbocharger (19) from exhaust manifold (15).

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

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

10. If necessary, remove the studs (16) (not shown) from turbocharger (19).

i04485908

Turbocharger - Remove (Second Stage Turbocharger)

Removal Procedure

Start By:

a. Remove the exhaust elbow from the second stage turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - 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: Plug and cap all open ports and tube assemblies.

1. Loosen the hose clamp and disconnect the air inlet hose from the turbocharger.

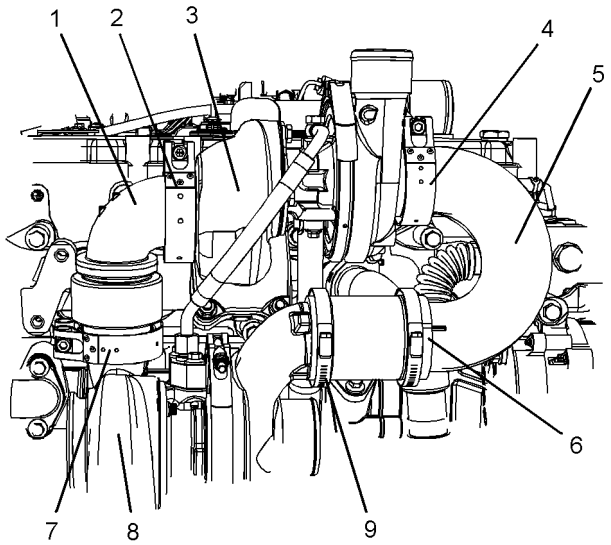

Illustration 95 g02529457

2. Loosen the bolt on V-band clamp (2) and loosen the bolt on V-band clamp (7) from elbow (1). Remove the V-band clamps from the elbow.

Note: If the V-band clamp (2) and V-band clamp (7) remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. 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 the elbow from turbocharger (3) and turbocharger (8).

4. Remove V-band clamp (4) from air duct (5) and loosen hose clamps (9). Remove hose assembly (6) and air duct (5) from the outlet of turbocharger (8) and turbocharger (3).

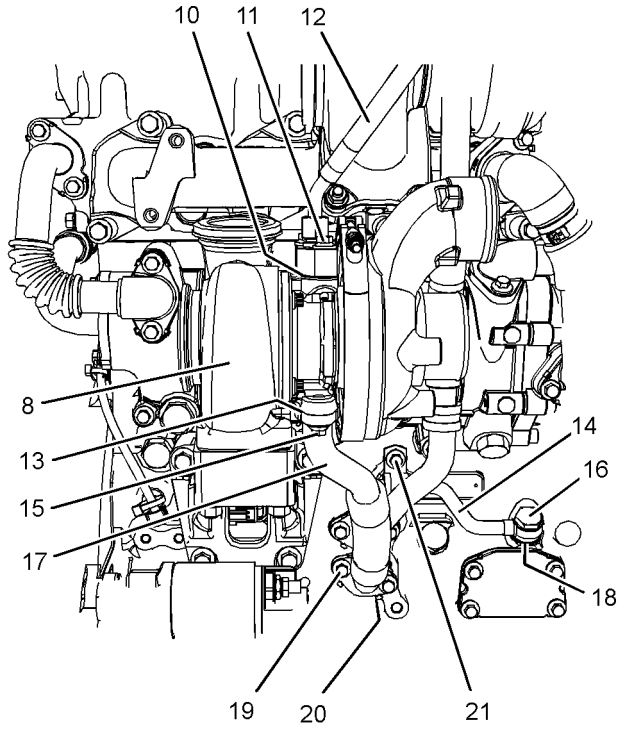

Illustration 96 g02529478

5. Disconnect hose assembly (12) from the connection on turbocharger (8). Plug the connection on the turbocharger. Cap the hose assembly.

6. Remove bolts (11) from tube assembly (14).

7. remove bolt (21) from clamp for tube assembly (14).

8. Remove banjo bolt (16). Remove sealing washers (18) (not shown).

9. Remove tube assembly (14) from turbocharger (8). Plug the tube assembly. Plug the turbocharger and the cylinder block.

10. Remove gasket (10) (not shown).

11. Remove bolts (15) and bolts (19) from tube assembly (17).

12. Remove tube assembly (17) from turbocharger (8).

13. Remove gasket (13) (not shown) and gasket (20) (not shown).

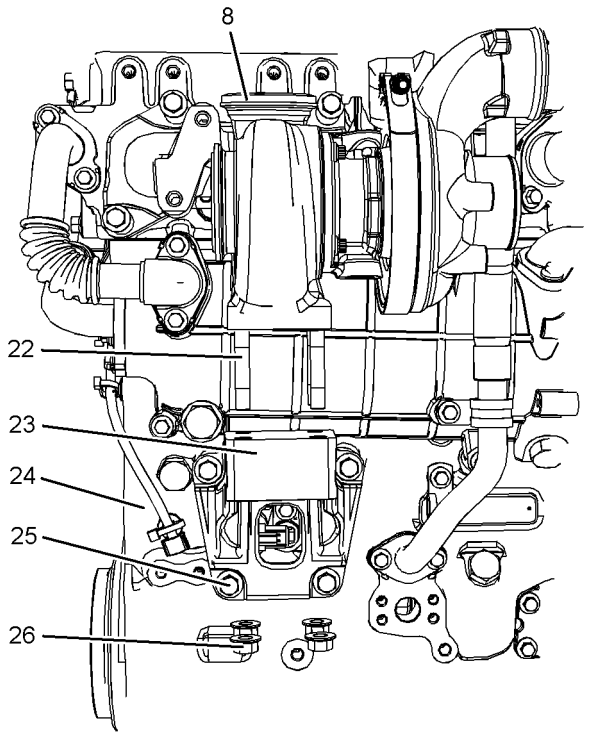

Illustration 97 g02529479

14. Remove nuts (26).

15. Remove turbocharger (8) from bracket (23).

16. If necessary, remove studs (22) from turbocharger (8).

17. If necessary, follow Step 17.a through Step 17.b in order to remove bracket (23) from cylinder block (24).

a. Remove bolts (25).

Note: Support the bracket as the bolts are removed.

b. Remove bracket (23) from cylinder block (24).

i04485905

Turbocharger - Install (First Stage Turbocharger)

Installation Procedure

Table 15

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.

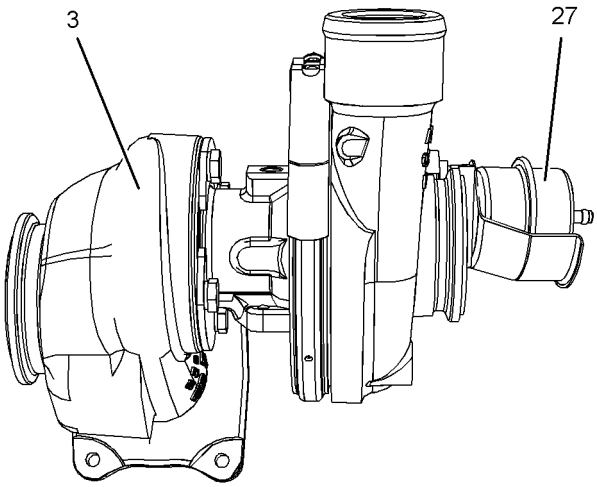

Illustration 98 g02527478

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 (27) 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.

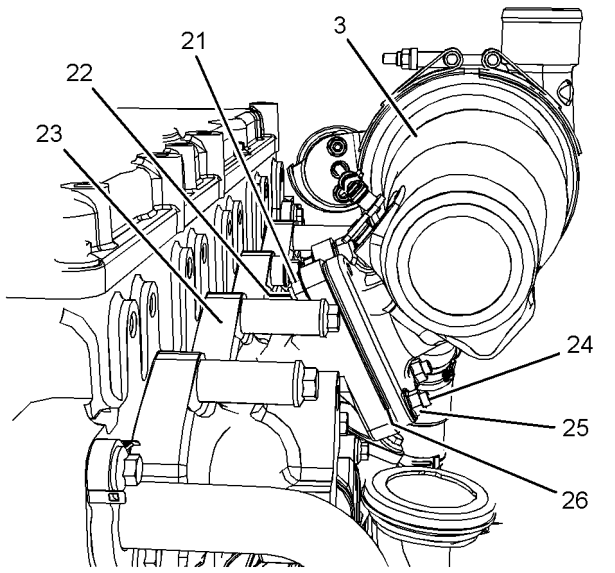

Illustration 99 g02526999

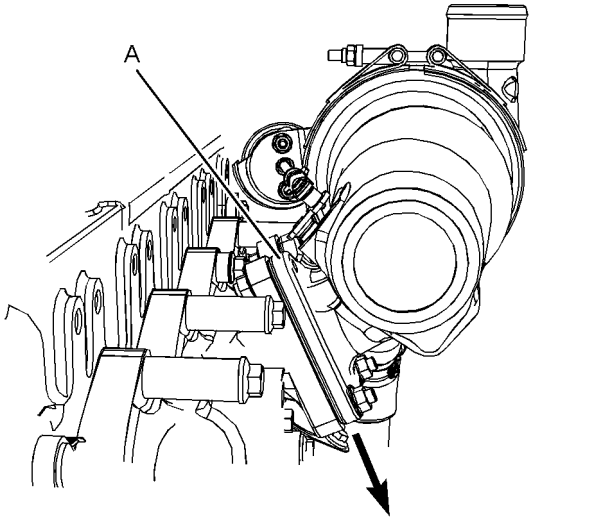

Illustration 100 g02614636

3. Clean the gasket surface of exhaust manifold (23).

4. If necessary, install studs (22) (not shown) to turbocharger (3). Tighten the studs to a torque of 18 N·m (160 lb in).

5. If necessary, install studs (24) to exhaust manifold (23). Tighten the studs to a torque of 18 N·m (160 lb in).

6. Install a new gasket (20) (not shown) onto exhaust manifold (23).

7. Position turbocharger (3) onto exhaust manifold (23). Install nuts (21) and nuts (25) finger tight.

8. Apply sufficient pressure in Position (A) to ensure that turbocharger (3) is at the lowest point on studs (22) (not shown) and studs (24). Do not release the pressure on the turbocharger in Position (A) until nuts (21) and nuts (25) have been tightened securely.

9. Tighten nuts (21) and nuts (25) to a torque of 22 N·m (195 lb in).

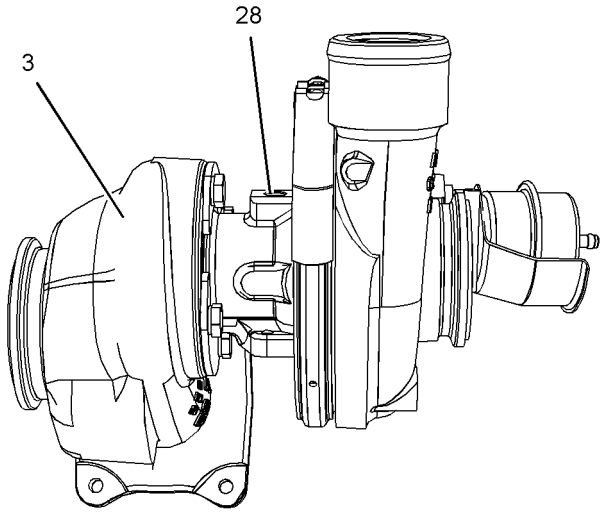

Illustration 101 g02527496

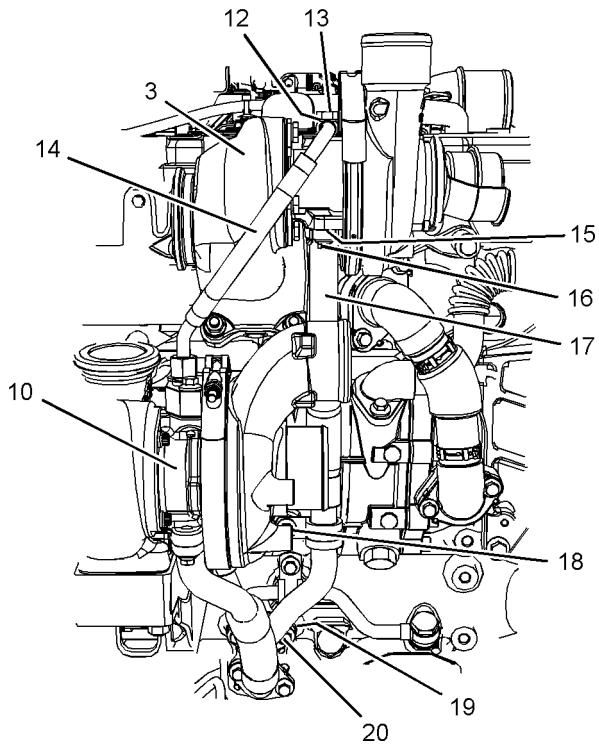

Illustration 102 g02526998

10. Remove plugs from tube assembly (17). Ensure that tube assembly (17) is clean and free from restriction. Replace any damaged components.

11. Position a new gasket (15) (not shown) and a new gasket (19) (not shown) onto tube assembly (17).

12. Remove plugs from turbocharger (3) and the cylinder block.

13. Position tube assembly (17) onto turbocharger (3) and the cylinder block.

14. Install bolts (16) and bolts (20).

15. Install bolt (18) to the clip for tube assembly (17).

16. Tighten bolts (20) to a torque of 22 N·m (195 lb in).

Tighten bolts (16) to a torque of 9 N·m (80 lb in).

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

17. Remove the plug from oil inlet port (28). 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.

18. Ensure that hose assembly (14) is clean and free from restriction. Replace any damaged components.

19. Remove cap from connection on turbocharger (10). Loosely connect hose assembly (14) to connection on turbocharger (10).

20. Position a new sealing washer (12) (not shown) onto banjo bolt (13).

21. Install banjo bolt (13) to hose assembly (14) and position the remaining new sealing washer (12) (not shown) onto banjo bolt (13).

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

Note: Ensure that the hose assembly does not come into contact with the turbine housing as the banjo bolt is tightened.

23. Tighten tube nut for hose assembly (14) on turbocharger (10) to a torque of 30 N·m (265 lb in).

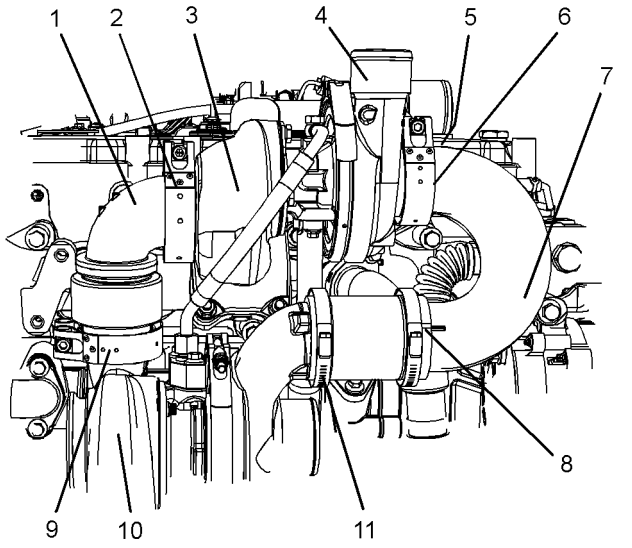

Illustration 103 g02526997

24. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (6). Position V-band clamp (6) onto air duct (7).

25. Position hose assembly (11) and air duct (7) onto the outlet of turbocharger (10) and turbocharger (3). Tighten the allen head bolt for V-band clamp to a torque of 12 N·m (106 lb in).

26. Tighten hose clamps (11) securely.

27. Ensure that elbow (1) is free from wear and damage. If necessary, replace the elbow.

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

29. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (9). Position V-band clamp (9) onto turbocharger (10).

30. Position elbow (1) onto turbocharger (3) and turbocharger (10).

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

32. Tighten the allen head bolt for V-band clamp (2) and the allen head bolt for V-band clamp (9) to a torque of 12 N·m (106 lb in).

33. Connect hose assembly (5) to the wastegate actuator. Slide hose clamp along hose assembly (5) ensure that hose clamp is correctly positioned.

34. Connect hose assembly to air outlet (4) to turbocharger (3). Tighten the hose clamps securely.

i04485912

Turbocharger - Install (Top Mounted Turbocharger)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

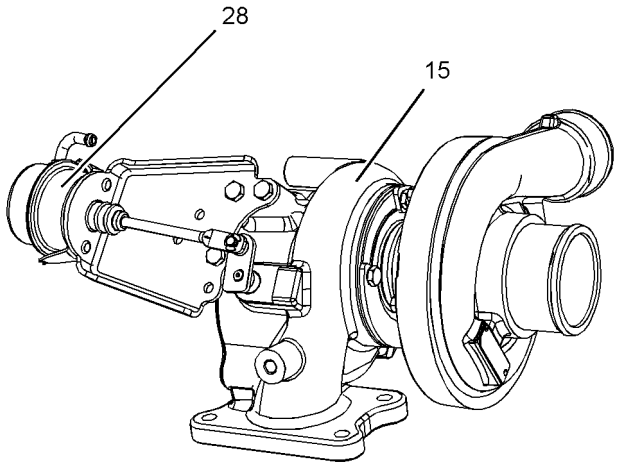

Illustration 104 g02570377

1. Ensure that turbocharger (15) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If the turbocharger is worn, the complete turbocharger must be replaced.

2. Test wastegate actuator (28) for correct operation. Refer to System Operation, Testing and Adjusting, “Turbocharger Inspect” for more information. If the wastegate actuator is damaged or the wastegate actuator does not operate within the specified limits, the complete turbocharger must be replaced.

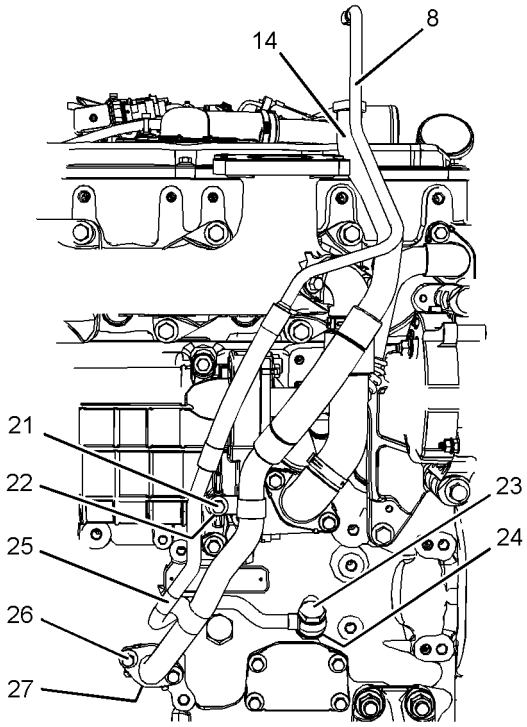

Illustration 105 g02570158

3. If necessary, follow Step 3.a through Step 3.i in order to install tube assembly (8) and tube assembly (14).

a. Ensure that tube assembly (8) and tube assembly (14) are clean and free from restriction. Clean the gasket surface of the cylinder block.

b. Position a new gasket (27) (not shown) onto tube assembly (14).

c. Position tube assembly (14) onto cylinder block. Install bolts (26) finger tight.

d. Install bolt (21) and spacer (22) (not shown) finger tight.

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

Tighten bolt (21) to a torque of 18 N·m (159 lb in).

f. Position a new sealing washer (24) (not shown) onto banjo bolt (23). Install banjo bolt (23) to tube assembly (8) and install remaining new sealing washer (24) (not shown) onto banjo bolt (23).

g. Position tube assembly (8) onto cylinder block. Tighten banjo bolt (23) finger tight.

h. Install clip (25) to tube assembly (8) and tube assembly (14).

Note: Ensure that the clip is correctly positioned onto tube assemblies.

i. Tighten banjo bolt (23) to a torque of 40 N·m (30 lb ft). Ensure tube assembly (8) is not strained as banjo bolts (23) is tightened.

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

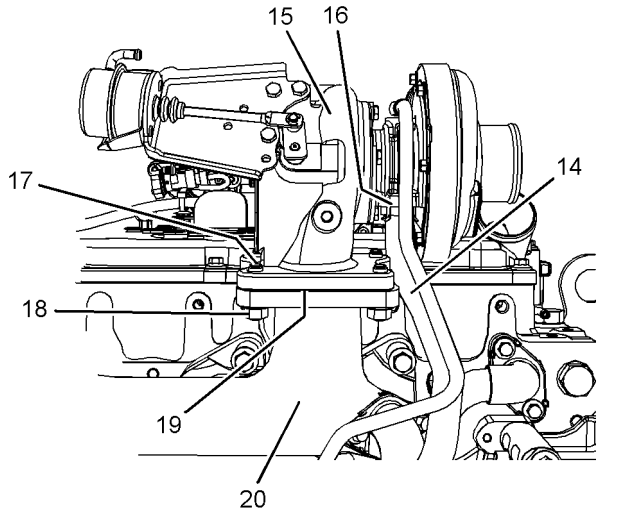

Illustration 106 g02568359

4. Clean the gasket surfaces of the exhaust manifold (20). If necessary, install studs (17) (not shown) to the turbocharger (15). Tighten the studs to a torque of 18 N·m (13 lb ft).

5. Position a new gasket (16) (not shown) onto tube assembly (14).

6. Position a new gasket (16) (not shown) onto exhaust manifold (20).

7. Position turbocharger (15) on exhaust manifold (20).

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

8. Install nuts (18). Tighten the nuts to a torque of 44 N·m (32 lb ft).

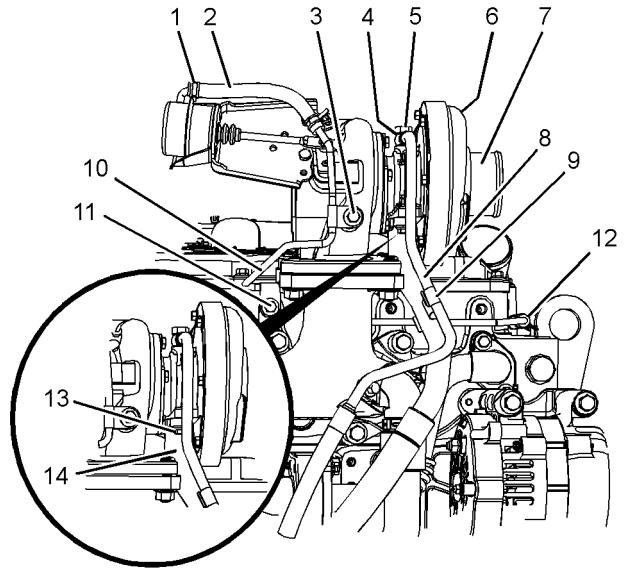

Illustration 107 g02568360

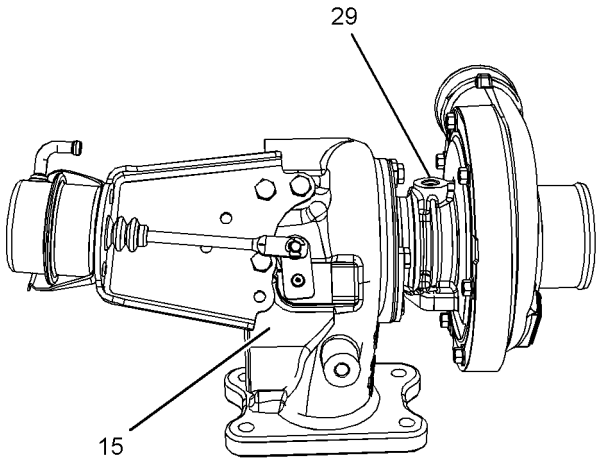

Illustration 108 g02572637

9. Install bolts (13) to tube assembly (14).

10. Tighten bolts (13) to a torque of 9 N·m (80 lb in).

11. Lubricate the bearings of turbocharger (15)with clean engine oil through oil inlet port (29). Rotate the shaft of the turbocharger in order to distribute the lubricant.

12. Position a new sealing washer (4) (not shown) onto banjo bolt (5). Install banjo bolt (5) onto tube assembly (8) and install remaining new sealing washer (4) (not shown) to banjo bolt (5).

13. Tighten banjo bolt (5) to a torque of 15 N·m (133 lb in).

14. Install clip (9) from tube assembly (8) and tube assembly (14).

15. Position tube assembly (10) onto turbocharger. Install bolt (3) and bolt (11) finger tight.

16. Connect hose assembly (2) to the wastegate actuator. Slide hose clamp (12) along the hose assembly.

Note: Ensure that hose clamp is correctly position onto the hose assembly.

17. Install the hose assembly to tube assembly (10). Slide hose clamp (12) along the hose assembly.

Note: Ensure that hose clamp is correctly position onto the hose assembly.

18. Tighten bolt (3) and bolt (11) to a torque of 22 N·m (195 lb in).

19. Connect the hose assemblies to turbocharger inlet (7) and to turbocharger outlet (6) (not shown). Tighten hose clamps securely

End By:

a. Install the exhaust elbow from the turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - Remove and Install” for the correct procedure.

i04485909

Turbocharger - Install (Side Mounted Turbochargers)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

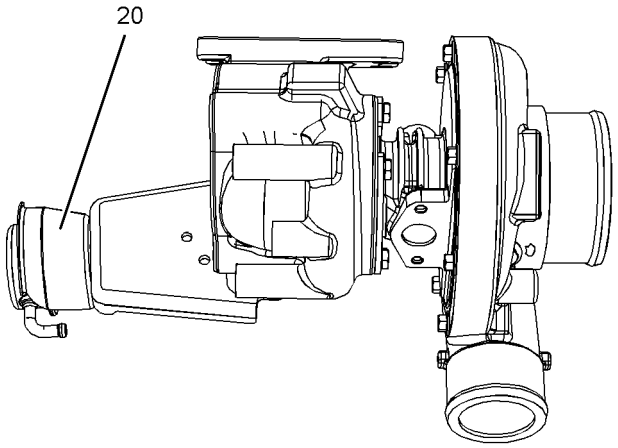

Illustration 109 g02567758

2. Test actuator (20) for correct operation. Refer to Systems Operation, Testing and Adjusting, “Turbocharger - Inspect” for more information. If the actuator is damaged or the actuator does not operate within the specified limits, the complete turbocharger must be replaced.

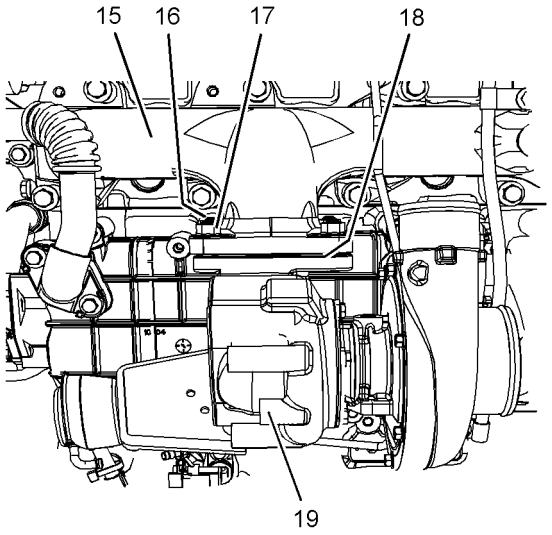

Illustration 110 g02530138

3. Clean the gasket surfaces of exhaust manifold (15). If necessary, install studs(16) (not shown) to turbocharger (19). Tighten the studs to a torque of 18 N·m (13 lb ft).

4. Install a new gasket (18) (not shown) to the exhaust manifold.

5. Position turbocharger (19) onto exhaust manifold (15) and install nuts (17). Tighten the nuts to a torque of 44 N·m (32 lb ft).

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

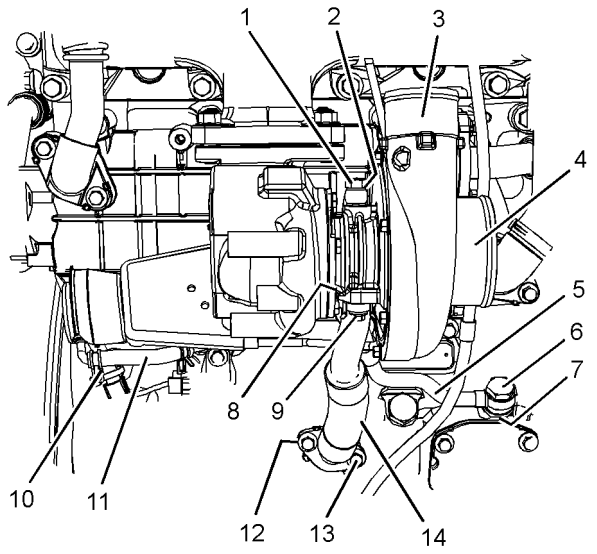

Illustration 111 g02530062

6. Position a new gasket (8) (not shown) and a new gasket (12) (not shown) onto tube assembly (14).

7. Install tube assembly (14) onto the turbocharger and the cylinder block.

8. Install bolts (9) and bolts (13) finger tight.

9. Tighten bolts (9) to a torque of 9 N·m (80 lb in). Tighten bolts (13) to a torque of 22 N·m (16 lb ft).

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

11. Position a new sealing washer (2) (not shown) onto banjo bolt (1). Install banjo bolt (1) onto tube assembly (5) and install remaining new sealing washer (2) to banjo bolt (1).

12. Position tube assembly (5) onto the turbocharger. Loosely tighten banjo bolt (1).

13. Position a new sealing washer (7) (not shown) onto banjo bolt (6). Install banjo bolt (6) to tube assembly (5) and install remaining new sealing washer (7) (not shown). Loosely tighten banjo bolt (6).

14. Tighten banjo bolt (6) to a torque of 40 N·m (30 lb ft). Tighten banjo bolt (1) to a torque of 15 N·m (1335 lb in).

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

15. Connect hose assembly (11) to wastegate actuator. Slide hose clamp (10) along hose assembly (11).

Note: Ensure that hose clamp is correctly positioned on the hose assembly.

16. Connect the hose assemblies to turbocharger inlet (4) and for turbocharger outlet (3). Securely tighten the hose clamps.

End By:

a. Install the exhaust elbow to the turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - Remove and Install” for the correct procedure.

i04485907

Turbocharger - Install (Second Stage Turbocharger)

Installation Procedure

Table 16

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.

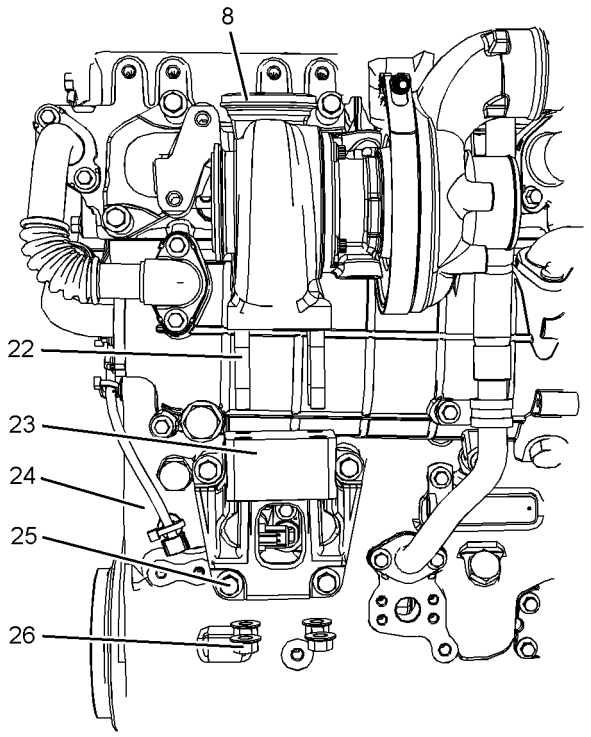

Illustration 112 g02529479

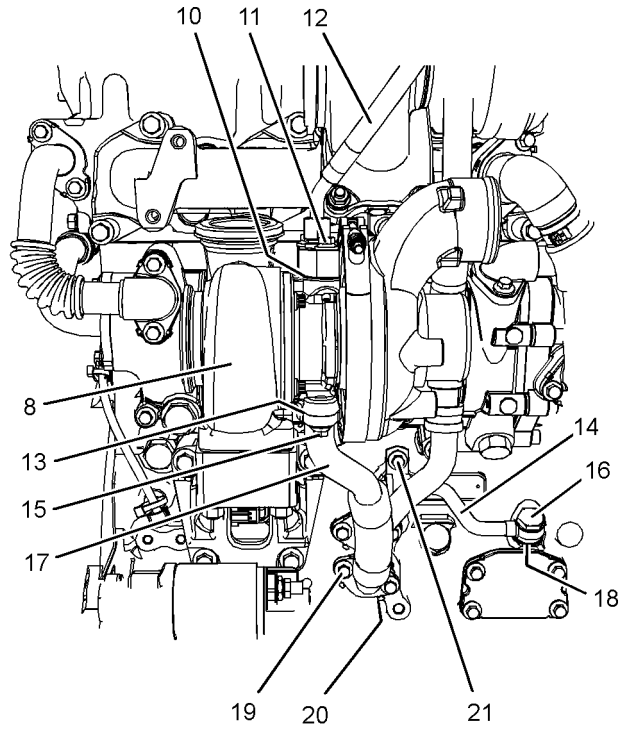

Illustration 113 g02529478

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 (23) onto cylinder block (24).

   a. Position bracket (23) onto cylinder block (24). Install bolts (25).

Note: Ensure that the camshaft position sensor is not damaged during the installation of the bracket.

   b. Tighten bolts (25) to a torque of 44 N·m (32 lb ft).

3. If necessary, install studs (22) to turbocharger (8). Tighten the studs to a torque of 18 N·m (159 lb in).

4. Install turbocharger (6) onto bracket (23).

5. Install nuts (26) and hand tighten the nuts.

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

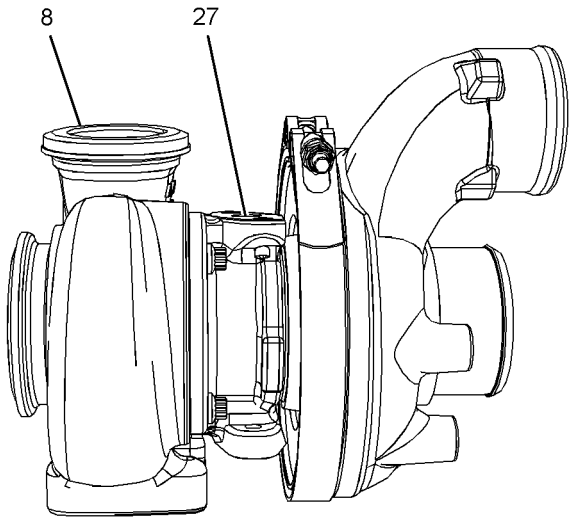

Illustration 114 g02529636

7. Position a new gasket (13) (not shown) and a new gasket (20) (not shown) onto tube assembly (17).

8. Position tube assembly (17) onto turbocharger (8) and the cylinder block.

9. Install bolts (15) and bolts (19).

10. Tighten bolts (15) and bolts (19) to a torque of 22 N·m (195 lb in).

11. Remove the plug from oil inlet port (27). Lubricate the turbocharger bearings with clean engine oil through the oil inlet port. Rotate the wheel of the compressor several times in order to lubricate the bearings.

12. Remove plugs from tube assembly (14). Ensure that tube assembly (14) is clean and free from restriction. Replace any damaged components.

13. Position a new gasket (10) (not shown) onto turbocharger (8).

14. Position tube assembly (14) onto turbocharger (8) and the cylinder block. Loosely install bolts (11) to the tube assembly.

15. Position a new sealing washer (18) (not shown) onto banjo bolt (16).

16. Install banjo bolt (16) to hose assembly (14). Install the remaining new sealing washer (18) (not shown) to banjo bolt (16).

17. Install bolt (21) to clamp for hose assembly (14).

18. Tighten banjo bolt (16) to a torque of 40 N·m (29 lb ft).

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

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

19. Remove plug from hose assembly (12) and connection on turbocharger (8). Ensure that hose assembly (12) and connection are clean and free from restriction. Replace any damaged components.

20. Connect hose assembly (12) from the connection on turbocharger (8). Tighten tube nut for hose assembly (12) on turbocharger (8) to a torque of 30 N·m (265 lb in).

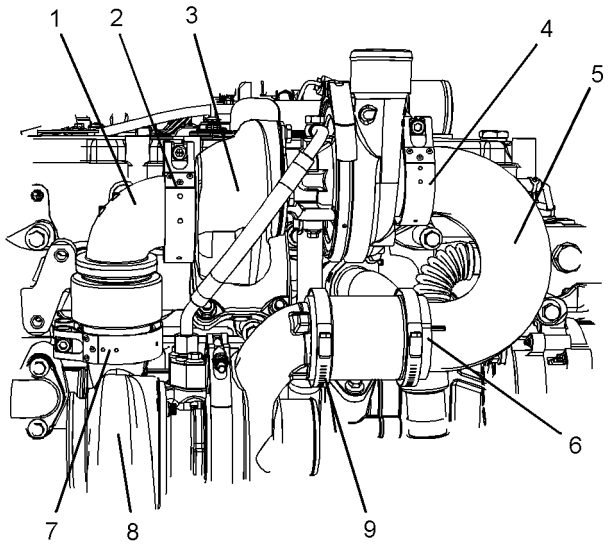

Illustration 115 g02529457

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

22. Position hose assembly (6) and air duct (5) onto the outlet of turbocharger (8) and turbocharger (3). Tighten the allen head volt V-band clamp to a torque of 12 N·m (106 lb in).

23. Tighten hose clamps (9) securely.

24. Ensure that elbow (1) is free from wear and damage. If necessary, replace the elbow that is worn or damaged.

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

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

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

28. Tighten V-band clamp (2) and V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.

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

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

End By:

a. Install the exhaust elbow from the second stage turbocharger. Refer to Disassembly and Assembly, “Exhaust Elbow - Remove and Install” for the correct procedure.

i04485915

Wastegate Solenoid - Remove and Install

Removal Procedure

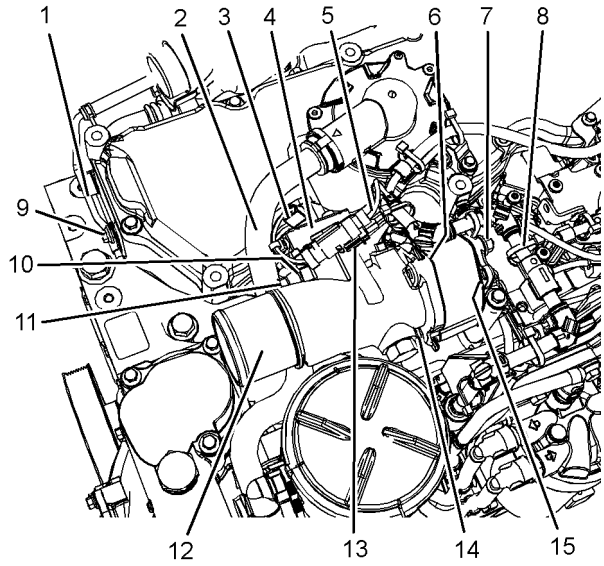

Illustration 116 g02522557

1. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, removal of the DPF assembly will be necessary in order to access the wastegate solenoid. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Remove” for the correct procedure.

2. Loosen hose clamps and remove hose assembly from connection (12).

3. Remove plastic tube assembly (2) from the valve mechanism cover and the crankcase breather canister.

4. Slide locking tab (13) into the unlocked position. Disconnect harness assembly (5) from the harness assembly for wastegate solenoid (3).

5. Slide the harness assembly for wastegate solenoid (3) from bracket (4).

6. Remove bolts (9) from tube assembly (1).

7. Remove banjo bolt (11) and remove sealing washers (10) (not shown).

8. Cut cable straps (8) from harness assembly (5). Position harness assembly (5) away from NRS induction mixer.

9. Remove nut (7) and bolts (14).

10. Remove the assembly of inlet connection (12) from the NRS induction mixer assembly.

11. Remove gasket (6) (not shown) and gasket (15) (not shown).

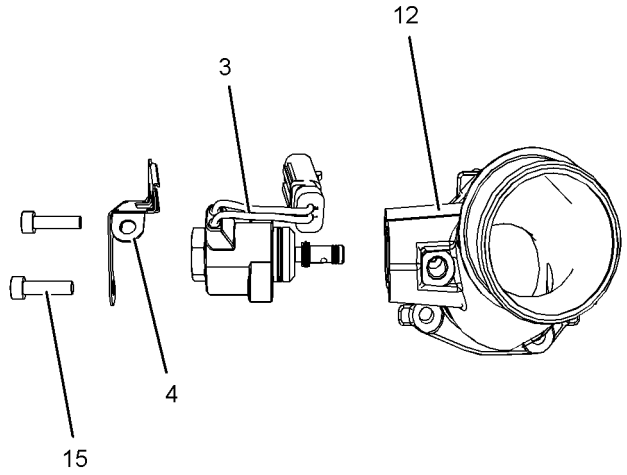

Illustration 117 g02522558

12. Remove allen head bolts (15) from wastegate solenoid (3). Remove bracket (4).

13. Remove wastegate solenoid (3) from inlet connection (12).

14. Plug inlet connection (12) and cap wastegate solenoid (3) with new plugs and caps.

Installation Procedure

Table 17

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Delphi Lockheed Rubber Grease	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 and the convoluting.

1. Ensure that all components of the wastegate solenoid are clean and free from wear and damage. If necessary, replace the wastegate solenoid as an assembly if any of the components are worn or damaged.

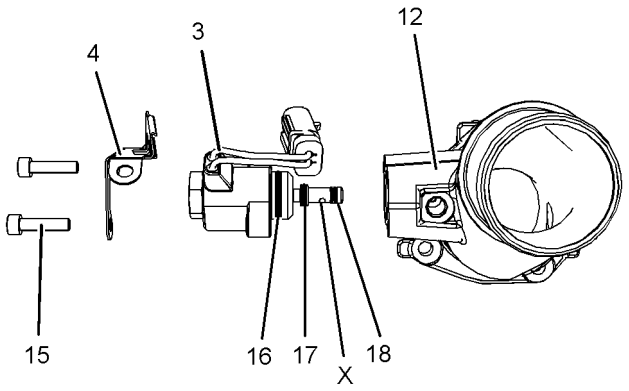

Illustration 118 g02522577

2. Ensure that O-ring seal (16), O-ring seal (17), and O-ring seal (18) on wastegate solenoid (3) 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. Remove the cap from wastegate solenoid (3) and remove plug from inlet connection (12).

6. Use Tooling (A) in order to lubricate O-ring seal (16), O-ring seal (17), and O-ring seal (18) on wastegate solenoid (3).

7. install wastegate solenoid (3) to inlet connection (12).

8. Position bracket (4) onto wastegate solenoid (3).

Note: Ensure that the bracket is correctly orientated.

9. Install allen head bolts (15) to wastegate solenoid (3). Tighten the allen head bolts to a torque of 9 N·m (80 lb in).

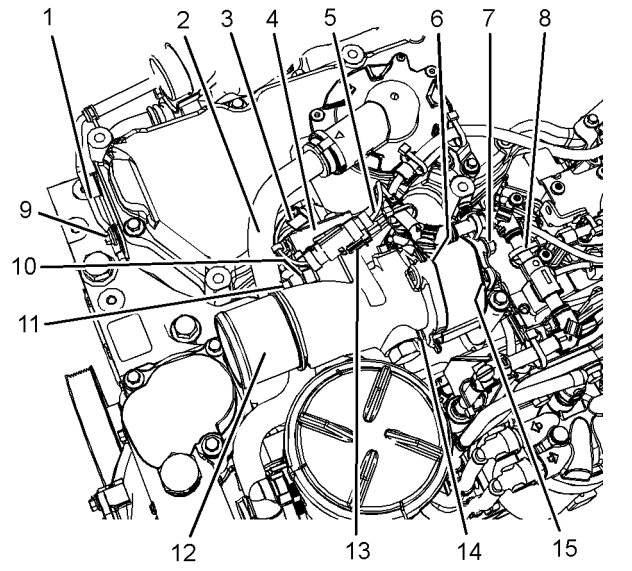

Illustration 119 g02522557

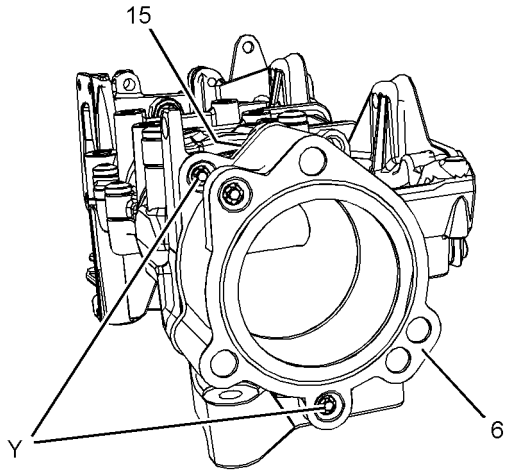

Illustration 120 g02524456

10. Position a new gasket (6) and a new gasket (15) (not shown) onto the NRS induction mixer assembly. Ensure that gasket (6) and gasket (15) (not shown) is correctly located on Pins (Y).

11. Position the assembly on inlet connection (12) onto the NRS induction mixer assembly.

12. Install nut (7) and bolts (14).

13. Tighten nut (7) and bolts (14) to a torque 22 N·m (195 lb in).

14. Position a new sealing washer (10) (not shown) onto banjo bolt (11). Install banjo bolt (11) to tube assembly (1) and install the remaining new sealing washer (10) (not shown) onto the banjo bolt. Tight the banjo bolt finger tight

15. Install bolts (9) to tube assembly (1). Tighten the bolts to a torque 22 N·m (195 lb in).

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

17. Slide the harness assembly for wastegate solenoid (3) onto bracket (4).

18. Position harness assembly (5) onto NRS induction mixer. Install new cable straps (8) to harness assembly (5).

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

19. Connect harness assembly (5) to the harness assembly for wastegate solenoid (3). Slide locking tab (13) into the locked position.

20. Install plastic tube assembly (2) to the valve mechanism cover and the crankcase breather canister.

21. Install hose assembly onto connection (12). Tighten hose clamps securely.

22. If the Diesel Particulate Filter (DPF) assembly was mounted on the valve mechanism cover, installation of the DPF assembly will be necessary after the installation of the wastegate solenoid. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Remove” for the correct procedure.

i04485845

Exhaust Back Pressure Valve - Remove and Install

Removal Procedure

Start By:

a. Remove the flexible exhaust pipe from the exhaust back pressure valve. Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

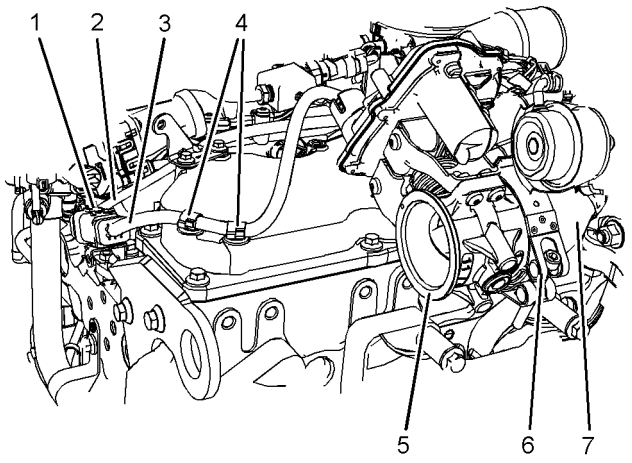

Illustration 121 g02476753

1. Unclip retaining clips (4) for exhaust back pressure valve wiring harness (3). Slide locking tab (1) into the unlocked position.

2. Disconnect exhaust back pressure valve wiring harness (3) from assembly of engine wiring harness (2).

3. Loosen allen head bolt on V-band clamp (6).

Note: If the V-band clamp (6) remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. 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.**

4. Make temporary marks on exhaust back pressure valve and the exhaust elbow in order to show correct position. Remove the exhaust back pressure valve (5) from exhaust elbow (7).

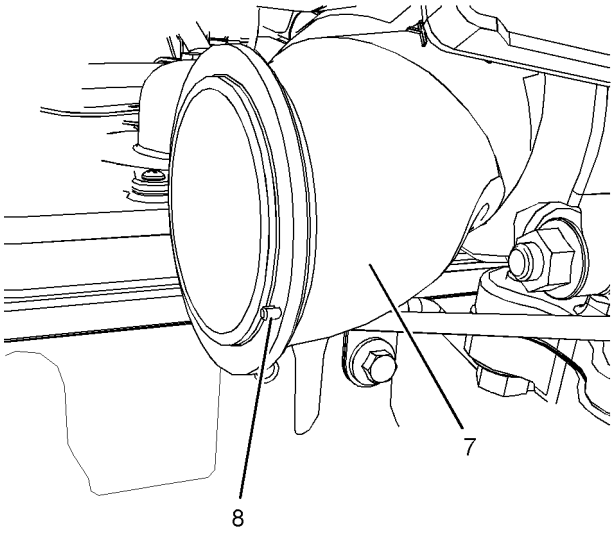

Illustration 122 g02476738

5. Note position of dowel (8) in exhaust elbow (7).

Installation Procedure

Table 18

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

1. Ensure that the exhaust back pressure valve and the exhaust elbow are free from damage. Replace any components that are damaged.

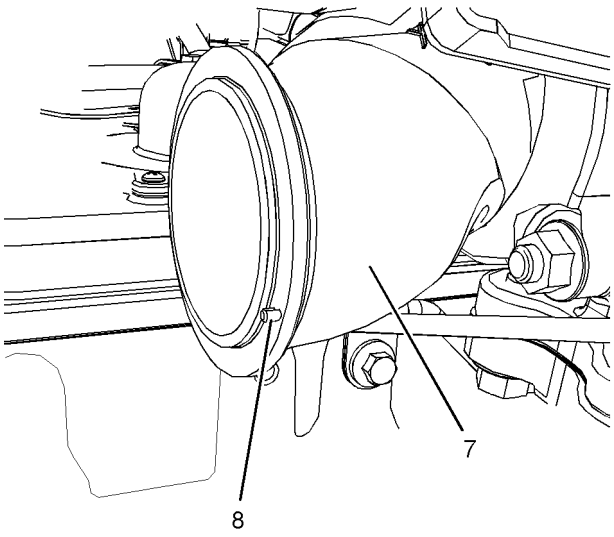

Illustration 123 g02476738

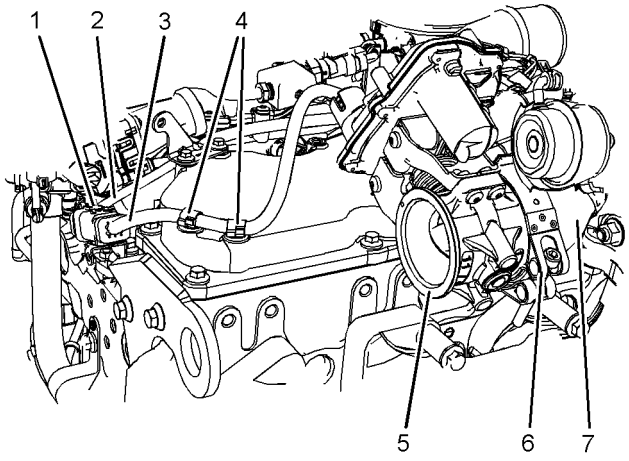

Illustration 124 g02476753

2. Ensure that dowel (8) is free from damage and is correctly positioned in exhaust elbow (7).

3. Use Tooling (A) to lubricate the threads of the allen head bolt for V-band clamp (6).

4. Position V-band clamp (6) onto exhaust elbow (7).

5. Install exhaust back pressure valve (5) onto exhaust elbow (7). Ensure that the exhaust back pressure valve is correctly located onto dowel (8) on the exhaust elbow.

6. Ensure that V-band clamp (6) is seated onto exhaust back pressure valve (5) and exhaust elbow (7). Tighten the allen head bolt for the V-band clamp hand tight.

7. Tighten the allen head bolt for V-band clamp (6) to a torque of 12 N·m (106 lb in).

8. Connect exhaust back pressure valve wiring harness (3) to the assembly of engine wiring harness (2).

9. Slide locking tab (1) into the locked position. Clip retaining clips (4) for exhaust back pressure valve wiring harness (3).

End By:

a. Install the flexible exhaust pipe to the exhaust back pressure valve. Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

i04485855

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.

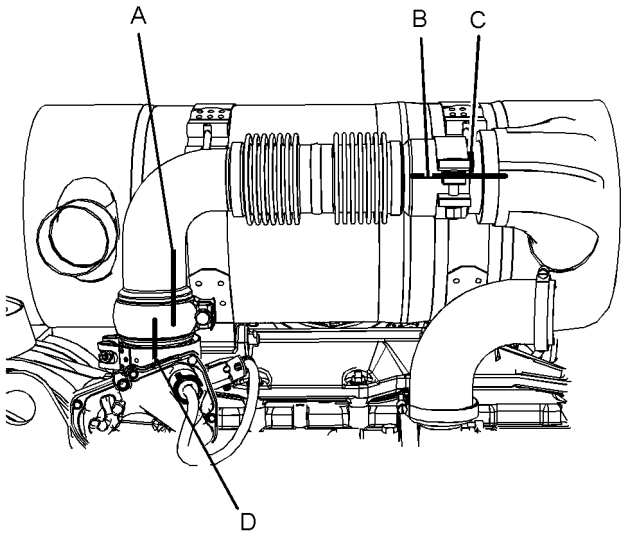

Illustration 125 g02478857

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, C, and D).

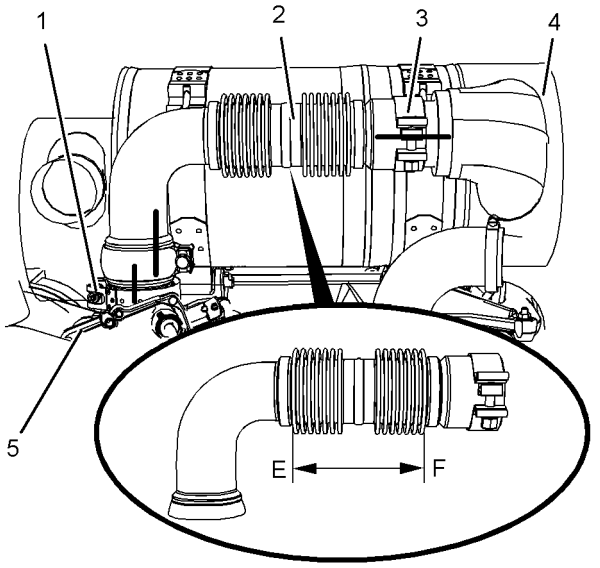

Illustration 126 g02478858

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 (2). Encasing the flexible exhaust pipe will prevent damage of the bellows. Encase bellows for the flexible exhaust pipe (2) between Position (E) and Position (F). Use cable straps in order to retain the suitable material.

Note: Ensure that the flexible exhaust pipe is supported at all times.

   b. Loosen clamp (3) on the flexible exhaust pipe assembly.

   c. Loosen the bolt for V-band clamp (1).

Note: If V-band clamp (1) 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 (4) and exhaust back pressure valve (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

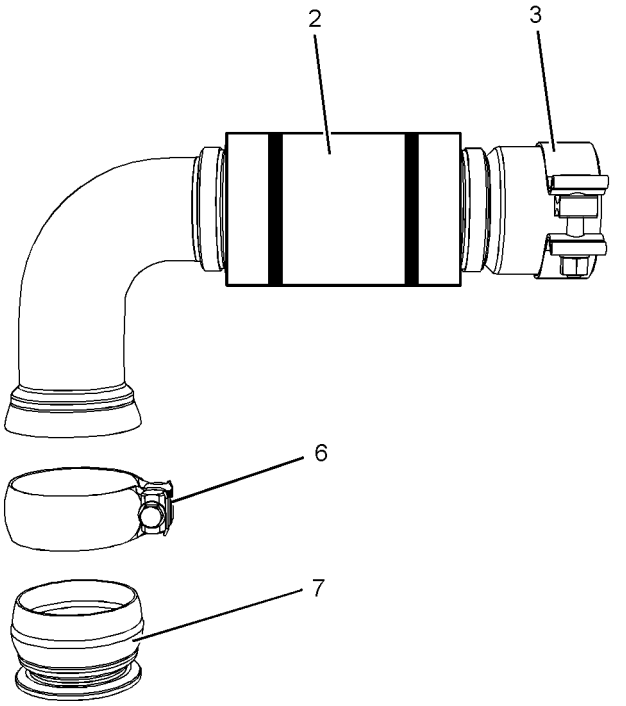

Illustration 127 g02478996

1. If necessary, follow Step 1.a through Step 1.b in order to disassemble the flexible exhaust pipe assembly.

   a. Loosen ball clamp (6) and remove the ball clamp.

   b. Remove the assembly of bellows (2) from the adapter (7).

Note: Ensure that the flexible exhaust pipe bellows are not subjected to any undue stress.

Assembly Procedure for the Flexible Exhaust Pipe Assembly

Table 19

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Drill Bit 3 mm (0.118 inch) Ø	1
B	-	Drill Bit 6.5 mm (0.256 inch) Ø	1

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.

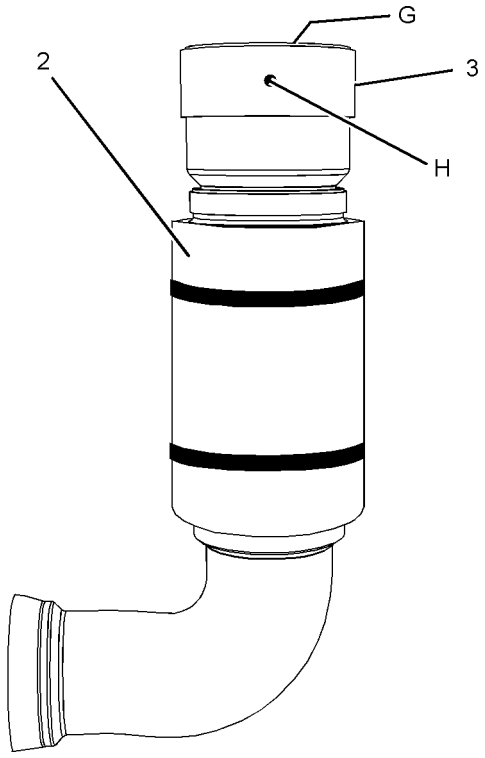

Illustration 128 g02478998

2. If the flexible exhaust pipe assembly was previously disassembled. Follow Step 2.a through Step 2.h 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) (not shown) of the bellows on a suitable support. Use Tooling (A) in order to drill a pilot hole through the spot weld in Position (H) on clamp (3).

Note: Do not center punch the spot weld on clamp (7).

   b. Use Tooling (B) in order to drill out spot weld in Position (H) on clamp (3). Remove clamp (3) from the bellows.

   c. Remove all burrs from the internal and external areas of bellows (3). **Ensure that debris does not enter bellows.**

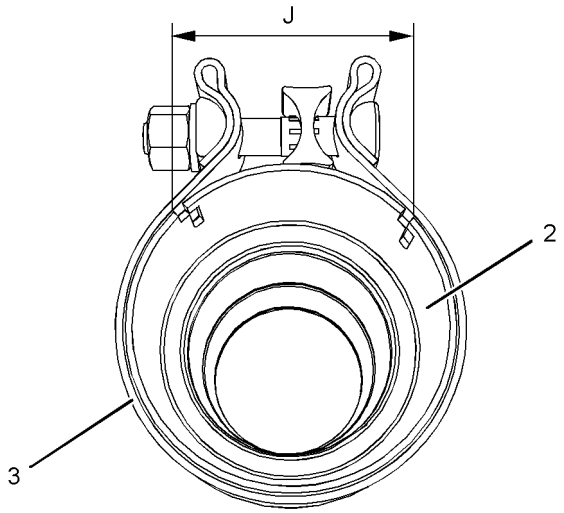

Illustration 129 g02479478

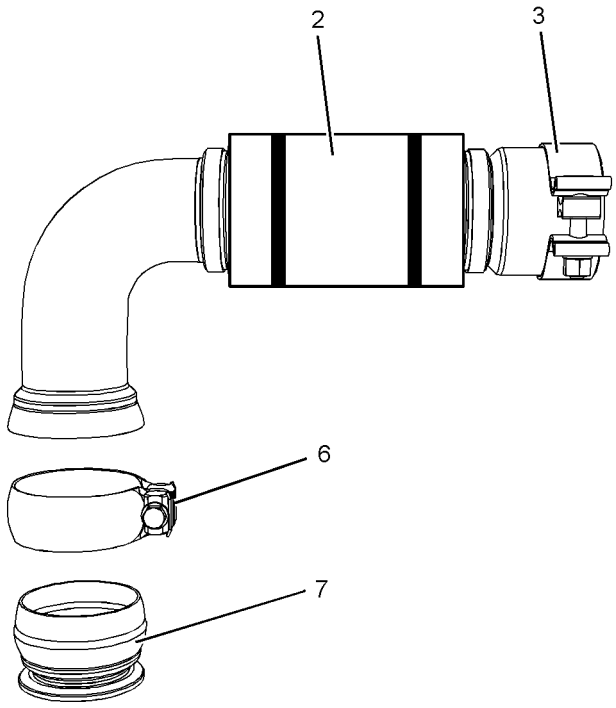

Illustration 130 g02478996

d. Position a new clamp (3) onto bellows (2). Hand tighten clamp (3). 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 (2).

Note: Ensure that the bellows are not subjected to any undue stress.

e. If new bellows (2) are installed, clamp (3) 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 (6) onto adapter (7).

g. Position bellow (2) onto adapter (7).

h. Tighten ball clamp (6) hand tight.

Note: Ensure that the bellows are not subjected to any undue stress.

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. 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.

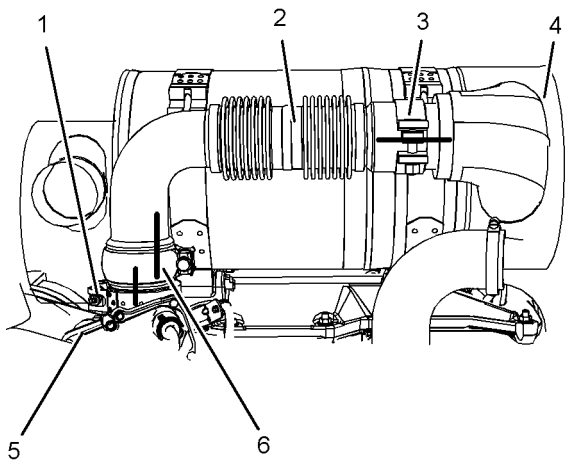

Illustration 131 g02479539

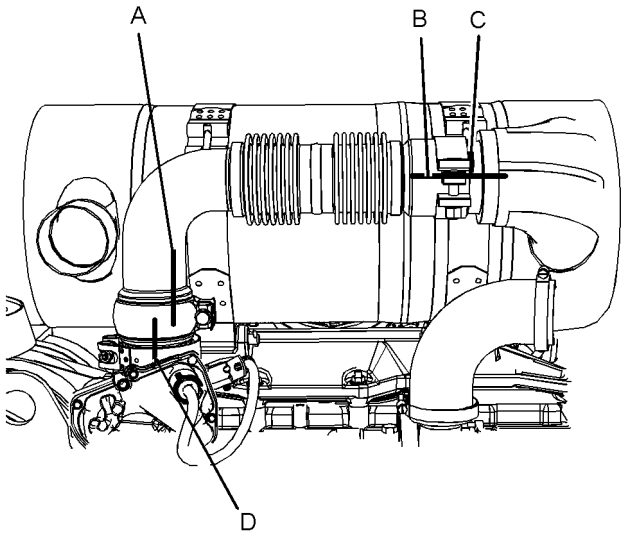

Illustration 132 g02479541

2. Install V-band clamp (1) onto exhaust back pressure valve (5).

3. Install assembly of the flexible exhaust pipe onto CEM (4) and exhaust back pressure valve (5).

Note: Ensure that the assembly of the flexible exhaust pipe is supported at all times.

4. Position V-band clamp (1) onto adapter.

5. Tighten V-band clamp (1) hand tight.

NOTICE
Failure to reinstall the bellows into the original position will result in a failure of the bellows and possible emissions failure.

6. Align the assembly of the flexible exhaust pipe with the temporary marks. Ensure that bellows (2) are not subjected to any undue stress.

7. 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.

8. Tighten clamp (3) to a torque of 55 N·m (40 lb ft).

9. Tighten ball clamp (6) to a torque of 35 N·m (26 lb ft).

10. Tighten V-band clamp (1) to a torque of 12 N·m (106 lb in).

11. Cut cable straps from the suitable material that was encasing the bellows (2) Remove the suitable material from bellows (2).

i04485852

Exhaust Manifold - Remove and Install (Twin Turbocharger Exhaust manifold)

Removal Procedure

Start By:

a. Remove the first stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger - Remove (First Stage Turbocharger)” for the correct procedure.

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

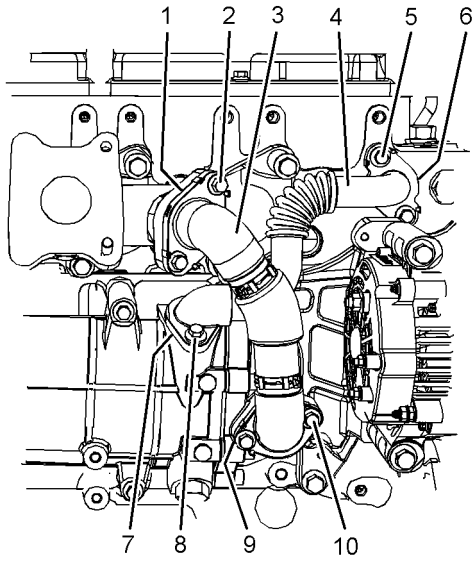

Illustration 133 g02477639

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. Prior to and during removal of bolts (2) and bolts (10) apply releasing fluid to the bolts. Remove bolts (2) and bolts (10) from tube assembly (3).

3. Remove tube assembly (3) from the exhaust cooler and the exhaust manifold.

4. Remove gasket (1) (not shown) and gasket (9) (not shown) from tube assembly (3).

5. Remove bolts (5) and bolt (8) from tube assembly (4).

6. Remove tube assembly (4) from the cylinder head and the exhaust cooler.

7. Remove gasket (6) (not shown) and O-ring seal (9) (not shown) from tube assembly (4).

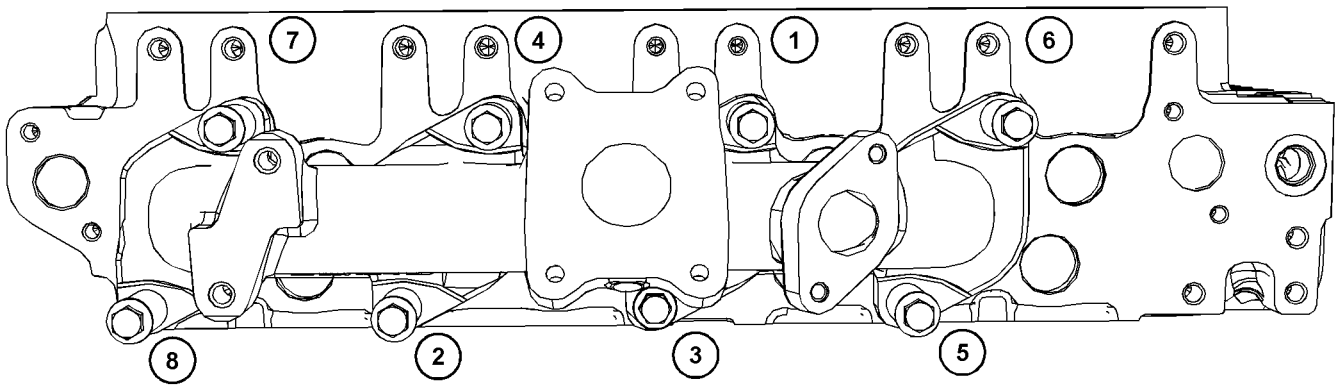

Illustration 134 g02477641

Tighten sequence of exhaust manifold

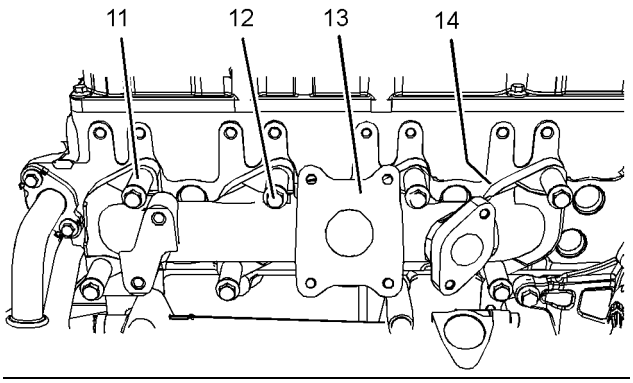

Illustration 135 g02477643

8. Loosen bolts (12) in reverse numerical order. Refer to Illustration 134.

Note: Loosen the bolts in reverse numerical order will help prevent distortion of the exhaust manifold.

9. Remove bolts (12) and spacers (11) from exhaust manifold (13). Note position of the different length spacer.

Note: Support the manifold as the bolts are removed.

10. Remove exhaust manifold (13).

11. Remove exhaust manifold gasket (14) (not shown).

Installation Procedure

Table 20

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400020	Manifold Alignment Pins	2
B	T400019	Manifold Alignment Pins	1
C	-	Loctite 575	1

1. Ensure that the exhaust manifold is clean and free from damage. If necessary, replace the exhaust manifold. Clean the gasket surface of the cylinder head.

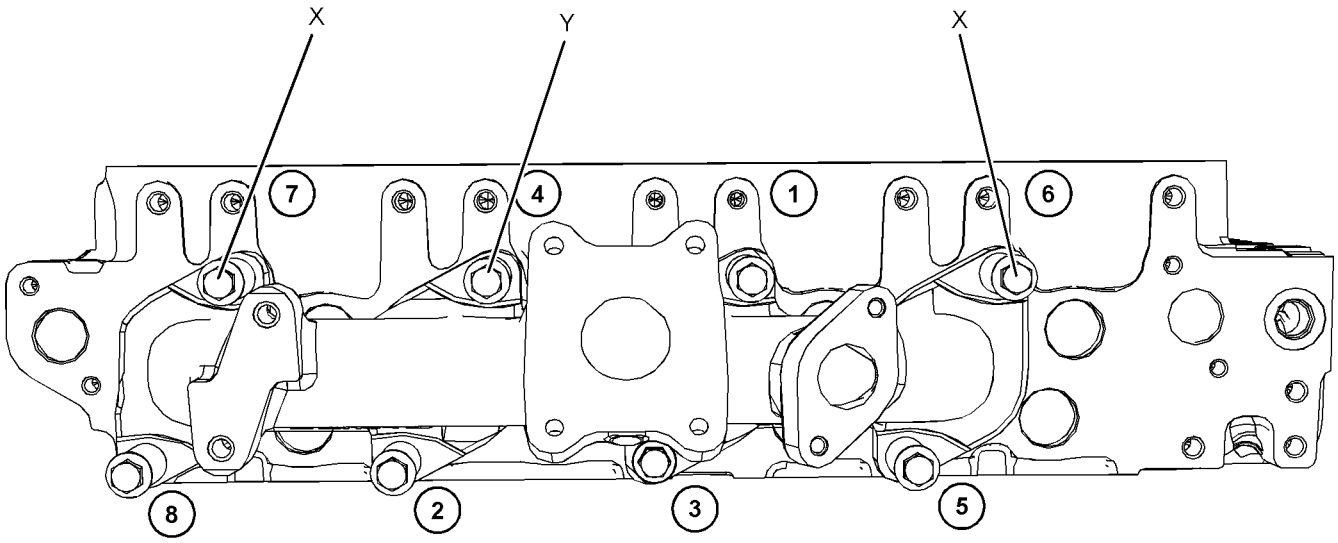

Illustration 136 g02477697

Tighten sequence of exhaust manifold and Tooling position

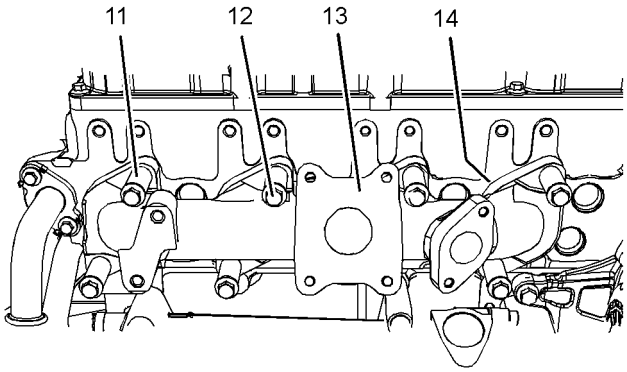

Illustration 137 g02477643

2. Position a new exhaust manifold gasket (14) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Tooling (B) in Positions (Y). Refer to Illustration 136.

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

3. Align exhaust manifold (13) with Tooling (A) and Tooling (B). Install the exhaust manifold to the cylinder head.

4. If bolts (12) have been previously used, thoroughly clean the bolts. Tooling (C) should be applied to the first two threads of the bolts.

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

5. Install bolts (12) and spacers (11) hand tight. Ensure that the different length spacer is installed into the correct position.

6. Remove Tooling (A) and Tooling (B). Install remaining bolts (12) and spacers (11) hand tight.

7. Tighten bolts (12) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 135.

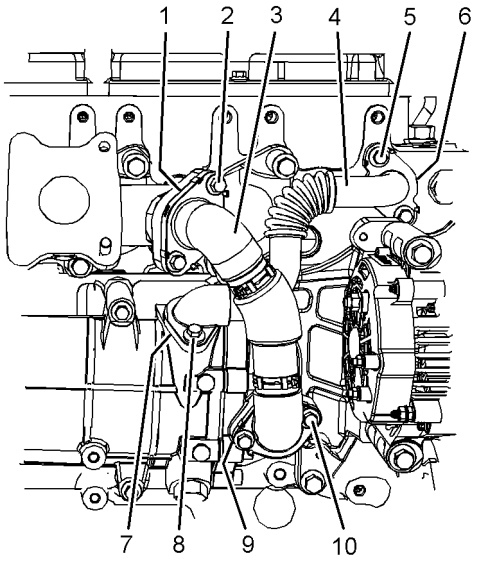

Illustration 138 g02477639

8. Position a new gasket (6) (not shown) and a new O-ring seal (9) (not shown) onto tube assembly (4).

9. Install tube assembly (4) to the cylinder head and the exhaust cooler.

Note: Ensure that the tube assembly is correctly installed into the exhaust cooler.

10. Install bolts (5) and bolt (8) to tube assembly (4).

11. Tighten bolt (8) to a torque of 18 N·m (159 lb in).

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

12. Position a new gasket (1) (not shown) and a new gasket (9) (not shown) to tube assembly (3).

13. Install tube assembly (3) to the exhaust cooler and the exhaust manifold.

14. Install new bolts (2) and new bolts (10) to tube assembly (3). Tighten the bolts to a torque of 22 N·m (195 lb in).

15. 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 first stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (First Stage Turbocharger) - Install” for the correct procedure.

b. Install the second stage turbocharger for twin turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Second Stage Turbocharger) - Install” for the correct procedure.

i04485851

Exhaust Manifold - Remove and Install (Single Turbocharger Exhaust Manifold)

Removal Procedure

Start By:

a. Remove the turbocharger for top mounted turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Top Mounted Turbocharger) - Remove” for the correct procedure.

b. Remove the turbocharger for side mounted turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Side Mounted Turbocharger) - Remove” for the correct procedure.

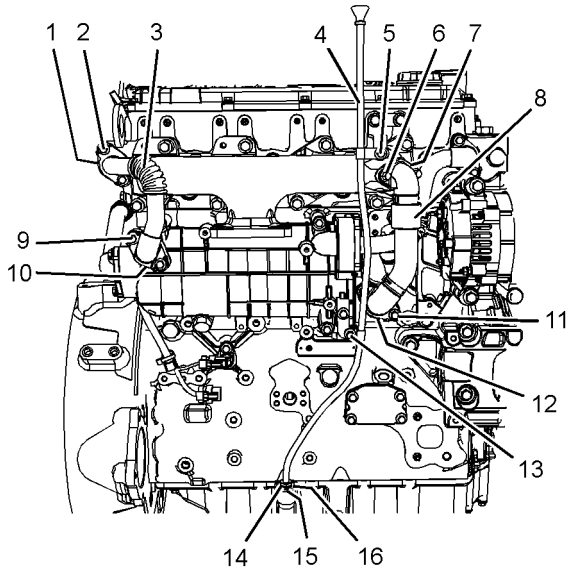

Illustration 139 g02478716

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. Remove bolts (2) and bolt (9) from tube assembly (3).

3. Remove tube assembly (3) from the cylinder head and the exhaust cooler.

4. Remove gasket (1) (not shown) and gasket (10) (not shown) from tube assembly (3).

5. Prior to and during removal of bolts (6) and bolts (11) apply releasing fluid to the bolts. Remove bolts (6) and bolts (11) from tube assembly (8).

6. Remove tube assembly (8) from the exhaust cooler and the exhaust manifold.

7. Remove gasket (7) (not shown) and gasket (12) (not shown) from tube assembly (8).

8. Remove bolt (5) and bolt (13) from dipstick tube assembly (4).

9. Loosen nut (14) on dipstick tube assembly (4). Remove the dipstick tube assembly.

10. Remove O-ring seal (15) (not shown) and seal (16) (not shown) from the dipstick tube assembly.

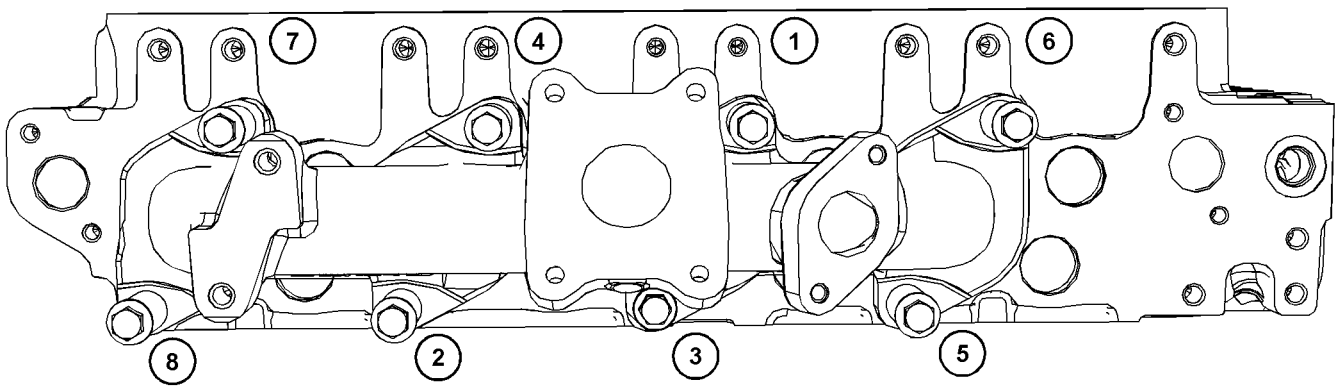

Illustration 140 g02477641

Tighten sequence of exhaust manifold

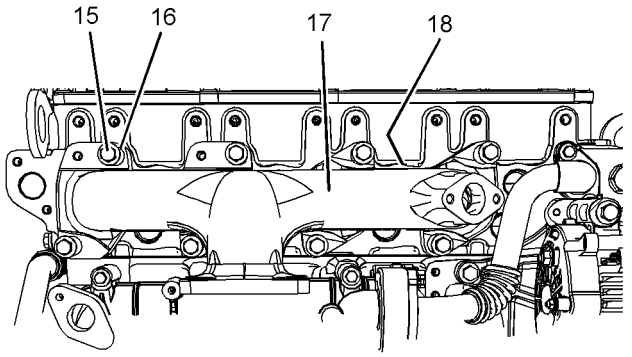

Illustration 141 g02478717

11. Loosen bolts (15) in reverse numerical order. Refer to Illustration 140.

Note: Loosen the bolts in reverse numerical order will help prevent distortion of the exhaust manifold.

12. Remove bolts (15) and spacers (16) from exhaust manifold (17). Note position of the different length spacer.

Note: Support the manifold as the bolts are removed.

13. Remove exhaust manifold (17).

14. Remove exhaust manifold gasket (18) (not shown).

Installation Procedure

Table 21

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400020	Manifold Alignment Pins	2
B	T400019	Manifold Alignment Pins	1
C	-	Loctite 575	1

1. Ensure that the exhaust manifold is clean and free from damage. If necessary, replace the exhaust manifold. Clean the gasket surface of the cylinder head.

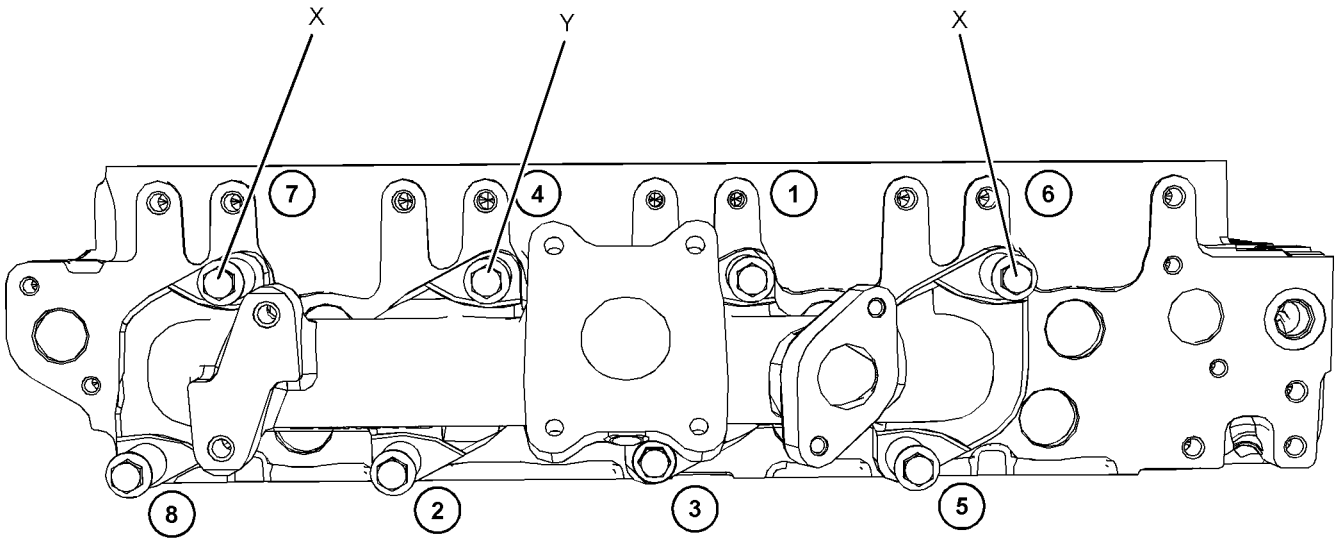

Illustration 142 g02477697

Tighten sequence of exhaust manifold and Tooling position

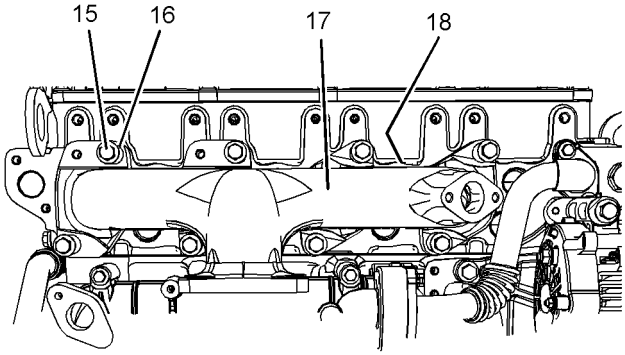

Illustration 143 g02478717

2. Position a new exhaust manifold gasket (18) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Tooling (B) in Positions (Y). Refer to Illustration 142.

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

3. Align exhaust manifold (17) with Tooling (A) and Tooling (B). Install the exhaust manifold to the cylinder head.

4. If bolts (15) have been previously used, thoroughly clean the bolts. Tooling (C) should be applied to the first two threads of the bolts.

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

5. Install bolts (15) and spacers (16) hand tight. Ensure that the different length spacer is installed into the correct position.

6. Remove Tooling (A) and Tooling (B). Install remaining bolts (15) and spacers (16) hand tight.

7. Tighten bolts (15) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 142.

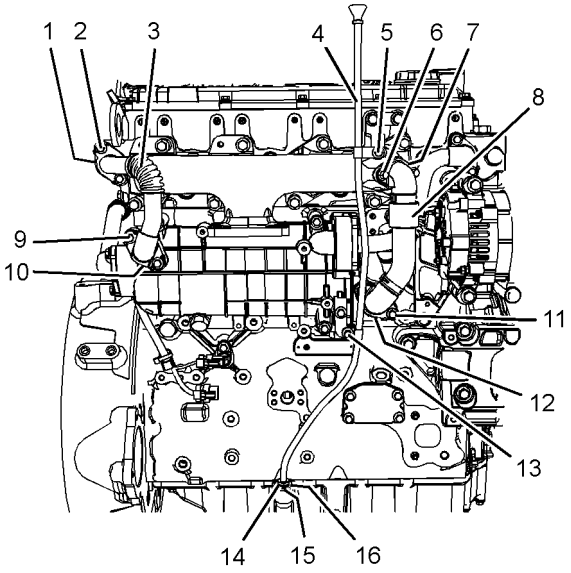

Illustration 144 g02478716

8. Ensure that all tube assemblies are free from restriction and damage.

9. Position a new gasket (7) (not shown) and a gasket (12) (not shown) onto tube assembly (8).

10. Install tube assembly (8) onto the exhaust cooler and the exhaust manifold.

11. Install bolts (6) and bolts (11) to tube assembly (8). Tighten the bolts to a torque of 22 N·m (195 lb in).

12. Position a new gasket (1) (not shown) a new gasket (10) (not shown) onto tube assembly (3).

13. Install tube assembly (3) onto the cylinder head and the exhaust cooler.

14. Install bolts (2) and bolt (9) to tube assembly (3).

15. Tighten bolt (9) to a torque of 18 N·m (159 lb in).

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

16. Install a new O-ring seal (15) (not shown) and a new seal (16) (not shown) to the dipstick tube assembly. Loosely install nut (14) for dipstick tube assembly (4).

17. Install bolt (5) and bolt (13) to dipstick tube assembly (4).

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

Tighten bolts (5) and bolt (13) to a torque of 22 N·m (195 lb in).

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

End By:

a. Install turbocharger for top mounted turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Top Mounted Turbocharger) - Install” for the correct procedure.

b. Install turbocharger for side mounted turbocharged engine. Refer to Disassembly and Assembly, “Turbocharger (Side Mounted Turbocharger) - Remove” for the correct procedure.

i04485850

Exhaust Elbow - Remove and Install

Removal Procedure

Start By:

a. Remove the exhaust back pressure valve from the exhaust elbow. Refer to Disassembly and Assembly, “Exhaust Back Pressure Valve - Remove and Install” for the correct procedure.

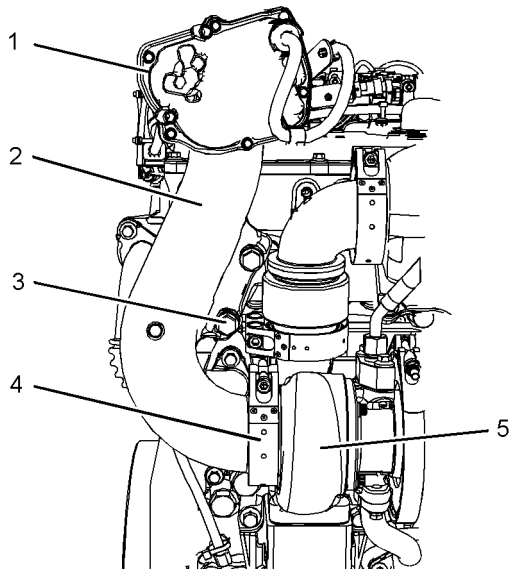

Illustration 145 g02476565

1. Loosen allen head bolt on V-band clamp (4).

Note: If the V-band clamp (4) remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. 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.**

2. Remove V-band clamp (4) from turbocharger (5) and exhaust elbow (2).

3. Remove bolts (3) and spacers. Remove exhaust elbow (2) from turbocharger (5).

Note: Support the weight of the exhaust elbow as the bolts are removed.

Installation Procedure

Table 22

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

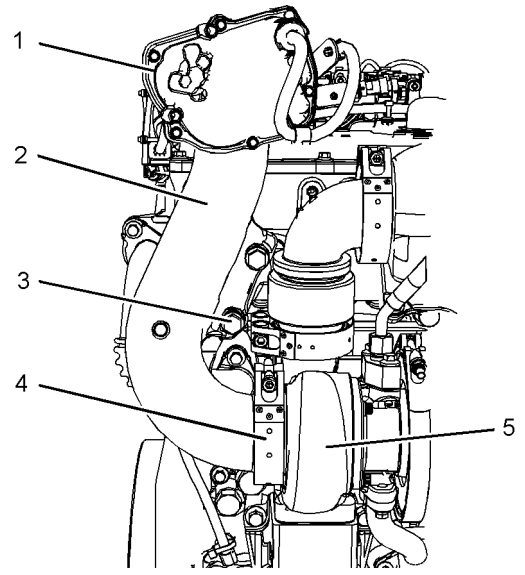

Illustration 146 g02476565

1. Ensure that the exhaust elbow and the outlet of the turbocharger are free from damage. Replace any components that are damaged.

2. Use Tooling (A) to lubricate the threads of the allen head bolt for V-band clamp (4).

3. Loosely position V-band clamp (4) onto turbocharger (5).

4. Position exhaust elbow (2) onto turbocharger (5). Install V-band clamp (4) onto exhaust elbow (2) and hand tighten the allen head bolt on the V-band clamp.

Note: Support the weight of the exhaust elbow as the V-band clamp is installed.

5. Install the spacers and bolts (3) hand tight. Ensure that exhaust elbow (2) is correctly positioned onto turbocharger (5) and is correctly aligned.

6. Tighten the allen head bolt for V-band clamp (4) to a torque of 12 N·m (106 lb in).

7. Tighten bolts (3) to a torque of 44 N·m (32 lb ft).

End By:

a. Install the exhaust back pressure valve to the exhaust elbow. Refer to Disassembly and Assembly, “Exhaust Back Pressure Valve - Remove and Install” for the correct procedure.

i04485849

Exhaust Elbow - Remove and Install (Top Mounted and Side Mounted Turbocharger Exhaust Elbow)

Removal Procedure

Start By:

a. Remove the exhaust back pressure valve from the exhaust elbow. Refer to Disassembly and Assembly, “Exhaust Back Pressure Valve - Remove and Install” for the correct procedure.

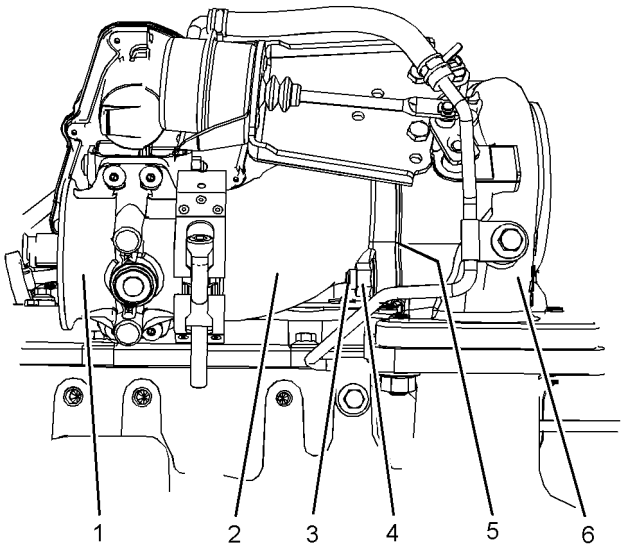

Illustration 147 g02476645
Typical example

1. Remove nuts (4) from turbocharger (6).
2. Make temporary marks on exhaust elbow (2) and turbocharger (6) to show correct orientation. Remove exhaust elbow (2) from turbocharger (6).
3. Remove gasket (5) (not shown) from turbocharger (6).
4. If necessary, remove studs (3) from turbocharger (6).

Installation Procedure

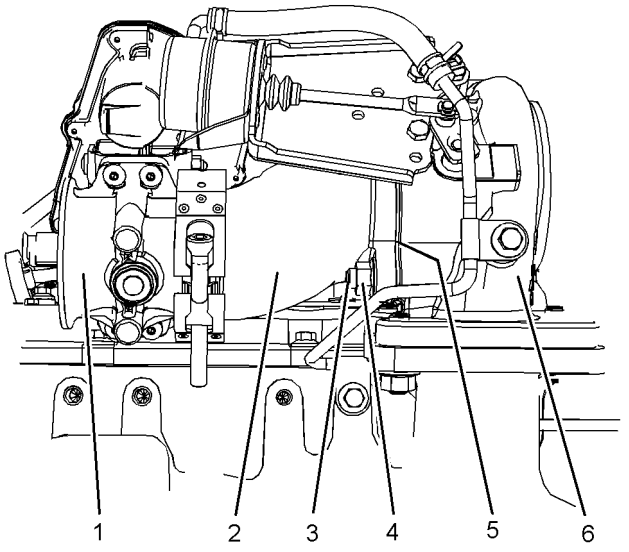

Illustration 148 g02476645
Typical example

1. Ensure that the exhaust elbow and the outlet of the turbocharger are free from damage. Replace any components that are damaged.
2. If necessary, install studs (3) to turbocharger (6). Tighten the studs to a torque of 18 N·m (159 lb in).
3. Position a new gasket (6) (not shown) onto turbocharger (6).
4. Install exhaust elbow (2) onto turbocharger (6). Ensure that the exhaust elbow is correctly orientated.
5. Install nuts (4) onto turbocharger (6). Tighten the nuts to a torque of 44 N·m (33 lb ft).

End By:

a. Install the exhaust back pressure valve to the exhaust elbow. Refer to Disassembly and Assembly, “Exhaust Back Pressure Valve - Remove and Install” for the correct procedure.

i04485827

Diesel Particulate Filter - Remove

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 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.

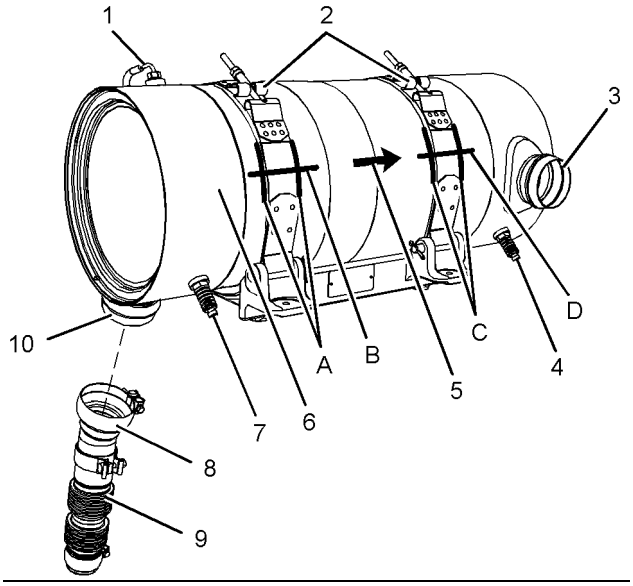

Illustration 149 g02520776

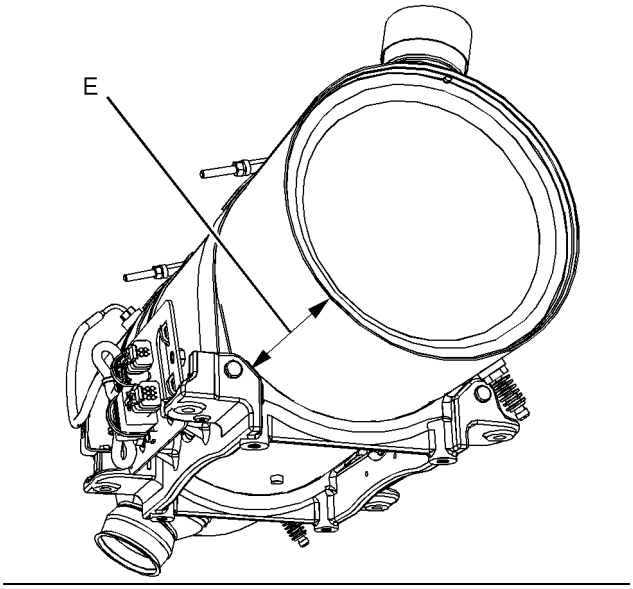

Illustration 150 g02496917

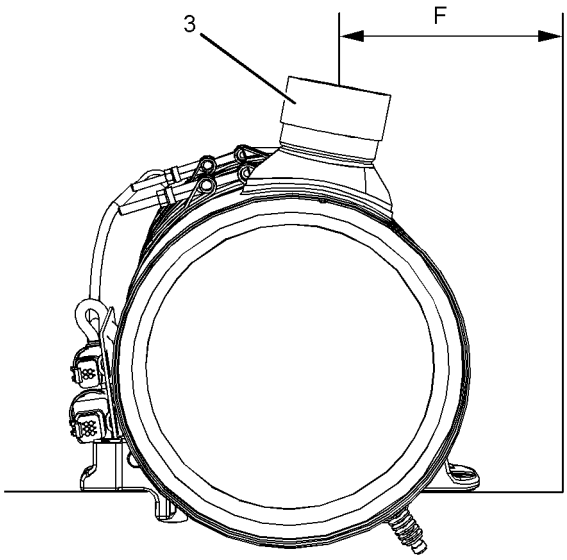

Illustration 151 g02496977

1. If necessary, remove the Original Equipment Manufacturer's (OEM) exhaust tube assembly from outlet (3).

2. Disconnect the flexible exhaust pipe assembly (9) from inlet (10). Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

3. Make a temporary mark (5) in order to show the direction of the exhaust gases.

4. Make temporary alignment marks in Positions (A), Position (B), Positions (C) and Position (D) in order to identify the correct position of clamps (2) and DPF (6).

5. Using a fixed position that is easily accessible, measure Dimension (E) from the DPF mounting bracket to the end of the DPF. Record Dimension (E) for installation purposes.

6. Using a fixed position that is easily accessible on the application, measure to the center of the DPF outlet (3). Record Dimension (F) for installation purposes.

7. Remove the temperature sensor. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

8. Disconnect the wiring harness from soot antenna (4) and soot antenna (7).

9. Remove the soot antenna's. Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

10. Remove the nuts from clamps (2). Position the clamps away from the DPF in order to allow removal of the DPF.

11. Attach a suitable lifting device to the DPF . The weight of the DPF is approximately 43 kg (95 lb).

12. Use the suitable lifting device in order to remove the DPF from the bracket for the clean emission module.

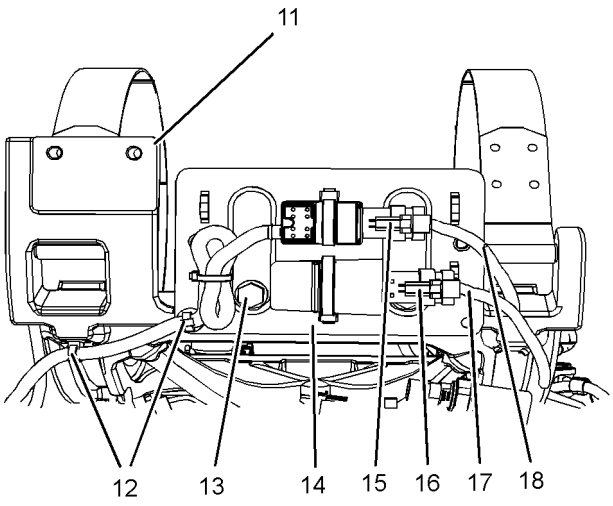

Illustration 152 g02464317

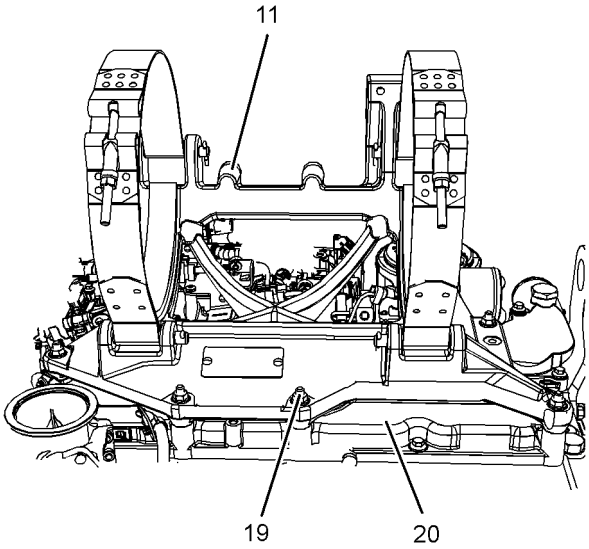

Illustration 153 g02464396

13. If necessary, follow Step 13.a thought Step 13.f in order to remove bracket (11) from valve mechanism cover (20).

a. Cut cable straps (12) from the harness assembly for the temperature sensor.

b. Slide locking tab (15) into the unlock position. Disconnect harness assembly (18).

c. Slide locking tab (16) into the unlock position. Disconnect harness assembly (17).

d. Remove bolts (13) and position bracket (14) away from bracket (11).

e. Remove nuts (19) from bracket (11).

f. Remove bracket (11) from valve mechanism cover (20).

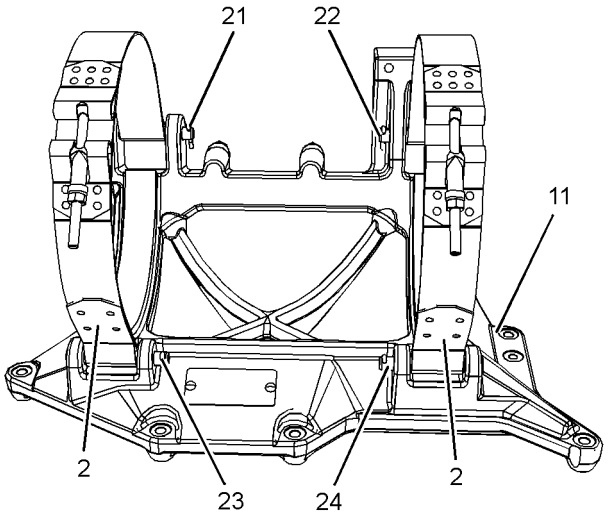

Illustration 154 g02464417

14. If necessary, follow Step 14.a thought Step 14.e in order to remove clamps (2) from bracket (11).

a. Make temporary marks on clamps (2) in order to show correct orientation on bracket (11).

b. Remove retaining pins (21) from pins (23). Remove pins (23).

c. Remove clamp (2) from bracket (11).

d. Remove retaining pins (22) from pins (24). Remove pins (24).

e. Remove clamp (2) from bracket (11).

i04485826

Diesel Particulate Filter - Install

Installation 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.

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 and the convoluting.

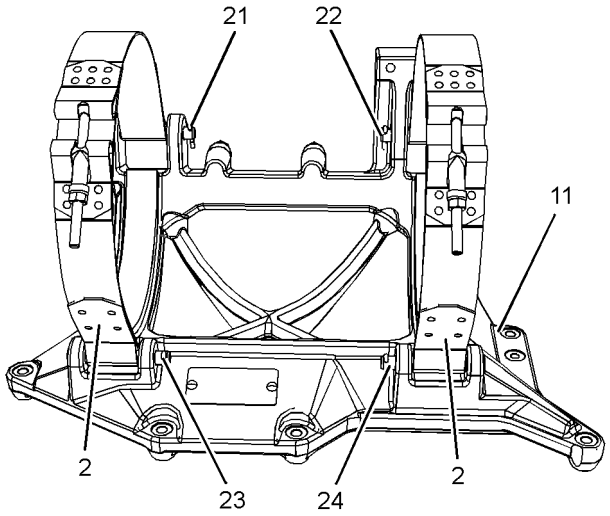

Illustration 155 g02464417

1. If necessary, follow Step 1.a thought Step 1.d in order to install clamps (2) to bracket (11).
   a. Position clamp (2) onto bracket (11). Ensure clamp (2) is correctly orientated. Install pins (23) to clamp (2).
   b. Install new retaining pins (21) to pins (23).
   c. Position clamp (2) to bracket (11). Ensure clamp (2) is correctly orientated. Install pins (24) to clamp (2).
   d. Install new retaining pins (22) to pins (24).

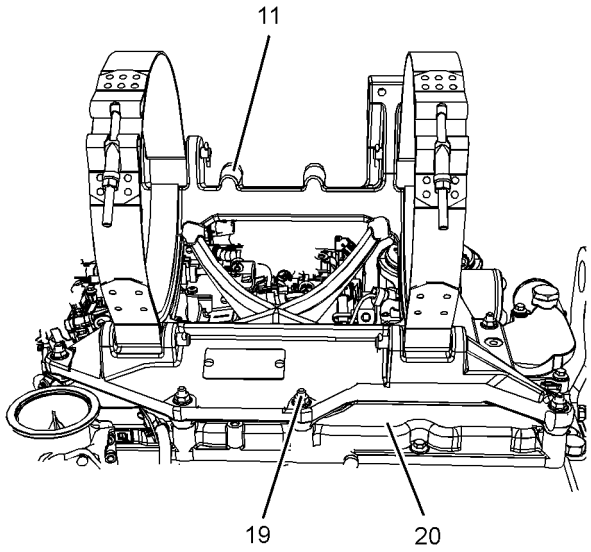

Illustration 156 g02464396

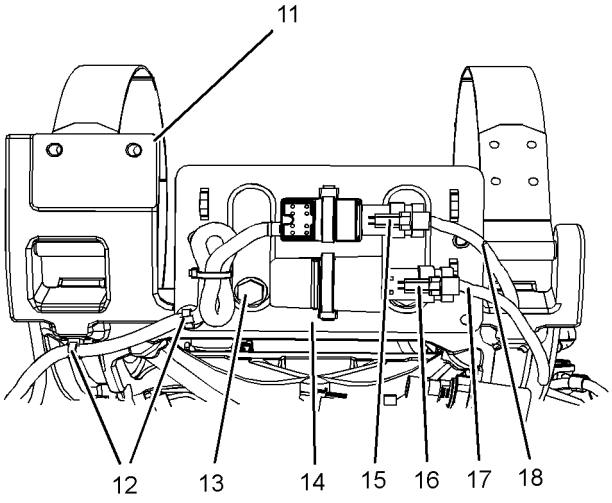

Illustration 157 g02464317

2. If necessary, follow Step 2.a thought Step 2.f in order to install bracket (11) to valve mechanism cover (20).
   a. Position bracket (11) onto valve mechanism cover (20).
   b. Install nuts (19) from bracket (11). Tighten the nuts to a torque of 22 N·m (195 lb in).

c. Position bracket (14) onto bracket (11). Install bolts (13). Tighten the bolts to a torque of 55 N·m (41 lb ft).

d. Connect harness assembly (18). Slide locking tab (15) into the lock position.

e. Connect harness assembly (17). Slide locking tab (16) into the lock position.

f. Install new cable straps (12) to the harness assembly for the temperature sensor.

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

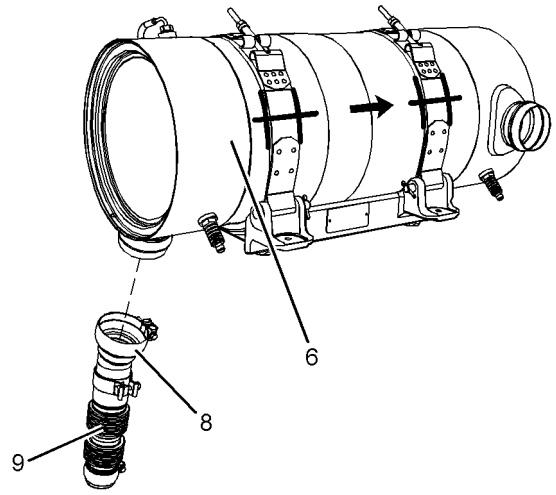

Illustration 158 g02313333

3. Position a new ball clamp (8) onto flexible exhaust pipe (9).

4. Attach a suitable lifting device to the assembly of the Diesel Particulate Filter (DPF) (6). The weight of the DPF is approximately 43 kg (95 lb).

5. Use the suitable lifting device in order to install the DPF to the mounting bracket for the clean emissions module.

Procedure for Reinstalling the Original Diesel Particulate Filter

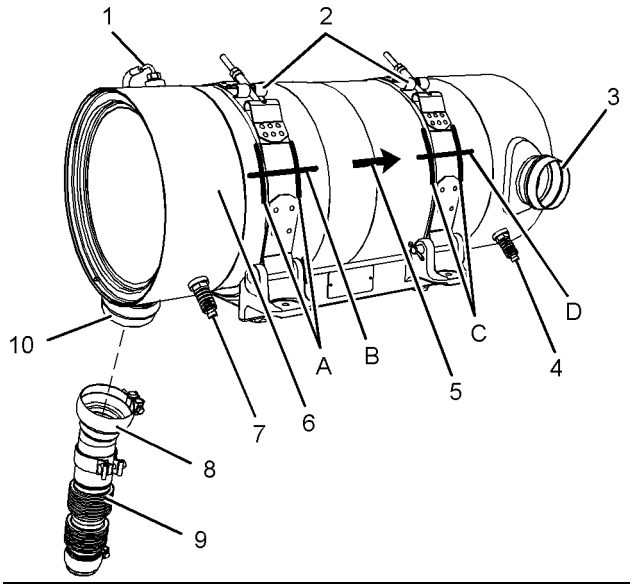

Illustration 159 g02520577

1. If the original DPF (6) will be reinstalled, follow Step 2 through Step 12 for the correct procedure.

2. Ensure that the exhaust gases flow in the direction of temporary mark (5).

3. Loosely install clamps (2).

4. Align temporary marks in Position (A), Position (B), Position (C), and Position (D) that were made on clamps (2) and DPF (6).

5. Tighten the nuts on clamps (2) to a torque of 17 N·m (151 lb in).

6. Loosely assemble the flexible exhaust pipe assembly (9) to inlet (10).

7. Loosely install the Original Equipment Manufacturer's (OEM) exhaust pipe assembly to outlet section (3) of the DPF.

8. Tighten the flexible exhaust pipe ball clamp (8) to a torque of 35 N·m (26 lb ft). Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

9. Tighten the OEM exhaust pipe assembly to the outlet section of the DPF. Refer to the OEM for the correct procedure.

10. Remove the suitable lifting device from the assembly of the DPF.

11. Install soot antenna (4) and soot antenna (7). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

12. Install temperature sensor (1) into the DPF. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

Procedure for Installing a Replacement Diesel Particulate Filter

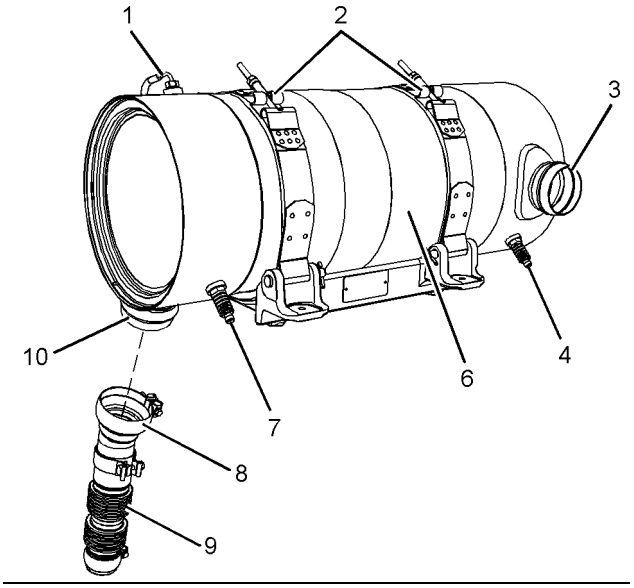

Illustration 160 g02520522

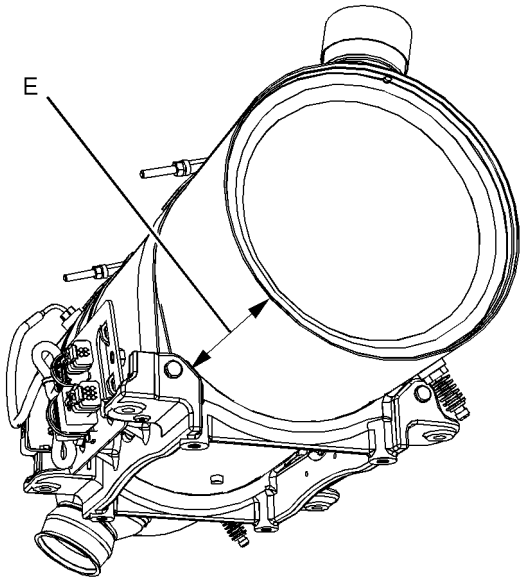

Illustration 161 g02520520

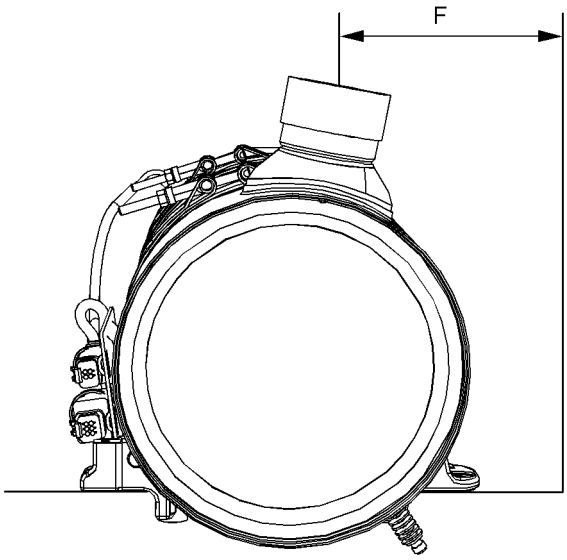

Illustration 162 g02520521

1. If a replacement DPF (6) is being installed, follow Step 2 through Step 10 for the correct procedure.

2. Loosely assemble the flexible exhaust pipe (9) to inlet (10).

3. Loosely install the Original Equipment Manufacturer's (OEM) exhaust pipe assembly to outlet section (3) of the DPF.

4. Using Dimension (E) and Dimension (F) that was recorded during the DPF removal procedure, position the DPF in the correct position.

5. Tighten the nuts on clamps (2) to a torque of 17 N·m (151 lb in).

6. Tighten the flexible exhaust pipe ball clamp (8). Refer to Disassembly and Assembly, “Flexible Exhaust Pipe - Remove and Install” for the correct procedure.

7. Tighten the OEM exhaust pipe assembly to the outlet section of the DPF. Refer to the OEM for the correct procedure.

8. Remove the suitable lifting device from the assembly of the DPF.

9. Install soot antenna (4) and soot antenna (7). Refer to Disassembly and Assembly, “Soot Antenna - Remove and Install” for the correct procedure.

10. Install temperature sensor (1) into the DPF. Refer to Disassembly and Assembly, “Temperature Sensor (DPF) - Remove and Install” for the correct procedure.

i04485888

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 23

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.

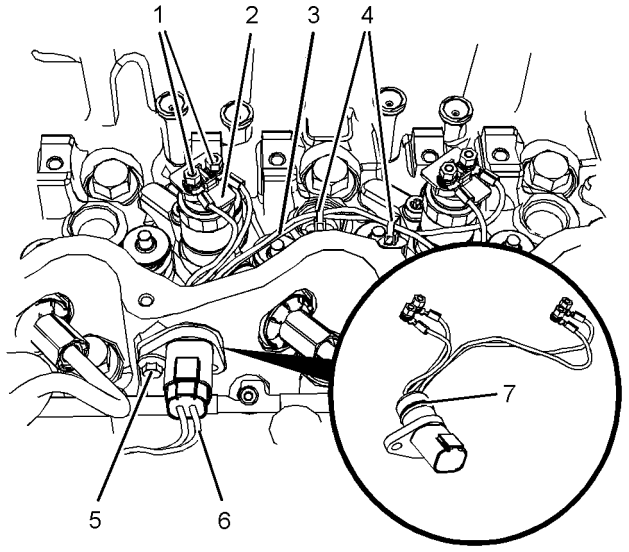

Illustration 163 g01978813

1. Follow Step 1.a through Step 1.h in order to remove the harness assemblies for the electronic unit injectors.

a. Place a temporary identification mark on connections (1) for harness assembly (3) for electronic unit injectors (2).

b. Use a deep socket to remove connections (1) from electronic unit injectors (2).

c. Cut cable straps (4) and remove the remaining sections of the cable straps from the cylinder head.

d. Disconnect plug (6) from harness assembly (3).

e. Remove bolt (5) from harness assembly (3).

f. Withdraw harness assembly (3) from the cylinder head.

g. Remove O-ring seal (7) from harness assembly (3).

h. Repeat Step 1.a through Step 1.g in order to remove the remaining harness assemblies.

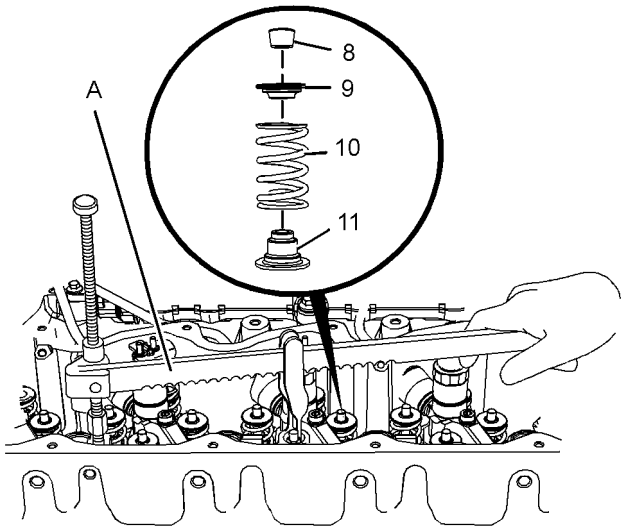

Illustration 164 g02501157

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.

a. Install Tooling (A) in position on the cylinder head in order to compress a valve spring (10) for the appropriate piston.

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 4 and 2 with 3. Ensure that all of the valve springs are installed before changing from one pair of cylinders to another pair of cylinders.

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).

Remove valve keepers (9).

4. Slowly release pressure on Tooling (A).

5. Remove valve spring retainer (9) and remove valve spring (10).

6. If necessary, remove valve stem seals (11).

7. Repeat Step 3 through Step 6 in order to remove the remaining valve springs from the appropriate cylinder.

8. Remove Tooling (A).

Installation Procedure

Table 24

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
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

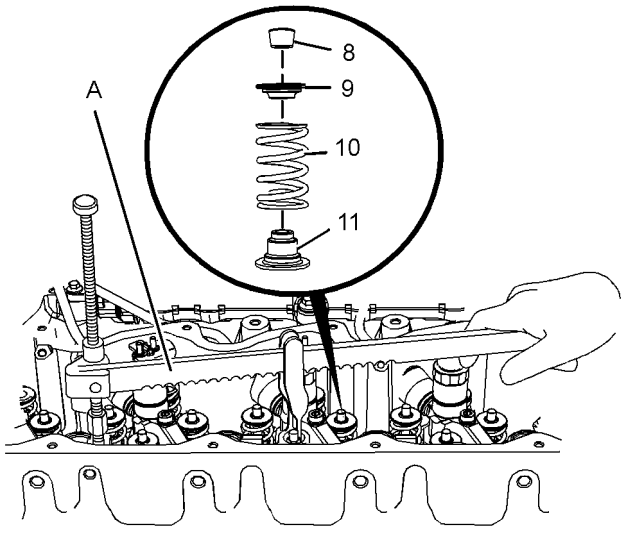

Illustration 165 g02501157

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

⚠ 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).

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 valves.

⚠ WARNING

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

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 4 and 2 and 3. 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.

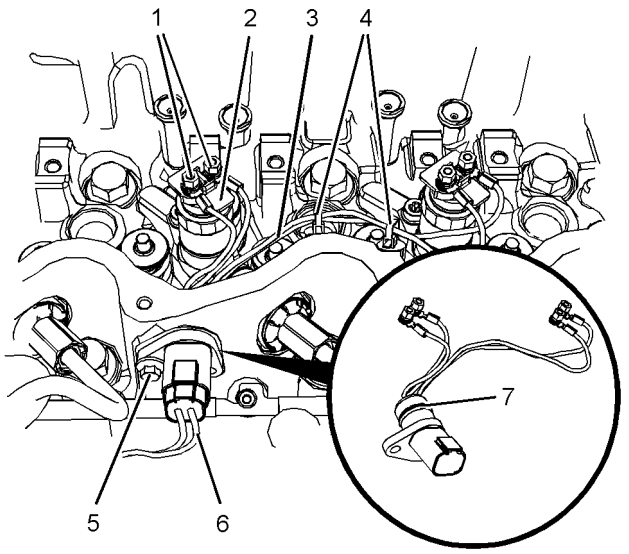

Illustration 166 g01978813

10. Follow Step 10.a through Step 10.g in order to install the harness assemblies for electronic unit injectors (2).

a. Ensure that harness assembly (3) for the electronic unit injectors is clean and free from damage. Replace any damaged components.

b. Install a new O-ring seal (7) onto harness assembly (3) for electronic unit injectors (2).

Note: Do not lubricate the O-ring seal.

c. Push harness assembly (3) into the cylinder head.

d. Install a new bolt (5) and tighten the bolt to a torque of 5.5 N·m (49 lb in).

e. Connect plug (6) from harness assembly (3).

f. 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).

g. Install new assemblies of the cable straps (4) to harness assembly (3).

Note: Ensure that the cable straps meet the OEM specification. Ensure that the assemblies of the cable straps are correctly installed into the cylinder head.

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

End By:

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

i04485889

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 25

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 65 kg (143 lb).

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

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

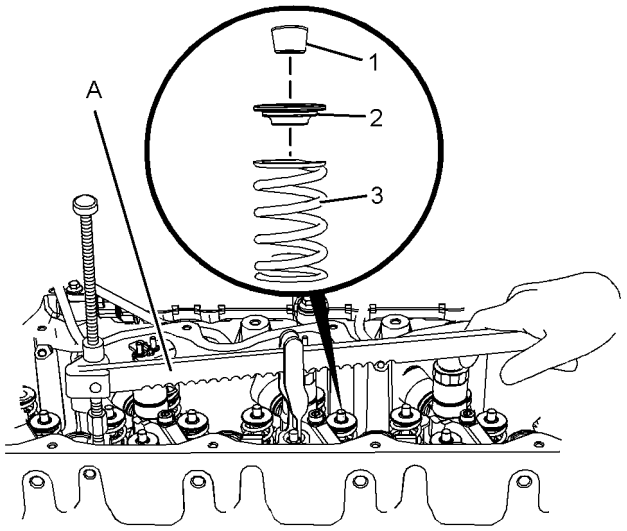

Illustration 167 g02511756

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

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

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

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

6. Slowly release pressure on Tooling (A).

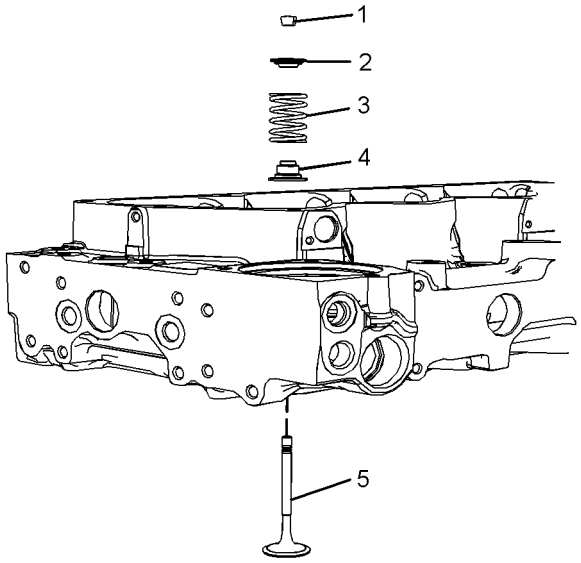

Illustration 168 g02511676

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 in order to carefully turn over the cylinder head.

13. Remove valves (5).

Installation Procedure

Table 26

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.d in order to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.

   a. Inspect the cylinder head for wear and for damage. Refer to System Operation, Testing and Adjusting, “Cylinder Head Inspect” for the correct procedure.

   b. Inspect the valve seats for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for further information.

   c. Inspect the valve guides for wear and for damage. Refer to Specifications, “Cylinder Head Valves” and System Operation, Testing and Adjusting, “Valve Guide - Inspect” for further information.

   d. Inspect the valves for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for further information.

   e. Inspect valve springs (3) for damage and for the correct length. Refer to Specifications, “Cylinder Head Valves ” for further information.

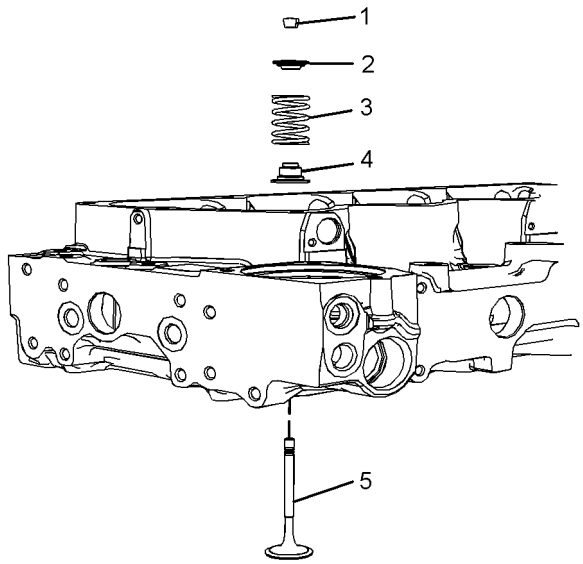

Illustration 169 g02511676

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 in order to carefully turn over the cylinder head. The weight of the cylinder head is approximately 65 kg (143 lb).

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

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

Note: The outer face of the valve guides must be clean and dry before installing valve stem seals (4).

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

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

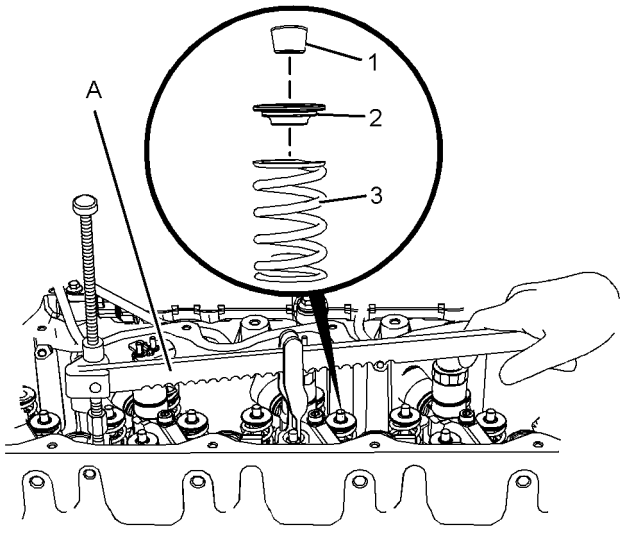

Illustration 170 g02511756

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.

i04485839

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 27

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

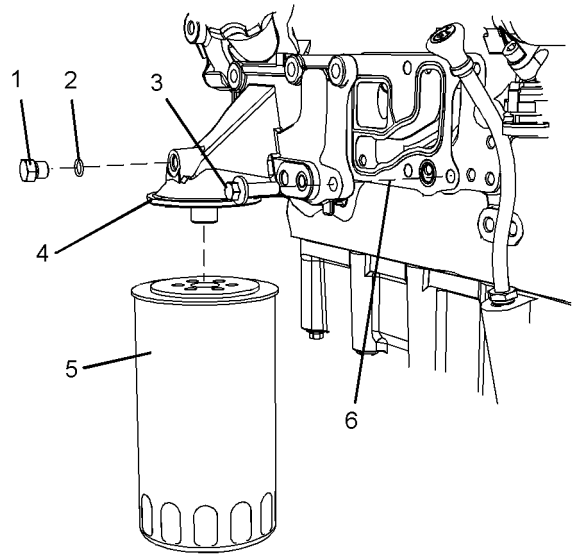

Illustration 171 g02475535

1. Place a suitable container below engine oil filter base (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).

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.

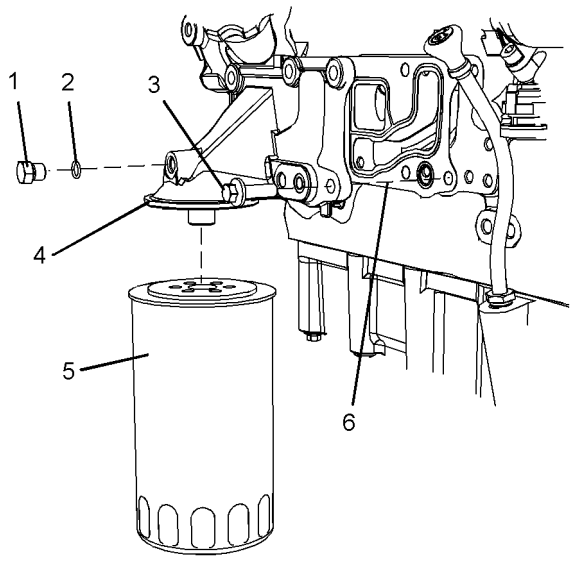

Illustration 172 g02475535

1. Clean engine oil filter base (4). Clean the gasket surfaces of the cylinder block.

2. If necessary, install new O-ring seals (2) to plugs (1). Install plugs (1) to engine oil filter base (4). Tighten the plugs 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.

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.

i04485838

Engine Oil Cooler - Remove

Removal Procedure

Start By:

a. Remove the Electronic Control Module (ECM). Refer to Disassembly and Assembly, “Electronic Control Module - Remove” 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.

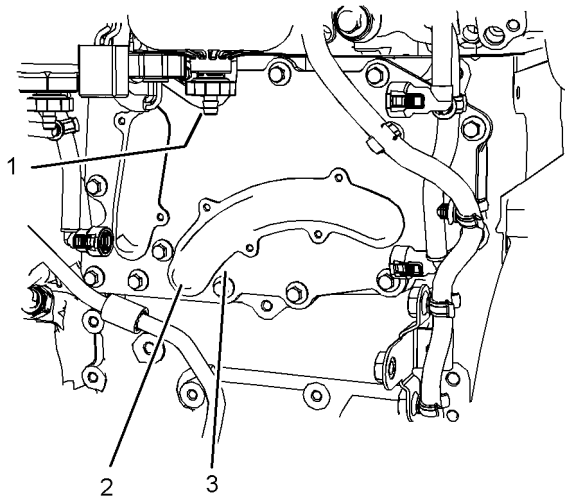

Illustration 173 g02475489

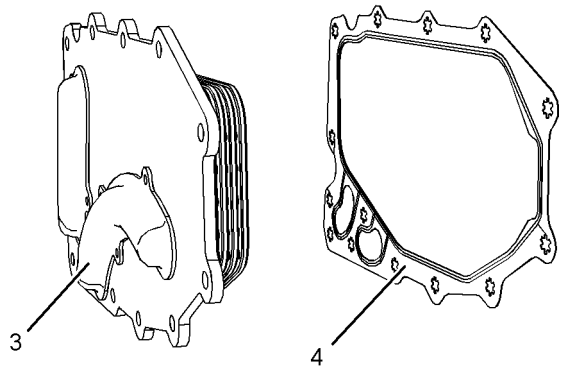

Illustration 174 g02475493

2. Remove spacer (1) (not shown) from the cylinder block.

3. Remove bolt (2) from the assembly of engine oil cooler (3).

Note: Support the engine oil cooler as the bolts are removed.

4. Remove the assembly of engine oil cooler (3) from the cylinder block.

5. Remove gasket (4) from engine oil cooler (3).

i04485836

Engine Oil Cooler - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

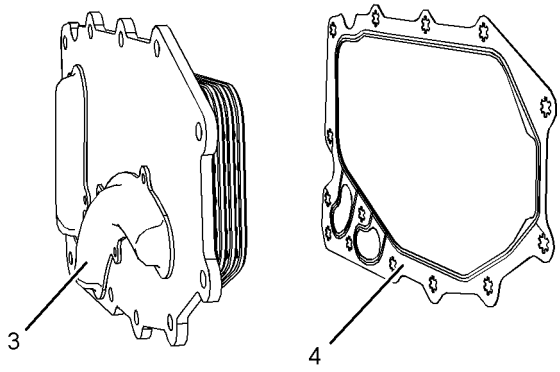

Illustration 175 g02475493

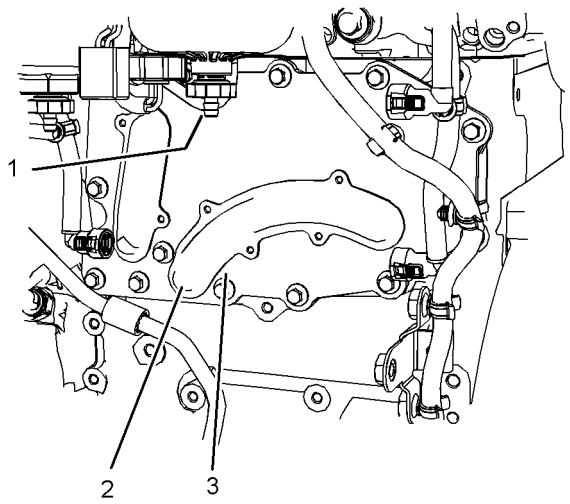

Illustration 176 g02475489

1. Ensure that engine cooler (3) is clean and free from damage. Ensure that the engine oil cooler is free from restriction.

2. Position a new gasket (3) onto engine oil cooler (2).

3. Push bolts (1) through the holes in the gasket.

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

4. Clean the gasket surfaces of the cylinder block.

5. Position engine oil cooler (3) onto the cylinder block. Hand tighten bolts (2).

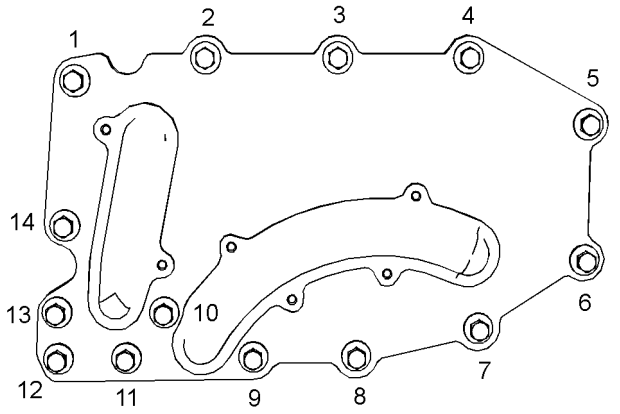

Illustration 177 g02475494

Tightening sequence for an engine oil cooler

6. Tighten the bolts to a torque of 26 N·m (230 lb in) in the sequence that is shown in Illustration 177.

7. Install spacer (1) (not shown). Tighten the bolts to a torque of 44 N·m (32 lb ft). Refer to Illustration 176

End By:

a. Install the Electronic Control Module (ECM). Refer to Disassembly and Assembly, “Electronic Control Module - Install” for the correct procedure.

i04485844

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.

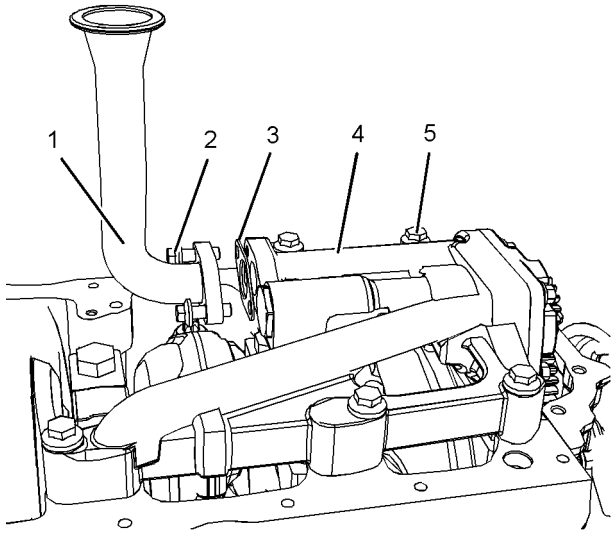

Illustration 178 g02476517

1. Remove bolts (2). Remove suction pipe (1) from engine oil pump (4).

2. Remove gasket (3).

3. Remove bolts (5) and remove the assembly of engine oil pump (4) from the cylinder block.

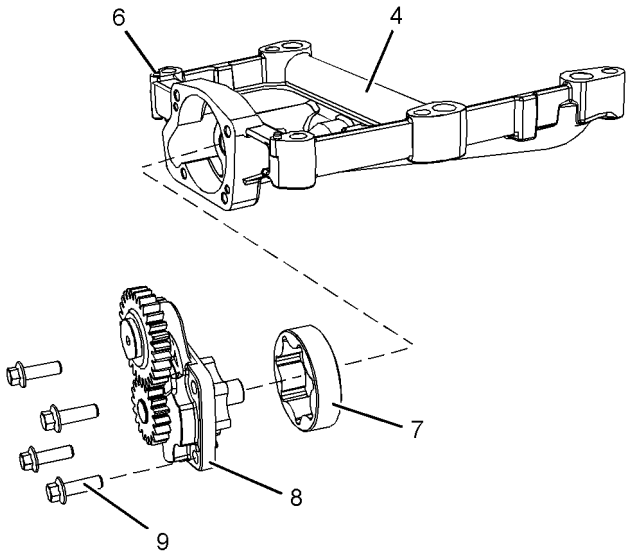

Illustration 179 g02476518

4. If necessary, follow Step 4.a through Step 4.d in order to disassembly engine oil pump (4).

   a. Remove bolts (9) from front cover assembly (8).

   b. Remove front cover assembly (8) from the housing of the engine oil pump (4).

   c. Remove outer rotor (7) from the housing of engine oil pump (4).

   d. Do not remove dowel (6) from the housing of engine oil pump (4) unless the dowels are damaged.

i04485843

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.

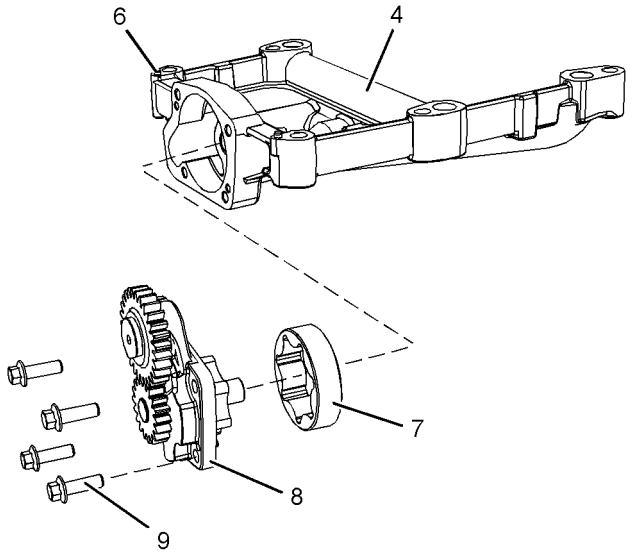

Illustration 180 g02476518

2. If necessary, follow Step 2.a through Step 2.f in order to assembly engine oil pump (4).

   a. Lubricate the internal components for the assembly of engine oil pump (4) with clean engine oil.

   b. Install outer rotor (7) to the housing of engine oil pump (4).

   c. Install front cover assembly (8) to the housing of the engine oil pump (4).

   d. Install bolts (9) to front cover assembly (8). Tighten the bolts finger tight.

   e. Tighten bolts (8) to a torque of 24 N·m (212 lb in).

   f. Ensure that dowels (6) are correctly located in the housing of engine oil pump (4).

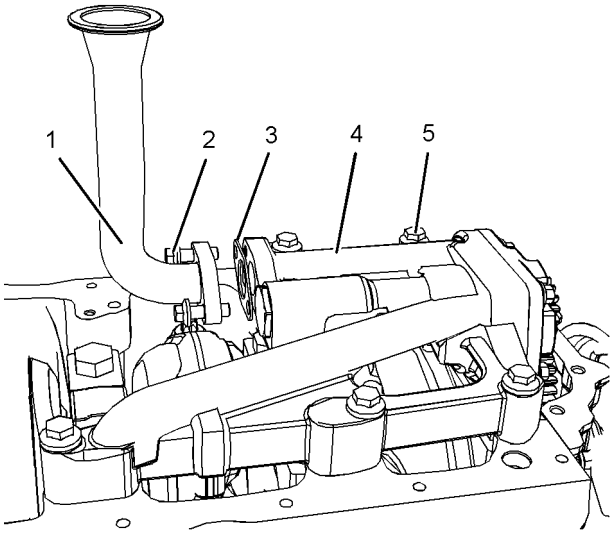

Illustration 181 g02476517

3. Position the assembly of engine oil pump (4) 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.

4. Install bolts (5). Tighten the bolts to a torque of 44 N·m (32 lb ft).

5. Check the backlash between idler gear and the crankshaft gear. Refer to Specifications, “Gear Group (Front)” for further information.

6. Position a new gasket (3) onto suction pipe (1). Install the assembly of suction pipe (1) onto the assembly of engine oil pump (4).

7. Install bolts (2) finger tight. Tighten the bolts to a torque to 22 N·m (195 lb in).

End By:

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

i04485917

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.

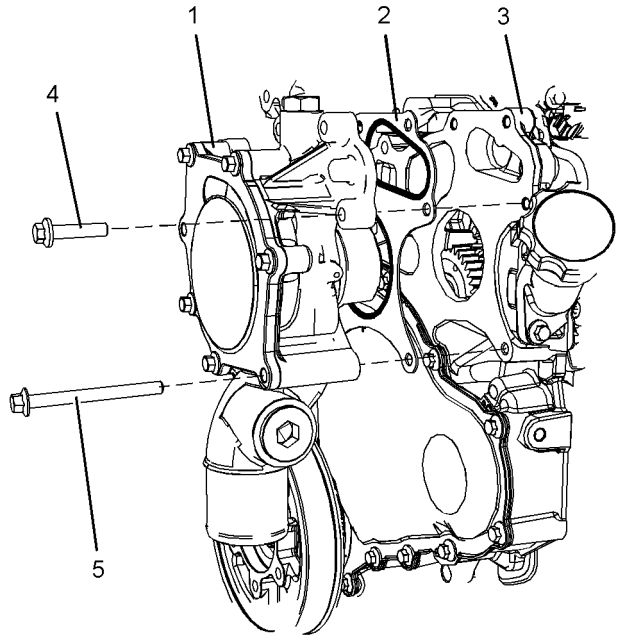

Illustration 182 g02524476

3. Remove bolts (4) and bolts (5).

4. Remove water pump (1) from housing (3).

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

5. Remove gasket (2).

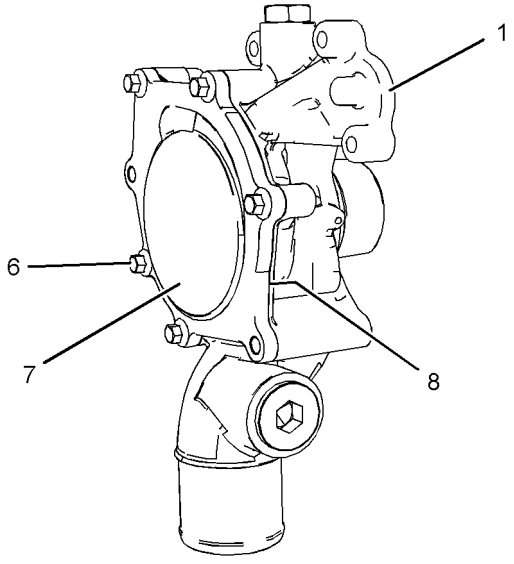

Illustration 183 g02524477

6. If necessary, remove cover (7) from the water pump. Follow Step 6.a through Step 6.c in order to remove the cover.

a. Remove bolts (6).

b. Remove cover (7).

c. Remove O-ring seal (8) (not shown).

i04485916

Water Pump - Install

Installation Procedure

Table 28

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.

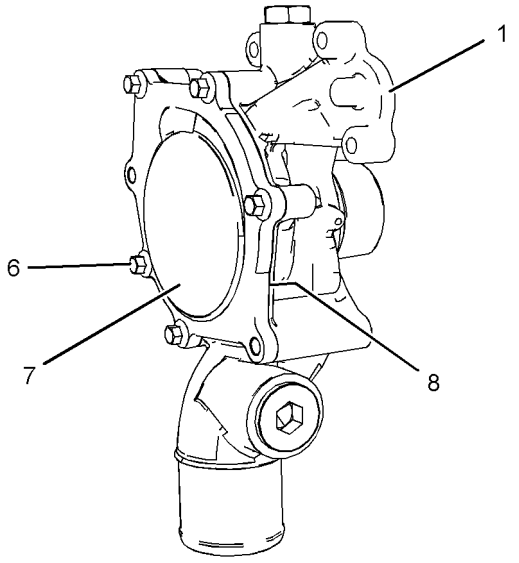

Illustration 184 g02524477

2. If necessary, install cover (7) to water pump (1). Follow Step 2.a through Step 2.d in order to install the cover.

a. Clean the gasket surface of cover (7).

b. Position a new O-ring seal (8) (not shown) onto water pump (1).

c. Install cover (7) to water pump (1).

d. Install bolts (6) to cover (7). Tighten the bolts to a torque of 22 N·m (195 lb in).

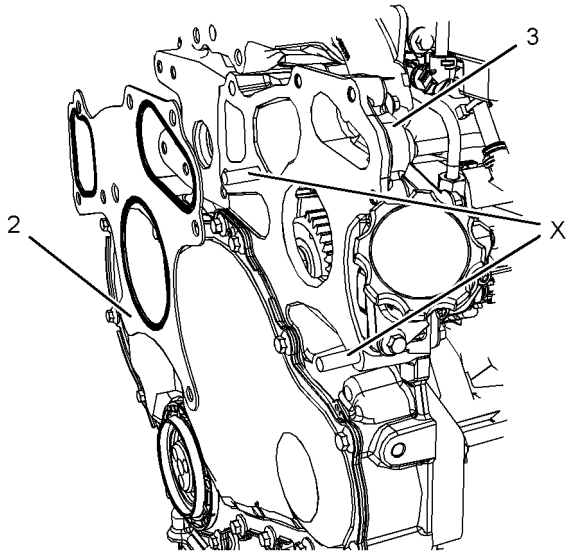

Illustration 185 g02524518

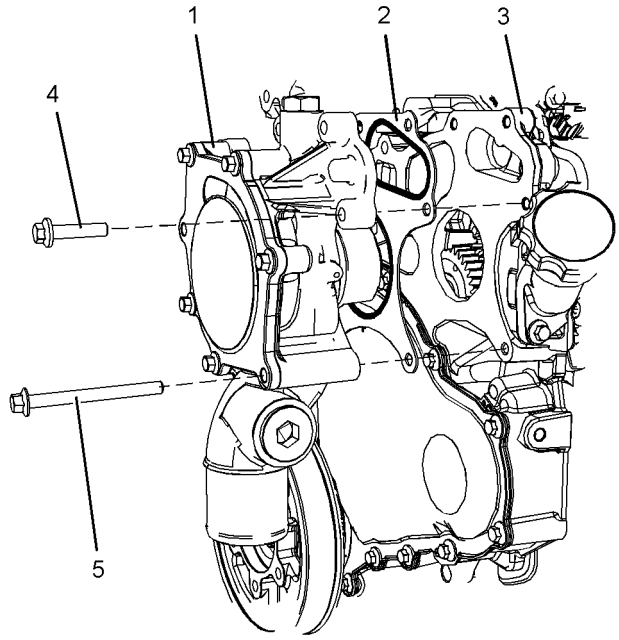

Illustration 186 g02524516

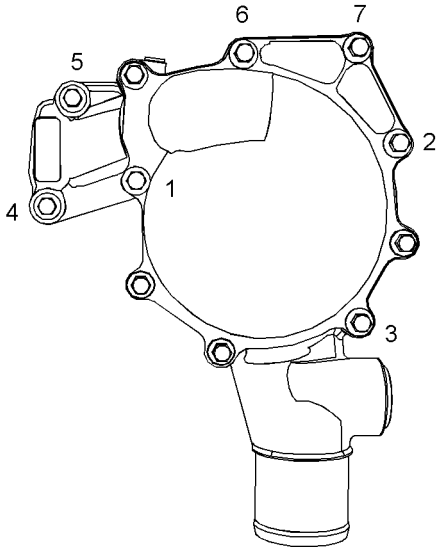

Illustration 187 g01985813

3. Clean the gasket surface of housing (3).

4. Install Tooling (A) in Position (X).

5. Use Tooling (A) in order to align new gasket (2) to housing (3). Install the gasket onto the housing.

6. Align water pump (1) 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.

7. Install bolts (4) and bolts (5). Refer to Illustration 186. Tighten the bolts finger tight.

8. Remove Tooling (A) and install remaining bolts (4) and bolts (5).

9. Tighten bolts (4) and bolts (5) in the sequence that is shown in Illustration 187 to a torque of 22 N·m (195 lb in).

10. Install the hose to the water pump inlet. Tighten the hose clamps.

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

End By:

a. Install the fan and the fan pulley. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04485919

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.

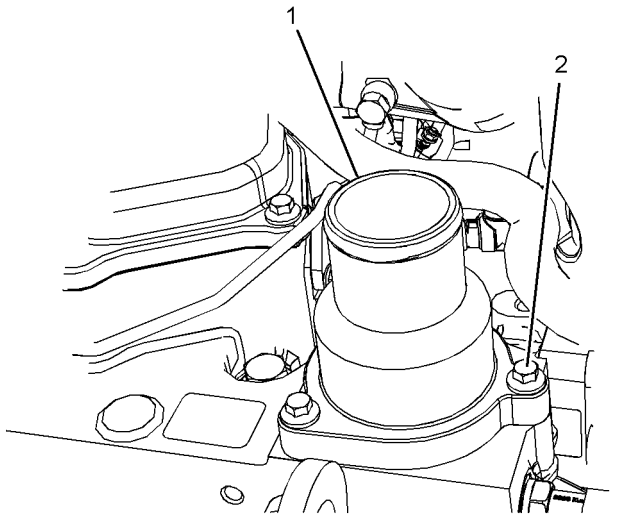

Illustration 188 g02524799

2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from water temperature regulator housing (1).

3. Remove bolts (2) from water temperature regulator housing (1).

4. Remove water temperature regulator housing (1) 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.

1. Ensure that all components of water temperature regulator housing (2) are clean and free of wear and damage. Check the water temperature regulator for correct operation. Refer to System Operation, Testing and Adjusting, “Water Temperature Regulator - Test” for the correct procedure to test the water temperature regulator. If any components of the water temperature regulator housing are worn or damaged, the complete assembly must be replaced.

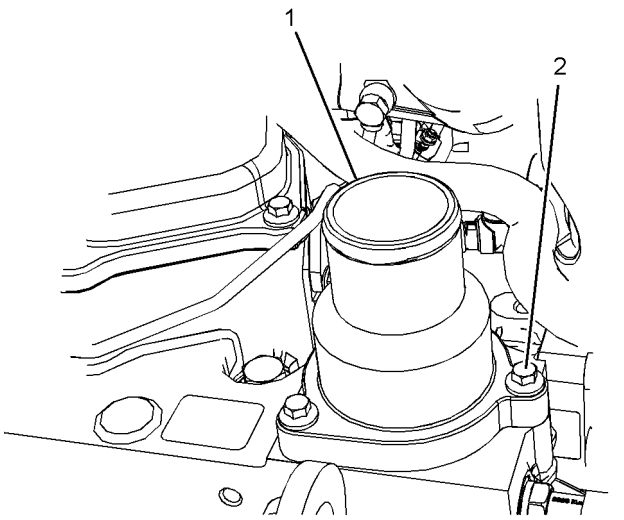

Illustration 189 g02524799
Typical example

2. If the original water temperature regulator (1) is to be installed. Ensure that the seal is not damaged and is correctly positioned in water temperature regulator housing (2).

3. Install water temperature regulator housing (1) to the cylinder head.

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

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

5. Connect the upper radiator hose and tighten the hose clamps.

6. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Check” and Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct filling procedure.

i04485858

Flywheel - Remove

Removal Procedure

Table 29

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.

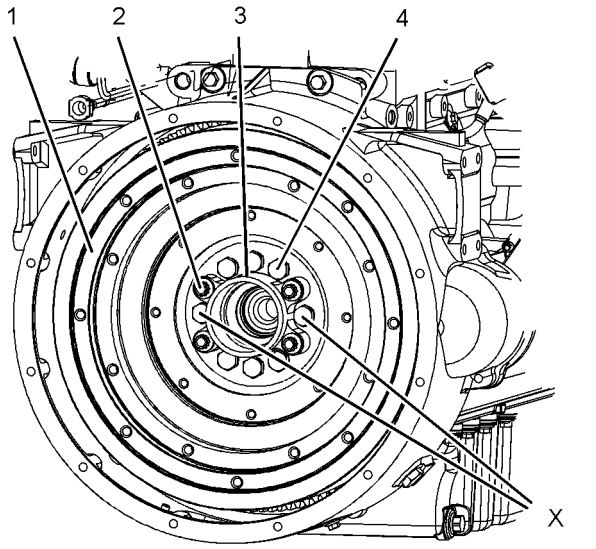

Illustration 190 g01336668
Typical example

1. Remove bolts from Position (X) on flywheel (1).

2. Install Tooling (A) in Position (X) on flywheel (1).

3. Install a suitable lifting device on 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.

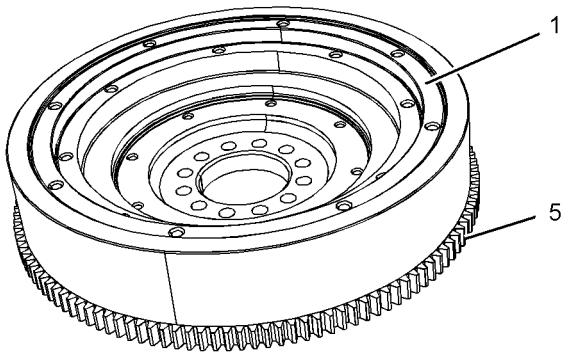

Illustration 191 g01336669
Typical example

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.

i04485857

Flywheel - Install

Installation Procedure

Table 30

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.

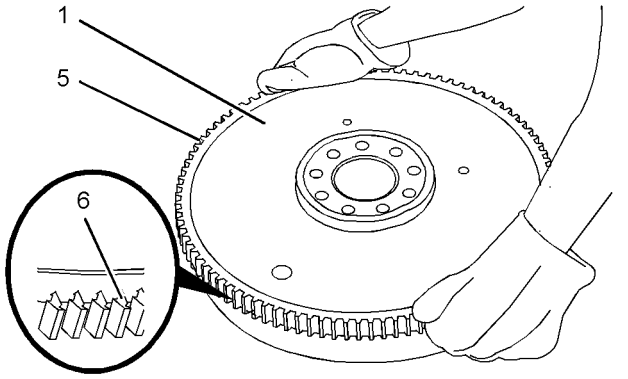

Illustration 192 g01336671
Typical example

⚠ 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. This will ensure the correct engagement of the starting motor.

   b. Heat flywheel ring gear (5) in an oven to a maximum temperature of 250 °C (482 °F) prior to installation.

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

   c. Ensure that the orientation of ring gear (5) is correct and quickly install the ring gear onto flywheel (1).

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

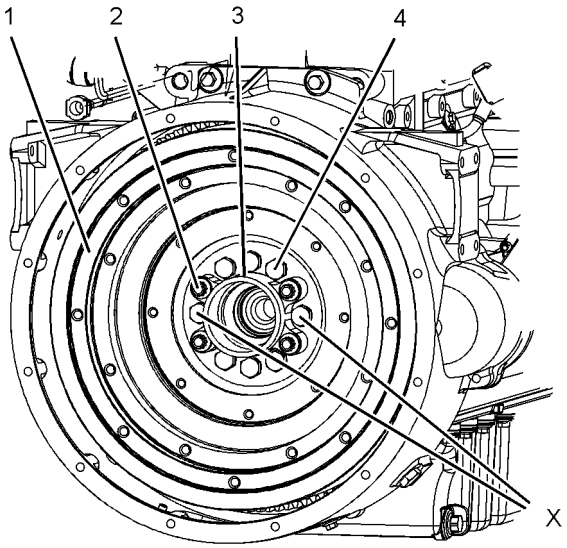

Illustration 193 g01336668
Typical example

3. Install a suitable lifting device on 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.

i04485822

Crankshaft Rear Seal - Remove

Removal Procedure

Table 31

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	E10 Torx Socket	1

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.

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

Dispose of all fluids according to local regulations and mandates.

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

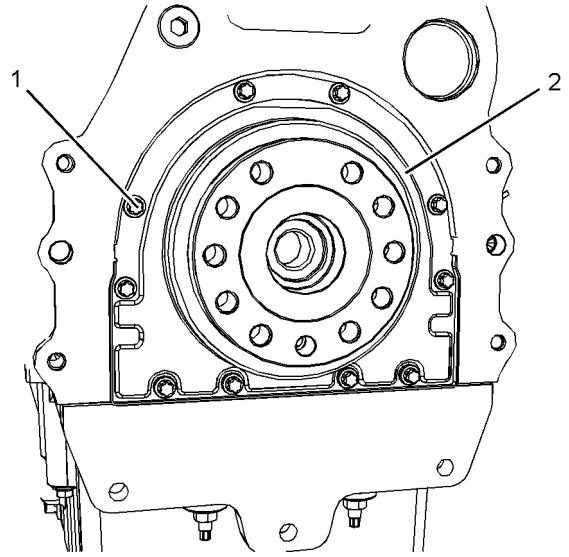

Illustration 194 g02449936

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

i04485821

Crankshaft Rear Seal - Install

Installation Procedure

Table 32

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	E10 Torx Socket	1
B	27610306	Alignment Tool	1

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

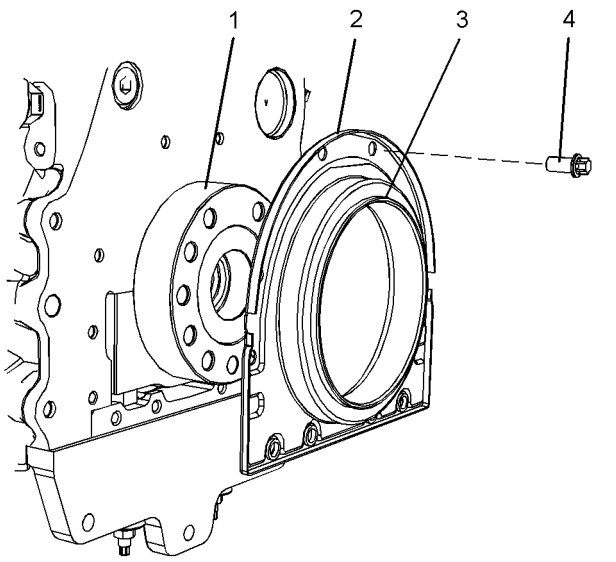

Illustration 195 g02450219

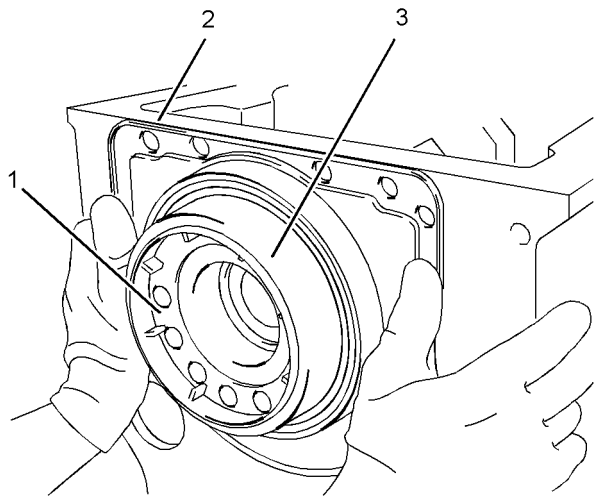

Illustration 196 g02450222

1. Ensure that crankshaft flange (1) is clean, dry, and free from damage.
2. Ensure that the face of the cylinder block and the bridge piece are clean and dry.
3. A new crankshaft rear seal is supplied with a plastic sleeve (3). Ensure that the plastic sleeve is squarely installed within crankshaft rear seal (2).

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

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

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

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

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

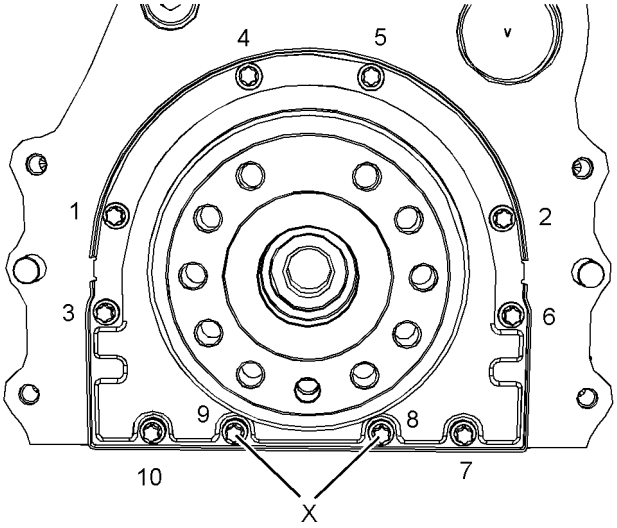

Illustration 197 g02451996

6. Install Torx screws (4) finger tight.

   Tightening sequence for the crankshaft rear seal

Note: Do not install Torx screws to Positions (X) at this stage.

7. Install Tooling (B) to crankshaft rear seal (2) and to crankshaft flange (1).

8. Use Tooling (A) in order to tighten Torx screws (4) to a torque of 22 N·m (195 lb in). Tighten Torx screws (4) in the sequence that is shown in Illustration 197.

9. Remove Tooling (B).

10. Install remaining Torx screws (4) to Positions (X). Use Tooling (A) in order to tighten the Torx screws to a torque of 22 N·m (195 lb in). Refer to Illustration 197.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i04485860

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

Removal Procedure

Table 33

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.

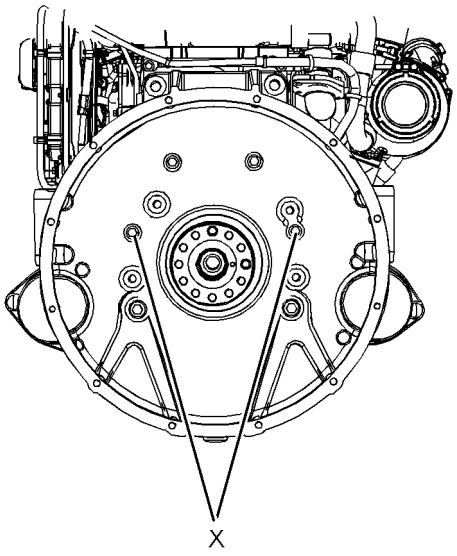

Illustration 198 g01986178
Typical example

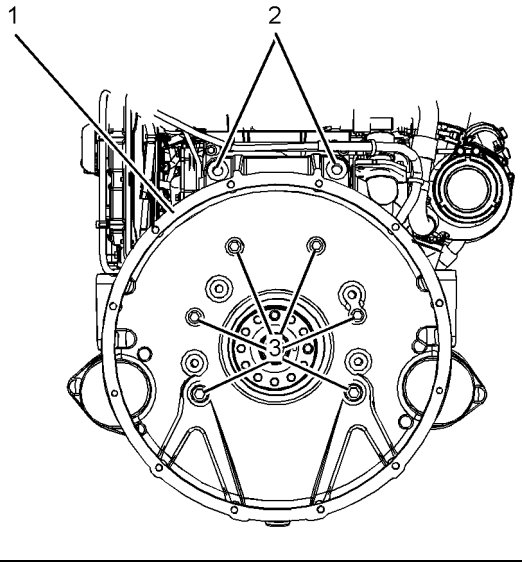

Illustration 199 g01988515

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 to the flywheel housing in order to support the flywheel housing. The flywheel housing can weigh 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.

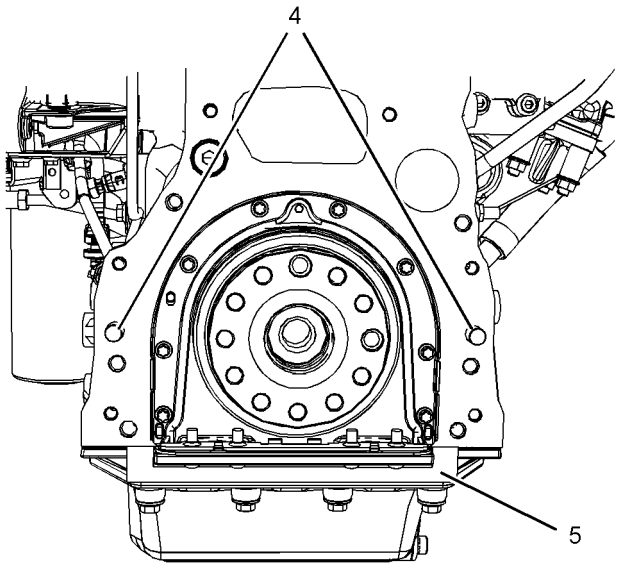

Illustration 200 g01988534
Typical example

6. Remove dust seal (5).

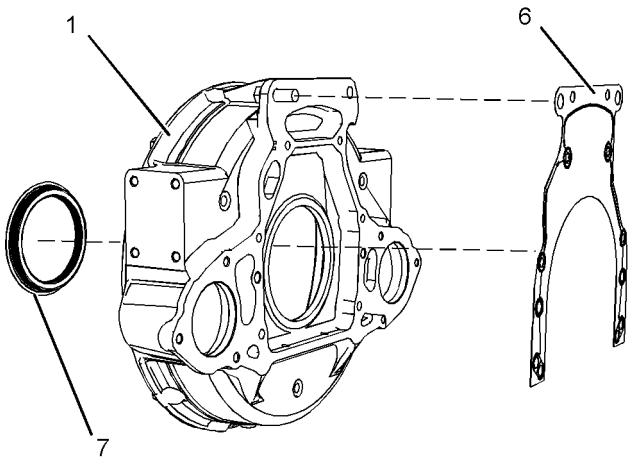

Illustration 201 g01988535
Typical example

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 34

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.

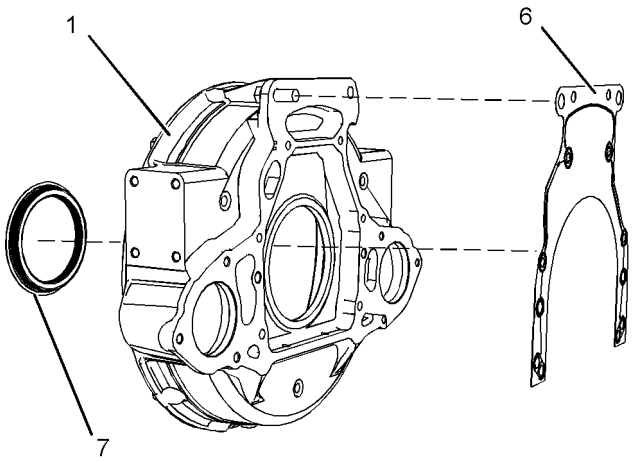

Illustration 202 g01988676
Typical example

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 .

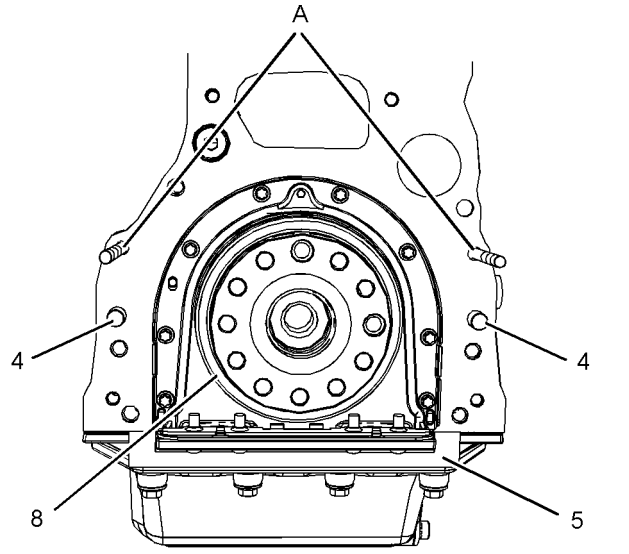

Illustration 203 g01988677
Typical example

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).

8. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 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).

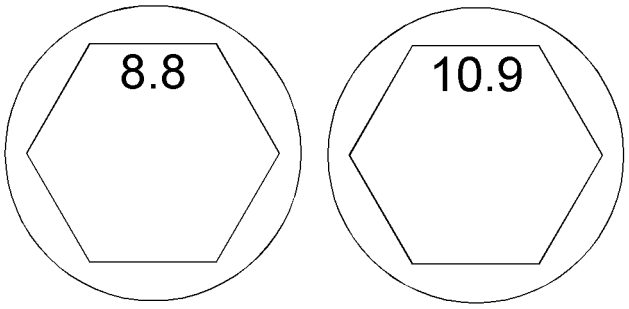

Illustration 204 g01984554
Identification of the bolt Grade.

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 further information.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i04485859

Flywheel Housing - Remove and Install (Standard Housing)

Removal Procedure

Table 35

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 pro.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

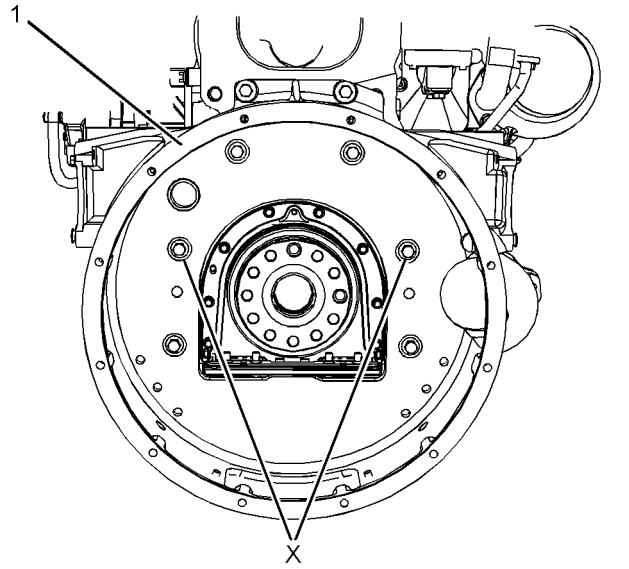

Illustration 205 g01983516
Typical example

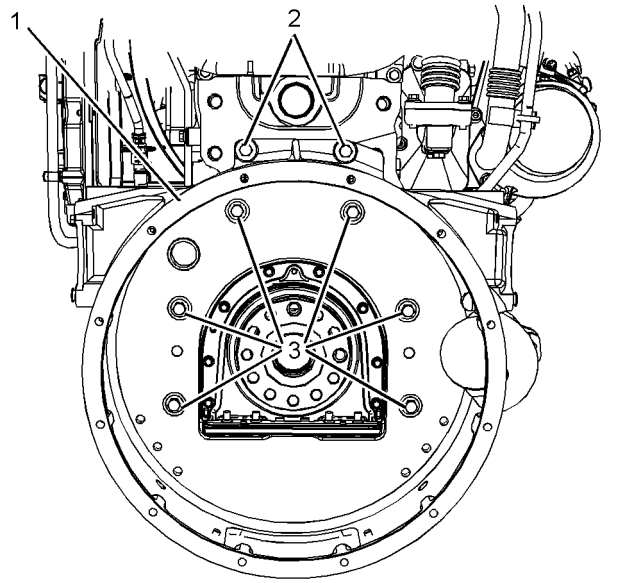

Illustration 206 g01981253

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 to the flywheel housing in order to support the flywheel housing. The flywheel housing can weigh 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.

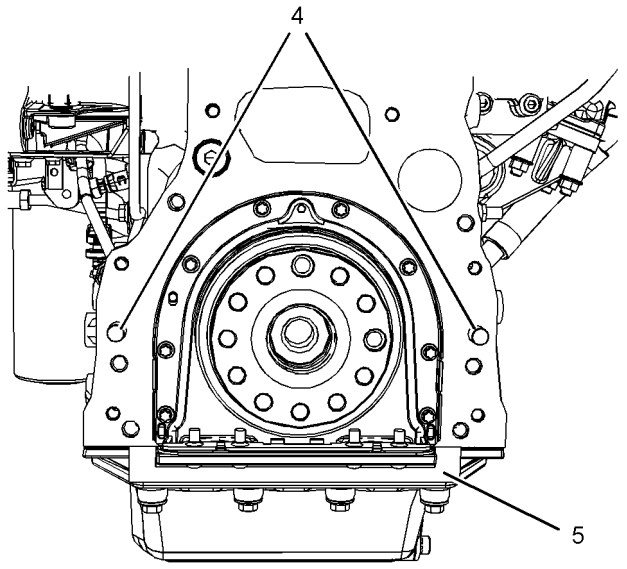

Illustration 207 g01983533
Typical example

6. Remove dust seal (5).

7. If necessary, remove dowels (4) from the cylinder block.

Installation Procedure (Standard Housing)

Table 36

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.

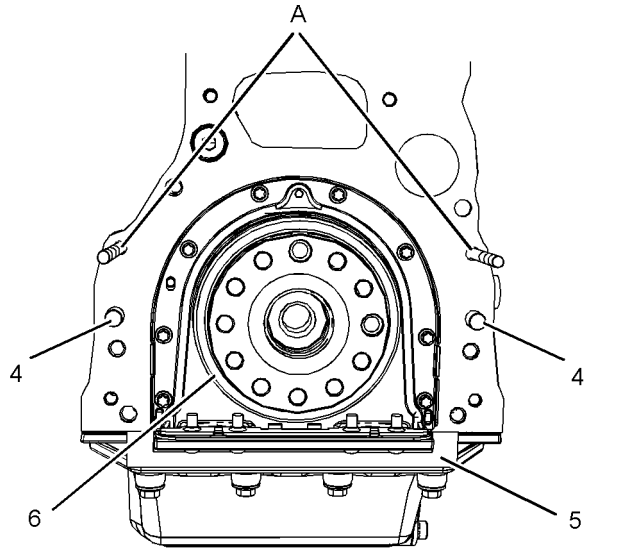

Illustration 208 g01983535
Typical example

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).

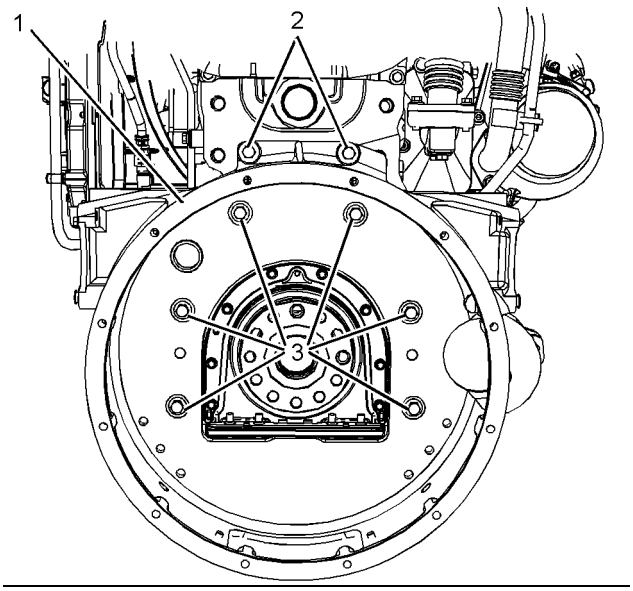

Illustration 209 g01981253
Typical example

6. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 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).

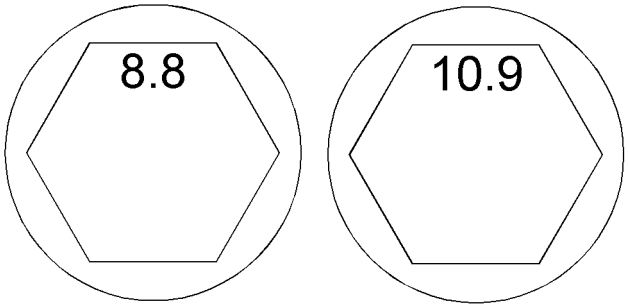

Illustration 210 g01984554

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 the correct procedure.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i04485820

Crankshaft Pulley - 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.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

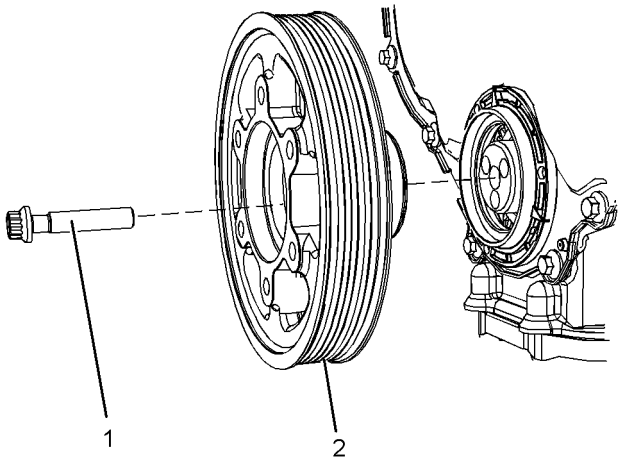

Illustration 211 g02449658

1. Use a suitable tool in order to prevent the crankshaft from rotating. Remove bolts (1).

2. Remove crankshaft pulley (2) from the crankshaft.

Installation Procedure

Table 37

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825607	Degree Wheel	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the pulley is clean and free from damage. Replace any components that are damaged.

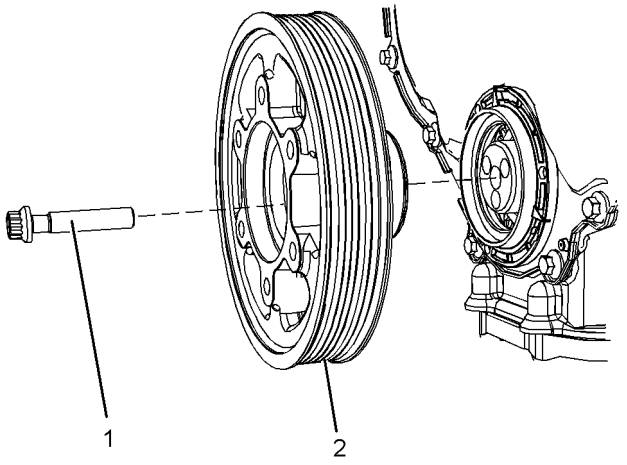

Illustration 212 g02449658

2. Install a new front seal to the front cover. Refer to Disassembly and Assembly, “Crankshaft Front Seal - Remove and Install” for the correct procedure.

3. Install crankshaft pulley (2) to the crankshaft.

Note: Do not lubricate the front seal or the seal face of the crankshaft pulley.

4. Install bolts (1).

5. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the bolts to a torque of 22 N·m (195 lb in).

6. Use tooling (A) in order to turn bolts (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.

i04485815

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 38

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, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

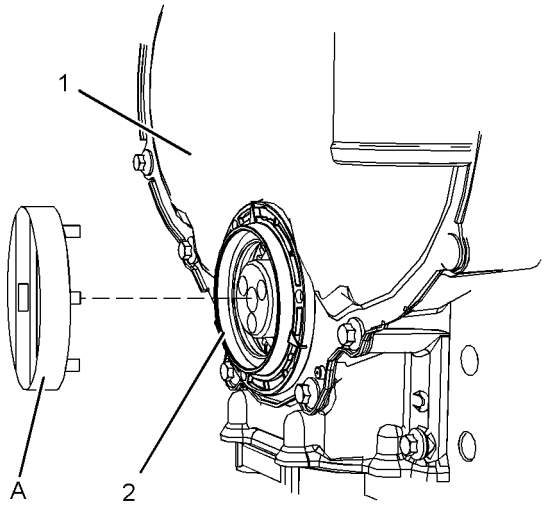

Illustration 213 g02445196

1. Align 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 39

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T400016	Oil Seal Removal & installer Tool	1
B	-	Loctite 5900 Silicone Gasket	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.

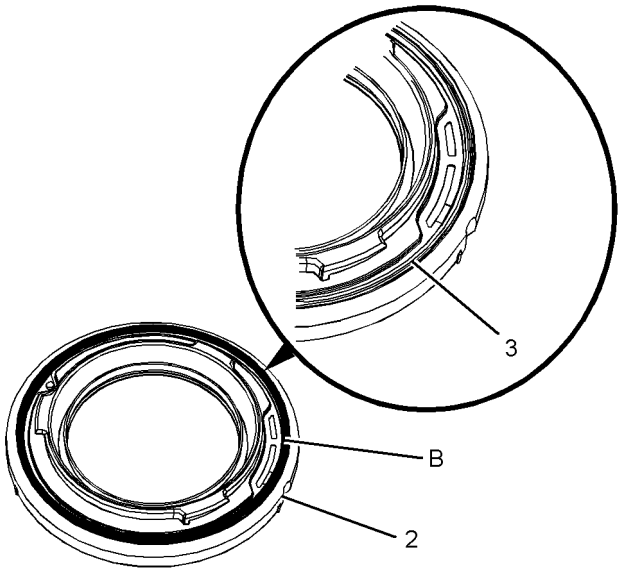

Illustration 214 g02445217

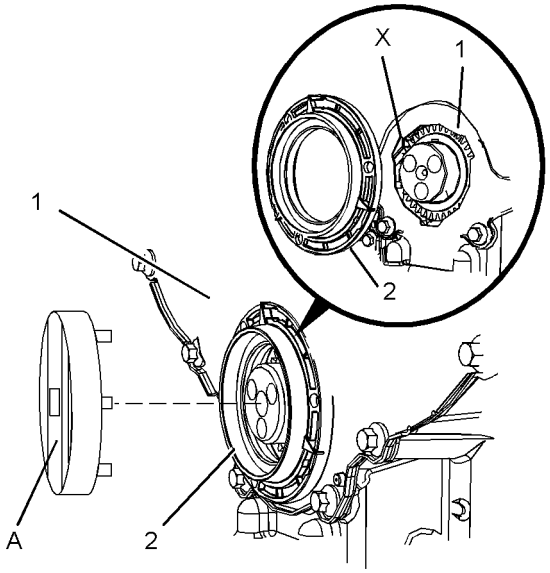

Illustration 215 g02445197

2. Apply a continuous bead of Tooling (B), approximately 3 mm (0.118 inch) in diameter, to the top of the static seal beads (3).

3. Correctly position a new crankshaft front seal (2) in Position (X) onto front cover (1).

4. Position Tooling (A) onto crankshaft front seal (2).

5. Use Tooling (A) in order to turn crankshaft front seal (2) in clockwise direction.

6. 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.

7. If necessary repeat Step 2 through Step 6 in order to install crankshaft front seal (2).

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

i04485814

Crankshaft Front Seal - Remove and Install (Crankshaft Front Seal for Heavy Duty Front Cover)

Removal Procedure

Table 40

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

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

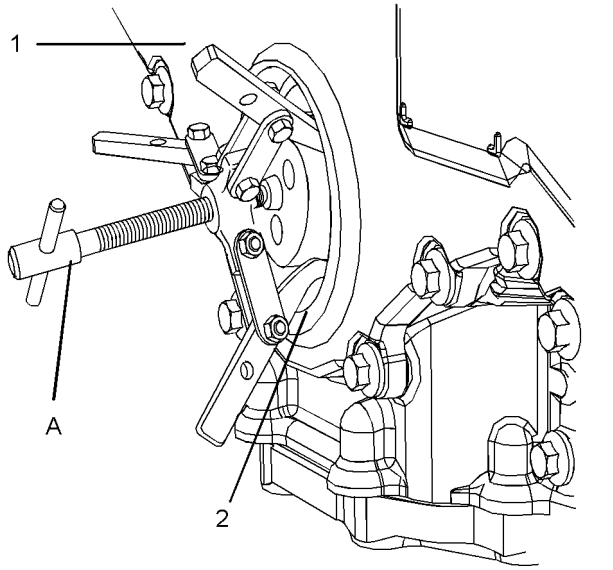

Illustration 216 g02443718

1. Install the legs of Tooling (A) behind crankshaft front seal (2). Install a suitable spacer between Tooling (A) and the crankshaft.

2. Use Tooling (A) in order to pull crankshaft front seal (2) out of front cover (1).

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

Installation Procedure

Table 41

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	21825577	Front Seal Installer	1
	21825578	Plate	1
	21825580	Anchor Plate	1
	27610284	Seal Installer Tool	1
	21825579	Sleeve	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

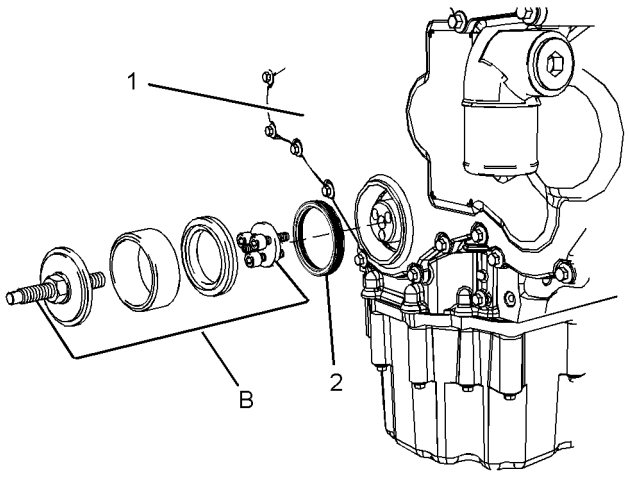

Illustration 217 g02443719

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, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

i04485862

Front Cover - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install” for the correct procedure.

b. If the engine has a fan, remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

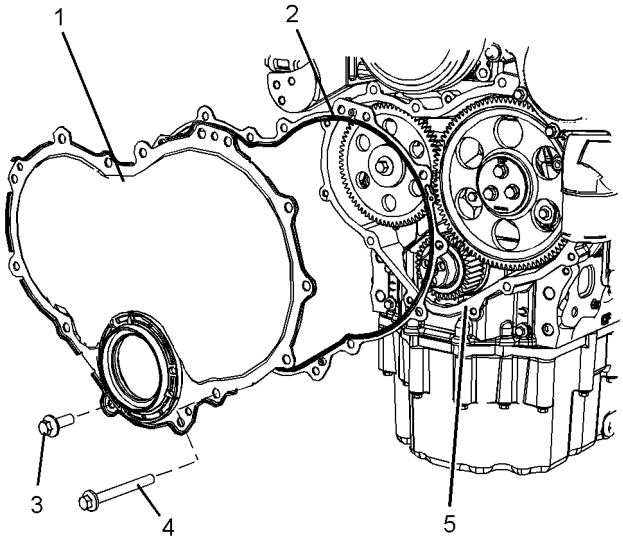

Illustration 218 g02481028

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 front housing (5).

4. Remove gasket (2).

Installation Procedure

Table 42

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 70 mm	2
B	T400017	Front Cover Alignment Tool	1

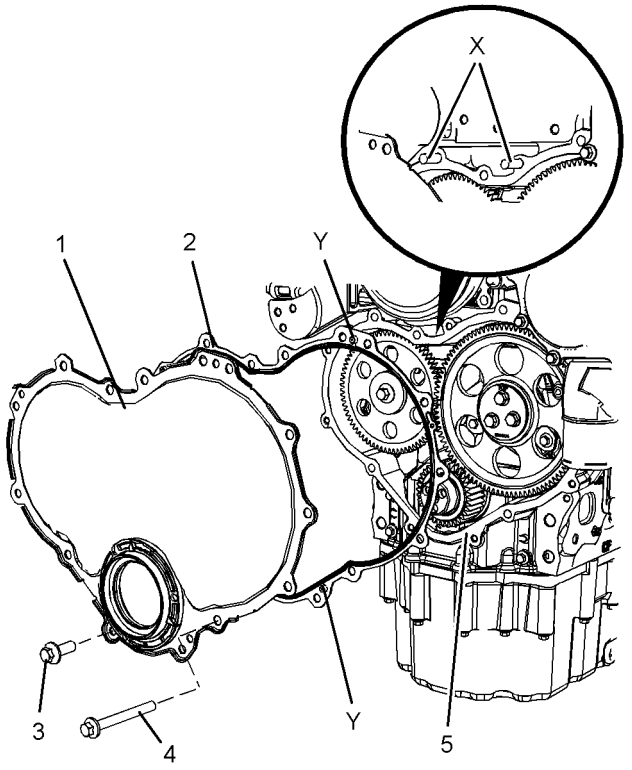

Illustration 219 g02481030

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 front housing (5).

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 the remaining bolts.

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, “Crankshaft Pulley - Remove and Install” for the correct procedure.

b. If the engine has a fan, install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04485861

Front Cover - Remove and Install (Heavy Duty Front Cover)

Removal Procedure

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install” for the correct procedure.

b. If the engine has a fan, remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

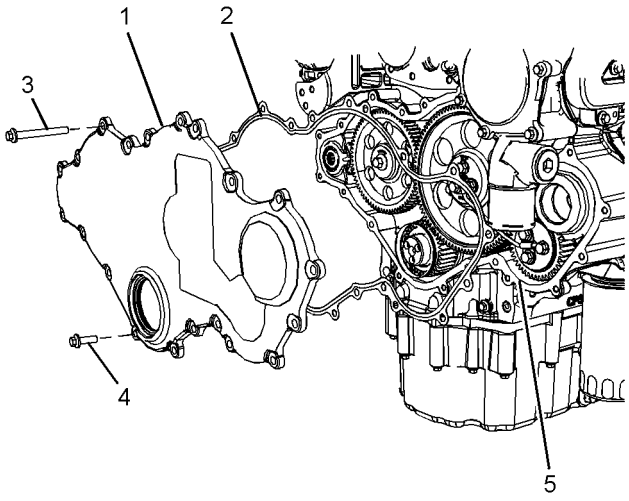

Illustration 220 g02480997

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 front housing (5).

4. Remove gasket (2).

Installation Procedure

Table 43

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud M8 by 70 mm	2
B	T400018	Front Cover Alignment Tool	1

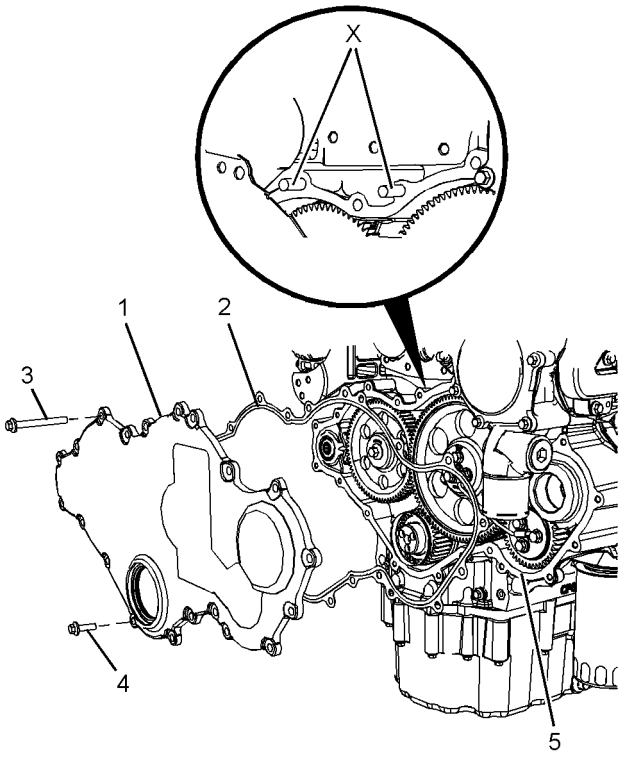

Illustration 221 g02480998

1. Ensure that all components are clean and free from damage. Replace any damaged components.
2. Thoroughly clean the gasket surface of front housing (5).
3. Thoroughly clean front cover (1).
4. Install Tooling (A) into Holes (X) in front housing (5).
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 the remaining bolts.
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, “Crankshaft Pulley - Remove and Install” for the correct procedure.

b. If the engine has a fan, install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i04485876

Gear Group (Front) - Remove and Install

Removal Procedure

Table 44

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	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.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

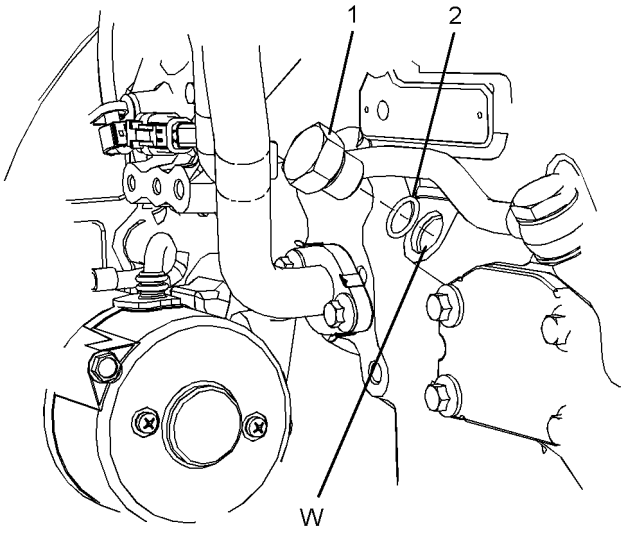

Illustration 222 g02485936

1. Remove plug (1) from the cylinder block. Remove O-ring seal (2) 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. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.

3. Remove Tooling (D).

4. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

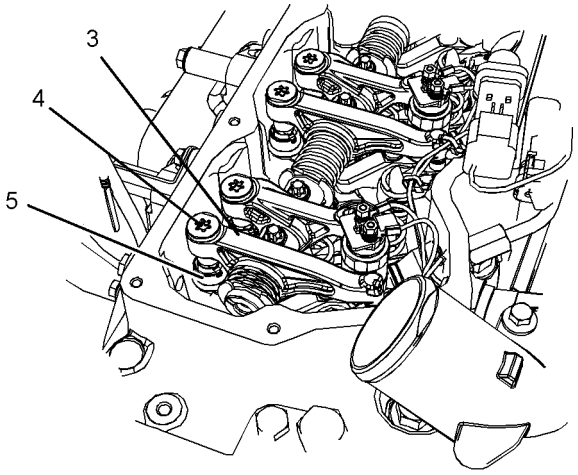

Illustration 223 g01992077

5. 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 the guides (5) for the pushrods are left in position on the threaded inserts (4).

Note: Ensure that ALL threaded inserts are fully unscrewed.

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 so that number one piston is at top dead center on the compression stroke. Refer to Illustration 222.

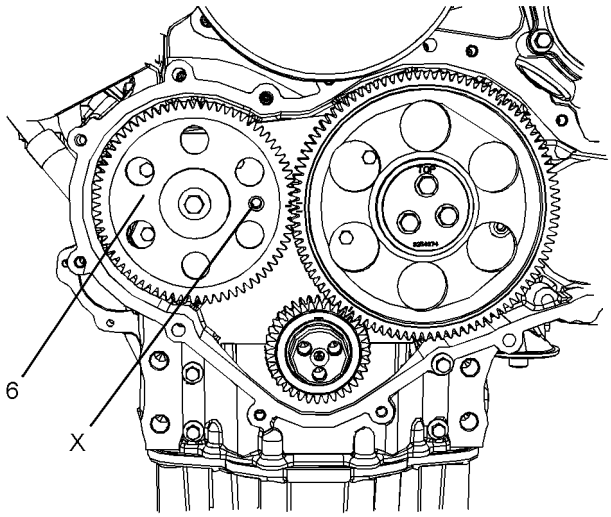

Illustration 224 g02485937

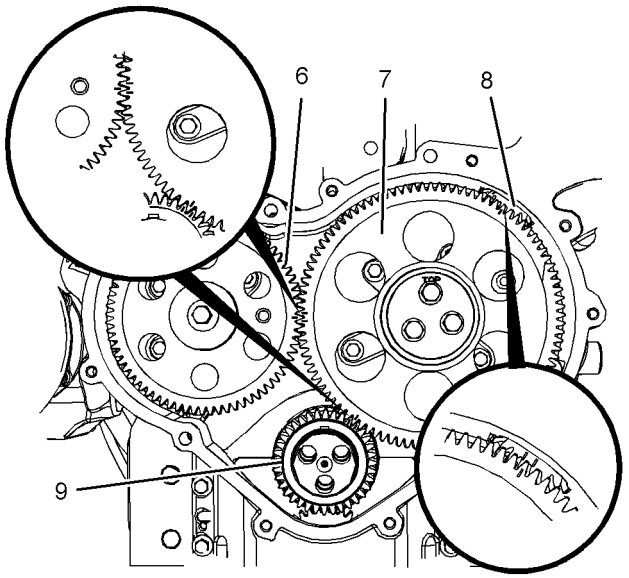

Illustration 225 g01992078

7. 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.

8. 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.

9. 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.

10. Mark gear (6), gear (7), gear (8) and gear (9) in order to show alignment. Refer to Illustration 225.

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

11. Remove camshaft gear (6). Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

12. Remove idler gear (7). Refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for the correct procedure.

Installation Procedure

Table 45

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	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 Position for No.1 Piston” for the correct procedure.

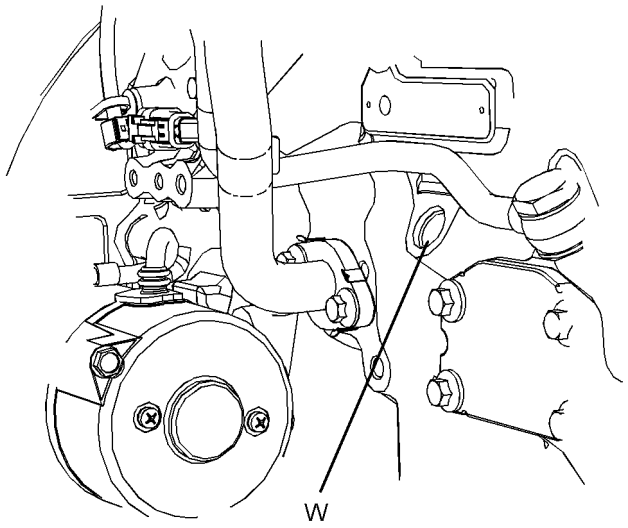

Illustration 226 g02485938

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.

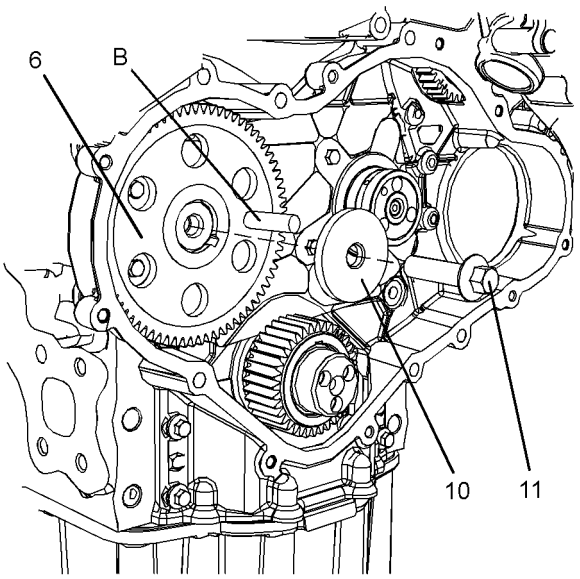

Illustration 227 g02485939

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 more information.

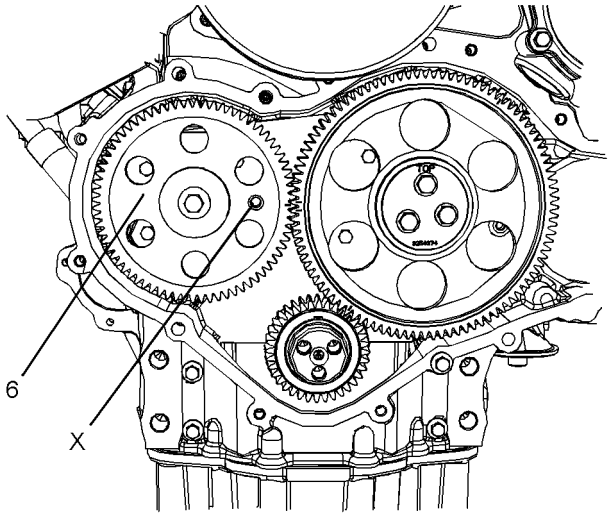

Illustration 228 g02485937

5. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing.

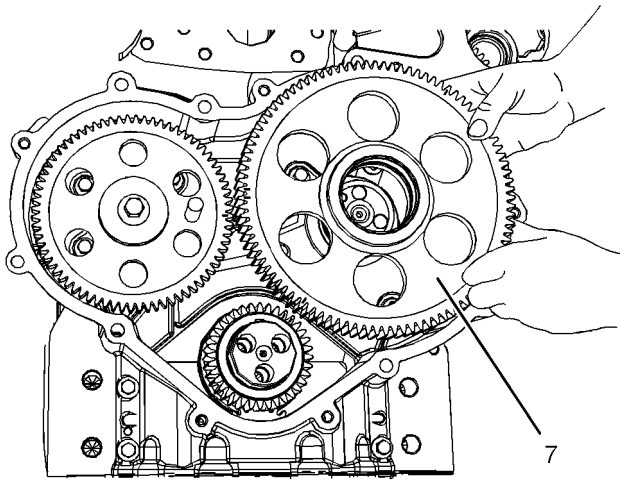

Illustration 229 g01993576

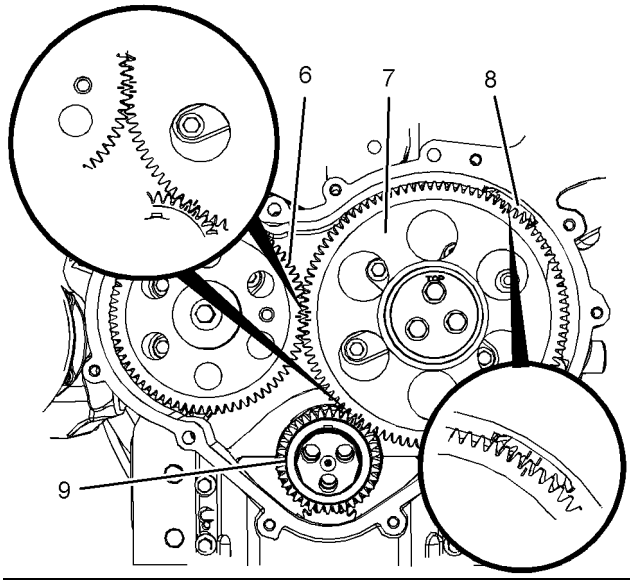

Illustration 230 g01992078

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 and that the mesh of the gears is correct.

7. Refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for the correct procedure.

8. Use Tooling (F) in order to check the end play of the idler gear. Refer to Specifications, “Gear Group (Front)” and refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for further information.

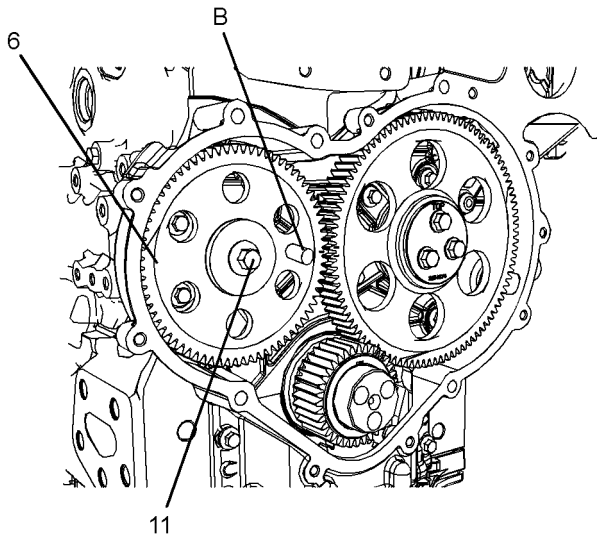

Illustration 231 g02485940

9. 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.

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

11. When bolt (11) is a 8.8 Grade. Tighten bolt (11) for camshaft gear (6) to a torque of 95 N·m (70 lb ft).

When bolt (11) is a 10.9 Grade. Tighten bolt (11) to a torque of 120 N·m (89 lb ft).

12. Use Tooling (F) in order to check the end play of the camshaft gear. Refer to Specifications, “Camshaft” for more information.

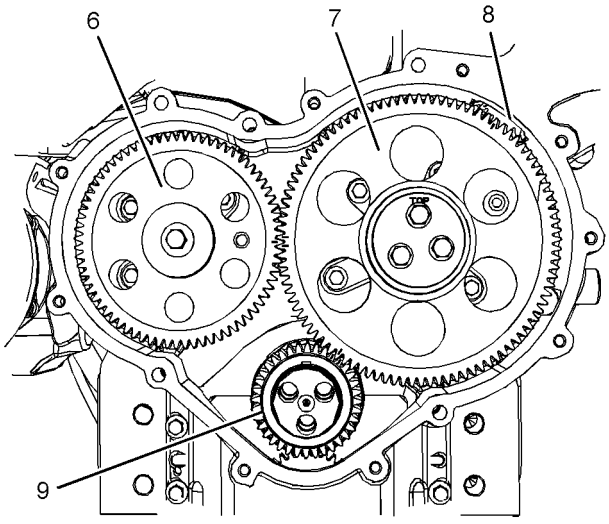

Illustration 232 g02086053

13. 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 further information.

14. Lubricate each gear with clean lubricating engine oil.

15. 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.

16. Remove Tooling (D).

NOTICE
Failure to ensure that the crankshaft is positioned at the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

17. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

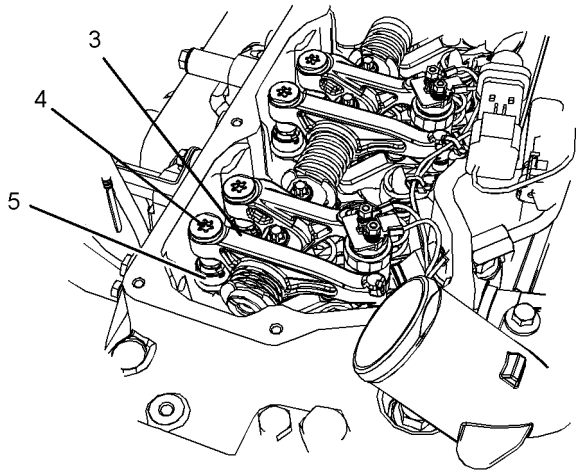

Illustration 233 g01992077

18. Ensure that the guides (5) for the pushrods are correctly positioned on the 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 correctly seated into the cup for the pushrod.

19. 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 of time will allow the force from the valve springs to purge off excessive engine oil from the hydraulic lifters.

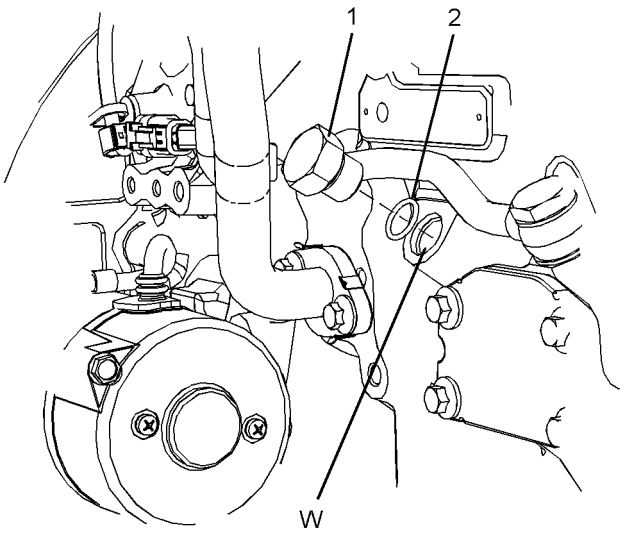

Illustration 234 g02485936

20. 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).

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.

i04485875

Gear Group (Front) - Remove and Install (Heavy Duty Gear Group (Front))

Removal Procedure

Table 46

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	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.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

1. 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 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.

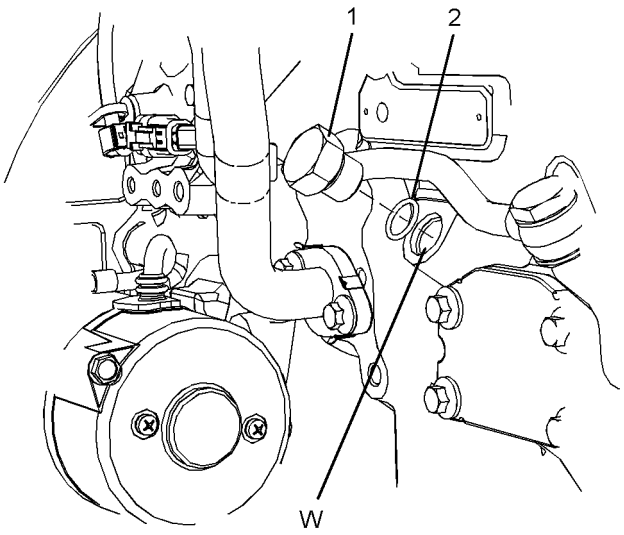

Illustration 235 g02486477

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) 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 so that number one piston is at top dead center on the compression stroke.

7. Remove Tooling (D).

8. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

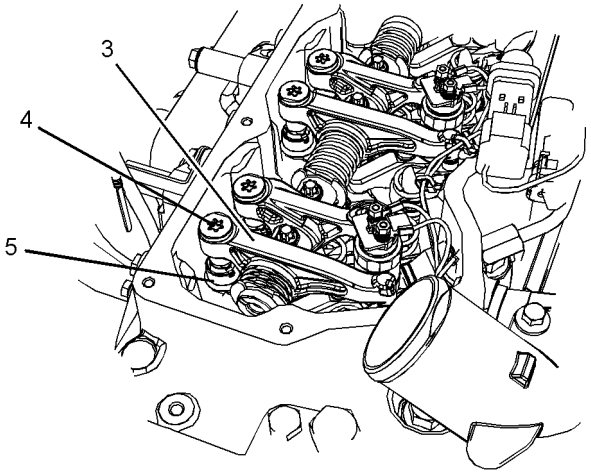

Illustration 236 g02048655

9. 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 the guides (5) for the pushrods are left in position on the 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 so that number one piston is at top dead center on the compression stroke. Refer to Illustration 235.

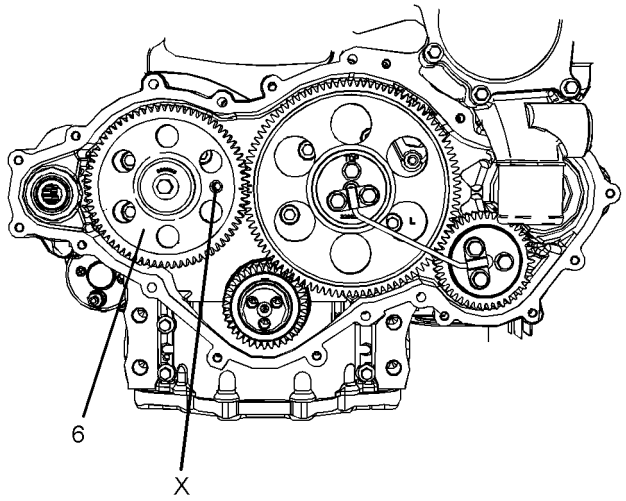

Illustration 237 g02488136

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.

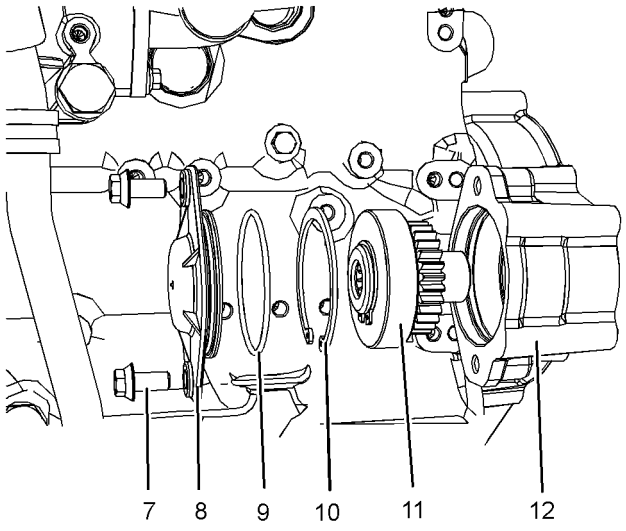

Illustration 238 g02052394

13. If the right-hand side of the engine is equipped with a hydraulic pump, remove the hydraulic pump. Refer to 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).

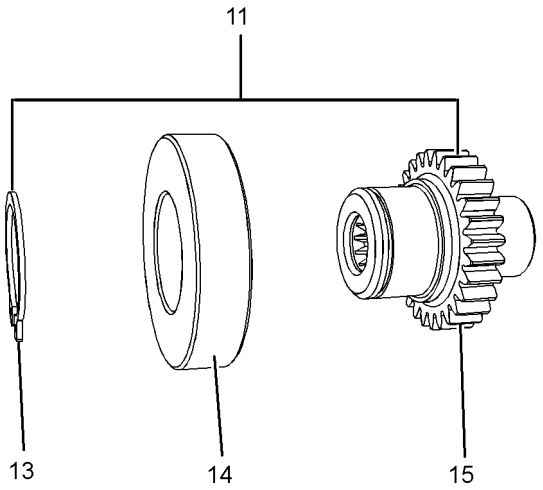

Illustration 239 g02053673

16. If necessary, follow Step 16.a through Step 16.b in order to disassemble gear assembly (11).

a. Remove circlip (13) from gear assembly (11).

b. Place gear assembly (11) on a suitable support. Press bearing (14) from gear (15).

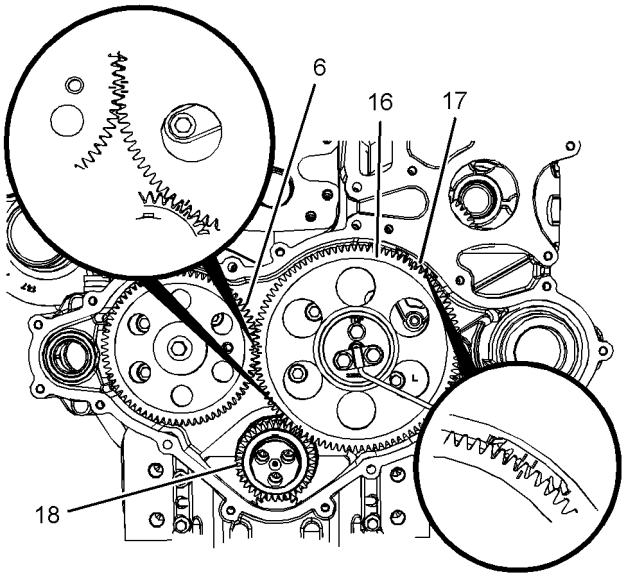

Illustration 240 g02048714

17. Mark gear (6), gear (16), gear (17) and gear (18) in order to show alignment. Refer to Illustration 240.

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.

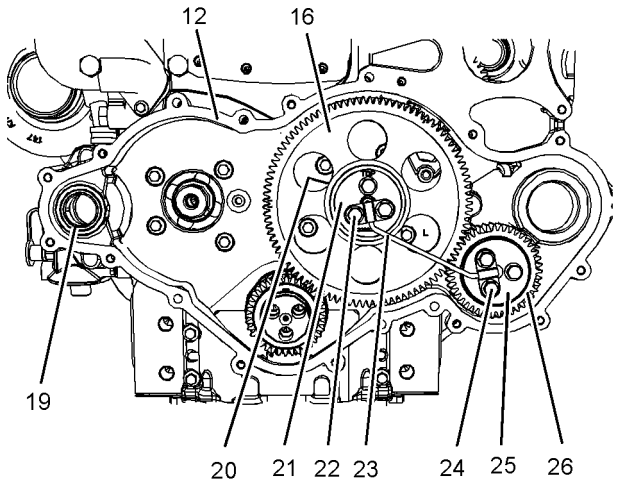

Illustration 241 g02053984

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 hub (20) (not shown).

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 47

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin(Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	T40 Torx Socket	1
F	-	Delphi Lockheed Rubber Grease	1
G	-	Loctite 609 Bearing Mount Compound	1
H	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 Position for No.1 Piston” for the correct procedure.

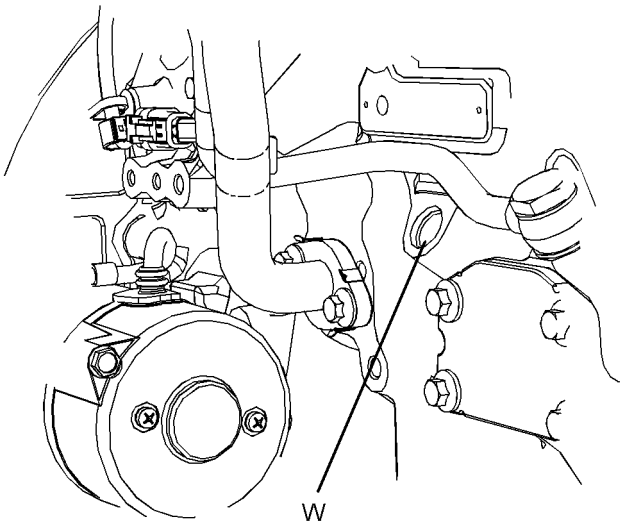

Illustration 242 g02488176

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.

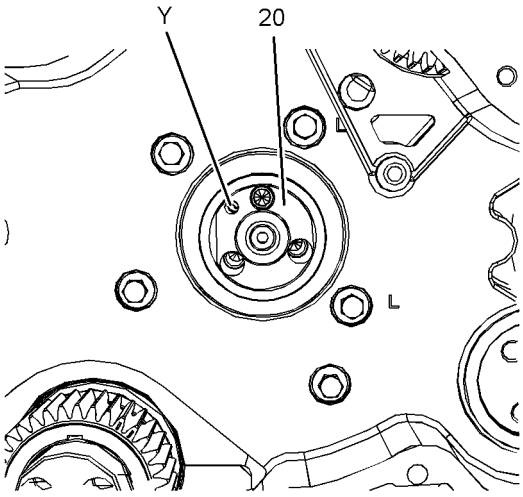

Illustration 243 g02048660

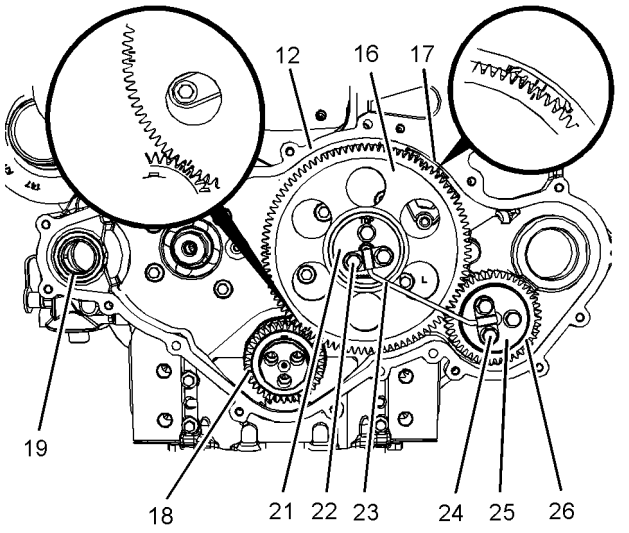

Illustration 244 g02053693

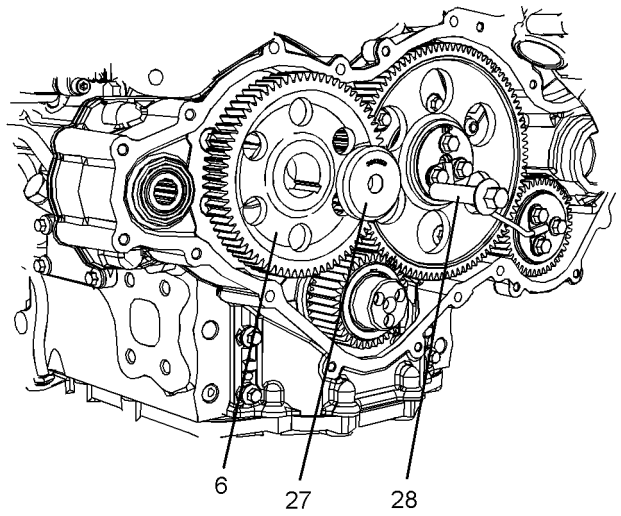

Illustration 245 g02488178

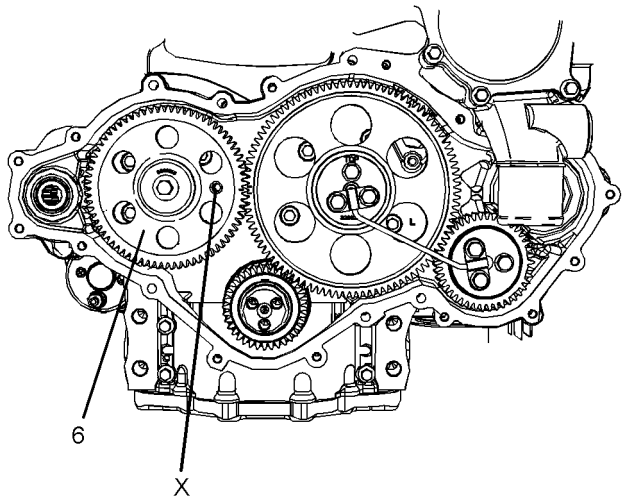

Illustration 246 g02488136

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 the 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” for the correct procedure.

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).

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.

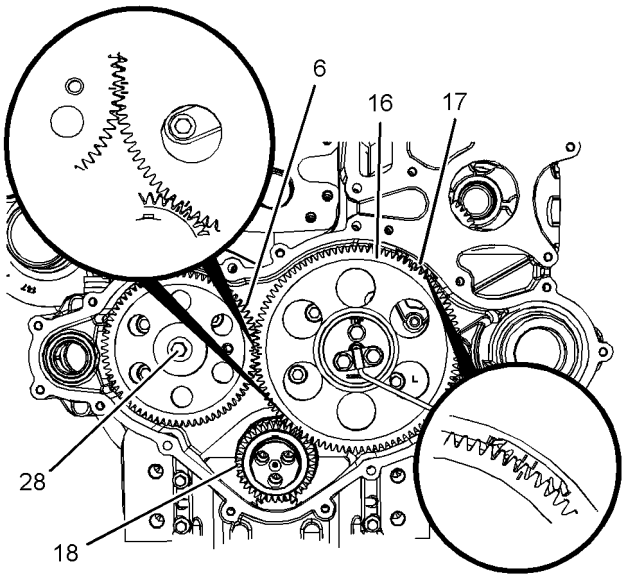

Illustration 247 g02488216

14. Ensure that the timing marks on gear (6), gear (16), gear (17) and gear (18) are in alignment and that the mesh of the gears is correct.

15. Remove Tooling (B), Tooling (C), and Tooling (D).

16. When bolt (28) is a 8.8 Grade. Tighten bolt (28) for camshaft gear (6) to a torque of 95 N·m (70 lb ft).

When bolt (28) is a 10.9 Grade. Tighten bolt (28) to a torque of 120 N·m (89 lb ft).

17. Use Tool (H) in order to check the end play of the camshaft gear. Refer to Specifications, “Camshaft” for more information.

18. Use Tool (H) 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 further information.

19. Use Tooling (H) in order to measure the backlash for gear (6), gear (16), gear (17) and gear (16). Refer to Specifications, “Gear Group (Front)” for further information.

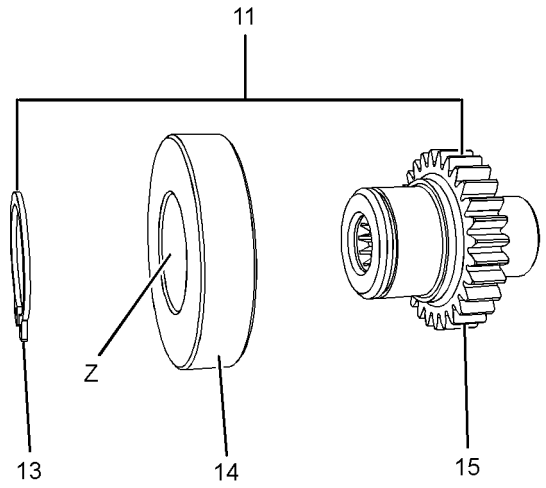

Illustration 248 g02058193

20. If necessary, follow Step 20.a through Step 20.c in order to assemble gear assembly (10).

a. Apply a small continuous bead of Tooling (G) 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 assembly (11).

c. Lightly lubricate bearing (14) and gear assembly (11) with clean lubricating oil.

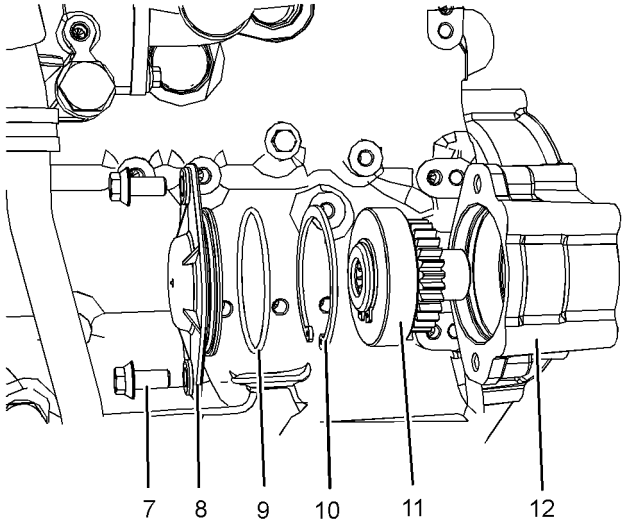

Illustration 249 g02052394

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 camshaft 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 OEM for the correct procedure.

25. If necessary, lightly lubricate a new O-ring seal (9) with Tooling (F). 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 10 N·m (88 lb in).

27. Lubricate each gear with clean engine oil.

NOTICE

Failure to ensure that the crankshaft is positioned at the safe position 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 the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

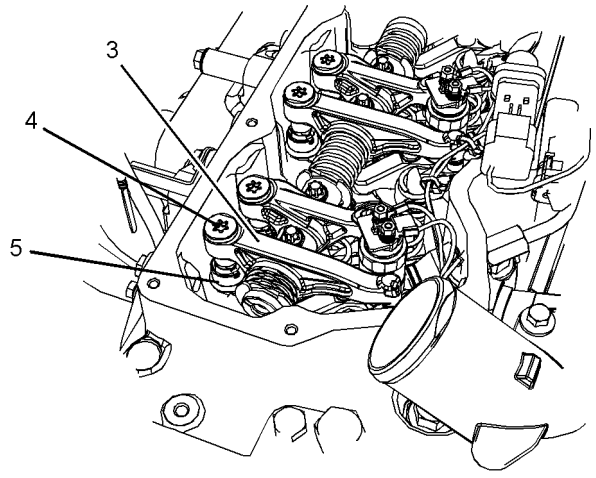

Illustration 250 g02048655

29. Ensure that the guides (5) for the pushrods are correctly positioned on the 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 correctly seated into the cup for the pushrod.

30. 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.

31. If the air compressor is equipped with a hydraulic pump, install the hydraulic pump. Refer to OEM for the correct procedure.

32. If the engine is equipped only with a hydraulic pump, install the hydraulic pump. Refer to OEM for the correct procedure.

33. 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 of time will allow the hydraulic lifters 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.

i04485883

Idler Gear - Remove

Removal Procedure

Table 48

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	T400015	Timing Pin (Fuel Injection Pump)	1
C	27610212	Timing Pin (Camshaft)	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	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 fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

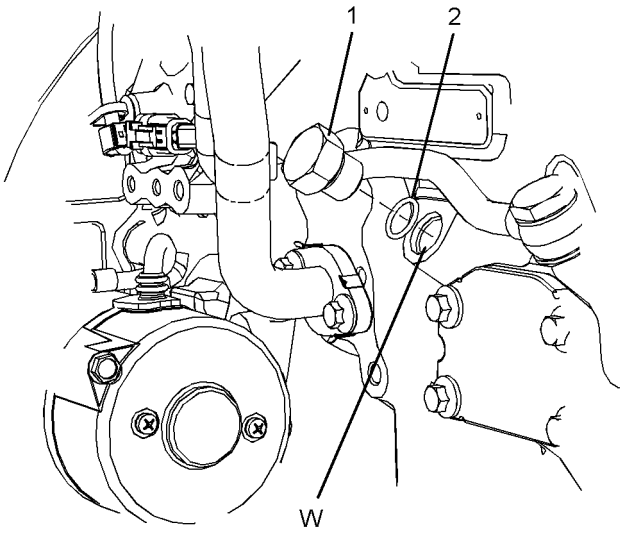

Illustration 251 g02485936

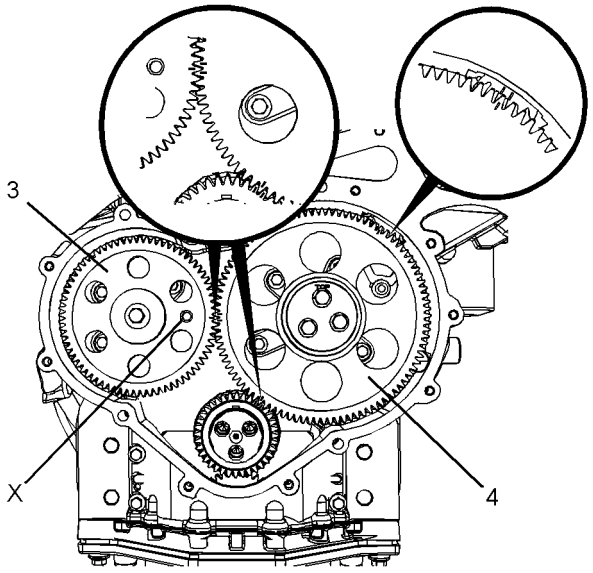

Illustration 252 g01994553

1. Remove plug (1) from the cylinder block and remove O-ring seal (2) 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 so that number one piston is at top dead center on the compression stroke.

4. Ensure that Tooling (C) is installed into Hole (X) in camshaft gear (3). Use Tooling (C) 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 252.

5. Use Tooling (B) 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.

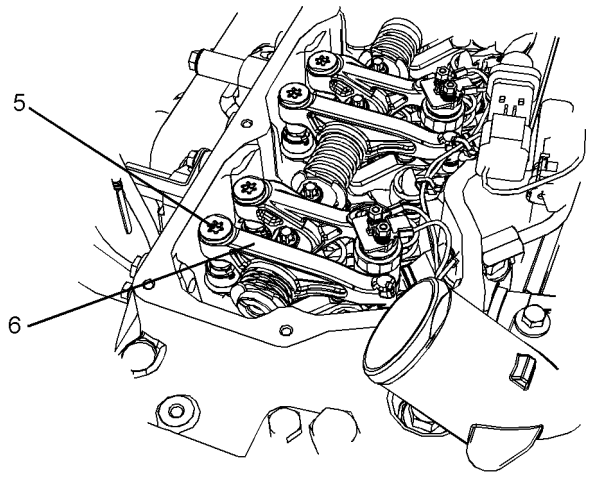

Illustration 253 g01994556

6. Use Tooling (E) 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.

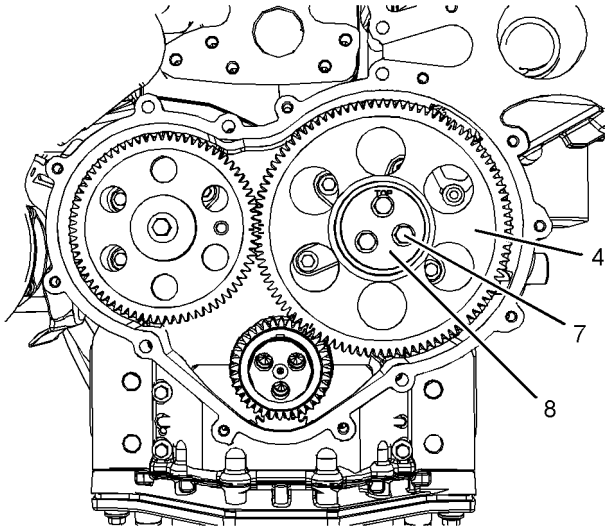

Illustration 254 g01994576

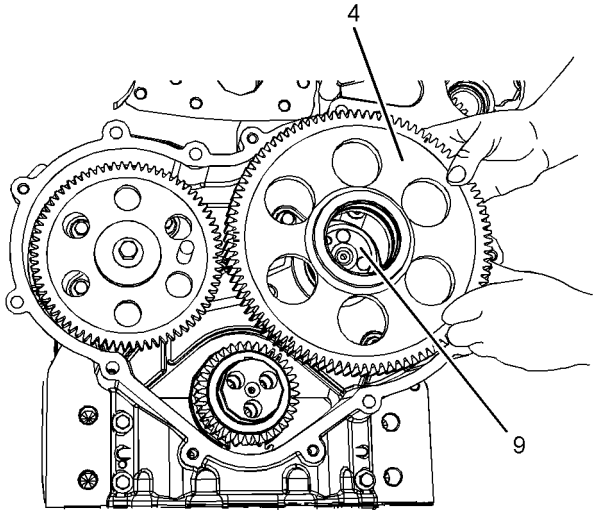

Illustration 255 g01994557

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.

i04485882

Idler Gear - Install

Installation Procedure

Table 49

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	T400015	Timing Pin (Fuel Injection Pump)	1
C	27610212	Timing Pin (Camshaft)	1
D	27610286	Timing Pin (Crankshaft)	1
E	-	T40 Torx Socket	1
F	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.

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.

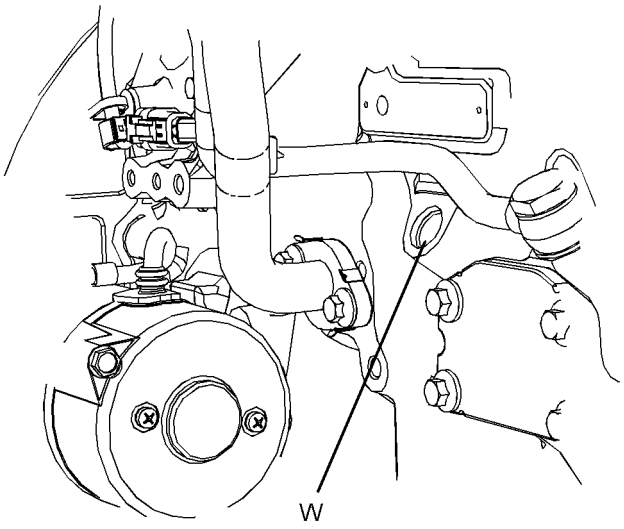

Illustration 256 g02491276

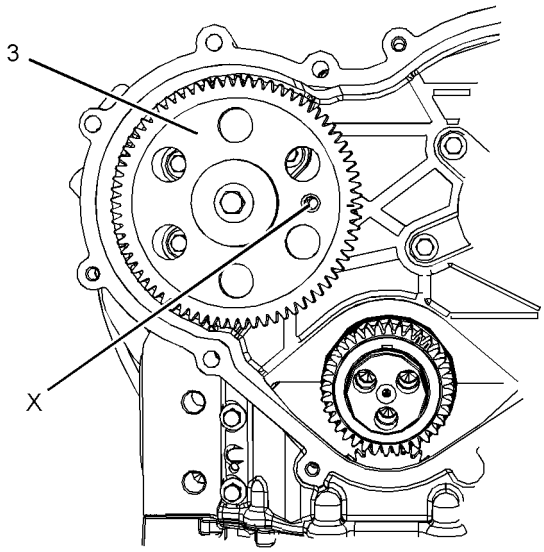

Illustration 257 g01996475

2. Ensure that Tooling (D) is installed in 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.

3. Ensure that Tooling (C) is installed into Hole (X) in camshaft gear (3).

4. Use Tooling (B) 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.

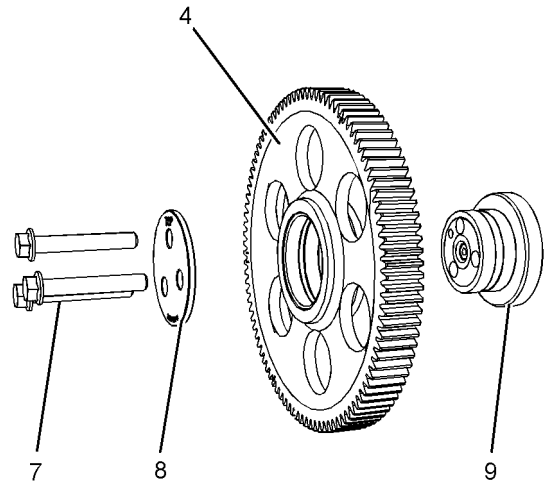

Illustration 258 g01996477

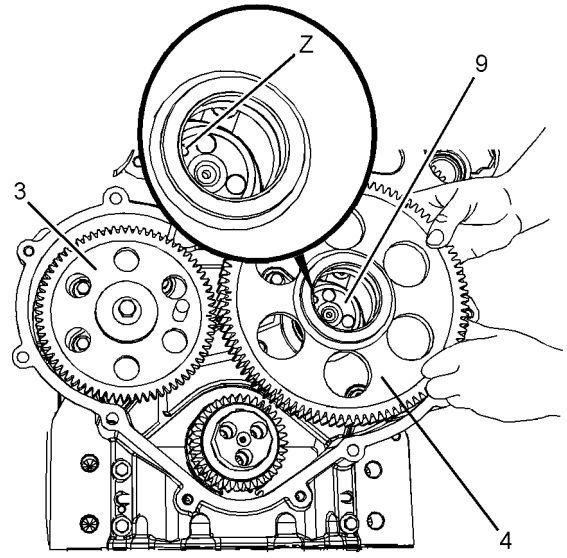

Illustration 259 g01996478

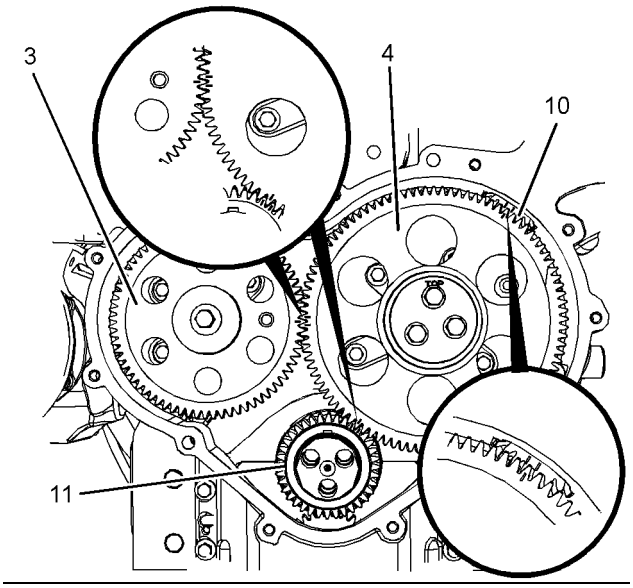

Illustration 260 g01996576

5. 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.

6. 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.

7. Lubricate hub (9) with clean engine oil. Install hub (9) into the recess in the front housing. Ensure that oil Hole (Z) is to the top of the hub.

8. Install idler gear (4) onto hub (9). Ensure that the timing marks are toward the front of the idler gear.

9. 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 260. Install the assembly of idler gear (4) to hub (9).

10. Clean plate (8) and inspect the plate for wear and damage. If necessary, replace the plate.

11. 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.

12. Install bolts (7). Tighten the bolts to a torque of 44 N·m (32 lb ft).

13. Remove Tooling (B), Tooling (C), and Tooling (D).

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

14. Use Tooling (F) in order to check the end play for the idler gear. Refer to Specifications, “Gear Group (Front)” for more information.

15. Use Tooling (F) 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 (F) 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 (F) 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.

NOTICE
Failure to ensure that the crankshaft is set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

19. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

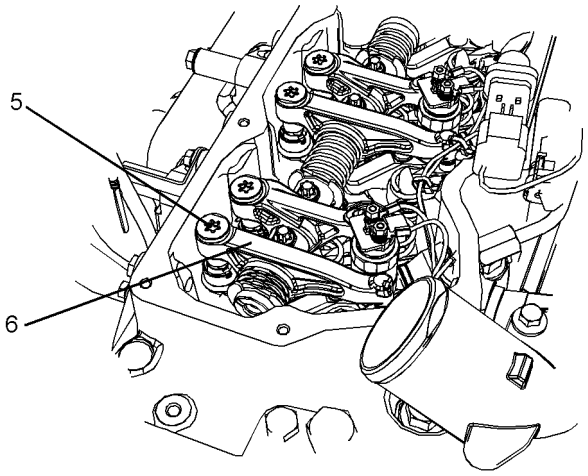

Illustration 261 g01994556

20. Ensure that the guides for the pushrods are correctly positioned on the threaded inserts (5). Use Tooling (E) in order to tighten threaded inserts (5) on all rocker arms (6). 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 correctly seated 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 of the valve springs to purge off excessive engine oil from the hydraulic lifters.

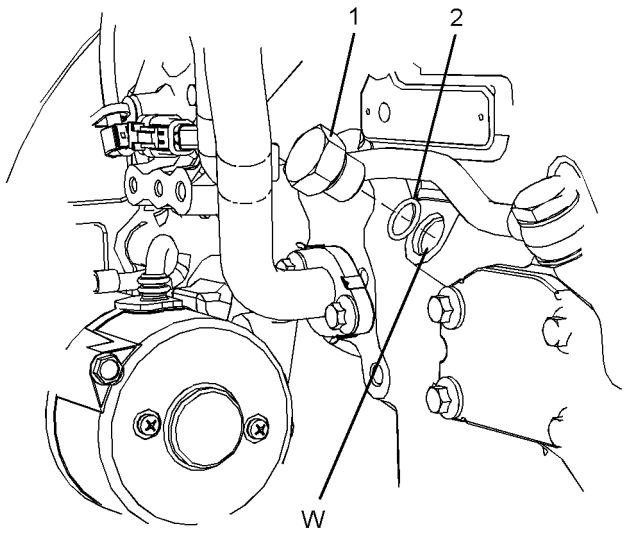

Illustration 262 g02485936

22. Position a new O-ring seal (2) onto plug (1). Install the plug to the cylinder block and tighten the plug to a torque of 21 N·m (186 lb in).

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.

i04485881

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, “Crankshaft Pulley - Remove and Install” for the correct procedure.

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

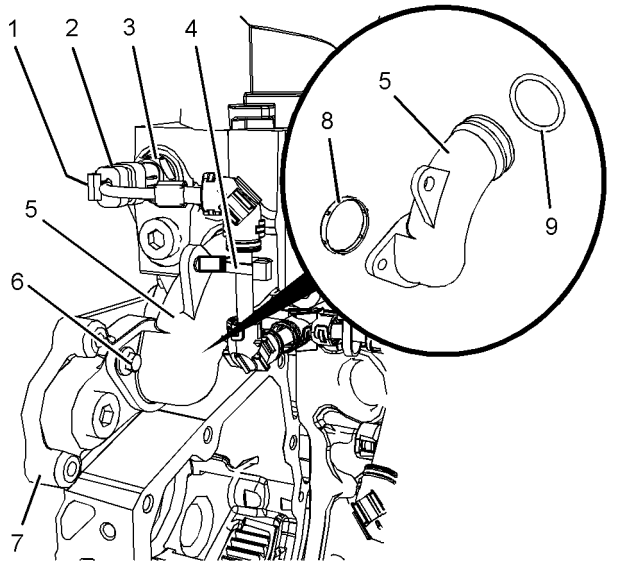

Illustration 263 g02488340

1. Slide locking tab (1) (not shown) into the unlocked position.

2. Disconnect harness assembly (2) from coolant temperature sensor (3).

3. Cut cable strap (4) and remove harness assembly (2) from bypass tube (5).

4. Remove bolts (6) that secure bypass tube (5) to front housing (7).

5. Remove bypass tube (5) from the cylinder head. Remove O-ring seal (8) and O-ring seal (9) from bypass tube (5).

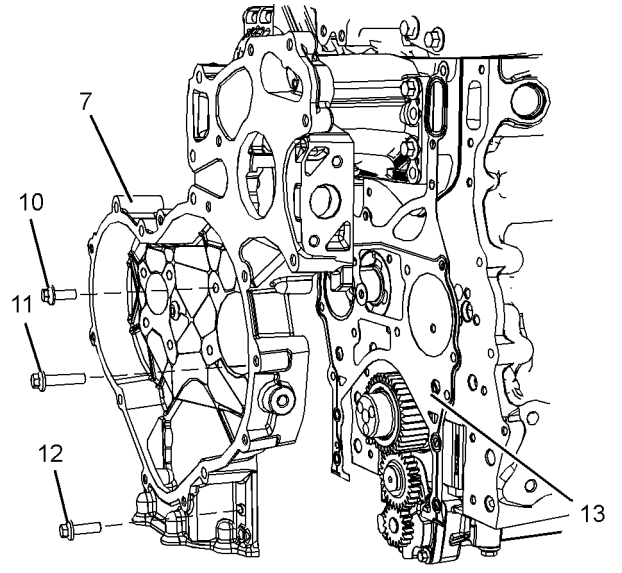

Illustration 264 g02488341

6. Remove bolts (10), bolts (11) and bolts (12) from front housing (7).

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

7. Remove front housing (7) from the cylinder block.

8. Remove gasket (13).

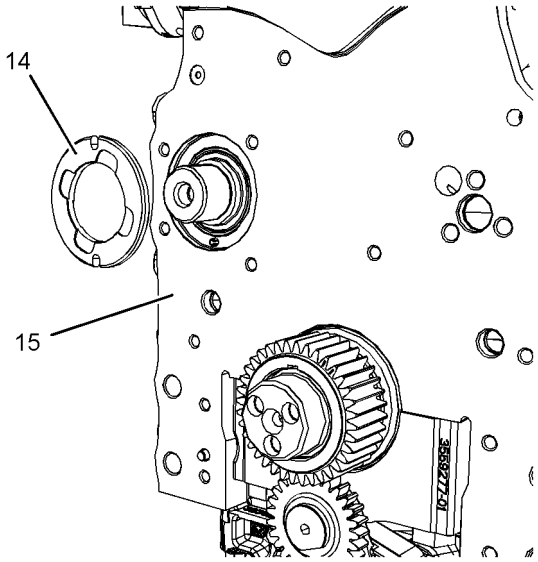

Illustration 265 g02488356

9. Remove thrust washer (14) from cylinder block (15).

i04485880

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, “Crankshaft Pulley - Remove” for the correct procedure.

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

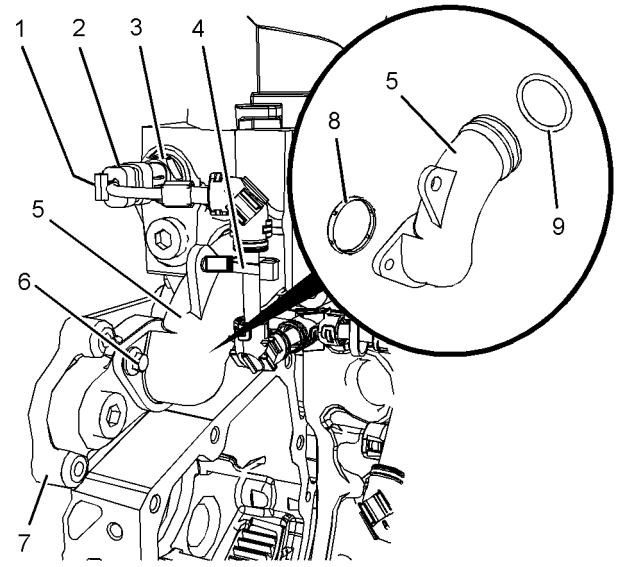

Illustration 266 g02490356

1. Slide locking tab (1) (not shown) into the unlocked position.

2. Disconnect harness assembly (2) from coolant temperature sensor (3).

3. Cut cable strap (4) and remove harness assembly (2) from bypass tube (5).

4. Remove bolts (6) that secure bypass tube (5) to front housing (7).

5. Remove bypass tube (5) from the cylinder head. Remove O-ring seal (8) and O-ring seal (9) from bypass tube (5).

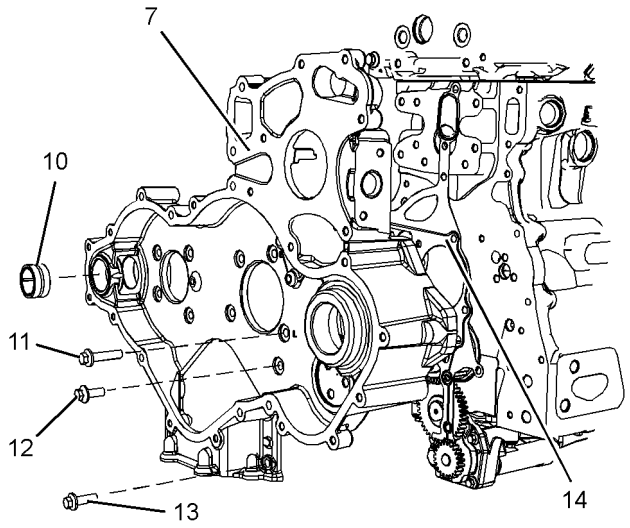

Illustration 267 g02490357

6. Remove bolts (11), bolts (12) and bolts (13) from front housing (7).

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

7. Remove front housing (7) from the cylinder block.

8. Remove gasket (14).

9. If necessary, follow Step 9.a through Step 9.b in order to remove bearing (10) from housing (7).

a. Place housing (7) onto a suitable support.

b. Use a suitable tool in order to press bearing (10) out of housing (7).

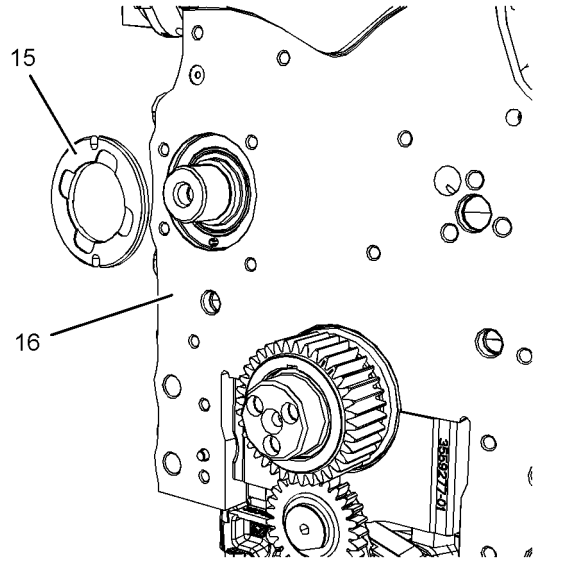

Illustration 268 g02490358

10. Remove thrust washer (15) from cylinder block (16).

i04485879

Housing (Front) - Install

Installation Procedure

Table 50

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 575 Sealant	1
B	-	Guide Studs M8 by 80 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 and the 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.

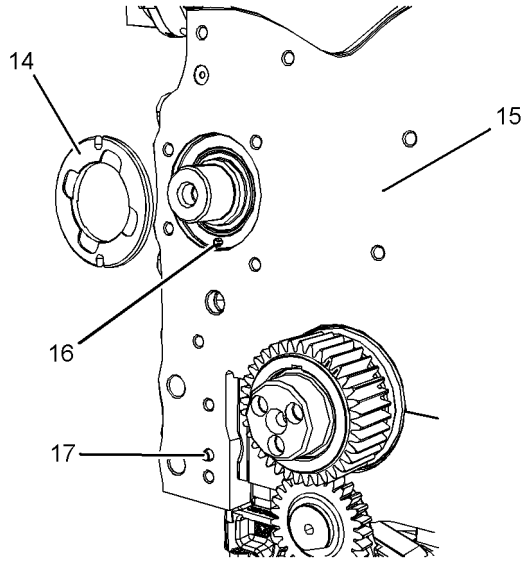

Illustration 269 g02490296

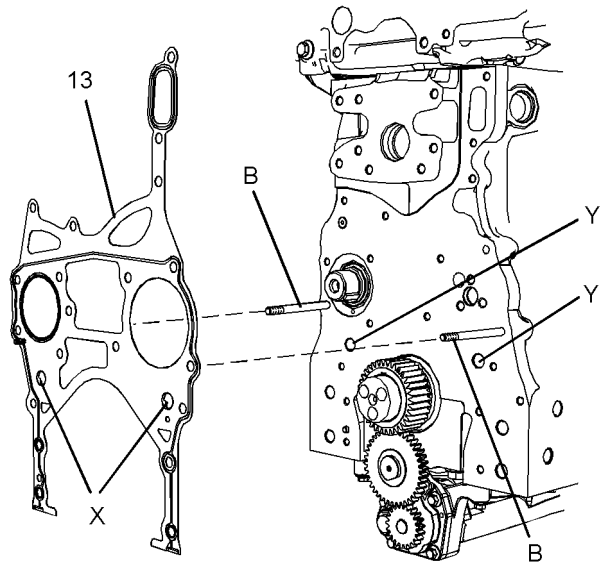

Illustration 270 g02490297

3. Inspect dowel (16) and dowel (17) for damage. If necessary, replace the dowels in cylinder block (15).

4. Install thrust washer (14) into the recess in cylinder block (15). Refer to Disassembly and Assembly, “Camshaft - Install” for more information.

5. Install Tooling (B) to cylinder block (15). Refer to Illustration 270.

6. Align a new gasket (13) with Tooling (B). Install the gasket to cylinder block (15).

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in cylinder block (15). Ensure that dowel (17) in cylinder block (15) is engaged on the gasket.

7. Install Tooling (C) to cylinder block (15).

8. Install the front housing over Tooling (B) and Tooling (C) onto cylinder block (15).

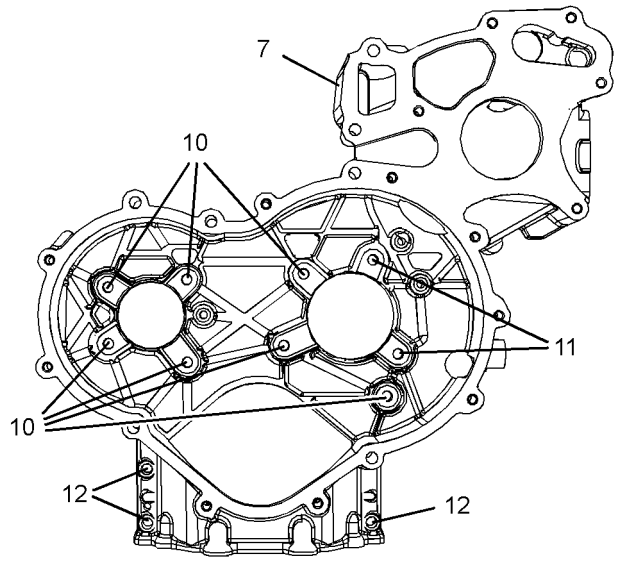

Illustration 271 g02490298

(10) M8 by 20 mm
(11) M8 by 35 mm
(12) M8 by 25 mm

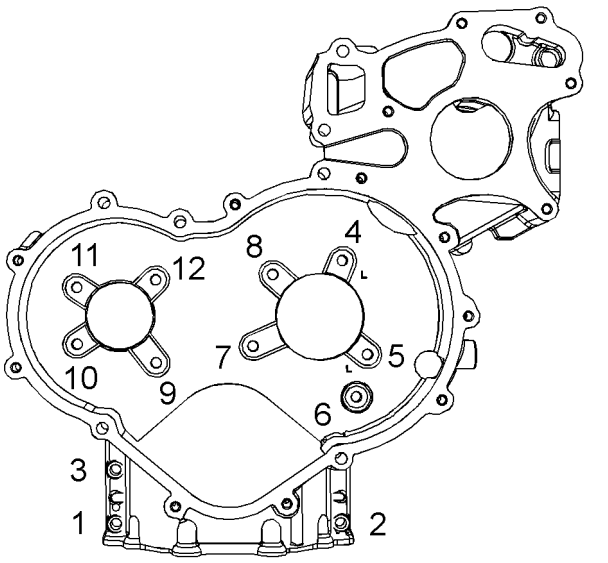

Illustration 272 g01998054

9. Install bolts (12) to front housing (7) finger tight.

10. Remove Tooling (B).

11. Loosely install bolts (10) and bolts (11). Refer to Illustration 271 for the correct position of the bolts.

12. Tighten bolts (10), bolts (11) and bolts (12) in the sequence that is shown in Illustration 272 to a torque of 28 N·m (248 lb in).

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

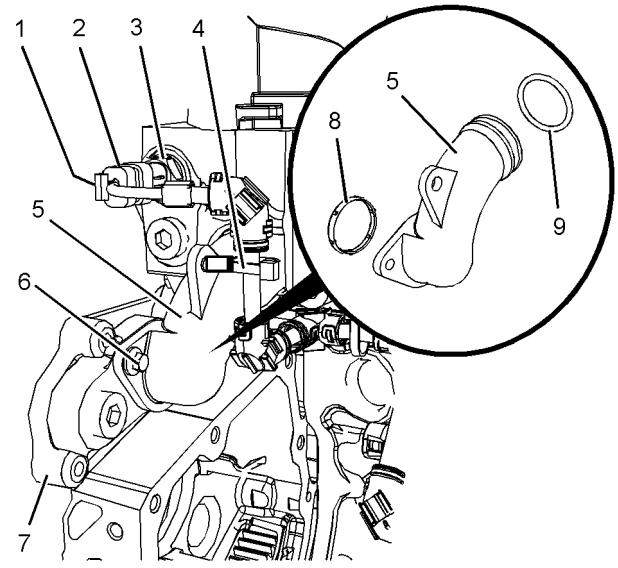

Illustration 273 g02488340

14. Install a new O-ring seal (8) and a new O-ring seal (9) to bypass tube (5). Use Tooling (D) in order to lubricate the O-ring seals.

15. Install bypass tube (5) to the cylinder head. Install bolts (6). Tighten the bolts to a torque of 9 N·m (80 lb in).

16. Connect harness assembly (2) to coolant temperature sensor (3).

17. Slide locking tab (1) (not shown) into the locked position.

18. Position harness assembly (2) onto bypass tube (5). Install a new cable strap (4).

Note: Ensure that the cable strap meets Original Equipment Manufactures (OEM) specification.

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, “Crankshaft 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.

i04485878

Housing (Front) - Install (Heavy Duty Housing (Front))

Installation Procedure

Table 51

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 575 Sealant	1
B	-	Guide Studs M8 by 80 mm	2
C	27610216	Alignment Tool	1
	-	Bolts M10 by 50 mm	3
D	-	Delphi 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 and the 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.

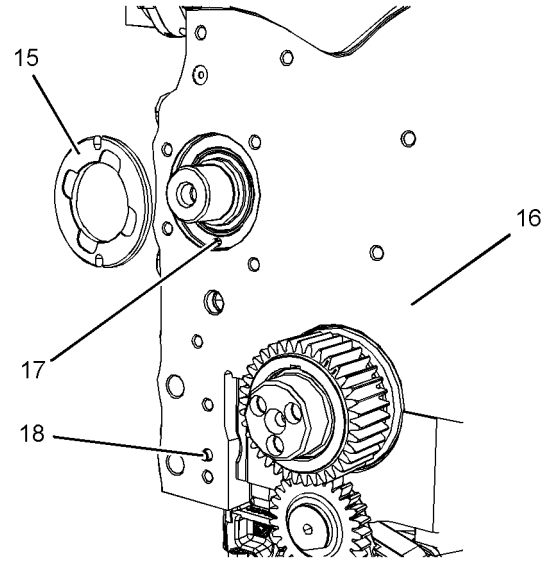

Illustration 274 g02490396

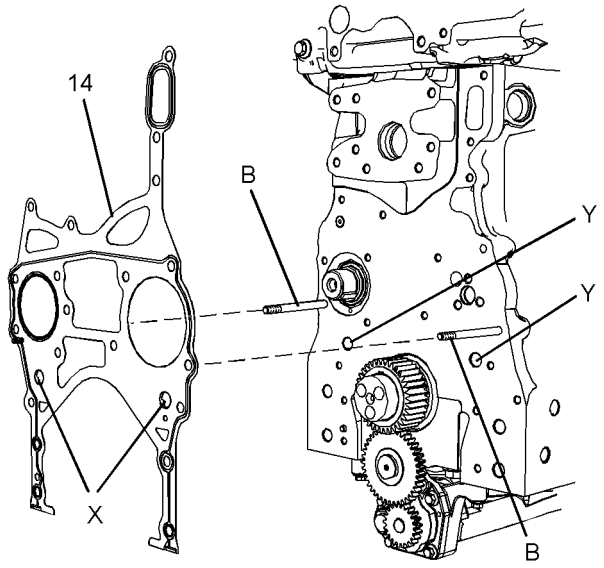

Illustration 275 g02490397

3. Inspect dowel (17) and dowel (18) for damage. If necessary, replace the dowels in the cylinder block.

4. Install thrust washer (15) into the recess in cylinder block (16). Refer to Disassembly and Assembly, “Camshaft - Install” for more information.

5. Install Tooling (B) to cylinder block (16). Refer to Illustration 275.

6. Align a new gasket (10) with Tooling (B). Install the gasket to (16) cylinder block.

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in cylinder block (16). Ensure that dowel (18) in cylinder block (16) is engaged on the gasket.

7. Install Tooling (C) to cylinder block (16).

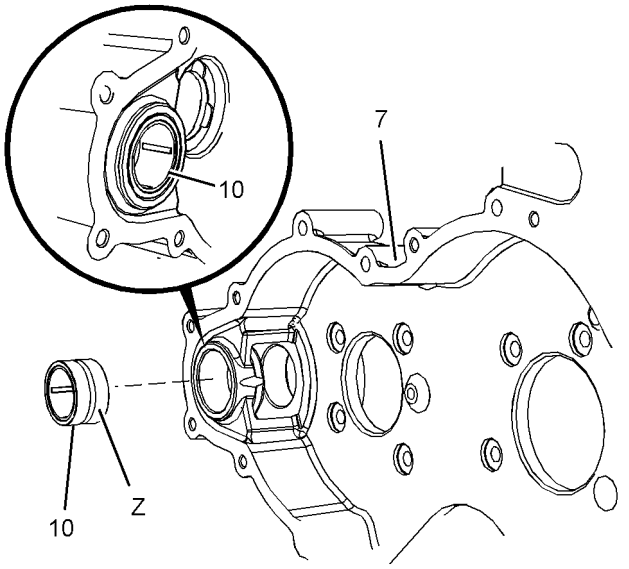

Illustration 276 g02490399

8. If necessary, follow Step 8.a through Step 8.c in order to install bearing (10) to housing (7).

a. Apply a small continuous bead of Tooling (E) to outer Surface (Z) of bearing (10).

b. Place housing (7) onto a suitable support.

c. Use a suitable tool in order to press bearing (10) into housing (7) 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 cylinder block (16).

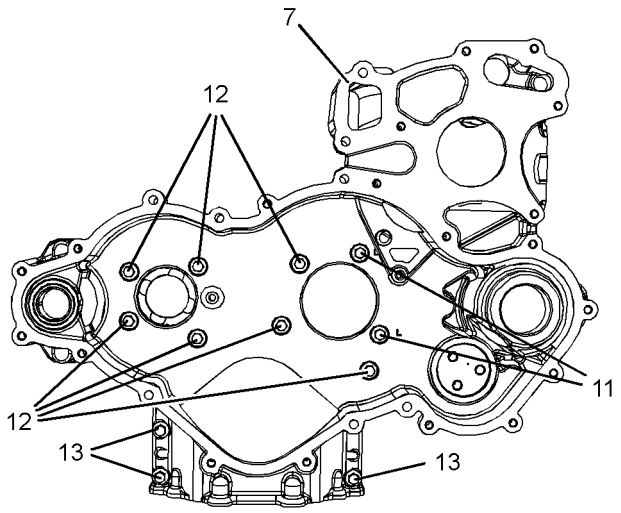

Illustration 277 g02490400

(11) M8 by 35 mm
(12) M8 by 20 mm
(13) M8 by 25 mm

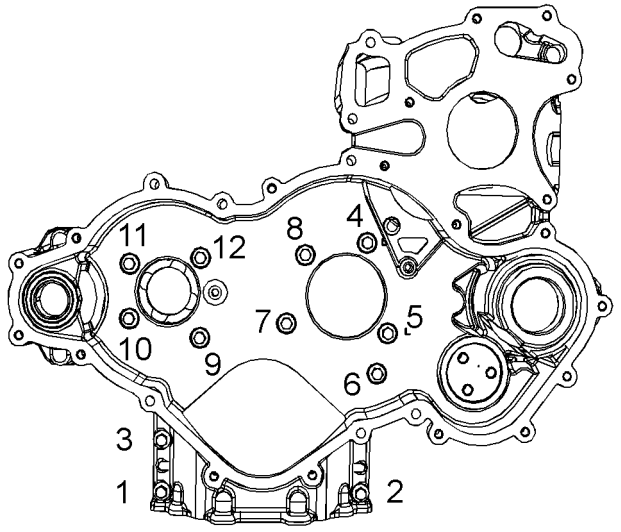

Illustration 278 g02058297

10. Install bolts (13) to front housing (7) finger tight.

11. Remove Tooling (B).

12. Loosely install bolts (11) and bolts (12). Refer to Illustration 277 for the correct position of the bolts.

13. Tighten bolts (11), bolts (12) and bolts (13) in the sequence that is shown in Illustration 278 to a torque of 28 N·m (248 lb in).

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

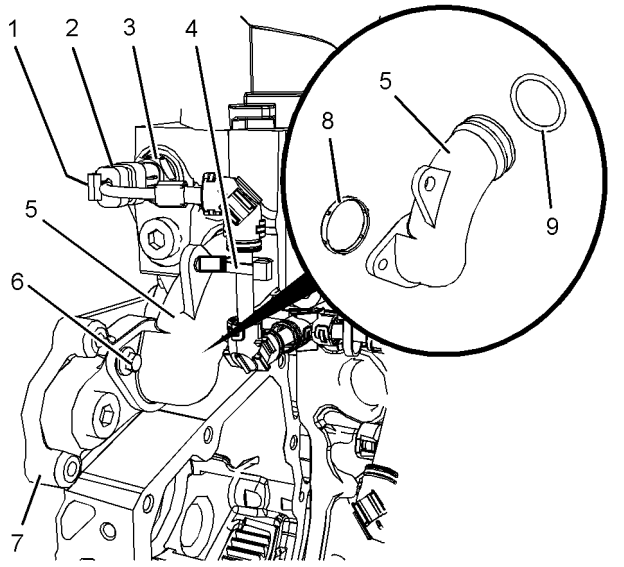

Illustration 279 g02490356

15. Install a new O-ring seal (8) and a new O-ring seal (9) to bypass tube (5). Use Tooling (D) in order to lubricate the O-ring seals.

16. Install bypass tube (5) to the cylinder head. Install bolts (6). Tighten the bolts to a torque of 9 N·m (80 lb in).

17. Connect harness assembly (2) to coolant temperature sensor (3).

18. Slide locking tab (1) (not shown) into the locked position.

19. Position harness assembly (2) onto bypass tube (5). Install a new cable strap (4).

Note: Ensure that the cable strap meets Original Equipment Manufactures (OEM) specification.

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 . Refer to Disassembly and Assembly, “Engine Oil Pan - Install” for the correct procedure.

e. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft 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.

i04485790

Accessory Drive - Remove and Install (Accessory Drive SAE "B")

Removal Procedure

Table 52

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. If necessary, remove the OEM driven equipment from the auxiliary drive.

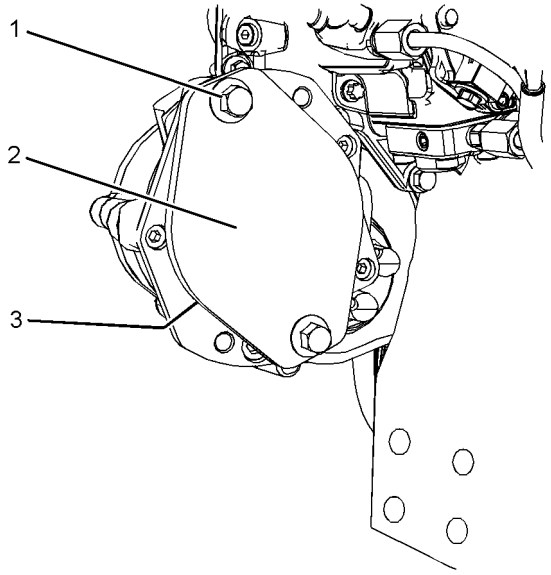

Illustration 280 g02418256

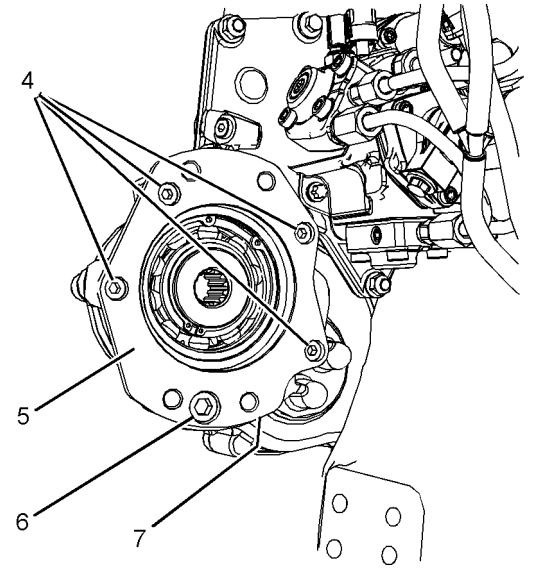

Illustration 281 g02418257

2. If 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).

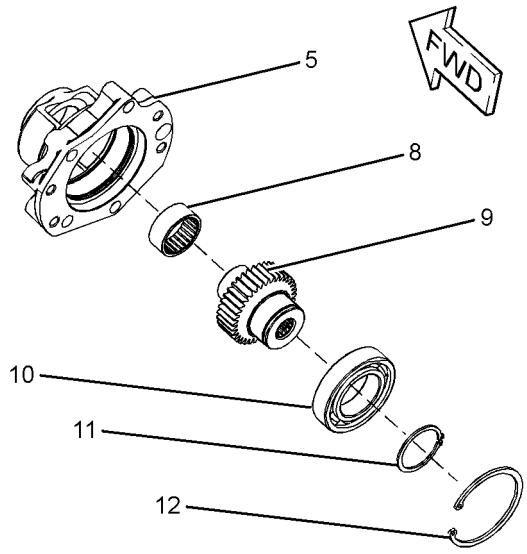

Illustration 282 g02646290

6. If necessary, follow Step 6.a through Step 6.c in order to disassemble the accessory drive.

a. Remove circlip (11) and circlip (12) from accessory drive housing (5).

b. 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).

c. Press bearing (8) out of accessory drive housing (5).

Note: Note the position of the bearing in the accessory drive housing before removal.

Installation Procedure

Table 53

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	Loctite 603 Retaining Compound	1
C	-	Loctite 242 Thread Lock Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

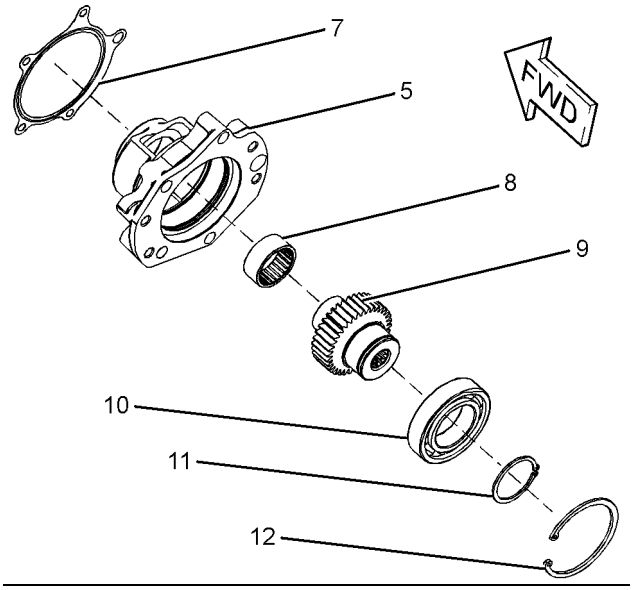

Illustration 283 g02050614

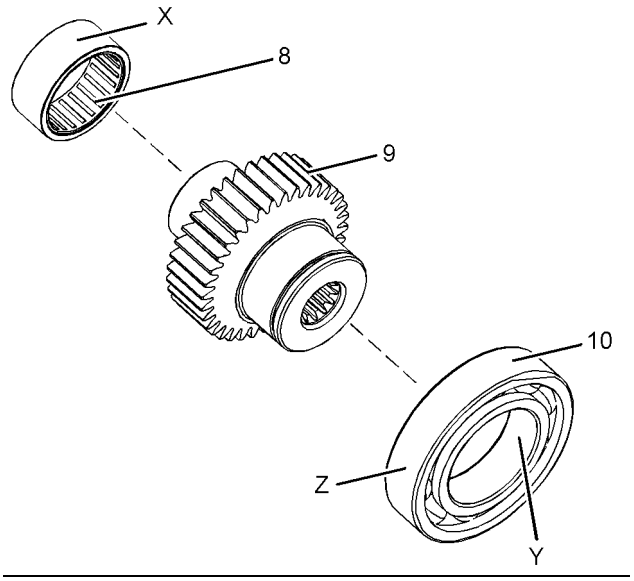

Illustration 284 g02052174

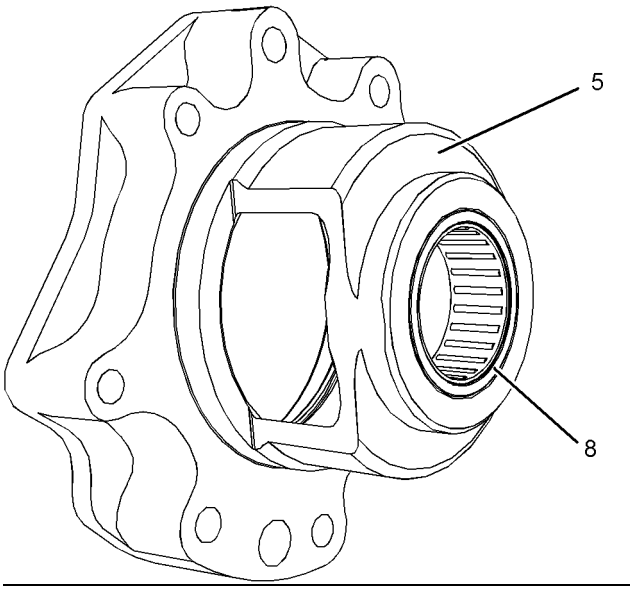

Illustration 285 g02052273

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 the 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 lubricating oil.

4. Install new gasket (7) to accessory drive assembly (5). Install the assembly of the accessory drive to the front housing.

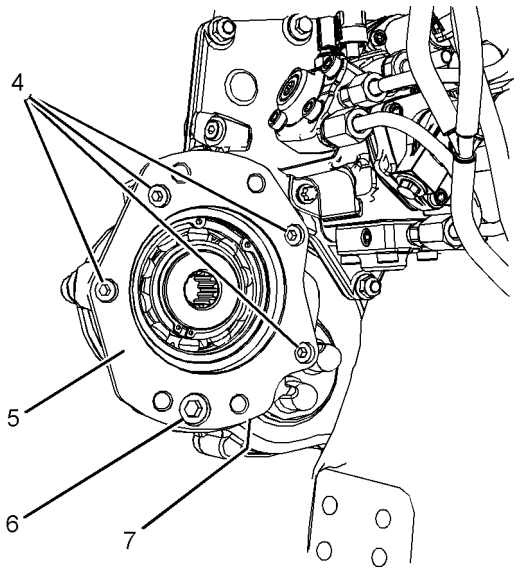

Illustration 286 g02418257

5. Apply Tooling (C) to allen head screws (4) and allen head screw (6). Install allen head screws (4) and allen head screw (6) to accessory drive housing (5).

6. Tighten allen head screws (4) to a torque of 22 N·m (195 lb in).

7. Tighten allen head screw (6) to a torque of 78 N·m (58 lb ft).

8. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

9. If necessary, install the OEM driven equipment to the auxiliary drive.

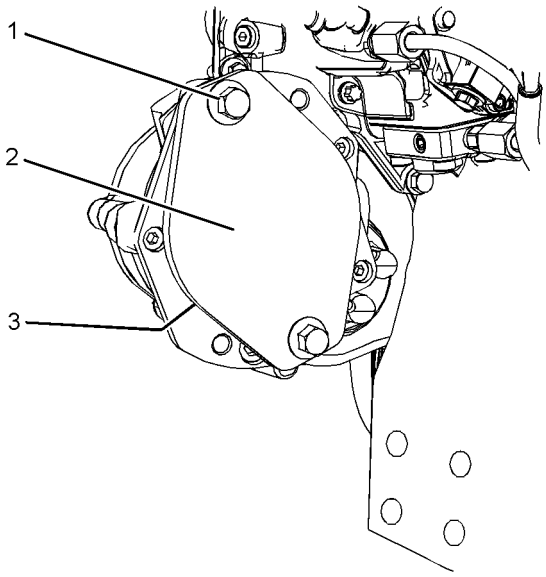

Illustration 287 g02418256

10. If 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).

i04485789

Accessory Drive - Remove and Install (Accessory Drive SAE "A")

Removal Procedure

Table 54

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.

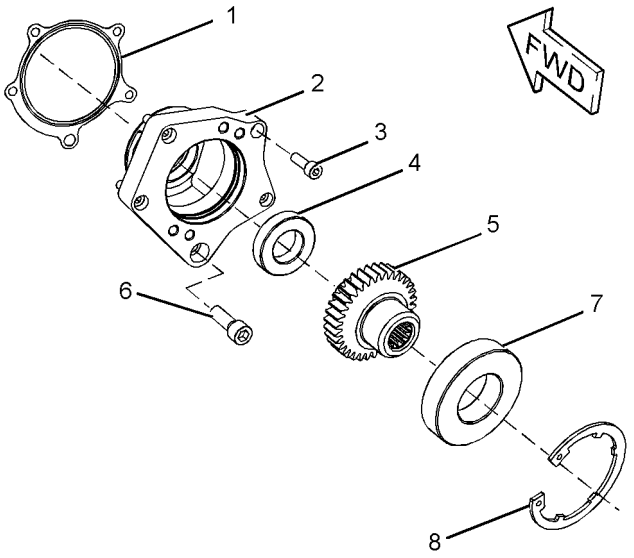

Illustration 288 g02086073
Typical example

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

Installation Procedure

Table 55

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	Loctite 603 Retaining Compound	1-
C	-	Loctite 242 Thread Lock Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

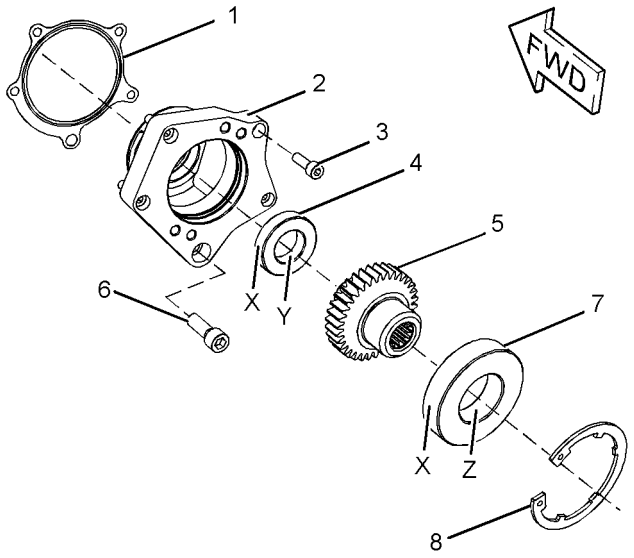

Illustration 289 g02086222
Typical example

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 (5) for wear and damage. Inspect bearing (7), bearing (4), and circlip (8). 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 inner Surface (Y) of bearing (4). Place the gear shaft on a suitable support. Press on the inner race of bearing (4) until bearing (4) is against the shoulder of gear (5). Remove any excess compound.

c. Apply a small continuous bead of Tooling (B) to inner Surface (Z) of bearing (7). Place the inner race of bearing (7) onto a suitable support. Press the shaft of gear (5) into bearing (7) 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 (X) of bearing (7) and bearing (4). Place accessory drive housing (2) on a suitable support. Press the assembly of the gear into the accessory drive housing. Ensure that bearing (4) is against the front face of the recess in accessory drive housing (2). Remove any excess compound.

e. Install circlip (8) into the groove in accessory drive housing (2). Ensure that circlip (8) is correctly positioned in the groove.

2. Install gasket (1) to accessory drive housing (2).

3. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” and Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

4. Lightly lubricate bearing (7), bearing (4), and gear (5) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing. Ensure that the flange on the accessory drive housing is flush with the front housing.

5. Install new M8 allen head screws (3) to accessory drive housing (2). Tighten the allen head screws to a torque of 22 N·m (195 lb in).

6. Install a new M12 allen head screw (6) to accessory drive housing (2). Tighten the allen head screw (6) to a torque of 78 N·m (58 lb ft).

7. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

i04485811

Crankcase Breather - Remove

Removal Procedure

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.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

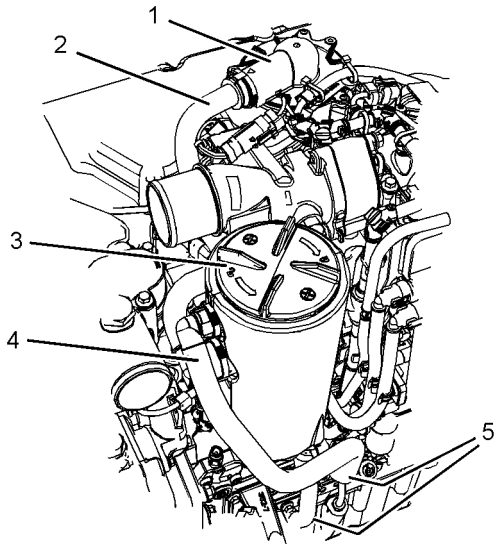

Illustration 290 g02439736

1. Disconnect plastic tube assembly (2) from breather canister (3) and breather connection (1) on the valve mechanism cover.

2. Disconnect plastic tube assembly (4) from breather canister (3).

3. Cut cable straps from clips (5) (not shown). Remove plastic tube assembly (4).

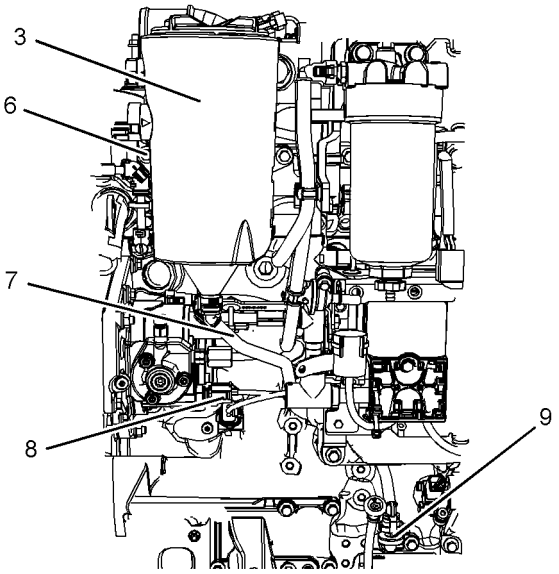

Illustration 291 g02439737

4. Disconnect harness assembly (8) from the fuel temperature sensor.

5. Remove plastic tube assembly (7) from breather canister (3) and valve (9) in the cylinder block.

6. Remove bolts (6) and remove breather canister (3) from the cylinder head.

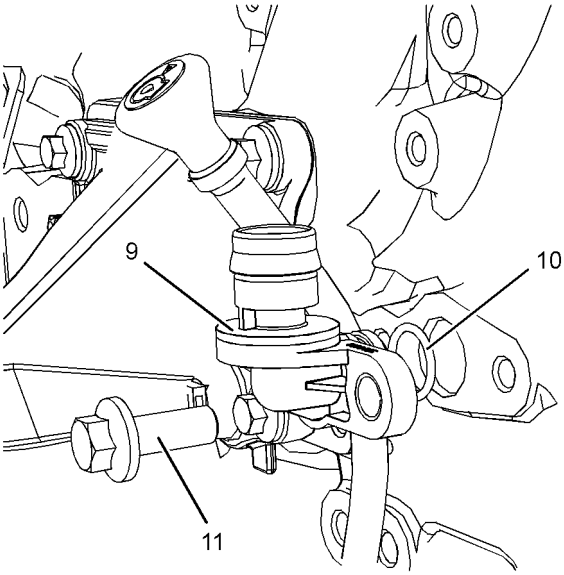

Illustration 292 g02439738

7. If necessary, follow Step 7.a through Step 7.b in order to remove valve (9) from the cylinder block.

   a. Remove bolt (11) from valve (9).

   b. Remove valve (9) from the cylinder block.

   c. Remove O-ring seal (10) from valve (9).

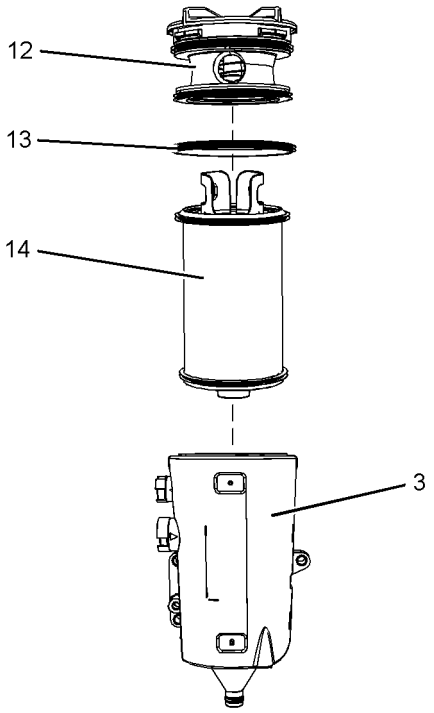

Illustration 293 g02439739

8. If necessary, follow Step 8.a through Step 8.c in order to disassemble the breather canister.

   a. Remove cap (12) from breather canister (3).

   b. Remove seal (13) from cap (12).

   c. Remove filter element (14) from breather canister (3). Refer to Operation and Maintenance Manual, “Engine Crankcase Breather Element - Replace” for the correct procedure.

i04485810

Crankcase Breather - Install

Installation Procedure

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.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.

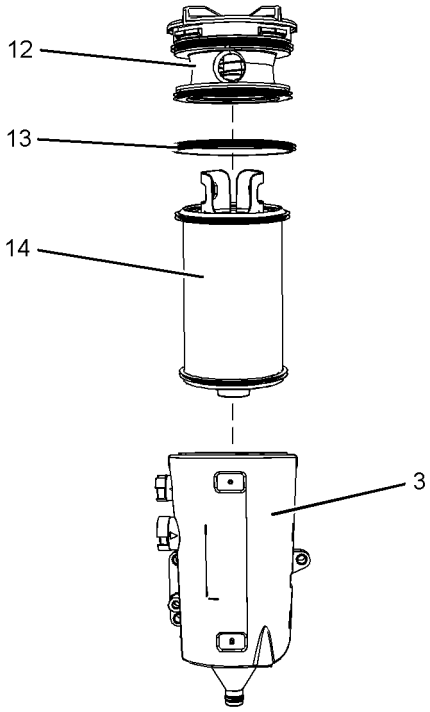

Illustration 294 g02439739

2. If necessary, follow Step 2.a through Step 2.c in order to assemble the breather canister.

   a. Install a new seal (3) to top cap (12).

   b. Install a new filter element (14) to breather canister (3). Refer to Operation and Maintenance Manual, “Engine Crankcase Breather Element - Replace” for the correct procedure.

   c. Install top cap (12) onto breather canister (3).

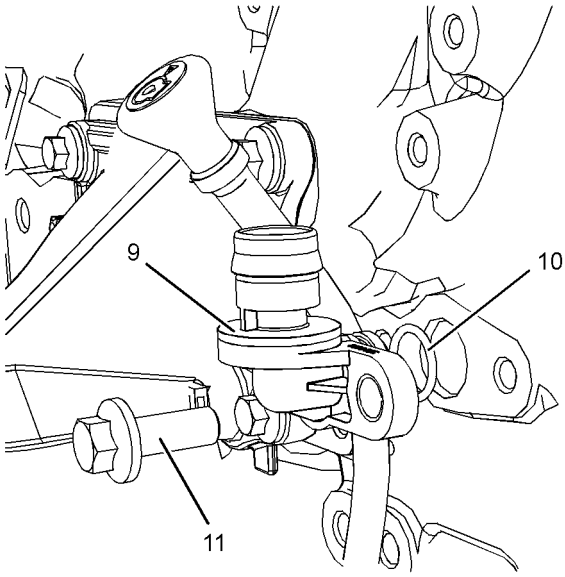

Illustration 295 g02439738

3. If necessary, follow Step 3.a through Step 3.c in order to install valve (9) to the cylinder block.

   a. Install a new O-ring seal (10) to valve (9).

Note: Do not lubricate the O-ring seal.

   b. Install valve (9) into the cylinder block. Install bolt (11).

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

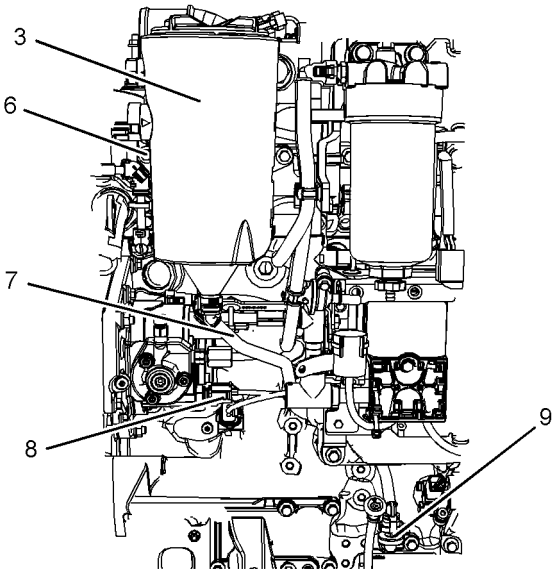

Illustration 296 g02439737

4. Position breather canister (3) onto the cylinder head and install bolts (6). Tighten the bolts to a torque of 22 N·m (195 lb in).

5. Connect plastic tube assembly (7) to breather canister (3) and valve (9) in the cylinder block.

6. Connect harness assembly (8) to the fuel temperature sensor.

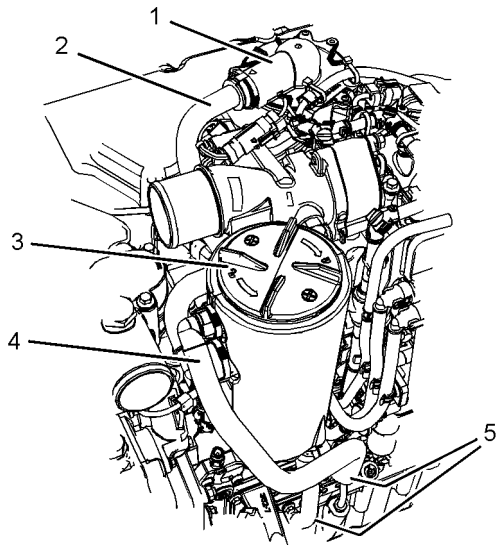

Illustration 297 g02439736

7. Connect plastic tube assembly (2) from breather canister (3) and breather connection (1) on the valve mechanism cover.

8. Connect plastic tube assembly (4) to breather canister (3).

9. Install new cable straps to clips (5) (not shown). Position plastic tube assembly (4) onto clips (5) (not shown). Install cable straps to the plastic tube assembly.

i04485914

Valve Mechanism Cover - Remove and Install

Removal Procedure

Start By:

a. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, removal of the DPF assembly will be necessary in order to access the valve mechanism cover. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Remove” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

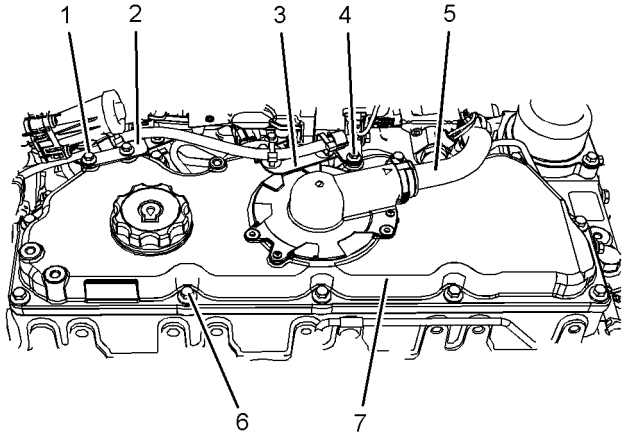

Illustration 298 g02522396

1. Remove bolts (1) and bolts (4) from bracket (2) and bracket (3). Position brackets and harness assembly away from valve mechanism cover (7).

2. Disconnect the plastic tube assembly (5) from the valve mechanism cover for the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

3. Remove bolt (6) from valve mechanism cover (7).

4. 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.

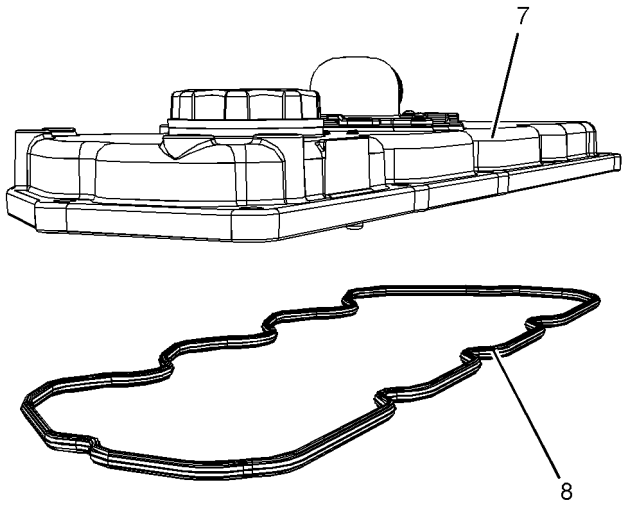

Illustration 299 g02522397

5. Remove gasket (8) from valve mechanism cover (7).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

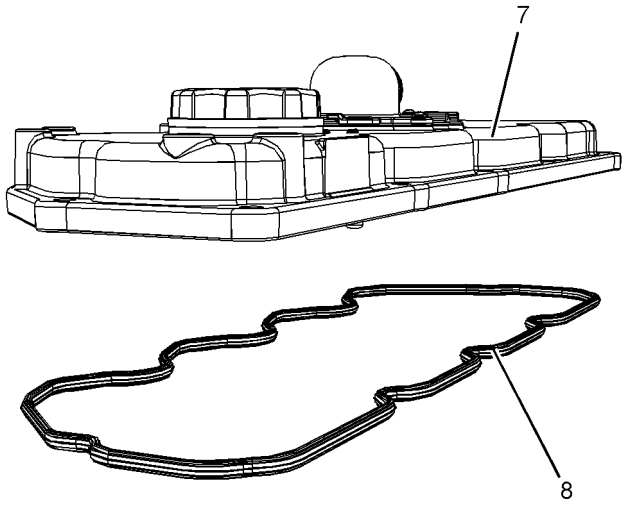

Illustration 300 g02522397

1. Thoroughly clean all gasket surfaces of valve mechanism cover (7). Clean the gasket surfaces of the cylinder head.

2. Inspect gasket (8) for damage. If necessary, install a new gasket (8) to valve mechanism cover (7).

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

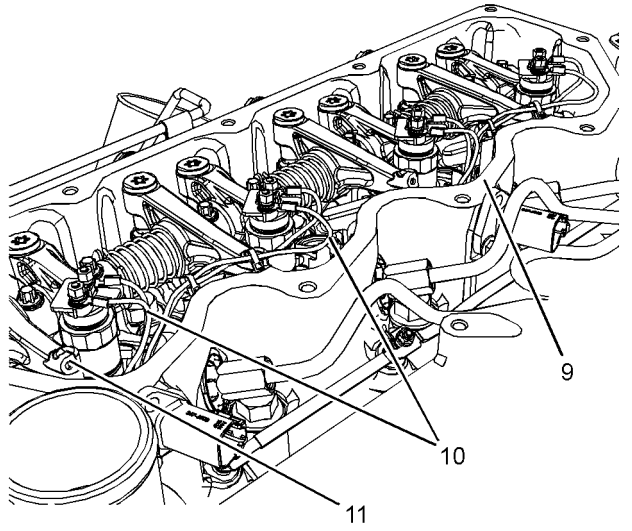

Illustration 301 g02522398

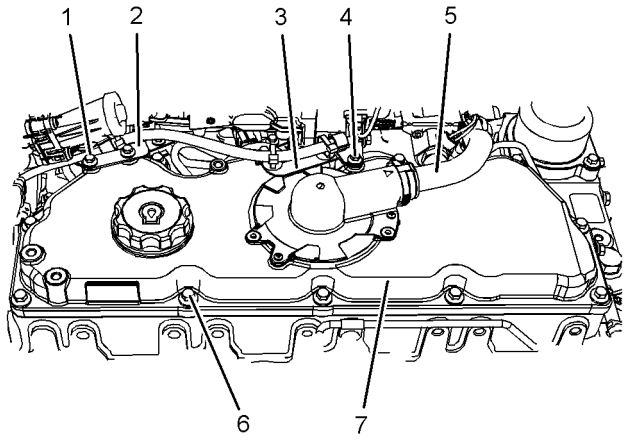

Illustration 302 g02522396

3. Ensure that harness assemblies (10) are not in contact with rocker arms (11) or cylinder head (9).

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 (9). Ensure that harness assemblies (10) are not trapped during the assembly procedure.

5. Install bolts (6).

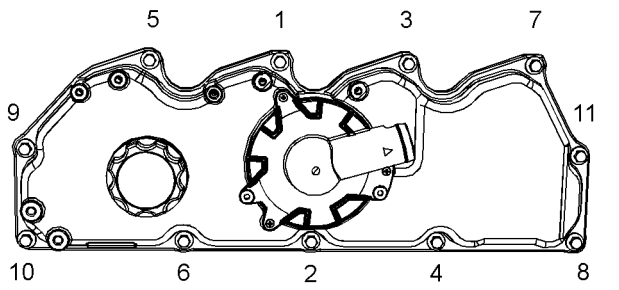

Illustration 303 g02522516

6. Tighten the bolts in the numerical sequence that is shown in Illustration 303. Tighten the bolts to a torque of 22 N·m (195 lb in).

Repeat Step 6 in order to ensure correct torque.

7. Position brackets and harness assembly onto the valve mechanism cover. Install bolts (1) and bolts (4) to bracket (2) and bracket (3).

8. Tighten bolts (1) and bolts (4) 9 N·m (79 lb in).

9. Connect the plastic tube assembly to the valve mechanism cover for the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Install” for the correct procedure.

End By:

a. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, installation of the DPF assembly will be necessary after the valve mechanism cover has been installed. Refer to Disassembly and Assembly, “Diesel Particulate Filter - Install” for the correct procedure.

i04485901

Rocker Shaft and Pushrod - Remove

Removal Procedure

Table 56

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 the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

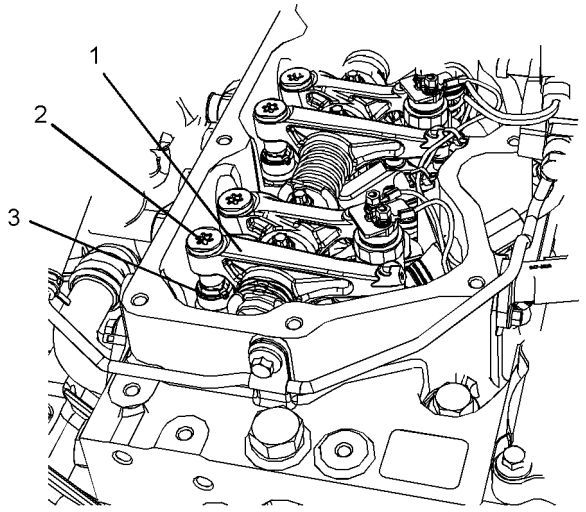

Illustration 304 g02518905

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 the guides (3) for the pushrods are left in position on the threaded inserts (2).

Note: Ensure that ALL threaded inserts are fully unscrewed.

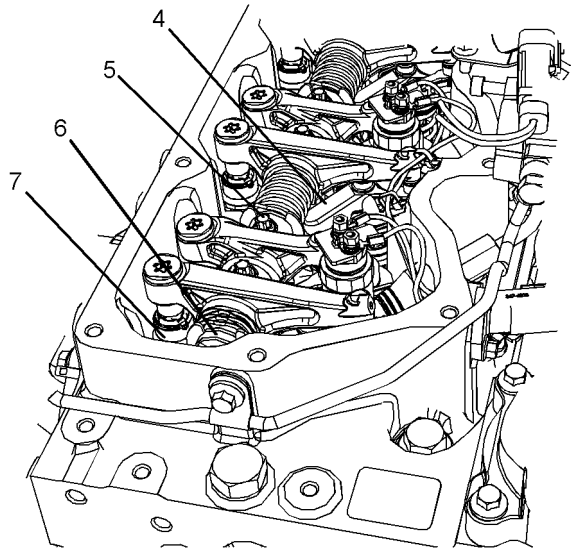

Illustration 305 g02518906

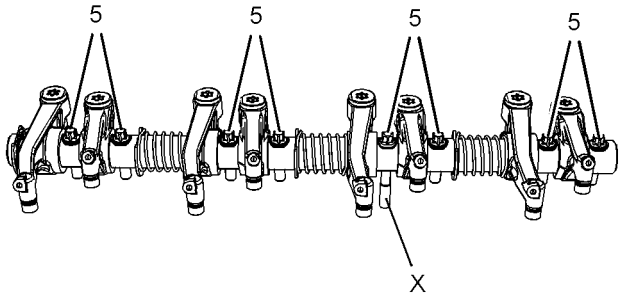

Illustration 306 g02518899

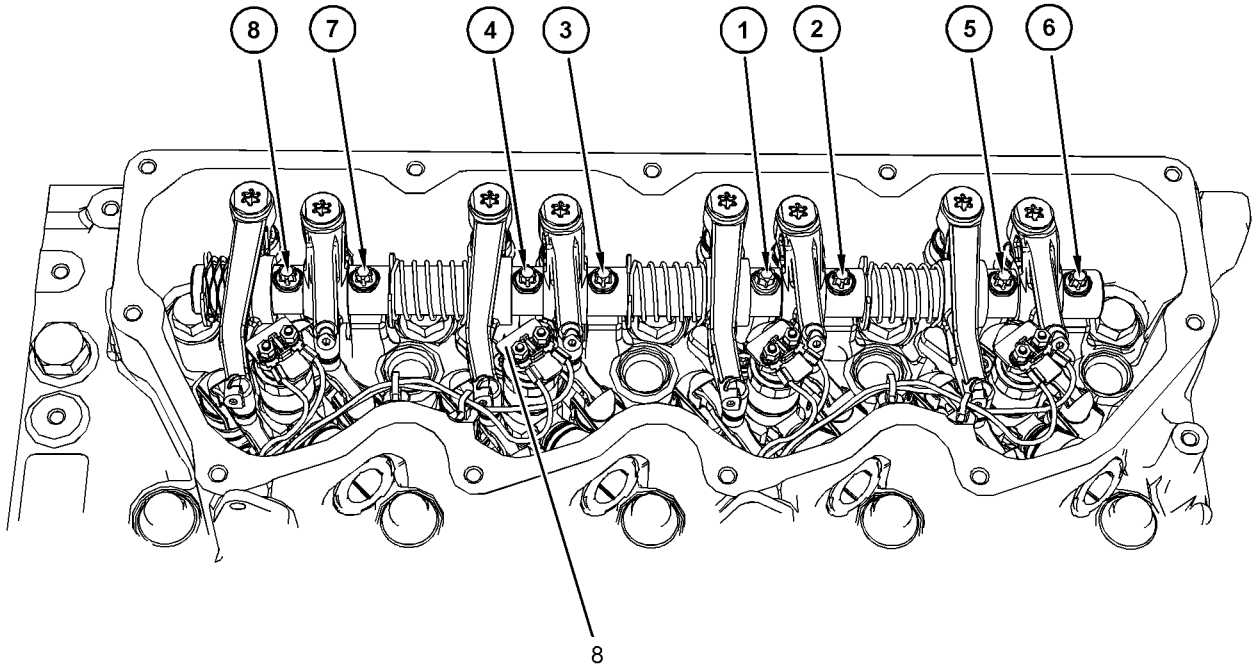

Illustration 307 g02520457

Sequence for tightening the bolts for the rocker shaft assembly

3. Use Tooling (C) to loosen Torx screws (5) in the reverse numerical order to the tightening sequence. Refer to the Illustration 307.

4. Loosen Torx screws (5) from sufficiently in order to allow removal of rocker shaft assembly (6).

Note: Note Position (X) of different length Torx screws (5).

5. Remove rocker shaft assembly (6) from the cylinder head. Ensure that rocker shaft assembly (6) does not come into contact with the electronic unit injector identification tag (8).

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.

i04485899

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.

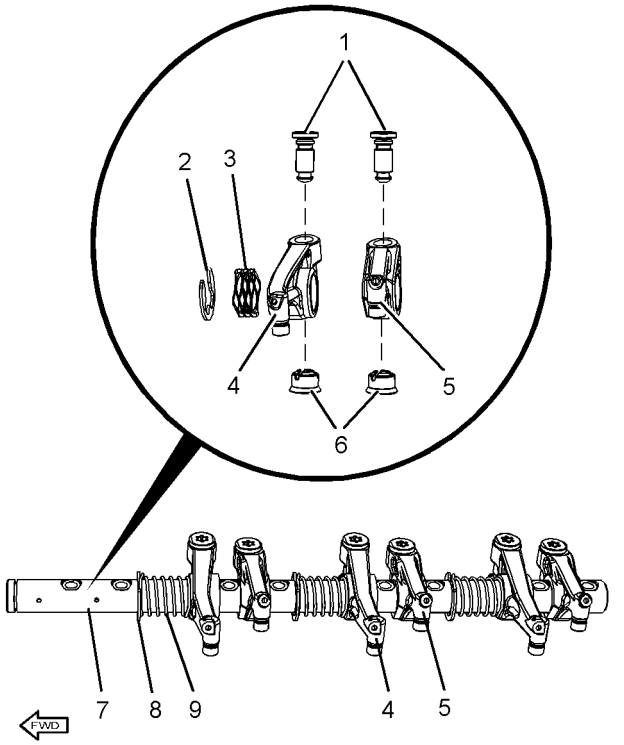

Illustration 308 g02520576

2. Remove the Torx screws from the rocker shaft assembly. Note position of different length Torx screws for assembly purposes.

3. Remove retaining clip (2) from rocker shaft (7). Remove spring (3) from the rocker shaft.

4. Remove rocker arm assembly (4) for the inlet valve from rocker shaft (7). Remove rocker arm assembly (5) for the exhaust 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.

5. Remove retaining clip (8) from rocker shaft (7). Remove spring (9) from the rocker shaft.

6. Remove rocker arm assembly (4) for the exhaust valve from rocker shaft (7). Remove rocker arm assembly (5) for the inlet valve from rocker shaft (7).

7. Repeat Step 5 through Step 6 in order to remove the remaining rocker arms from rocker shaft (7).

8. If necessary, follow Step 8.a through Step 8.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 (1).

   c. Remove threaded inserts (1) from the rocker arms.

i04485898

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.

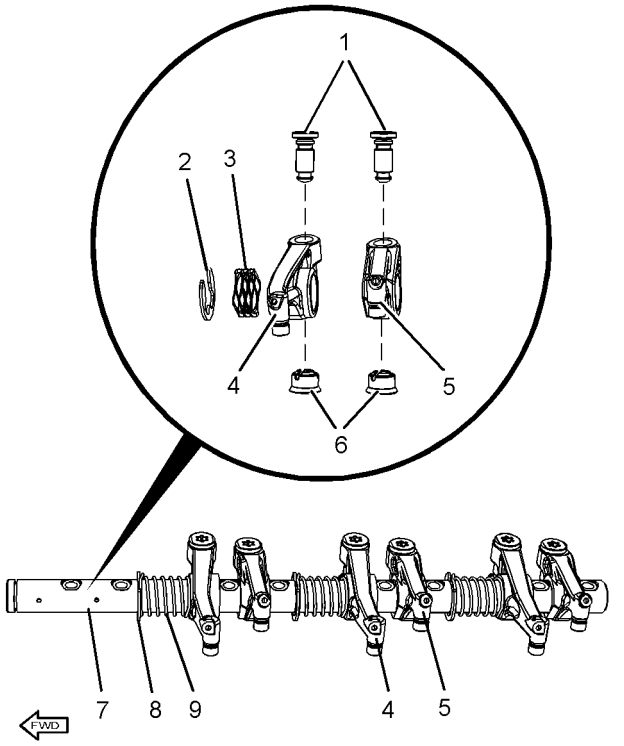

Illustration 309 g02520576

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 bores of rocker arm assembly (4) for the inlet valve and rocker arm assembly (5) for the exhaust valve and rocker shaft (7) with clean engine oil.

4. Install retaining clip (2) and spring (3) to the front end of rocker shaft (7).

5. Install rocker arm assembly (4) for number one inlet valve to the rocker shaft. Install rocker arm assembly (5) for number one 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.

6. Install retaining clip (8) to rocker shaft (7).

7. Install spring (9) to rocker shaft (7).

8. Install rocker arm assembly (4) for number two inlet valve to the rocker shaft. Install rocker arm assembly (5) for number two 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.

9. Repeat Step 6 through Step 8 in order to assemble the remaining components to rocker shaft (7).

10. Install the Torx screws to the rocker shaft assembly. Ensure that the different length Torx screws is installed into the correct position.

End By:

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

i04485900

Rocker Shaft and Pushrod - Install

Installation 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	-	T40 Torx Socket	1
C	-	E10 Torx Socket	1
D	T400027	Rocker Arm Spacer	4

(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.

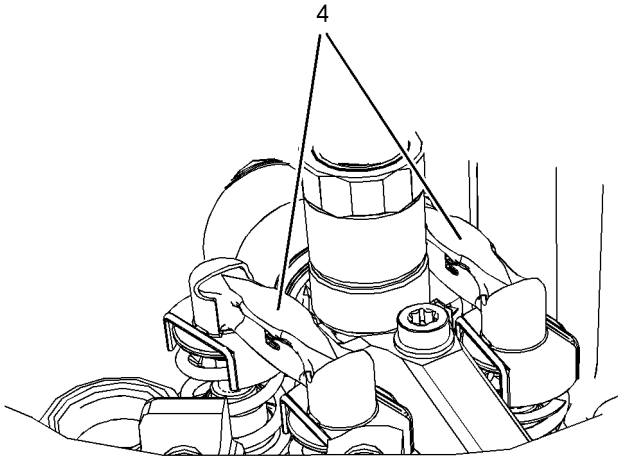

Illustration 310 g02623139

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 (6) 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.

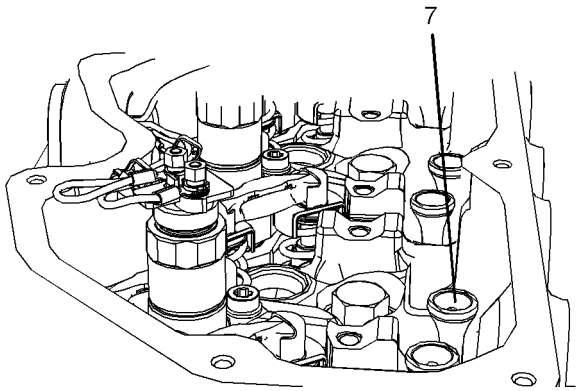

Illustration 311 g02623141

4. Clean pushrods (7). Inspect the pushrods for wear and damage. Replace any pushrods that are worn or damaged.

5. Apply clean engine 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 set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves 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 the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

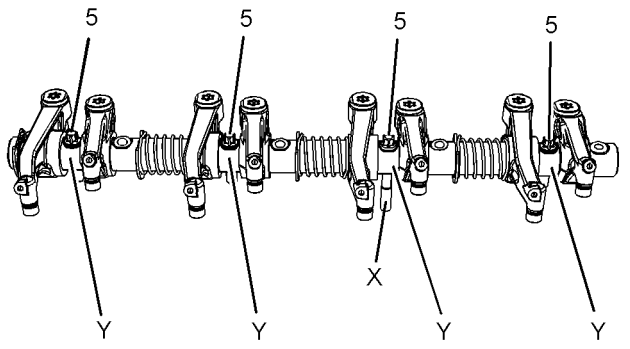

Illustration 312 g02520517

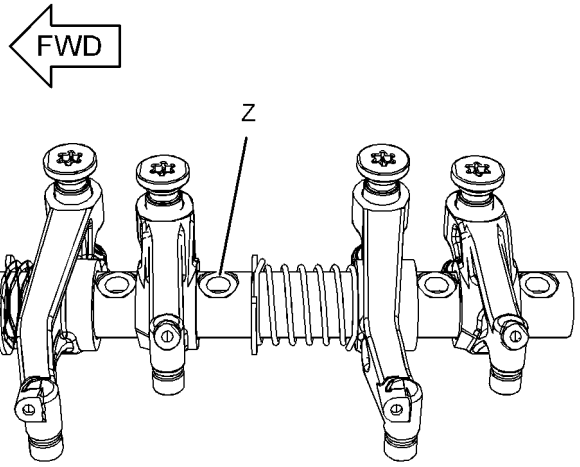

Illustration 313 g02623177

7. Ensure that the rocker shaft assembly is clean and free from wear and damage.

8. Position the rocker shaft assembly with Spotfaces (Z) for Torx screws (5) in the up ward position.

9. Install Tooling (D) to rocker shaft assembly.

10. Install Torx screws (5) in the rocker shaft in Positions (Y).

Note: Ensure that the correct Torx screw (5) is installed to Position (X).

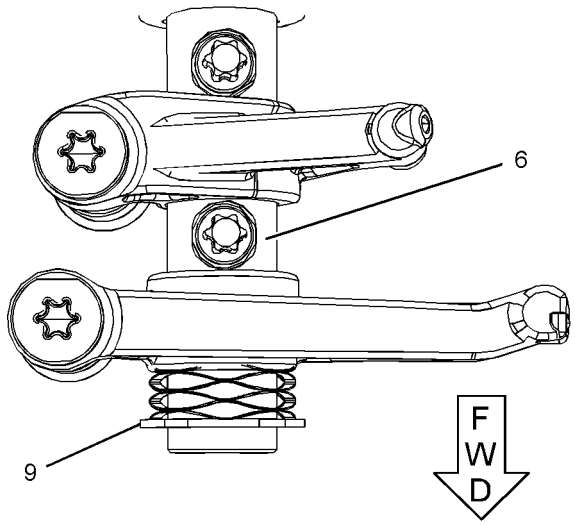

Illustration 314 g02623145

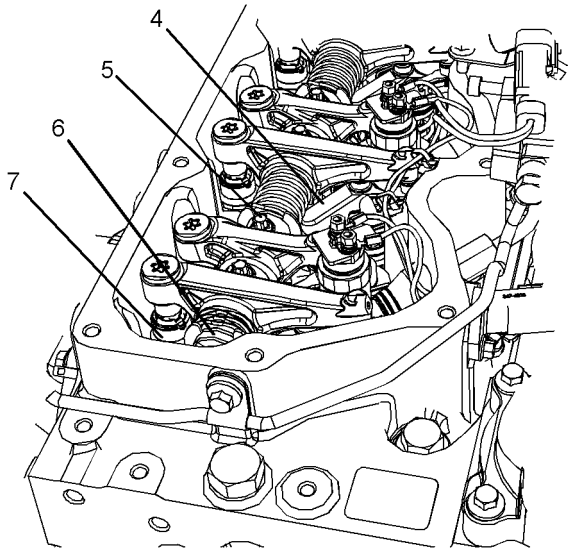

Illustration 315 g02518906

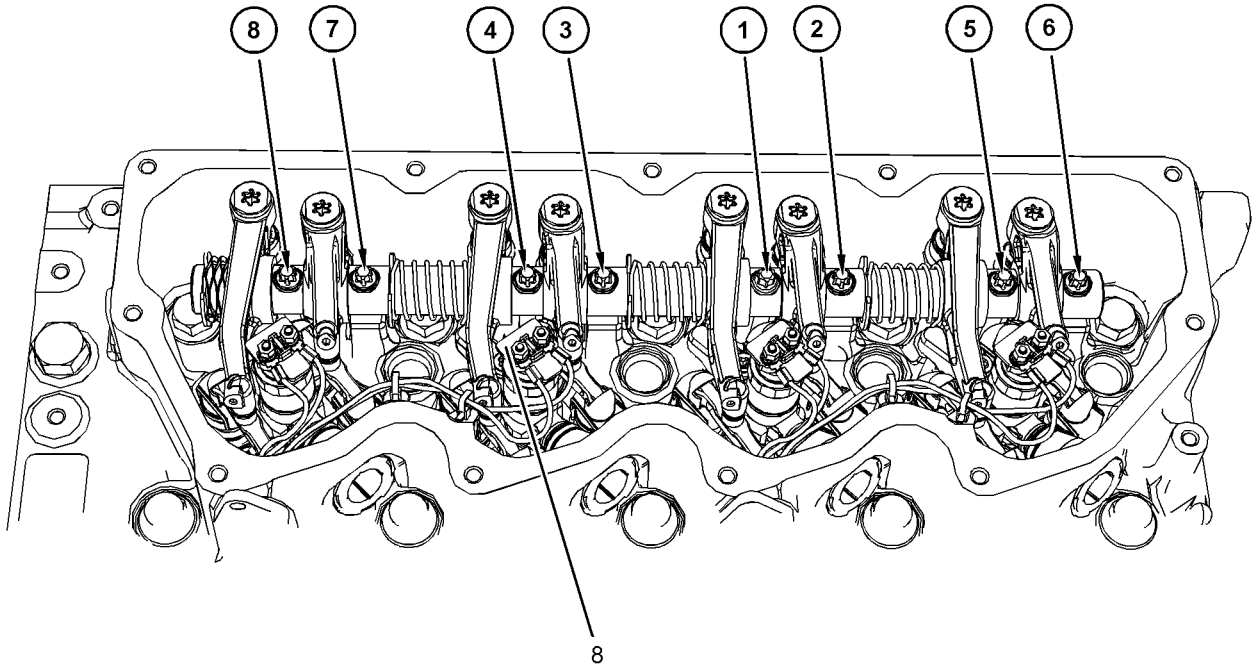

Illustration 316 g02520457

Sequence for tightening the bolts for the rocker shaft assembly

11. Ensure that ALL threaded inserts are fully unscrewed.

12. Position rocker shaft assembly (6) onto the cylinder head. The retaining clip (9) should face the front of the engine. Ensure that the rocker shaft assembly (6) does not come into contact with the electronic unit injector identification tag (8).

Note: Ensure that the threaded inserts are correctly seated in ends of the pushrods.

13. Use Tooling (C) in order to tighten Torx screws (5).

14. Remove Tooling (D) from rocker shaft assembly. Install remaining Torx screws (5). Use Tooling (C) in order to tighten the remaining Torx screws (5).

15. Tighten Torx screws (5) to a torque of 35 N·m (26 lb ft) in the numerical sequence. Refer to Illustration 316.

16. Ensure that valve bridges (4) are still located correctly on the valve stems.

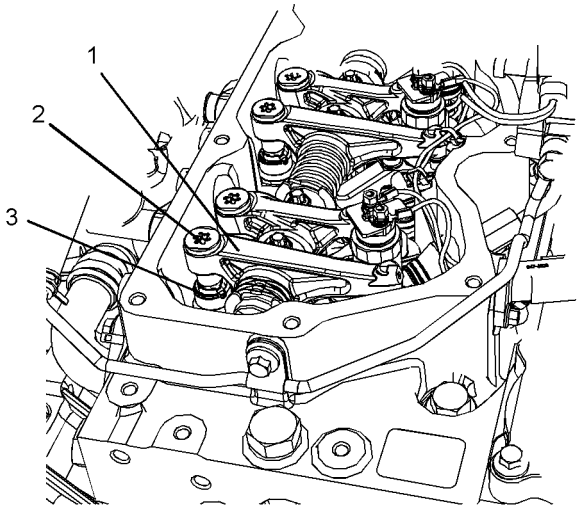

Illustration 317 g02518905

17. Ensure that the guides (3) for the pushrods are correctly positioned on the 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 be seated correctly in the cup for the pushrod.

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 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.

i04485825

Cylinder Head - Remove

Removal Procedure

Table 58

Required Tools			
Tool	**Part Number**	**Parts Description**	**Qty**
A	T410437	Cap 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, “Fuel 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 fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (Rail) - Remove and Install” for the correct procedure.

e. Remove the electronic unit injectors. Refer to Disassembly and Assembly, “Electronic Unit Injector - Remove” for the correct procedure.

f. 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.

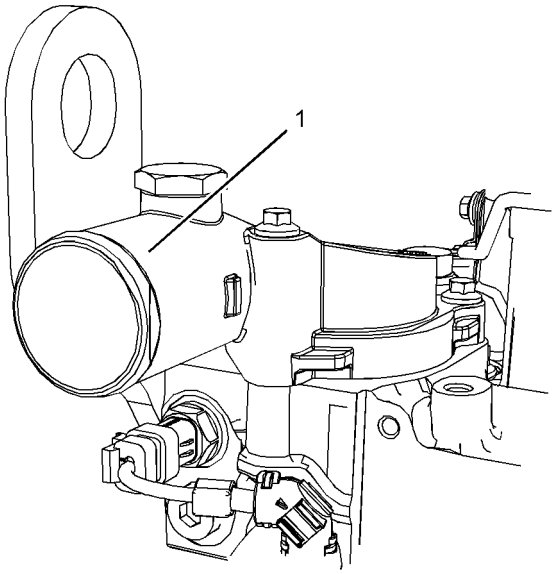

Illustration 318 g02452914

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

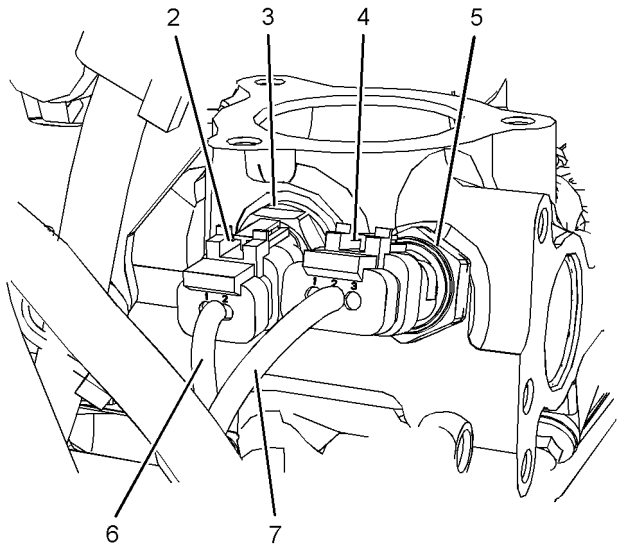

Illustration 319 g02452915

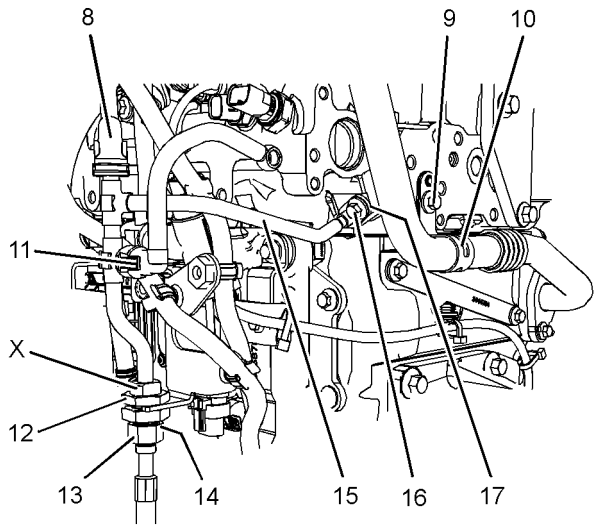

Illustration 320 g02452919

3. Follow Step 3.a through Step 3.b in order to disconnect harness assembly (7) from boost pressure sensor (5).

a. Slide the locking tab into unlocked position (4).

b. Disconnect harness assembly (7) from boost pressure sensor (5).

4. Follow Step 4.a through Step 4.b in order to disconnect harness assembly (6) from inlet air temperature sensor (3).

a. Slide the locking tab into unlocked position (2).

b. Disconnect harness assembly (6) from inlet air temperature sensor (3).

5. Remove all cable straps that secure 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.

6. Disconnect plastic tube assembly (8) and plastic tube assembly (11) from tube assembly (15). Use Tooling (A) in order to plug the plastic tube assemblies and to cap the tube assembly.

7. Disconnect hose assembly (13) from connection on tube assembly (15). Remove O-ring seal (14) (not shown). Use Tooling (A) in order to plug the hose assembly and to cap the tube assembly.

8. Use a suitable tool in Position (X) in order to hold tube assembly (15) as nut (12) is loosened. Remove bolt (16) from tube assembly (15).

9. Remove tube assembly (15) from the bracket and the cylinder head. Use Tooling (A) in order to plug the cylinder head and to cap the tube assembly.

10. Remove O-ring seal (15) from tube assembly (17).

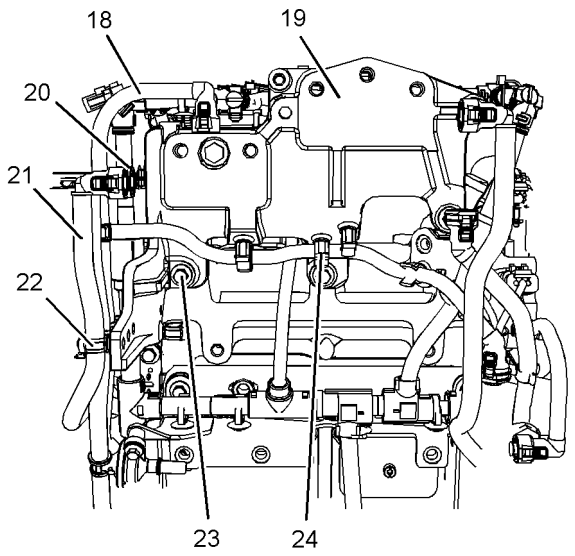

Illustration 321 g02456139

11. Disconnect plastic tube assembly (18) plastic tube assembly (20) and plastic tube assembly (21) from clips (22) and clips (24).

12. Remove bolts (23) from fuel filter bracket (19).

13. Remove fuel filter bracket (19) from the cylinder head.

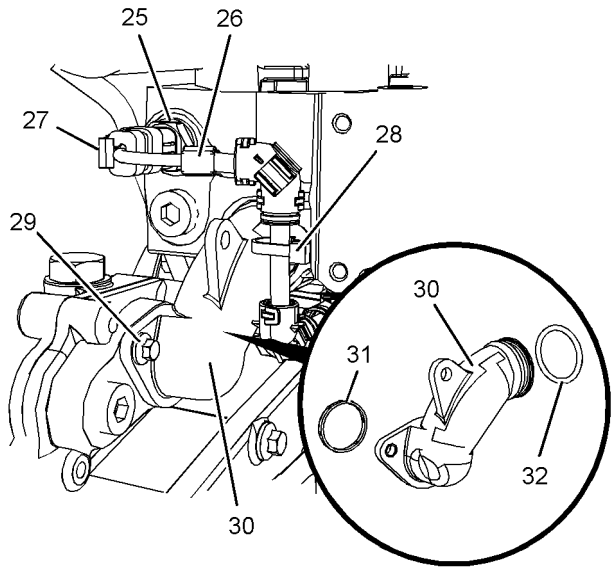

Illustration 322 g02452920

14. Follow Step 14.a through Step 14.c in order to disconnect harness assembly (26) from coolant temperature sensor (25).

a. Slide locking tab (27) into the unlocked position.

b. Disconnect harness assembly (26) from coolant temperature sensor (25).

c. Cut cable strap (28) and remove harness assembly (26) from bypass tube (30). 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.

15. Remove bolts (29). Remove bypass tube (30) from the cylinder head. Remove O-ring seal (31) and O-ring seal (32) from bypass tube (30).

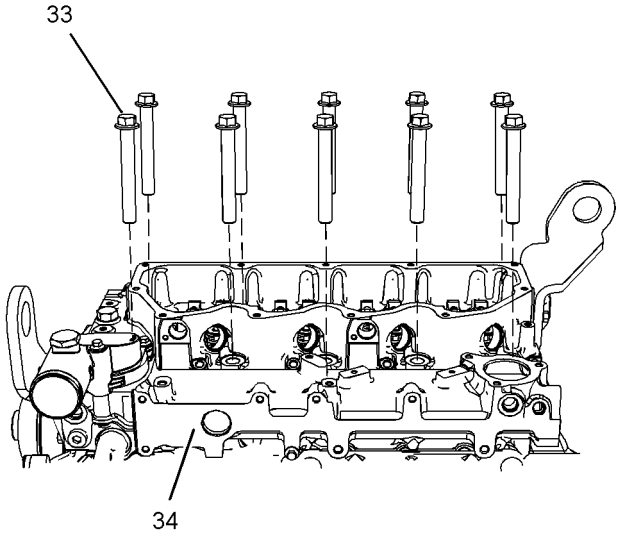

Illustration 323 g02452921

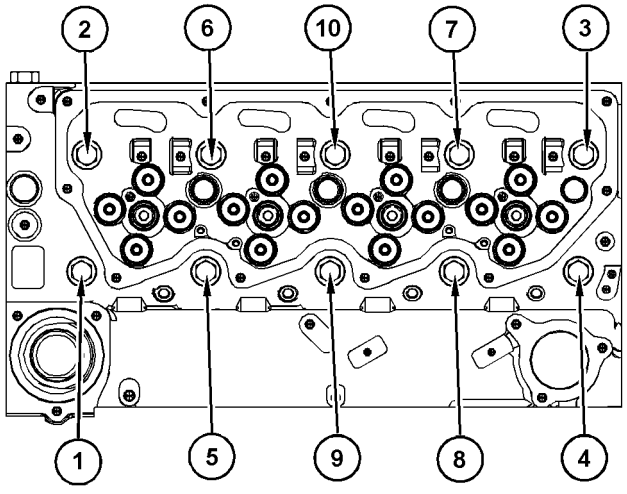

Illustration 324 g02452922

Sequence for tightening the bolts for the cylinder head

16. Gradually loosen bolts (33) in the reverse numerical order to the tightening sequence. Refer to the Illustration 324.

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

17. Remove bolts (33) from cylinder head (34).

18. Attach a suitable lifting device to cylinder head (34). Support the weight of the cylinder head. The weight of the cylinder head is approximately 66 kg (146 lb).

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

19. Use the suitable lifting device to carefully lift cylinder head (34) 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.

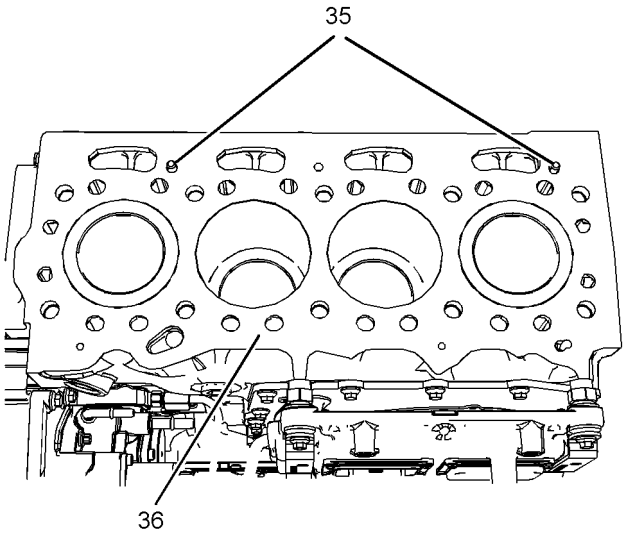

Illustration 325 g02452924

20. Remove cylinder head gasket (36).

21. Note the position of dowels (35) in the cylinder block.

22. 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.

i04485824

Cylinder Head - Install

Installation Procedure

Table 59

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Studs M16 by 115mm	2
B	21825607	Degree Wheel	1
C	-	Delphi 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 of 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.

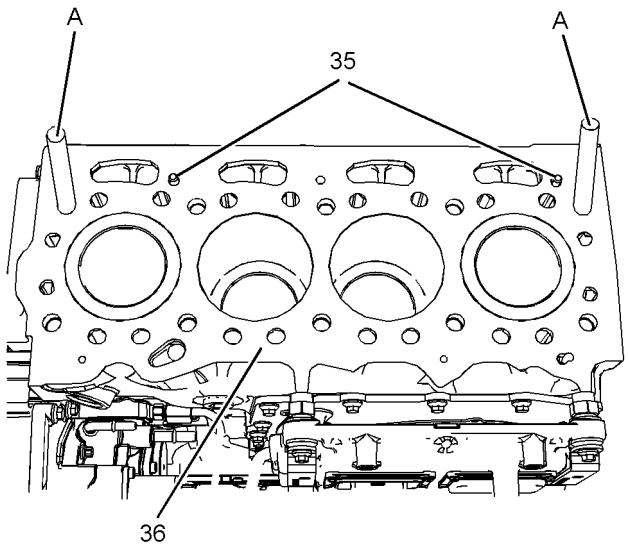

Illustration 326 g02460199

3. Inspect dowels (35) for damage. If necessary, replace the dowels in the cylinder block.

4. Install Tooling (A) to the cylinder block.

5. Align cylinder head gasket (36) with dowels (35). Install cylinder head gasket (36) onto the cylinder block.

6. Use a suitable lifting device to lift cylinder head. The weight of the cylinder head is approximately 66 kg (146 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 (A) to align the cylinder head with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned on dowels (35).

8. Remove Tooling (A).

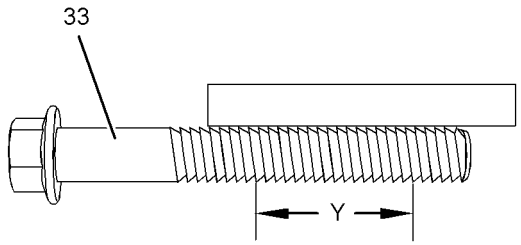

Illustration 327 g02460202

9. Clean bolts (33). 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 327. 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 (33) with clean engine oil.

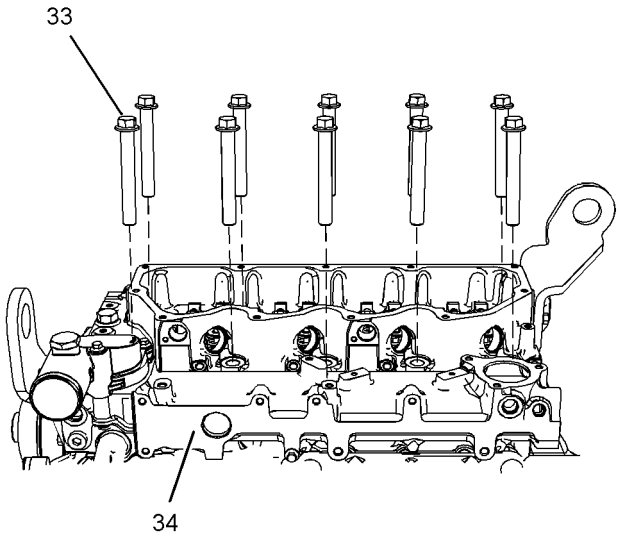

Illustration 328 g02452921

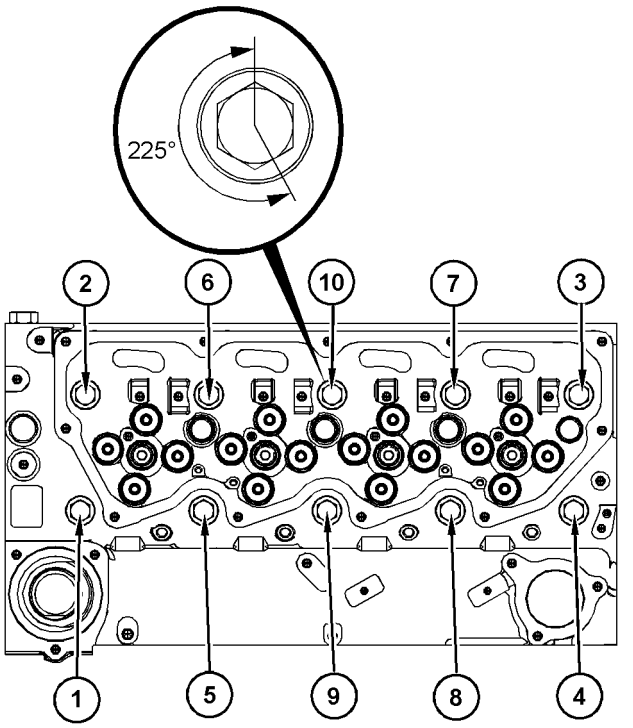

Illustration 329 g02460204

11. Install bolts (33) to cylinder head (34).

12. Tighten the bolts to a torque of 50 N·m (37 lb ft) in the numerical sequence. Refer to Illustration 329.

13. Tighten the bolts to a torque of 100 N·m (74 lb ft) in the numerical sequence. Refer to Illustration 329.

14. Use Tooling (B) in order to turn the bolts through an additional 225 degrees in the numerical sequence. Refer to Illustration 329.

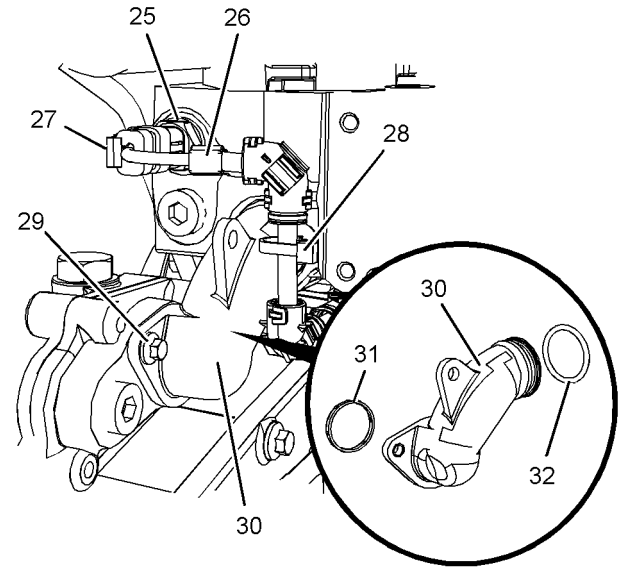

Illustration 330 g02452920

15. Use Tooling (C) in order to lubricate the O-ring seals. Install new O-ring seal (31) and O-ring seal (32) to bypass tube (30). Install the bypass tube in the cylinder head. Install bolts (29). Tighten the bolts to a torque of 22 N·m (195 lb in).

16. Follow Step 16.a through Step 16.d in order to connect harness assembly (26) to coolant temperature sensor (25).

a. Connect harness assembly (26) to coolant temperature sensor (25).

b. Slide locking tab (27) into the locked position.

c. Position harness assembly (26) onto bypass tube (30).

d. Install a new cable strap (28).

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

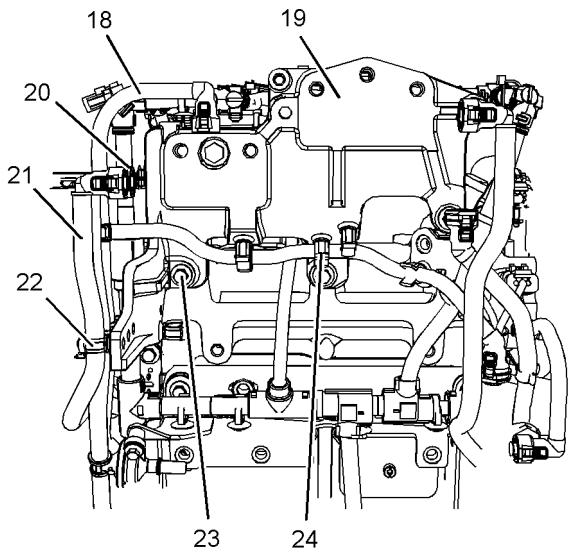

Illustration 331 g02456139

17. Position fuel filter bracket (19) onto the cylinder head.

18. Install bolts (23) to fuel filter bracket (19). Tighten the bolts to a torque of 22 N·m (195 lb in).

19. Connect plastic tube assembly (18) plastic tube assembly (20) and plastic tube assembly (21) to clips (22) and clips (24).

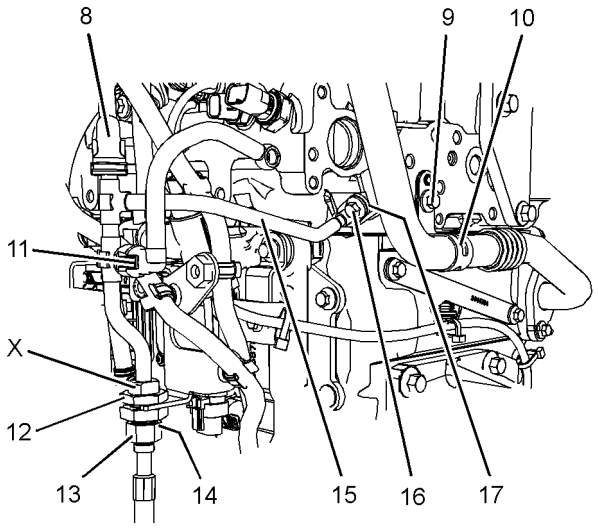

Illustration 332 g02452919

20. Remove cap from tube assembly (15). Install a new O-ring seal (17) (not shown) to tube assembly (15).

21. Install tube assembly (15) to the bracket and the cylinder head.

22. Loosely install bolt (16) to tube assembly (15). Loosely tighten nut (12) on connection for tube assembly (15).

23. Tighten bolt (16) to a torque of 22 N·m (195 lb in).

24. Use a suitable tool in order to hold tube assembly (15) in Position (X). Tighten nut (12) to a torque of 28 N·m (248 lb in).

25. Install a new O-ring seal (14) (not shown). Connect hose assembly (13) to connection on tube assembly (15). Tighten Hose assembly securely.

26. Remove the plugs from plastic tube assembly (8) and plastic tube assembly (11). Remove caps from tube assembly (15).

27. Connect plastic tube assembly (8) and plastic tube assembly (11) to tube assembly (15).

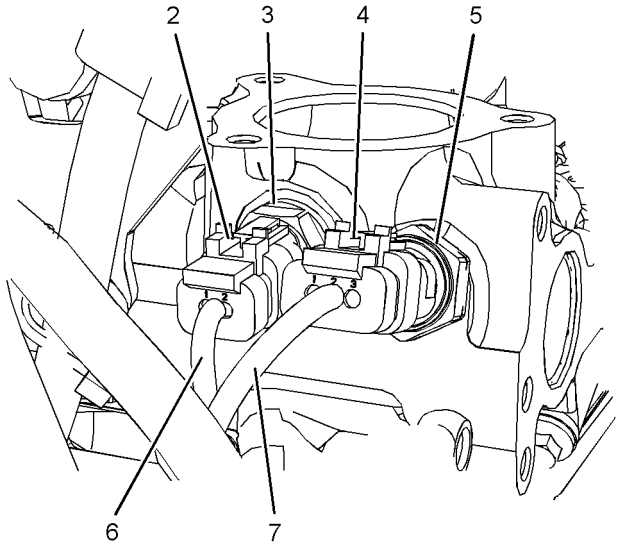

Illustration 333 g02452915

28. Follow Step 28.a through Step 28.b in order to connect harness assembly (6) to inlet air temperature sensor (3).

a. Connect harness assembly (6) to inlet air temperature sensor (3).

b. Slide locking tab (2) into the locked position.

29. Follow Step 29.a through Step 29.b in order to connect harness assembly (7) to boost pressure sensor (5).

a. Connect harness assembly (7) to boost pressure sensor (5).

b. Slide locking tab (4) into the locked position.

30. 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 cable straps meet the OEM specification. Ensure that the harness assembly is not strained.

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

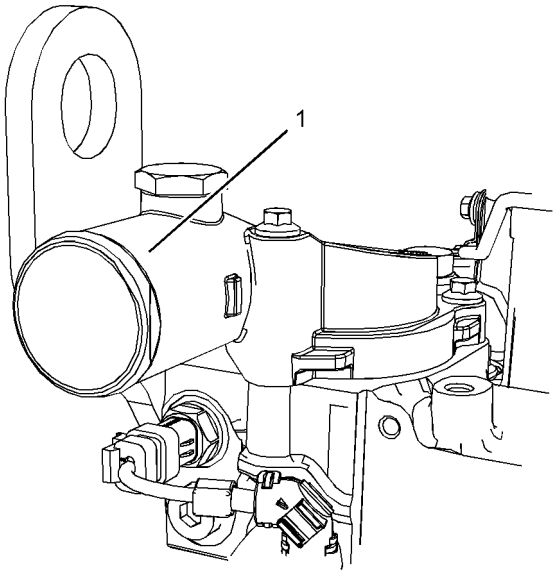

Illustration 334 g02452914

31. 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.

32. Connect the upper radiator hose to water temperature regulator housing (1) on the cylinder head.

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

34. 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 glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.

c. Install the fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (rail) - Remove and Install” for the correct procedure.

d. 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.

e. If necessary, install the water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Fuel Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

f. Install the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.

i04485929

Lifter Group - Remove and Install (Hydraulic Lifter Group)

Removal Procedure

Table 60

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

Start By:

a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

c. 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.

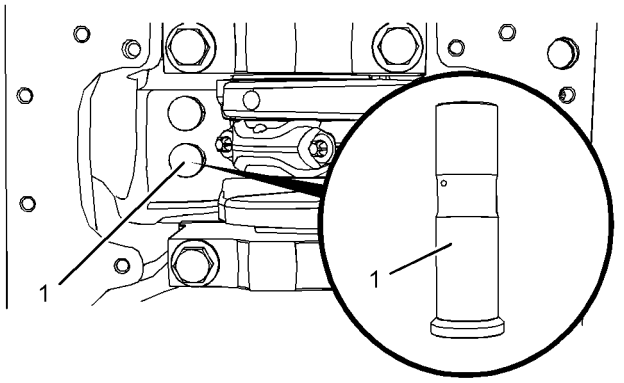

Illustration 335 g02008013

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to 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 61

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
It is strongly recommended that all lifters should be replaced 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 access to the cylinder block in order to install appropriate lifters (1).

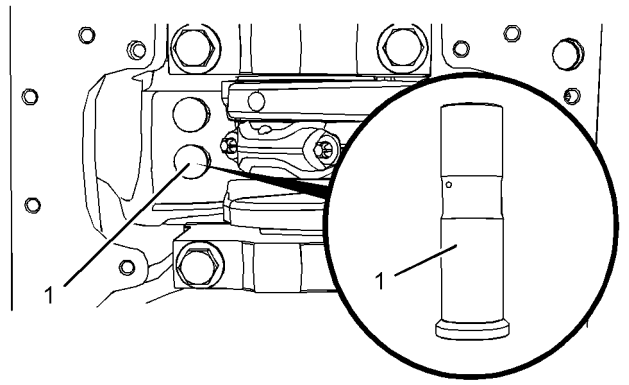

Illustration 336 g02008013

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.

b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.

c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485803

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.

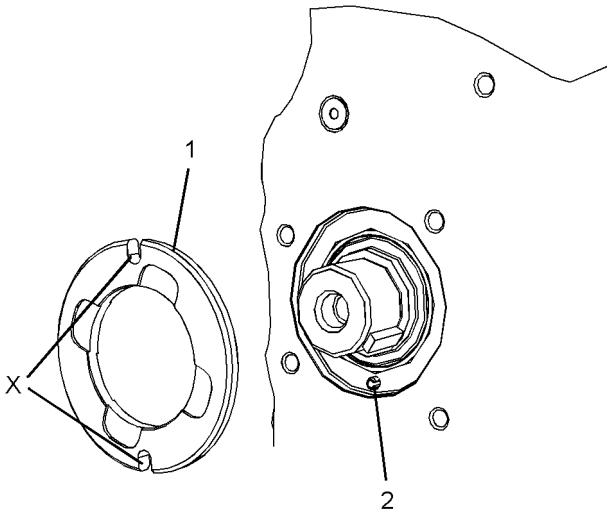

Illustration 337 g02009034

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

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

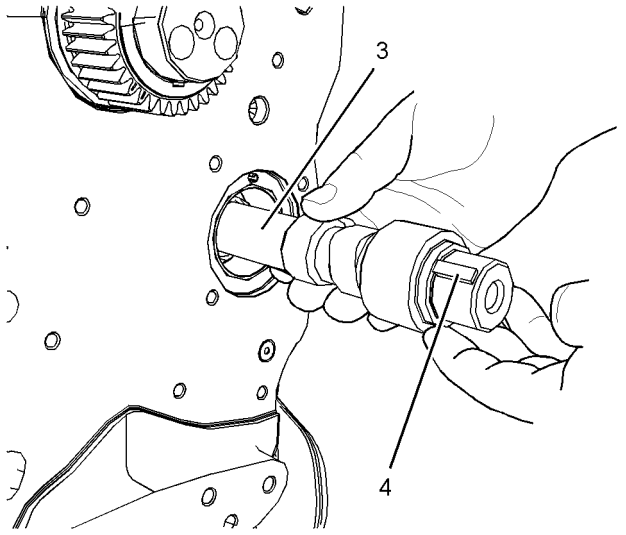

Illustration 338 g02009035

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 worn components or any damaged components.

2. Clean the camshaft bearing in the cylinder block. Inspect the camshaft bearing for wear and for damage. Refer to Specifications, “Camshaft Bearings” for more information. If necessary, replace the camshaft bearing. Refer to Disassembly and Assembly, “Camshaft Bearing - Remove and Install” for the correct procedure.

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

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

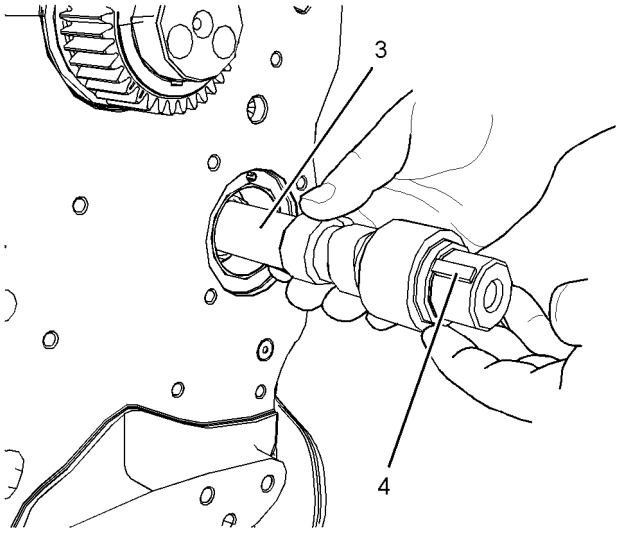

Illustration 339 g02009035

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.

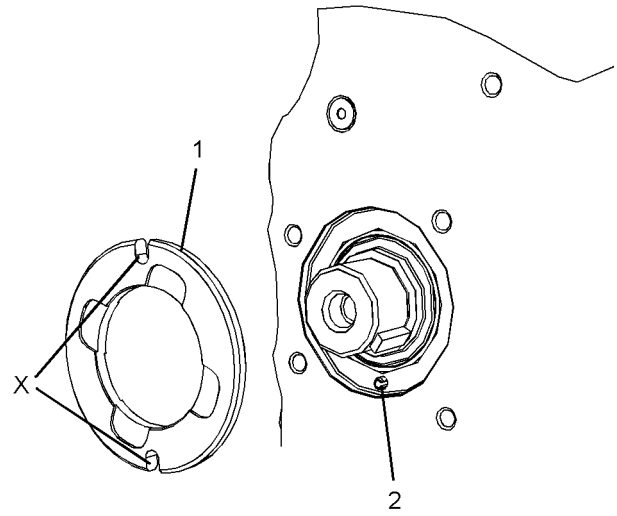

Illustration 340 g02009034

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

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

End By:

a. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

b. Install the rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker shaft and Pushrod - Install” for the correct procedure.

i04485805

Camshaft Gear - Remove and Install

Removal Procedure

Table 62

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T400015	Timing Pin (Fuel Injection Pump)	1
E	27610286	Timing Pin (Crankshaft)	1

Start By:

a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

b. Remove the front cover. Refer to Disassembly and Assembly, “Front 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.

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” for the correct procedure.

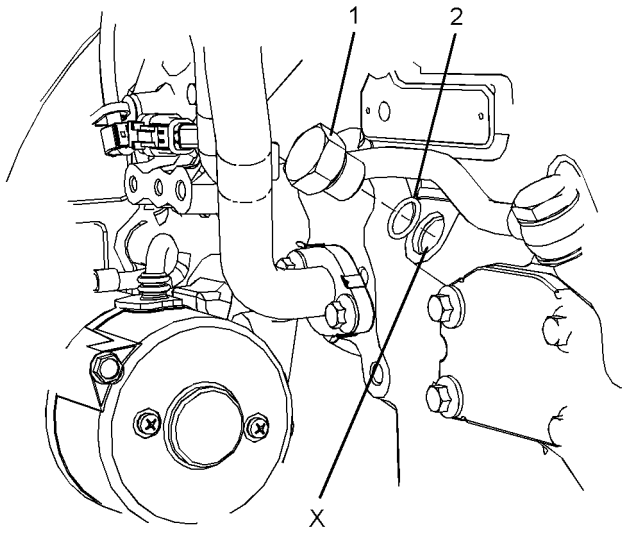

Illustration 341 g02437697

2. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.

3. Install Tooling (E) into Hole (X) 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.

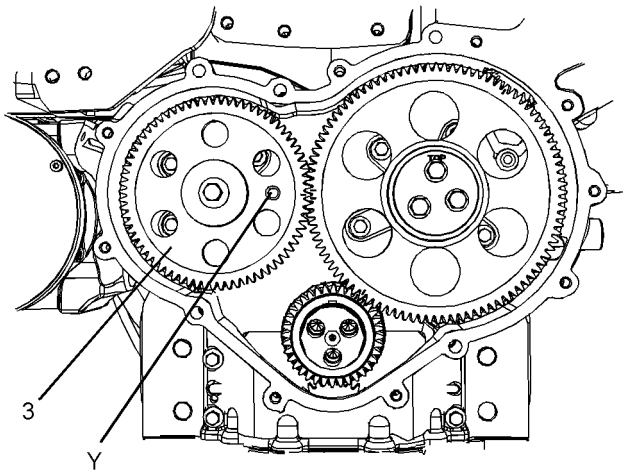

Illustration 342 g02437699

4. Install Tooling (C) through Hole (Y) in camshaft gear (3) into the front housing. Use Tooling (C) in order to lock the camshaft in the correct position.

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.

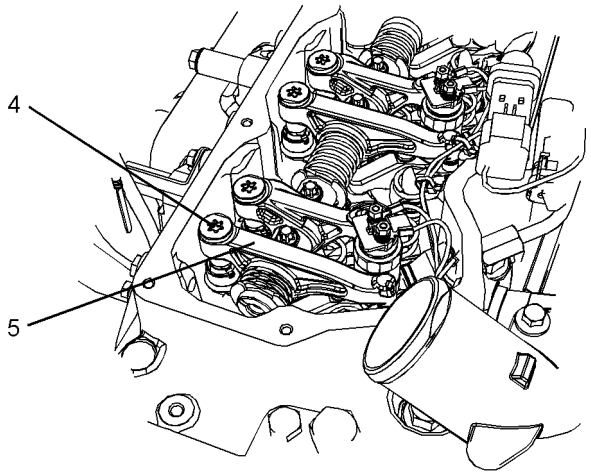

Illustration 343 g02437700

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.

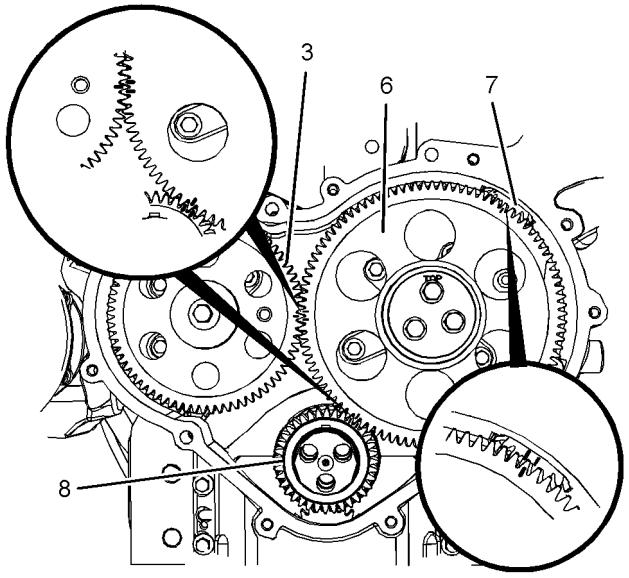

Illustration 344 g02437701
Alignment of timing marks

7. Mark gear (3), gear (6), gear (7) and gear (8) in order to show alignment. Refer to Illustration 344.

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

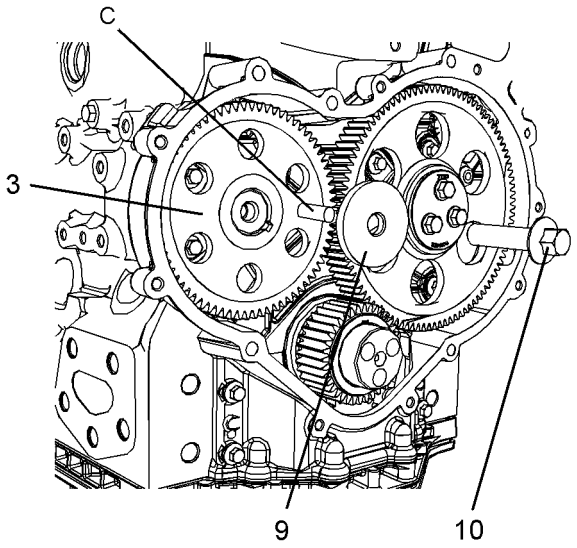

Illustration 345 g02437702

8. Remove Tooling (C). Remove bolt (10) and washer (9) from camshaft gear (3).

9. Remove camshaft gear (3) 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.

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

Installation Procedure

Table 63

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T400015	Timing Pin (Fuel Injection Pump)	1
E	27610286	Timing Pin (Crankshaft)	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.

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.

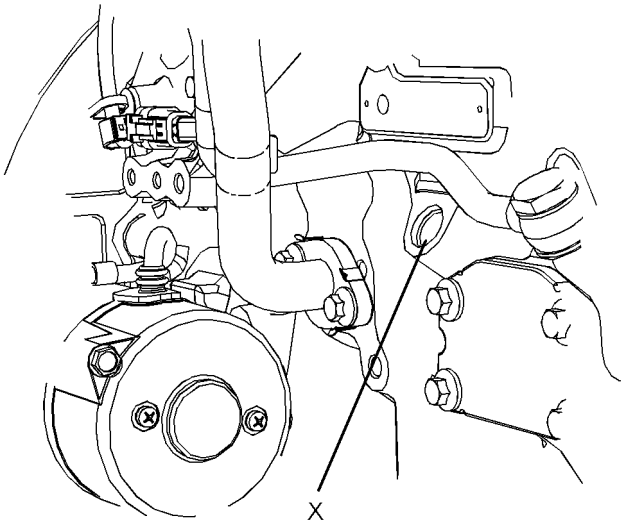

Illustration 346 g02437698

2. Ensure that Tooling (E) is installed in Hole (X) 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. Ensure that the camshaft gear and the key are clean and free from wear and damage.

4. If necessary, install the key into the nose of the camshaft.

Note: Ensure that the key is squarely seated.

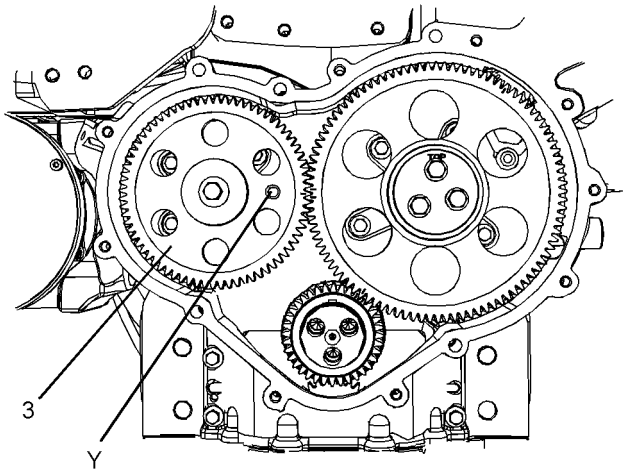

Illustration 347 g02437699

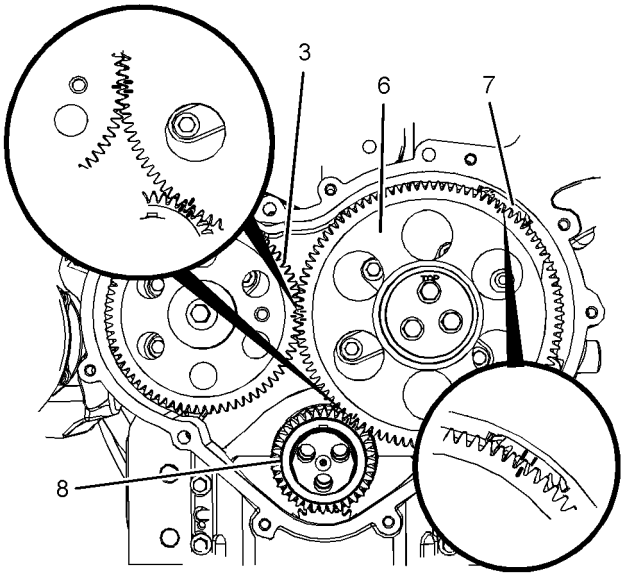

Illustration 348 g02437701
Alignment of timing marks

5. Align the keyway in camshaft gear (3) with the key in the camshaft. Install camshaft gear onto the camshaft. Ensure that the timing marks on gear (3), gear (6), gear (7) and gear (8) are in alignment and that the mesh of the gears is correct. Refer to Illustration 348.

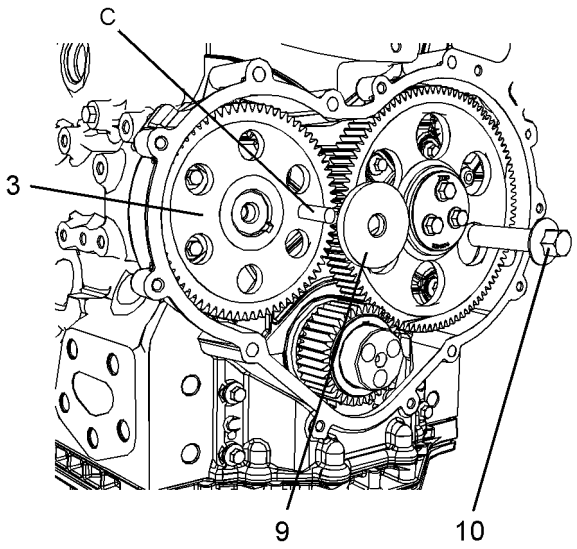

Illustration 349 g02437702

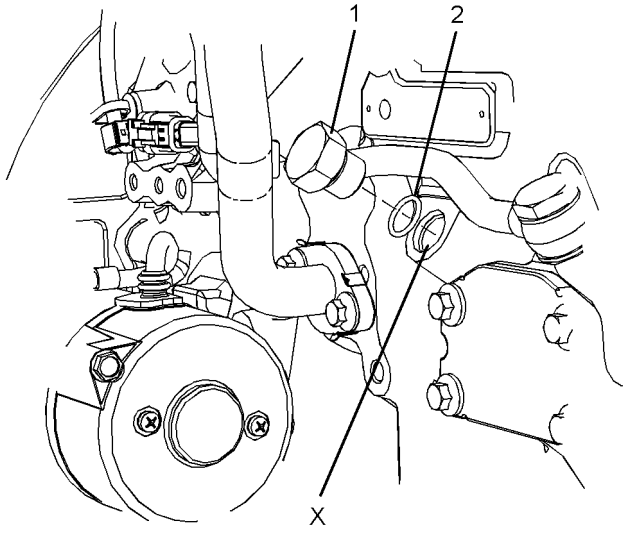

Illustration 350 g02437697

6. Install Tooling (C) through Hole (X) in the camshaft gear into the front housing. Install washer (9) and bolt (10) to camshaft gear (3).

7. Remove Tooling (E) and Tooling (C).

8. Install a new O-ring seal (2) to plug (1). Install the plug into Hole (Y) in the cylinder block. Refer to Illustration 350. Tighten plug (1) to a torque of 21 N·m (186 lb in).

9. When bolt (10) is a 8.8 Grade. Tighten bolt (10) to a torque of 95 N·m (70 lb ft).

When bolt (10) is a 10.9 Grade. Tighten bolt (10) to a torque of 120 N·m (89 lb ft).

10. Use Tooling (F) in order to measure the backlash for gear (3), gear (6), gear (7) and gear (8). Refer to Specifications, “Gear Group (Front)” for further information.

11. Use Tooling (F) in order to measure the end play of camshaft gear (1). Refer to Specifications, “Camshaft” for further information.

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

NOTICE
Failure to ensure that the crankshaft is set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

13. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

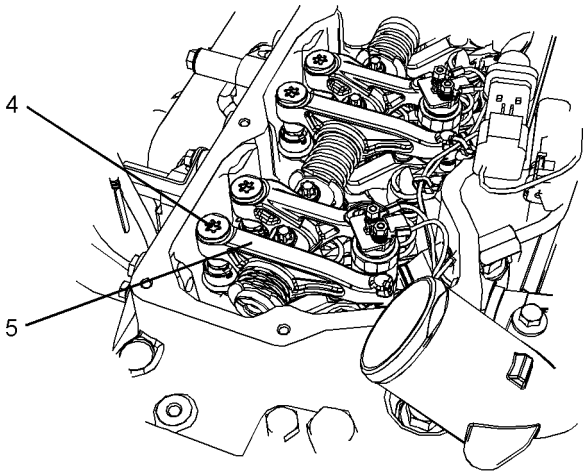

Illustration 351 g02009115

14. Ensure that the guides for the pushrods are correctly positioned on the threaded inserts (4). 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 correctly seated into the cup for the pushrod.

15. 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 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.

i04485804

Camshaft Bearings - Remove and Install

Removal Procedure

Table 64

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

Start By:

a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

c. 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.

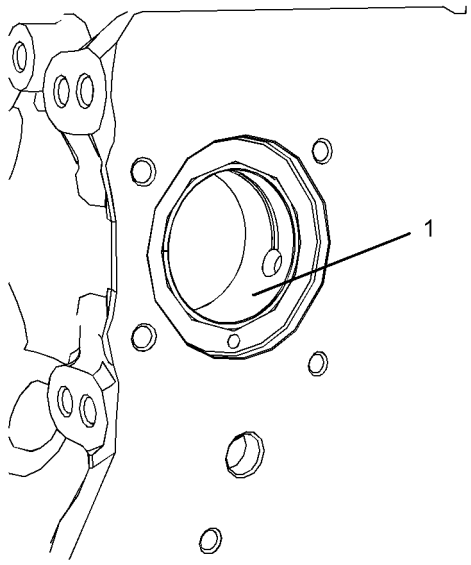

Illustration 352 g02010213

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 65

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.

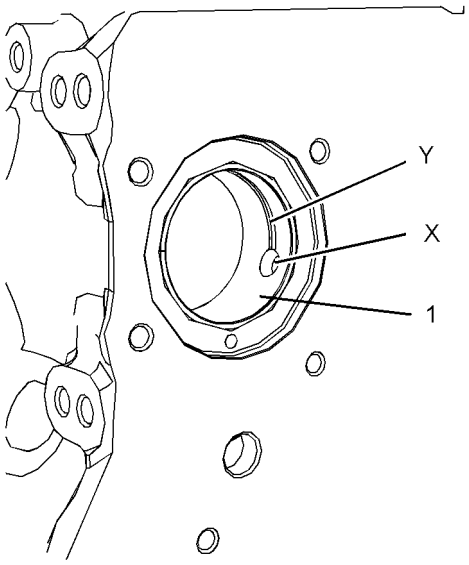

Illustration 353 g02010216

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.

b. If the engine was equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure. If the engine was not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485841

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

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

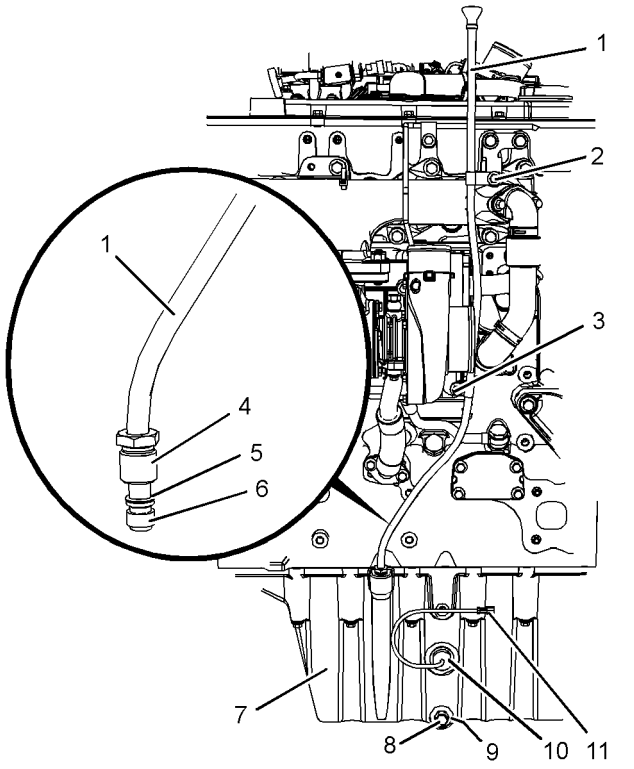

Illustration 354 g02475996

1. Place a suitable container below the engine oil pan. Remove drain plug (8) and drain the engine lubricating oil. Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for correct procedure.

2. Remove O-ring seal (9) (not shown) from drain plug (8).

3. If necessary, remove the assembly of the dipstick tube. Follow Step 3.a through Step 3.c in order to remove dipstick tube (1) from the engine oil pan (7).

   a. Remove bolt (2) and bolt (3).

   b. Loosen nut (4) and remove tube assembly (1).

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

   c. Remove O-ring seal (5) and seal (6) from tube assembly (1).

4. Disconnect the Original Equipment Manufactures (OEM) wiring harness assembly from wiring harness assembly (11) for oil level switch (10).

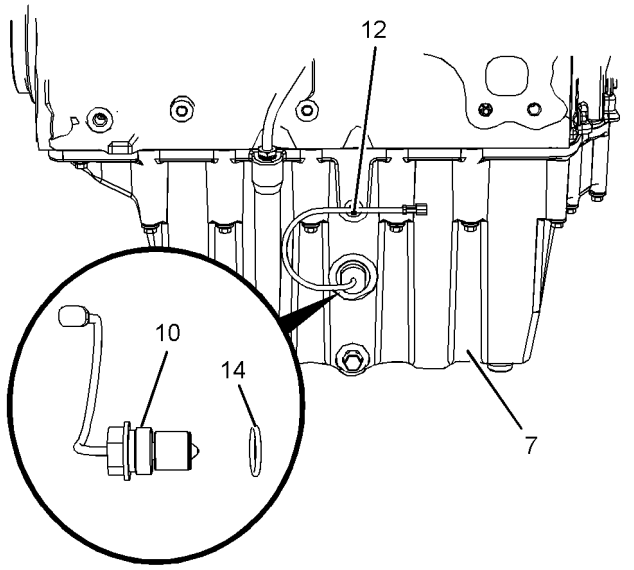

Illustration 355 g02476004

5. If necessary, remove the oil level switch. Follow Step 5.a through Step 5.c in order to remove oil level switch (10) from the engine oil pan (7).

   a. Cut cable strap (9).

   b. Remove oil level switch (10) from the engine oil pan (7).

   c. Remove O-ring seal (14) from oil level switch (10).

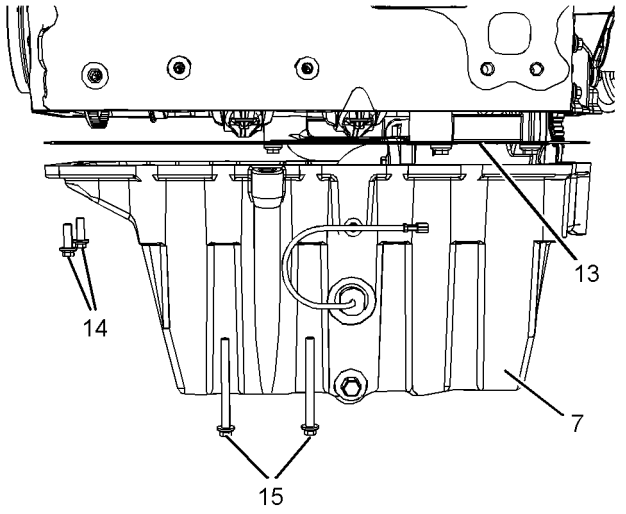

Illustration 356 g02475997

6. Support the assembly of the engine oil pan. Remove bolts (14) and bolts (15).

7. Remove engine oil pan (7) and remove gasket (13).

Installation Procedure

Table 66

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Studs M8 by 100 mm	4
B	-	Loctite 5900 Silicone Sealant	1
C	-	Loctite 575 Thread Sealant	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 and the convoluting.

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

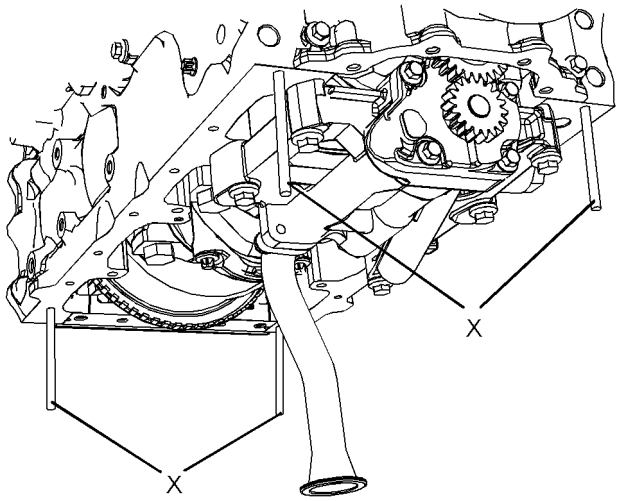

Illustration 357 g02476001

2. Install Tooling (A) to Positions (X) in the cylinder block.

3. Ensure that the engine oil pan is clean and free from damage.

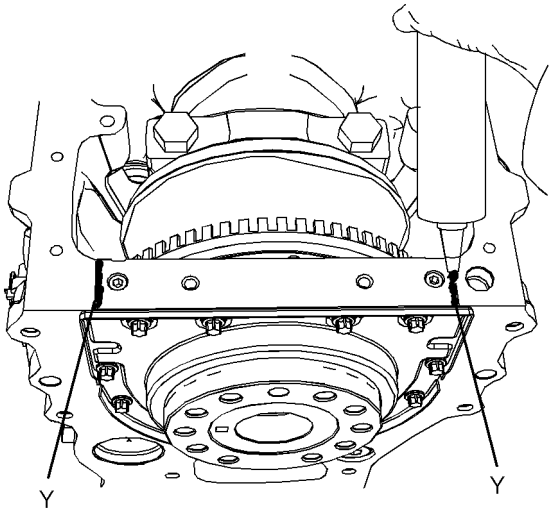

Illustration 358 g02476000

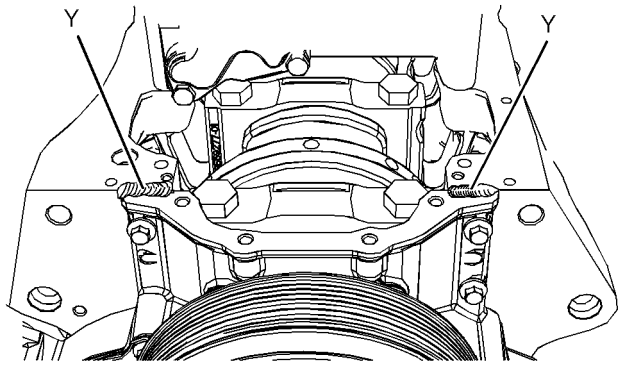

Illustration 359 g02475999

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

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

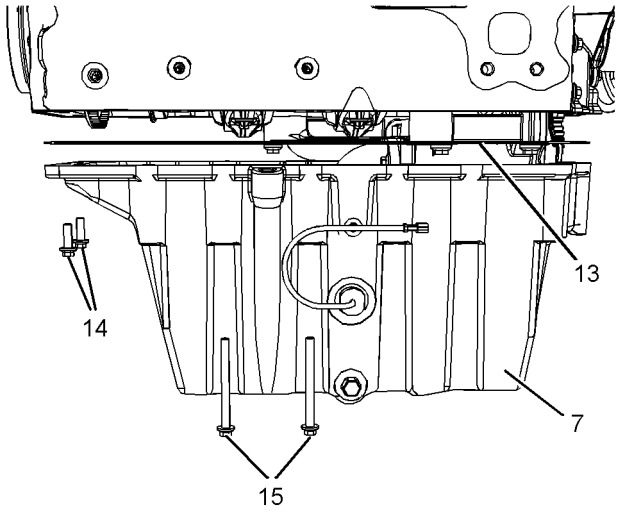

Illustration 360 g02475997

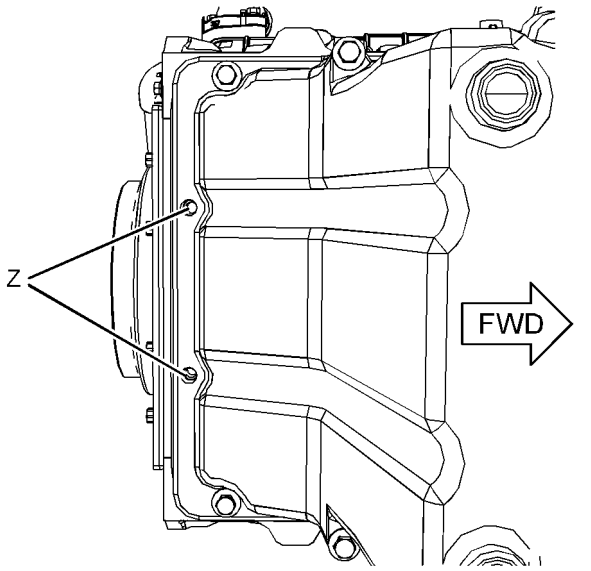

Illustration 361 g02476166

5. Position a new gasket (13) onto engine oil pan (7).

6. Align the assembly of the engine oil pan with Tooling (A). Install the assembly of engine oil pan (7) to the cylinder block.

7. Install bolts (15) finger tight.

8. Remove Tooling (A).

9. Install new bolts (14) in Position (Z) hand tight.

10. Install remaining bolts (14) and the remaining bolts (15).

11. Tighten bolts (14) and bolts (15) to a torque of 22 N·m (195 lb in). Refer to Specifications, “Engine Oil Pan” for the correct tightening sequence.

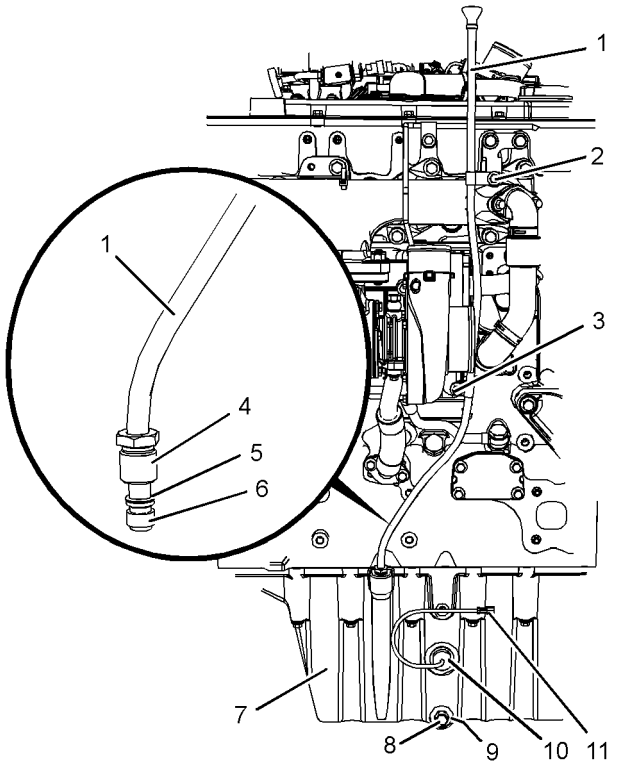

Illustration 362 g02475996

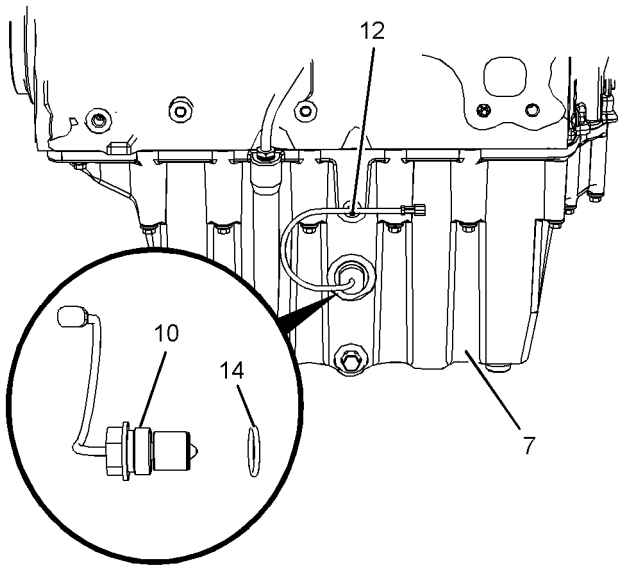

Illustration 363 g02476004

12. Install a new O-ring seal (9) (not shown) to drain plug (8). Install the drain plug to the engine oil pan. 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.f in order to install the assembly of the dipstick tube.

a. Install a new O-ring seal (5) and a new seal (6) to tube assembly (1).

b. Apply Tooling (C) to nut (4).

c. Install the tube assembly (1) to engine oil pan (7). Loosely tight nut (4).

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

d. Install bolt (2) and bolt (3) finger tight.

e. Tighten nut (4) to a torque of 18 N·m (159 lb in). Install the dipstick.

f. Tighten bolt (2) and bolt (3) to a torque of 22 N·m (195 lb in).

14. If necessary, install the oil level switch. Follow Step 14.a through Step 14.c in order to install oil level switch (10) to the engine oil pan (7).

a. Install a new O-ring seal (14) oil level switch (10).

b. Install oil level switch (10) to engine oil pan (7). Tighten the oil level switch to a torque of 34 N·m (301 lb in).

c. Install a new cable strap (7).

Note: Ensure that the cable strap meets the OEM specification.

15. Connect the OEM wiring harness assembly to wiring harness assembly (11) for oil level switch (10).

16. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for correct procedure.

i04485840

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

Removal Procedure

Table 67

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. In order to remove a cast iron oil pan, the engine must be removed from the machine. The engine should be mounted in a suitable stand and placed in the inverted position.

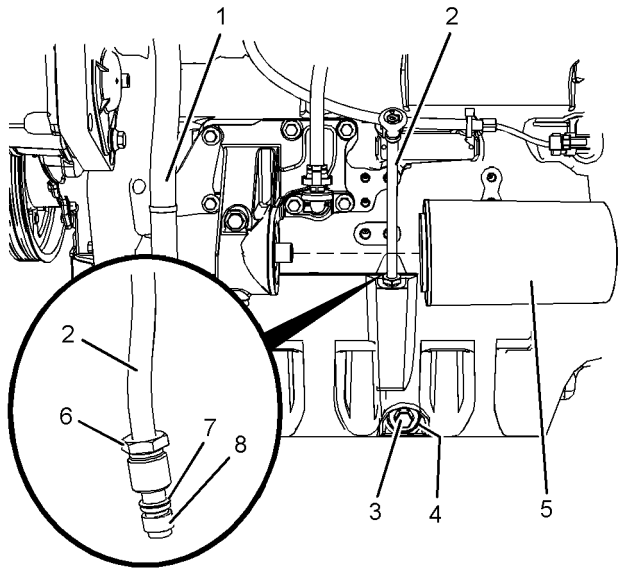

Illustration 364 g02475578

2. Use Tooling (A) in order to remove engine oil filter (5). Remove plug (3) and drain the engine lubricating oil. Remove O-ring seal (4) (not shown) from plug (3). Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for correct procedure.

3. Remove breather hose (1) from the clip. Position the breather hose away from the engine oil pan.

4. Loosen nut (6) and remove tube assembly (2). Remove O-ring seal (7) and seal (8) from the tube assembly.

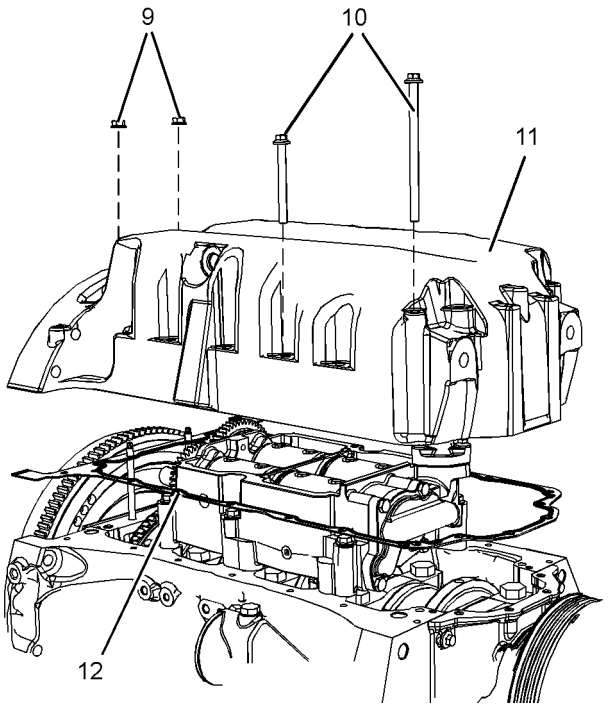

Illustration 365 g02475581

5. Remove nuts (9) and bolts (10) from engine oil pan (11).

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

6. Attach a suitable lifting device to engine oil pan (11). Support the weight of the engine oil pan. The engine oil pan weighs approximately 41 kg (90 lb).

7. Use the lifting device to remove engine oil pan (11) from the cylinder block.

8. Remove gasket (12) from the cylinder block.

Installation Procedure

Table 68

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 5900 Silicone Sealant	1
B	-	Loctite 575 Thread Sealant	1
C	-	Straight Edge	1

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the face of the cylinder block is clean and free from damage. Inspect the studs in the cylinder block for damage. If necessary, replace the studs.

2. Ensure that the engine oil pan is clean and free from damage.

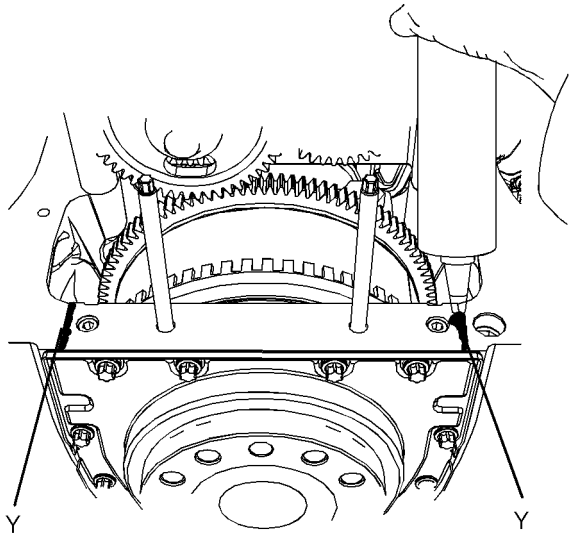

Illustration 366 g02475645

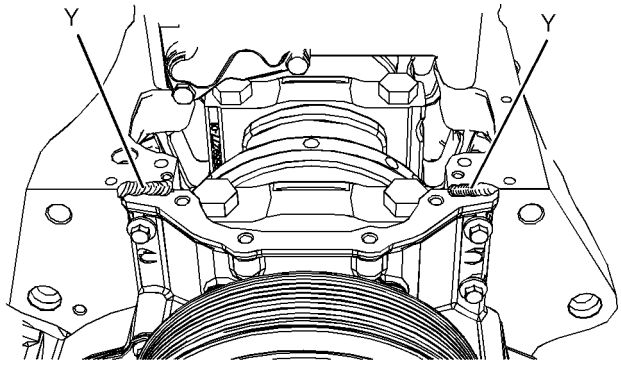

Illustration 367 g02475646

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

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

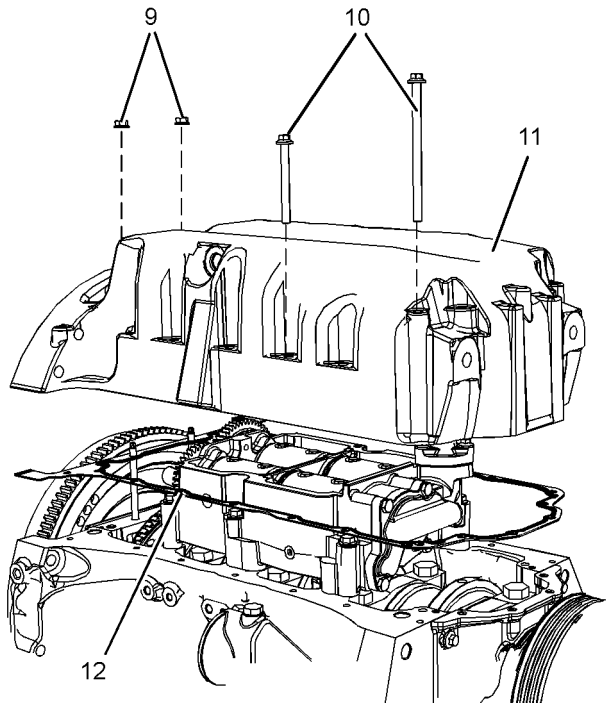

Illustration 368 g02475581

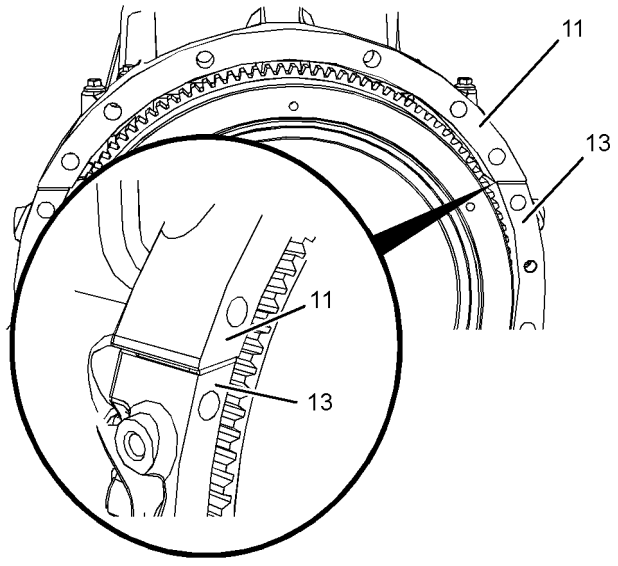

Illustration 369 g02475647

4. Align a new gasket (12) with the studs in the cylinder block. Install the gasket to the cylinder block.

5. Attach a suitable lifting device to engine oil pan (11). The engine oil pan weighs approximately 41 kg (90 lb).

6. Use the lifting device to align engine oil pan (11) with the studs in the cylinder block. Install the engine oil pan to the cylinder block. Remove the lifting device from the engine oil pan.

7. Install nuts (9) and bolts (10) finger tight.

8. Align the rear face of engine oil pan (11) to the rear face of cylinder block (13) on both sides. Use Tooling (C) and a feeler gauge in order to check the alignment between the engine oil pan and the cylinder block. The maximum step that is allowed between the cylinder block and the sump is 0.1 mm (0.004 inch).

9. Tighten bolts (9) and nuts (10) to a torque of 22 N·m (195 lb in). Refer to Specifications, “Engine Oil Pan” for the correct tightening sequence.

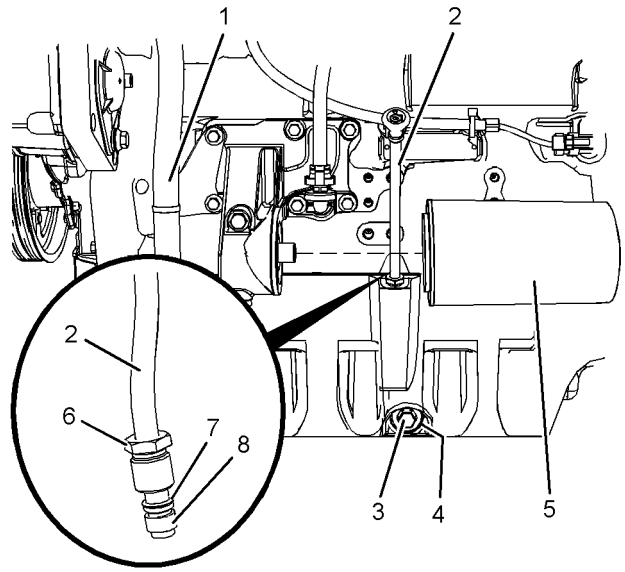

Illustration 370 g02475578

10. If necessary, install a new O-ring seal (4) (not shown) to drain plug (5). Install drain plug (3) to the engine oil pan. Tighten the drain plug to a torque of 34 N·m (301 lb in).

11. Follow Step 11.a through Step11.c in order to install the assembly of the dipstick tube.

    a. Install a new O-ring seal (7) and a new seal (8) to tube assembly (2).

    b. Apply Tooling (B) to the nut of dipstick tube (2). Install the tube assembly to the engine oil pan.

Note: Ensure the correct orientation of the tube assembly.

    c. Tighten the nut to a torque of 18 N·m (159 lb in). Install the dipstick .

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

13. Install a new oil filter (5). After the engine has been installed, ensure that the engine oil pan is filled with lubricating oil to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for correct procedure.

i04485800

Balancer - 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	27610286	Timing Pin (Crankshaft)	1
C	27610225	Timing Pin (Balancer)	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 pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install”.

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

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, “Fuel Injection Timing - Check”.

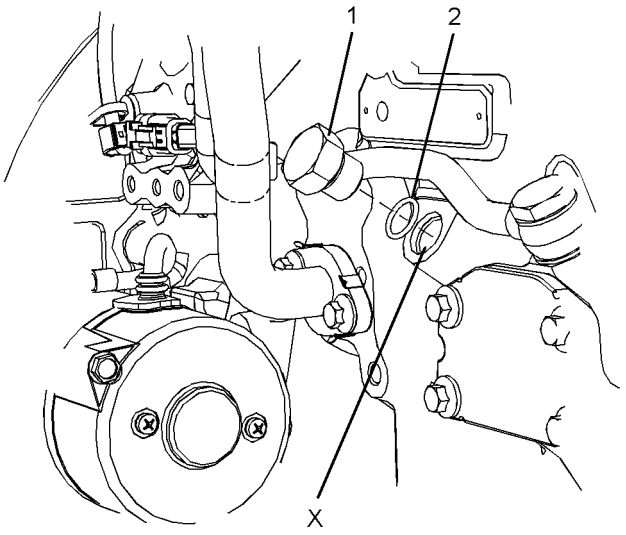

Illustration 371 g02435336

2. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.

3. Install Tooling (B) through Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

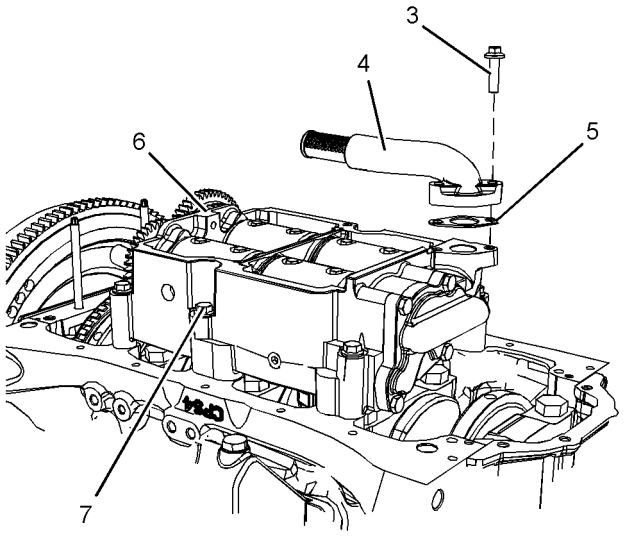

Illustration 372 g02435356

4. Remove bolts (3) from suction pipe (4).

5. Remove suction pipe (4) from balancer (6).

6. Remover gasket (5).

7. Remove bolts (7) from balancer (6).

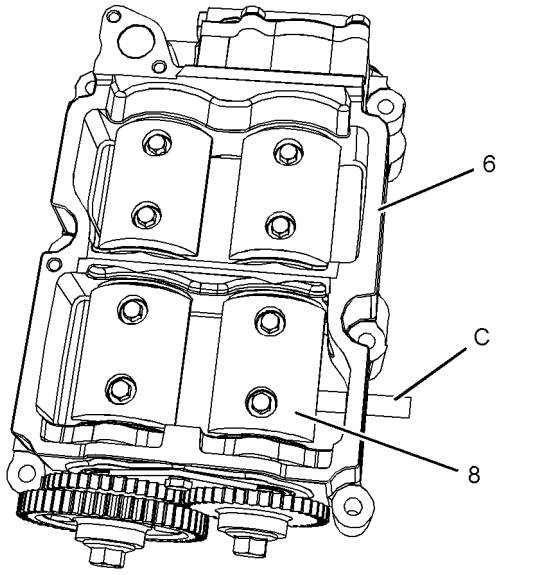

Illustration 373 g02435357

8. Install Tooling (C) into balancer (6). Ensure that Tooling (C) is engaged into the hole in drive shaft (8).

9. Attach a suitable lifting device to balancer (6). Support the weight of the balancer. The balancer weighs approximately 23 kg (51 lb).

10. Use the lifting device to remove balancer (6) from the cylinder block.

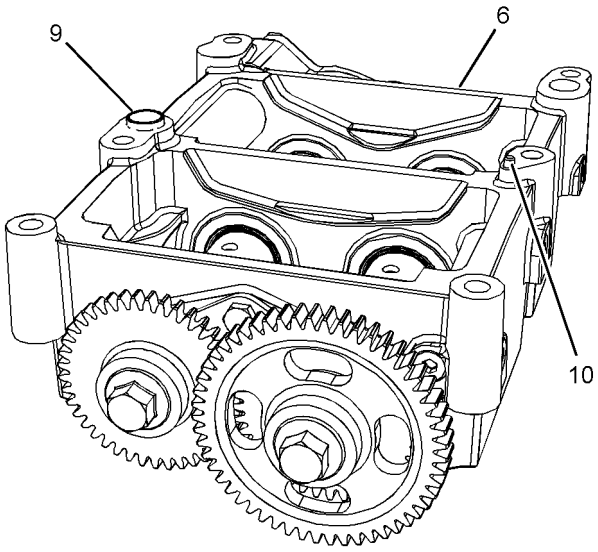

Illustration 374 g02435366

11. Do not remove dowel (9) and dowel (10) from the balancer (6) unless the dowels are damaged.

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

i04485799

Balancer - Install

Installation Procedure

Table 70

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	27610286	Timing Pin (Crankshaft)	1
C	27610225	Timing Pin (Balancer)	1
F	21835496	Indicator Bracket	1
	21825617	Dial Indicator	1
	-	Indicator Contact Point	1
	-	Universal Attachment	1
G	-	Guide Studs M10 by 75mm	2

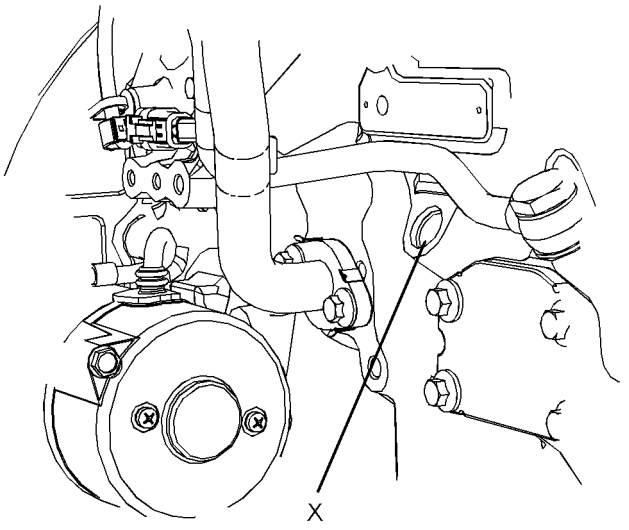

Illustration 375 g02429601

1. 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.

2. Ensure that the surfaces of the cylinder block are clean and free from damage.

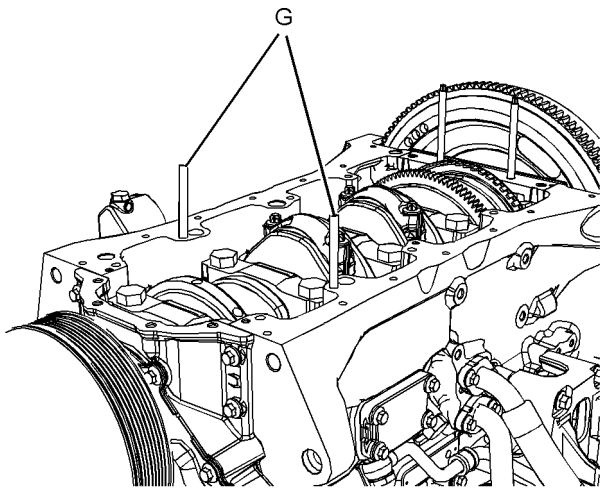

Illustration 376 g02435516

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

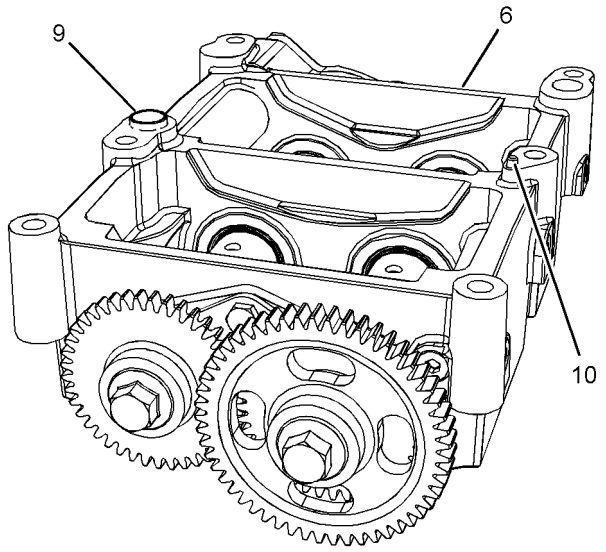

Illustration 377 g02435366

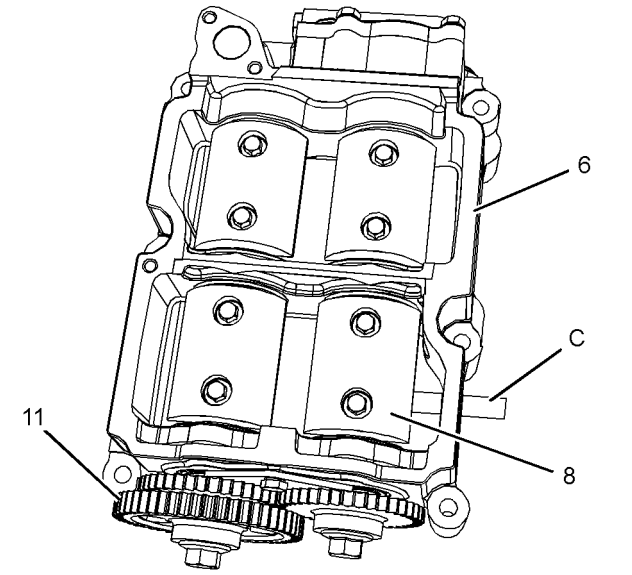

Illustration 378 g02435776

4. Ensure that dowel (9) and dowel (10) are seated in the housing of balancer (6).

5. Install Tooling (C) to balancer (6). Ensure that Tooling (C) is correctly engaged into shaft (8).

6. Attach a suitable lifting device to the balancer. The balancer weighs approximately 23 kg (51 lb).

7. Use the lifting device to align balancer (6) with Tooling (G). Install the balancer to the cylinder block. Ensure that dowel (9) and dowel (10) are aligned with the holes in the cylinder block. Ensure that gear (11) and the crankshaft gear mesh. Remove the lifting device.

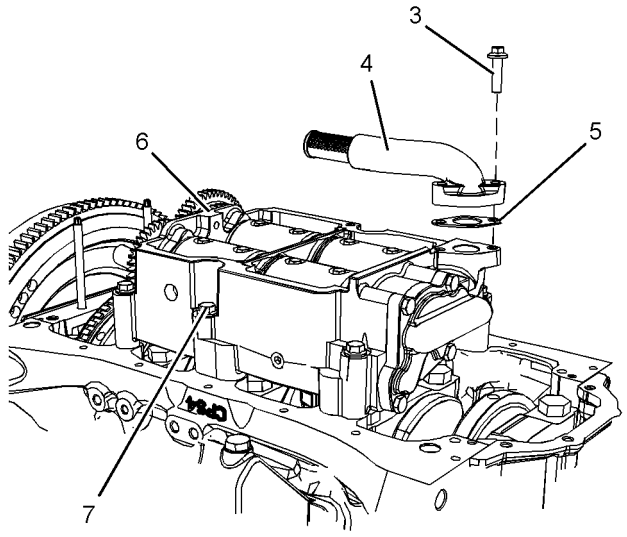

Illustration 379 g02435356

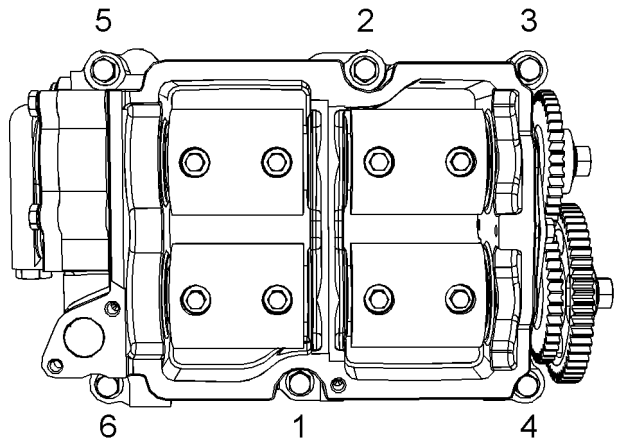

Illustration 380 g02435998

8. Install bolts (7) to balancer (6) and hand tighten the bolts.

9. Remove Tooling (G). Install remaining bolts (7) and hand tighten the bolts.

10. Tighten the bolts to a torque of 54 N·m (40 lb ft). Tighten the bolts in the sequence that is shown in Illustration 380.

11. Position a new gasket (5) onto balancer (6).

12. Position suction pipe (2) onto balancer (6).

Note: Ensure that the suction pipe is correctly orientated.

13. Install bolts (3) finger tight.

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

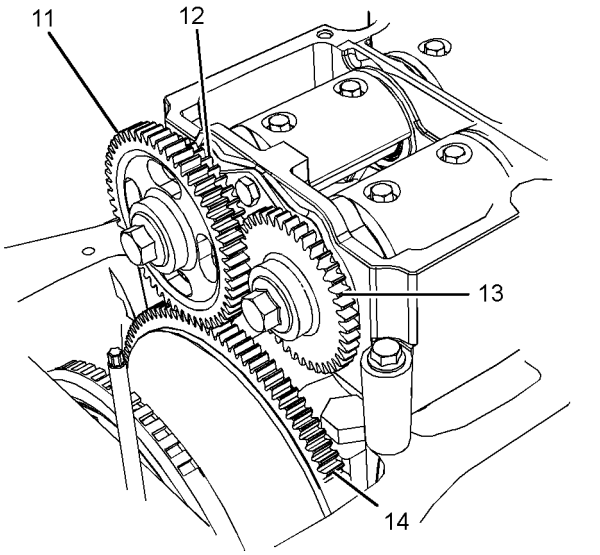

Illustration 381 g02435521

15. Use Tooling (F) in order to check the backlash between gear (11) and gear (14). Refer to Specifications, “Balancer Group” for correct information.

16. Use Tooling (F) in order to check the backlash between gear (12) and gear (13). Refer to Specifications, “Balancer Group” for correct information.

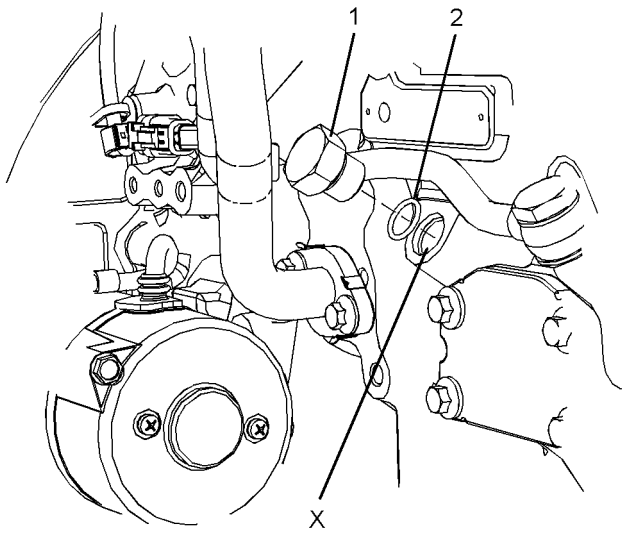

Illustration 382 g02435336

17. Remove Tooling (B) from Hole (X) in the cylinder block.

18. 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).

End By:

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

i04485891

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 71

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. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, 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.

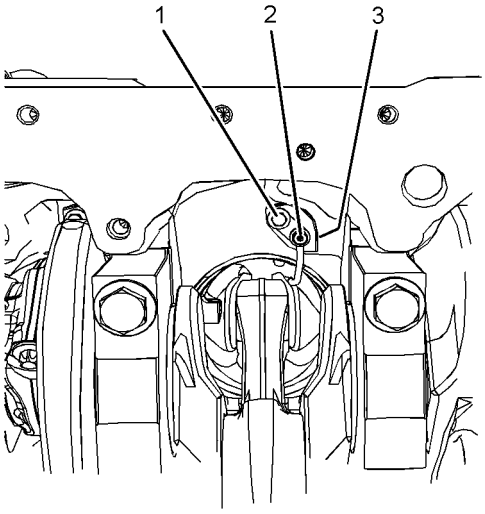

Illustration 383 g02011713

2. Remove bolt (2) and piston cooling jet (1) from the cylinder block. Remove O-ring seal (3).

3. Repeat Step 1 through Step 2 for the remaining piston cooling jets.

Installation Procedure

Table 72

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.

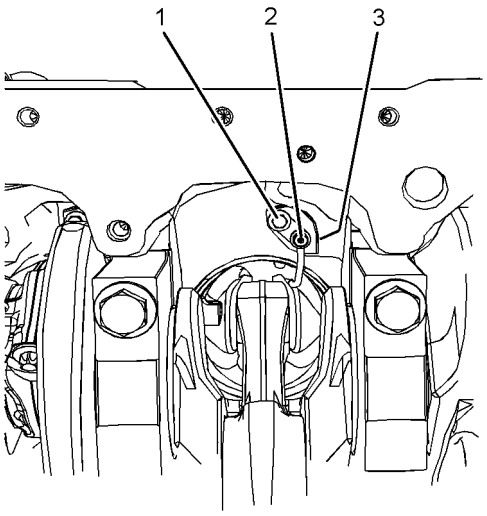

Illustration 384 g02011713

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 the alignment of the piston cooling jets is described in Specifications, “Piston Cooling Jet Alignment”.

2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to access the mounting flange for the piston cooling jet.

3. Install a new O-ring seal (3) onto piston cooling jet (2).

4. Position piston cooling jet (2) in the cylinder block. Install bolt (1). Tighten the bolt to a torque of 9 N·m (80 lb in).

5. Repeat Step 2 through Step 4 for the remaining piston cooling jets.

End By:

a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.

b. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485895

Pistons and Connecting Rods - Remove

Removal Procedure

Table 73

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.

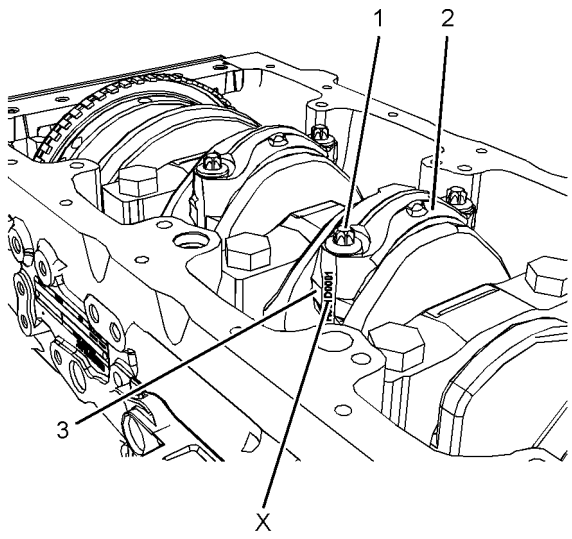

Illustration 385 g02511838

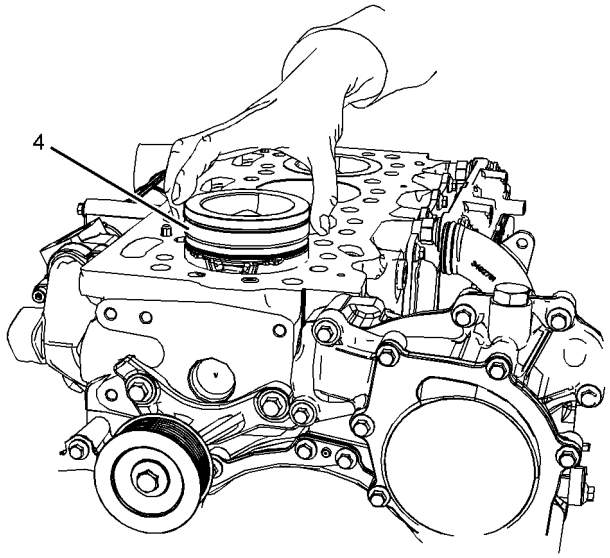

Illustration 386 g02511840

3. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. Ensure that connecting rod (3) 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) remove bolts (1). Remove connecting rod cap (2) from connecting rod (3).

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 (1) to connecting rod (3) 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 (1) to a torque of 20 N·m (177 lb in).

i04485893

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 74

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. Marking the components 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.

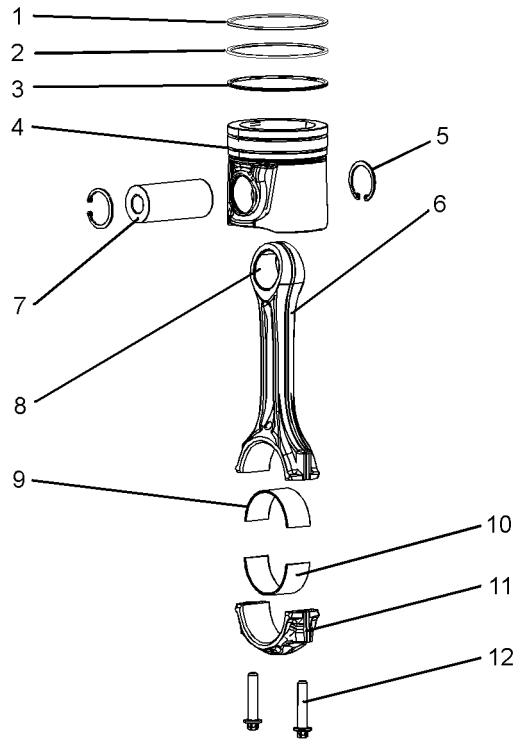

Illustration 387 g02513777

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.

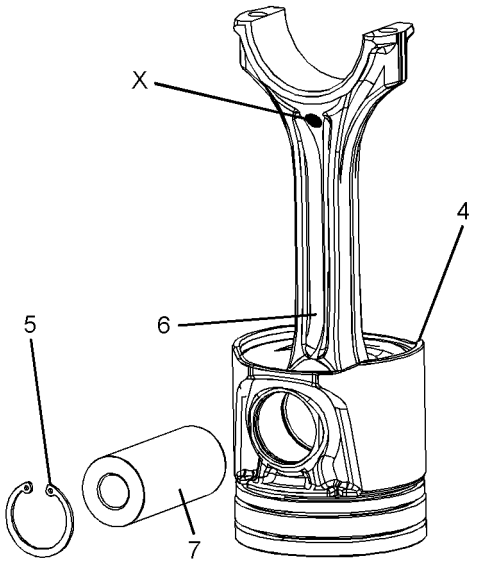

Illustration 388 g02513720

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 the 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 rings (1) and (2), and oil control ring (3) from piston (4).

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

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

6. Inspect the connecting rod for wear and damage. If necessary, replace connecting rod (6) or replace the bush for piston pin (8).

Note: If the connecting rod or the bush for the piston pin are replaced, refer to Specifications, “Connecting Rods” for the correct procedure.

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

i04485892

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 75

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.

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.

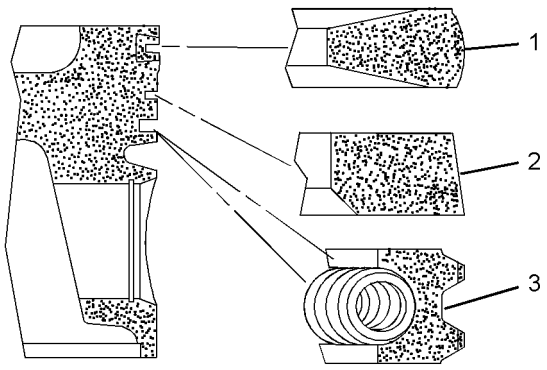

Illustration 389 g02090036

b. Position the oil control ring with the word “TOP” in the upward position and 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.

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

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

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

3. If connecting rod assembly (6), the bush for piston pin (8), connecting rod cap (11), and bolts (12) or the bush for piston pin (8) is replaced, refer to Specifications, “Connecting Rods” for further information.

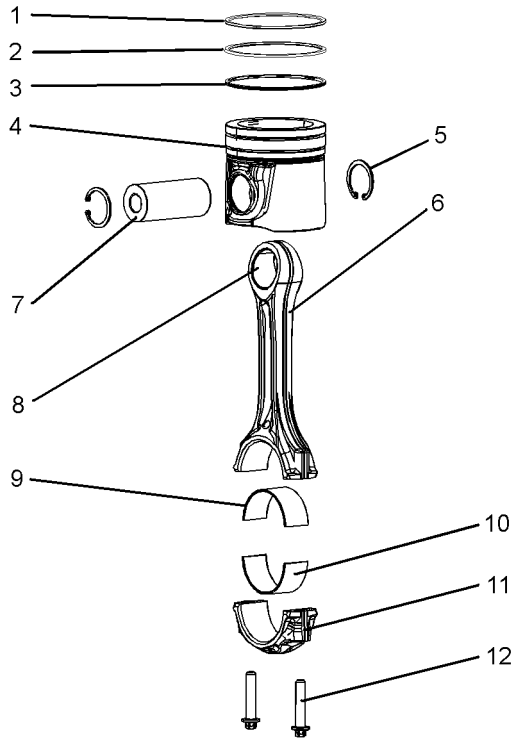

Illustration 390 g02513777

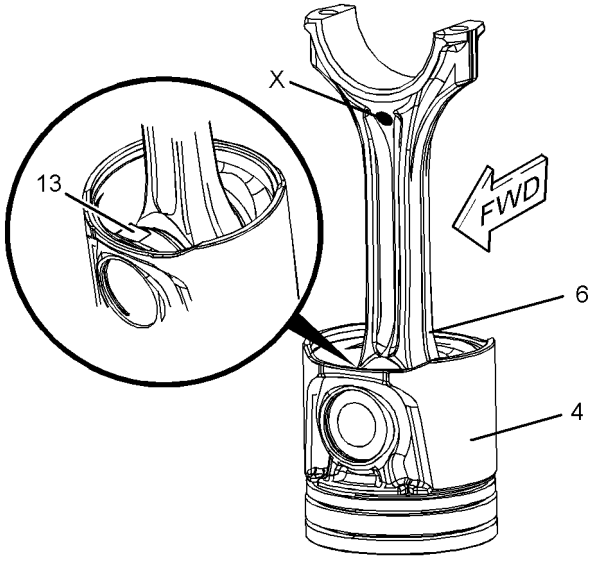

Illustration 391 g02514076

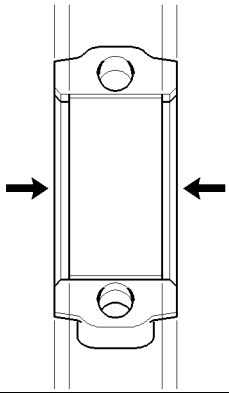

Illustration 392 g02514164

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

4. Lubricate the bush for piston pin (8) in connecting rod (6) with clean engine oil.

5. Lubricate the bore for the piston pin in piston (4) with clean engine oil.

6. Place piston (4) on a suitable surface with the crown downward. Position connecting rod (6) with the forged Mark (X) to the square (13) on the piston.

7. 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).

8. 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.

9. Install upper bearing shell (9) into connecting rod (6). Ensure that the bearing is centralized in the connecting rod. Refer to 392.

10. Install lower bearing shell (10) into connecting rod cap (11). Ensure that the bearing is centralized in the connecting rod. Refer to 392.

11. Repeat Step 2 through Step 10 for the remaining piston and connecting rod assemblies.

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

End By:

a. Install the pistons and the connecting rods. Refer to Disassembly and Assembly, “Piston and Connecting Rods - Install” for the correct procedure.

i04485894

Pistons and Connecting Rods - Install

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	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, to the piston rings, to the outer surface of the piston and to the bearing shells for the connecting rod.

Note: Install the bearing shells for the connecting rods dry when clearance checks are performed. Refer to Disassembly and Assembly, “Bearing Clearance - Check” 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.

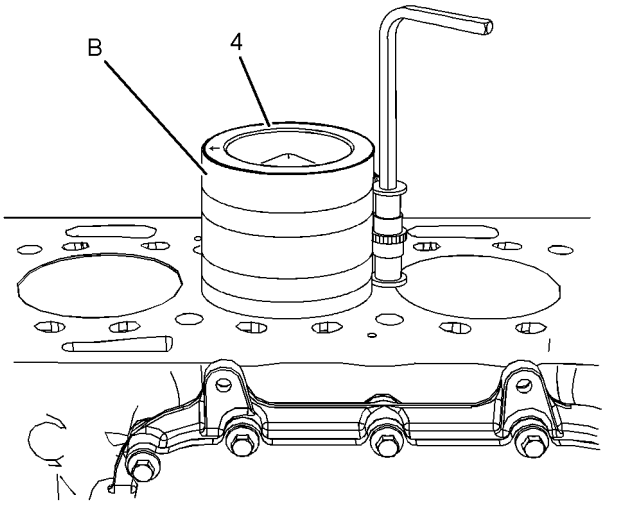

Illustration 393 g02013213

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.

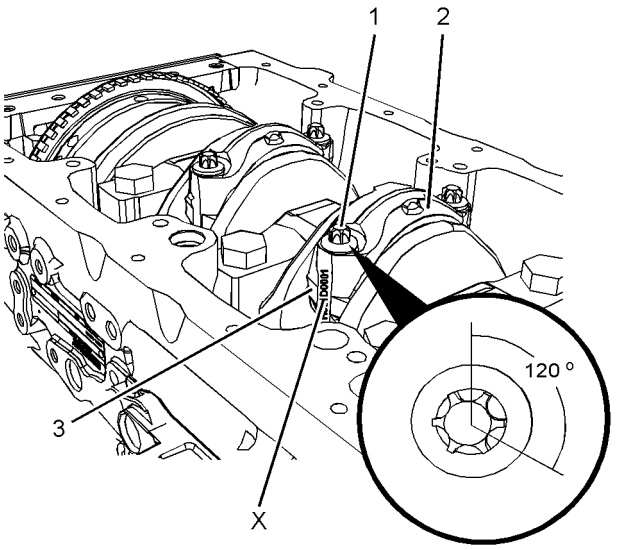

Illustration 394 g02512136

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

Note: Ensure that etched Number (X) on connecting rod cap (2) matches etched Number (X) on connecting rod (3). 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 connecting rod bolts in order to secure the connecting rod cap.

7. Install new bolts (1) to connecting rod (3). 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.

i04485808

Connecting Rod Bearings - Remove (Connecting Rods in Position)

Removal Procedure

Table 77

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. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, 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 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders**. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

1. Use Tooling (A) to rotate the crankshaft until the crank pin is 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 glow plug aids removal of the connecting rod bearing. It is not essential.

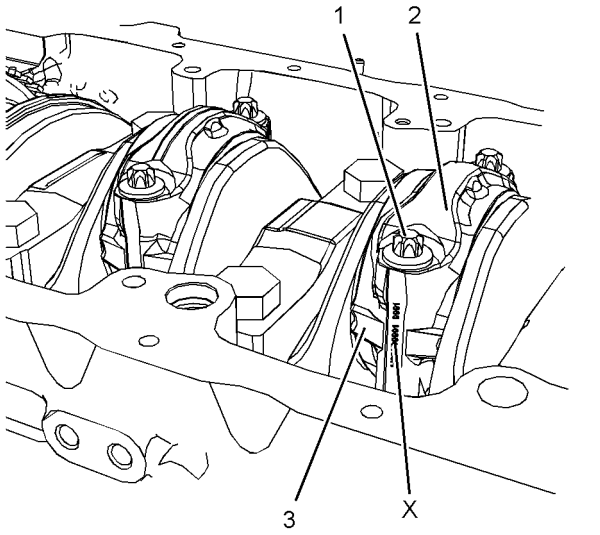

Illustration 395 g02437998

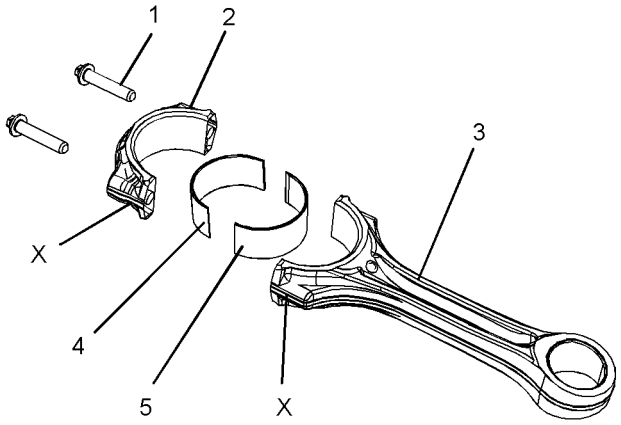

Illustration 396 g02437999

2. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. If necessary, make a temporary mark on connecting rod (3) 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) to remove bolts (1). Remove connecting rod cap (2) from connecting rod (3). Discard bolts (1).

4. Remove lower bearing shell (4) from connecting rod cap (2). Keep the bearing shell and the connecting rod cap together.

5. Carefully push connecting rod (3) into the cylinder bore until connecting rod (3) is clear of the crankshaft. Remove upper bearing shell (5) from the connecting rod. Keep the bearing shells together.

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

6. Repeat Step 1 through Step 5 for the remaining bearing shells.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the bearing shells is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, “Connecting Rod Bearings - Install” for the correct procedure.

i04485807

Connecting Rod Bearings - Install (Connecting Rods in Position)

Installation Procedure

Table 78

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	27610289	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.

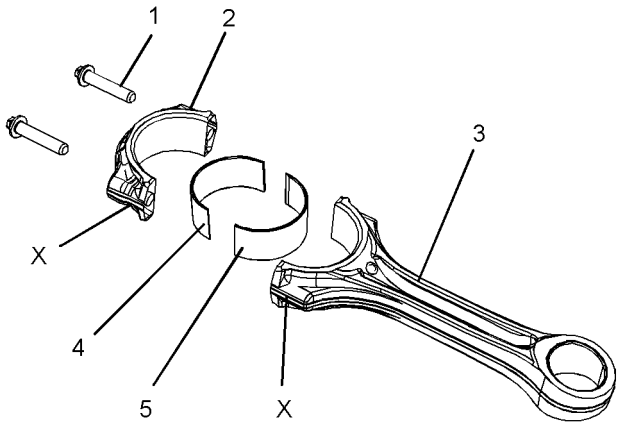

Illustration 397 g02437999

2. Install upper bearing shell (5) into connecting rod (3). 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 (5) with clean engine oil.

4. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom dead center position.

5. Carefully pull connecting rod (3) 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 (4) 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 (4) with clean engine oil.

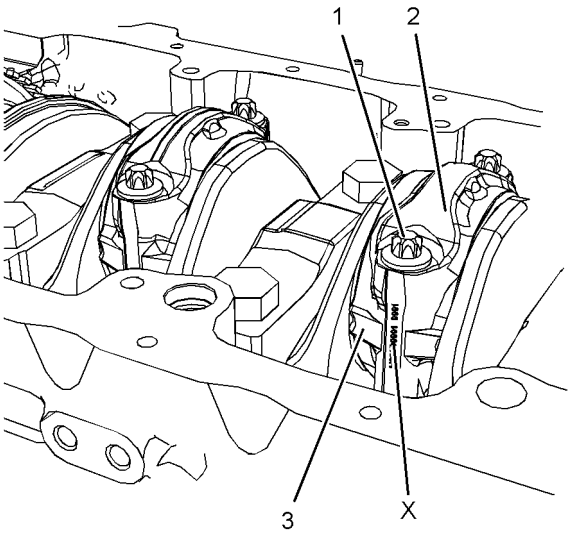

Illustration 398 g02437998

8. Install connecting rod cap (2) to connecting rod (3).

Note: Ensure that etched Number (X) on connecting rod cap (2) matches etched Number (X) on connecting rod (3). 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 connecting rod bolts in order to secure the connecting rod cap.

9. 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) 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 for the remaining connecting rod bearings.

Note: If all connecting rod bearings require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders**. 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. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.

b. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485818

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

Removal Procedure

Table 79

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	-	5mm Allen 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. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” for the correct procedure.

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

NOTICE
This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

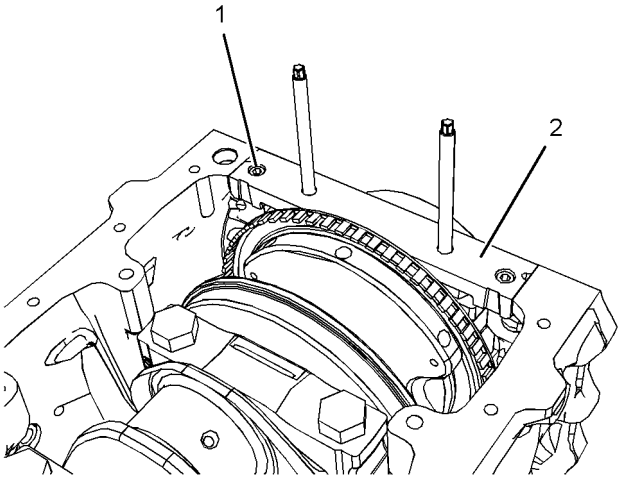

Illustration 399 g02441836

1. Use Tooling (B) in order to remove allen head screws (1). Remove bridge piece (2).

2. Ensure that the main bearing cap is marked for the correct location and orientation.

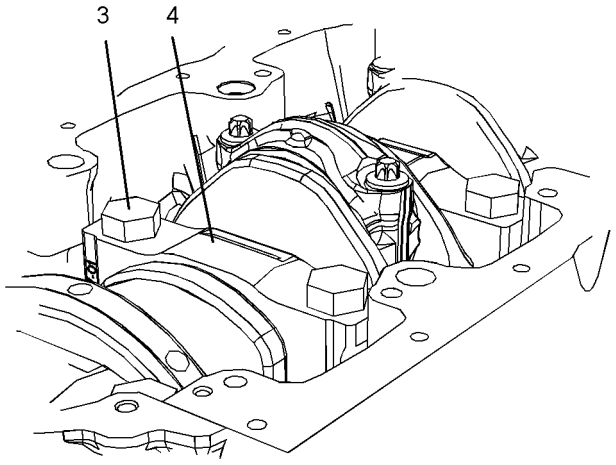

Illustration 400 g02447416

3. Remove bolts (3) and main bearing cap (4) from the cylinder block.

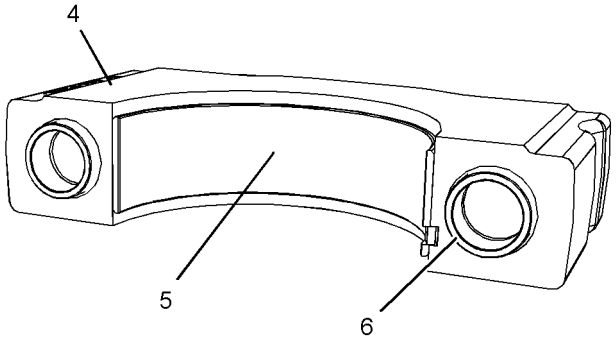

Illustration 401 g02447418

4. Remove lower main bearing shell (5) from main bearing cap (4). Keep the main bearing shell and the main bearing cap together. Take care not to displace dowels (6).

Note: The lower main bearing shell is a plain bearing that has no oil holes.

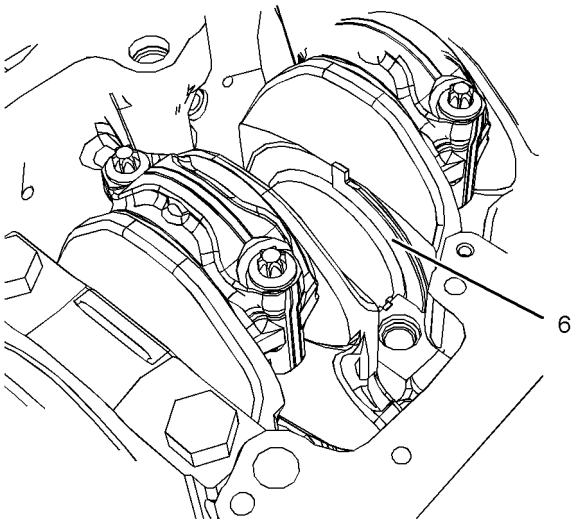

Illustration 402 g02447419

5. For number No. 3 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.

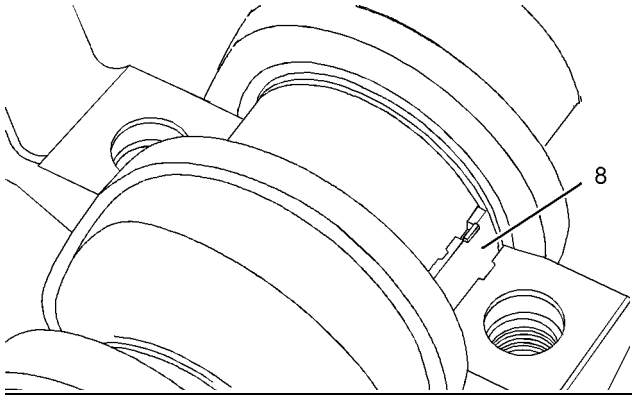

Illustration 403 g02447420

6. 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 80

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
B	-	5mm Allen Socket	1
C	21825617	Dial Indicator	1
	21825496	Indicator Bracket	1
D	-	Straight Edge	1
E	-	Loctite 5900 Silicon Sealant	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.

2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

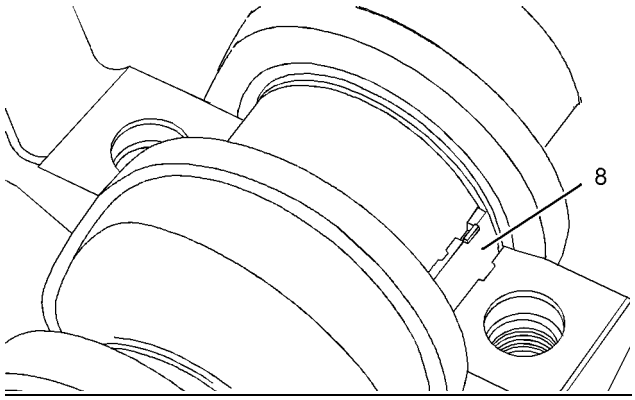

Illustration 404 g02447420

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.

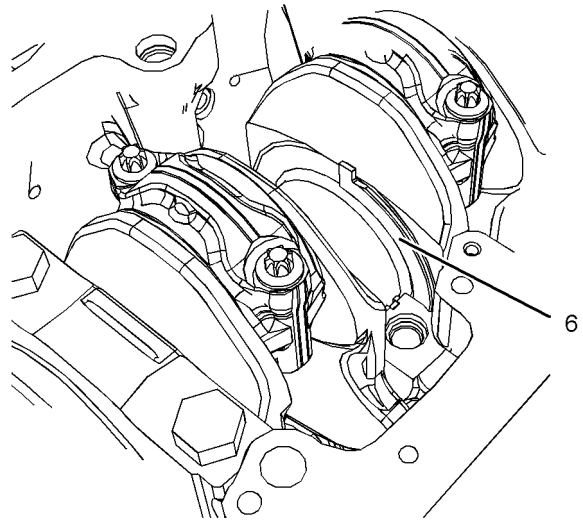

Illustration 405 g02447419

4. For number No. 3 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 (4) into position between the crankshaft and the cylinder block. Ensure that the locating tab is correctly seated in the cylinder block.

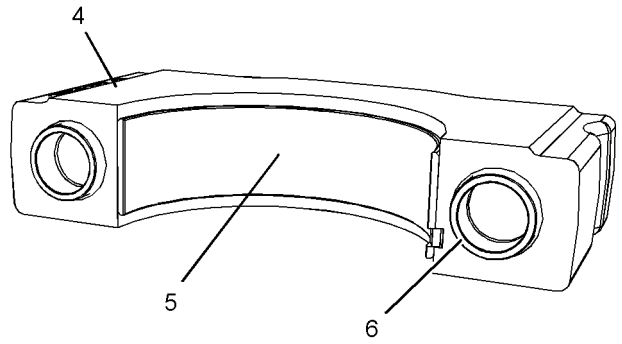

Illustration 406 g02447418

5. Install lower main bearing shell (3) into main bearing cap (2). Ensure that the locating tab for the lower main bearing shell is correctly seated into the slot in the bearing cap. Ensure that the dowel (6) is correctly located.

Note: The lower main bearing shell is a plain bearing that has no oil holes.

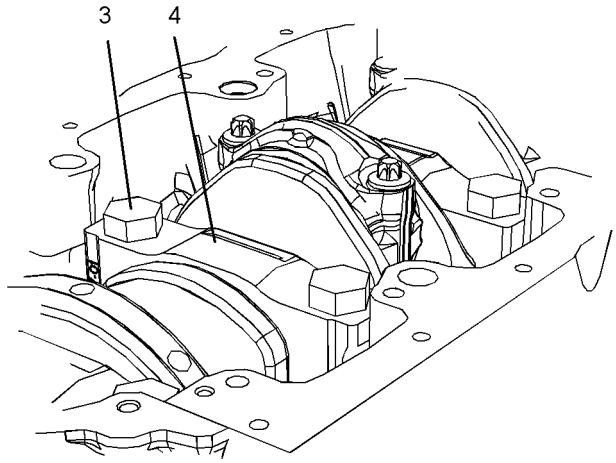

Illustration 407 g02447416

6. Lubricate the crankshaft journal and the lower main bearing shell with clean engine oil. Install main bearing cap (4) to the cylinder block.

Note: Ensure the correct orientation of the main bearing cap. The locating tab for the upper and the lower bearing should be on the same side of the engine.

7. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of bolts (3) with clean engine oil.

8. Install bolts (3) to main bearing cap (4). Evenly tighten the bolts in order to pull cap (3) 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 (3) to a torque of 245 N·m (181 lb ft).

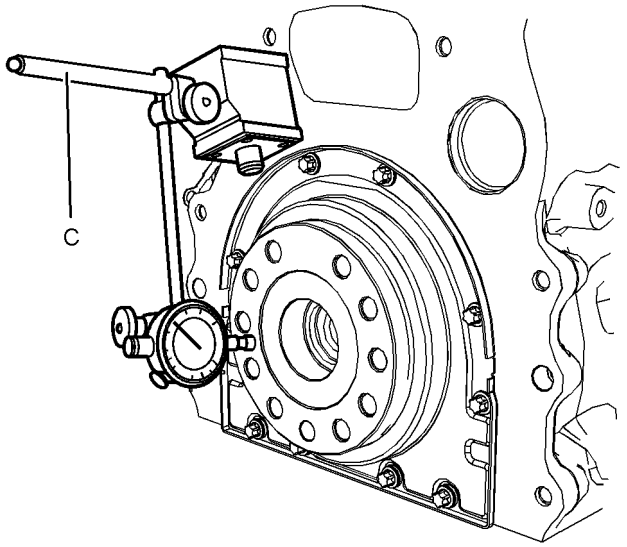

Illustration 408 g02447421

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).

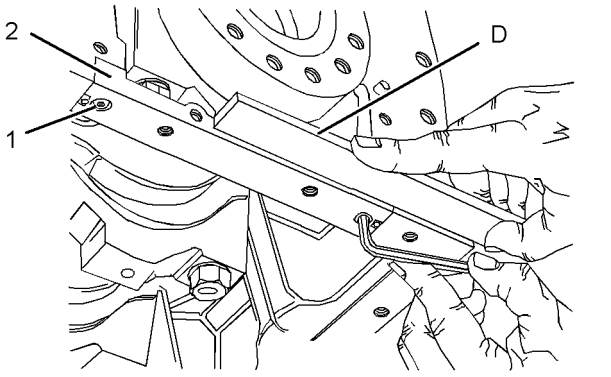

Illustration 409 g02447422

11. Follow Steps 11.a through Step 11.d in order to install the bridge piece.

a. Ensure that the cylinder block and the bridge piece are clean, dry, and free from old sealant.

b. Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.

c. Use Tooling (D) in order to align the rear face of the bridge piece with the rear face of the cylinder block.

d. Use Tooling (B) in order to tighten the allen head screws to a torque of 16 N·m (142 lb in).

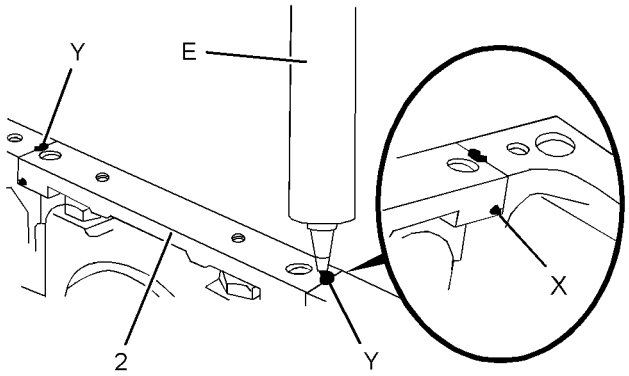

Illustration 410 g02442239

12. Apply Tooling (E) to cavities (Y) in the bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

a. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.

c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485813

Crankshaft - Remove

Removal Procedure

Table 81

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Sling	2
B	-	5mm Allen Socket	1

Start By:

a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

c. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

d. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove” for the correct procedure.

e. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove” for the correct procedure.

f. If necessary, remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

g. 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.

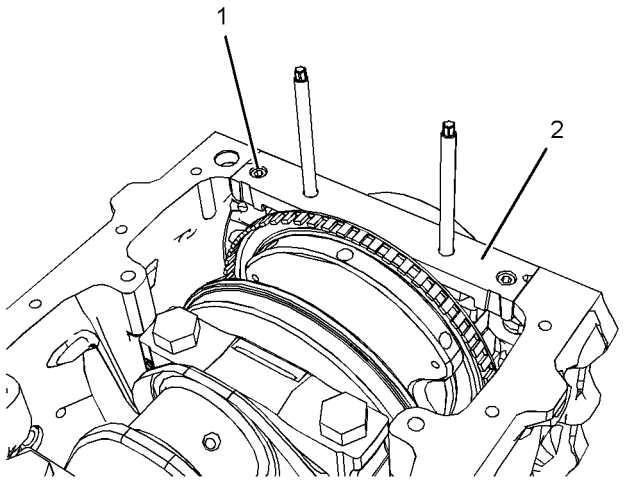

Illustration 411 g02441836

3. Use Tooling (B) in order to remove allen head screws (1). Remove bridge piece (2).

4. Ensure that the main bearing caps are marked for the location and orientation.

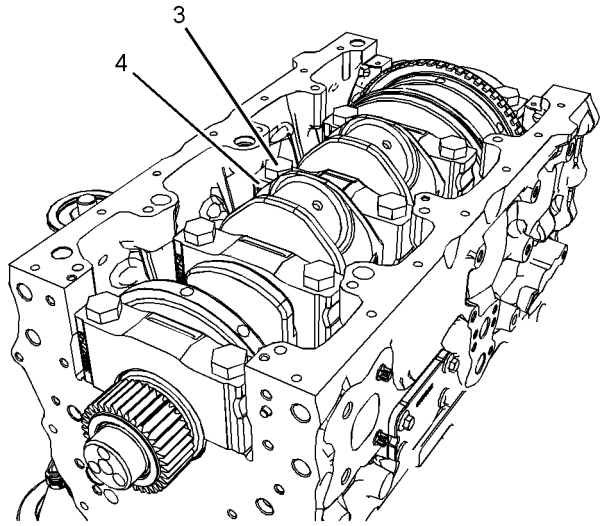

Illustration 412 g02441837

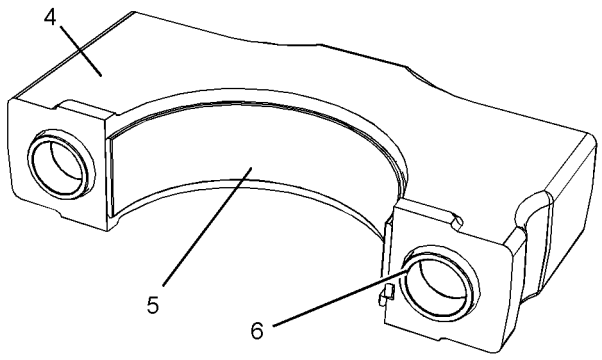

Illustration 413 g02441838

5. Remove bolts (3) from main bearing caps (2). Remove main bearing caps (2) from the cylinder block.

6. Take care not to displace dowels (6).

7. Remove lower main bearing shells (5) from main bearing caps (4). 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.

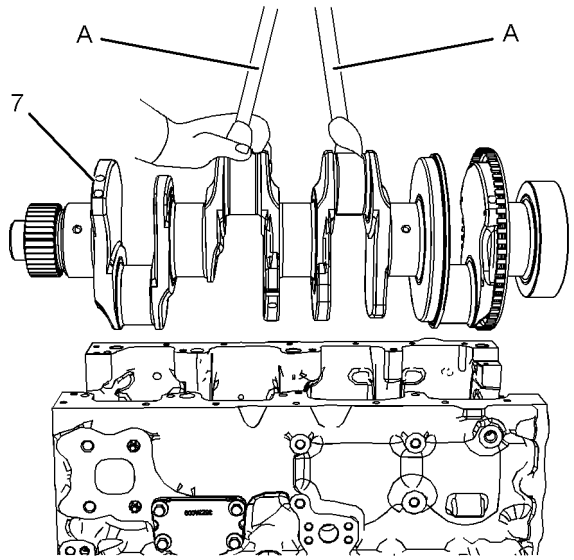

Illustration 414 g02441839

8. Attach Tooling (A) and a suitable lifting device to crankshaft (7). Lift crankshaft (7) out of the cylinder block. The weight of the crankshaft is approximately 39 kg (86 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.

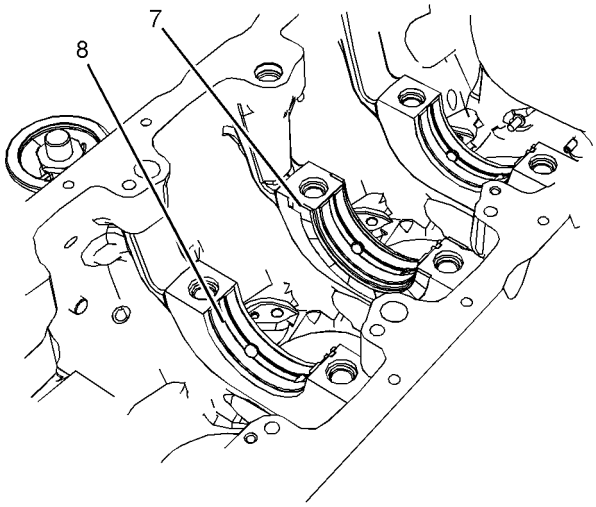

Illustration 415 g02441840

9. Remove upper main bearing shells (8) 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.

10. Remove thrust washers (7).

11. If necessary, remove the crankshaft timing ring. Refer to Disassembly and Assembly, “Crankshaft Timing Ring - Remove and Install” for the correct procedure.

12. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, “Crankshaft Gear - Remove and Install” for the correct procedure.

13. If necessary, remove the balancer drive gear. Refer to Disassembly and Assembly, “Crankshaft Gear (Balancer Drive) - Remove and Install” for the correct procedure.

i04485812

Crankshaft - Install

Installation Procedure

Table 82

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Sling	2
B	-	5mm Allen Socket	1
C	21825617	Dial Indicator	1
	21825496	Indicator Bracket	1
D	-	Straight Edge	1
E	-	Loctite 5900 Silicon Sealant	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 balancer drive gear. Refer to Disassembly and Assembly, “Crankshaft Gear (Balancer Drive) - Remove and Install” for the correct procedure.

3. If necessary, install the crankshaft gear. Refer to Disassembly and Assembly, “Crankshaft Gear - Remove and Install” for the correct procedure.

4. If necessary, install a new crankshaft timing ring. Refer to Disassembly and Assembly, “Crankshaft Timing Ring - Remove and Install” for the correct procedure.

5. 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.

6. 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.

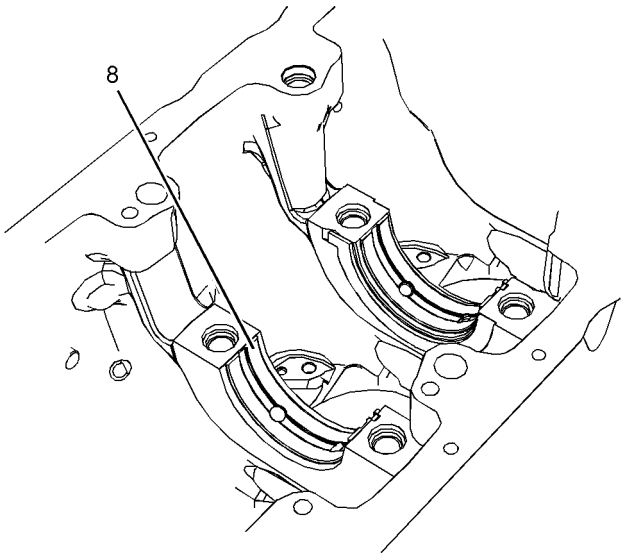

Illustration 416 g02443436

7. Install upper main bearing shells (8) 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.

8. Lubricate upper main bearing shells (8) with clean engine oil.

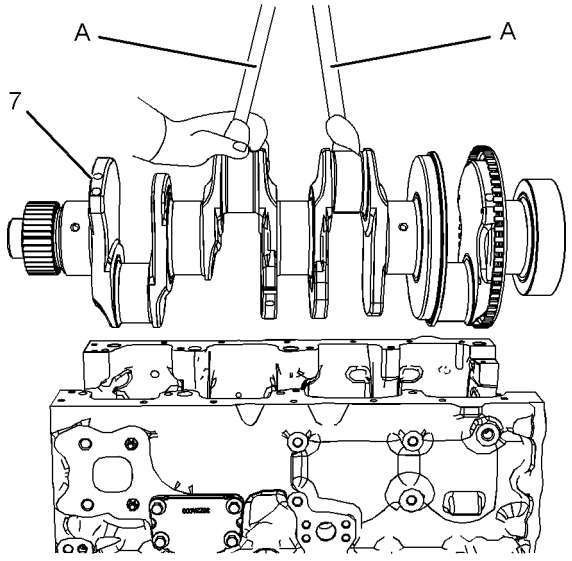

Illustration 417 g02441839

9. Attach Tooling (A) and a suitable lifting device to crankshaft (7). Lift crankshaft (7) into the cylinder block. The weight of the crankshaft is approximately 39 kg (86 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. Do not damage the main bearing shells.

10. Remove Tooling (A) after installation of the crankshaft to the cylinder block.

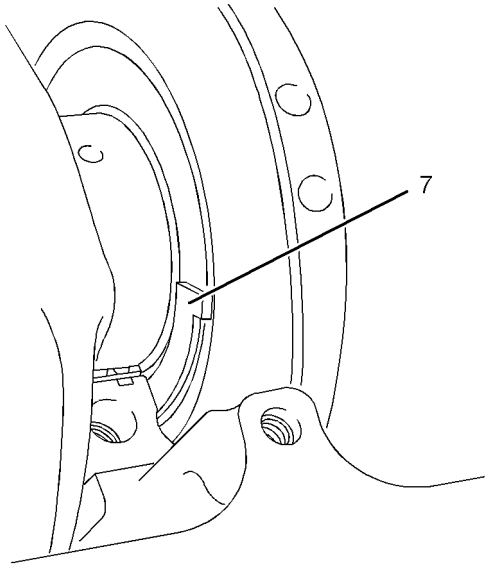

Illustration 418 g02442118

11. Lubricate thrust washers (7) with clean engine oil. Install thrust washers (7) to No. 3 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.

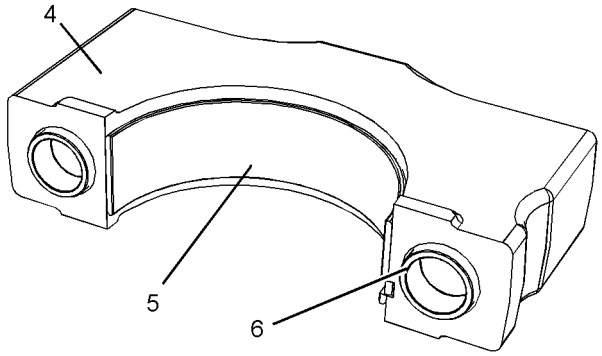

Illustration 419 g02441838

12. Install lower main bearing shells (5) into main bearing caps (4). 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.

13. Ensure that the dowels (6) are correctly located.

14. Lubricate lower main bearing shells (5) and lubricate the journals of the crankshaft with clean engine oil. Install main bearing caps (4) to the cylinder block.

Note: Ensure the correct location and orientation of main bearing caps (4). The locating tabs for the upper and the lower main bearing shells should be on the same side of the engine.

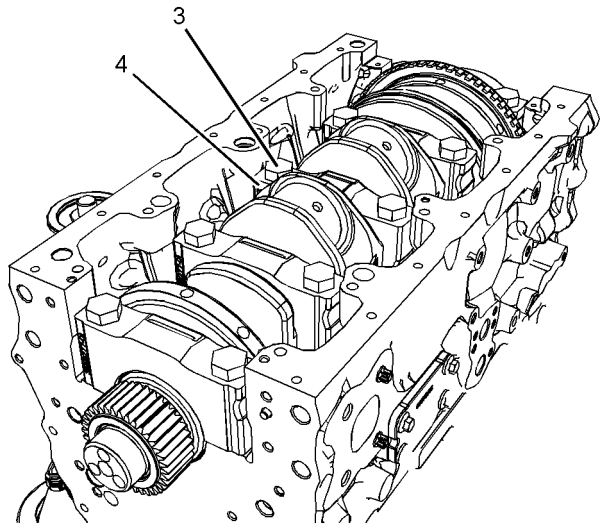

Illustration 420 g02441837

15. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of bolts (3) with clean engine oil.

16. Install bolts (3) to main bearing caps (4). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.

Note: Do not tap the main bearing caps into position as the bearing shells may be dislodged.

17. Tighten bolts (3) to a torque of 245 N·m (181 lb ft).

18. Rotate the crankshaft in order to ensure that there is no binding.

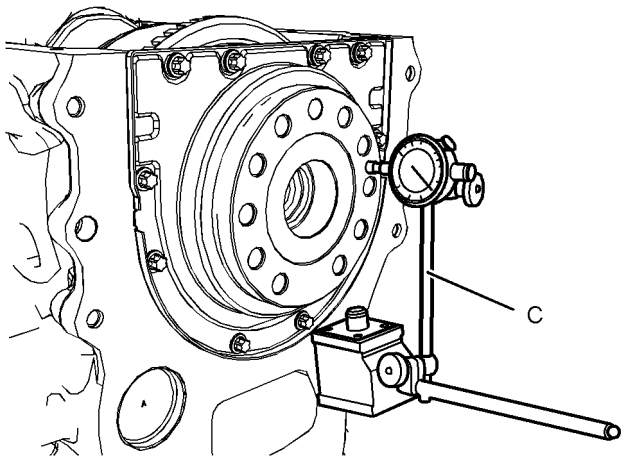

Illustration 421 g02443497

19. 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).

20. If the crankshaft has been replaced or the crankshaft has been reconditioned, inspect the height of the piston above the cylinder block. Refer to System Operation, Testing and Adjusting, “Piston Height - Inspect” for more information.

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.

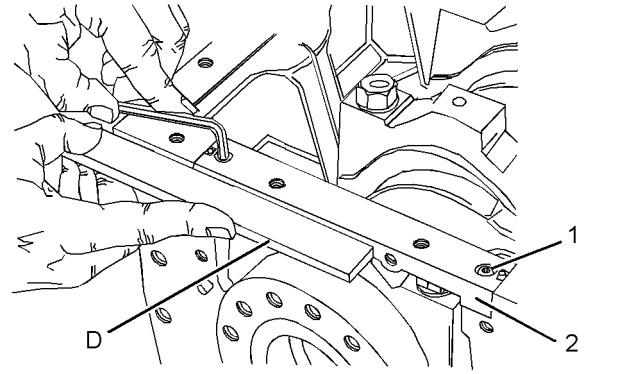

Illustration 422 g02442123

22. Follow Steps 22.a through Step 22.d in order to install the bridge piece.

a. Ensure that the cylinder block and the bridge piece are clean, dry, and free from old sealant.

b. Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.

c. Use Tooling (D) in order to align the rear face of the bridge piece with the rear face of the cylinder block.

d. Use Tooling (B) in order to tighten the allen head screws to a torque of 16 N·m (142 lb in).

23. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

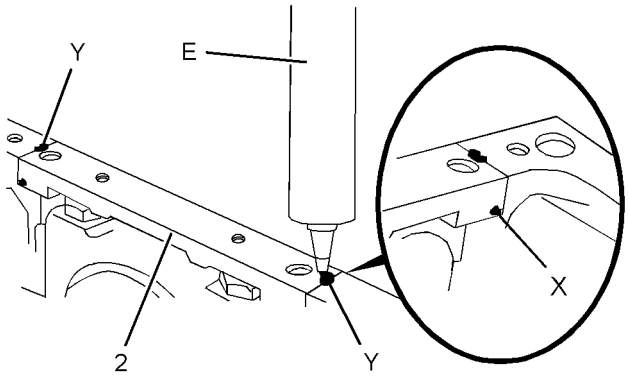

Illustration 423 g02442239

24. Apply Tooling (E) to cavities (Y) in the bridge piece (2). Continue to apply Tooling (E) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

a. If 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 rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker shaft and Push Rods - Install” for the correct procedure.

d. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Install” for the correct procedure.

e. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

f. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

g. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

i04485823

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.

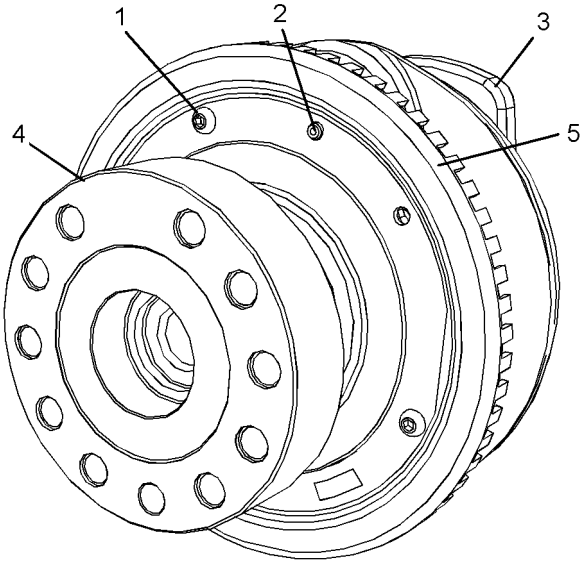

Illustration 424 g02452037

1. Support crankshaft (3) on a suitable stand.

2. Remove allen head screws (1) from crankshaft timing ring (5). Do not reuse the allen head screws.

3. Carefully remove crankshaft timing ring (5) from crankshaft (3). 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 (2) from crankshaft (3) 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.

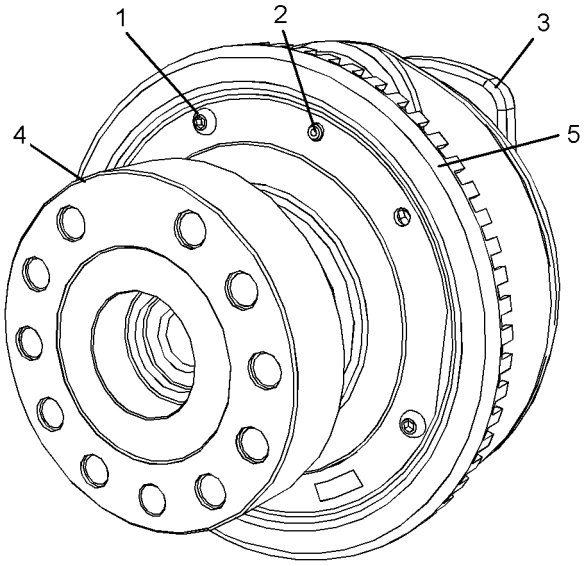

Illustration 425 g02452037

2. Support crankshaft (3) on a suitable stand.

3. If dowel (2) was removed, install a new dowel to crankshaft (3).

4. Position a new crankshaft timing ring (5) on the crankshaft with the teeth toward the crankshaft web. Align the hole in crankshaft timing ring (5) with dowel (2) in the crankshaft. Carefully install crankshaft timing ring (5) to crankshaft (3).

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 (1). 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.

i04485817

Crankshaft Gear - Remove and Install

Removal Procedure

Table 83

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. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.

c. If the engine is not equipped with a balancer, 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.

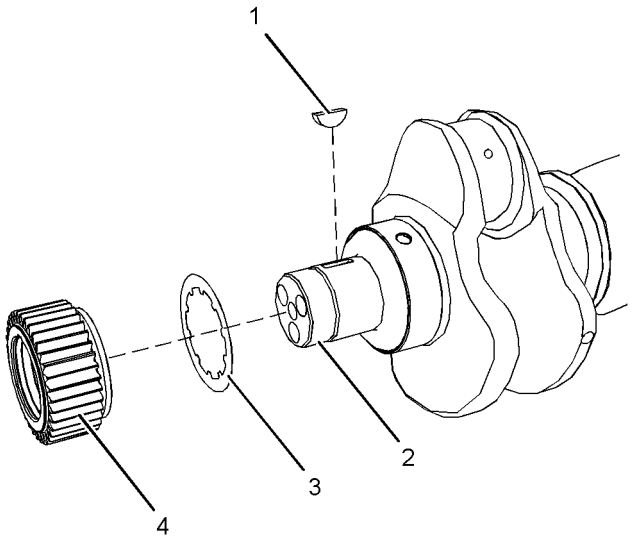

Illustration 426 g02445757

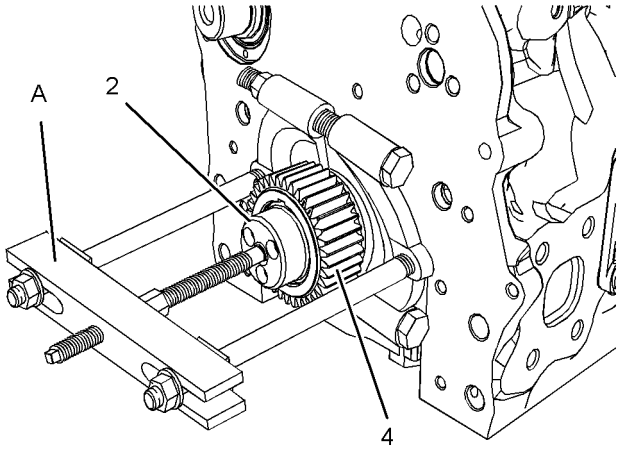

Illustration 427 g02445756

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.

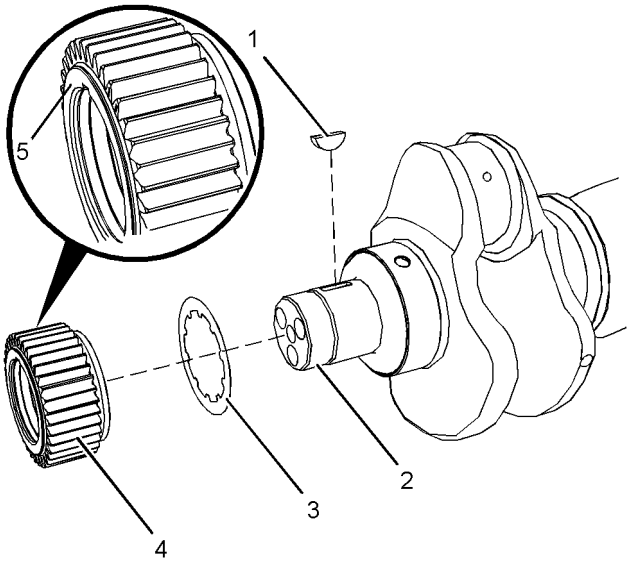

Illustration 428 g02445758

2. If necessary, install a new friction shim (3) to crankshaft (2).

3. If necessary, install a new key (1) to crankshaft (2).

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

⚠ WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

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. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.

c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i04485816

Crankshaft Gear (Balancer Drive) - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” for the correct procedure.

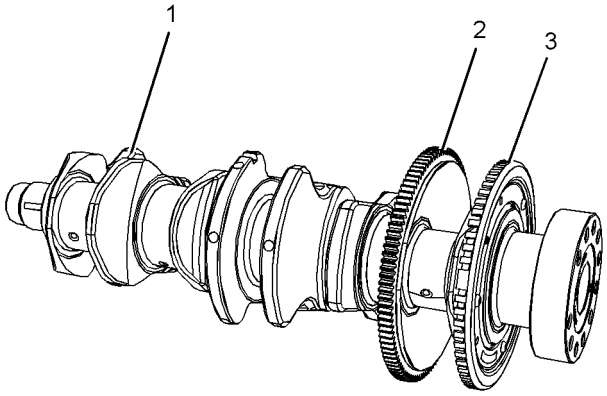

Illustration 429 g02649077

1. Place crankshaft assembly (1) on a suitable stand. Ensure that crankshaft timing ring (3) is not damaged.

2. Use a suitable tool in order to apply heat evenly around the diameter of the balancer drive gear (2). Ensure that heating is performed without causing any discoloration to either crankshaft assembly (1) or crankshaft balancer gear (2).

3. Use a suitable tool in order to remove the balancer drive gear (2) from crankshaft assembly (1).

Note: Ensure that the bearing surfaces or the crankshaft timing ring are not damaged as the balancer drive gear is removed.

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.

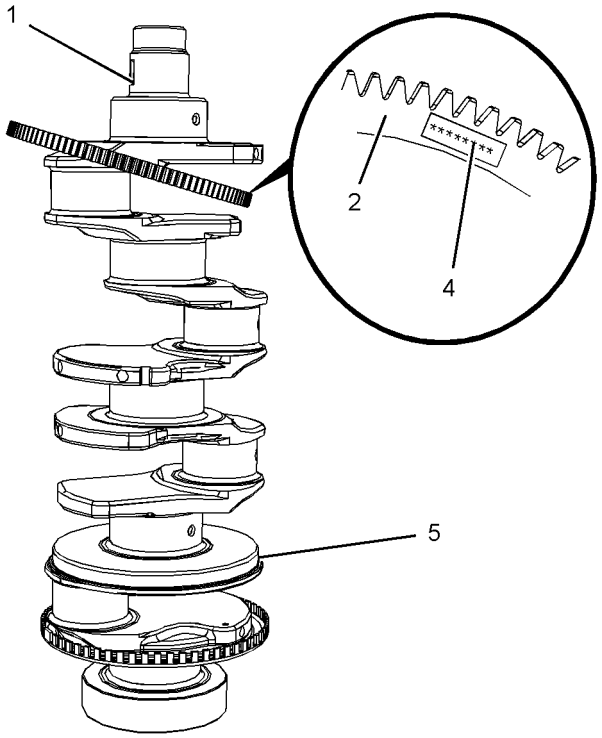

Illustration 430 g02649080

⚠ 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.

2. Position the crankshaft (1) in a suitable stand with the crankshaft in the vertical position.

3. Heat a new balancer drive gear (2) in an oven to 150° ± 50°C (302° ± 90°F) for 1 hour.

4. Ensure that the balancer drive gear serial number (4) is facing upward position.

5. Position the balancer drive gear (2) onto the crankshaft (1) ensure that the balancer drive gear is correctly seated onto machined surface (5).

Note: Take care when manipulating the balancer drive gear over the crankshaft not to damage or scratch the crankshaft bearing surfaces.

End By:

a. Install the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” for the correct procedure.

i02748526

Bearing Clearance - Check

Measurement Procedure

Table 84

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 431.

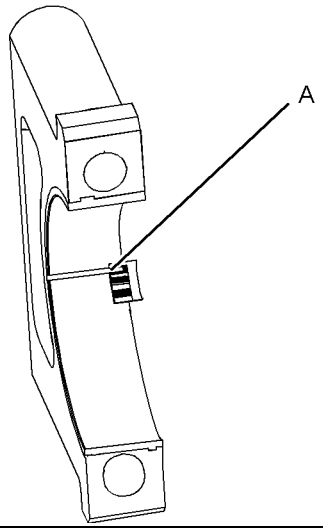

Illustration 431 g01152855
Typical Example

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.

i04485897

Refrigerant Compressor - 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.

Note: Cleanliness is an important factor. Before the disassembly procedure, the exterior of the component should be cleaned thoroughly. Thoroughly cleaning the component will help to prevent dirt from entering the internal mechanism.

⚠ 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 assemblies. Plugging all lines, hoses, and tubes assemblies can prevent fluid loss and to keep contaminants from entering the system.

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

2. If the hose assemblies are to be removed from the refrigerant compressor. Removal of the refrigerant from the air conditioning system will be necessary. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

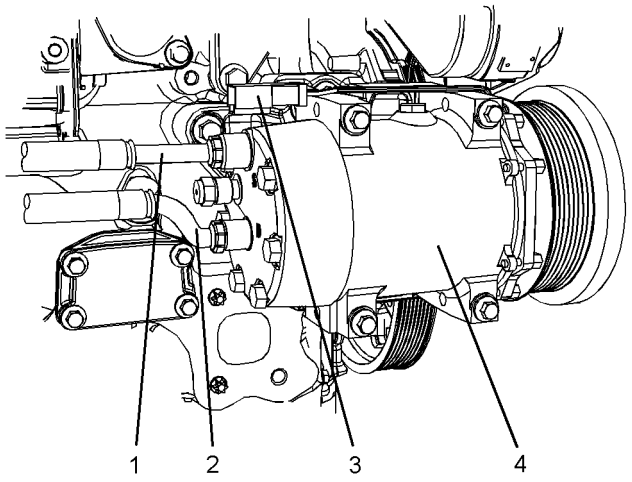

Illustration 432 g02518538

3. Disconnect hose assembly (1) and hose assembly (2) from refrigerant compressor (4). Refer to the OEM for the correct procedure.

Note: Plug the hose assemblies with new plugs. Cap the ports in the refrigerant compressor with new caps.

4. Disconnect harness assembly (3) from refrigerant compressor (4).

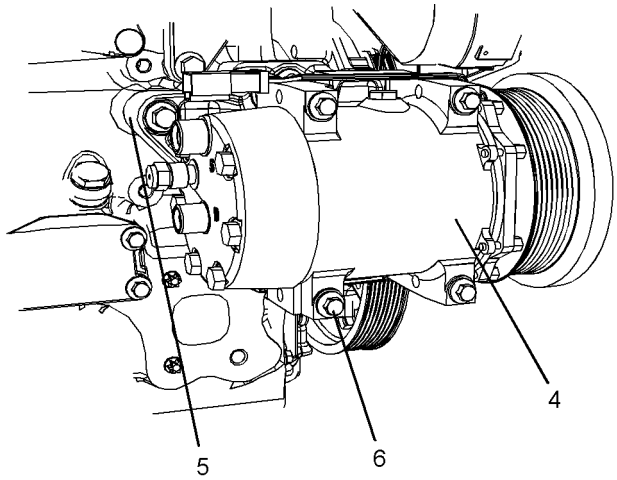

Illustration 433 g02518539

5. Remove the alternator belt. Refer to Disassembly and Assembly Manual, “Alternator Belts - Remove and Install” for the correct procedure.

6. Remove bolts (6) 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).

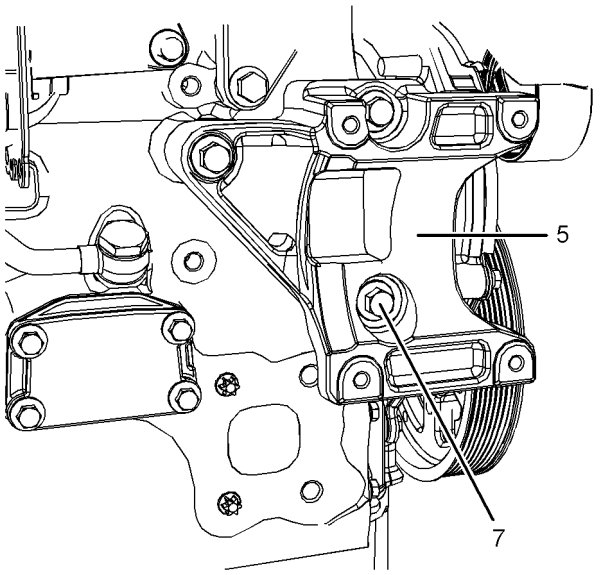

Illustration 434 g02518540

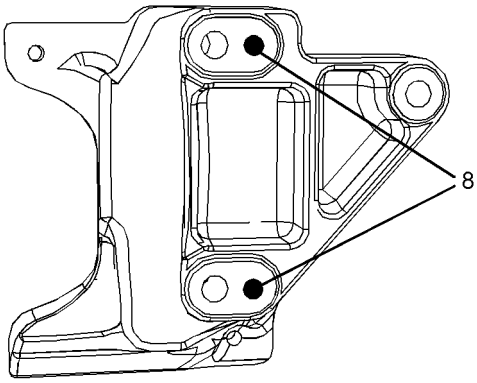

Illustration 435 g02518541

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 (7) from bracket (5).

b. Remove bracket (5) from the cylinder block.

c. Note the position of dowels (8) in bracket (5).

Installation Procedure

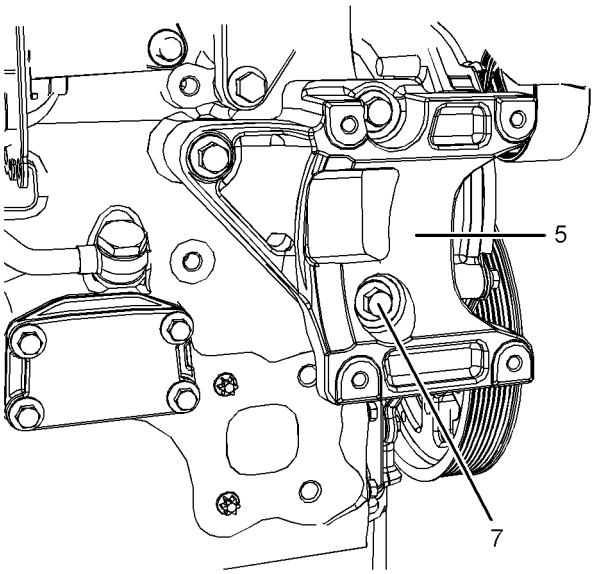

Illustration 436 g02518540

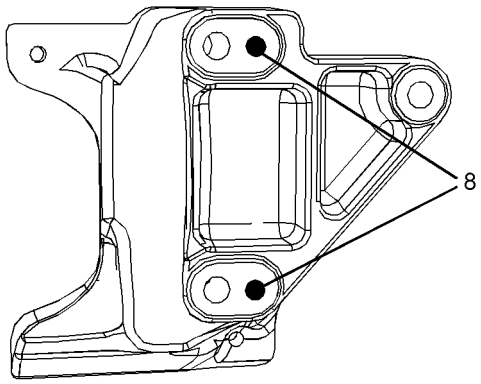

Illustration 437 g02518541

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 (8) are free from wear and damage. If necessary, replace the dowels.

c. Position bracket (5) onto the cylinder block. Install bolts (7) and hand tighten bolts.

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

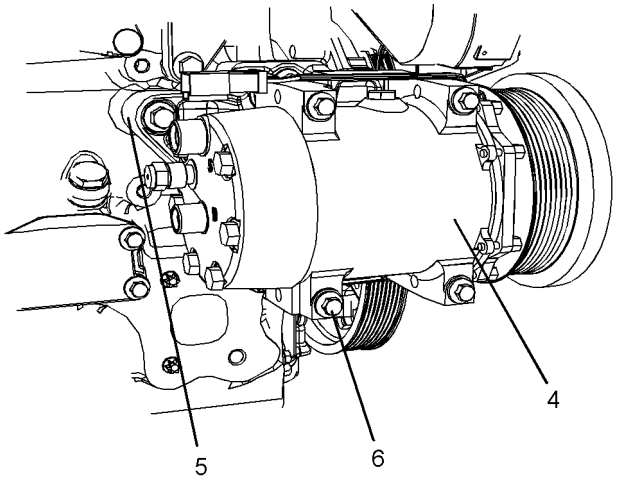

Illustration 438 g02518539

2. Position refrigerant compressor (4) onto bracket (5).

Note: Support the weight of the refrigerant compressor.

3. Install bolts (6) to the refrigerant compressor (4).

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

5. Install the alternator belt. Refer to Disassembly and Assembly Manual, “Alternator Belts - Remove and Install” for the correct procedure.

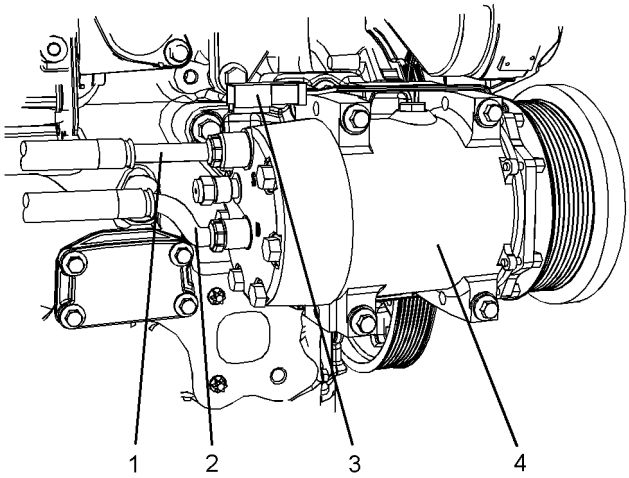

Illustration 439 g02518538

6. Connect harness assembly (3) to refrigerant compressor (4).

7. Remove the plugs 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. If the hose assemblies were removed from the refrigerant compressor. Refer to the Original Equipment Manufactures (OEM) for the correct charging procedures.

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

i04485797

Atmospheric Pressure Sensor - Remove and Install

Removal Procedure

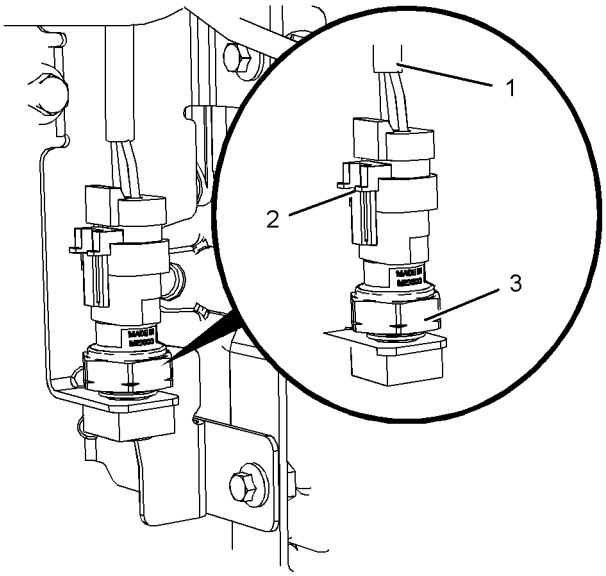

Illustration 440 g02433676

1. Slide locking tab (2) into the unlocked position. Disconnect harness assembly (1).

2. Remove atmospheric pressure sensor (3) from the bracket.

Installation Procedure

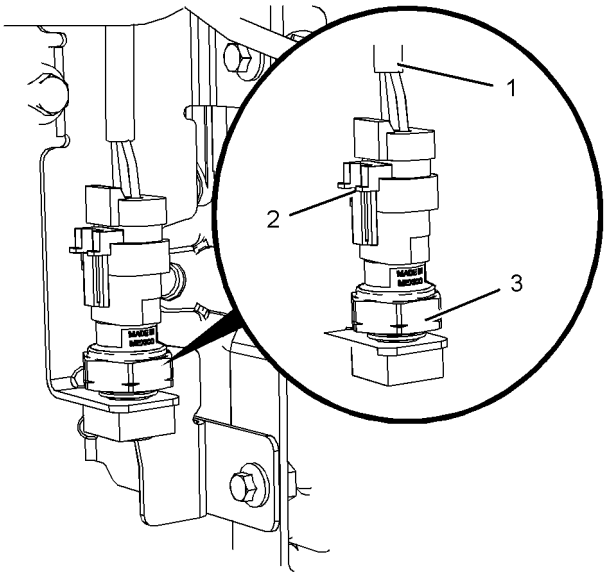

Illustration 441 g02433676

1. Install atmospheric pressure sensor (3). 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.

i04485806

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.

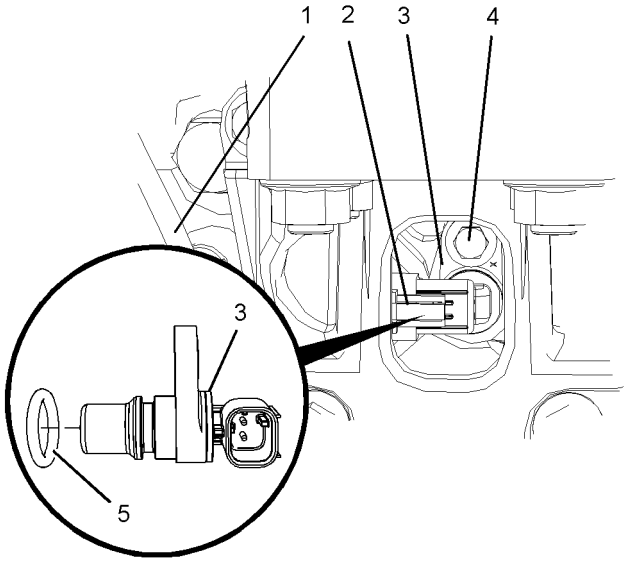

Illustration 442 g02437917

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

2. Remove bolt (2). 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.

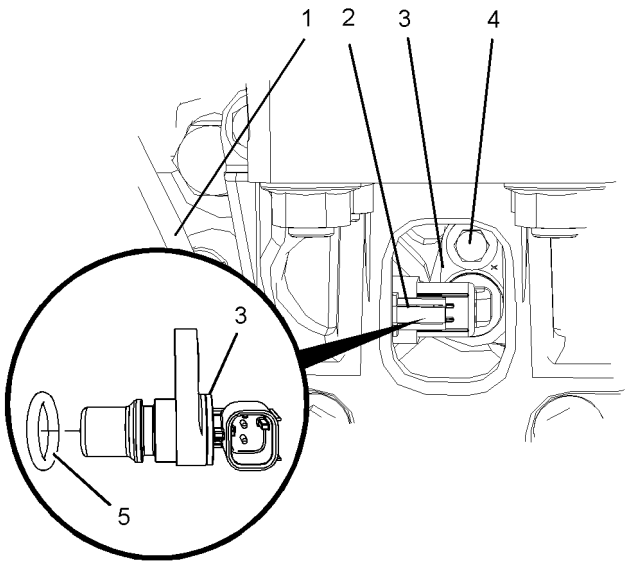

Illustration 443 g02437917

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.

i04485819

Crankshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

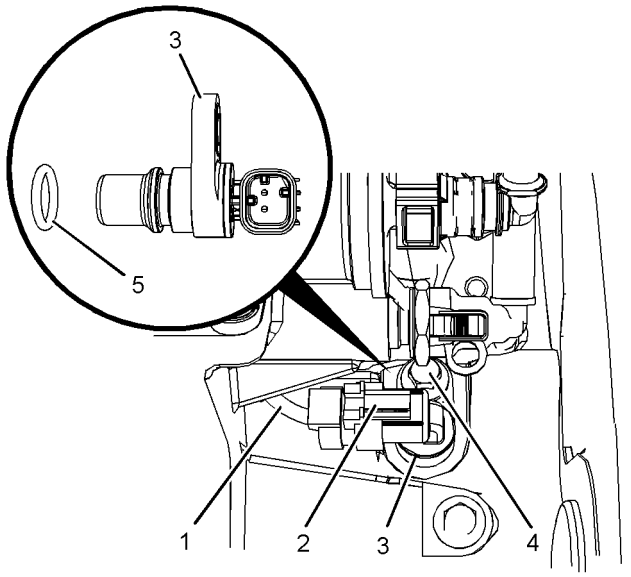

Illustration 444 g02449496

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.

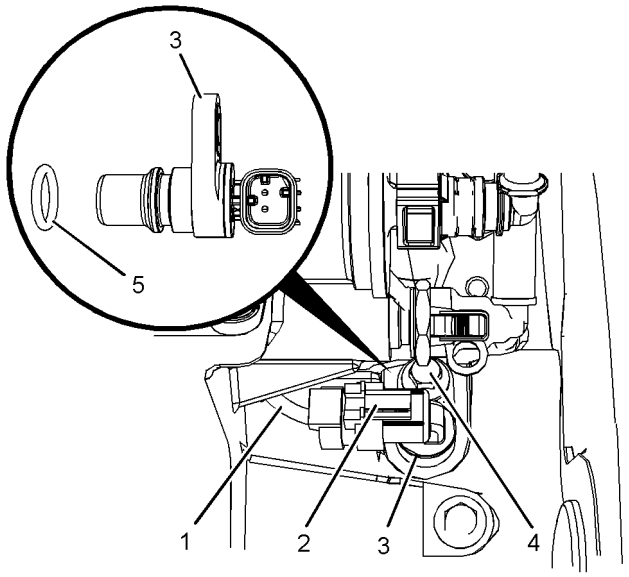

Illustration 445 g02449496

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.

i04485809

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.

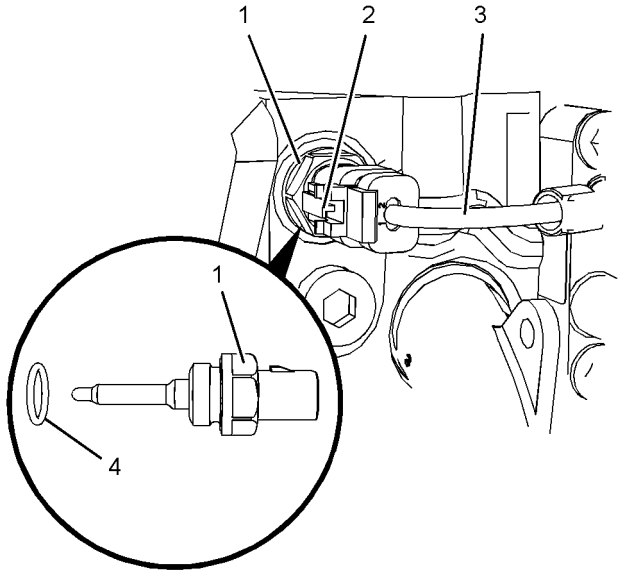

Illustration 446 g02439656

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.

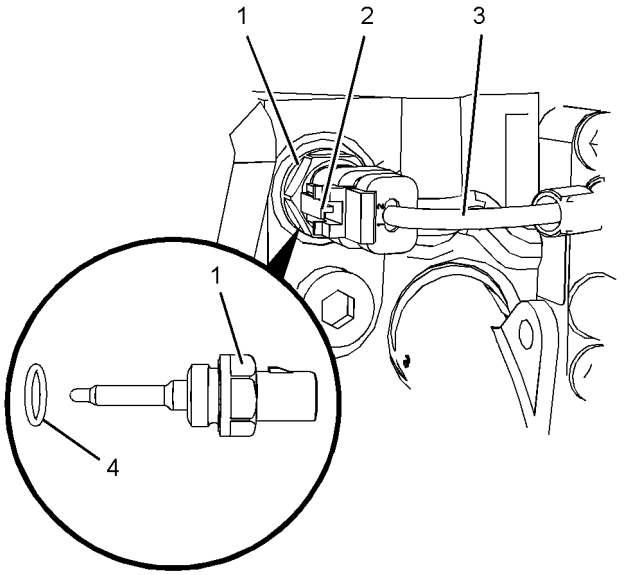

Illustration 447 g02439656

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 procedure.

i04485842

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.

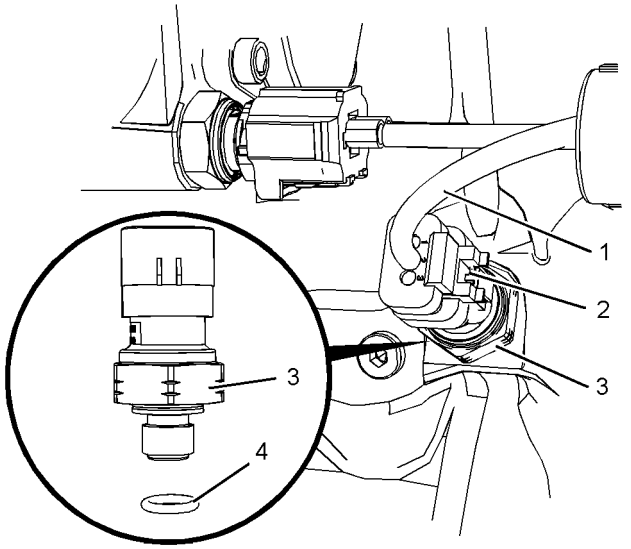

Illustration 448 g02476247

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.

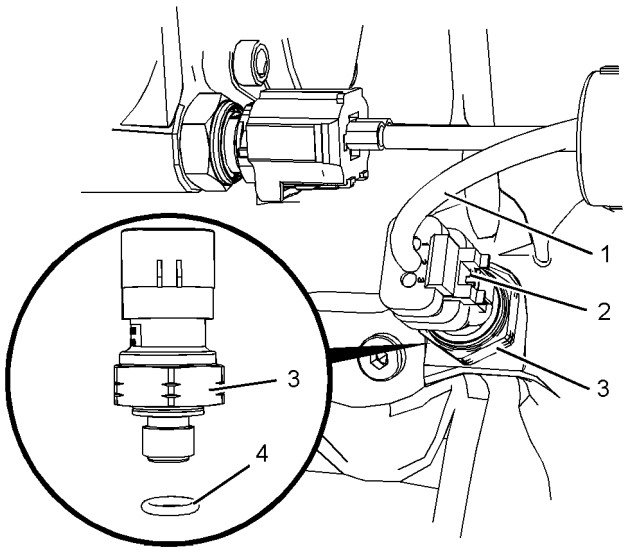

Illustration 449 g02476247

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.

i04485874

Fuel Temperature Sensor - Remove and Install

Removal Procedure

Table 85

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

⚠ WARNING

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

NOTICE

Ensure that all adjustments and repairs that are carried out to the fuel system are performed by 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.

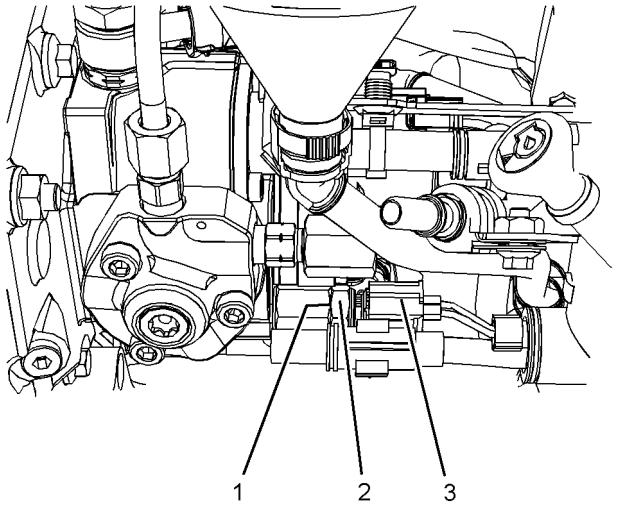

Illustration 450 g02596796

3. Disconnect harness assembly (3) 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 (1) (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.

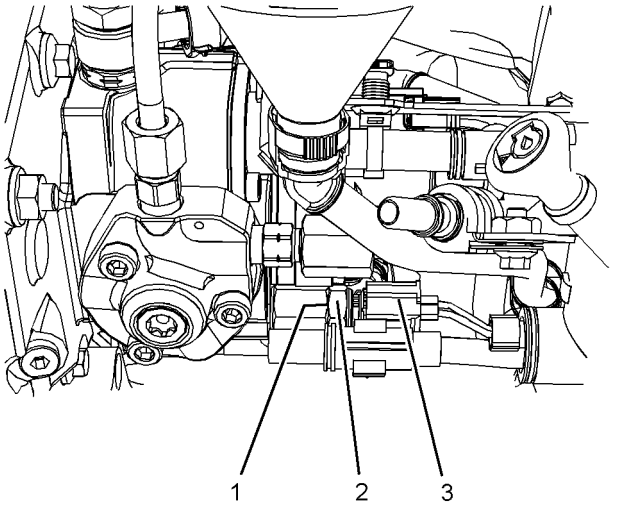

Illustration 451 g02596796

2. Install a new O-ring seal (1) (not shown) on the fuel temperature sensor (2).

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 (3) to fuel temperature sensor (2).

6. Turn the fuel supply to the ON position.

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

i04485902

Soot Antenna - Remove and Install

Removal Procedure

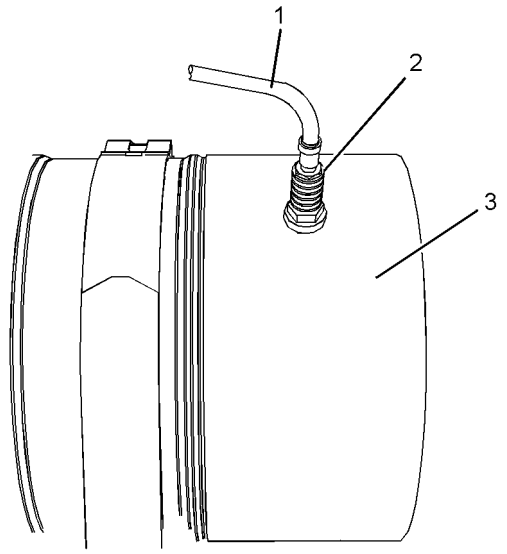

Illustration 452 g02520616

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 86

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.

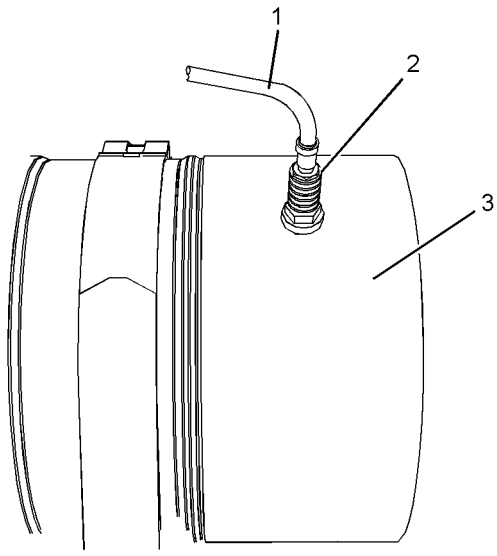

Illustration 453 g02520616

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.

i04485903

Temperature Sensor (DPF) - Remove and Install

Removal Procedure

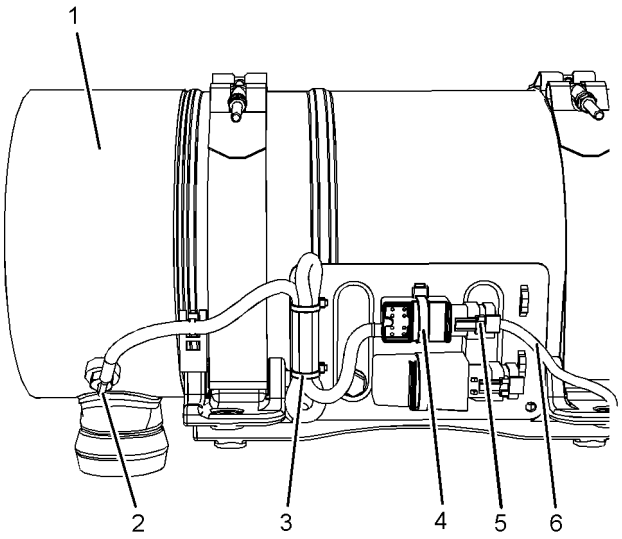

Illustration 454 g02520676

1. Slide locking tab (5) into the unlocked position. Disconnect harness assembly (6) from harness assembly for temperature sensor (2).

2. Cut cable straps (3) and cable strap (4) from harness assembly for temperature sensor (2).

Note: Ensure that all cable straps are removed for the harness assemblies.

3. Remove temperature sensor (2) from Diesel Particulate Filter (DPF) (1).

Note: Make temporary mark on the temperature sensor to show correct orientation.

4. Remove the harness assembly for temperature sensor (2) from the bracket on the Clean Emission Module (CEM)

Installation Procedure

Table 87

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.

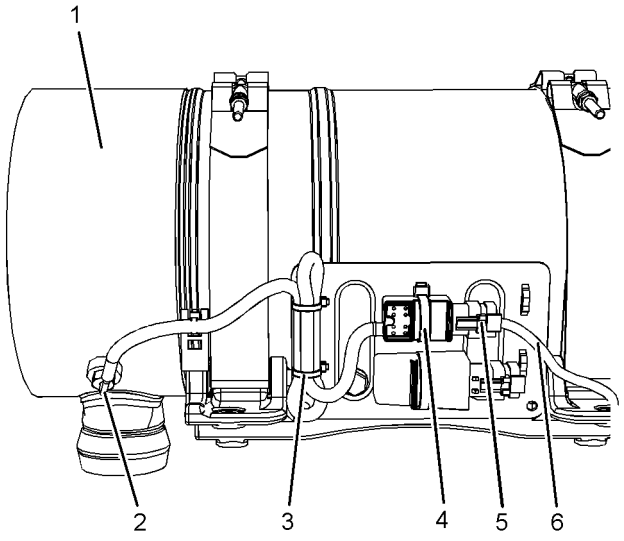

Illustration 455 g02520676

2. Lightly lubricate the thread of temperature sensor (2) with Tooling (A). Install temperature sensor (2) to DPF (1).

Note: Ensure that the temperature sensor is correctly orientated.

3. Torque temperature sensors (2) to a torque of 45 N·m (33 lb ft).

4. Position harness assembly for temperature sensors (2) onto the bracket on the CEM.

5. Install new cable straps (10) and a new cable straps (4) harness assembly for temperature sensors (2).

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

6. Connect harness assembly (6) to harness assembly for temperature sensor (2). Slide locking tab (5) into the locked position.

i04485904

Temperature Sensor (Cooled Exhaust Gas) - Remove and Install

Removal Procedure

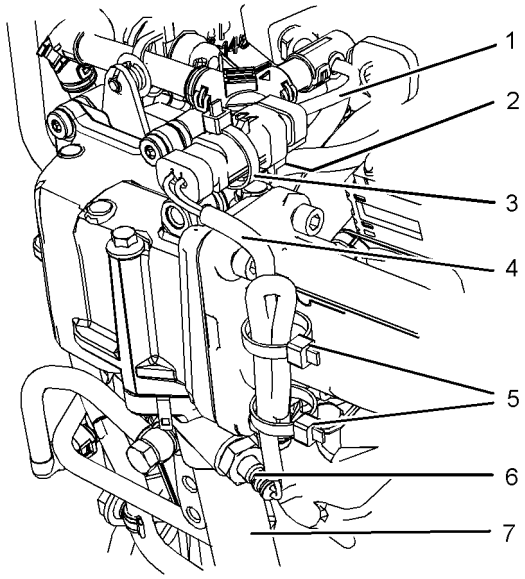

Illustration 456 g02520941

1. Slide locking tab (2) (not shown) into the unlocked position. Disconnect harness assembly (1) from harness assembly (4) for the temperature sensor.
2. Cut cable straps (5) and cable strap (3).
3. Remove temperature sensor (6) from tube assembly (7) for the NRS Induction mixer.

Installation Procedure

Table 88

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 and the convoluting.

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

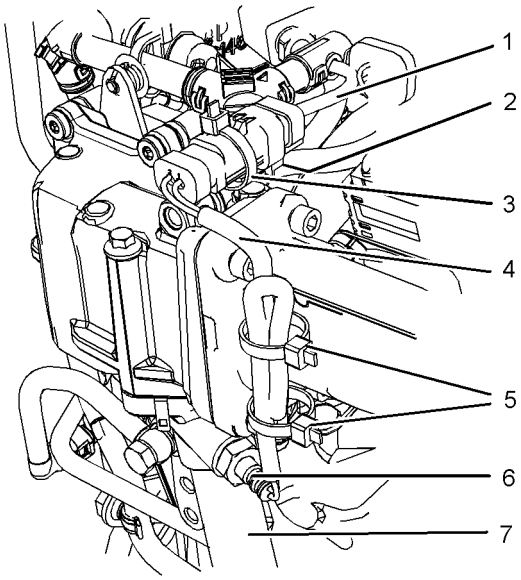

Illustration 457 g02520941

2. Lightly lubricate the thread of temperature sensor (6) with Tooling (A). Install temperature sensor (6) to tube assembly (7) for the NRS Induction mixer.
3. Torque temperature sensors (6) to a torque of 24 N·m (212lb in).
4. Connect harness assembly (1) to harness assembly (4) for the temperature sensor. Slide locking tab (2) (not shown) into the locked position.
5. Install new cable straps (5) and a new cable strap (3) to harness assembly (4).

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

i04485896

Pressure Sensor (Cooled Exhaust Gas) - Remove and Install (NRS Inlet and Outlet Pressure Sensors)

Removal Procedure

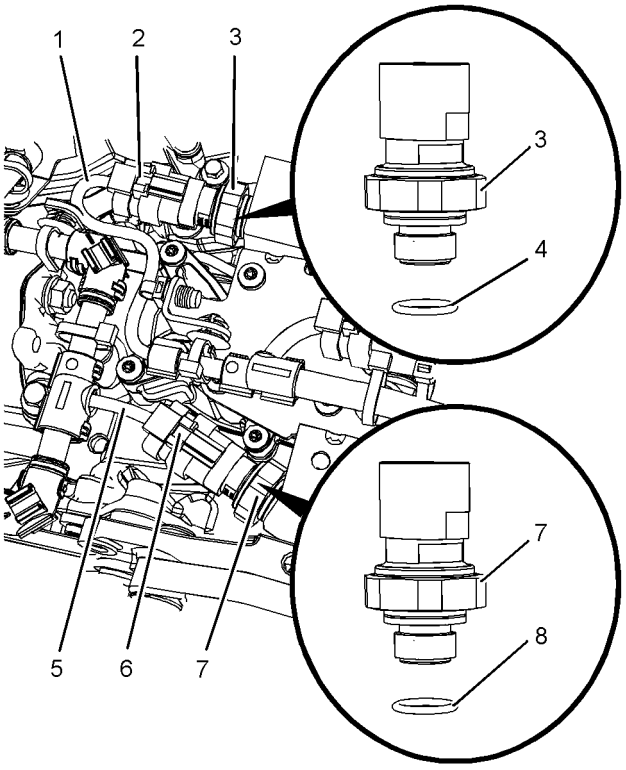

Illustration 458 g02514417

1. Slide locking tab (2) in to the unlocked position. Disconnect harness assembly (1) from inlet pressure sensor (3).
2. Use a deep socket in order to remove inlet pressure sensor (3).
3. Remove O-ring seal (4) from inlet pressure sensor (3).
4. Slide locking tab (6) in to the unlocked position. Disconnect harness assembly (5) from outlet pressure sensor (7).
5. Use a deep socket in order to remove outlet pressure sensor (7).
6. Remove O-ring seal (8) from outlet pressure sensor (7).

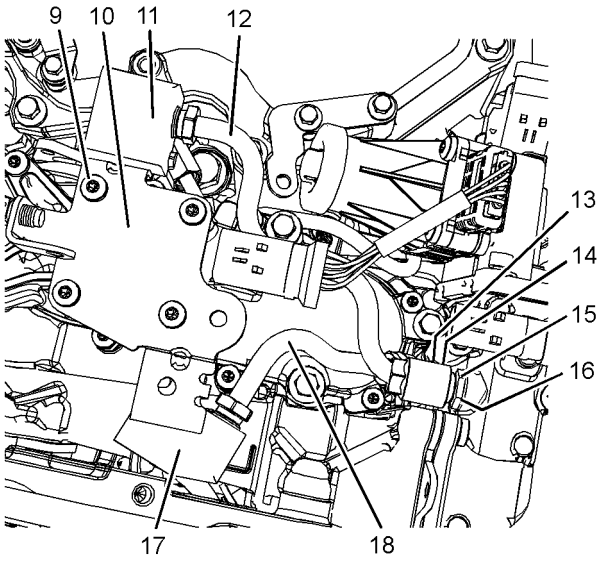

Illustration 459 g02514418

7. If necessary, follow Step 7.a through Step 7.j in order to remove the bracket assembly and the tube assemblies from NRS Induction mixer.
   - **a.** Cut cable strap from the harness assembly for the pressure sensors. Position the harness assembly away from bracket assembly (10) and NRS Induction mixer.
   - **b.** Use a suitable tool in order to hold manifold (11). Loosen tube assembly (12) at both ends.
   - **c.** Use a suitable tool in order to hold manifold (17). Loosen tube assembly (18) at manifold (17).
   - **d.** Remove Torx screws (9) from bracket (10).
   - **e.** Remove the assembly of bracket (10) and disconnect from tube assembly (12) and tube assembly (18) from the assembly of the bracket.
   - **f.** Disconnect tube assembly (12) from connection (15).
   - **g.** Loosen tube assembly (18) from connection (13) (not shown). Disconnect tube assembly (18) from connection (13) (not shown).
   - **h.** If necessary, remove connection (13) (not shown) and connection (15) from the NRS Induction mixer.
   - **i.** Remove O-ring seal (14) (not shown) from connection (13) (not shown).
   - **j.** Remove O-ring seal (16) (not shown) from connection (15).

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 and the convoluting.

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

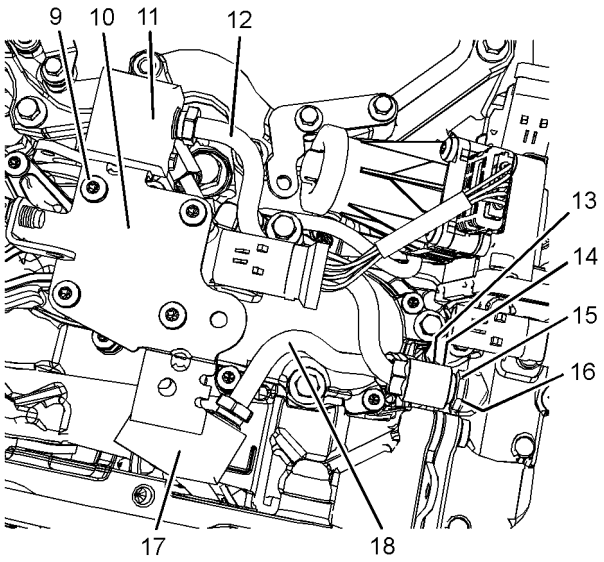

Illustration 460 g02514418

2. If necessary, follow Step 2.a through Step 2.n in order to install the bracket assembly and the tube assemblies to NRS Induction mixer.

a. Install a new O-ring seal (14) (not shown) to connection (13) (not shown).

b. Install a new O-ring seal (16) (not shown) to connection (15).

c. Install connection (13) and connection (15) (not shown) to NRS Induction mixer. Tighten connections to a torque of 30 N·m (266 lb in).

d. Installation of tube assembly (18) and bracket (10) is required in order to position the tube assembly. Loosely install tube assembly (18) to connection (13) on the NRS Induction mixer.

e. Position the assembly of bracket (10) onto the NRS Induction mixer. Connect tube assembly (18) to manifold (17).

f. Install Torx screws (9) to bracket (10) finger tight.

g. Tighten tube assembly (18) at connection (13). Tighten tube assembly to a torque of 20 N·m (177 lb in).

h. Loosen tube assembly (18) at manifold (17). Remove Torx screws (9) from bracket (10) and remove the bracket.

i. Loosely install tube assembly (12) to connection (15) on the NRS Induction mixer. Hand tighten tube assembly (12).

j. Position bracket assembly (10) onto the NRS Induction mixer and connect tube assembly (12) and tube assembly (18) hand tighten the tube assemblies.

k. Install Torx screws (9) to bracket (10).

l. Tighten Torx screws (9) to a torque of 12 N·m (106lb in).

m. Use a suitable tool in order to hold manifold (11). Tighten tube assembly (12) to a torque of 20 N·m (177 lb in).

n. Use a suitable tool in order to hold manifold (17). Tighten tube assembly (18) to a torque of 20 N·m (177 lb in).

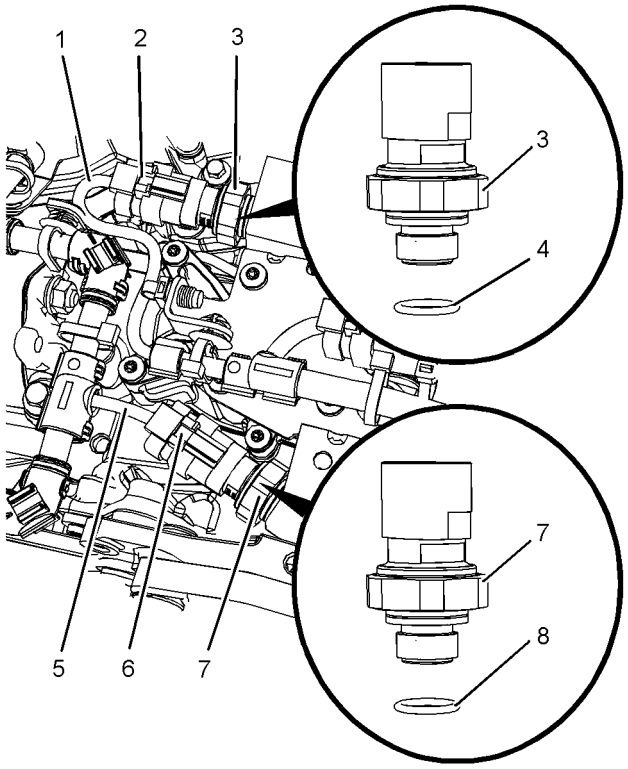

Illustration 461 g02514417

3. Install a new O-ring seal (8) to outlet pressure sensor (7).

Note: Do not lubricate the O-ring seal.

4. Use a deep socket in order to install outlet pressure sensor (7). Tighten the outlet pressure sensor to a torque of 10 N·m (89 lb in).

5. Connect harness assembly (5) to outlet pressure sensor (7). Slide locking tab (6) in to the locked position.

6. Install a new O-ring seal (4) to inlet pressure sensor (3).

Note: Do not lubricate the O-ring seal.

7. Use a deep socket in order to install inlet pressure sensor (7). Tighten the inlet pressure sensor to a torque of 10 N·m (89 lb in).

8. If necessary, position harness assembly onto bracket assembly (10) and NRS Induction mixer. Install new cable straps to the harness assembly.

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

9. Connect harness assembly (1) to inlet pressure sensor (3). Slide locking tab (2) in to the locked position.

i04485802

Boost Pressure Sensor - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

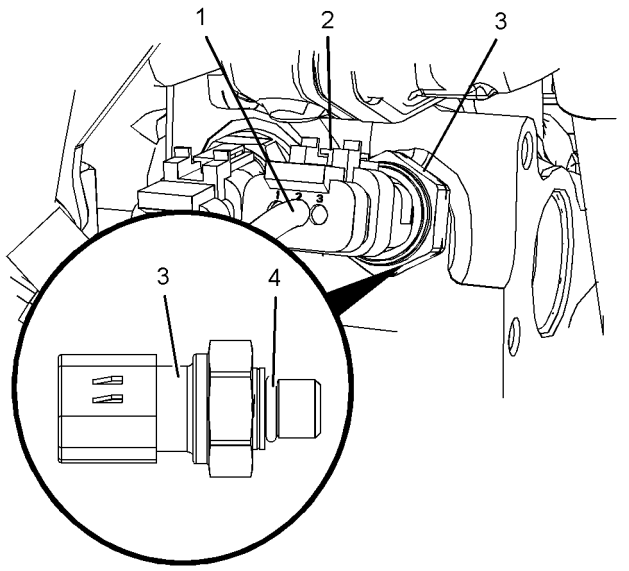

Illustration 462 g02437637

1. Slide locking tab (2) into the unlocked position.

2. Disconnect harness assembly (1) 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 cylinder head.

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.

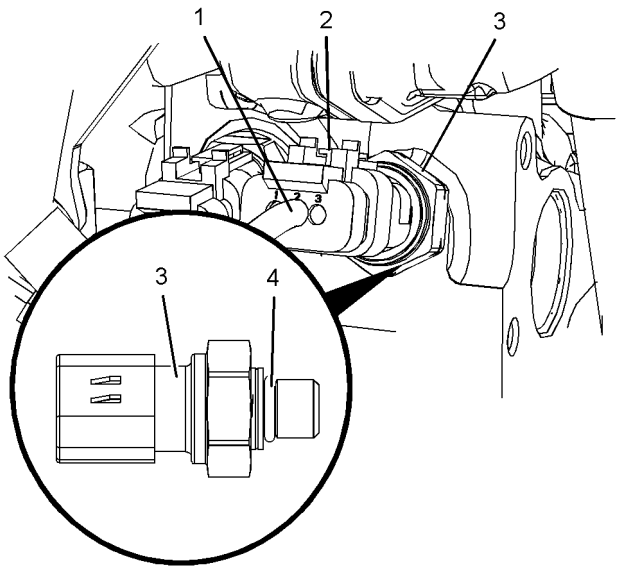

Illustration 463 g02437637

1. Install the 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 cylinder head. Tighten the boost pressure sensor to a torque of 10 N·m (89 lb in).

3. Connect harness assembly (1) to boost pressure sensor (3).

4. Slide locking tab (2) into the locked position.

i04485890

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.

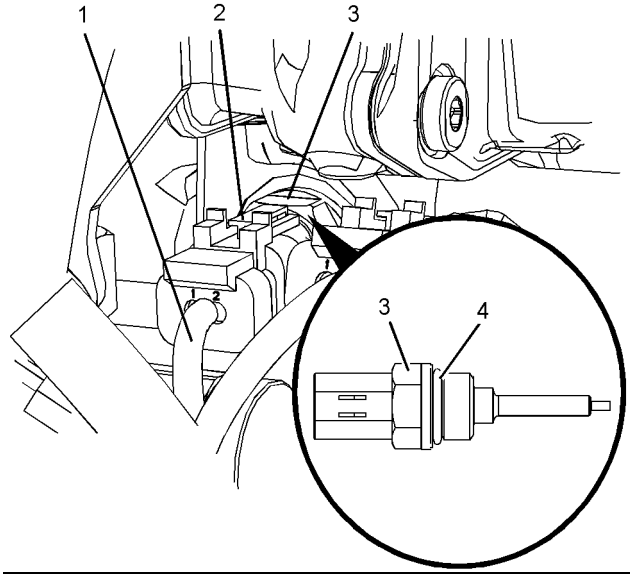

Illustration 464 g02437677

1. Slide locking tab (2) into the unlocked position.

2. Disconnect harness assembly (1) 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 cylinder head.

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.

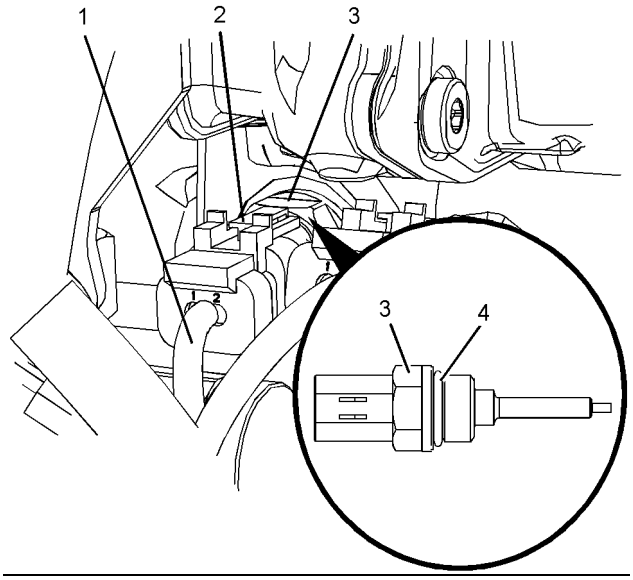

Illustration 465 g02437677

1. Install the 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 cylinder head. Tighten the inlet manifold temperature sensor to a torque of 20 N·m (177 lb in).

3. Connect harness assembly (1) to inlet manifold temperature sensor (3).

4. Slide locking tab (2) into the locked position.

i04485877

Glow Plugs - 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.

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

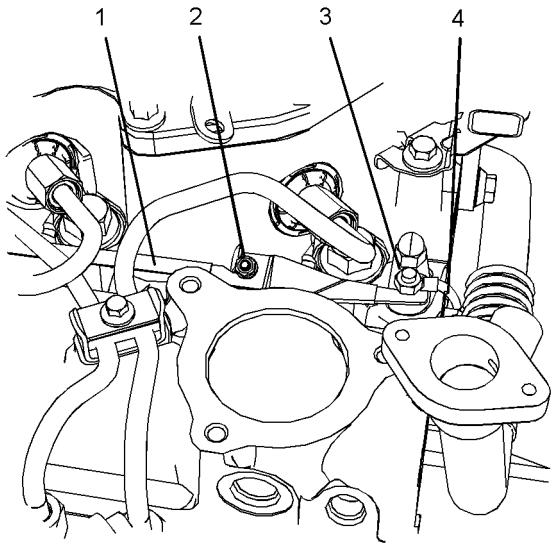

Illustration 466 g02488236

2. Remove nut (3) from the terminal insulator.

3. Disconnect wire (4) from the terminal insulator.

4. Remove nuts (2) that secure bus bar (1) to the glow plugs.

5. Remove bus bar (1) from the glow plugs.

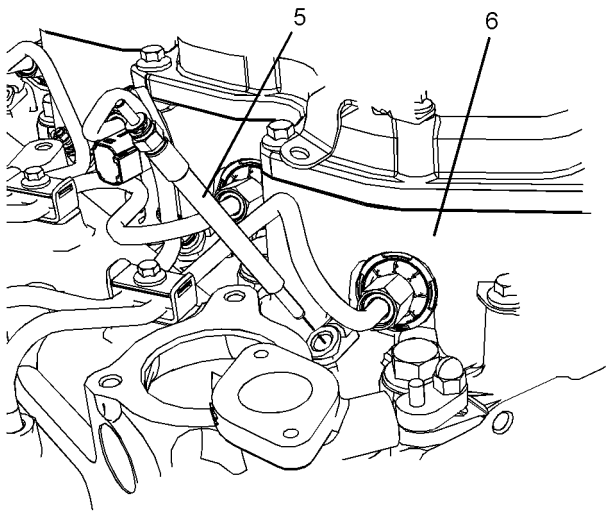

Illustration 467 g02488237

6. Remove glow plugs (5) from cylinder head (6).

Installation Procedure

Table 89

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.

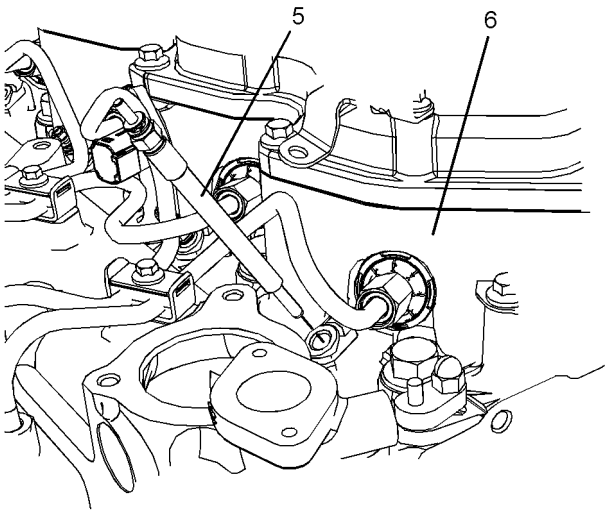

Illustration 468 g02488237

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.
2. Install glow plugs (5) into cylinder head (6). Tighten the glow plugs to a torque of 15 N·m (132 lb in).

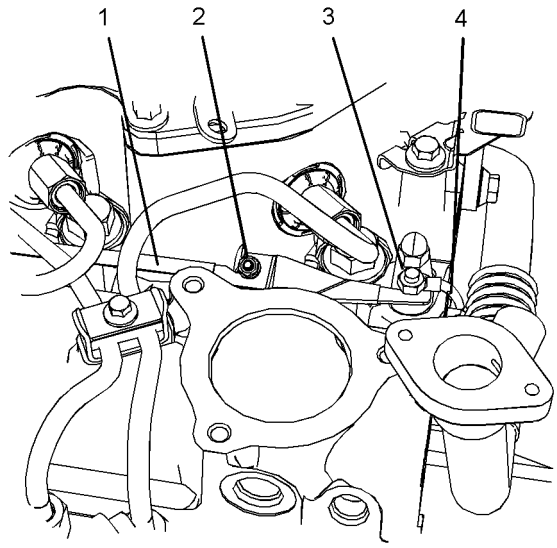

Illustration 469 g02488236

3. Position bus bar (1) onto the glow plugs. Install nuts (2) onto the glow plugs.
4. Use Tooling (A) to tighten nuts (2) to a torque of 2 N·m (17 lb in).
5. Connect wire (4) to the stud on the terminal insulator.
6. Install nut (3) to the stud on the terminal insulator. Tighten the nut to a torque of 6 N·m (53 lb in).
7. Turn the battery disconnect switch to the ON position.

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.

i04485796

Alternator Belt - Remove and Install

Removal Procedure

Table 90

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

1. If the engine has guards, remove the guards. Refer to the OEM for the correct procedure.

Note: Mark the direction of rotation of the alternator belt, if the belt will be reused.

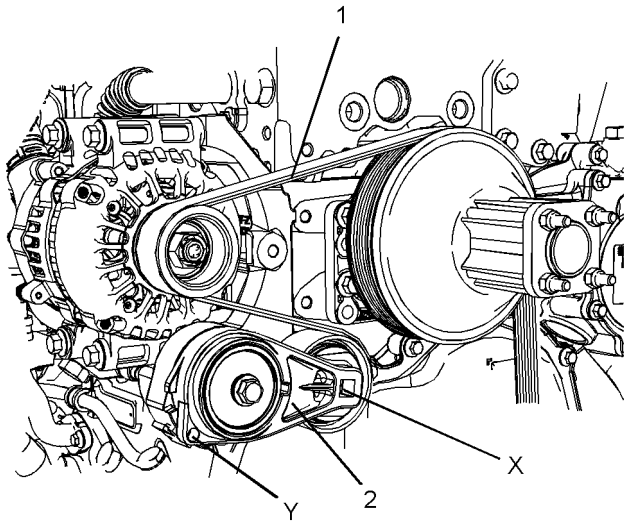

Illustration 470 g02433716
Typical example

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 91

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

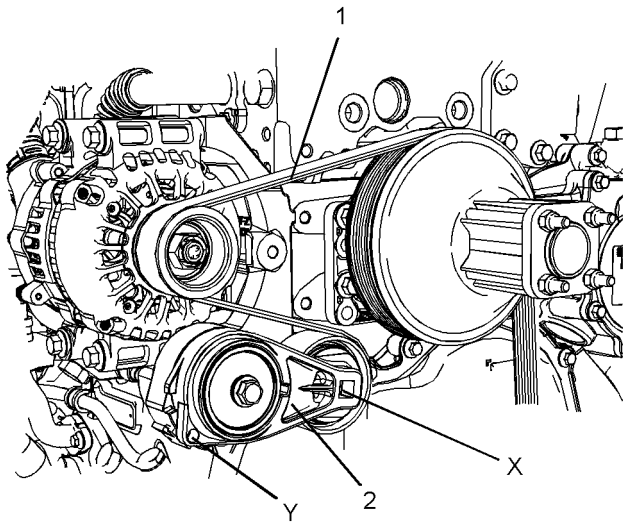

Illustration 471 g02433716
Typical example

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. Clean all pulleys and guide rollers. Ensure that the 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.

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

3. 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.

4. 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).

5. 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.

6. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i04485885

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.

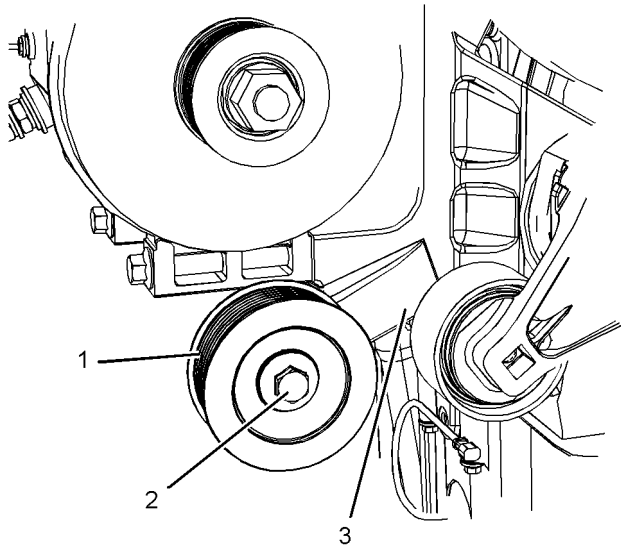

Illustration 472 g02501039
Typical example

1. Remove bolt (2).
2. Remove grooved idler pulley (4) from bracket (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

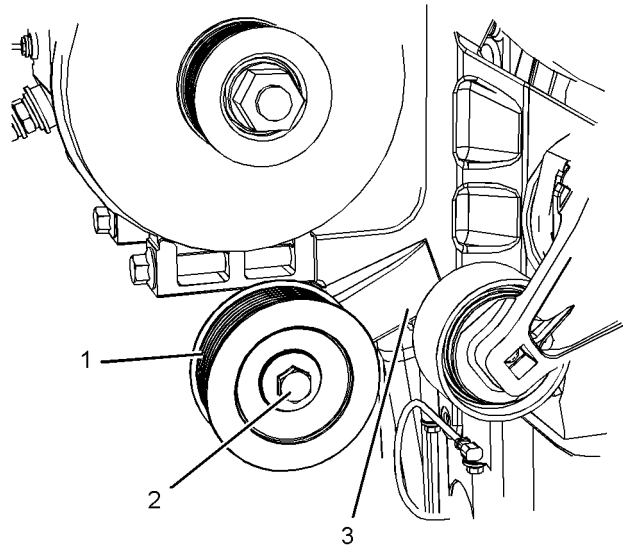

Illustration 473 g02501039
Typical example

1. Position grooved idler pulley (1) onto bracket (3). Loosely tighten bolt (2).
2. Tighten bolt (2) 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.

i04485884

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.

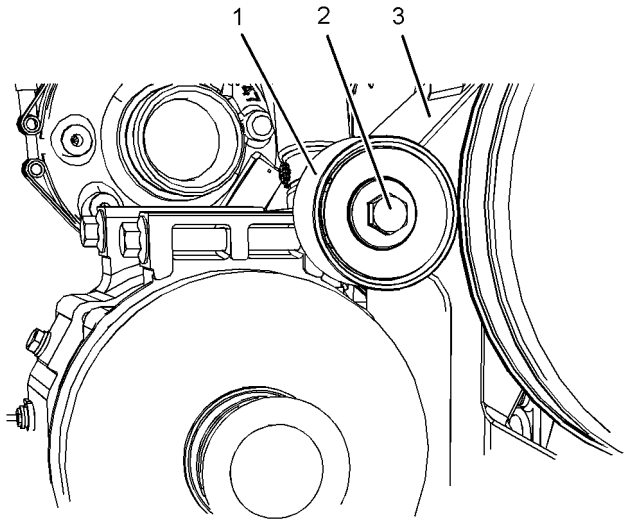

Illustration 474 g02501036
Typical example

2. Remove bolt (2).

3. Remove flat idler pulley (1) from bracket (3).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

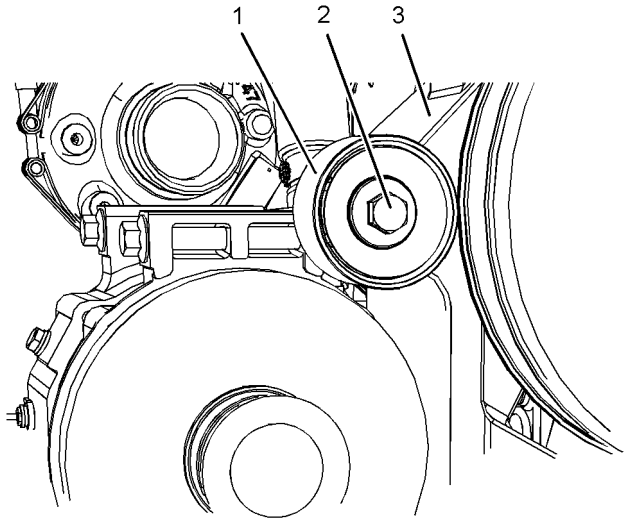

Illustration 475 g02501036
Typical example

1. Position flat idler pulley (1) on bracket (3). Loosely tighten bolt (2).

2. Install bolt (2). Tighten the bolt to a torque of 44 N·m (32 lb ft).

3. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install” for the correct procedure.

i04485801

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.

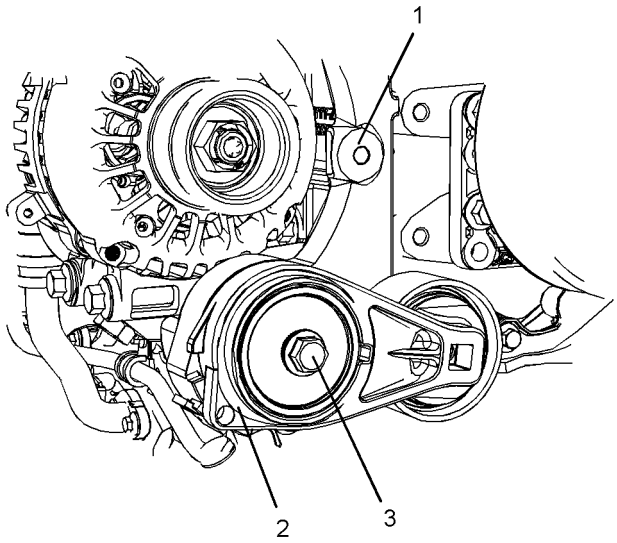

Illustration 476 g02437576

3. Loosen bolt (3) sufficiently in order to remove tensioner (2) from mounting bracket (1).

4. Remove tensioner (2) from mounting bracket (1).

Installation Procedure

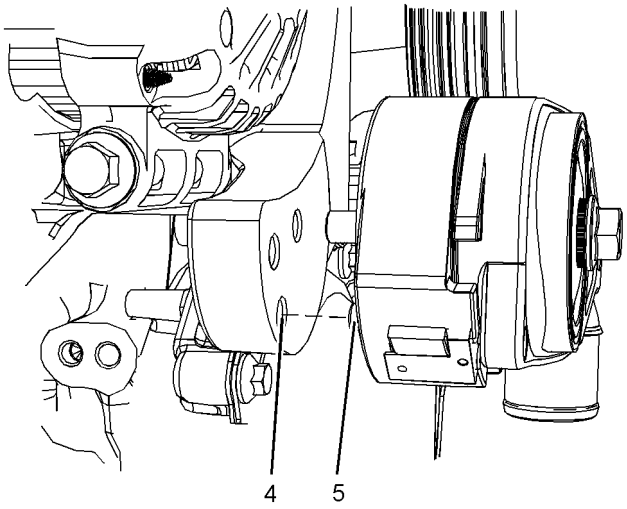

Illustration 477 g02437596

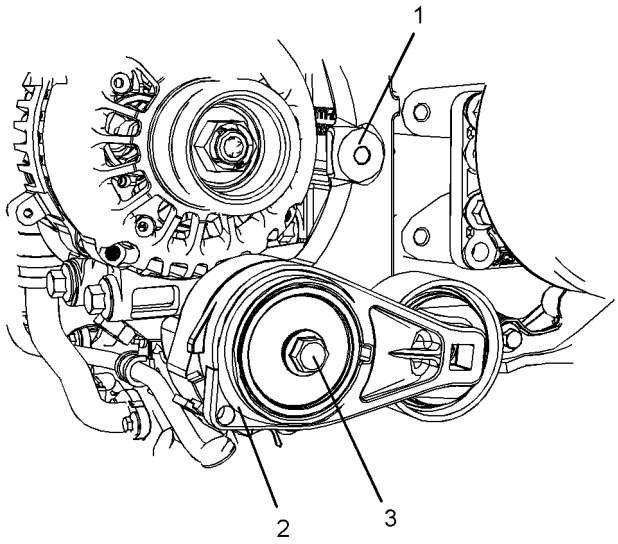

Illustration 478 g02437576

1. Position belt tensioner (3) with locating pin (5) in locating hole (4) on the mounting bracket. Tighten bolt (3) finger tight.
2. Tighten bolt (3) to a torque of 45 N·m (33 lb ft).
3. Install the alternator belt. Refer to Disassembly and Assembly, “Alternator Belt - Remove and Install.” for the correct procedure.
4. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i04485853

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.

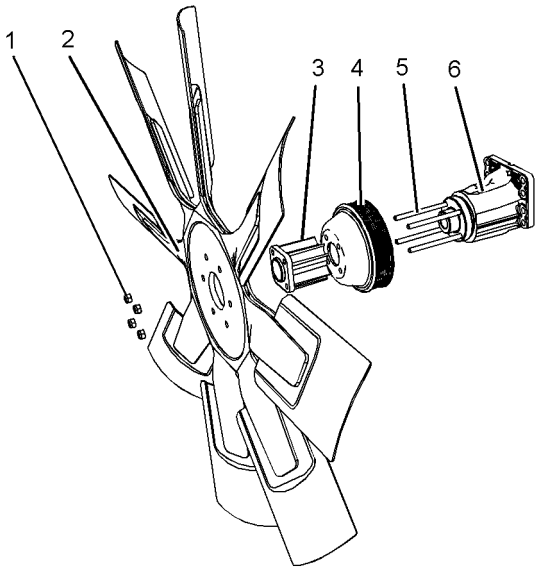

Illustration 479 g02101373
Typical example

1. Remove locking nuts (1).
2. Remove fan (2).

Note: Note the orientation of the fan.

3. Remove fan adapter (3).
4. Remove fan pulley (4).
5. If necessary, remove studs (5) from fan drive (6).

Installation Procedure

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

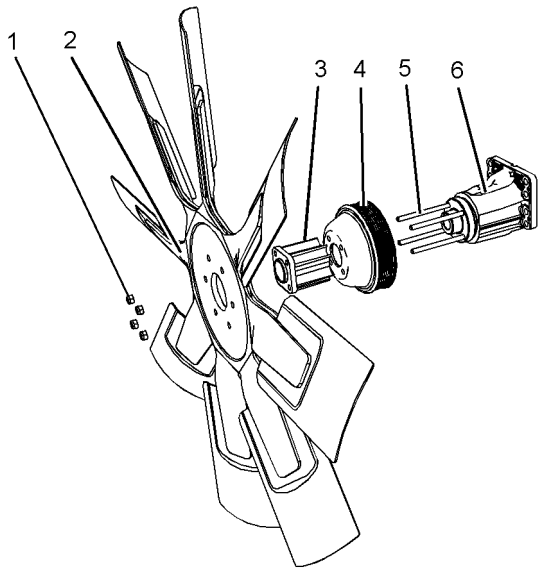

Illustration 480 g02101373
Typical example

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 installed to 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.

i04485854

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.

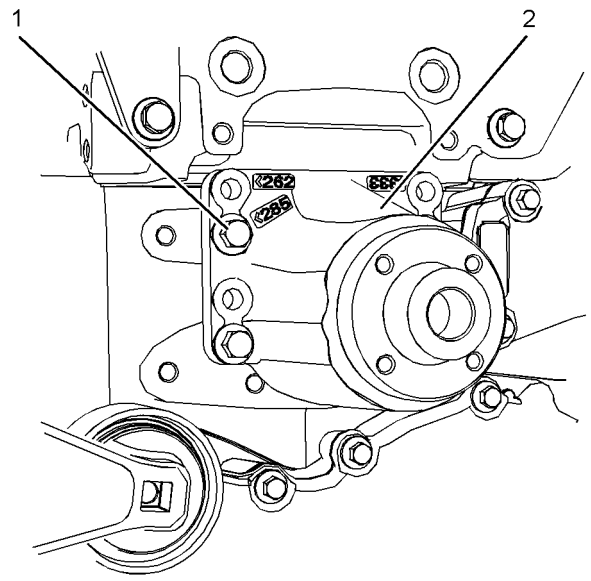

Illustration 481 g02014594
Typical example

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

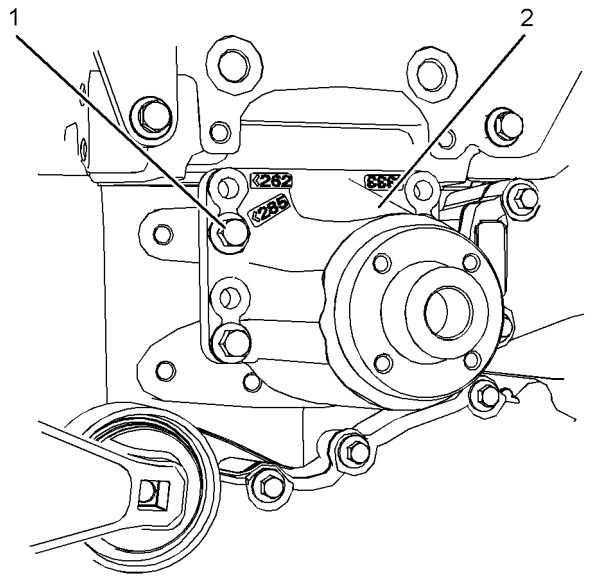

Illustration 482 g02014594
Typical example

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.

i04485831

Electronic Control Module - Remove

Removal Procedure

Table 92

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

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.
3. If necessary, remove the secondary filter assembly. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
4. If necessary, remove the primary fuel filter assembly. Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
5. If necessary, remove the dipstick tube assembly. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

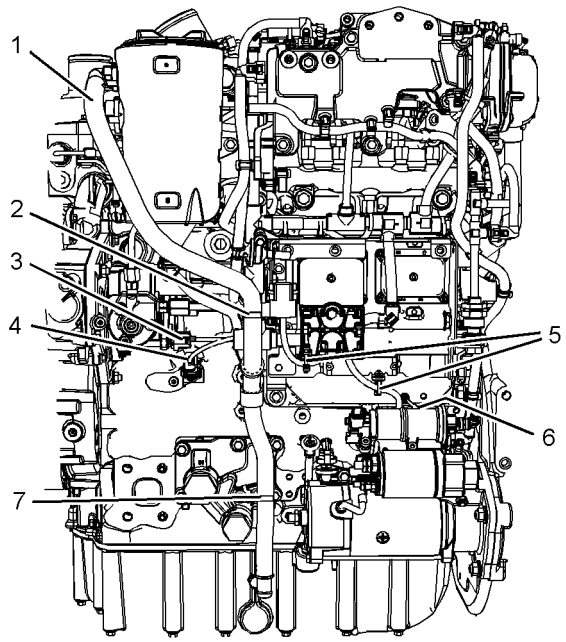

Illustration 483 g02601037

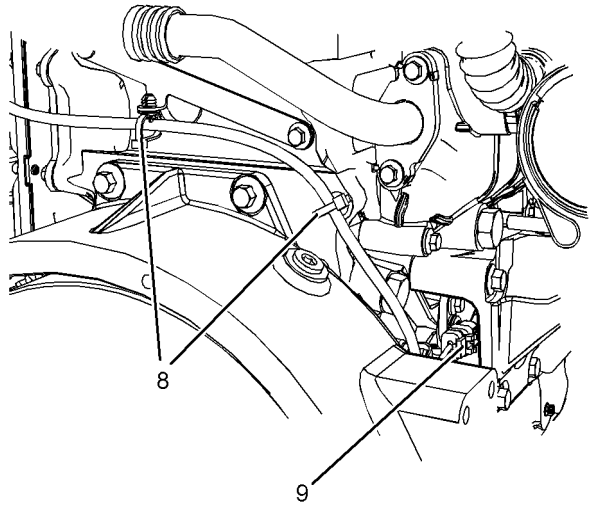

Illustration 484 g02603416

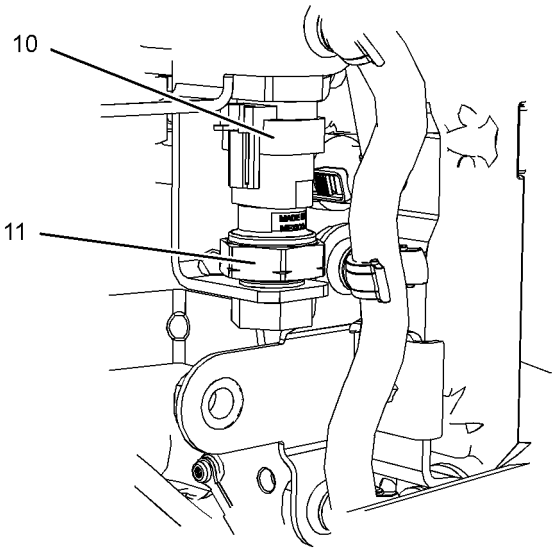

Illustration 485 g02603456

6. Cut cable strap (2) and cable strap (7) from plastic tube assembly (1).

7. Remove plastic tube assembly (1) from the crankcase breather canister. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

8. Disconnected harness assembly (3) from the fuel temperature sensor. Refer to Disassembly and Assembly, “Fuel Temperature Sensor- Remove and Install” for the correct procedure.

9. Disconnected harness assembly (4) from the engine oil pressure sensor. Refer to Disassembly and Assembly, “Engine Oil Pressure Sensor - Remove and Install” for the correct procedure.

10. Cut cable straps (5) from harness assembly for crankshaft position sensor (6) (not shown). Disconnect the harness assembly from crankshaft position sensor (6) (not shown). Refer to Disassembly and Assembly, “Crankshaft Position Sensor - Remove and Install” for the correct procedure.

11. Cut cable straps (8) from harness assembly for camshaft position sensor (9) (not shown). Disconnect the harness assembly from camshaft position sensor (9) (not shown). Refer to Disassembly and Assembly, “Camshaft Position Sensor - Remove and Install” for the correct procedure.

12. Disconnect harness assembly (10) from atmospheric pressure sensor (10). Refer to Disassembly and Assembly, “Atmospheric Pressure Sensor - Remove and Install” for the correct procedure.

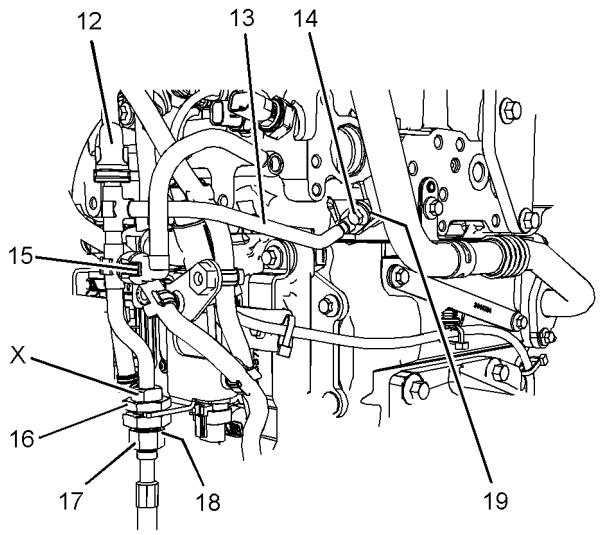

Illustration 486 g02467198

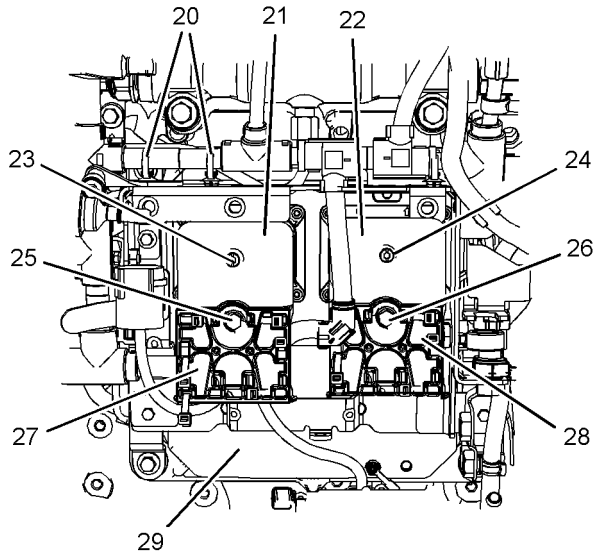

Illustration 487 g02466856

13. Disconnect plastic tube assembly (12) and plastic tube assembly (15) from tube assembly (13). Use Tooling (A) in order to plug the plastic tube assemblies and to cap the tube assembly.

14. Disconnect hose assembly (17) from connection on tube assembly (13). Remove O-ring seal (18) (not shown). Use Tooling (A) in order to plug the hose assembly and to cap the tube assembly.

15. Use a suitable tool in Position (X) in order to hold tube assembly (13) as nut (19) is loosened. Remove bolt (14) from tube assembly (13).

16. Remove tube assembly (13) from the bracket and the cylinder head.

17. Remove O-ring seal (19) (not shown) from tube assembly (13).

18. Use Tooling (A) in order to plug the cylinder head and to cap the tube assembly.

19. Cut cable straps (20) from engine harness assembly. Ensure that all the cable straps are removed.

20. Loosen bolt (25) and remove bolt from Electronic Control Module (ECM) plug (21).

21. Loosen the allen head bolt (23) that secures ECM plug (21) for engine harness assembly (27) to ECM (29). Disconnect the engine harness assembly from the ECM.

22. Position engine harness assembly (27) away from the ECM.

23. Loosen bolt (26) and remove the bolt from Original Equipment Manufacture (OEM) plug (22).

24. Loosen the allen head bolt (24) that secures OEM plug (22) for the OEM harness assembly (28) to ECM (29). Disconnect the OEM harness assembly from the ECM.

25. Position OEM harness assembly (28) away from the ECM.

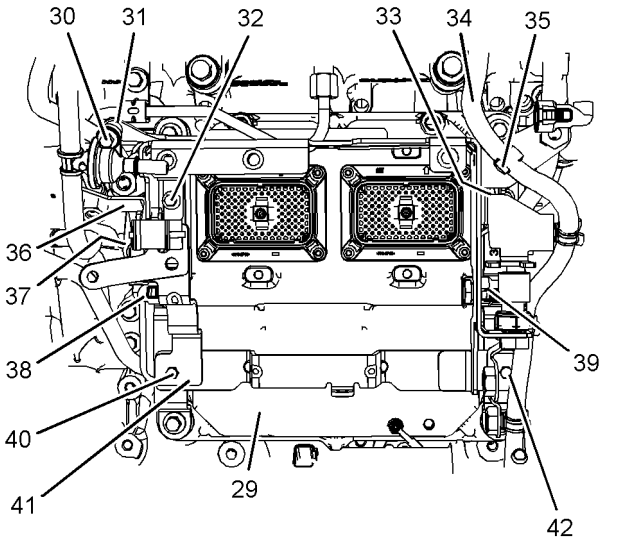

Illustration 488 g02466957

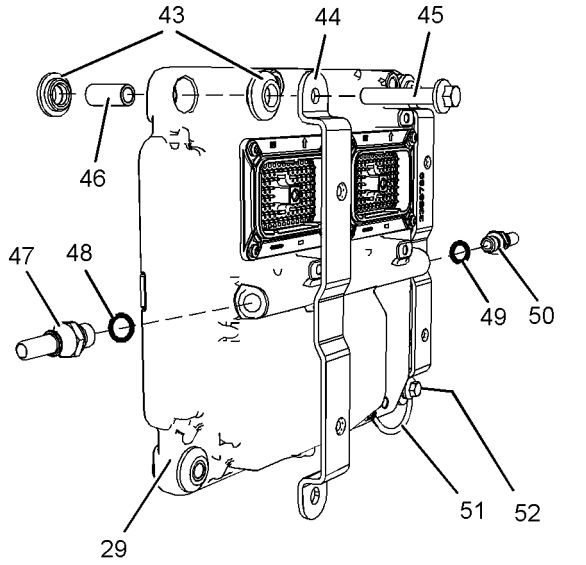

Illustration 489 g02469577

26. Make temporary identification marks on the plastic tube assembly (38), plastic tube assembly (39) in order to show the correct position of the plastic tube assemblies.

27. Place a suitable container below the ECM (29) in order to catch any fuel that might be spilled.

28. Disconnect plastic tube assembly (38) and plastic tube assembly (39). Drain the fuel from ECM (29).

29. Use Tooling (A) in order to plug plastic tube assembly (38) and plastic tube assembly (39).

30. Use Tooling (A) in order to cap connections on the ECM for plastic tube assemblies.

31. Remove plastic tube assembly (34) from clips (35).

32. Remove bolt (30) from bracket (31) for the valve.

33. Remove bolt (37) (not shown) from bracket (36).

34. Remove bolts (32) and bolts (40).

Remove bolts (33) (not shown) and bolts (43).

35. Remove bracket (41) from ECM (29).

Note: Note the orientation and position of the brackets

36. Loosen bolts (45) on ECM (29). Take care to prevent damage to ground connection (51).

Note: When removing the bolts from the ECM, ensure that the fuel injection line from the fuel injection pump to the fuel manifold is not damaged.

37. Remove the assembly of ECM (29) from the engine.

Note: Support the ECM as the bolts are removed. Note the orientation of the ECM.

38. If necessary, follow Step 38.a through Step 38.e in order to disassemble ECM (29).

a. Remove bolts (45) and washer (52) from ground connection (51). Remove brackets (44) from the ECM.

Note: Note orientation of the brackets for assembly purposes.

b. Remove isolation mounts (43) and limit sleeves (46).

c. Remove connection (47) and connection (50) from ECM (29).

d. Remove O-ring seal (48) and O-ring seal (49) from the connections.

e. Use Tooling (A) in order to plug ECM (29). Use Tooling (A) in order to cap the connection (47) and connection (50).

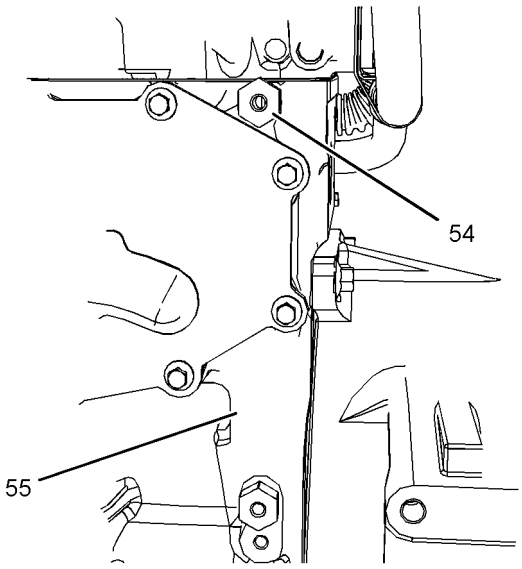

Illustration 490 g02472396

39. If necessary, remove spacers (54) from cylinder block (55).

i04485829

Electronic Control Module - 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 and the convoluting.

1. If a replacement Electronic Control Module (ECM) is installed, the replacement ECM 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.

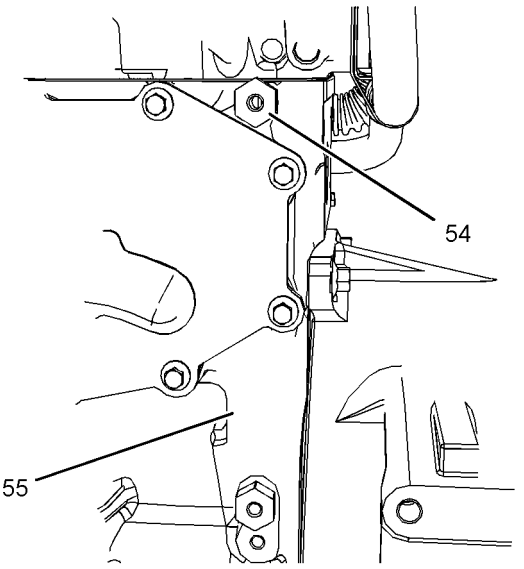

Illustration 491 g02472396

3. If necessary, install spacers (53) to cylinder block (54). Tighten the spacers to a torque of 44 N·m (32 lb ft).

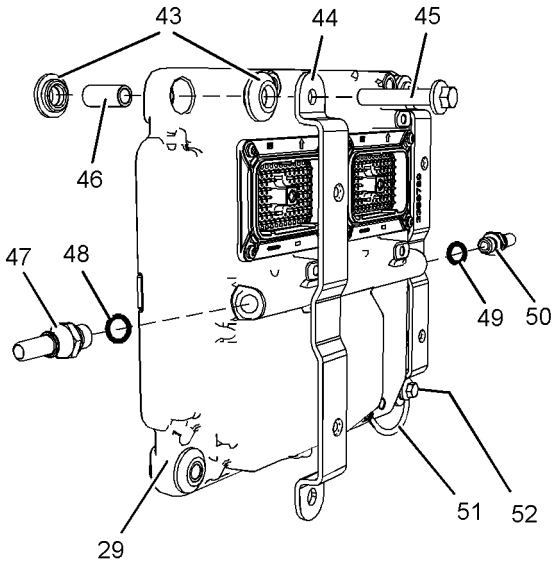

Illustration 492 g02469577

4. If necessary, follow Step 4.a through Step 4.f in order to assemble ECM (29).

a. Install new O-ring seal (49) to connection (48).

b. Install a new O-ring seal (50) to connection (51).

c. Install connection (48) and connection (51) to ECM (29). Tighten the connections to a torque of 18 N·m (159 lb in).

d. Install isolation mounts (44) and limit sleeves (47) to ECM (29).

e. Position brackets (45) onto ECM (29).

Note: Ensure that the brackets are correctly orientated.

f. Position bolts (46) onto ECM (29). Ensure the ground connection (52) and washer (53) are correctly located onto the ECM.

5. Position the assembly of ECM (29) onto the engine.

Note: Ensure that the ECM is correctly orientation.

6. Hand tighten bolts (46) for ECM (29). Take care to prevent damage to ground connection (52).

7. Tighten bolts (46) to a torque of 22 N·m (195 lb in).

Note: Ensure that the ground connection is not strained as the bolts are tightened.

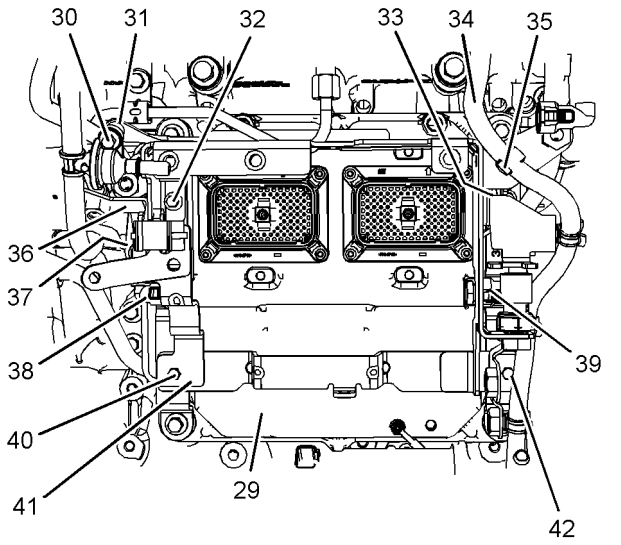

Illustration 493 g02466957

8. Ensure that all new cable straps are installed before the bracket (41) is installed.

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

9. Position bracket (41) onto ECM (29). Ensure that the brackets are correctly orientated.

Note: Ensure that the fuel injection line is not damaged during the installation of the bracket.

10. Install bolt (32) and bolt (40). Install bolt (33) (not shown) and bolt (42). Tighten the bolts to a torque of 9 N·m (80 lb in).

11. Install bolt (37) (not shown) to bracket (36). Tighten the bolt to a torque of 9 N·m (80 lb in).

12. Install bolt (30) to bracket (31) for the valve. Tighten the bolt to a torque of 9 N·m (80 lb in).

13. Install plastic tube assembly (34) to clips (35).

14. Remove the plugs from plastic tube assembly (38) and plastic tube assembly (39). Remove caps from connections on ECM (29) for the plastic tube assemblies.

15. Connect plastic fuel line (38) and plastic fuel line (39) to ECM (29).

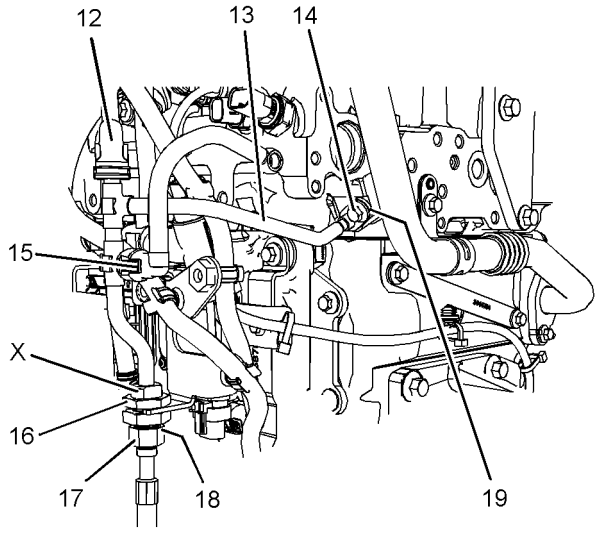

Illustration 494 g02467198

16. Remove cap from tube assembly (13). Install a new O-ring seal (19) (not shown) to tube assembly (13).

17. Install tube assembly (13) to the bracket and the cylinder head.

18. Loosely install bolt (14) to tube assembly (13). Hand tighten nut (16) on connection for tube assembly (13).

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

20. Use a suitable tool in order to hold tube assembly (13) in Position (X). Tighten nut (16) to a torque of 28 N·m (248 lb in).

21. Remove cap from tube assembly (13). Install a new O-ring seal (18) (not shown).

22. Remove cap from hose assembly (17). Connect hose assembly (17) to connection on tube assembly (13). Tighten the nut for hose assembly to a torque of 43 N·m (32 lb ft).

23. Remove the plugs from plastic tube assembly (12) and plastic tube assembly (15). Remove caps from tube assembly (13).

24. Connect plastic tube assembly (12) and plastic tube assembly (18) to tube assembly (15).

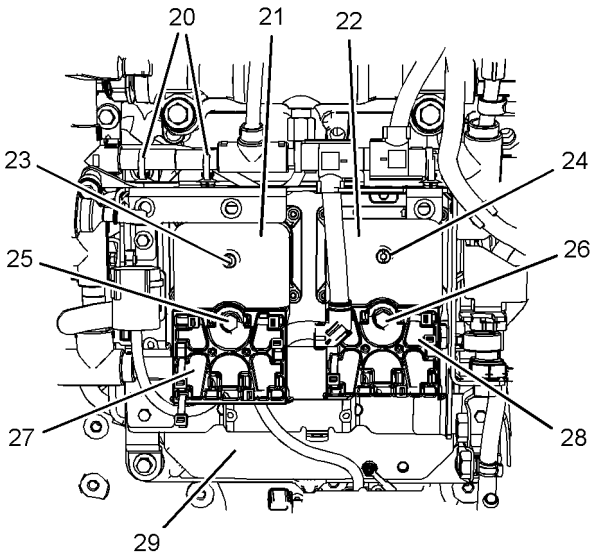

Illustration 495 g02466856

25. Position the engine harness assembly (27) onto Electronic Control Module (ECM) (29). Ensure that the engine wiring harness is correctly routed.

26. Connect the ECM plug (21) for engine harness assembly (27) to the ECM. Loosely tighten bolt (25) and the allen head bolt (23).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness.

27. Tighten allen head bolt (23) to a torque of 6 N·m (53 lb in).

Tighten bolt (25) to a torque of 6.5 N·m (59 lb in).

28. Position the OEM harness assembly (28) onto ECM (29). Ensure that the OEM wiring harness is correctly routed.

29. Connect OEM plug (22) for OEM harness assembly (28) onto the ECM. Loosely tighten bolt (26) and the allen head bolt (24).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness.

30. Tighten allen head bolt (24) to a torque of 6 N·m (53 lb in).

Tighten bolt (26) to a torque of 6.5 N·m (59 lb in).

31. Tighten new cable straps (20) for engine harness assembly and the OEM harness assembly.

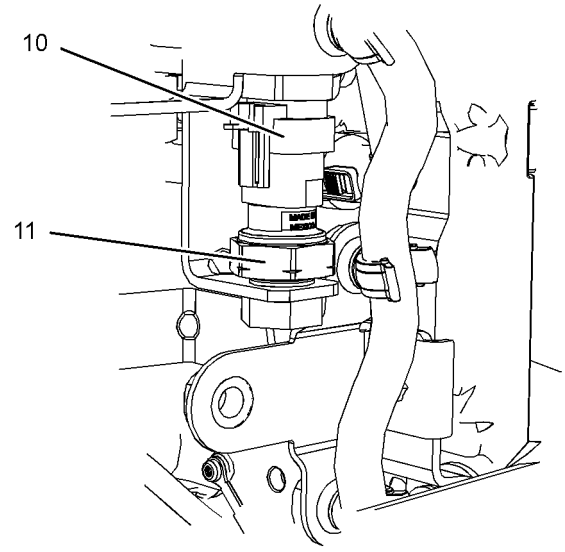

Illustration 496 g02603456

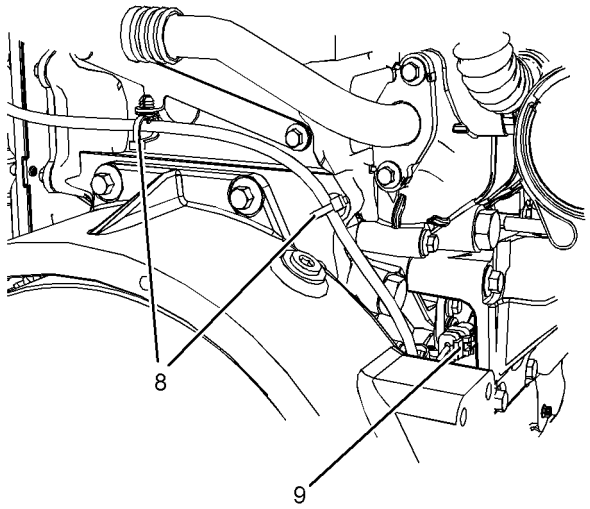

Illustration 497 g02603416

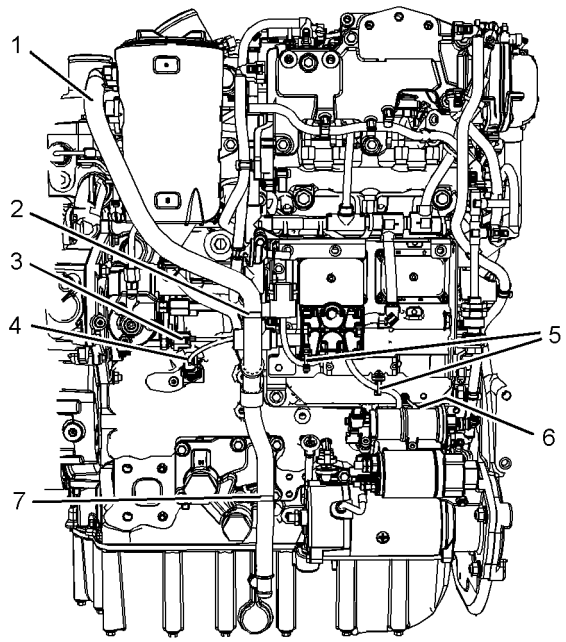

Illustration 498 g02601037

32. Connect harness assembly (10) to atmospheric pressure sensor (11). Refer to Disassembly and Assembly, “Atmospheric Pressure Sensor - Remove and Install” for the correct procedure.

33. Connect the harness assembly to camshaft position sensor (9). Refer to Disassembly and Assembly, “Camshaft Position Sensor - Remove and Install” for the correct procedure.

34. Install new cable straps (8) to harness assembly for camshaft position sensor (9).

Note: Ensure that cable straps meet the OEM specification.

35. Connect the harness assembly from crankshaft position sensor (6) (not shown). Refer to Disassembly and Assembly, “Crankshaft Position Sensor - Remove and Install” for the correct procedure.

36. Tighten new cable straps (5) to harness assembly for crankshaft position sensor (6) (not shown).

Note: Ensure that cable straps meet the OEM specification.

37. Connected harness assembly (4) to the engine oil pressure sensor. Refer to Disassembly and Assembly, “Engine Oil Pressure Sensor - Remove and Install” for the correct procedure.

38. Connected harness assembly (3) to the fuel temperature sensor. Refer to Disassembly and Assembly, “Fuel Temperature Sensor- Remove and Install” for the correct procedure.

39. Install plastic tube assembly (1) to the crankcase breather canister. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.

40. Install new cable strap (2) and cable strap (7) to plastic tube assembly (1).

Note: Ensure that cable straps meet the OEM specification.

41. If necessary, install the dipstick tube assembly. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

42. If necessary, install the primary fuel filter assembly. Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.

43. If necessary, install the secondary filter assembly. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.

44. Turn the fuel supply to the ON position.

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

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

i04485795

Alternator - Remove

Removal Procedure

Table 93

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.

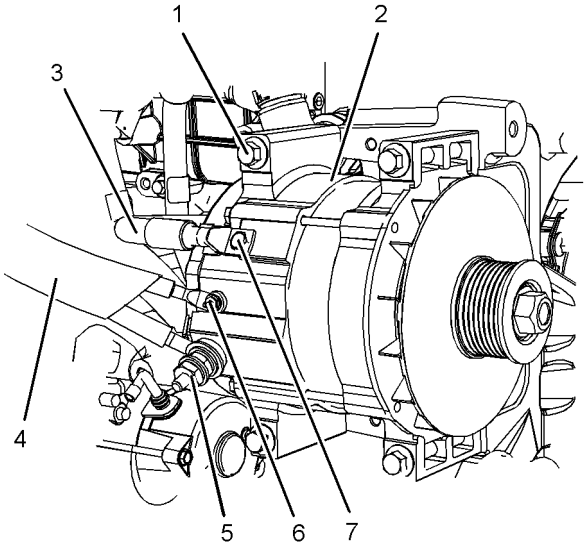

Illustration 499 g02422737
HEDC Heavy Duty Alternator

2. Place identification marks on all of the wiring harness connections (4). Remove nut (5) and nut (6).

3. Disconnect harness assembly (4) from alternator (2).

4. Remove bolt (7) from alternator (2). Disconnect grounding strap (3) from alternator (2).

5. Support the weight of the alternator and remove bolts (1). Remove alternator (2) from the alternator bracket.

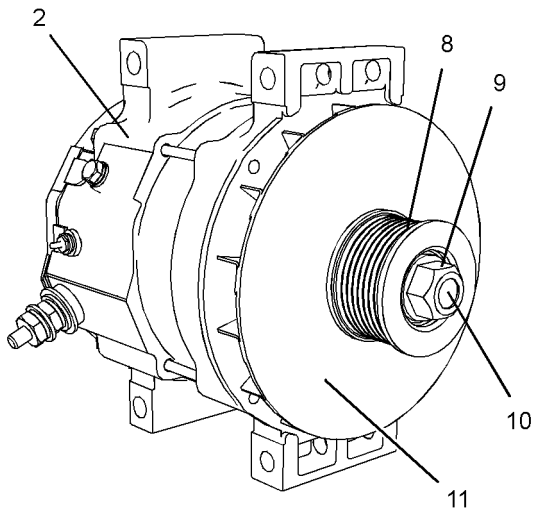

Illustration 500 g02422738
HEDC Heavy Duty Alternator

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. Hold shaft (10) of alternator (2) with Tooling (A). Use a cranked ring spanner to loosen nut (9).

b. Make a temporary mark on pulley (8) in order to show correct orientation.

c. Remove nut (9) and pulley (8) from alternator (2).

d. Remove fan (11) from alternator (2).

Note: Note on some alternator the fan is an internal part of the alternator.

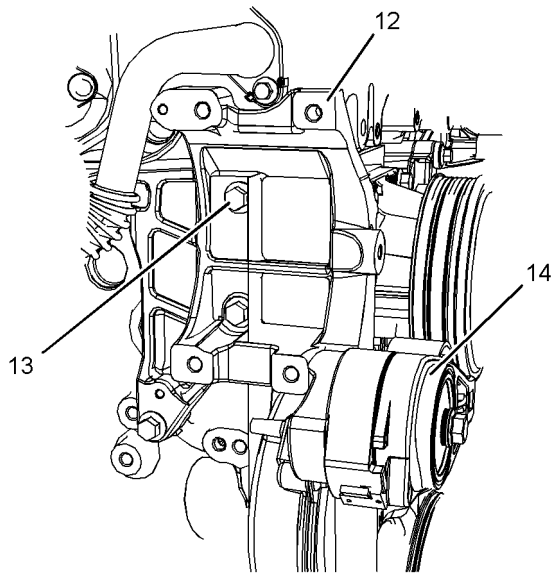

Illustration 501 g02422739

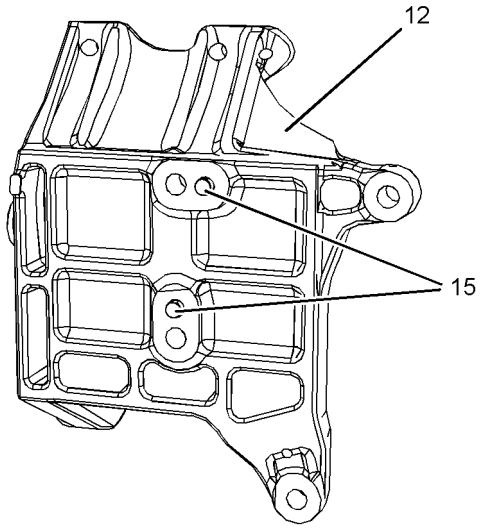

Illustration 502 g02422740

7. If necessary, follow Step 7.a through Step 7.d in order to remove alternator bracket (12) from the cylinder block.

a. If necessary, remove belt tensioner (14) from alternator bracket (12). Refer to Disassembly and Assembly, “Belt Tensioner - Remove and Install” for the correct procedure.

b. Remove bolts (13) from alternator bracket (12).

c. Remove alternator bracket (12) from the cylinder block.

d. Note the position of dowels (15) in alternator bracket (12).

Removal Procedure for Alternator Bracket for Hydraulic Excavator

Start By:

a. Remove fan drive. Refer to Disassembly and Assembly, “Fan Drive - Remove and Install” for the correct procedure.

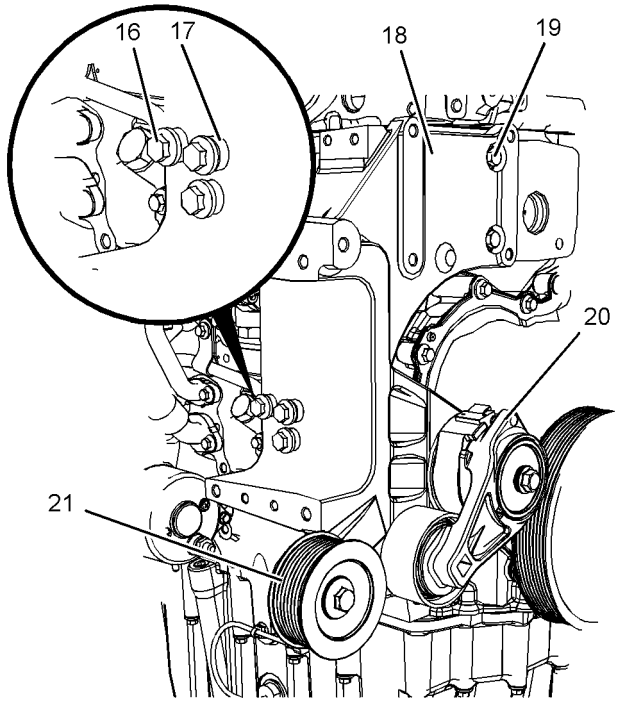

Illustration 503 g02422756

1. If necessary, follow Step 1.a through Step 1.e in order to remove the alternator bracket for the hydraulic excavator from the cylinder block.

a. If necessary, remove belt tensioner (20) from alternator (18). Refer to Disassembly and Assembly, “Belt Tensioner - Remove and Install” for the correct procedure.

b. If necessary, remove idler pulley (21) from alternator (18). Refer to Disassembly and Assembly, “Idler Pulley (Grooved) - Remove and Install” for the correct procedure.

c. Remove bolts (18). Note the position of spacers (19) in the bracket (18).

d. Remove bolts (19) from bracket (18). Support the bracket as bolts (19) are removed.

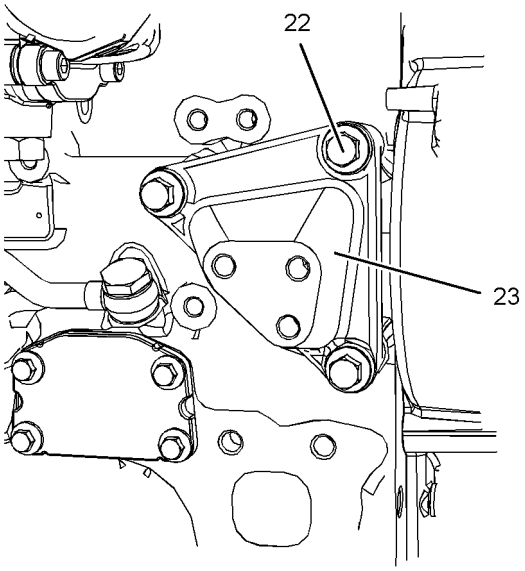

Illustration 504 g02422757

e. Remove bolts (22) and remove bracket (23) from the cylinder block.

i04485828

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.

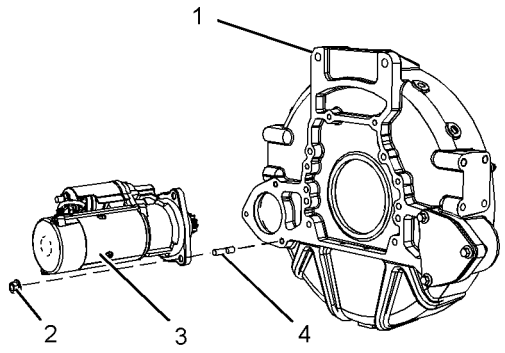

Illustration 505 g02646292

Typical example

3. Disconnect the harness assembly from the electric starting motor and the solenoid.

4. Support electric starting motor (3). Remove nuts (2).

5. Remove electric starting motor (3) from flywheel housing (1).

6. If necessary, remove studs (5) from flywheel housing (1).

Installation Procedure

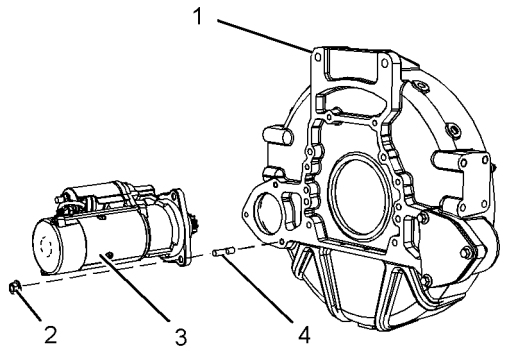

Illustration 506 g02646292

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).

2. Position electric starting motor (3) onto the studs in flywheel housing (1).

3. Install nuts (2).

Tighten M10 nuts to a torque of 44 N·m (32 lb ft).

4. Connect the harness assembly to the electric starting motor and the solenoid.

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

i04485794

Alternator - Install

Installation Procedure for the Alternator Bracket for Hydraulic Excavator

Table 94

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 install the alternator pulley.

1. If necessary, follow Step 1.a through Step 1.j 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. If necessary, replace any components that are worn or damaged.

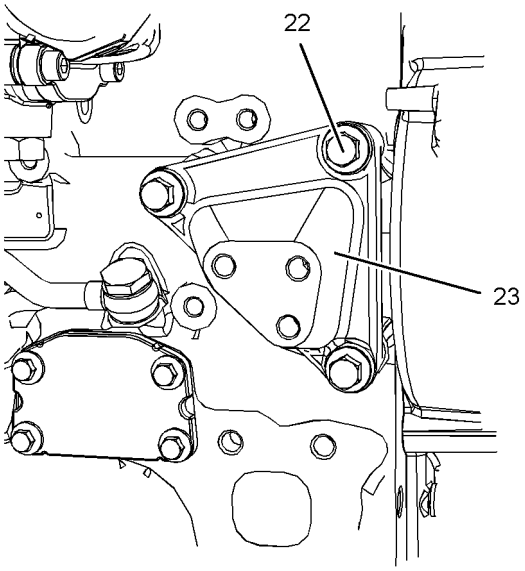

Illustration 507 g02422757

   b. Position bracket (23) onto the cylinder block. Ensure that the bracket is correctly oriented.

   c. Install bolts (22) and tighten the bolts to a torque of 44 N·m (32 lb ft).

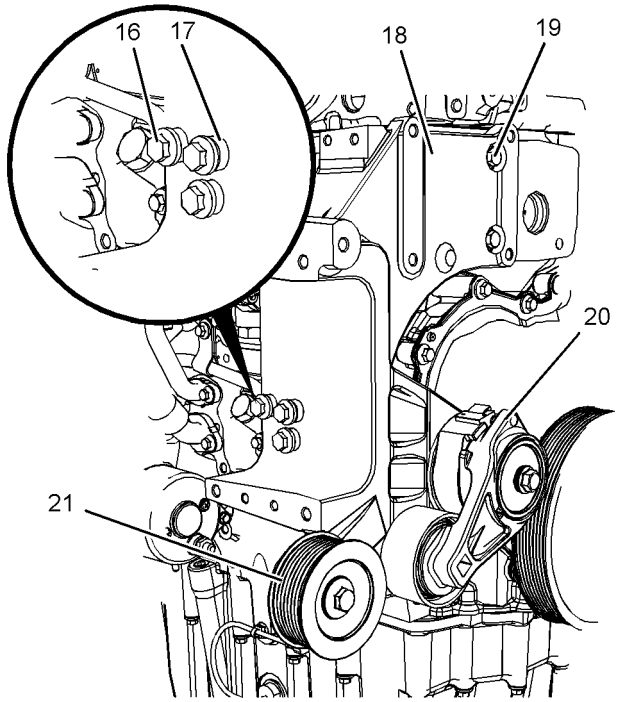

Illustration 508 g02422756

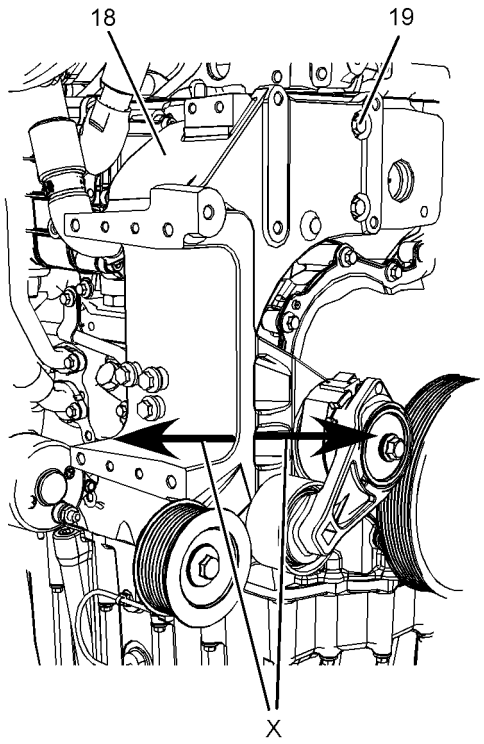

Illustration 509 g02425358

d. Position bracket (18) onto the cylinder block. Install bolts (19) to the bracket and hand tighten the bolts.

Note: Support the bracket as the bolts are installed.

e. Ensure that the spacers (17) are correctly installed to bracket (18).

f. Install bolts (16) to bracket (18). Hand tighten the bolts.

g. Tighten bolts (19) to a torque of 44 N·m (32 lb ft).

Note: Ensure that Position (X) on bracket (18) does not move in either direction as the bolts are tightened.

h. Tighten bolts (16) to a torque of 44 N·m (32 lb ft).

i. If necessary, install belt tensioner (20) from alternator (18). Refer to Disassembly and Assembly, “Belt Tensioner - Remove and Install” for the correct procedure.

j. If necessary, remove idler pulley (21) from alternator (18). Refer to Disassembly and Assembly, “Idler Pulley (Grooved) - Remove and Install” for the correct procedure.

Installation Procedure

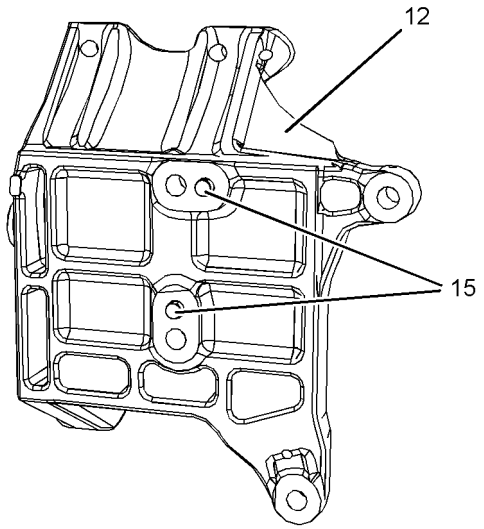

Illustration 510 g02422740

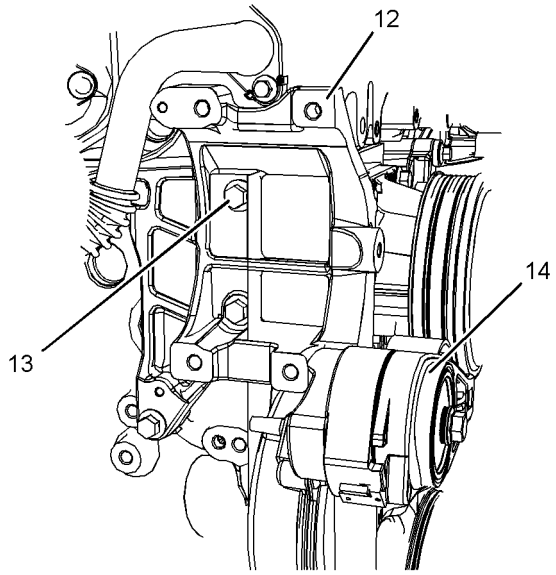

Illustration 511 g02422739

1. If necessary, follow Step 1.a through Step 1.f in order to install alternator bracket (12) onto the cylinder block.

a. Ensure that bracket (12) is clean and free from wear and damage. If necessary, replace the bracket.

b. Ensure that dowels (15) are free from wear and damage. If necessary, replace the dowels.

c. Position bracket (12) onto the cylinder block. Ensure that the dowels (15) are correctly located into the cylinder block.

d. Install bolts (13) hand tight.

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

f. If necessary, install the belt tensioner (14) onto alternator bracket (12). Refer to Disassembly and Assembly, “Belt Tensioner - Install” for the correct procedure.

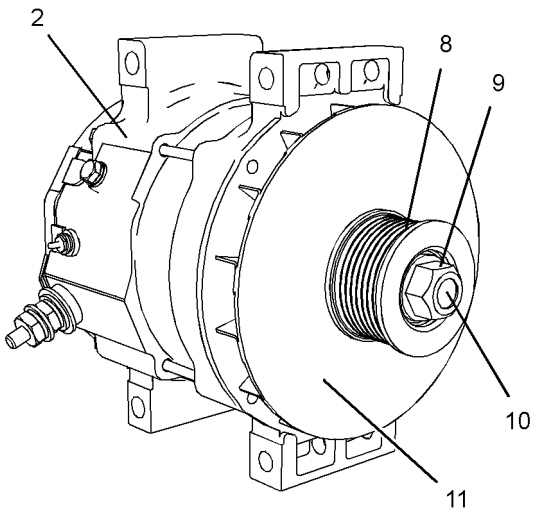

Illustration 512 g02422738
HEDC Heavy Duty Alternator

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. Install fan (11) from alternator (2). Ensure that the fan is correct oriented.

Note: Note on some alternator the fan is an internal part of the alternator.

b. Ensure that the pulley (8) is correctly oriented.

c. Install pulley (8) and nut (9) to alternator (2).

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.

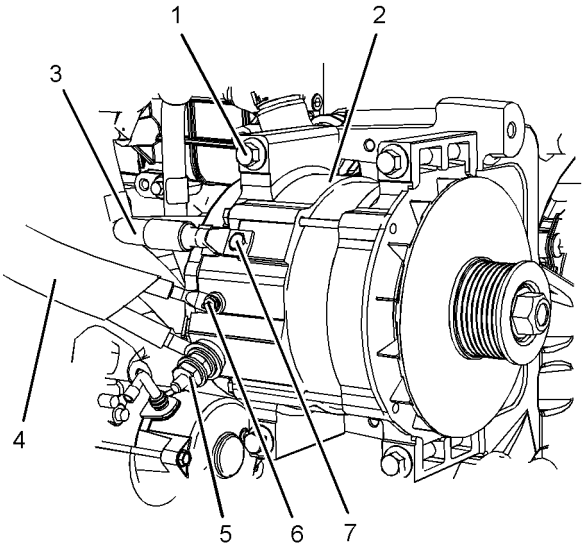

Illustration 513 g02422737
HEDC Heavy Duty Alternator

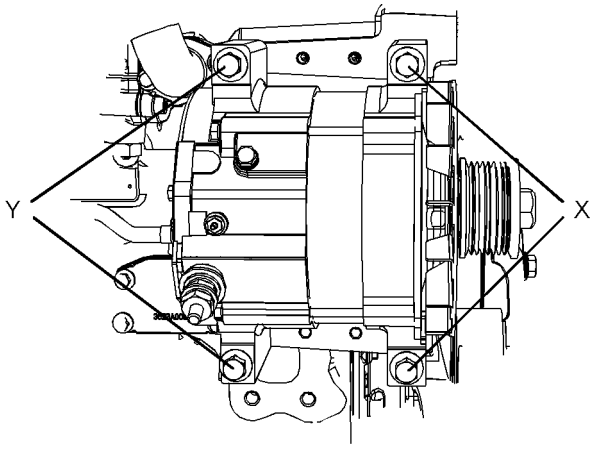

Illustration 514 g02426956
HEDC Heavy Duty Alternator

3. Position alternator (2) onto the alternator mounting bracket. Install bolts (1). Tighten the bolts hand tight.

4. Tighten the bolts in Position (X) to a torque of 50 N·m (37 lb ft).

5. Tighten the bolts in Position (Y) to a torque of 50 N·m (37 lb ft).

6. Connect wiring harness assembly (4) to alternator (2). Install nut (5) and nut (6). Tighten the nuts to the correct torque. Refer to Specifications, “Alternator” for the correct torque.

7. Connect grounding strap (3) to alternator (2). Install bolt (7). Tighten the bolt to the correct torque. Refer to Specifications, “Alternator” for the correct torque.

8. Install the alternator belt. Refer to Disassembly and Assembly , “Alternator Belt - Remove and Install” for the correct procedure.

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

i04485792

Air Compressor - Remove and Install (Twin Cylinder Compressor)

Removal Procedure

Table 95

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	-	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. This helps to prevent fluid loss and this helps to keep contaminants from entering the system.

WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. 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 Systems 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.

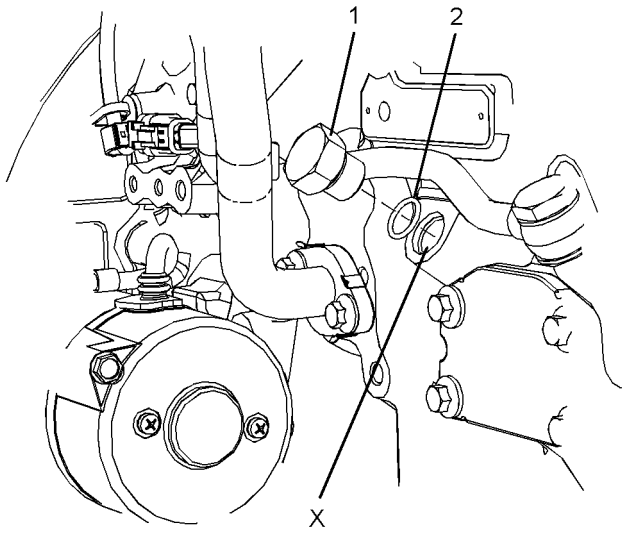

Illustration 515 g02418379

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) 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.

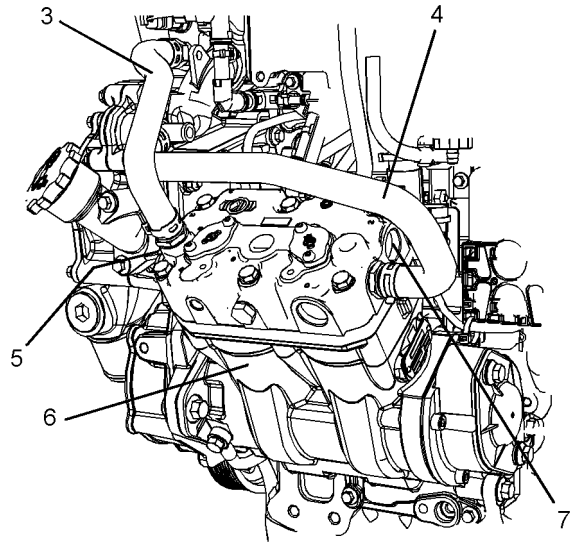

Illustration 516 g02418397

7. Slide hose clamps for coolant hose (3) and coolant hose (4) along the hose assemblies.

8. Disconnect coolant hose (3) and coolant hose (4) from the connections on air compressor (6).

9. Disconnect the air line from port (5) (not shown) and air line from port (7). Refer to the OEM for the correct procedure.

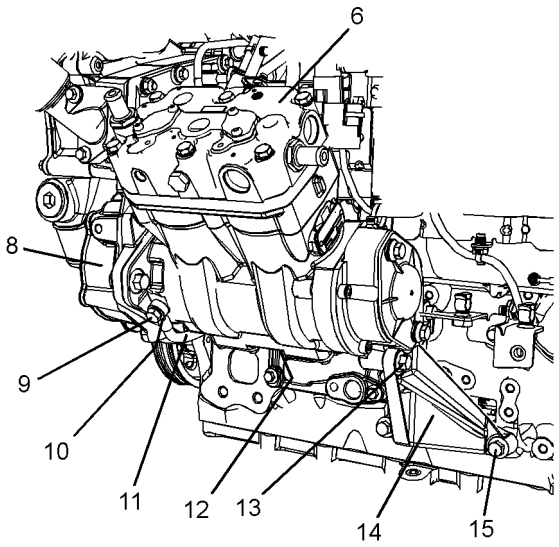

Illustration 517 g02418398

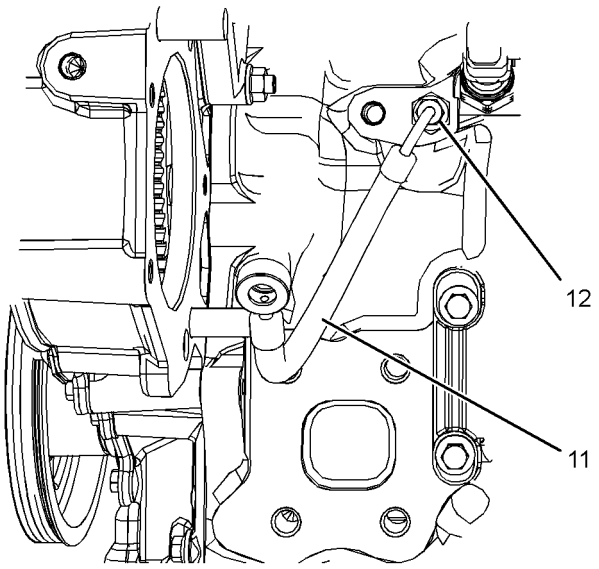

Illustration 518 g02420556

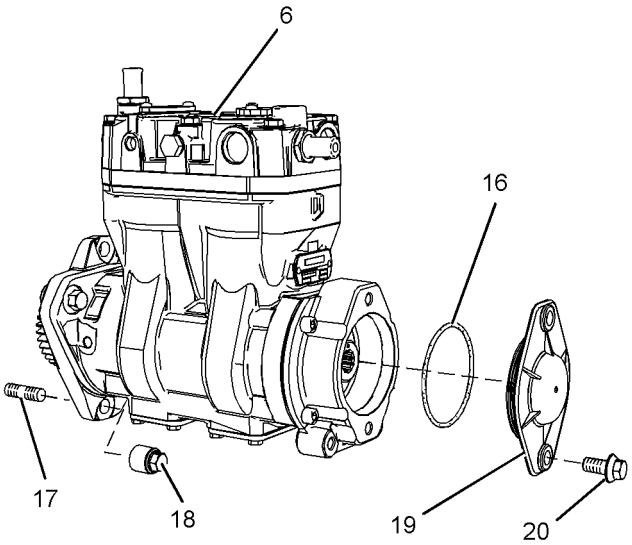

Illustration 519 g02418399

10. Remove banjo bolt (9) and remove sealing washers (10) (not shown).

11. Remove bolt (13) and bolt (15) from support bracket (14). Remove support bracket (14) from compressor (6) and the cylinder block.

12. Support air compressor (6). Remove nuts (18) and remove the air compressor from front housing (8).

13. If necessary, follow Step 13.a through Step 13.b in order to remove the hose assembly.

a. Make a temporary mark in order to identify the position of hose assembly (11).

b. Disconnect nut (12) and remove hose assembly (11).

14. If necessary, remove studs (17) from front housing (8).

15. If necessary, remove bolts (20) and remove plate (19). Remove O-ring seal (16) from plate (19). Refer to Illustration 519.

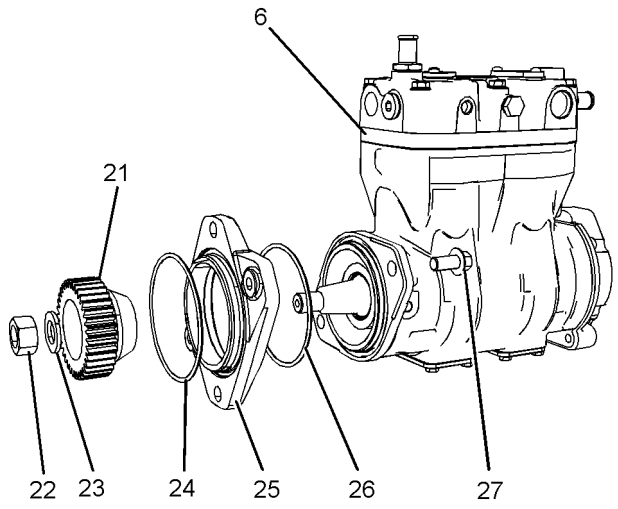

Illustration 520 g02418401

16. Remove O-ring seal (24) from the adapter on air compressor (6).

17. If necessary, follow Step 17.a through Step 17.b in order to remove gear (21) from the crankshaft of the air compressor.

a. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Remove nut (22) and remove spring washer (23) (not shown).

b. Use Tooling (C) in order to remove gear (21) from the crankshaft of the air compressor.

18. If necessary, follow Step 18 through Step 18.c in order to remove adapter (25) from air compressor (6).

a. Remove bolts (27) from adapter (25).

b. Remove adapter (25) from air compressor (6).

c. Remove O-ring seal (26).

Installation Procedure

Table 96

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
D	-	Loctite 638 High Strength Retaining	1
E	-	Delphi 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.

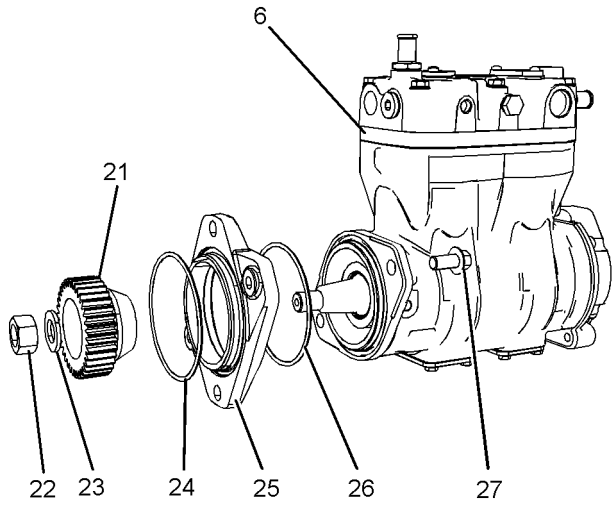

Illustration 521 g02418401

1. If necessary, follow Step 18 through Step 18.c in order to install adapter (25) to air compressor (6).

   a. Use Tooling (E) in order to lubricate a new O-ring seal (26). Install the O-ring seal to air compressor (6).

   b. Position adapter (25) onto air compressor (6).

   c. Install bolts (27) to air compressor (6).

   d. Tighten bolts (27) to a torque of 78 N·m (58 lb ft).

2. If necessary, follow Step 2.a through Step 2.d in order to install gear (21) to the crankshaft of the air compressor.

   a. Ensure that the crankshaft of air compressor (6) is clean and dry. Ensure that gear (21) is clean and free from damage.

   b. Install gear (21) and a new spring washer (23) (not shown) to the crankshaft of the air compressor.

   c. Apply Tooling (D) to the threads of the crankshaft. Install nut (22) to the crankshaft of air compressor (6).

   d. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Tighten nut (22) to a torque of 190 N·m (140 lb ft).

3. Use Tooling (E) in order to lubricate O-ring seal (24). 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 Systems 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.

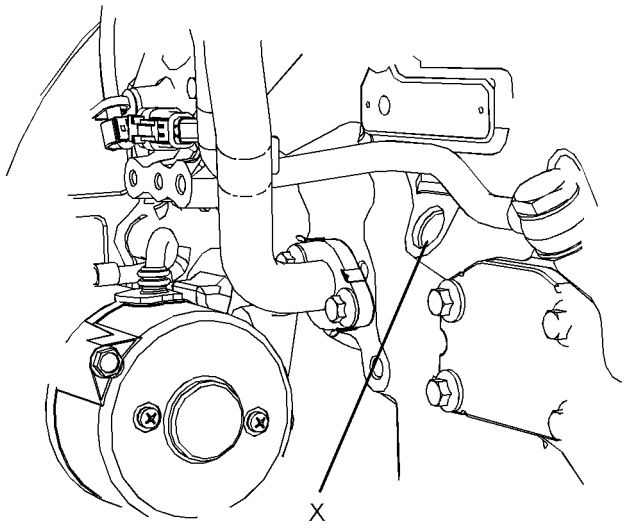

Illustration 522 g02420499

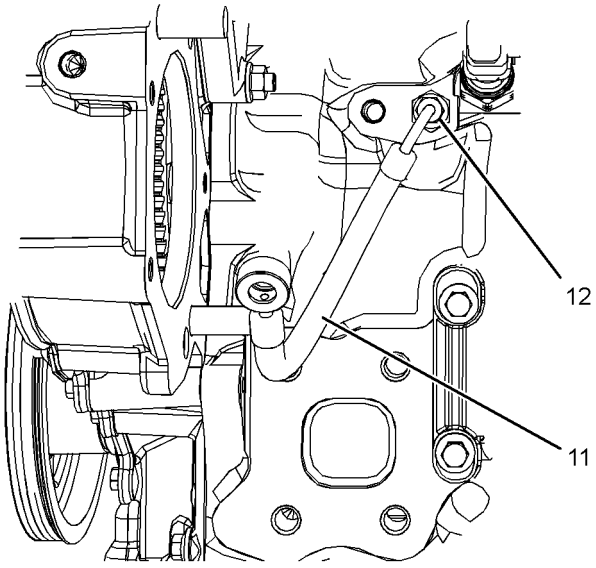

Illustration 523 g02420556

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.

6. If necessary, install hose assembly (11) to the connection on the cylinder block. Align hose assembly with the temporary marks. Tighten nut (12) to a torque of 9 N·m (80 lb in).

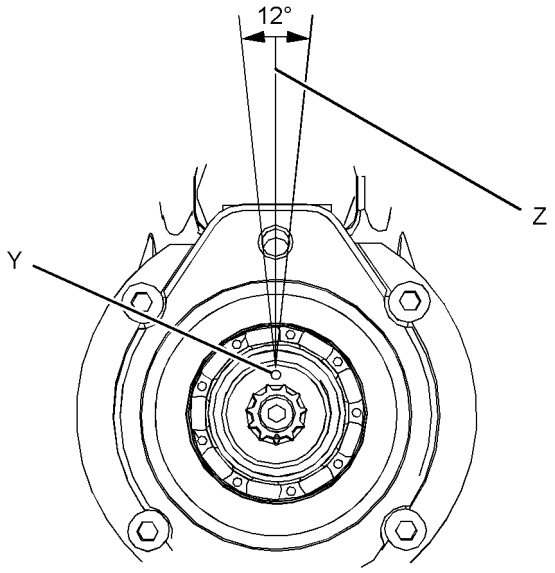

Illustration 524 g01970516

7. Rotate the crankshaft of the air compressor until timing Mark (Y) is within (+/-) 6 degrees of Position (Z).

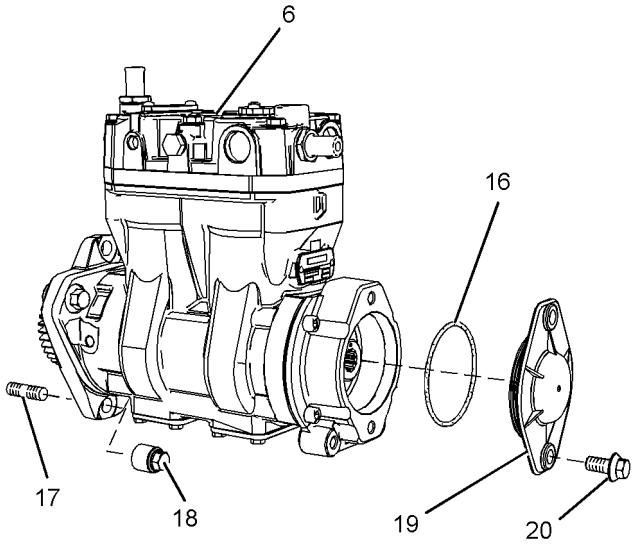

Illustration 525 g02418399

8. If necessary, install studs (17) from the front housing. Tighten the studs to a torque 25 N·m (221 lb in).

9. 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 524 for the correct position of timing marks.

10. Install nuts (18). Tighten the nuts to a torque of 78 N·m (58 lb ft).

11. If necessary, follow Step 11.a through Step 11.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).

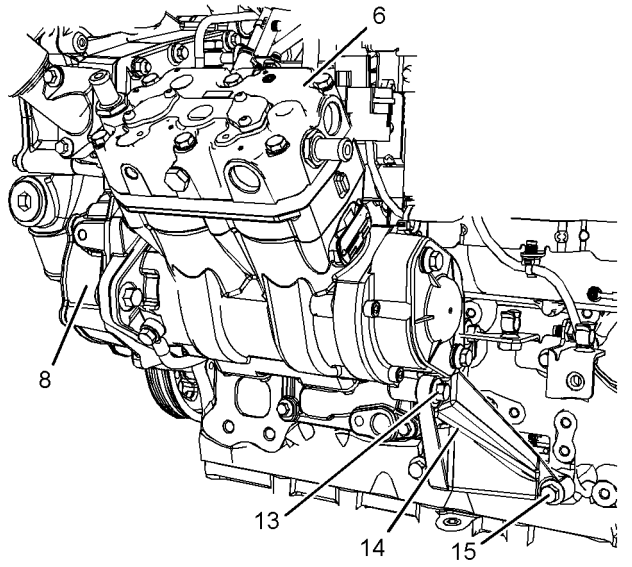

Illustration 526 g02432317

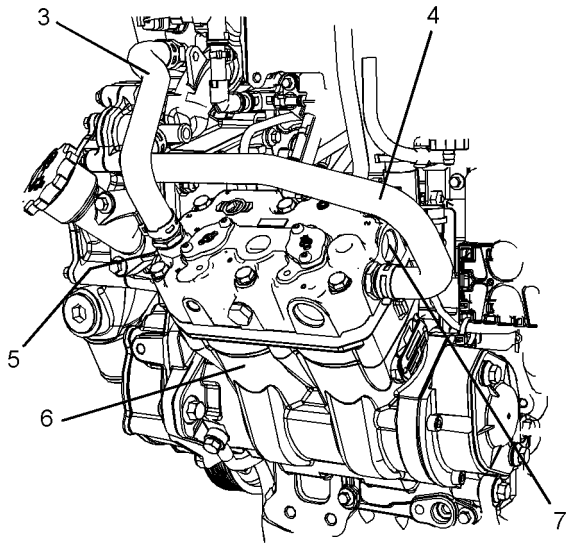

Illustration 527 g02418397

12. Position support bracket (14) onto air compressor (6) and the cylinder block.

13. Install bolts (13) and bolts (15) finger tight.

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

15. Tighten bolts (15) to a torque of 44 N·m (32 lb ft).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

16. Connect the air line to port (5) (not shown) and the air line to port (7) in the air compressor. Refer to the OEM for the correct procedure.

17. Connect coolant hose (3) and coolant hose (4) onto the connections on the air compressor.

18. Slide hose clamps along coolant hose (3) and coolant hose (4). Ensure that the hose clamps are correctly positioned over coolant hoses.

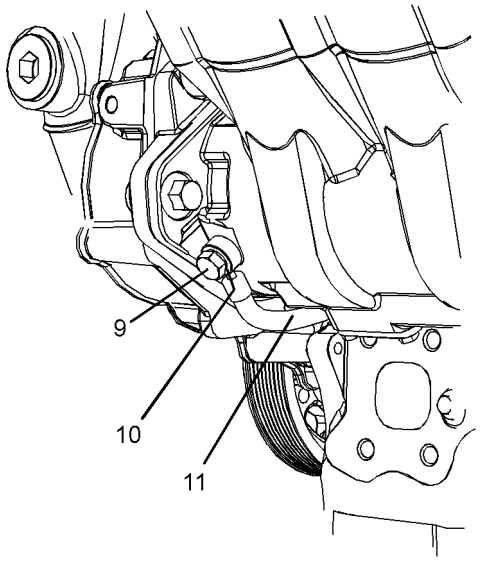

Illustration 528 g02420683

19. Install new sealing washer (10) (not shown) onto banjo bolt (10). Position the banjo bolt onto tube assembly (11) and install remaining sealing washer (10).

20. Connect hose assembly (27) onto the air compressor. Tighten the banjo bolt to a torque of 17 N·m (150 lb in).

Note: Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.

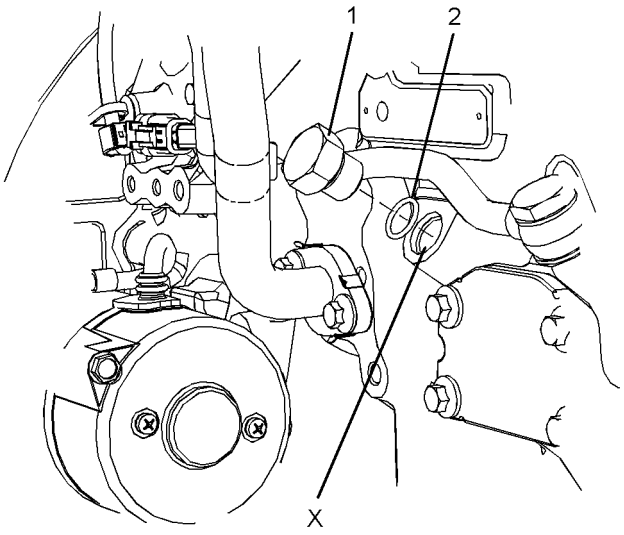

Illustration 529 g02418379

21. Remove Tooling (B) from Hole (X) in the cylinder block.

22. Install a new O-ring seal (2) to plug (1). Install the plug to the cylinder block. Tighten the plug to a torque of 21 N·m (186 lb in).

23. 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.

24. 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.

i04485791

Air Compressor - Remove and Install (Single Cylinder)

Removal Procedure

Table 97

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	-	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. This helps to prevent fluid loss and this helps to keep contaminants from entering the system.

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. 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 Systems 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.

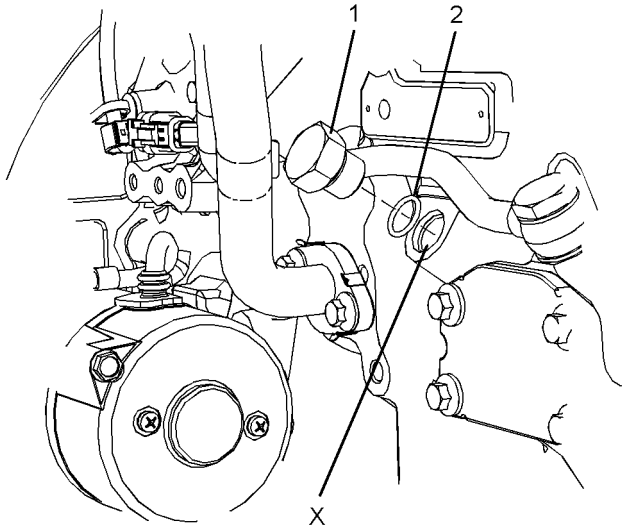

Illustration 530 g02429600

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) 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.

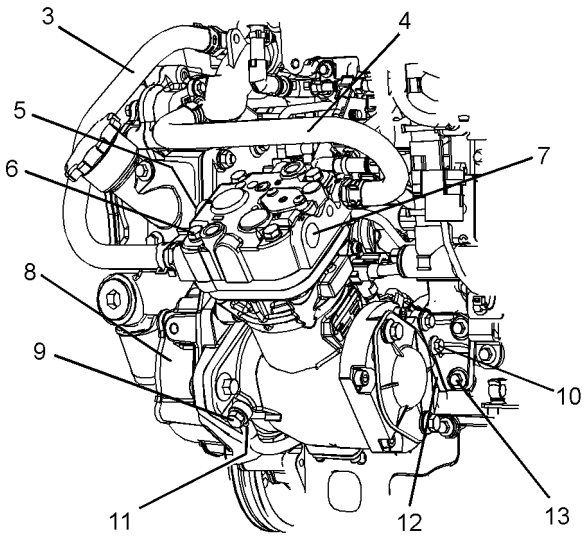

Illustration 531 g02429596

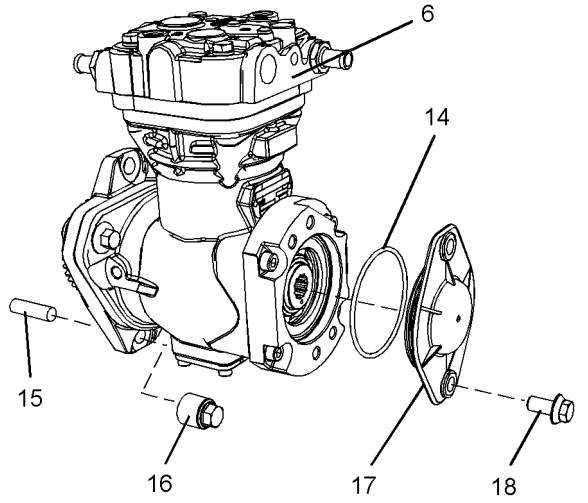

Illustration 532 g02429597

7. Slide hose clamps for coolant hose (3) and coolant hose (4) along the hose assemblies.

8. Disconnect coolant hose (3) and coolant hose (4) from the connections on air compressor (6).

9. Disconnect the air lines from port (5) (not shown) and air lines from port (7). Refer to the OEM for the correct procedure.

10. Remove banjo bolt (9) and remove sealing washers (11) (not shown) from air compressor (6).

11. Remove bolts (10) and bolts (13) from support bracket (12) and remove the support bracket.

12. Support air compressor (6). Remove nuts (16) and remove the air compressor from front housing (8).

13. If necessary, remove studs (15) from front housing (8).

14. If necessary, remove bolts (18) and remove plate (17). Remove O-ring seal (14) from plate (17).

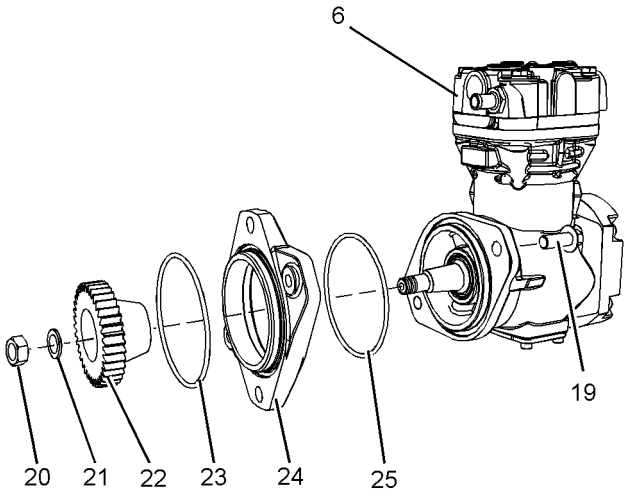

Illustration 533 g02429598

15. Remove O-ring seal (23) from adapter (24).

16. If necessary, follow Step 16.a through Step 16.b in order to remove gear (22) from the crankshaft of the air compressor.

a. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Remove nut (20) and remove spring washer (21).

b. Use Tooling (C) in order to remove gear (22) from the crankshaft of air compressor (6).

17. If necessary, follow Step 17 through Step 17.c in order to remove adapter (24) from air compressor (6).

a. Remove bolts (19) from adapter (24).

b. Remove adapter (24) from air compressor (6).

c. Remove O-ring seal (25).

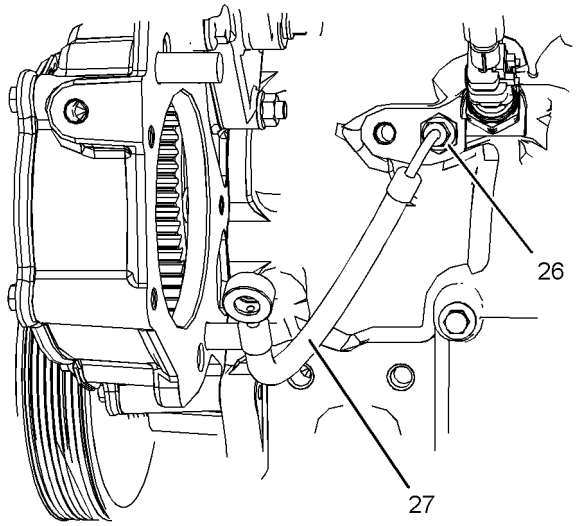

Illustration 534 g02429599

18. If necessary, follow Step 18.a through Step 18.b in order to remove the hose assembly.

a. Make a temporary mark in order to identify the position of hose assembly (27).

b. Disconnect nut (26) and remove hose assembly (27).

Installation Procedure

Table 98

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
D	-	Loctite 638 High Strength Retaining	1
E	-	Delphi 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.

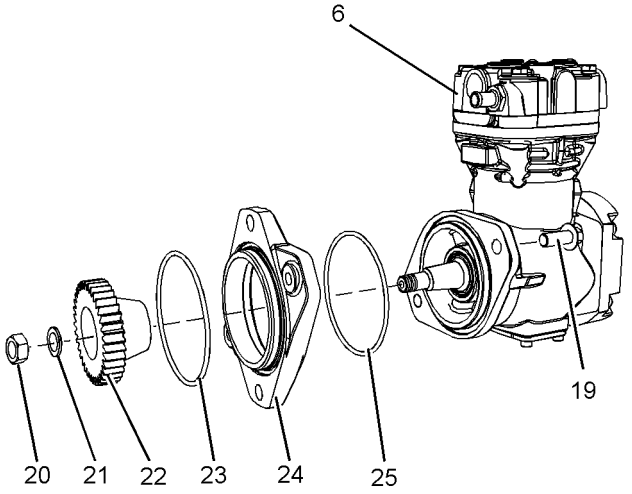

Illustration 535 g02429598

1. If necessary, follow Step 1.a through Step 1.d in order to install adapter (24) to air compressor (6).

a. Use Tooling (E) in order to lubricate a new O-ring seal (25). Install the O-ring seal to air compressor (6).

b. Position adapter (24) onto air compressor (6).

c. Install bolts (19) to air compressor (6).

d. Tighten bolts (19) to a torque of 78 N·m (58 lb ft).

2. If necessary, follow Step 2.a through Step 2.e in order to install gear (22) to the crankshaft of the air compressor.

a. Ensure that the crankshaft of air compressor (6) is clean and dry. Ensure that gear (22) is clean and free from damage.

b. Install gear (22) and a new spring washer (21) to the crankshaft of the air compressor.

c. Apply Tooling (D) to the threads of the crankshaft. Install nut (20) to the crankshaft of air compressor (6).

d. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Tighten nut (20) to a torque of 120 N·m (89 lb ft).

e. Use Tooling (E) in order to lubricate O-ring seal (23). 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 Systems 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.

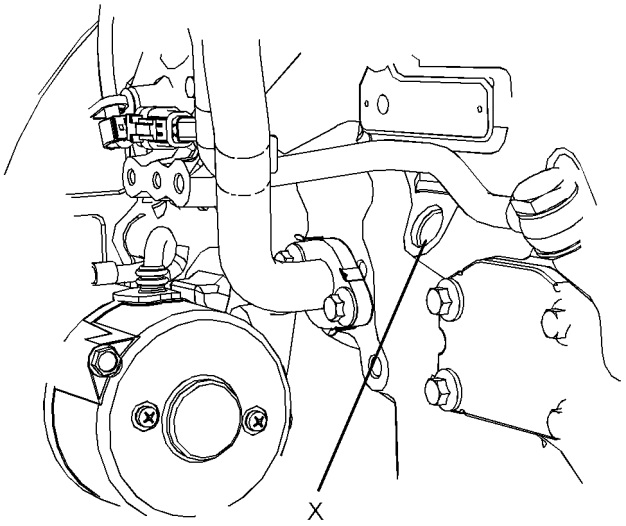

Illustration 536 g02429601

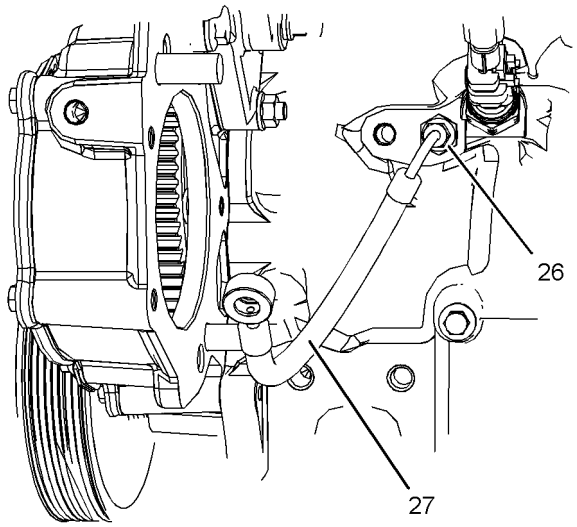

Illustration 537 g02429599

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. If necessary, install hose assembly (27) to the connection on the cylinder block. Align hose assembly with the temporary marks. Tighten nut (26) to a torque of 9 N·m (80 lb in).

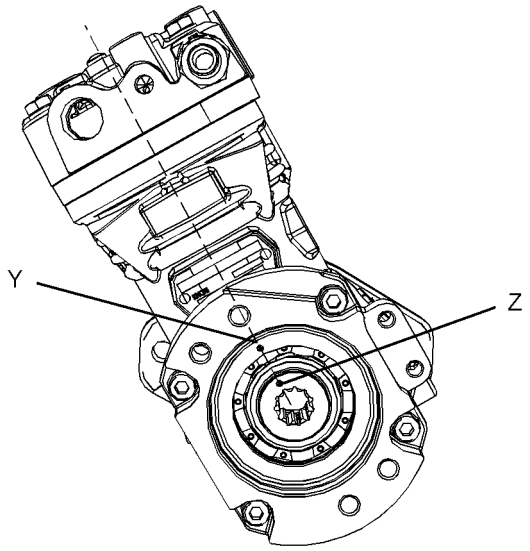

Illustration 538 g02430197

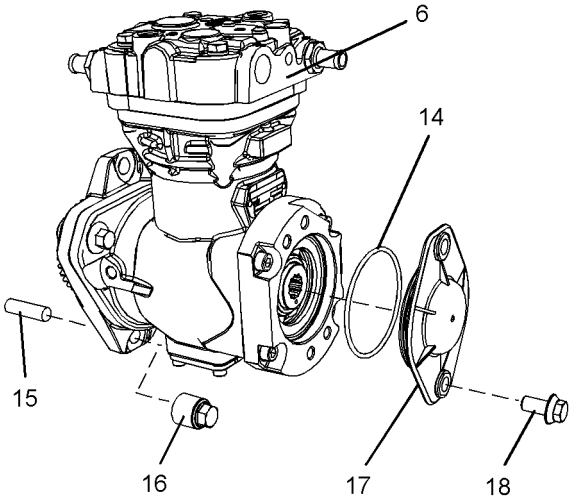

Illustration 539 g02429597

6. Rotate the crankshaft of the air compressor until timing Mark (Z) is aligned with center Line (Y) of the cylinder of the air compressor.

7. If necessary, install studs (15) from the front housing. Tighten the studs to a torque 25 N·m (221 lb in).

8. Align air compressor (6) with studs (15). 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 (16). 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 (14). Install the O-ring seal to cover (17).

b. Install cover (17) to the air compressor.

c. Install bolts (18). Tighten the bolts to a torque of 16 N·m (142 lb in).

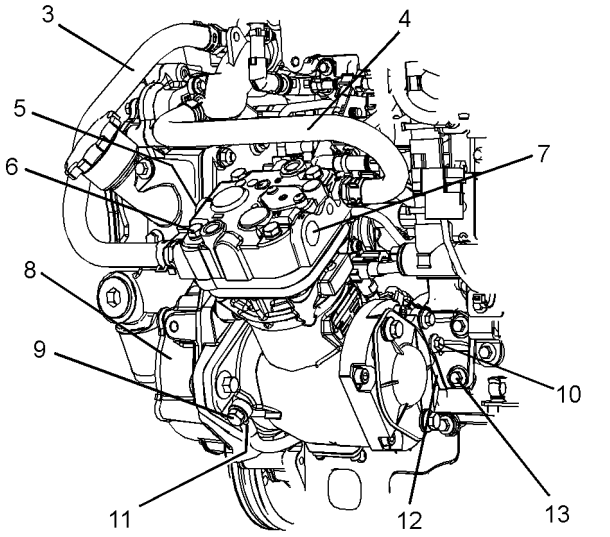

Illustration 540 g02429596

11. Position support bracket (12) onto air compressor (6) and the cylinder block.

12. Install bolts (13) and bolts (10) finger tight.

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

14. Tighten bolts (10) to a torque 22 N·m (195 lb in).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

15. Connect coolant hose (3) and coolant hose (4) onto the connections on the air compressor.

16. Slide hose clamps along coolant hose (3) and coolant hose (4). Ensure that the hose clamps are correctly positioned over coolant hoses.

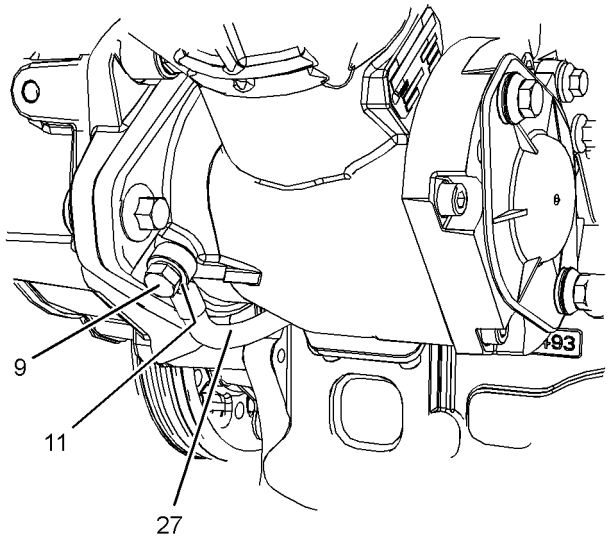

Illustration 541 g02430379

17. Install new sealing washer (11) (not shown) onto banjo bolt (9). Install the banjo bolt onto tube assembly (27) and install remaining sealing washer (11) (not shown).

18. Connect hose assembly (27) onto the air compressor. Tighten the banjo bolt to a torque of 17 N·m (150 lb in).

Note: Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.

19. Connect the air line to port (5) (not shown) and the air line to port (7) in the air compressor. Refer to the OEM for the correct procedure.

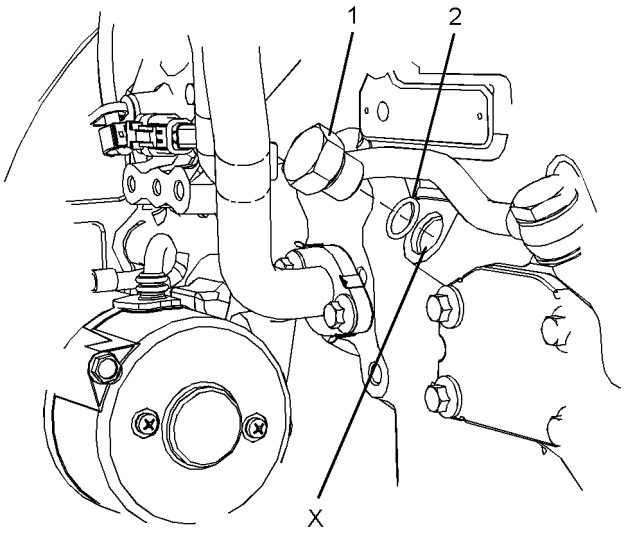

Illustration 542 g02429600

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. Refer to Illustration 542. 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 procedures.

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