M0103175-04 (en-us)
July 2021

Perkins®

THE HEART OF EVERY GREAT MACHINE

Disassembly and Assembly

402F-05, 403F-07, 403F-11 and 403F-15 Industrial Engines

EG (Engine)
EH (Engine)
EJ (Engine)
EK (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 correctly.

Incorrect 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. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. 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 you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

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.

In the United States, the maintenance, replacement, or repair of the emission control devices and systems may be performed by any repair establishment or individual of the owner's choosing.

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Disassembly and Assembly Section

i07676436

Fuel Filter Base - Remove and Install
(402F-05 , 403F-07 , 403F-11, and 403F-15 Engines)

Removal Procedure

NOTICE
Do not allow dirt to enter the fuel system. Thoroughly clean the area around a fuel system component that will be disconnected. Fit a suitable cover over any disconnected fuel system components.

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: Place identification marks on all hoses for installation purposes. Plug all hoses and all the ports in the fuel filter base. Plugging all hoses and all the ports helps prevent fluid loss, and to keep contaminants from entering the system.

1. Turn the fuel supply to the OFF position.

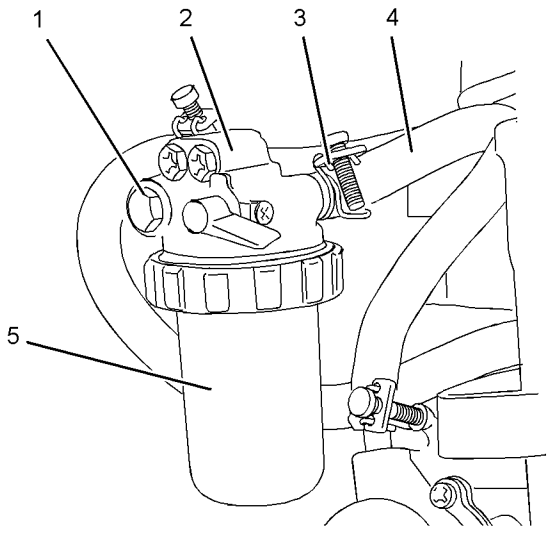

Illustration 1 g01303701
Typical example

2. Loosen hose clamps (3) and disconnect hoses (4).

3. If necessary, remove fuel filter element (5). Refer to Operations and Maintenance Manual, “Fuel System Filter - Replace” for the correct procedure.

4. Remove bolt (1) and remove fuel filter base (2) from the mounting bracket.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

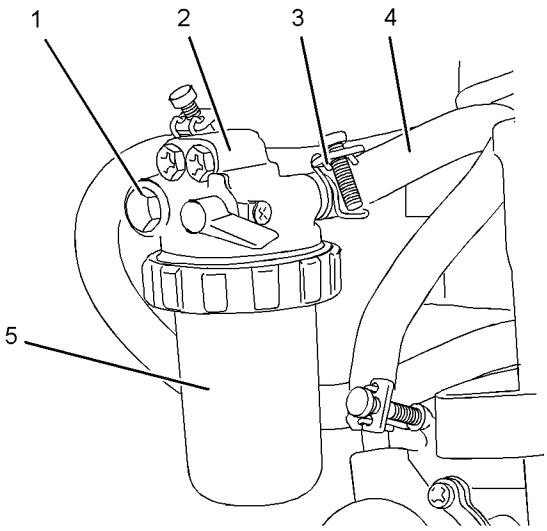

Illustration 2 g01303701
Typical example

2. Align fuel filter base (2) with the mounting bracket. Install bolt (1). Tighten the bolt to a torque of 25 N·m (221 lb in).

3. If necessary, install a new fuel filter element (6) to fuel filter base (2). Refer to Operation and Maintenance Manual, “Fuel System Filter - Replace” for the correct procedure.

4. Connect hoses (4) and tighten hose clamps (3).

Note: Ensure that the hoses do not contact any other engine components.

5. Turn the fuel supply to the ON position.

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

i08095573

Fuel Filter Base - Remove
(402F-05 - If Equipped)

S/N: EG11–Up

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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug and cap all open ports.

1. Turn the fuel supply to the OFF position.

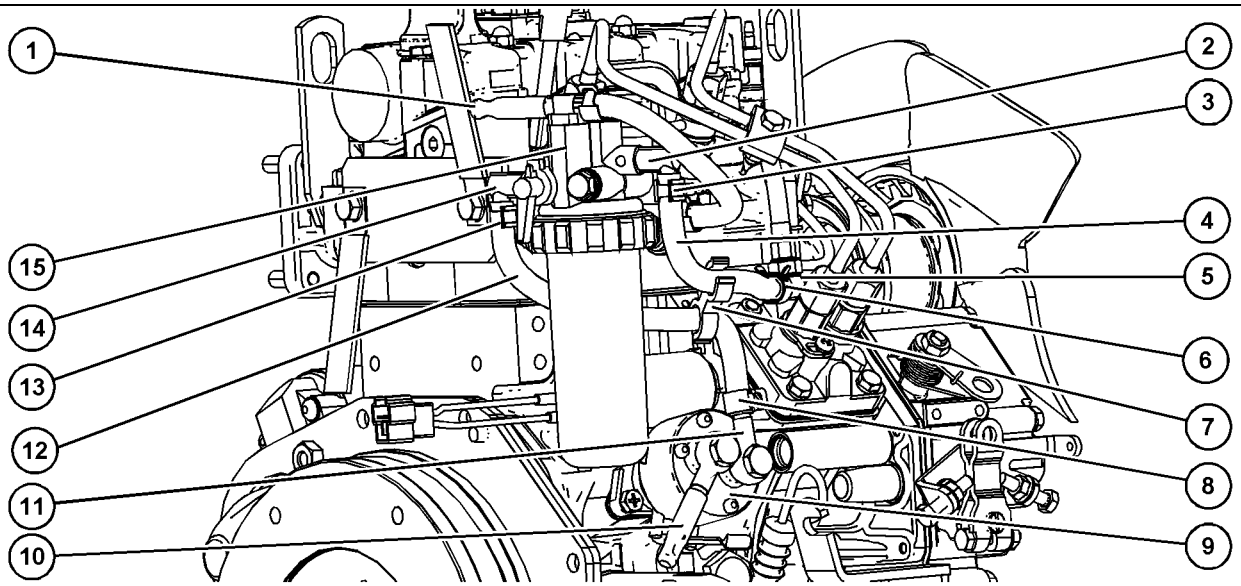

Illustration 3 g06538368

Typical example

2. Place a suitable container below fuel filter base (15) and fuel transfer pump (9) to catch any fuel that might be spilled.

3. Follow Step 3a through Step 3f to remove low-pressure fuel line (4) and low-pressure fuel line (12).

a. Disconnect Original Engine Manufacturer (OEM) fuel lines from low-pressure fuel line connection (1) and low-pressure fuel line connection (10).

b. Remove hose clamp (7) from hose (4) and hose (12).

Note: Note hose clamp position for installation purposes.

c. Using a suitable tool, position hose clamp (3) away from connection (2) and hose clamp (6) away from connection (5).

Note: Note hose clamp position and orientation for installation purposes.

d. Remove hose (4) from connection (2) and connection (5).

Note: Note hose position and orientation for installation purposes.

e. Using a suitable tool, position hose clamp (13) away from connection (14) and hose clamp (8) away from connection (11).

Note: Note hose clamp position and orientation for installation purposes.

f. Remove hose (12) from connection (15) and connection (11).

Note: Note hose position and orientation for installation purposes.

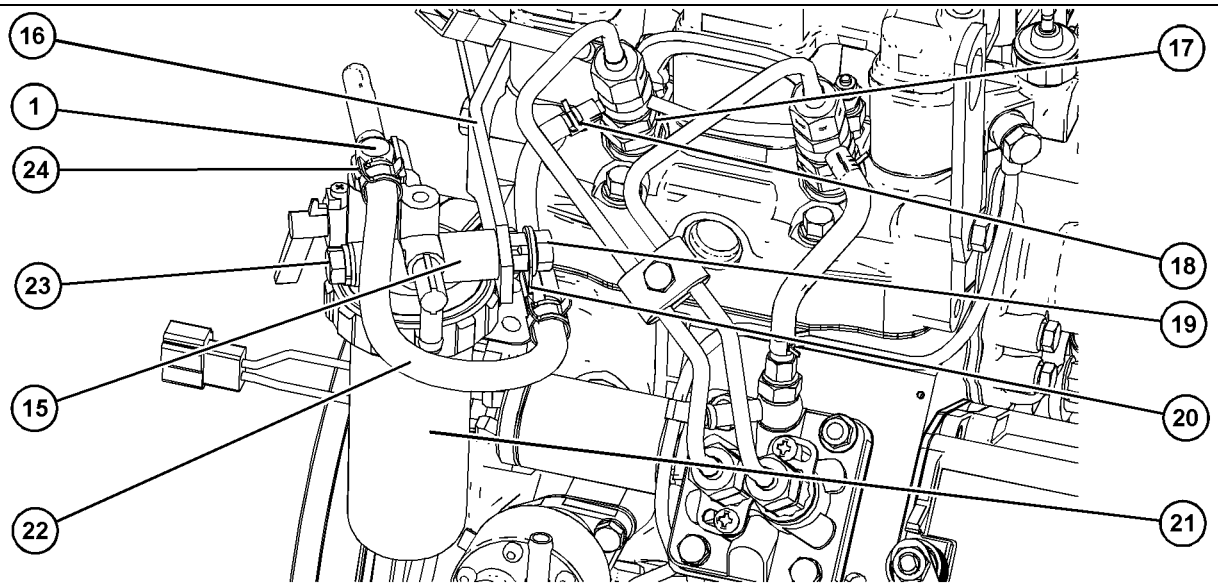

Illustration 4 g06538791
Typical Example

4. If necessary, remove fuel filter element (21). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

5. Follow Step 5a through Step 5e to remove low-pressure fuel line (22).

a. Using a suitable tool, position hose clamp (24) away from connection (1).

Note: Note hose clamp position for installation purposes.

b. Using a suitable tool, position hose clamp (18) away from fuel injector (17).

Note: Note hose clamp position for installation purposes.

c. Disconnect hose (22) from connection (1) and fuel injector (16).

d. Remove nut (19) from bolt (23). Remove hose (22) and hose clamp (20)from the bolt.

Note: Note hose position and orientation for installation purposes.

e. Support fuel filter base (15). Remove bolt (23) from the fuel filter base. Remove the fuel filter base from bracket (16).

Note: Note fuel filter base position for installation purposes.

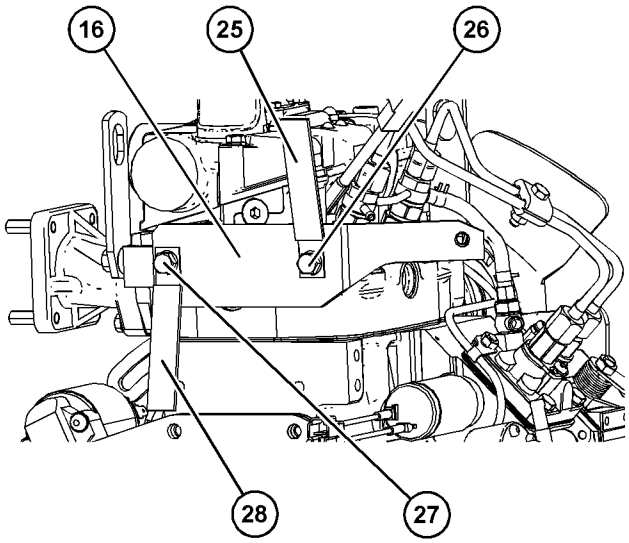

Illustration 5 g06538801
Typical Example

6. If necessary, Remove bolt assembly (27) from bracket (15). Remove clamp (28) from the bolt.

Note: Note bolt and clamp position for installation purposes.

7. Support bracket (15), remove bolt assembly (26) from the bracket. Remove the bracket from the cylinder head. Remove clamp (25) from the bolt.

Note: Note bolt and clamp position for installation purposes.

Note: Note bracket position and orientation for installation purposes.

i08097734

Fuel Filter Base - Remove
(403F-07 - If Equipped)

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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug and cap all open ports.

1. Turn the fuel supply to the OFF position.

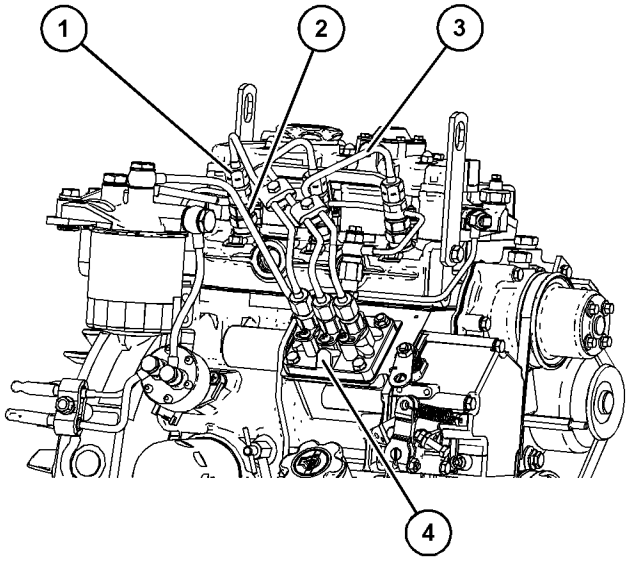

Illustration 6 g06530092
Typical example

2. Place a suitable container below fuel injection pump (4) and fuel injectors (2) to catch any fuel that might be spilled.

3. Disconnect tube nuts (1) for fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

4. Remove fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

5. Use suitable caps to cap the open ports of fuel injectors (2) and fuel injection pump (4) immediately.

6. Use suitable caps to cap the open ports of fuel injection lines (3) immediately.

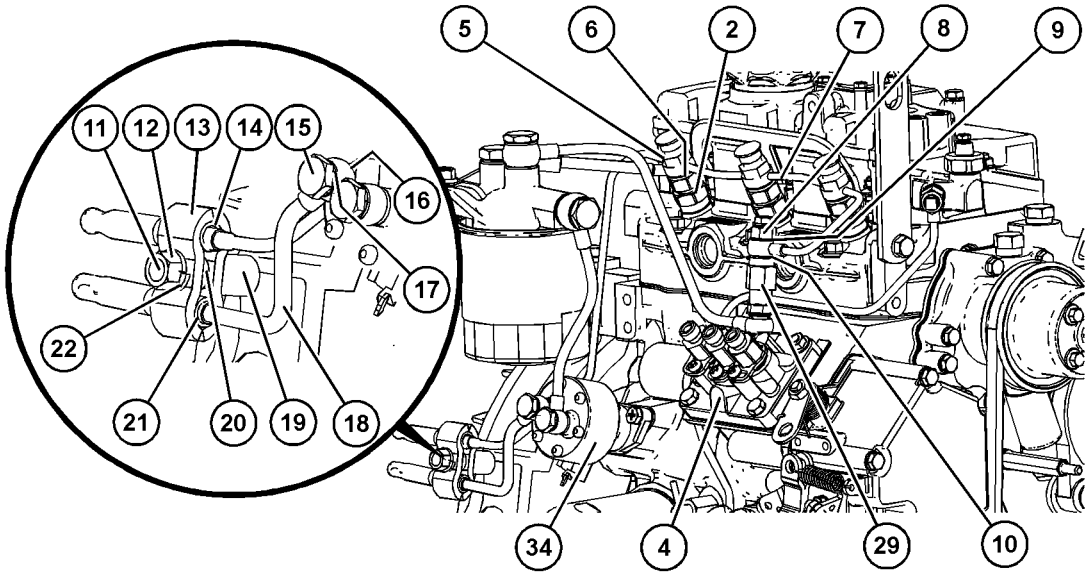

Illustration 7 g06530070
Typical Example

7. Follow Step 7a through Step 7l to remove low-pressure fuel line (7).

a. Disconnect fuel lines from low-pressure fuel line (7) and low-pressure fuel line (18).

b. Remove nut (12), lock washer (22), pipe clamp (13), and spacer (20) from stud (11).

c. Remove nuts (5) from fuel injectors (2).

Note: Note nuts position and orientation for installation purposes.

d. Remove banjo bolt (8) from low-pressure fuel line (7).

e. Remove sealing washer (9) (not shown) and sealing washer (10) (not shown) from low-pressure fuel line (7) Discard the sealing washers.

f. Remove low-pressure fuel line (7) from fuel injectors (2). Remove sealing washers (6) (not shown). Discard the sealing washers.

g. If necessary, remove rubber sleeve (14) from low-pressure fuel line (7).

Note: Note the rubber sleeve position for installation purposes.

h. If necessary, remove banjo bolt (15) from low-pressure fuel line (18).

i. Remove sealing washer (16) (not shown) and sealing washer (17) (not shown) from low-pressure fuel line (18). Discard the sealing washers.

j. If necessary, remove rubber sleeve (21) from low-pressure fuel line (18).

Note: Note the rubber sleeve position for installation purposes.

k. If necessary, remove bottom section of pipe clamp (13).

l. If necessary, remove spacer (19) and stud (11) from the flywheel housing.

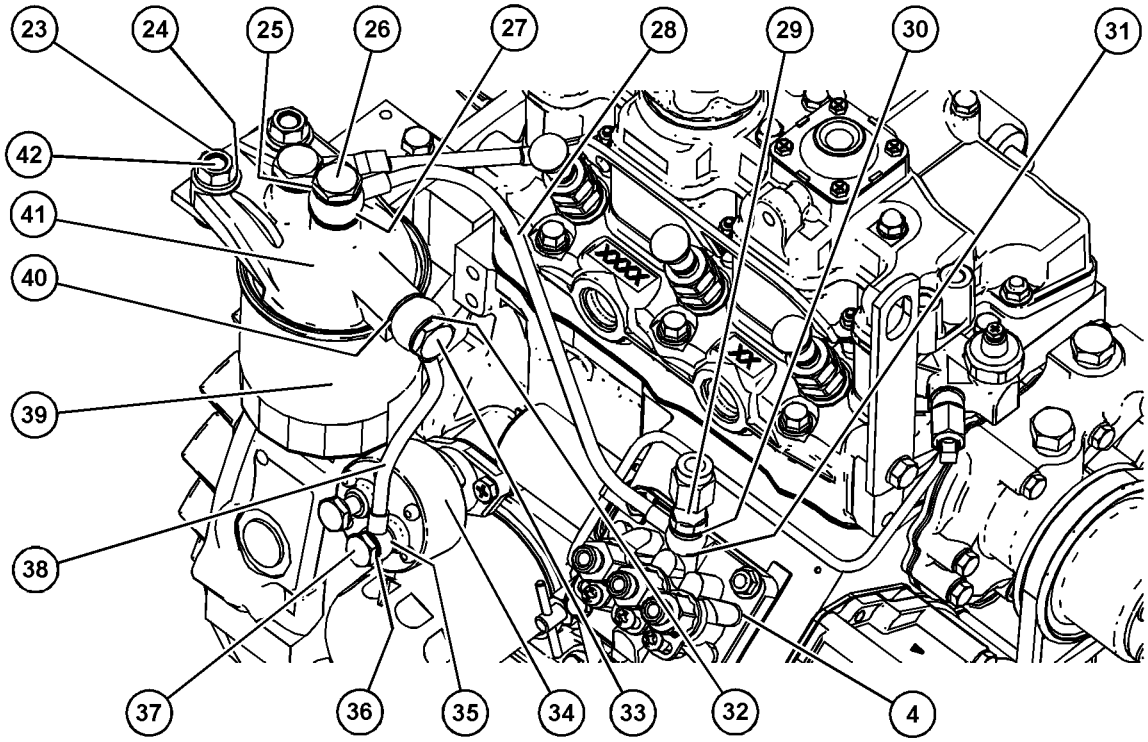

Illustration 8 g06530148
Typical Example

8. Remove connector (29) and banjo bolt (26) from low-pressure fuel pipe (28). Remove the low-pressure fuel line from fuel filter base (41).Remove sealing washer (30) (not shown) and sealing washer (31) (not shown) from the connector. Discard the sealing washers.

9. Remove sealing washer (25) (not shown) and sealing washer (27) (not shown) from the banjo bolt . Discard the sealing washers.

10. Remove banjo bolt (33) and banjo bolt (37) from low-pressure fuel pipe (38). Remove the low-pressure fuel line from fuel filter base (41). Remove sealing washer (32) (not shown) and sealing washer (40) (not shown) from the connector. Discard the sealing washers.

11. Remove sealing washer (35) (not shown) and sealing washer (36) (not shown) from the banjo bolt . Discard the sealing washers.

12. If necessary, remove fuel filter element (39). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

13. If necessary, support fuel filter base (41). Remove nuts (23), lock washers (24) (not shown) from bolts (42). Remove the fuel filter base.

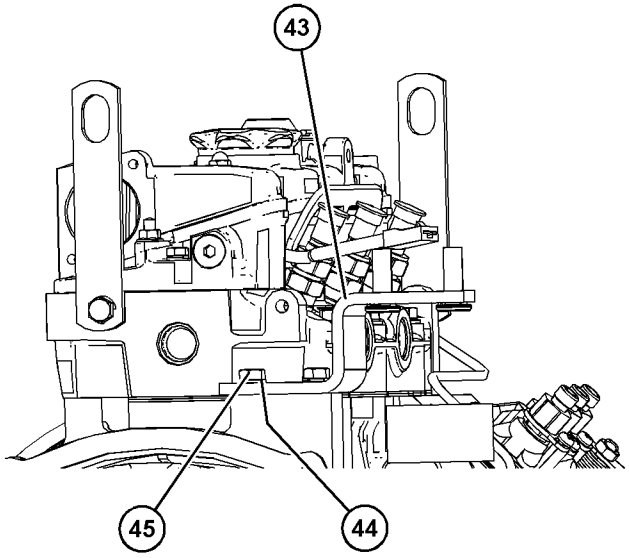

Illustration 9 g06530201
Typical Example

14. Remove bolts (45) and lock washers (44) (not shown) from bracket (43). Remove the bracket from the flywheel housing.

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

i08148404

Fuel Filter Base - Remove
(403F-11 - If Equipped)

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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug and cap all open ports.

1. Turn the fuel supply to the OFF position.

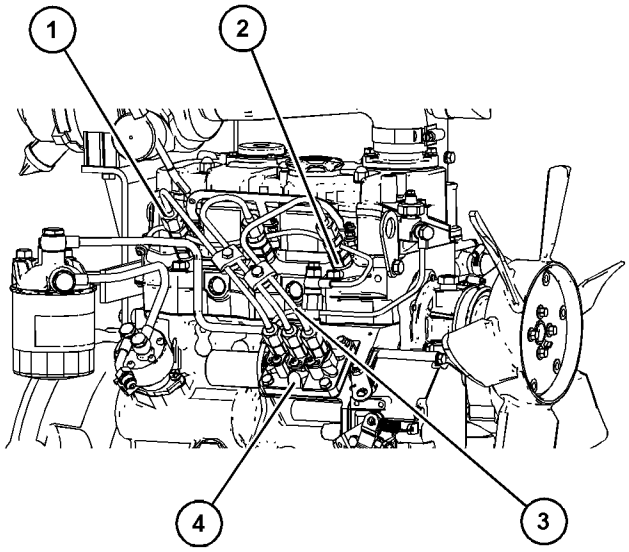

Illustration 10 g06566209
Typical example

2. Place a suitable container below fuel injection pump (4) and fuel injectors (2) to catch any fuel that might be spilled.

3. Disconnect tube nuts (1) for fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

4. Remove fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

5. Use suitable caps to cap the open ports of fuel injectors (2) and fuel injection pump (4) immediately.

6. Use suitable caps to cap the open ports of fuel injection lines (3) immediately.

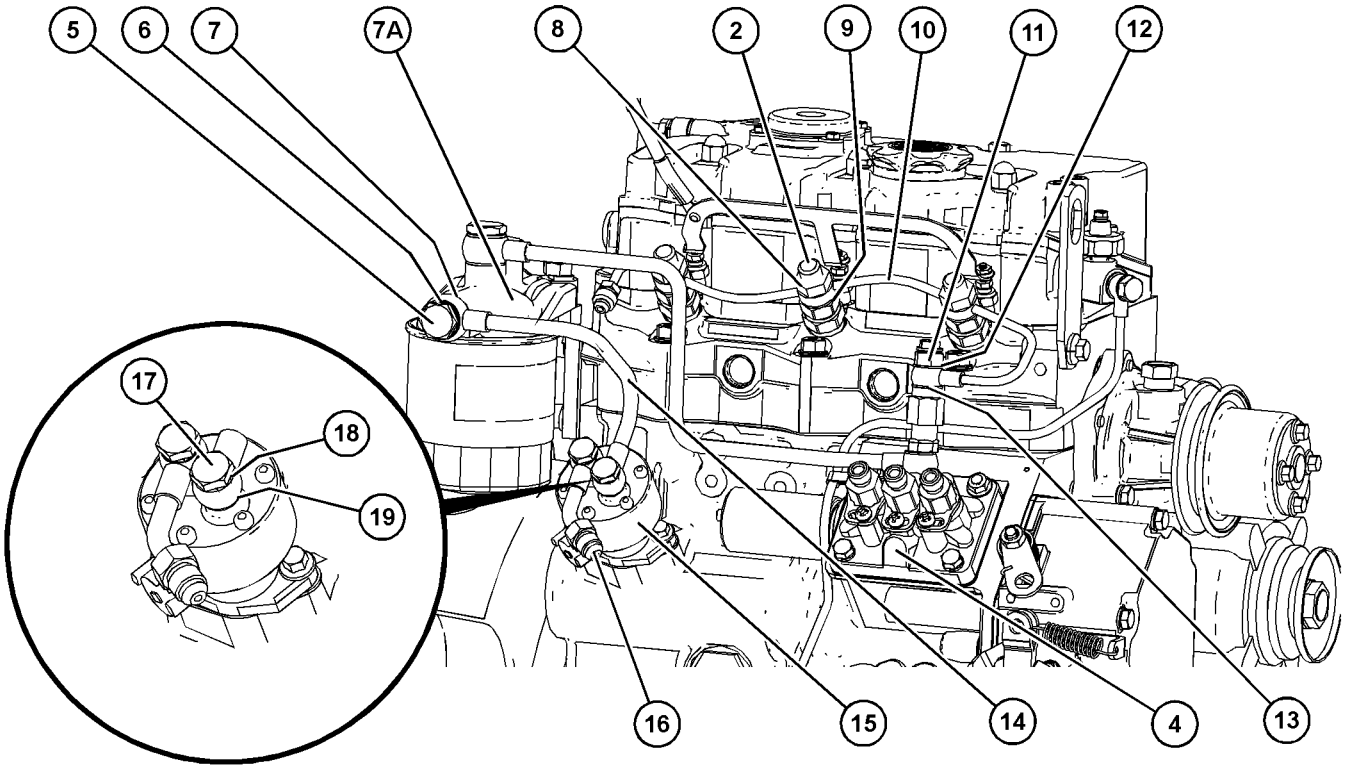

Illustration 11 g06566210

Typical Example

7. Follow Step 7a through Step 7j to remove low-pressure fuel line (10).

a. Disconnect fuel lines from low-pressure fuel line (10) and low-pressure fuel line (16).

b. Remove nuts (8) from fuel injectors (2).

Note: Nuts position and orientation for installation purposes.

c. Remove banjo bolt (11) from low-pressure fuel line (10).

d. Remove sealing washer (12) (not shown) and sealing washer (13) (not shown) from low-pressure fuel line (10) Discard the sealing washers.

e. Remove low-pressure fuel line (10) from fuel injectors (2). Remove sealing washers (9) (not shown). Discard the sealing washers.

f. Remove banjo bolt (17) from low-pressure fuel line (14).

g. Remove sealing washer (18) (not shown) and sealing washer (19) (not shown) from low-pressure fuel line (14). Discard the sealing washers.

h. Remove banjo bolt (5) from low-pressure fuel line (14).

i. Remove sealing washer (6) (not shown) and sealing washer (7) (not shown) from low-pressure fuel line (14). Discard the sealing washers.

j. Remove low-pressure fuel line (14) from fuel filter base (7A) and fuel transfer pump (15).

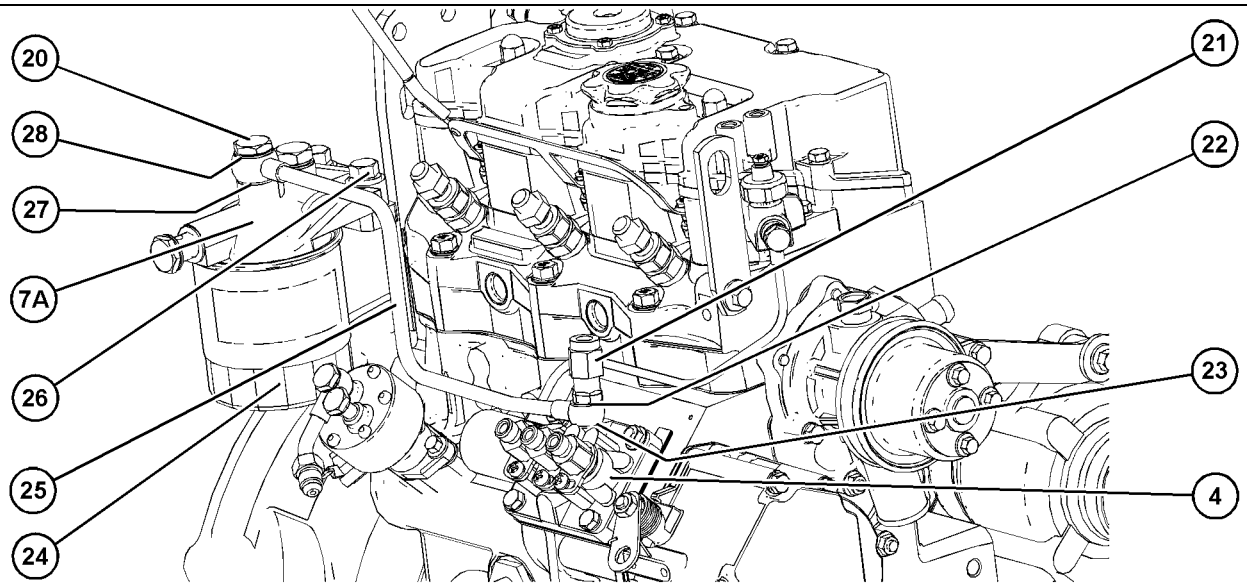

Illustration 12 g06532650
Typical Example

8. Remove connector (21) and banjo bolt (20) from low-pressure fuel pipe (25). Remove the low-pressure fuel line from fuel filter base (7A) and fuel injection pump (4). Remove sealing washer (22) (not shown) and sealing washer (23) (not shown) from the connector. Discard the sealing washers.

9. Remove sealing washer (27) (not shown) and sealing washer (28) (not shown) from the banjo bolt . Discard the sealing washers.

10. If necessary, remove fuel filter element (24). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

11. Remove bolt assemblies (26) and remove fuel filter base (7A).

Note: Position and orientation of the fuel filter base for installation purposes.

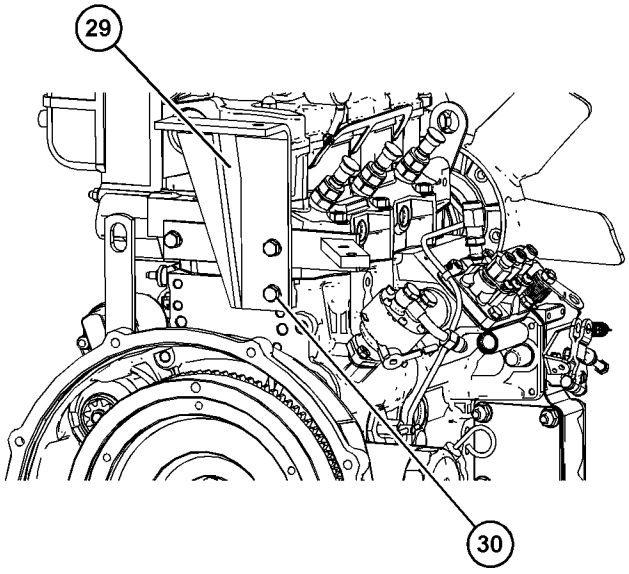

Illustration 13 g06566211
Typical Example

12. If necessary, support bracket (29) and remove bolt assemblies (30) from the bracket . Remove the bracket from the engine cylinder head and engine block.

Note: Bracket position and orientation for installation purposes.

Note: Bolt position for installation purposes.

i08095577

Fuel Filter Base - Install
(402F-05 - If Equipped)

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 component that is worn or damaged.

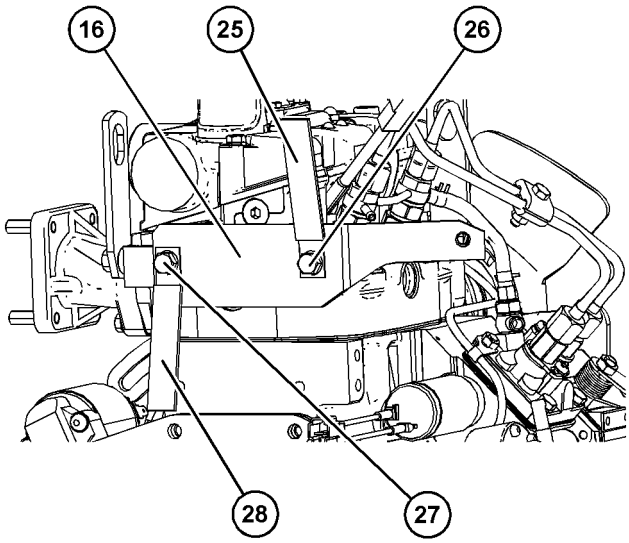

Illustration 14 g06538801
Typical Example

2. If necessary, follow Step 2a through Step 2c to install bracket (16).

a. Position clamp (28) onto bolt (27) and clamp (25) onto bolt (26).

b. Install bolt assembly (27) and bolt assembly (26) into bracket (16) in the positions noted on removal.

c. Position bracket (16) onto the cylinder head, install bolt assembly (27) and bolt assembly (26) and tighten the bolts to a torque of 25 N·m (221 lb in).

Note: Ensure that the clamps are in the positions noted on removal.

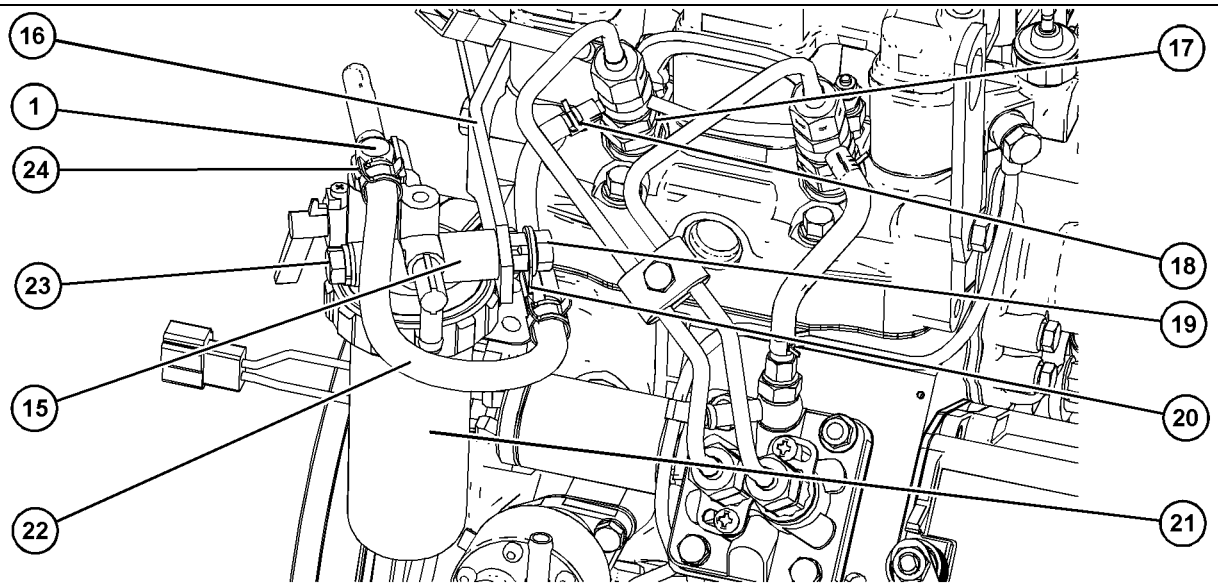

Illustration 15 g06538791
Typical Example

3. Follow Step 3a through Step 3f to install low-pressure fuel line (22).

a. Position bolt assembly (23) into fuel filter base (15).

b. Position fuel filter base (15) onto bracket (16) in the position noted on removal, install bolt assembly (23) and tighten to a torque of 25 N·m (221 lb in).

c. Install fuel filter element (21). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

d. Position new hose clamp (18) and new hose clamp (24) on to hose (22).

Note: Ensure that the hose clamps are correctly orientated.

e. Install hose (22) onto fuel injector (17) and connection (1). Using a suitable tool, reposition the new hose clamp (18) and new hose clamp (24) into the positions noted on removal.

f. Reposition hose clamp (20) onto bolt (23). Install nut (19) onto the bolt and torque to 10 N·m (89 lb in).

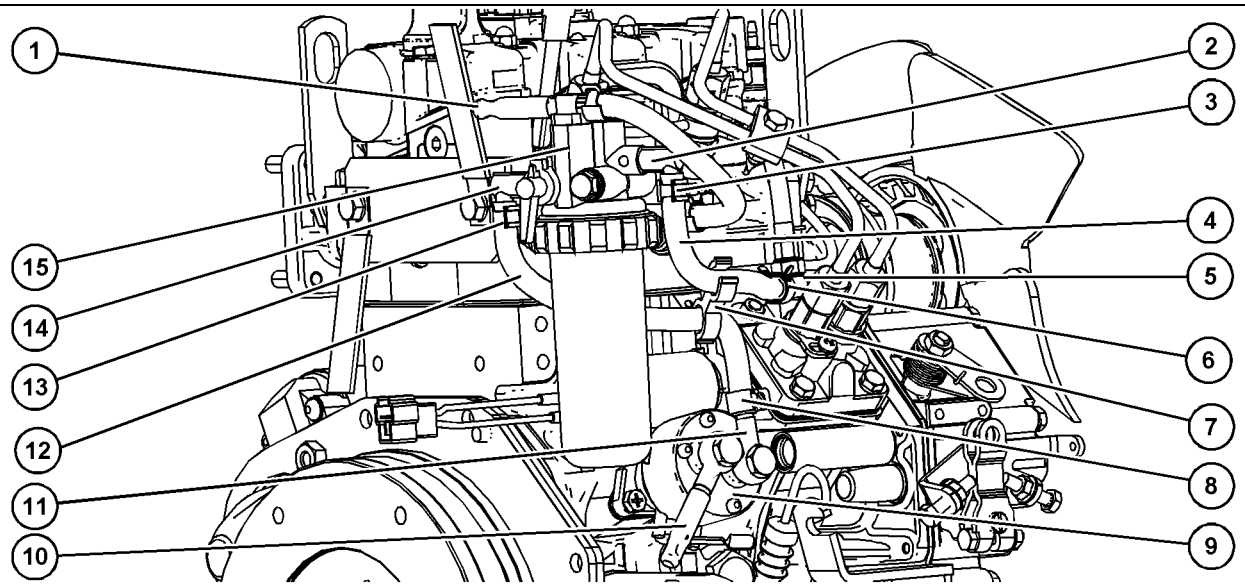

Illustration 16 g06538368
Typical example

4. Follow Step 4a through Step 4e to install low-pressure fuel line (4) and low-pressure fuel line (12).

a. Using a suitable tool, position new hose clamp (3) and new hose clamp (6) on to hose (4).

Note: Ensure that the hose clamps are correctly orientated.

b. Install hose (4) onto connection (2) and connection (5). Using a suitable tool, reposition the new hose clamp (3) and new hose clamp (6) into the positions noted on removal.

c. Using a suitable tool, position new hose clamp (13) and new hose clamp (8) on to hose (12).

Note: Ensure that the hose clamps are correctly orientated.

d. Install hose (12) onto connection (14) and connection (11). Using a suitable tool, reposition the new hose clamp (13) and new hose clamp (8) into the positions noted on removal.

e. Install hose clamp (7) to hose (4) and hose (12) in the position noted on removal.

5. Reconnect Original Engine Manufacturer (OEM) fuel lines to low-pressure fuel line connection (1) and low-pressure fuel line connection (10).

End By:

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

i08097735

Fuel Filter Base - Install (403F-07 - If Equipped)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

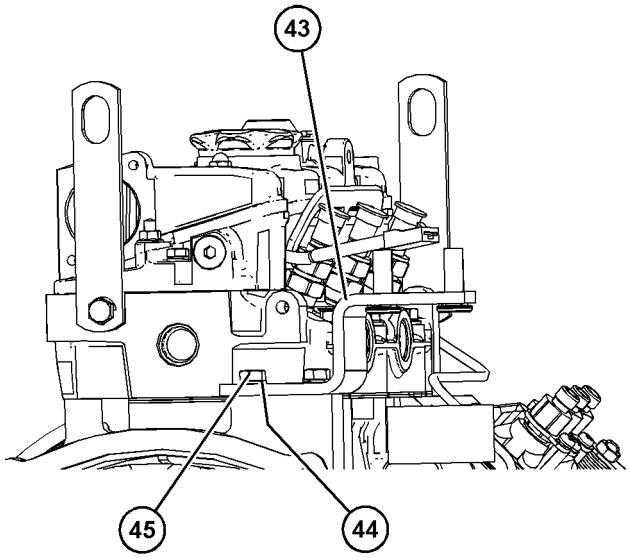

Illustration 17 g06530201

Typical Example

1. Position lock washers (44) (not shown) onto bolts (45).

2. Position bracket (43) onto the flywheel housing in the position noted on removal. Install bolts assemblies (45) to the bracket, tighten the bolts to a torque of 25 N·m (221 lb in).

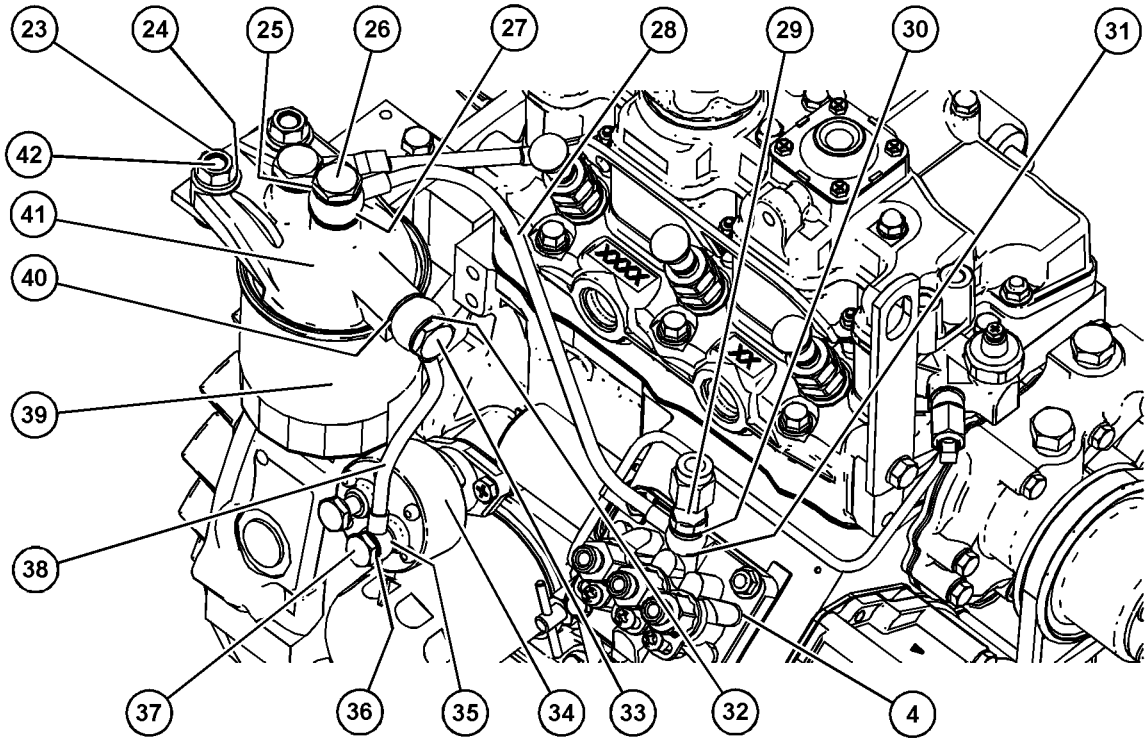

Illustration 18 g06530148
Typical Example

3. Position fuel filter base (41) onto bolts (42), install lock washers (24) (not shown) and nuts (23) onto the bolts. Tighten the nuts to a torque of 44 N·m (33 lb ft)

4. If necessary, install fuel filter element (39). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

5. Follow Step 6a through Step 6e to install low-pressure fuel line (38).

a. Install new sealing washer (32) (not shown) onto banjo bolt (33). Position the banjo bolt assembly into low-pressure fuel line (38), and position a new sealing washer (40) (not shown) onto the banjo bolt assembly.

b. Install banjo bolt and pipe assembly (38) into fuel filter base (41), and tighten the banjo bolt finger tight.

c. Position new sealing washer (36) (not shown) onto banjo bolt (37). Position new sealing washer (35) (not shown) between low-pressure fuel line (38) and fuel transfer pump (34). Install the banjo bolt assembly to the union and the new sealing washer. Tighten the banjo bolt finger tight.

Note: When, installing banjo bolt (37) ensure that the new sealing washer (35) (not shown) is installed correctly.

d. Tighten banjo bolt (33) to a torque of 17 N·m (151 lb in).

e. Tighten banjo bolt (37) to a torque of 12 N·m (106 lb in).

6. Follow Step 6a through Step 6e to install low-pressure fuel line (28).

a. Install new sealing washer (25) (not shown) onto banjo bolt (26). Position the banjo bolt assembly into low-pressure fuel line (28), and position a new sealing washer (27) (not shown) onto the banjo bolt assembly.

b. Install banjo bolt and pipe assembly (28) into fuel filter base (41), and tighten the banjo bolt finger tight.

c. Position new sealing washer (30) (not shown) onto connector (29). Position new sealing washer (31) (not shown) between low-pressure fuel line (28) and fuel injection pump (4). Install the connector assembly to the union and the new sealing washer. Tighten the connector finger tight.

Note: When, installing connector (29) ensure that the new sealing washer (31) (not shown) is installed correctly.

d. Tighten banjo bolt (33) to a torque of 17 N·m (151 lb in).

e. Tighten connector (29) to a torque of 17 N·m (151 lb in).

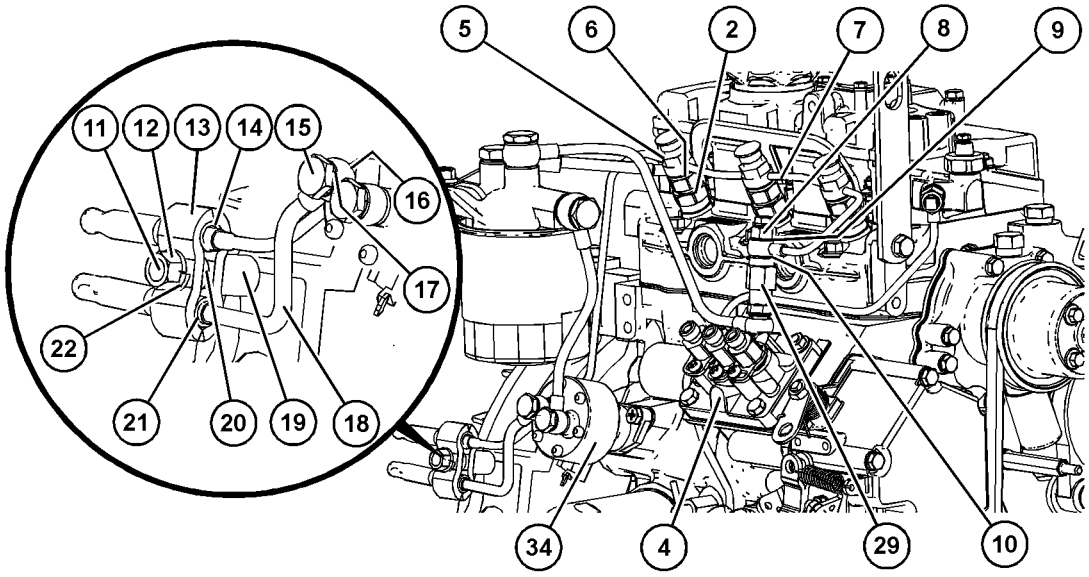

Illustration 19 g06530070

Typical Example

7. Follow Step 7a through Step 7l to install low-pressure fuel line (7) and low-pressure fuel line (18).

a. If necessary, install stud (11) to the flywheel housing. Tighten the stud to a torque of 11 N·m (97 lb in). Position spacer (19) and bottom half of pipe clamp (13) onto the stud.

b. If necessary, position rubber sleeve (21) onto low-pressure fuel line (18) in the position noted on removal.

c. Install new sealing washer (17) (not shown) onto banjo bolt (15). Position the banjo bolt assembly into low-pressure fuel line (18), and position a new sealing washer (16) (not shown) onto the banjo bolt assembly.

d. Install banjo bolt and pipe assembly (18) into fuel transfer pump (34), and tighten the banjo bolt finger tight.

e. If necessary, position rubber sleeve (14) onto low-pressure fuel line (7) in the position noted on removal.

f. Install new sealing washer (9) (not shown) onto banjo bolt (8). Position the banjo bolt assembly into low-pressure fuel line (7), and position a new sealing washer (10) (not shown) onto the banjo bolt assembly.

g. Install new sealing washers (6) (not shown) onto fuel injectors (2). Position low-pressure fuel line (7)onto the fuel injectors. Install banjo bolt assembly (8) into connector (29) finger tight.

h. Install nuts (5)in the position and orientation noted on removal finger tight.

i. Position spacer (20), and pipe clamp (18) onto stud (11), install lockwasher (22) and nut (12) onto the stud, tighten the nut finger tight.

j. Tighten nut (5) to a torque of 27 N·m (239 lb in).

k. Tighten banjo bolt (8) to a torque of 7 N·m (62 lb in).

l. Tighten nut (12) to a torque of 22 N·m (195 lb in).

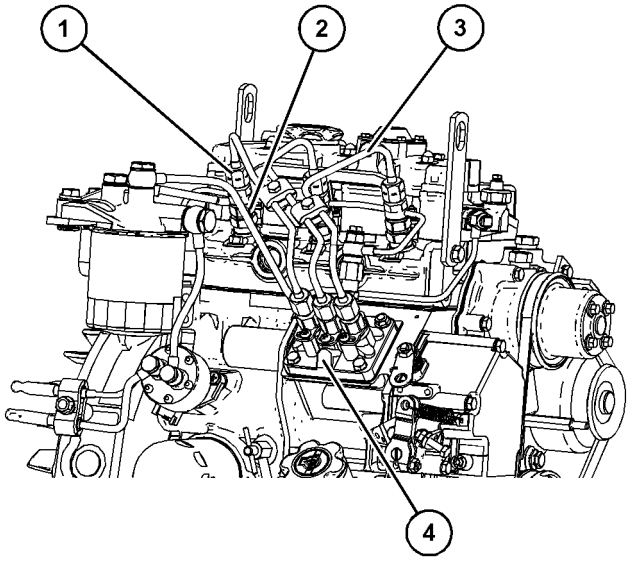

Illustration 20 g06530092
Typical example

8. Position fuel injection lines (3) onto fuel injectors (2) and fuel injection pump (4), install tube nuts (1) finger tight.

9. Tighten the tube nuts (1) to a torque of 20 N·m (177 lb in).

10. Turn the fuel supply to the ON position.

End By:

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

i08148411

Fuel Filter Base - Install
(403F-11 - If Equipped)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

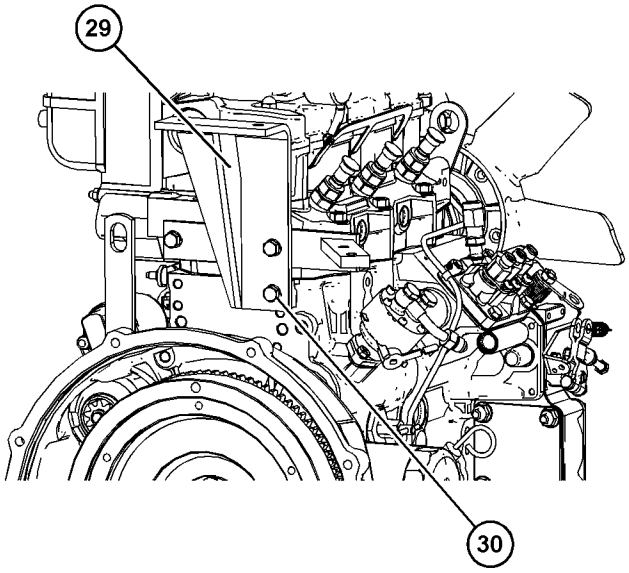

Illustration 21 g06566211
Typical Example

1. Position bracket (29) onto the engine cylinder head and cylinder block in the position noted on removal. Install bolt assemblies (30) to the bracket, tighten the bolts to a torque of 22 N·m (195 lb in).

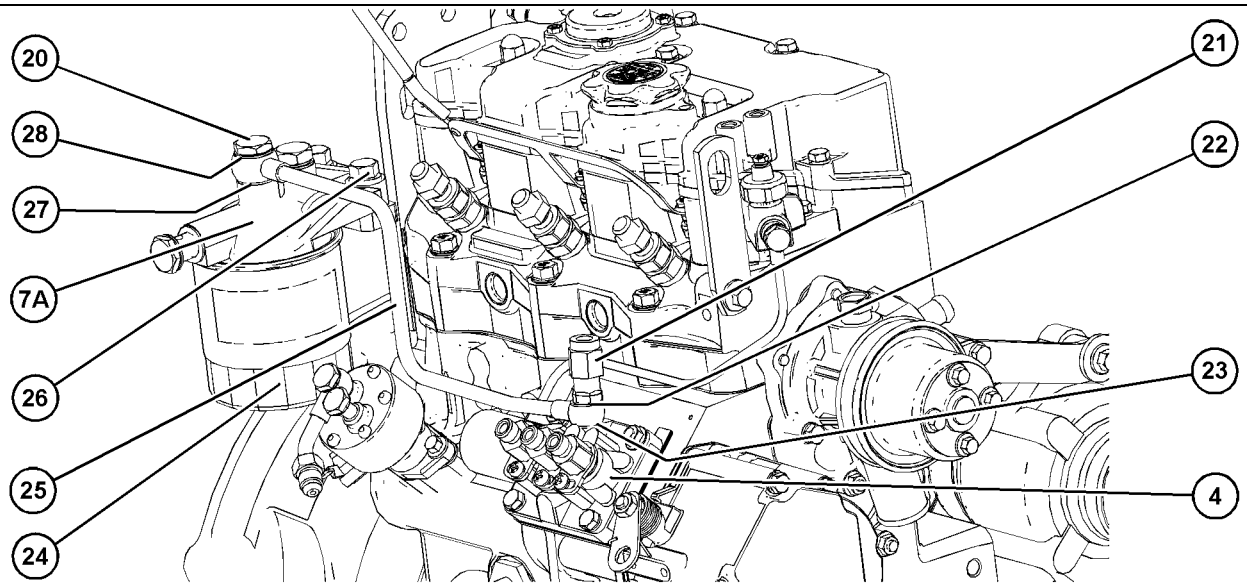

Illustration 22 g06532650
Typical Example

2. Position fuel filter base (7A) onto bracket (29) in the position noted on removal. Install bolt assemblies (26) to the fuel filter base and tighten the bolts to a torque of 44 N·m (33 lb ft).

3. If necessary, install fuel filter element (24). Refer to Operations and Maintenance Manual, “Fuel Systems Filter - Replace” for the correct procedure.

4. Follow Step 4a through Step 4e to install low-pressure fuel line (25).

a. Install new sealing washer (28) (not shown) onto banjo bolt (20). Position the banjo bolt assembly into low-pressure fuel line (25), and position a new sealing washer (27) (not shown) onto the banjo bolt assembly.

b. Install banjo bolt and pipe assembly (20) into fuel filter base (7A), and tighten the banjo bolt finger tight.

c. Position new sealing washer (22) (not shown) onto connector (21). Position new sealing washer (23) (not shown) between low-pressure fuel line (25) and fuel injection pump (4) and install the connector to the low-pressure fuel line. Tighten the connector finger tight.

Note: When, installing connector (21) ensure that the new sealing washer (23) (not shown) is installed correctly.

d. Tighten banjo bolt (20) to a torque of 17 N·m (150 lb in).

e. Tighten connector (21) to a torque of 17 N·m (150 lb in).

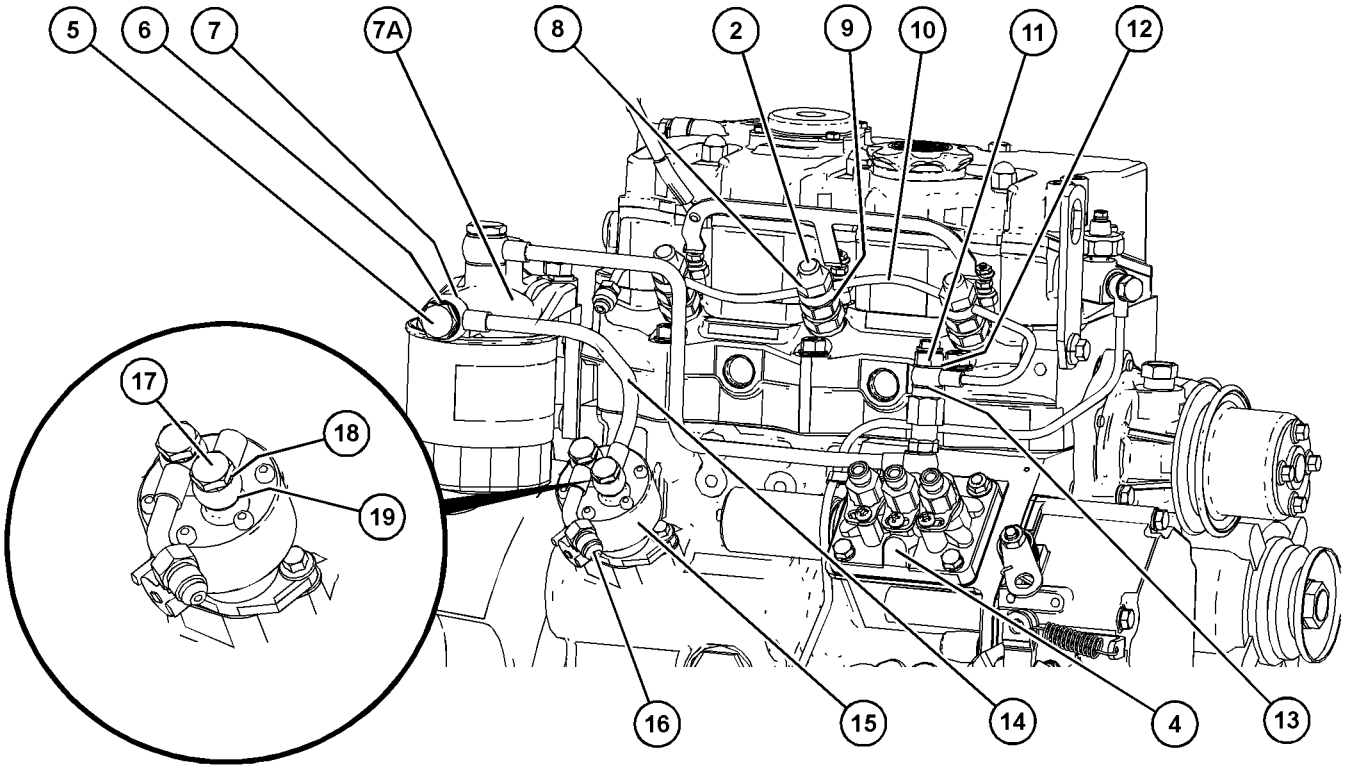

Illustration 23 g06566210

Typical Example

5. Follow Step 5a through Step 5j to install low-pressure fuel line (10), install low-pressure fuel line (14).

a. Install new sealing washers (9) (not shown) onto fuel injectors (2) in the position and orientation noted on removal.

b. Position new sealing washer (12) (not shown) onto banjo bolt (11). Position the banjo bolt assembly into low-pressure fuel line (10), and position a new sealing washer (13) (not shown) onto the banjo bolt assembly.

c. Position low-pressure fuel line (10) onto fuel injectors (2) install banjo bolt assembly (11) into connector (21), tighten the banjo bolt finger tight.

d. Install nuts (8) in the position and orientation noted on removal and tighten finger tight.

e. Install new sealing washer (6) (not shown) onto banjo bolt (5). Position the banjo bolt assembly into low-pressure fuel line (14), and position a new sealing washer (7) (not shown) onto the banjo bolt assembly.

f. Install banjo bolt assembly (5) into fuel filter base (7A), and tighten the banjo bolt finger tight.

g. Position new sealing washer (18) (not shown) onto banjo bolt (17). Position new sealing washer (19) (not shown) between low-pressure fuel line (14) and fuel transfer pump (15) and install the banjo bolt to the low-pressure fuel line. Tighten the banjo bolt finger tight.

Note: When, installing banjo bolt (17) ensure that the new sealing washer (19) (not shown) is installed correctly.

h. Tighten nuts (8) to a torque of 27 N·m (239 lb in).

i. Tighten banjo bolt (5) and banjo bolt (11) to a torque of 17 N·m (151 lb in).

j. Tighten banjo bolt (17) to a torque of 12 N·m (106 lb in).

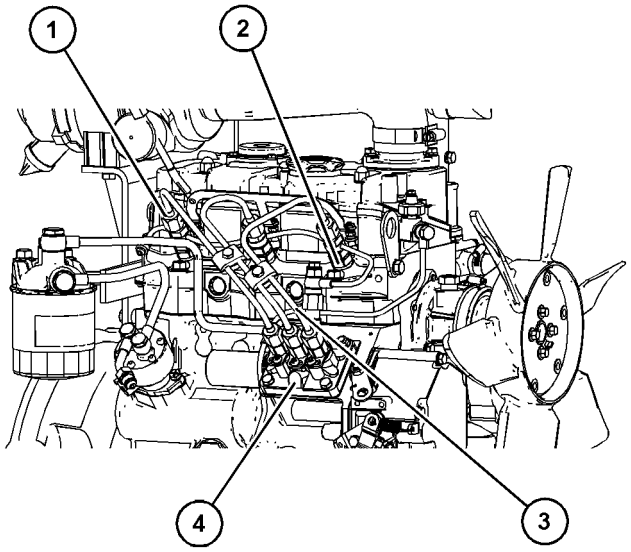

Illustration 24 g06566209
Typical example

6. Position fuel injections lines (3) onto fuel injectors (2) and fuel injection pump (4), install tube nuts (1) finger tight.

7. Tighten the tube nuts (1) to a torque of 20 N·m (177 lb in).

8. Reconnect fuel lines to low-pressure fuel line (10) and low-pressure fuel line (16).

9. Turn the fuel supply to the ON position.

End By:

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

i08095579

Fuel Lines - Remove and Install
(402F-05 - If Equipped)

Removal Procedure

Table 1

Required Tools			
Tool	Part Number	Description	Qty
A	27610294	Injector Pipe Nut Tool	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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug all lines and tube assemblies to prevent contamination.

1. Turn the fuel supply to the OFF position.

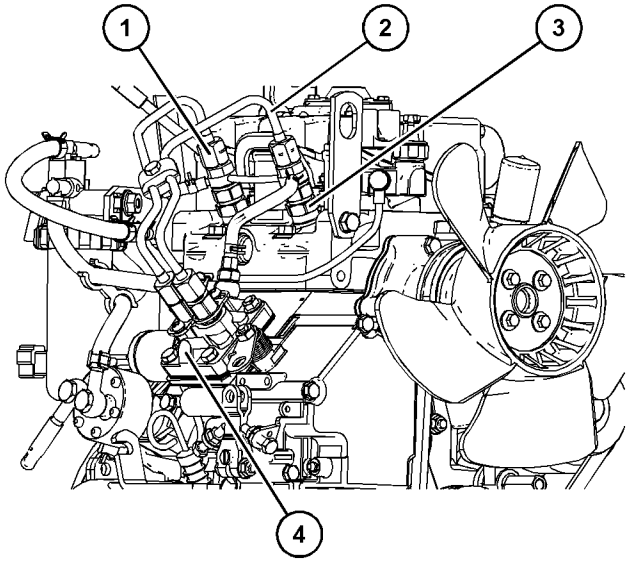

Illustration 25 g06539715
Typical Example

2. Using Tool (A) disconnect tube nuts (1) for fuel injection lines (2) from fuel injectors (3).

3. Using Tool (A) disconnect tube nuts (1) for fuel injection lines (2) from fuel injection pump (4).

4. Remove fuel injection lines (2) from the engine as a unit.

5. Use suitable caps to plug the open ports of the fuel injection pump immediately.

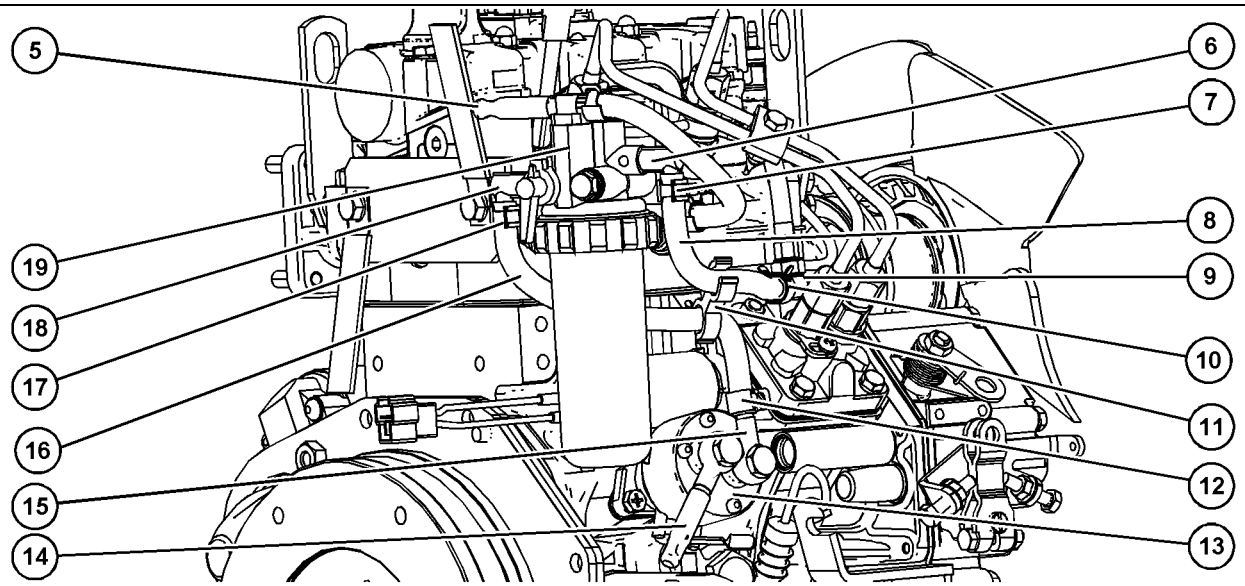

Illustration 26 g06539746

Typical example

6. Place a suitable container below fuel filter base (19) and fuel transfer pump (13) to catch any fuel that might be spilled.

7. Follow Step 7a through Step 7f to remove low-pressure fuel line (8) and low-pressure fuel line (16).

a. Disconnect Original Engine Manufacturer (OEM) fuel lines from low-pressure fuel line connection (5) and low-pressure fuel line connection (14).

b. Remove hose clamp (11) from hose (8) and hose (16).

Note: Note hose clamp position for installation purposes.

c. Using a suitable tool, position hose clamp (7) away from connection (6) and hose clamp (10) away from connection (9).

Note: Note hose clamp position and orientation for installation purposes.

d. Remove hose (8) from connection (6) and connection (9).

Note: Note hose position and orientation for installation purposes.

e. Using a suitable tool, position hose clamp (17) away from connection (18) and hose clamp (12) away from connection (15).

Note: Note hose clamp position and orientation for installation purposes.

f. Remove hose (16) from connection (18) and connection (15).

Note: Note hose position and orientation for installation purposes.

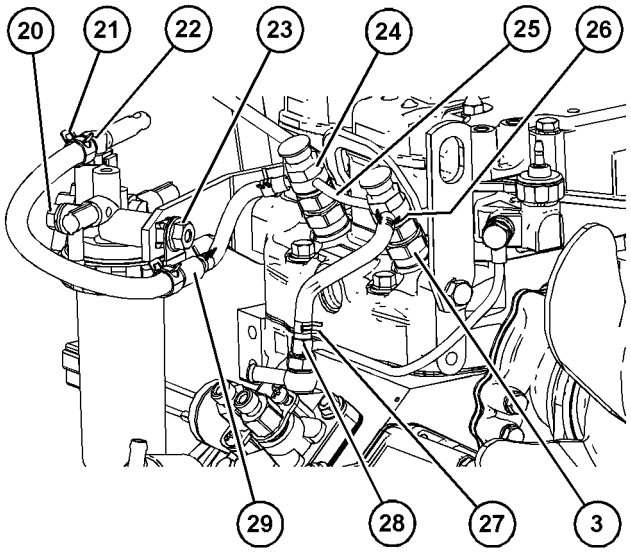

Illustration 27 g06539765

Typical Example

8. Follow Step 8a through Step 8f to remove low-pressure fuel line (25).

a. Using a suitable tool, position hose clamp (21) away from connection (22).

Note: Note hose clamp position for installation purposes.

b. Using a suitable tool, position hose clamp (27) away from connection (28).

Note: Note hose clamp position for installation purposes.

c. Remove nuts (24) from injectors (3).

d. Remove nut (23) from bolt (20). Position hose clamp (29) away from the bolt.

Note: Note hose clamp position and orientation for installation purposes.

e. Disconnect low-pressure fuel line (25) from connection (22) and connection (28). Remove the low-pressure fuel line from injectors (3).

Note: Note hose orientation and position for installation purposes.

f. Remove sealing washers (26) (not shown) from injectors (3).

Note: Note sealing washers position for installation purposes.

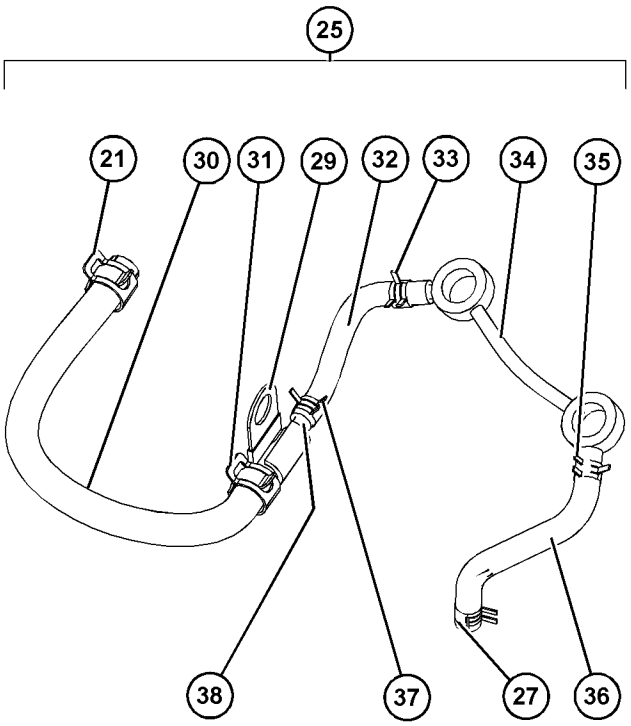

Illustration 28 g06539779

Typical Example

9. If necessary, follow Step 9a through Step 9g to disassemble low-pressure fuel line (25).

a. Using a suitable tool, remove hose clamp (21) from hose (30).

Note: note hose clamp orientation for installation purposes.

b. Using a suitable tool, remove hose clamp (27) from hose (36).

Note: note hose clamp orientation for installation purposes.

c. Using a suitable tool, reposition hose clamp (31) away from hose clamp (29).

Note: note hose clamps orientation and position for installation purposes.

d. Remove hose (30) from pipe (38) (not shown). Remove hose clamp (31) from the hose.

Note: Note hose clamp, hose position, and orientation for installation purposes.

e. Using a suitable tool, reposition hose clamp (35) away from fuel line (34). Remove hose (36) from the from fuel line. Remove the hose clamp from the hose.

Note: note hose clamp, hose position, and orientation for installation purposes.

f. Using a suitable tool, reposition hose clamp (37) away from hose clamp (29) and hose clamp (33) away from fuel line (34).

Note: note hose clamps position and orientation for installation purposes.

g. Remove hose (32) from fuel line (34). Remove hose clamp (29) from pipe (38) (not shown). Remove the pipe from the hose.

Note: note hose, pipe position, and orientation for installation purposes.

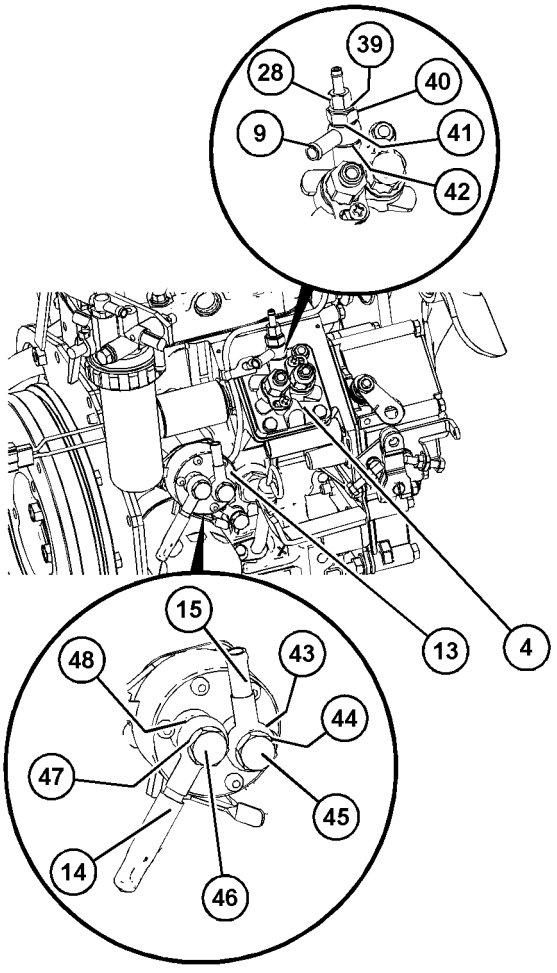

Illustration 29 g06540109

Typical Example

10. If necessary, follow Step 10a through Step 10c to remove connector (28) and connector (9).

a. Remove connector (28) from banjo bolt (40). Remove sealing washer (39) (not shown) from the connector.

b. Remove banjo bolt assembly (40) from fuel injection pump (4).

Note: Note connector (9) orientation and position for installation purposes.

c. Remove sealing washer (42) (not shown), connector (9), and sealing washer (41) (not shown) from banjo bolt (40).

11. If necessary, follow Step 11a through Step 11e to remove connector (14) and connector (15).

a. Loosen banjo bolt (45) and banjo bolt (46).

Note: Note connector (14) and connector (15) positions for installation purposes.

b. Remove banjo bolt assembly (46) from the fuel transfer pump (13).

c. Remove sealing washer (48) (not shown), connector (14), and sealing washer (47) (not shown) from banjo bolt (46).

d. Remove banjo bolt assembly (45) from the fuel transfer pump (13).

e. Remove sealing washer (43) (not shown), connector (15), and sealing washer (44) (not shown) from banjo bolt (45).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

1. Ensure that all components are free from wear and damage. Replace any component that is worn or damaged.

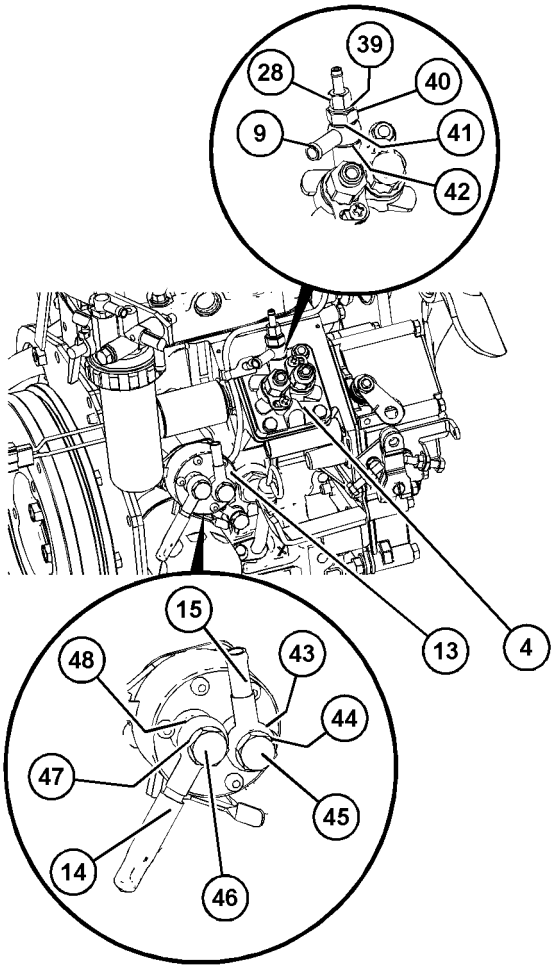

Illustration 30 g06540109
Typical Example

2. If necessary, follow Step 2a through Step 2d to Install connector (28) and connector (9).

a. Position new sealing washer (41) (not shown), connector (9), and sealing washer (42) (not shown) on to banjo bolt (40)

b. Install banjo bolt assembly into fuel injection pump (4) and tighten the banjo bolt finger tight. Ensure that connector (9) is in the position noted on removal.

c. Tighten banjo bolt to a torque of 17 N·m (150 lb in).

Note: Ensure that connector (9) is still in the correct position.

d. Position a new sealing washer (39) (not shown) onto connector (28). Install the connector into banjo bolt (40) and tighten the connector to a torque of 17 N·m (150 lb in).

3. If necessary, follow Step 3a through Step 3f to install connector (14) and connector (15).

a. Position new sealing washer (47) (not shown), connector (14), and sealing washer (48) (not shown) on to banjo bolt (46)

b. Install banjo bolt assembly (46) into the fuel transfer pump (13) and tighten finger tight. Ensure that connector (14) is in the position noted on removal.

c. Tighten banjo bolt (46) to a torque of 12 N·m (1060 lb in).

Note: Ensure that connector (14) is still in the correct position.

d. Position new sealing washer (44) (not shown), connector (15), and sealing washer (43) (not shown) on to banjo bolt (45)

e. Install banjo bolt assembly (45) into the fuel transfer pump (13) and tighten finger tight. Ensure that connector (15) is in the position noted on removal.

f. Tighten banjo bolt (45)to a torque of 12 N·m (1060 lb in).

Note: Ensure that connector (15) is still in the correct position.

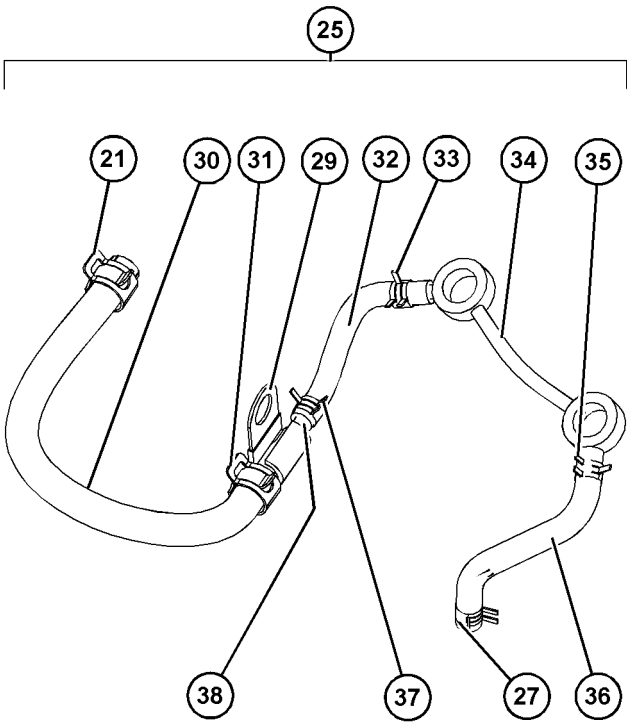

Illustration 31 g06539779
Typical Example

4. If necessary, follow Step 4a through Step 4g to assemble low-pressure fuel line (25).

a. Using a suitable tool, position new hose clamp (27) and new hose clamp (35) onto hose (36) in the orientation noted on removal.

b. Install hose (36) onto fuel line (34) in the position noted on removal. Using a suitable tool, reposition hose clamp (35) into the position noted on removal.

Note: note ensure that the hose clamp is correctly orientation.

c. Using a suitable tool, position new hose clamp (33) and new hose clamp (37) onto hose (32) in the orientation noted on removal.

d. Install hose (32) onto fuel line (34) in the position noted on removal. Using a suitable tool, reposition hose clamp (33) into the position noted on removal.

Note: note ensure that the hose clamp is correctly orientation.

e. Using a suitable tool, position new hose clamp (21) and new hose clamp (31) onto hose (30) in the orientation noted on removal.

f. Install pipe (38) (not shown) into hose (30) in the position noted on removal. Reposition hose clamp (31) into the position noted on removal.

g. Position hose clamp (29) onto pipe (38) (not shown) in the orientation noted on removal. Install pipe assembly into hose (32). Reposition hose clamp (37) into the position noted on removal.

Note: note ensure that the hose clamps are correctly orientation.

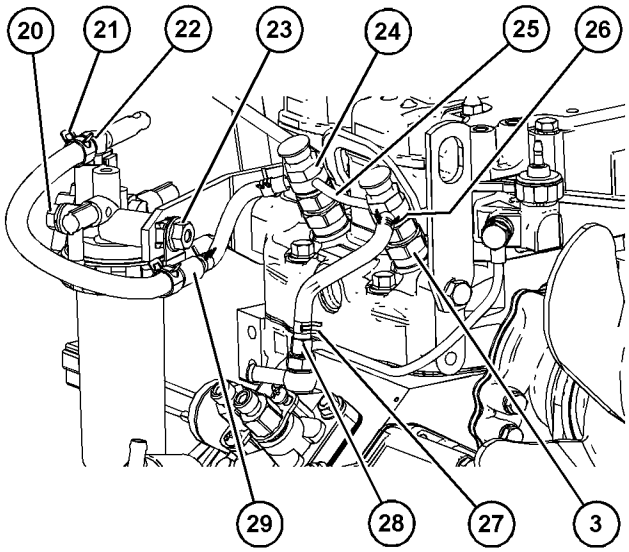

Illustration 32 g06539765
Typical Example

5. Follow Step 5a through Step 5e to install low-pressure fuel line (25).

a. Position new sealing washers (26) (not shown) onto fuel injectors (3).

b. Position low-pressure fuel line (25) onto fuel injectors (3) and install nuts (24) in the positions noted on removal. Tighten the nuts to a torque of 27 N·m (239 lb in).

c. Install low-pressure fuel line (25) onto connector (28). Using a suitable tool reposition hose clamp (27) into the position noted on removal.

d. Install low-pressure fuel line (25) onto connector (22). Using a suitable tool reposition hose clamp (21) into the position noted on removal.

e. Position hose clamp (29) onto bolt (20). Install nut (23) onto the bolt and tighten to torque of 10 N·m (89 lb in).

6. Use suitable caps to plug the open ports of the fuel injection pump immediately.

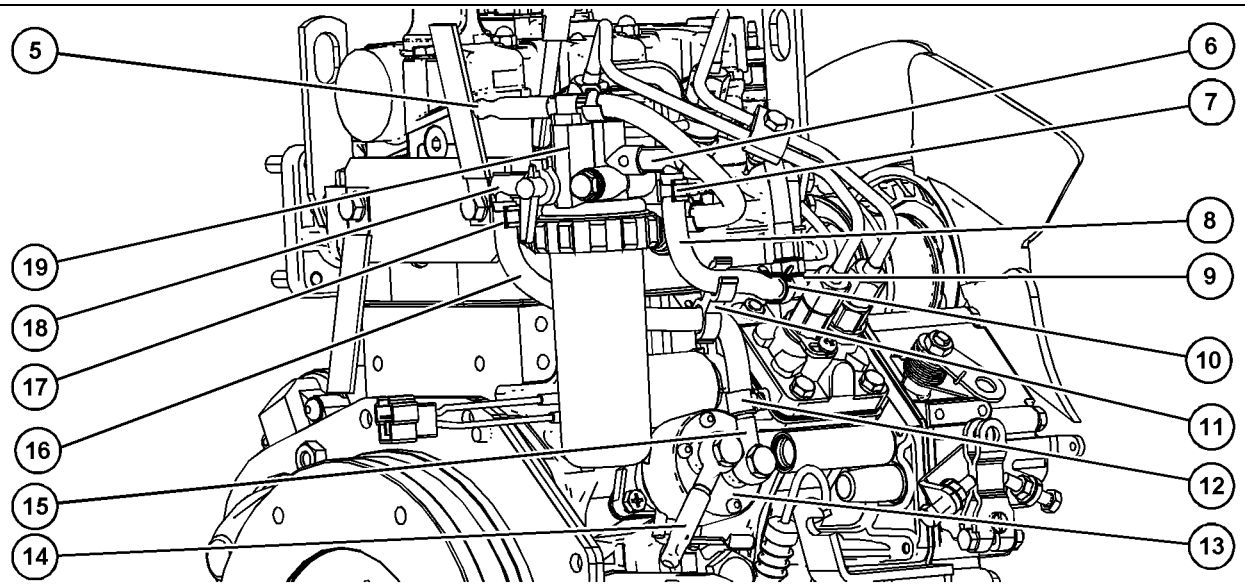

Illustration 33 g06539746

Typical example

7. Follow Step 7a through Step 7e to install low-pressure fuel line (8) and low-pressure fuel line (16).

a. Using a suitable tool, position new hose clamp (7) and new hose clamp (10) on to hose (8).

Note: Ensure that the hose clamps are correctly orientated.

b. Install hose (8) onto connection (6) and connection (9). Using a suitable tool, reposition the new hose clamp (7) and new hose clamp (10) into the positions noted on removal.

c. Using a suitable tool, position new hose clamp (17) and new hose clamp (12) on to hose (16).

Note: Ensure that the hose clamps are correctly orientated.

d. Install hose (16) onto connection (18) and connection (15). Using a suitable tool, reposition the new hose clamp (17) and new hose clamp (12) into the positions noted on removal.

e. Install hose clamp (11) to hose (8) and hose (16) in the position noted on removal.

8. Reconnect Original Engine Manufacturer (OEM) fuel lines from connection (5) and connection (14).

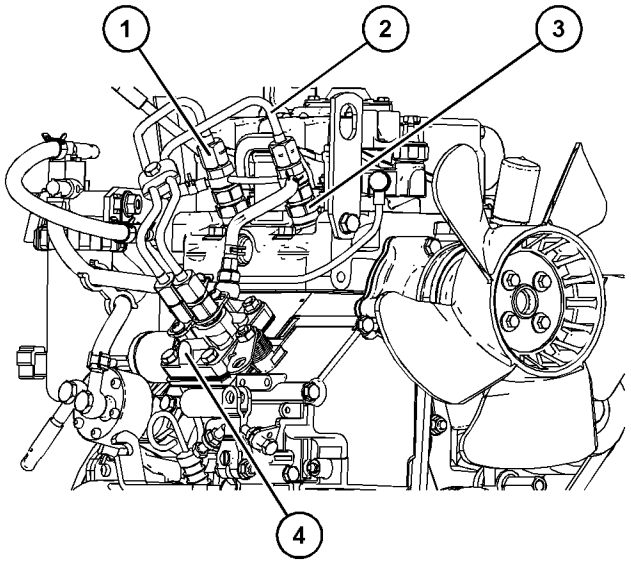

Illustration 34 g06539715

Typical Example

9. Remove the caps from the outlet connections of the fuel injection pump. Install the fuel injection lines to the engine as a unit.

10. Position fuel injection lines (2) onto fuel injectors (3) and fuel injection pump (4). Tighten the tube nuts (1) finger tight.

11. Use Tooling (A) to tighten tube nuts (1) at the fuel injection pump to a torque of 20 N·m (15 lb ft).

12. Use Tooling (A) to tighten tube nuts (1) at the fuel injectors to a torque of 20 N·m (15 lb ft).

13. Turn the fuel supply to the ON position.

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

i08097867

Fuel Lines - Remove and Install
(403F-07 - If Equipped)

Removal Procedure

Table 2

Required Tools			
Tool	Part Number	Description	Qty
A	27610294	Injector Pipe Nut Tool	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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug all lines and tube assemblies to prevent contamination.

1. Turn the fuel supply to the OFF position.

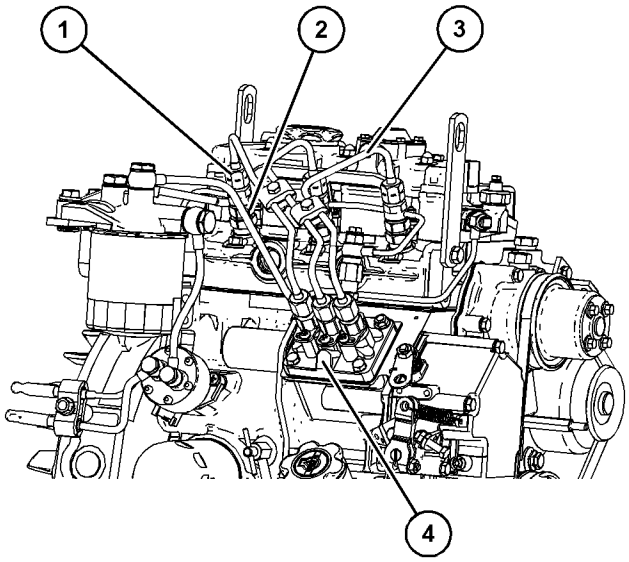

Illustration 35 g06530092
Typical example

2. Place a suitable container below fuel injection pump (4) and fuel injectors (2) to catch any fuel that might be spilled.

3. Using Tooling (A) disconnect tube nuts (1) for fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

4. Remove fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

5. Use suitable caps to cap the open ports of fuel injectors (2) and fuel injection pump (4) immediately.

6. Use suitable caps to cap the open ports of fuel injection lines (3) immediately.

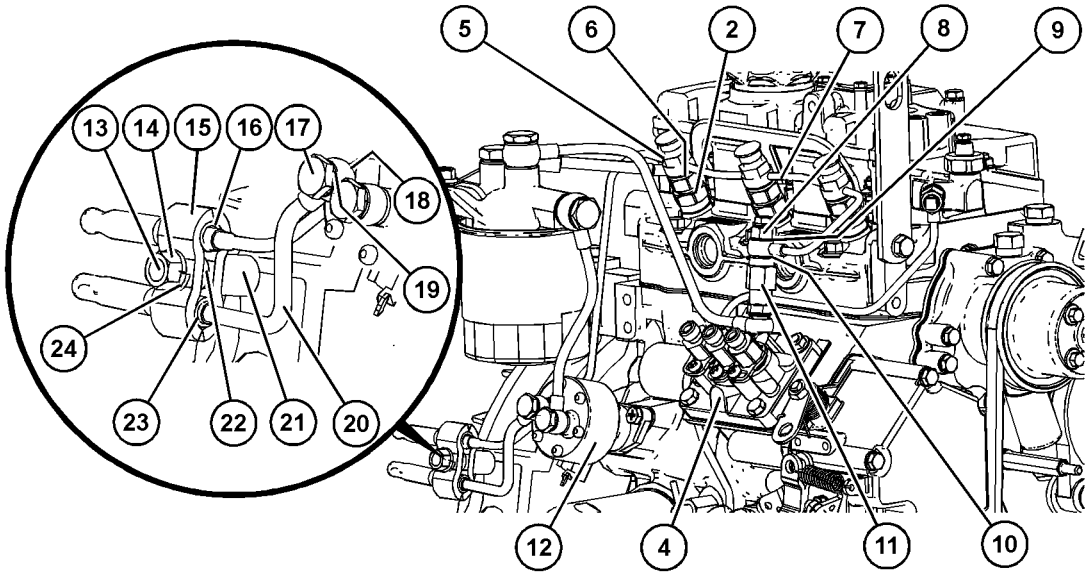

Illustration 36 g06543874
Typical Example

7. Follow Step 7a through Step 7l to remove low-pressure fuel line (7) and low-pressure fuel line (20).

a. Disconnect fuel lines from low-pressure fuel line (7) and low-pressure fuel line (20).

b. Remove nut (14), lock washer (24), pipe clamp (15), and spacer (22) from stud (13).

c. Remove nuts (5) from fuel injectors (2).

Note: Note nuts position and orientation for installation purposes.

d. Remove banjo bolt (8) from low-pressure fuel line (7).

e. Remove sealing washer (9) (not shown) and sealing washer (10) (not shown) from low-pressure fuel line (7) Discard the sealing washers.

f. Remove low-pressure fuel line (7) from fuel injectors (2). Remove sealing washers (6) (not shown). Discard the sealing washers.

g. If necessary, remove rubber sleeve (16) from low-pressure fuel line (7).

Note: Note the rubber sleeve position for installation purposes.

h. If necessary, remove banjo bolt (17) from low-pressure fuel line (20).

i. Remove sealing washer (18) (not shown) and sealing washer (19) (not shown) from low-pressure fuel line (20). Discard the sealing washers.

j. If necessary, remove rubber sleeve (23) from low-pressure fuel line (20).

Note: Note the rubber sleeve position for installation purposes.

k. If necessary, remove bottom section of pipe clamp (15).

l. If necessary, remove spacer (21) and stud (13) from the flywheel housing.

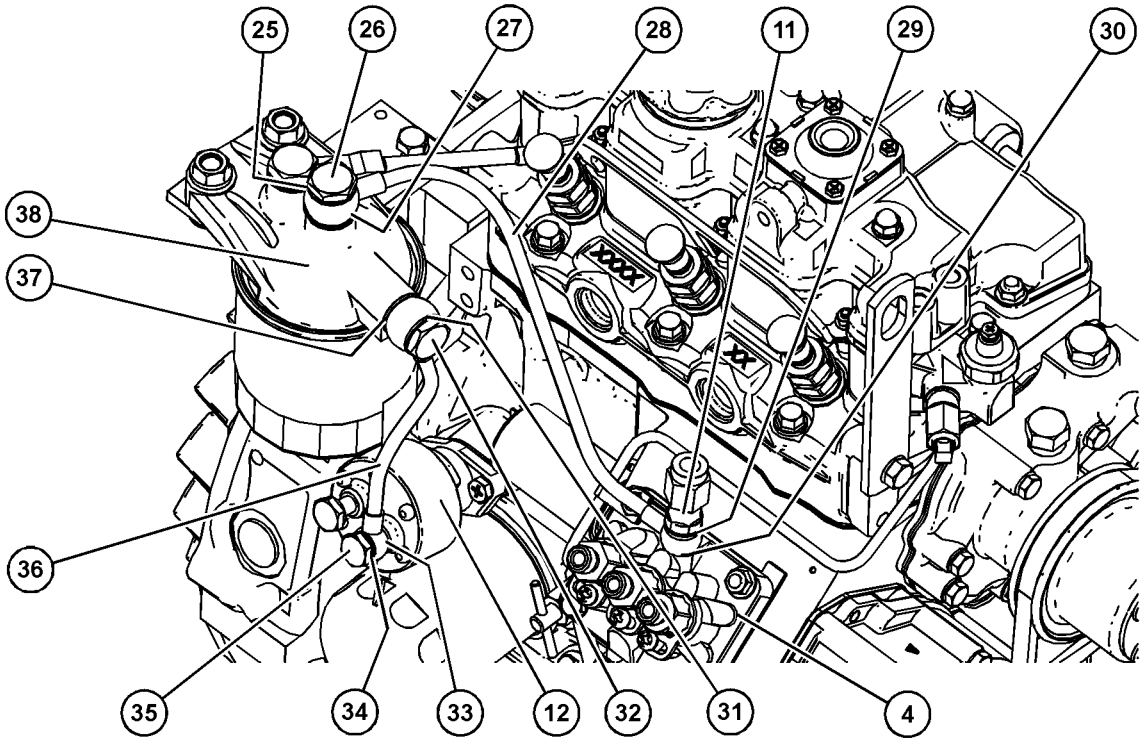

Illustration 37 g06543850

Typical Example

8. Remove connector (11) and banjo bolt (26) from low-pressure fuel pipe (28). Remove the low-pressure fuel line from fuel filter base (38) and fuel injection pump (4). Remove sealing washer (29) (not shown) and sealing washer (30) (not shown) from the connector. Discard the sealing washers.

9. Remove sealing washer (27) (not shown) and sealing washer (25) (not shown) from banjo bolt (26). Discard the sealing washers.

10. Remove banjo bolt (32) and banjo bolt (35) from low-pressure fuel pipe (36). Remove the low-pressure fuel line from fuel filter base (38) and fuel transfer pump (12). Remove sealing washer (37) (not shown) and sealing washer (31) (not shown) from the banjo bolt. Discard the sealing washers.

11. Remove sealing washer (33) (not shown) and sealing washer (34) (not shown) from banjo bolt (35). Discard the sealing washers.

Installation Procedure

Table 3

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

1. Ensure that all components are free from wear and damage. Replace any component that is worn or damaged.

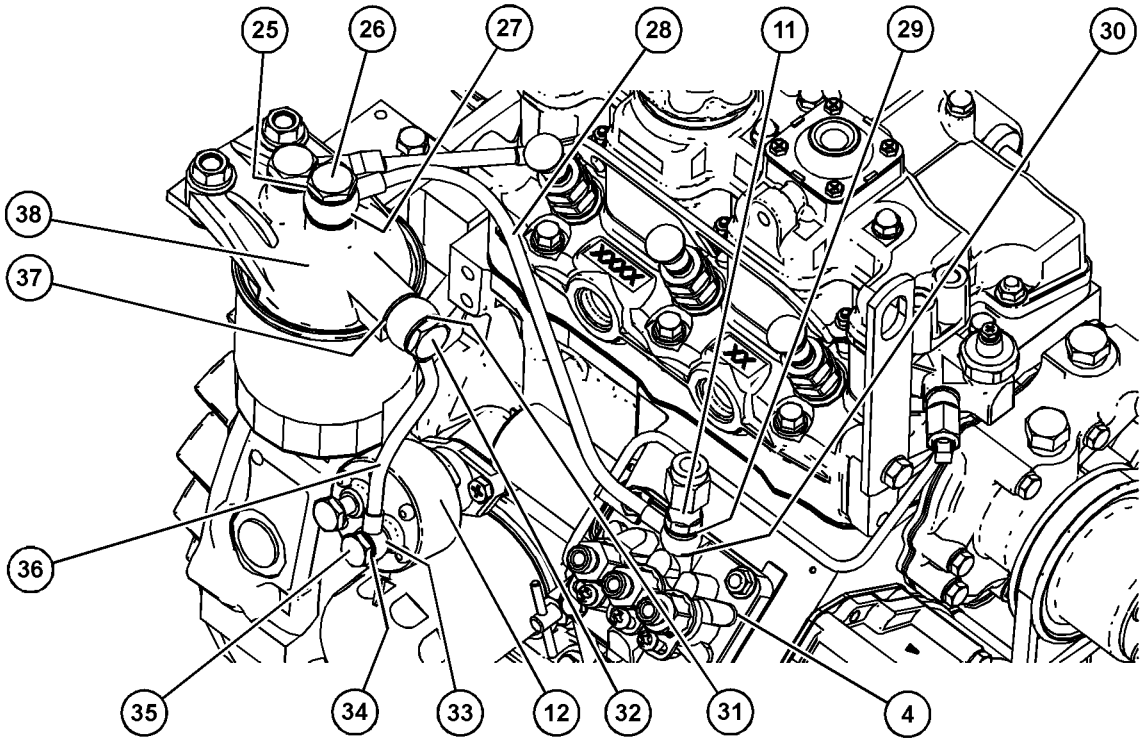

Illustration 38 g06543850

Typical Example

2. Follow Step 2a through Step 2e to install low-pressure fuel line (36).

a. Install new sealing washer (31) (not shown) onto banjo bolt (32). Position the banjo bolt assembly into low-pressure fuel line (36), and position a new sealing washer (37) (not shown) onto the banjo bolt assembly.

b. Install banjo bolt and pipe assembly (36) into fuel filter base (38), and tighten the banjo bolt finger tight.

c. Position new sealing washer (34) (not shown) onto banjo bolt (35). Position new sealing washer (33) (not shown) between low-pressure fuel line (36) and fuel transfer pump (12). Install the banjo bolt assembly to the low-pressure fuel line and the new sealing washer. Tighten the banjo bolt finger tight.

Note: When, installing banjo bolt (35) ensure that the new sealing washer (33) (not shown) is installed correctly.

d. Tighten banjo bolt (32) to a torque of 17 N·m (151 lb in).

e. Tighten banjo bolt (35) to a torque of 12 N·m (106 lb in).

3. Follow Step 3a through Step 3e to install low-pressure fuel line (28).

a. Install new sealing washer (25) (not shown) onto banjo bolt (26). Position the banjo bolt assembly into low-pressure fuel line (28), and position a new sealing washer (27) (not shown) onto the banjo bolt assembly.

b. Install banjo bolt and pipe assembly (28) into fuel filter base (38), and tighten the banjo bolt finger tight.

c. Position new sealing washer (29) (not shown) onto connector (11). Position new sealing washer (30) (not shown) between low-pressure fuel line (28) and fuel injection pump (4). Install the connector assembly to the low-pressure fuel line and the new sealing washer. Tighten the connector finger tight.

Note: When, installing connector (11) ensure that the new sealing washer (30) (not shown) is installed correctly.

d. Tighten banjo bolt (26) to a torque of 17 N·m (151 lb in).

e. Tighten connector (11) to a torque of 17 N·m (151 lb in).

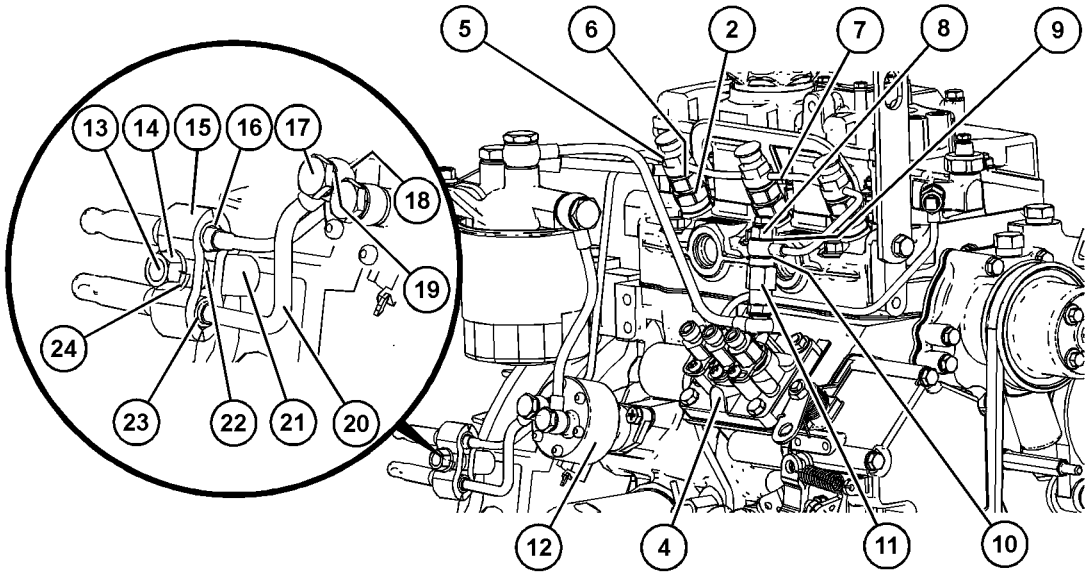

Illustration 39 g06543874
Typical Example

4. Follow Step 4a through Step 4l to install low-pressure fuel line (7) and low-pressure fuel line (20).

a. If necessary, install stud (13) to the flywheel housing. Tighten the stud to a torque of 11 N·m (97 lb in). Position spacer (21) and bottom half of pipe clamp (15) onto the stud.

b. If necessary, position rubber sleeve (23) onto low-pressure fuel line (20) in the position noted on removal.

c. Install new sealing washer (19) (not shown) onto banjo bolt (17). Position the banjo bolt assembly into low-pressure fuel line (20), and position a new sealing washer (18) (not shown) onto the banjo bolt assembly.

d. Install banjo bolt and pipe assembly (20) into fuel transfer pump (12), and tighten the banjo bolt finger tight.

e. If necessary, position rubber sleeve (16) onto low-pressure fuel line (7) in the position noted on removal.

f. Install new sealing washer (9) (not shown) onto banjo bolt (8). Position the banjo bolt assembly into low-pressure fuel line (7), and position a new sealing washer (10) (not shown) onto the banjo bolt assembly.

g. Install new sealing washers (6) (not shown) onto fuel injectors (2). Position low-pressure fuel line (7)onto the fuel injectors. Install banjo bolt assembly (8) into connector (11) finger tight.

h. Install nuts (5)in the position and orientation noted on removal finger tight.

i. Position spacer (22), and pipe clamp (15) onto stud (13), install lockwasher (24) and nut (14) onto the stud, tighten the nut finger tight.

j. Tighten nut (5) to a torque of 27 N·m (239 lb in).

k. Tighten banjo bolt (8) to a torque of 7 N·m (62 lb in).

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

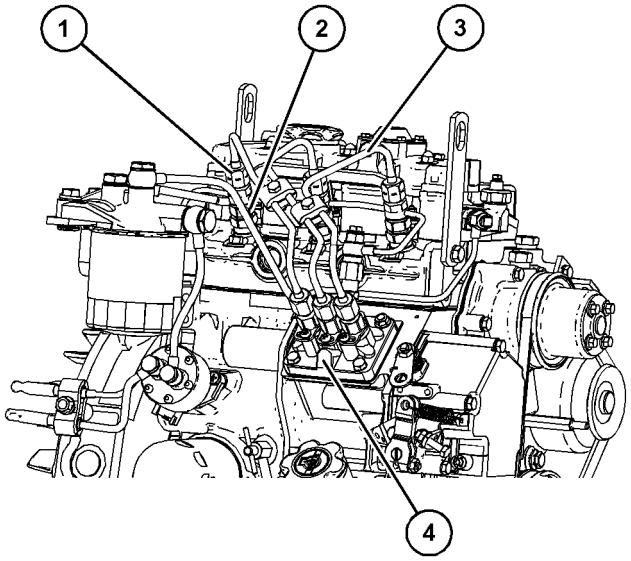

Illustration 40 g06530092
Typical example

5. Position fuel injection lines (3) onto fuel injectors (2) and fuel injection pump (4), install tube nuts (1) finger tight.

6. Using Tooling (A) tighten the tube nuts (1) to a torque of 20 N·m (177 lb in).

7. Turn the fuel supply to the ON position.

End By:

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

i08148435

Fuel Lines - Remove and Install
(403F-11 - If Equipped)

Removal Procedure

Table 4

Required Tools			
Tool	Part Number	Description	Qty
A	27610294	Injector Pipe Nut Tool	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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug all lines and tube assemblies to prevent contamination.

1. Turn the fuel supply to the OFF position.

2. Place suitable container below the engine to catch any fuel that might be spilled.

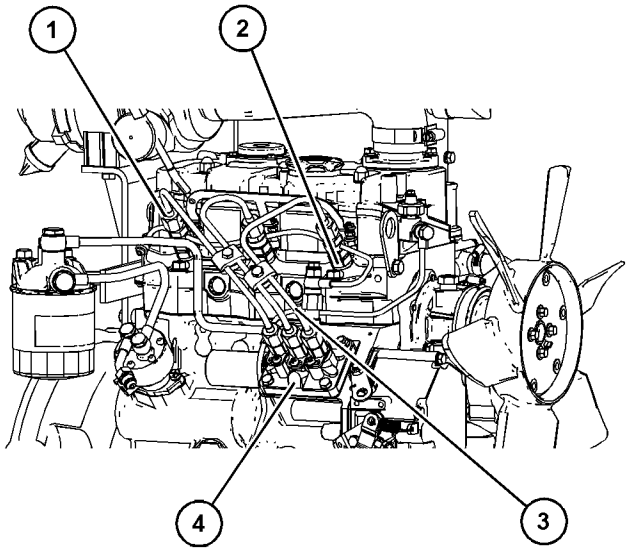

Illustration 41 g06566209
Typical Example

3. Using Tool (A) disconnect tube nuts (1) for fuel injection lines (2) from fuel injectors (3).

4. Using Tool (A) disconnect tube nuts (1) for fuel injection lines (2) from fuel injection pump (4).

5. Remove fuel injection lines (2) from the engine as a unit.

6. Use suitable caps to plug the open ports of the fuel injection pump immediately.

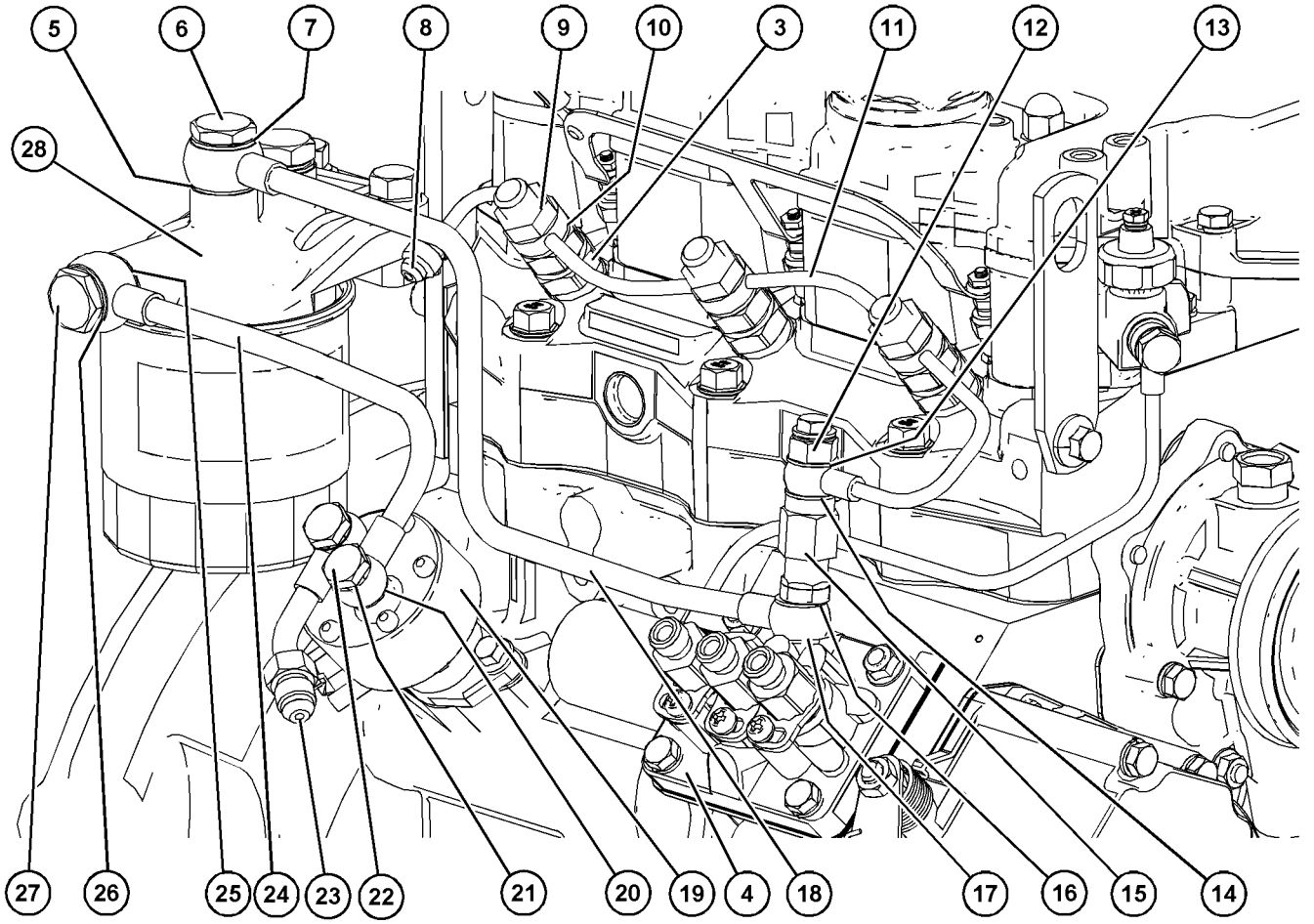

Illustration 42 g06539283

Typical Example

7. Disconnect Original Engine Manufacturer (OEM) fuel lines from connection (8) and connection (23).

8. Follow Step 8a through Step 8d to remove low-pressure fuel line (24).

a. Loosen banjo bolt (22) and banjo bolt (27).

b. Remove banjo bolt (22) and sealing washer (21) (not shown), from low-pressure fuel line (24). Remove sealing washer (20) (not shown), from between the low-pressure fuel line and fuel transfer pump (19).

Note: Note banjo bolt position for installation purposes.

c. Support low-pressure fuel line (24). Remove banjo bolt (27) and sealing washer (26) (not shown), from low-pressure fuel line. Remove sealing washer (25) (not shown), from between the low-pressure fuel line and fuel filter base (28).

Note: Note banjo bolt position for installation purposes.

d. Remove low-pressure fuel line (24) from fuel transfer pump (19) and fuel filter base (28).

Note: Note low-pressure fuel line position and orientation for installation purposes.

9. Follow Step 9a through Step 9c to remove low-pressure fuel line (11).

a. Remove banjo bolt (12) and sealing washer (13) (not shown), from connector (15). Remove sealing washer (14) (not shown), from between the low-pressure fuel line (11) and the connector.

b. Remove nuts (9) from injectors (3).

Note: Note nut orientation and position for installation purposes.

c. Remove low-pressure fuel line (11) from injectors (3). Remove sealing washers (10) (not shown) from the injectors.

Note: Note low-pressure fuel line position and orientation for installation purposes.

Note: Note sealing washers position for installation purposes.

10. Follow Step 10a through Step 10d to remove low-pressure fuel line (18).

a. Loosen banjo bolt (6) and connector (15).

b. Remove connector (15) and sealing washer (16) (not shown), from low-pressure fuel line (18). Remove sealing washer (17) (not shown) from between the low-pressure fuel line and fuel injection pump (4).

Note: Note connector position for installation purposes.

c. Support low-pressure fuel line (18). Remove banjo bolt (6) and sealing washer (7) (not shown) from the low-pressure fuel line. Remove sealing washer (5) (not shown) from between the low-pressure fuel line and fuel filter base (28).

Note: Note banjo bolt position for installation purposes.

d. Remove low-pressure fuel line (18) from fuel injection pump (4) and fuel filter base (28).

Note: Note low-pressure fuel line position and orientation for installation purposes.

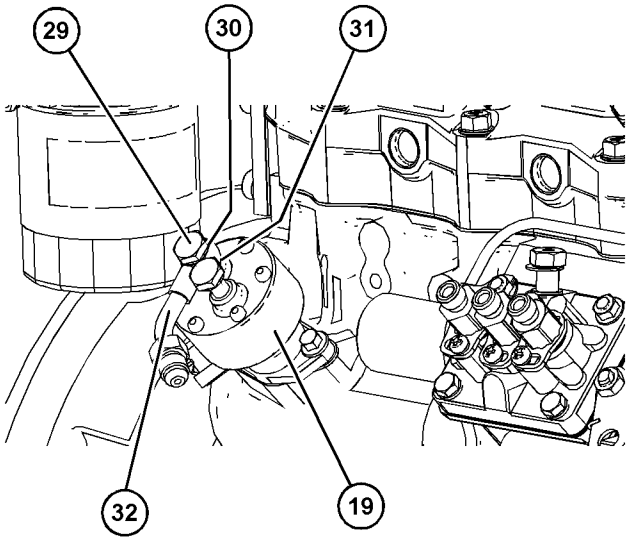

Illustration 43 g06539697

Typical Example

11. If necessary, follow Step 11a through Step 11c to remove low-pressure line (32).

a. Loosen banjo bolt (29).

b. Remove banjo bolt assembly (29) from fuel transfer pump (19). Remove banjo bolt assembly from the fuel transfer pump.

Note: Note low-pressure line position and orientation for installation purposes.

c. Remove sealing washer (31) (not shown), low-pressure fuel line (32), and sealing washer (30) from banjo bolt (29).

Note: Note low-pressure line orientation for installation purposes.

Installation Procedure

Table 5

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

1. Ensure that all components are free from wear and damage. Replace any component that is worn or damaged.

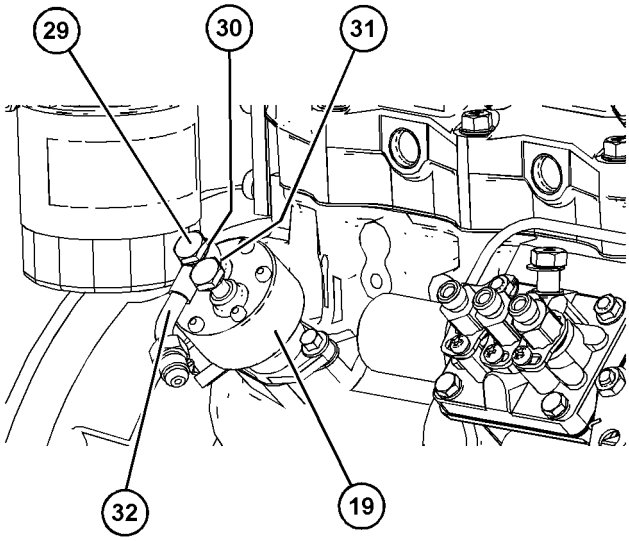

Illustration 44 g06539697
Typical Example

2. If necessary, follow Step 11a through Step 11c to install low-pressure line (32).

a. Position new sealing washer (30) (not shown), low-pressure fuel line (32), and new sealing washer (31) (not shown) on to banjo bolt (29).

Note: Ensure that the low-pressure fuel line (32) is correctly orientated.

b. Install the banjo bolt assembly (29) into the fuel transfer pump (19) and tighten to a torque of 12 N·m (106 lb in).

Note: Ensure that the low-pressure fuel line (32) is correctly orientated and positioned.

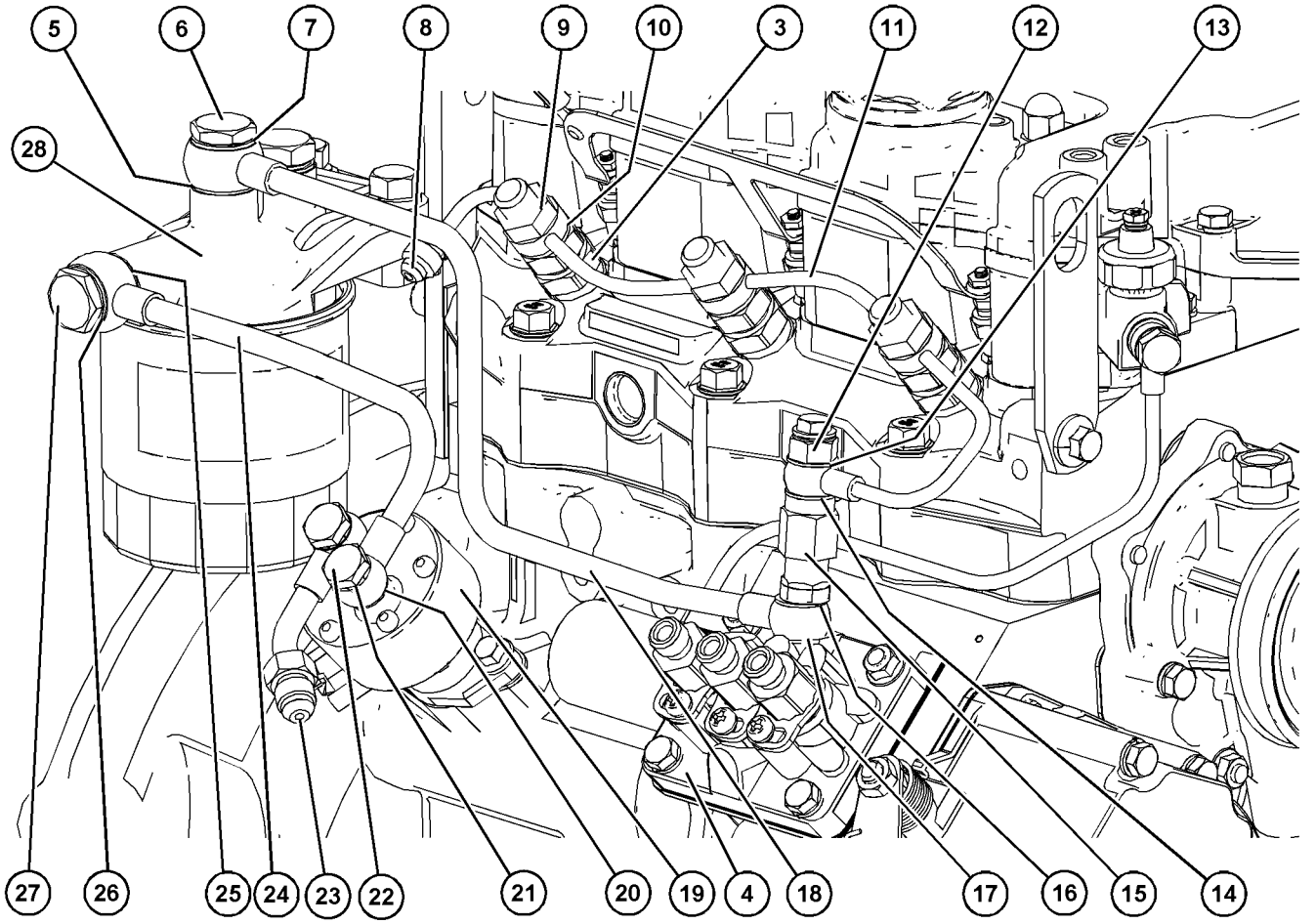

Illustration 45 g06539283
Typical Example

3. Follow Step 3a through Step 3f to install low-pressure fuel line (18).

a. Position new sealing washer (7) onto banjo bolt (6). Install the banjo bolt assembly into low-pressure fuel line (18) in the position noted on removal. Position new sealing washer (5) onto the low-pressure fuel line assembly.

b. Install banjo bolt assembly (6) to fuel filter base (28) finger tight.

Note: Note ensure that new sealing washer (5) is installed correctly.

c. Position new sealing washer (16) onto connector (15).

d. Position new sealing washer (17) between low-pressure fuel line (18) and the fuel injection pump (4). Install connector (15) finger tight.

Note: Note ensure that new sealing washer (17) is installed correctly.

e. Tighten banjo bolt (6) to a torque of 17 N·m (151 lb in).

f. Tighten connection (15) to a torque of 17 N·m (151 lb in).

4. Follow Step 4a through Step 4f to install low-pressure fuel line (11).

a. Position new sealing washers (10) (not shown) onto fuel injectors (3) in the positions noted on removal.

b. Position low-pressure fuel line (11) onto fuel injectors (3). Install nuts (9) to the fuel injectors finger tight.

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

d. Position new sealing (14) between low-pressure fuel line (11) and connector (16). Install banjo bolt assembly (12) to the low-pressure fuel line and the connector, tighten the

banjo bolt finger tight.

Note: Note ensure that new sealing washer (14) is installed correctly.

e. Tighten nuts (10) (not shown) to a torque of 27 N·m (239 lb in).

f. Tighten banjo bolt (12) to a torque of 17 N·m (151 lb in).

5. Follow Step 5a through Step 5f to install low-pressure fuel line (24).

a. Position new sealing washer (26)onto banjo bolt (27). Install the banjo bolt assembly into low-pressure fuel line (24) in the position noted on removal. Position new sealing washer (25) onto the low-pressure fuel line assembly.

b. Install banjo bolt assembly (27) to fuel filter base (28) finger tight.

Note: Note ensure that new sealing washer (25) is installed correctly.

c. Position new sealing washer (21) onto banjo bolt (22).

d. Position new sealing (20) between low-pressure fuel line (24) and fuel transfer pump (19). Install banjo bolt assembly (22) to the low-pressure fuel line and the fuel transfer pump, tighten the banjo bolt finger tight.

e. Tighten banjo bolt (22) to a torque of 12 N·m (106 lb in).

f. Tighten banjo bolt (27) to a torque of 17 N·m (151 lb in).

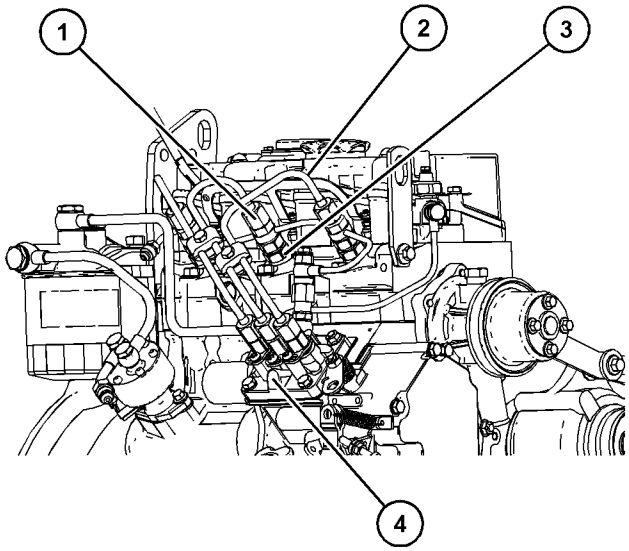

Illustration 46 g06539263
Typical Example

6. Remove the caps from the outlet connections of the fuel injection pump. Install the fuel injection lines to the engine as a unit.

7. Position fuel injection lines (2) onto fuel injectors (3) and fuel injection pump (4). Tighten the tube nuts (1) finger tight.

8. Use Tooling (A) to tighten tube nuts (1) at the fuel injection pump to a torque of 20 N·m (15 lb ft).

9. Use Tooling (A) to tighten tube nuts (1) at the fuel injectors to a torque of 20 N·m (15 lb ft).

10. Reconnect Original Engine Manufacturer (OEM) fuel lines from connection (8) and connection (23).

11. Turn the fuel supply to the ON position.

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

i07676447

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

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.

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. Plugging the hose assemblies and tube assemblies helps to prevent fluid loss and keep contaminants from entering the fuel system.

1. Turn the fuel supply to the OFF position.

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

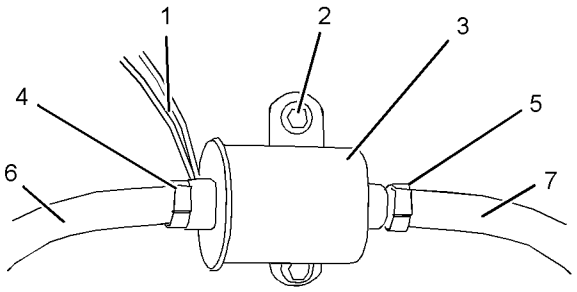

Illustration 47 g01304057
Typical example

3. Disconnect harness assembly (1).

4. Loosen hose clamps (4) and (5). Disconnect hose (6) and hose (7).

5. Remove bolts (2) and remove electric transfer pump (3).

Installation Procedure

1. Ensure that the electric transfer pump is clean and free from damage. If necessary, replace the electric transfer pump.

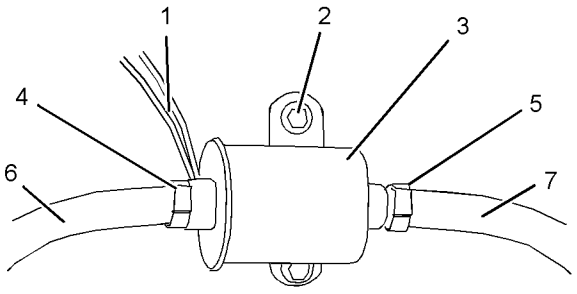

Illustration 48 g01304057
Typical example

2. Position electric transfer pump (3) on the mounting and install bolts (2).

3. Tighten bolts (2) to a torque of 9 N·m (79 lb in).

4. Connect hose (6) and hose (7). Securely tighten hose clamp (4) and hose clamp (5).

5. Connect harness assembly (1).

6. Turn the fuel supply to the ON position.

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

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

i07676450

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

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.

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. Plugging the hose assemblies and tube assemblies helps to prevent fluid loss and keep contaminants from entering the fuel system.

1. Turn the fuel supply to the OFF position.

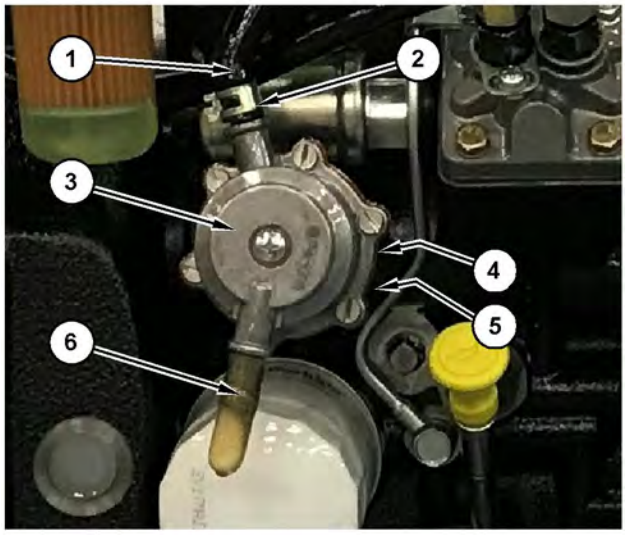

Illustration 49 g06275640
Typical example

2. Use suitable tooling to compress clip (2) on hose assembly (1). Move the clip up the hose assembly. Disconnect the hose assembly from mechanical transfer pump (3). Plug and cap all open ports.

3. Disconnect the Original Equipment Manufacture (OEM) hose assembly from connection (6). Refer to the OEM for the correct procedure. Plug and cap all open ports.

4. Remove bolts (4) (not shown). Remove mechanical transfer pump (3). Remove gasket (5) (not shown).

Installation Procedure

1. Ensure that the mechanical transfer pump is clean and free from damage. If necessary, replace the mechanical transfer pump.

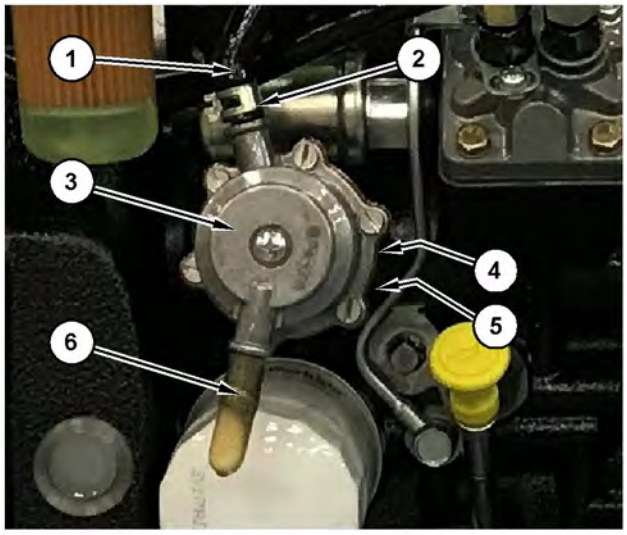

Illustration 50 g06275640
Typical example

2. Install a new gasket (5) (not shown) onto mechanical transfer pump (3).

3. Install mechanical transfer pump (3). Ensure that the mechanical transfer pump is correctly orientated. Install bolts (4) (not shown) hand tight. Ensure that the mechanical transfer pump is correctly seated onto the cylinder block.

4. Tighten bolts (4) (not shown) to a torque of 9 N·m (79 lb in).

5. Remove plug and cap from all open ports. Connect the OEM hose assembly to connection (6). Refer to the OEM for the correct procedure.

6. Remove plug and cap from all open ports. Connect hose assembly (1) to mechanical transfer pump (3). Use suitable tooling to compress clip (2) on the hose assembly and move the clip up the hose assembly. Ensure that the clip is correctly positioned onto the hose assembly.

7. Turn the fuel supply to the ON position.

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

i08095596

Fuel Transfer Pump - Remove and Install
(402F-05 - If Equipped)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

1. Turn the fuel supply to the “OFF” position.

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

3. Thoroughly clean the area around the fuel transfer pump and associated fuel lines before disassembly.

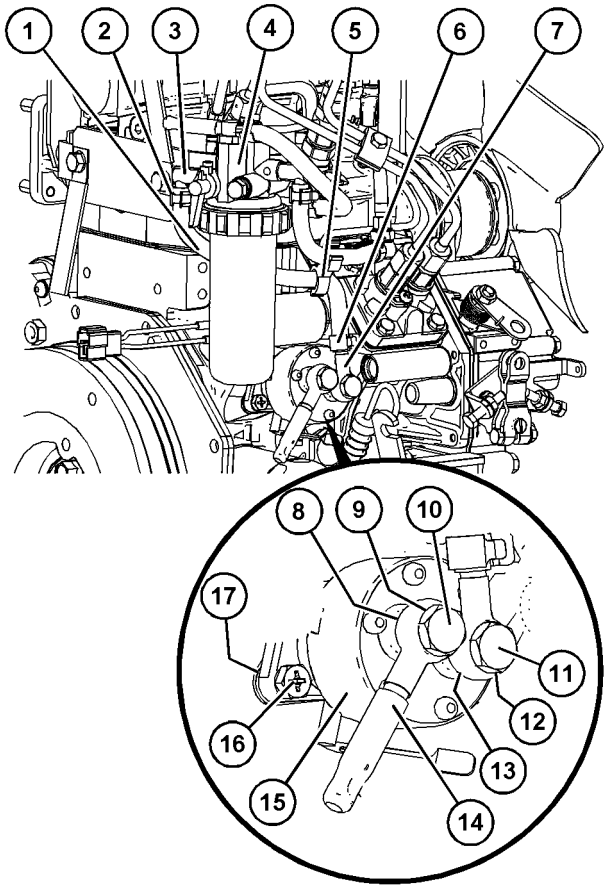

Illustration 51 g06532464

Typical example

4. Follow Step 4a through Step 4h to remove low-pressure fuel line (1) and low-pressure fuel line (14).

a. Place a suitable container below the assembly of fuel transfer pump (15) and fuel filter base (4) to catch any fuel that might be spilled.

b. Disconnect fuel line from low-pressure fuel line (14).

c. Remove banjo bolt (10) from low-pressure fuel line (14). Remove the low-pressure fuel line from fuel transfer pump (15).

Note: Note orientation and position of the low-pressure fuel line.

d. Remove sealing washer (8) (not shown) and remove sealing washer (9) (not shown) from banjo bolt (10). Discard the sealing washers.

e. Remove low-pressure tube (1) from hose clamp (5).

f. If necessary, using a suitable tool position hose clamp (6) away from connection (7) and hose clamp (2) away from connection (3). Remove tube assembly (1) from the connections. Remove the hose clamps from the tube assembly.

Note: Note orientation and position of the clamps and hose assembly for installation purposes.

g. Remove banjo bolt (11) from connection (7). Remove the connection from fuel transfer pump (15).

Note: Note orientation and position of the low-pressure fuel line.

h. Remove sealing washer (12) (not shown) and remove sealing washer (13) (not shown) from banjo bolt (11). Discard the sealing washers.

5. Remove the two bolt assemblies (16) that fasten the fuel transfer pump (15) to the cylinder block.

Note: note the orientation of the fuel transfer pump for installation purposes.

6. Remove fuel transfer pump (15) from the engine block. Remove gasket (17) (not shown). Discard the gasket.

Note: To remove the fuel transfer pump from the engine, it may be necessary to rotate the crankshaft until the operating plunger of the fuel priming pump is not under pressure.

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

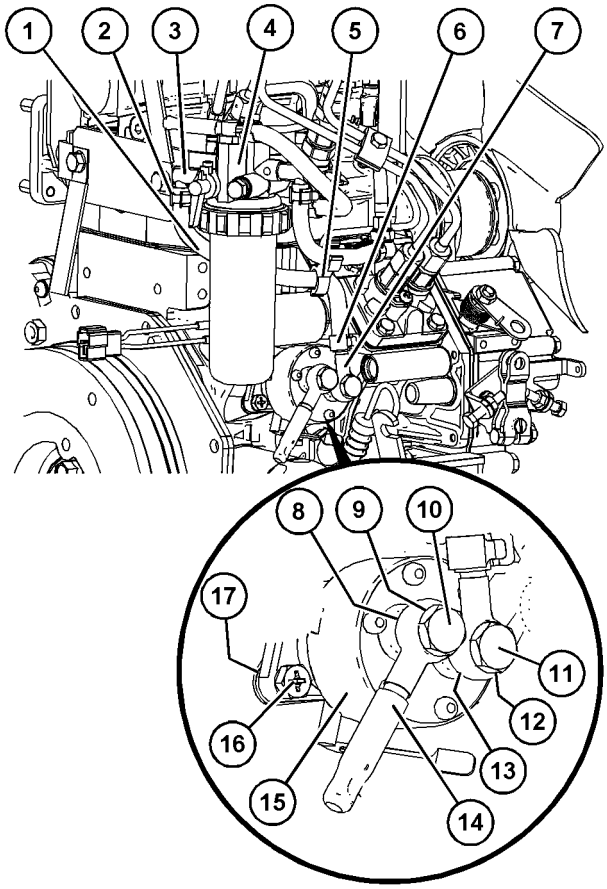

Illustration 52 g06532464
Typical example

2. Clean the mating surfaces of the fuel transfer pump on the cylinder block and clean the flange of fuel transfer pump (15).

Note: Ensure that the camshaft lobe for the fuel transfer pump is at minimum lobe lift before the fuel transfer pump is installed.

3. Install bolt assemblies (16) to fuel transfer pump (15). Position new gasket (17) (not shown) onto the bolt assemblies.

4. Lubricate the operating plunger of the fuel transfer pump (15) with clean engine oil.

5. Position fuel transfer pump (15) onto the cylinder block in the orientation noted on removal. Ensure that the operating plunger is positioned correctly on the camshaft lobe.

6. Install bolt assemblies (16) to the cylinder block. Tighten the bolt assemblies to a torque of 10 N·m (89 lb in).

7. Follow Step 7c through Step 7i to install low-pressure fuel line (1) and low-pressure fuel line (14).

a. Install new sealing washer (12) (not shown) onto banjo bolt (10). Position the banjo bolt assembly into connection (7), and position new sealing washer (13) (not shown) onto the banjo bolt assembly.

b. Install the banjo bolt and connection assembly (7) into fuel transfer pump (15) in the position noted on removal, and tighten the banjo bolt finger tight.

c. Install new sealing washer (9) (not shown) onto banjo bolt (10). Position the banjo bolt assembly into low-pressure fuel line (14), and position new sealing washer (8) (not shown) onto the banjo bolt assembly.

d. Install the banjo bolt and low-pressure fuel line assembly (14) into fuel transfer pump (15) in the position noted on removal, and tighten the banjo bolt finger tight.

e. If necessary, using a suitable tool position new hose clamp (2) and hose clamp (6) onto tube assembly (1).

f. If necessary, install the hose assembly onto connection (7) and connection (3) in the position and orientation noted on removal. Using a suitable reposition hose clamp (2) and hose clamp (6) into the positions noted on removal.

g. Tighten banjo bolt (11) to a torque of 12 N·m (106 lb in).

h. Tighten banjo bolt (10) to a torque of 12 N·m (106 lb in).

i. Install tube assembly (1) into pipe clamp (5).

8. Reconnect fuel line to low-pressure fuel line (14).

9. Turn the fuel supply to the “ON” position.

10. Turn the battery disconnect to the “ON” position.

11. Prime the fuel system. Refer to Testing and Adjusting, “Fuel System - Prime” for additional information.

i08097736

Fuel Transfer Pump - Remove (403F-07 - If Equipped)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

1. Turn the fuel supply to the “OFF” position.

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

3. Thoroughly clean the area around the fuel transfer pump and associated fuel lines before disassembly.

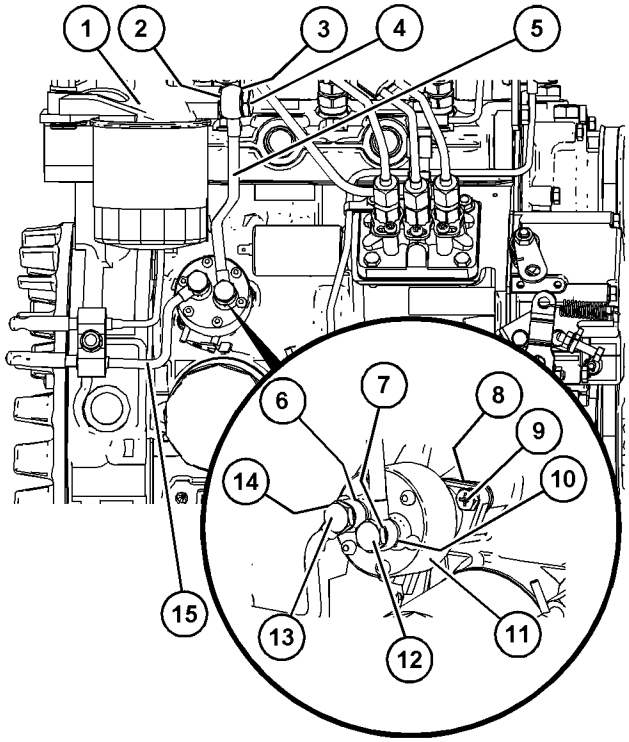

Illustration 53 g06524765
Typical example

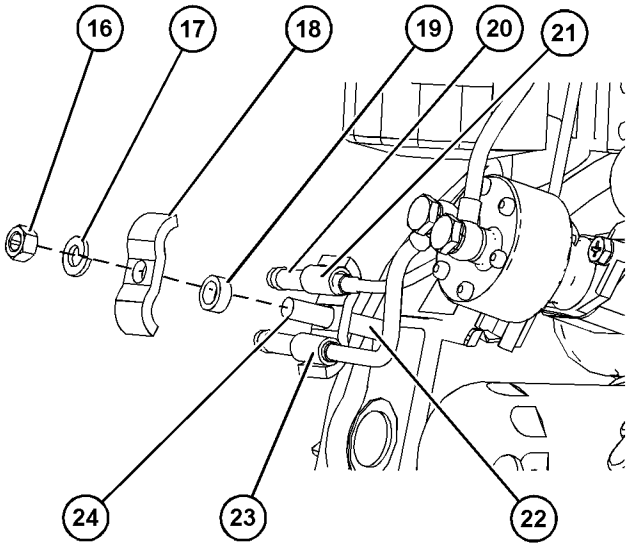

Illustration 54 g06526297
Typical example

4. Follow Step 4a through Step 4j to remove low-pressure fuel line (5) and low-pressure fuel line (15).

a. Place a suitable container below the assembly of fuel transfer pump (11) and fuel filter base (1) to catch any fuel that might be spilled.

b. Disconnect fuel lines from low-pressure fuel line (5) and low-pressure fuel line (15).

c. Remove nut (16), lock washer (17), pipe clamp (18), and spacer (19) from stud (24).

d. Remove banjo bolt (13) from low-pressure fuel line (15). Remove the low-pressure fuel line from fuel transfer pump (11).

e. Remove sealing washer (14) (not shown) and remove sealing washer (6) (not shown) from banjo bolt (13). Discard the sealing washers.

f. Remove banjo bolt (12) and banjo bolt (4) from low-pressure fuel line (5). Remove the low-pressure fuel line from fuel transfer pump (11) and fuel filter base (1). Remove sealing washer (7) (not shown) and sealing washer (10). Discard the sealing washers.

g. Remove sealing washer (3) (not shown) and sealing washer (2) (not shown) from banjo bolt (4). Discard the sealing washers.

h. If necessary, remove rubber sleeve (21) from low-pressure fuel line (20), and rubber sleeve (23) from low-pressure fuel line (15).

Note: Note the rubber sleeve positions for installation purposes.

i. If necessary, remove bottom section of clamp (18).

j. If necessary, remove spacer (22) and stud (24) from the flywheel housing.

5. Remove the two bolt assemblies (9) that fasten the fuel transfer pump (11) to the cylinder block.

Note: note the orientation of the fuel transfer pump for installation purposes.

6. Remove fuel transfer pump (11) from the engine block. Remove gasket (8) (not shown). Discard the gasket.

Note: To remove the fuel transfer pump from the engine, it may be necessary to rotate the crankshaft until the operating plunger of the fuel priming pump is not under pressure.

i08097737

Fuel Transfer Pump - Install (403F-07 - If Equipped)

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

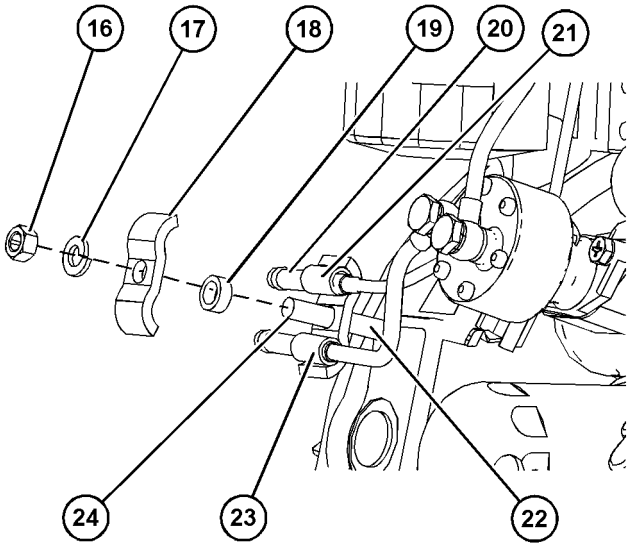

Illustration 55 g06526297
Typical example

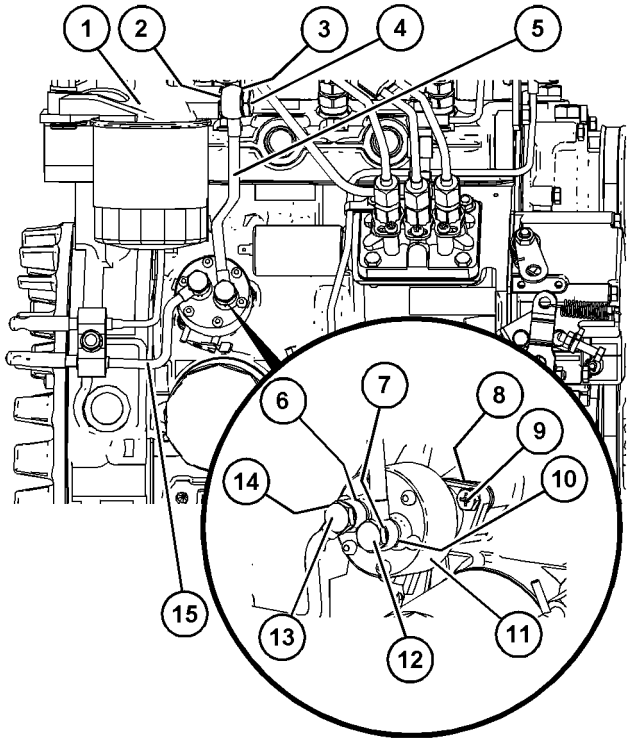

Illustration 56 g06524765
Typical example

2. Clean the mating surfaces of the fuel transfer pump on the cylinder block and clean the flange of fuel Transfer pump (11).

Note: Ensure that the camshaft lobe for the fuel transfer pump is at minimum lobe lift before the fuel Transfer pump is installed.

3. Install bolt assemblies (9) to fuel transfer pump (11). Position new gasket (8) (not shown) onto the bolt assemblies.

4. Lubricate the operating plunger of the fuel transfer pump (11) with clean engine oil.

5. Position fuel transfer pump (11) onto the cylinder block in the orientation noted on removal. Ensure that the operating plunger is positioned correctly on the camshaft lobe.

6. Install bolt assemblies (9) to the cylinder block. Tighten the bolt assemblies to a torque of 10 N·m (89 lb in).

7. Follow Step 7a through Step 7k to install low-pressure fuel line (5) and low-pressure fuel line (15).

a. If necessary, install stud (24) to the flywheel housing. Tighten the stud to a torque of 11 N·m (97 lb in). Position spacer (22), bottom half of pipe clamp (18) onto the stud.

b. If necessary' position rubber sleeve (21) onto low-pressure fuel line (20) and rubber sleeve (23) onto low-pressure fuel line (15) in the positions noted on removal.

c. Install new sealing washer (3) (not shown) onto banjo bolt (4). Position the banjo bolt assembly into low-pressure fuel line (5), and position new sealing washer (2) (not shown) onto the banjo bolt assembly.

d. Install the banjo bolt and pipe assembly (5) into fuel filter base (1), and tighten the banjo bolt finger tight.

e. Position new sealing washer (7) (not shown) onto banjo bolt (12). Position new sealing washer (10) (not shown) between low-pressure fuel line (5) and the fuel transfer pump (11). Install the banjo bolt assembly to the union and the new sealing washer. Tighten the banjo bolt finger tight.

Note: When, installing banjo bolt (12) ensure that the new sealing washer (10) (not shown) is installed correctly.

f. Position new sealing washer (14) (not shown) onto banjo bolt (13). Position the banjo bolt assembly into low-pressure fuel line (15). Install new sealing washer (6) (not shown) between low-pressure fuel line (15) and the fuel transfer pump (11). Install the banjo bolt assembly to the

union and the new sealing washer. Tighten the banjo bolt finger tight.

g. Position spacer (19), and pipe clamp (18) onto stud (24), install lockwasher (17) and nut (16) onto the stud, tighten the nut finger tight.

h. Tighten banjo bolt (4) to a torque of 17 N·m (151 lb in).

i. Tighten banjo bolt (12) to a torque of 12 N·m (106 lb in).

j. Tighten banjo bolt (13) to a torque of 12 N·m (106 lb in).

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

8. Reconnect fuel lines to low-pressure fuel line (5) and low-pressure fuel line (15).

9. Turn the fuel supply to the “ON” position.

10. Turn the battery disconnect to the “ON” position.

11. Prime the fuel system. Refer to Testing and Adjusting, “Fuel System - Prime” for additional information.

i07676452

Fuel Injection Lines - 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.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: Place identification marks on all tube assemblies for installation. Plug all lines and tube assemblies to prevent contamination.

Note: The removal procedure for the fuel injection lines is similar for the 402F-05, 403F-07, 403F-11, and 403F-15.

1. Turn the fuel supply to the OFF position.

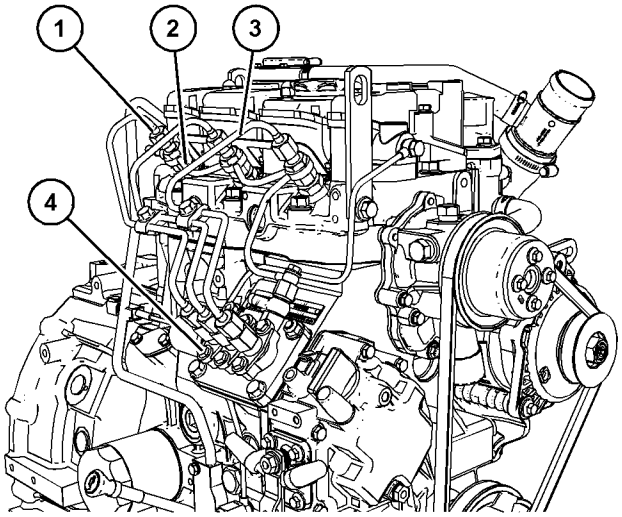

Illustration 57 g06273518
Typical example

2. Disconnect tube nuts (1) for fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

3. Remove fuel injection lines (3) from fuel injectors (2) and fuel injection pump (4).

4. Use suitable caps to cap the open ports of fuel injectors (2) and fuel injection pump (4) immediately.

5. Use suitable caps to cap the open ports of fuel injection lines (3) immediately.

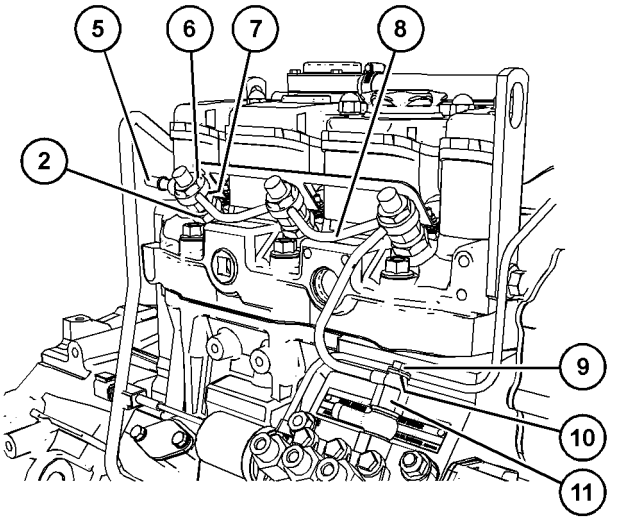

Illustration 58 g06273540
Typical example

6. If necessary, follow Step 6a through Step 6f to remove fuel return line (8).

a. Temporarily remove caps from fuel injectors (2).

b. Disconnect the Original Equipment Manufacture (OEM) fuel line from connection (5).

c. Remove nuts (6) from fuel injectors (2).

d. Remove banjo bolt (9) from adapter (11). Remove sealing washers (10) (not shown).

e. Remove fuel return line (8) and sealing washers (7) (not shown) from fuel injectors (2).

f. Install the caps to fuel injectors (2).

Installation Procedure

Table 6

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Do not let the tops of fuel injectors turn when the fuel line nuts are loosened or tightened.

The fuel injectors will be damaged if the top of the injector turns in the body.

The engine will be damaged if a defective fuel injector is used because the shape of fuel (spray pattern) that comes out of the nozzle will not be correct.

Note: The installation procedure for the fuel injection lines is similar for the 402F-02, 403F-07, 403F-11, and 403F-15.

1. Ensure that all components are free from wear, restriction, or damage. If necessary, replace any component that is not free from wear, restriction, or damage.

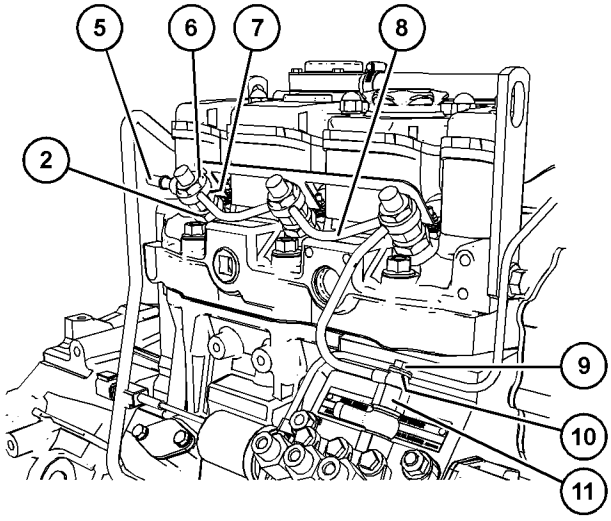

Illustration 59 g06273540
Typical example

2. If necessary, follow Step 6a through Step 2i to install fuel return line (8).

a. Temporarily remove caps from fuel injectors (2).

b. Install new sealing washers (7) (not shown) to fuel injectors (2).

Note: The sealing washers (7) (not shown) have two small holes.

c. Install fuel return line (8) onto fuel injectors (2). Ensure that the fuel return line is correctly orientated.

d. Install nuts (6) to fuel injectors (2).

e. Install a new sealing washer (7) (not shown) onto banjo bolt (9). Install the banjo bolt to fuel return line (8) and install remaining sealing washer. Hand tighten the banjo bolt.

f. Connect the OEM fuel line from connection (5).

g. Install the caps to fuel injectors (2).

h. Tighten nuts (6) to a torque of 27 N·m (239 lb in).

i. Tighten banjo bolt (9) to a torque of 7 N·m (62 lb in).

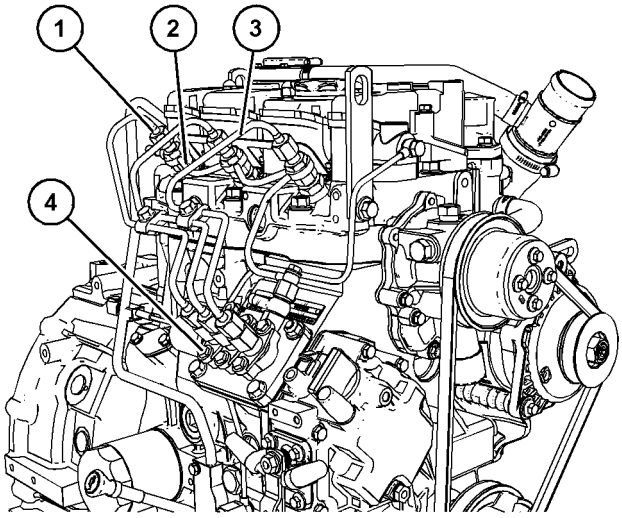

Illustration 60 g06273518
Typical example

3. Remove caps from fuel injectors (2) and fuel injection pump (4).

4. Remove caps from fuel injection lines (3) Position the fuel injection lines onto fuel injectors (2) and fuel injection pump (4).

5. Position fuel injection lines (3) onto fuel injectors (2) and fuel injection pump (4). Connect tube nuts (1) for the fuel injection lines to the fuel injectors and the fuel injection pump hand tight.

6. For 402F-05, and 403F-07 engines. Use Tooling (A) to tighten tube nuts (1) to a torque of 20 N·m (177 lb in).

7. For 403F-11, and 403F-15, 403J-17T engines. Use Tooling (A) to tighten tube nuts (1) to a torque of 23 N·m (204 lb in).

8. Turn the fuel supply to the ON position.

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

i08106554

Fuel Shutoff Solenoid - 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.

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

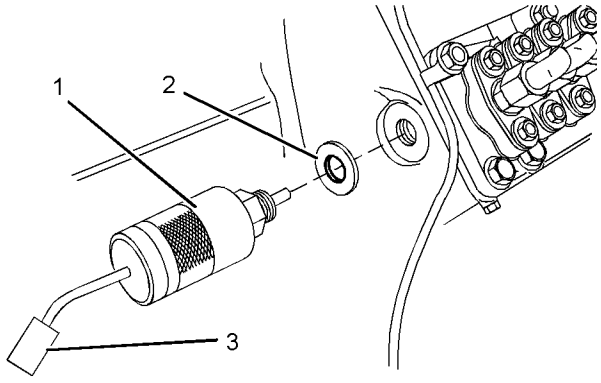

Illustration 61 g01326564
Typical example

2. Disconnect electrical connection (3) from the Original equipment Manufacture (OEM) harness assembly.

3. Remove fuel shutoff solenoid (1) from the fuel injection pump housing by rotating the fuel shutoff solenoid in a counterclockwise direction.

4. Remove sealing washer (2) from fuel shutoff solenoid (1).

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 or damage. If necessary, replace any component the are worn or damaged.

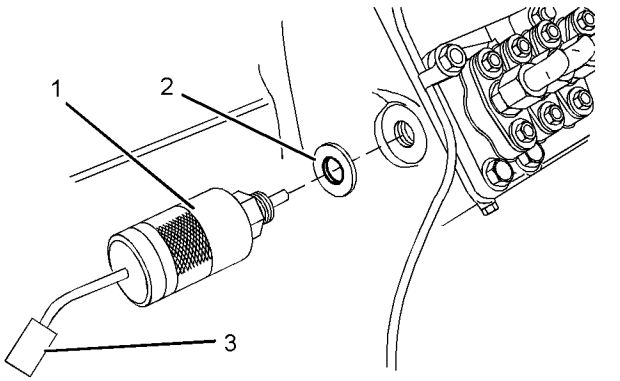

Illustration 62 g01326564
Typical example

2. Install sealing washer (2) to fuel shutoff solenoid (1).

3. Install fuel shutoff solenoid (1) into the fuel injection pump housing by rotating the fuel shutoff solenoid in a clockwise direction. Tighten the fuel shutoff solenoid to a torque of 26 N·m (230 lb in).

4. Connect electrical connection (3) to the OEM harness assembly.

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

i07676456

Fuel Injection Pump - Remove and Install

Removal Procedure

Start By:

a. Remove the fuel shutoff solenoid. Refer to Disassembly and Assembly, "Fuel Shutoff Solenoid - Remove and Install" for the correct procedure.

b. Remove the fuel injection lines and the tube assembly for fuel return. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove and Install" for correct 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.

Note: The removal procedure is similar for the two cylinder and the three cylinder. The Illustrations show a three cylinder engine.

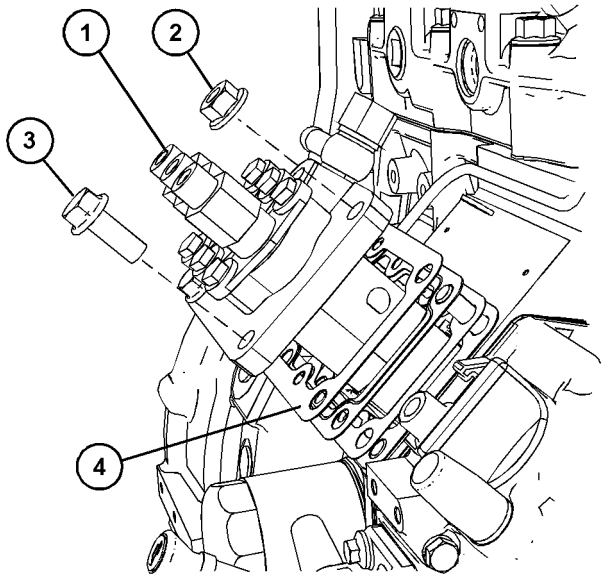

Illustration 63 g06274331
Typical example

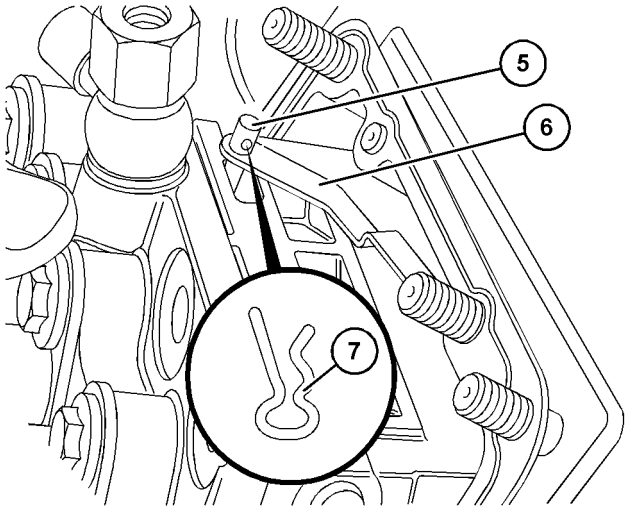

Illustration 64 g06274332
Typical example

1. Gradually loosen bolts (3) and nuts (2) that retain fuel injection pump (1) to the cylinder block.

Note: One of nut (2) retains the clip for the tube assembly for the oil feed.

2. Carefully raise fuel injection pump (1) from the cylinder block and remove clip (7) that connects link (6) to fuel rack control (5).

3. Remove fuel injection pump (1) from the cylinder block.

4. Remove shims (4) from the cylinder block.

Note: Record the thickness of each shim and the number of shims for reassembly. The fuel injection timing is determined by the thickness of the shim pack that is between fuel injection pump (1) and the cylinder block. Refer to Specifications, “Fuel Injection Pump” for further information.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The installation procedure is similar for the two cylinder and the three cylinder. The Illustrations show a three cylinder engine.

1. Clean the gasket surfaces of the cylinder block and the fuel injection pump.

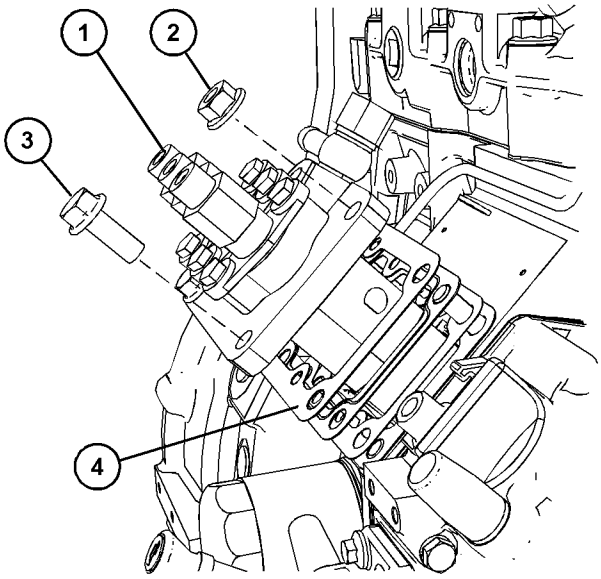

Illustration 65 g06274331
Typical example

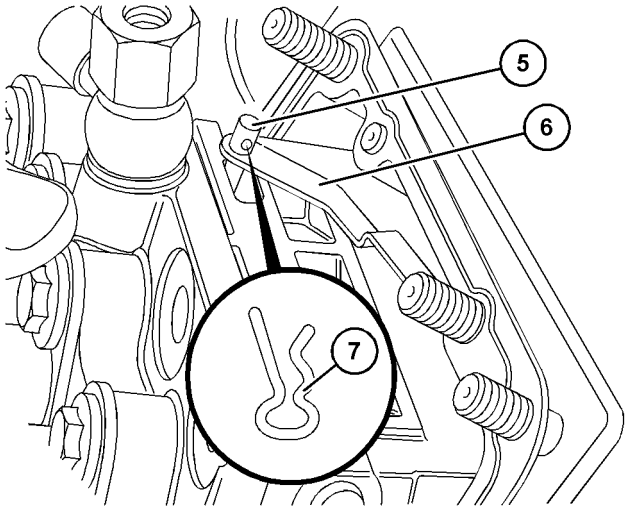

Illustration 66 g06274332
Typical example

2. New shims (4) must be used during assembly. Install the correct thickness and the correct number of shims on the mounting face of the cylinder block. Refer to Specifications, “Fuel Injection Pump” for further information.

3. Position fuel injection pump (1) close to the cylinder block. Connect link (6) to fuel rack control (5) and install clip (7). Ensure that the clip is correctly installed into the fuel rack.

4. Align fuel injection pump (1) with the studs on the cylinder block. Install the fuel injection pump to the cylinder block.

Note: One of nut (2) retains the clip for the tube assembly for the oil feed.

5. Install bolts (3) and nuts (2).

For 402F-05 engines. Evenly tighten bolts (3) and nuts (2) to a torque of 6 N·m (53 lb in).

For 403F-07, 403F-11, and 403F-15 engines. Evenly tighten bolts (3) and nuts (2) to a torque of 15 N·m (11 lb ft).

End By:

a. Install the fuel shutoff solenoid. Refer to Disassembly and Assembly, “Fuel Shutoff Solenoid - Remove and Install” for the correct procedure.

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

i07676460

Fuel Injector - Remove and Install

Removal Procedure

Start By:

a. Remove the fuel injection lines and the tube assembly for fuel return. Refer to Disassembly and Assembly, “Fuel Injection Lines - Remove and Install” for correct 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.

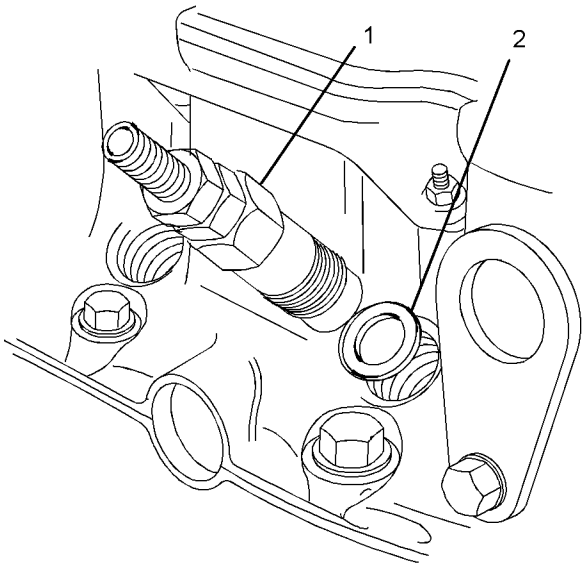

Illustration 67 g01320610
Typical example

1. Use a deep socket to remove fuel injector (1) from the cylinder head.

2. Remove seat washers (2) from the cylinder head.

Note: 402F-05 and 403F-07 engines have **two** seat washers. The seat washers are different diameters. The 403F-11, 403F-15 engines have **one** seat washer.

3. Cap all openings or plug all openings immediately.

Installation Procedure

Table 7

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Hyloma Universal Sealing Compound	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

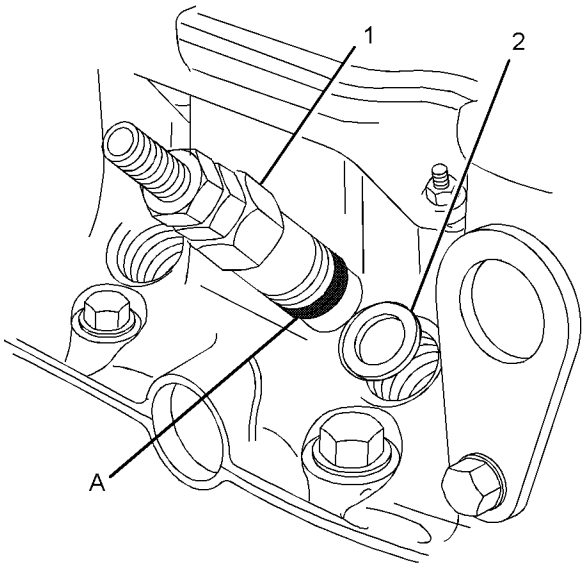

Illustration 68 g01304054
Typical example

1. Clean the bore for the fuel injector in the cylinder head. Ensure that no debris enters the cylinder. Clean the threads on the body of the fuel injector.

2. Install new seat washers (2) into the bore for the fuel injector in the cylinder head.

Note: 402F-05 and 403F-07 engines have **two** seat washers. The seat washers are different diameters. The 403F-11, 403F-15 engines have **one** seat washer.

3. Apply a bead of Tooling (A) to the first two threads of fuel injector (1) that engage into the cylinder head. The bead should have a diameter of 2 mm (0.08 inch) and a length of 6 mm (0.25 inch).

Note: Ensure that Tooling (A) does not cover the body of fuel injector (1) below the threads.

4. Install fuel injector (1) into the cylinder head. Use a deep socket to tighten the fuel injector to a torque of 64 N·m (47 lb ft).

End By:

a. Install the fuel injection lines and the tube assembly for fuel return. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove and Install" for correct procedure.

i07676463

Turbocharger - 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.

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

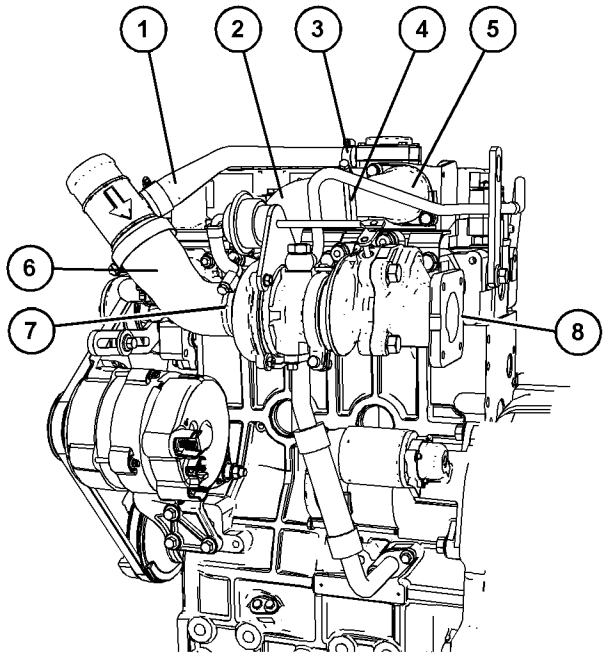

Illustration 69 g06274352

1. Loosen hose clamp (3) for hose assembly (1). Disconnect the hose assembly from the valve mechanism cover.

2. Loosen hose clamp (7) for hose assembly (6). Remove the hose assembly from the turbocharger. Position the hose assembly away from the turbocharger.

3. Loosen hose clamps (4) for hose assembly (2). Remove the hose assembly from the inlet elbow (5) and the turbocharger.

4. Disconnect the Original Equipment Manufacture (OEM) from exhaust adapter (8). Refer to the OEM for the correct procedure.

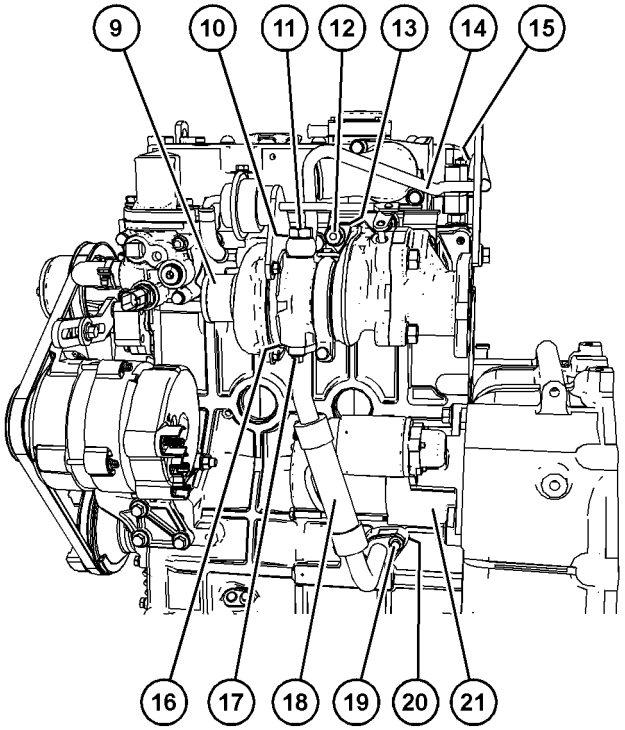

Illustration 70 g06274371

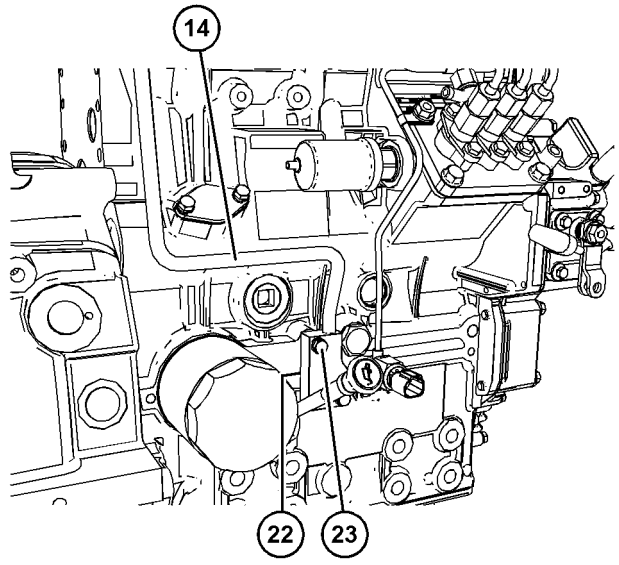

Illustration 71 g06274409

5. Remove banjo bolt (11) from tube assembly (14). Remove sealing washers (10) (not shown) from the banjo bolt.

6. Remove nut (15) (not shown) from the clip for tube assembly (14). Position the tube assembly away from turbocharger (9).

7. Remove bolts (17) from tube assembly (18). Remove gasket (16) (not shown).

8. Remove nut (12). Support the weight of turbocharger (9) as the nuts are removed. Remove turbocharger from the exhaust manifold.

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

9. Remove gasket (13) (not shown).

10. If necessary, follow Step 10a through Step 10d to remove tube assembly (14) and tube assembly (18).

a. Remove bolts (23) from tube assembly (14). Remove the tube assembly from cylinder block (21).

b. Remove O-ring seal (22) (not shown).

c. Remove bolts (19) from tube assembly (18). Remove the tube assembly from cylinder block (21).

d. Remove gasket (20) (not shown).

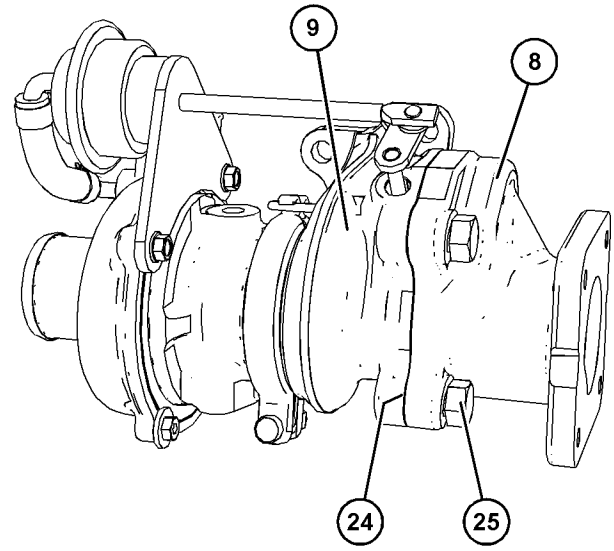

Illustration 72 g06274413

11. If necessary, follow Step 11a through Step 11c to remove exhaust adapter (8) from turbocharger (9).

a. Install turbocharger (9) in a suitable support.

b. Remove bolts (25) from adapter (8). Remove the adapter from turbocharger (9).

c. Remove gasket (24) (not shown).

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. If the turbocharger is worn, the complete turbocharger must be replaced.

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

3. Ensure that all gasket surfaces are clean and free from damage.

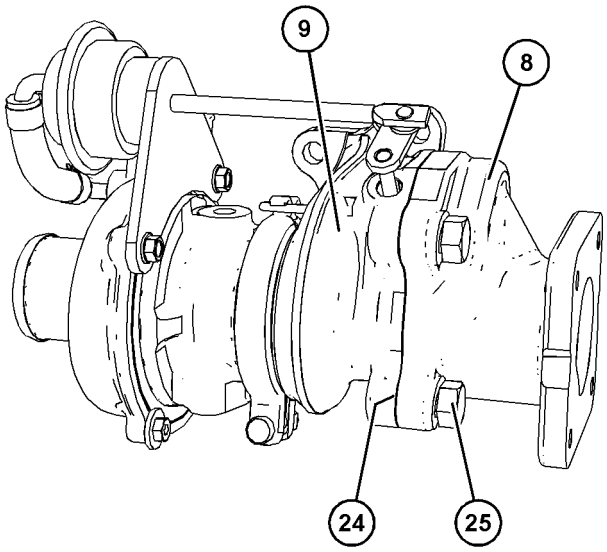

Illustration 73 g06274413

4. If necessary, follow Step 11a through Step 11b to install exhaust adapter (8) to turbocharger (9).

a. Install turbocharger (9) in a suitable support.

b. Install a new gasket (24) (not shown). Ensure that the gasket is correctly orientated.

c. Install adapter (8) onto turbocharger (9). Ensure that the adapter is correctly orientated.

d. Install bolts (25) adapter (8). Tighten the bolts to a torque of 32 N·m (283 lb in).

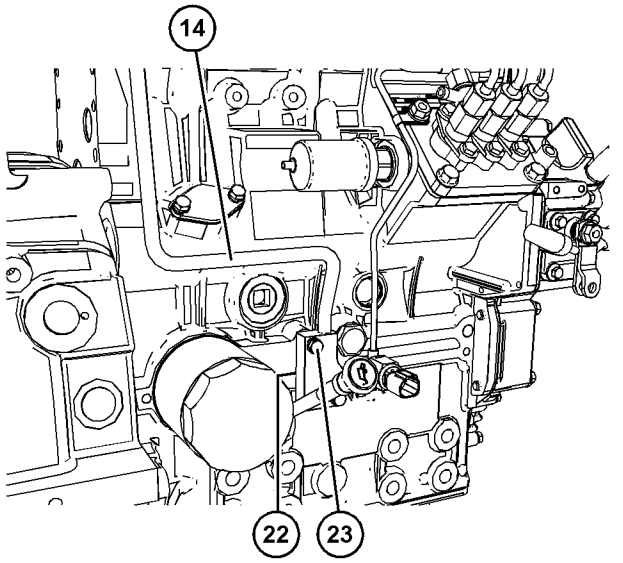

Illustration 74 g06274409

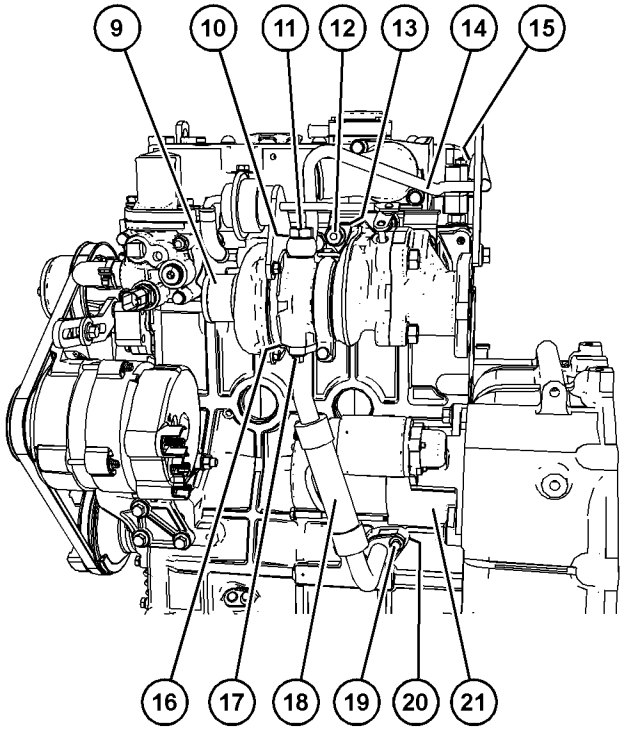

Illustration 75 g06274371

5. If necessary, follow Step 5a through Step 5c to install tube assembly (14) and tube assembly (18).

a. Position a new gasket (20) (not shown) onto tube assembly (18). Install the tube assembly onto cylinder block (21). Loosely install bolts (23) to tube assembly.

Note: Tightening of the bolts should be carried after the turbocharger has been installed.

b. Install a new O-ring seal (22) (not shown) to the adapter for tube assembly (14). Ensure that the O-ring seal is correctly seated into the recess of the adapter.

c. Install tube assembly (14) onto cylinder block (21). Loosely install bolts (23).

Note: Tightening of the bolts should be carried after the turbocharger has been installed.

6. Install a new gasket (13) (not shown) to the exhaust manifold. Ensure that the gasket is correctly orientated.

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

7. Install turbocharger (9) onto the exhaust manifold. Install nut (12). Support the weight of the turbocharger as the nuts are installed.

8. Tighten nut (12) to a torque of 25 N·m (221 lb in).

9. Install a new gasket (16) (not shown) between turbocharger (9) and tube assembly (18). Install bolts (17) hand tight.

10. Tighten bolts (17) and bolts (19) to a torque of 10 N·m (89 lb in).

11. Lubricate the bearings of turbocharger (9) with clean engine oil through the oil inlet port. Rotate the shaft of the turbocharger to distribute the lubricant.

12. Install one new sealing washers (10) (not shown) to banjo bolt (11). Install the banjo bolt to tube assembly (14) and install remaining sealing washer. Hand tighten the banjo bolts.

13. Install nut (15) (not shown) to the clip for tube assembly (14).

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

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

15. Tighten nut (15) (not shown) and bolts (23) to a torque of 10 N·m (89 lb in).

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

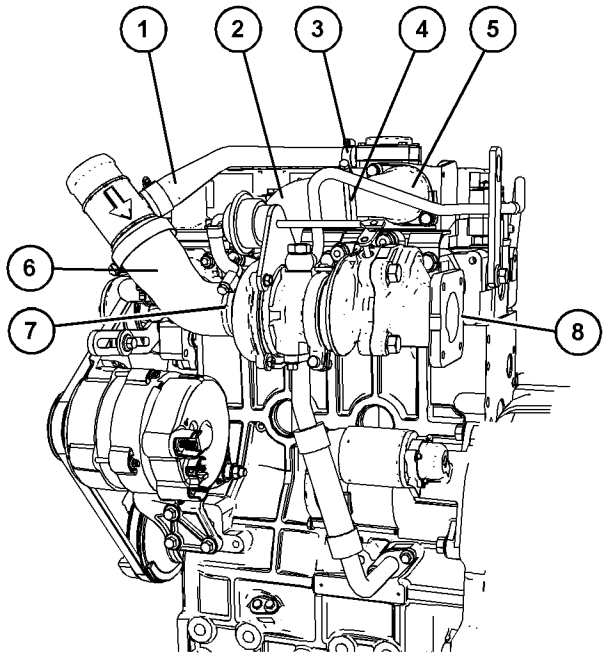

Illustration 76 g06274352

16. Connect the OEM from exhaust adapter (8). Refer to the OEM for the correct procedure.

17. Install hose assembly (2) to inlet elbow (5) and the turbocharger. Securely tighten hose clamps (4) for the hose assembly.

18. Install hose assembly (6) onto the turbocharger. Securely tighten hose clamps (7) for the hose assembly. Ensure that the hose assembly is correctly orientated.

19. Install hose assembly (1) to the valve mechanism cover. Securely tighten hose clamps (3) for the hose assembly.

i07676465

Exhaust Manifold - Remove and Install

Removal Procedure

Start By:

a. If the engine is equipped with a turbocharger, remove the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove and Install" for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The two cylinder and three cylinder engines have different exhaust manifolds. The removal procedure is similar for all models.

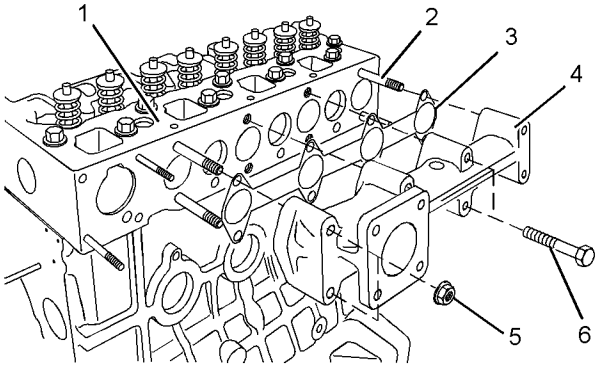

Illustration 77 g01326567
Typical example

1. Loosen nuts (5) and bolts (6).

Note: To prevent distortion of the exhaust manifold, loosen the outer fasteners first.

2. Remove nuts (5) and bolts (6).

Note: Identify bolts of different lengths so that the bolts can be installed in the correct positions.

3. Remove exhaust manifold (4) from cylinder head (1). Note the orientation of the exhaust manifold for installation.

4. Remove gasket (3) from cylinder head (1).

5. If necessary, remove exhaust manifold studs (2) from cylinder head (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The two cylinder and three cylinder engines have different exhaust manifolds. The installation procedure is similar for all models.

1. Ensure that the gasket surfaces of the cylinder head and the exhaust manifold are clean and free from damage.

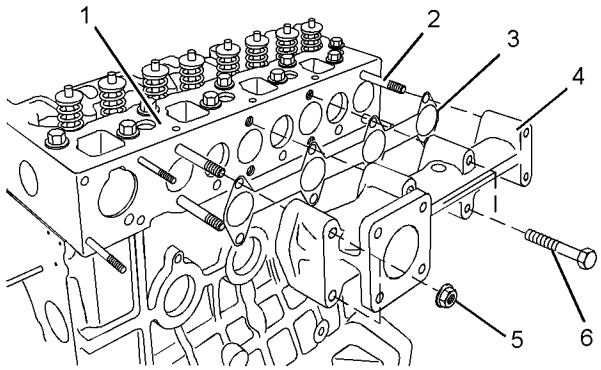

Illustration 78 g01326567
Typical example

2. If necessary, install exhaust manifold studs (2) to cylinder head (1).

3. Install a new exhaust manifold gasket (3) to cylinder head (1).

4. Align exhaust manifold (4) with studs (2) and install the exhaust manifold to cylinder head (1).

Note: Ensure that the exhaust manifold is installed in the correct orientation.

5. Install nuts (5) and bolts (6) finger tight.

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

6. For 402F-05 engines. Tighten nuts (5) and bolts (6) to a torque of 10 N·m (89 lb in).

For 403F-07, 403F-11, and 403F-15 engines. Tighten nuts (5) and bolts (6) to a torque of 25 N·m (18 lb ft).

Note: On three cylinder engines tighten the inner bolts first.

End By:

a. If the engine is equipped with a turbocharger, install the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove and Install" for the correct procedure.

i08095600

Exhaust Manifold - Remove and Install
(402F-05 - If Equipped)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

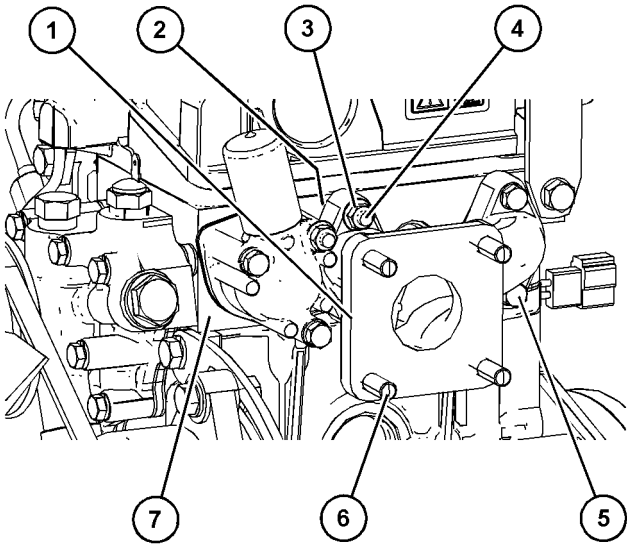

Illustration 79 g06536487
Typical example

1. Disconnect Original Engine Manufacturer (OEM) supplied exhaust from exhaust manifold (1). Refer to the OEM for the correct procedure.

2. Loosen the nuts (3) and bolts (5).

Note: To prevent distortion of the exhaust manifold, loosen the outer fixings first.

3. Remove the nuts (3) and the bolts (5).

Note: Bolt positions for installation purposes.

4. Remove exhaust manifold (1) from cylinder head (7).

5. Remove gasket (2) (not shown) from cylinder head (7).

6. Remove any remaining gasket material and carbon from the cylinder head and the exhaust manifold. Be careful not to damage the mating surface on the cylinder head or the mating surface on the exhaust manifold.

7. If necessary, remove the exhaust manifold studs (4) from cylinder head (7).

Note: Stud positions for installation purposes.

8. If necessary, remove the exhaust manifold studs (6) from exhaust manifold (1).

Note: Stud positions for installation purposes.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

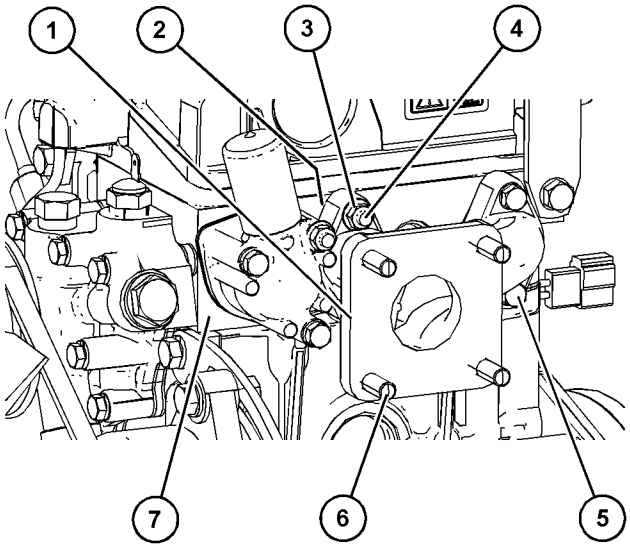

Illustration 80 g06536487
Typical example

1. If necessary, install exhaust manifold studs (6) into exhaust manifold (1) in the positions noted on removal. Tighten the studs to a torque of 17 N·m (151 lb in).

2. If necessary, install exhaust manifold studs (4) to cylinder head (7) in the positions noted on removal. Tighten the studs to a torque of 17 N·m (151 lb in).

3. Install a new exhaust manifold gasket (2) (not shown) to exhaust manifold studs (4).

Note: Do not use any sealant on the exhaust manifold gasket.

4. Position exhaust manifold (1) onto exhaust manifold studs (4) and install new nuts (3) finger tight.

5. Install bolts (5) to exhaust manifold (1) finger tight.

6. Tighten the nuts (3) and the bolts (5) to a torque of 25 N·m (221 lb in).

i08097743

Exhaust Manifold - Remove and Install
(403F-07 - If Equipped)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

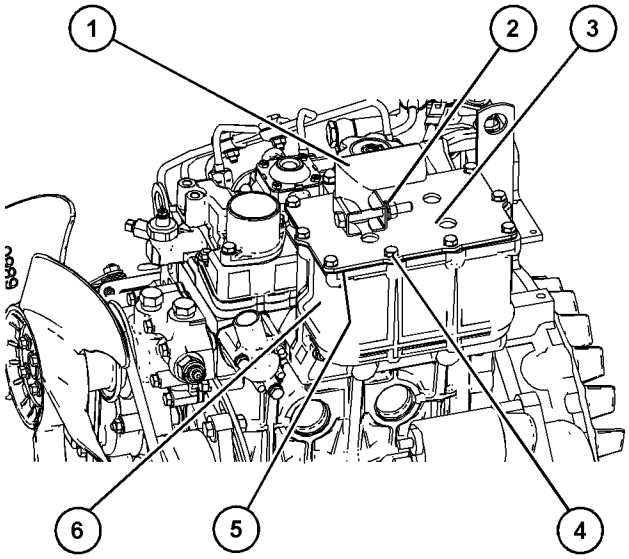

Illustration 81 g06543411
Typical Example

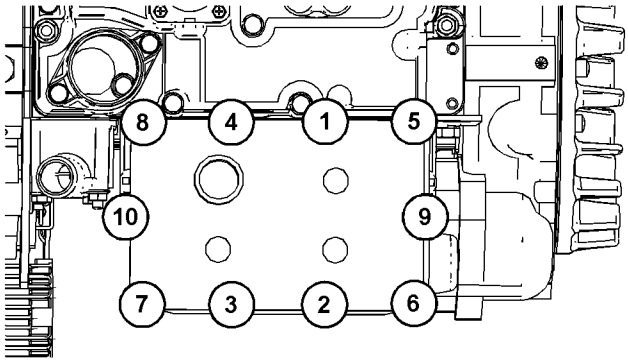

Illustration 82 g06543412
Typical Example

1. Disconnect Original Engine Manufacturer (OEM) supplied exhaust from exhaust elbow (1). Refer to the OEM for the correct procedure.

2. If necessary, sufficiently loosen clamp (2) and remove exhaust elbow (1) from muffler assembly (3).

Note: Note elbow position and orientation for installation purposes.

3. If necessary, remove bolt assemblies (4) in reverse of the sequence shown in Illustration 82 . Remove muffler assembly (3) and gasket (5) (not shown) from exhaust manifold (6).

Note: Note exhaust muffler position and orientation for installation purposes.

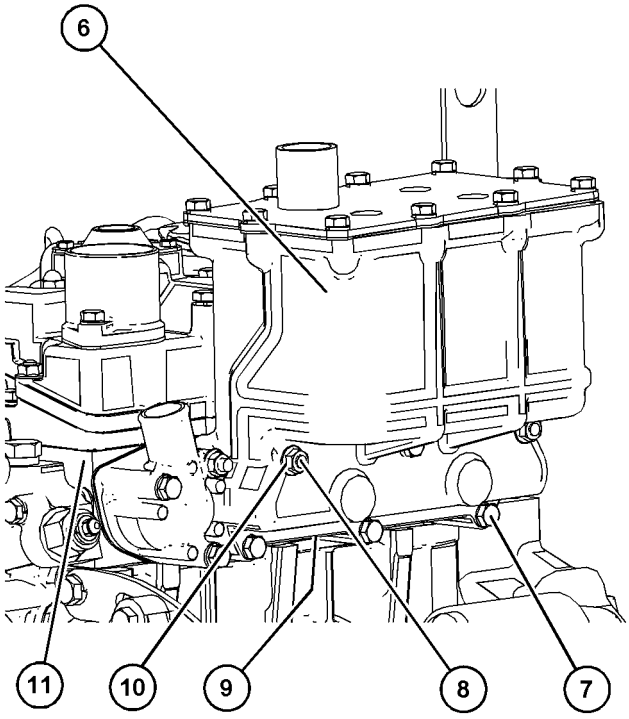

Illustration 83 g06543424

Typical example

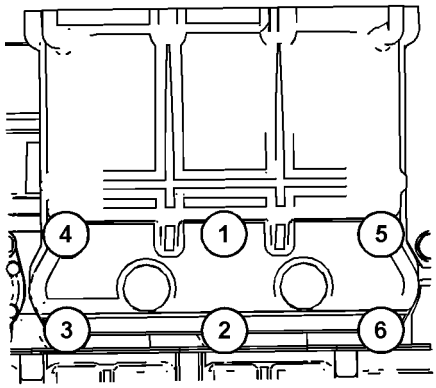

Illustration 84 g06543414

Typical example

4. Loosen the nuts (10) and bolt assemblies (7) in reverse of the sequence shown in Illustration 84 .

5. Remove the nuts (10) and the bolt assemblies (7).

Note: Bolt positions for installation purposes.

6. Remove exhaust manifold (6) from cylinder head (11).

7. Remove gasket (9) (not shown) from cylinder head (11).

8. If necessary, remove the exhaust manifold studs (8) from cylinder head (11).

Note: Note stud positions for installation purposes.

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 component that is worn or damaged.

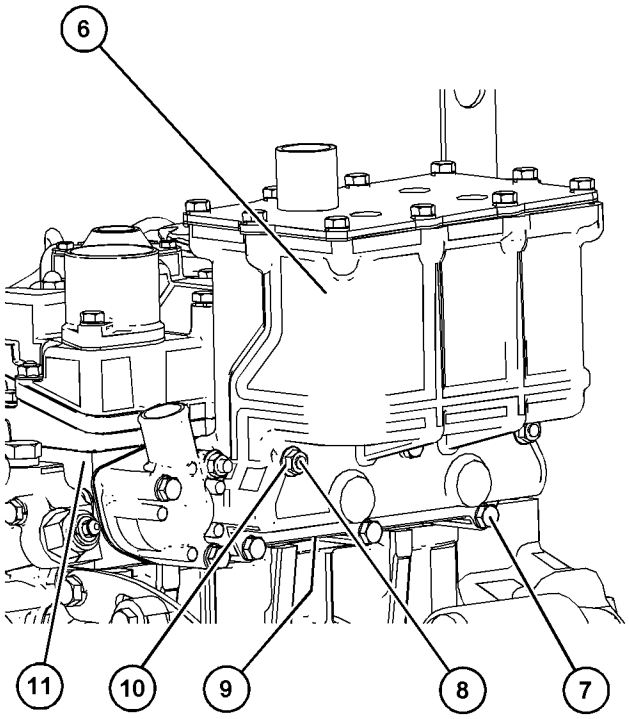

Illustration 85 g06543424

Typical example

2. If necessary, install exhaust manifold studs (8) to cylinder head (11) in the positions noted on removal. Tighten the studs to a torque of 6 N·m (53 lb in).

3. Install a new exhaust manifold gasket (9) (not shown) to exhaust manifold studs (8).

Note: Do not use any sealant on the exhaust manifold gasket.

4. Position exhaust manifold (6) onto exhaust manifold studs (9) and install new nuts (10) finger tight.

5. Install bolt assemblies (7) to exhaust manifold (6) finger tight.

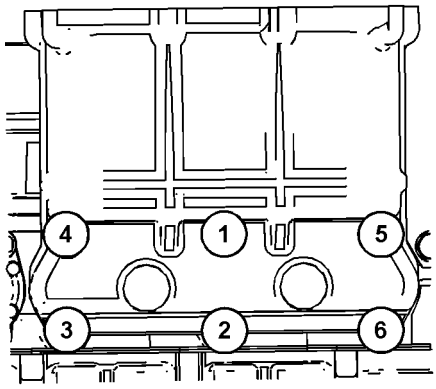

Illustration 86 g06543414
Typical example

6. Tighten the nuts (10) and the bolt assemblies (7) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 86 .

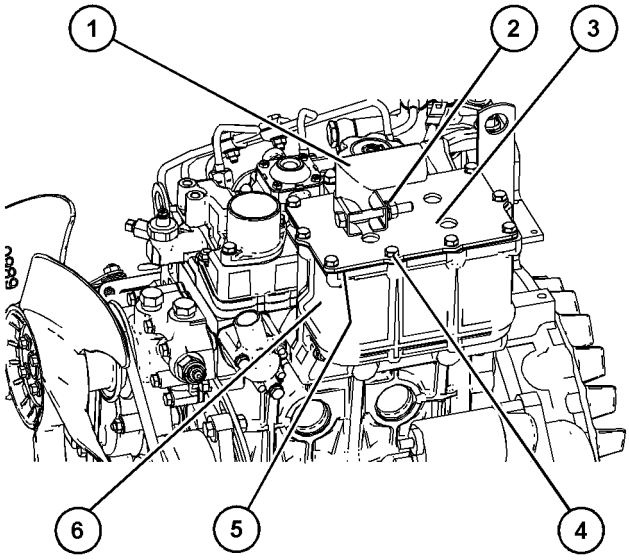

Illustration 87 g06543411
Typical Example

7. Position new gasket (5) (not shown) onto exhaust manifold (6), install muffler assembly (3) into the exhaust manifold in the position and orientation noted on removal.

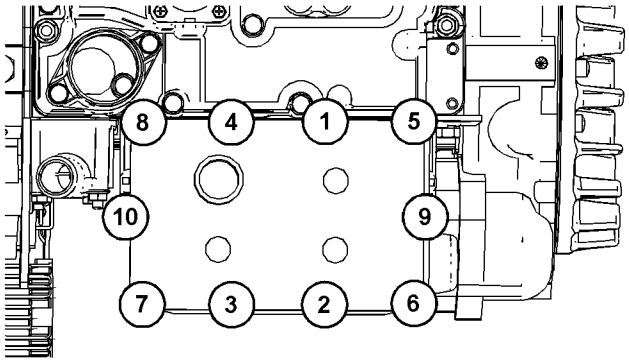

Illustration 88 g06543412
Typical Example

8. Tighten bolt assemblies (4) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 88 .

9. If necessary, Position new clamp (2) onto exhaust elbow (1). Install the exhaust elbow assembly onto the exhaust muffler (3) in the position noted on removal. Tighten the clamp to a torque of 25 N·m (221 lb in).

10. Reconnect Original Engine Manufacturer (OEM) supplied exhaust to exhaust elbow (1). Refer to the OEM for the correct procedure.

i08148469

Exhaust Manifold - Remove and Install
(403F-11 - If Equipped)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

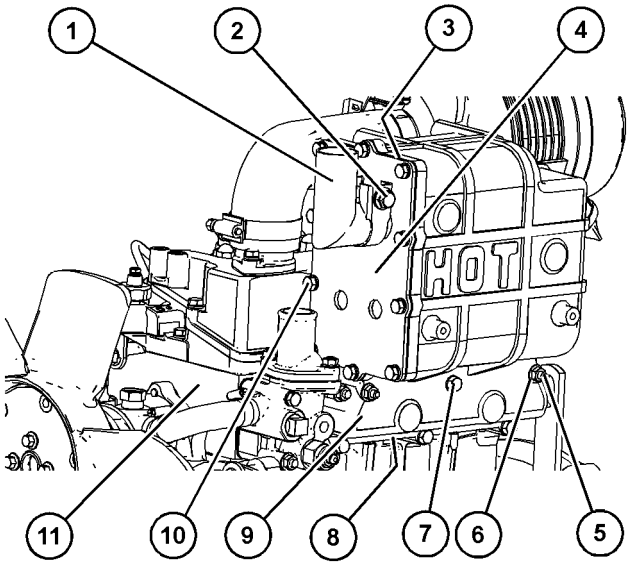

Illustration 89 g06566298

Typical Example

1. Disconnect Original Engine Manufacturer (OEM) supplied exhaust from exhaust elbow (1). Refer to the OEM for the correct procedure.

2. If necessary, sufficiently loosen clamp (2) and remove exhaust elbow (1) from muffler assembly (4).

Note: Note elbow position and orientation for installation purposes.

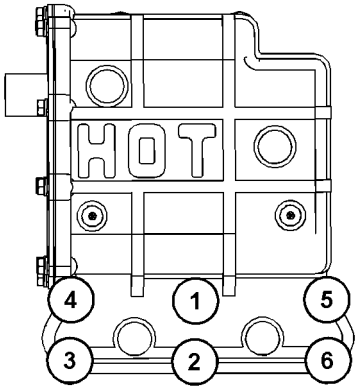

Illustration 90 g06566623

Typical example

3. Loosen the nuts (6) and bolt assemblies (7) in reverse of the sequence shown in Illustration 90 .

4. Remove the nuts (6) and the bolt assemblies (7).

Note: Bolt positions for installation purposes.

5. Remove exhaust manifold (9) from cylinder head (11).

6. Remove gasket (8) (not shown) from cylinder head (11).

7. If necessary, remove the exhaust manifold studs (5) from cylinder head (11).

Note: Stud positions for installation purposes.

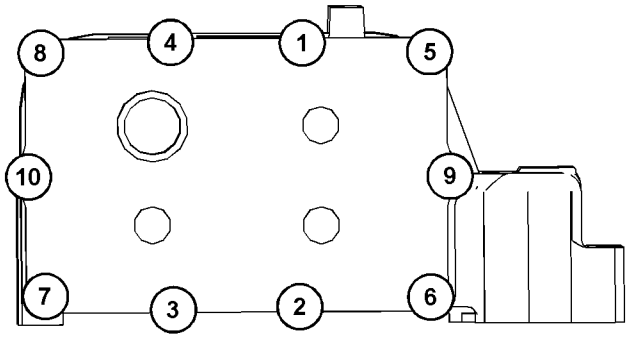

Illustration 91 g06566632

Typical Example

8. If necessary, Place exhaust manifold (9) in a suitable support and remove bolt assemblies (10) in reverse of the sequence shown in Illustration 91 . Remove muffler assembly (4) and gasket (3) (not shown) from the exhaust manifold.

Note: Note exhaust muffler position and orientation for installation purposes.

Note: Note bolt positions for installation purposes.

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 component that is worn or damaged.

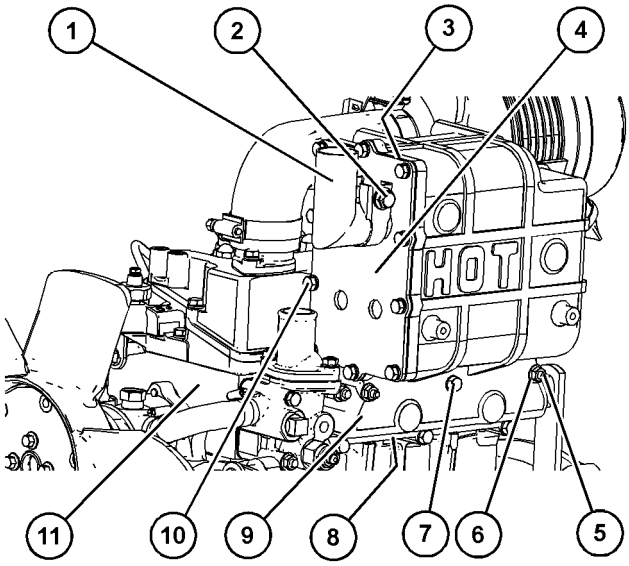

Illustration 92 g06566298
Typical example

2. If necessary, place exhaust manifold (9) in a suitable support. Position new gasket (3) (not shown) onto the exhaust manifold, install muffler assembly (4) into the exhaust manifold in the position and orientation noted on removal. Install bolt assemblies (10) finger tight.

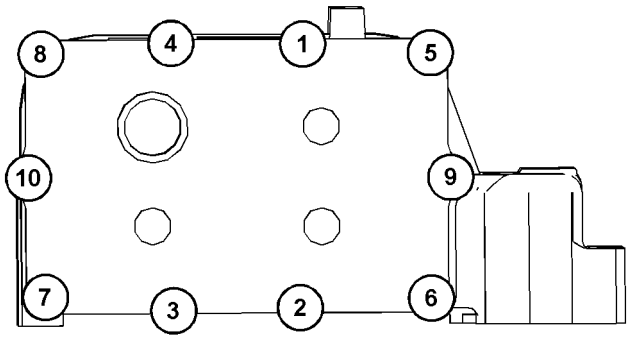

Illustration 93 g06566632
Typical Example

3. Tighten bolt assemblies (10) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 93 .

4. If necessary, Position new clamp (2) onto exhaust elbow (1). Install the exhaust elbow assembly onto the exhaust muffler (4) in the position noted on removal. Tighten the clamp to a torque of 25 N·m (221 lb in).

5. If necessary, install exhaust manifold studs (5) to cylinder head (11) in the positions noted on removal. Tighten the studs to a torque of 6 N·m (53 lb in).

6. Install a new exhaust manifold gasket (8) (not shown) to exhaust manifold studs (5).

Note: Do not use any sealant on the exhaust manifold gasket.

7. Position exhaust manifold (9) onto exhaust manifold studs (5) and install new nuts (6) finger tight.

8. Install bolt assemblies (7) to exhaust manifold (9) finger tight.

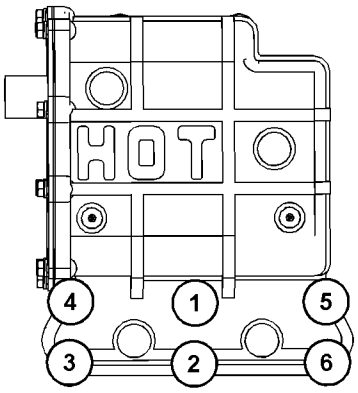

Illustration 94 g06566623
Typical example

9. Tighten the nuts (6) and the bolt assemblies (7) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 94 .

10. Reconnect Original Engine Manufacturer (OEM) supplied exhaust to exhaust elbow (1). Refer to the OEM for the correct procedure.

i07676469

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 8

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825739	Valve Spring Compressor	1

(continued)

(Table 8, contd)

B(1)	-	Adapter	1
B(2)	27610235	Adapter	1

(1) 402F-05 and 403F-07 engines
(2) 403F-11, and 403F-15 engines

Start By:

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

⚠ 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
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
Install suitable plugs to the inlet ports of the cylinder head in order to prevent the entry of loose parts into the engine.

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

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

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

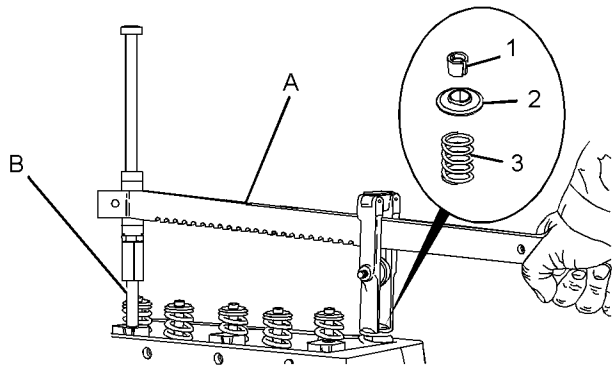

Illustration 95 g01304583
Typical example

1. Follow Step 1a through Step 1d to position the appropriate piston at top center.

a. Install Tooling (A) and (B) in position on the cylinder head to compress a valve spring for the appropriate piston.

b. Use Tooling (A) to compress valve spring (3) and open the valve slightly.

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

c. Carefully rotate the crankshaft 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 center position. The valve is now held in a position that allows the valve spring to be safely removed.

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

2. Use tool (A) to compress valve spring (3). Remove valve keepers (1).

Note: Ensure that all the valve springs are installed before changing from one pair of valve springs to another pair valve springs.

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

3. Apply sufficient pressure to Tooling (A) to allow removal of the valve keepers (1).

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

Remove valve keepers (1).

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

5. Remove valve spring retainer (2) and remove valve spring (3).

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

Installation Procedure

Table 9

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825739	Valve Spring Compressor	1
B(1)	-	Adapter	1
B(2)	27610235	Adapter	1

(1) 402F-05 and 403F-07 engines
(2) 403F-11, and 403F-15 engines

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.

NOTICE
Install suitable plugs to the inlet ports of the cylinder head in order to prevent the entry of loose parts into the engine.

1. Inspect the valve springs for the correct length. Refer to Specifications, “Cylinder Head Valves” for further information.

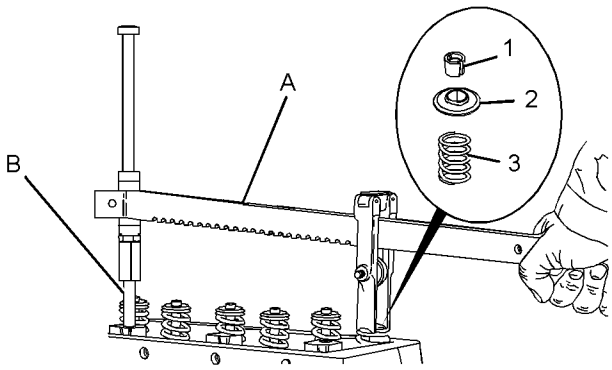

Illustration 96 g01304583
Typical example

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

WARNING

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

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

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

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

4. Apply sufficient pressure to Tooling (A) to install valve keepers (1).

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

Install the valve spring keepers.

5. Carefully release the pressure on Tooling (A).

Note: Ensure that the valve keepers are correctly seated.

⚠ 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.

6. Remove Tooling (A) and Tooling (B). Ensure that all the valves are secured in place by a valve spring and valve keepers. Rotate the crankshaft through about 45 degrees to clear the piston from the valve. Lightly strike the top of the valve with a soft hammer to ensure that the valve keepers are properly installed.

End By:

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

i07676474

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 10

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825663	Valve Spring Compressor	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.

Note: The removal procedure is identical for the two cylinder and three cylinder engines. The Illustrations show a three cylinder engine.

1. Clean the bottom face of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, "Cylinder Head Valves" for the correct dimensions.

2. Place a temporary identification mark on the heads of the valves to identify the correct position.

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

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

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

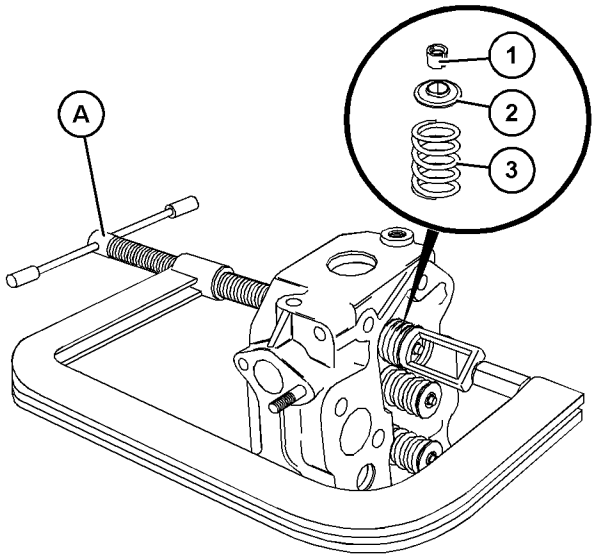

Illustration 97 g06274733
Typical example

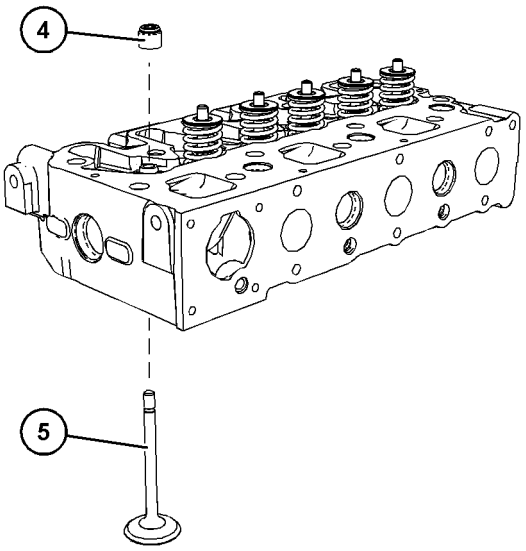

Illustration 98 g06274734
Typical example

3. Use Tooling (A) to compress the appropriate valve spring (3). Remove valve keepers (1).

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

4. Remove Tooling (A).

5. Remove valve spring retainer (2). Remove valve spring (3).

6. Remove valve (5).

7. Remove valve stem seal (4).

8. Repeat Step 3 through 7 for the remaining valves.

Installation Procedure

Table 11

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825663	Valve Spring Compressor	1
B(1)	21825622	Valve Stem Seal Replacer	1
B(2)	21825623	Valve Stem Seal Replacer	1

(1) 402F-05 and 403F-07 engines
(2) 403F-11, 403F-15, engines

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The installation procedure is identical for the two cylinder and the three cylinder engines. The Illustrations show a three cylinder engine.

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 1a through Step 1e to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.

a. Inspect the cylinder head for wear and for damage. Refer to Systems Operation, Testing and Adjusting, “Cylinder Head Inspect” for further information.

b. Inspect the valve seats for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for further information.

c. Inspect the valve guides for wear and for damage. Refer to Specifications, “Cylinder Head Valves” and Systems Operation, Testing and Adjusting, “Valve Guide - Inspect” for further information.

d. Inspect the valves for wear and for damage. Refer to Specifications, “Cylinder Head Valves” for further information.

e. Inspect the valve springs for the correct length. Refer to Specifications, “Cylinder Head Valves” for further information.

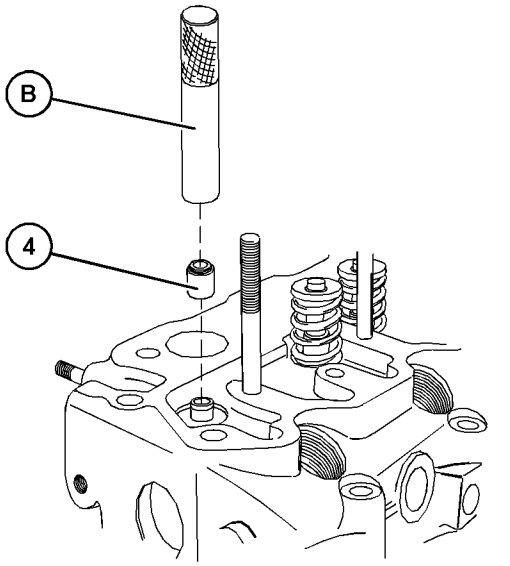

Illustration 99 g06274735
Typical example

2. Use Tooling (B) to install new valve stem seals (4) onto each of the valve guides.

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

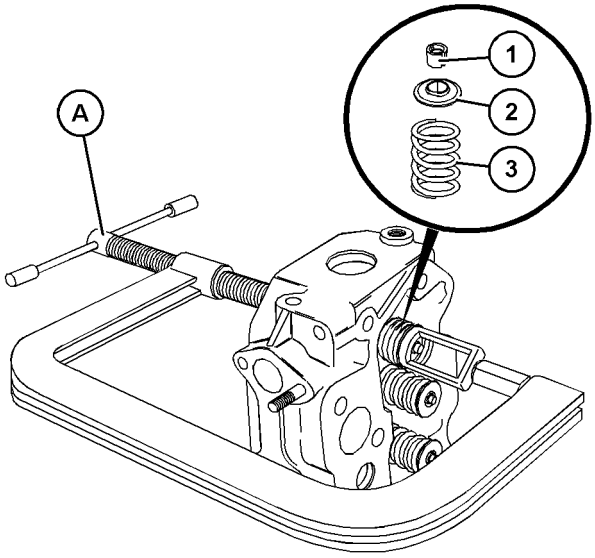

Illustration 100 g06274733

Typical example

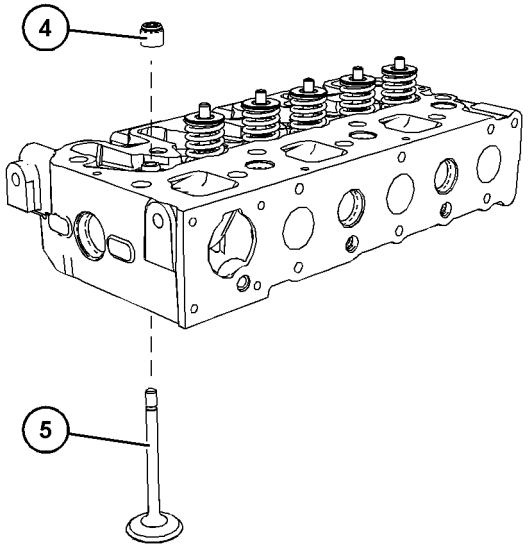

Illustration 101 g06274734

Typical example

3. Lubricate the stem of valve (5) with clean engine oil. Install valve (5) in the appropriate position in the cylinder head. Check the depth of the valve below the face of the cylinder head. Refer to Systems Operation, Testing and Adjusting, “Valve Depth - Inspect” for more information.

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

⚠ WARNING

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

Make sure to wear all necessary protective equipment.

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

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

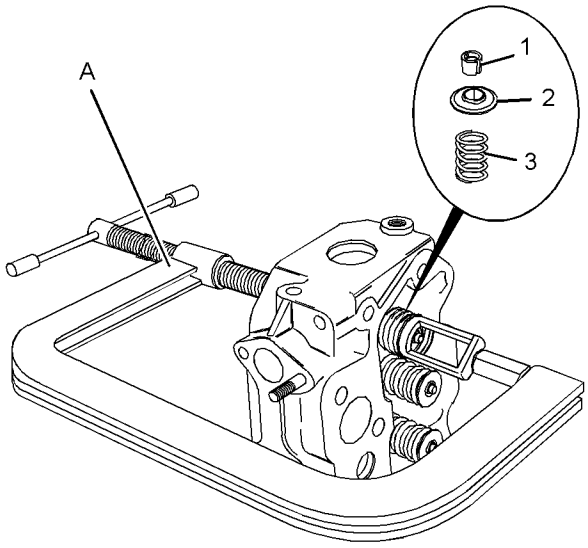

Illustration 102 g01315963

Typical example

5. Use Tooling (A) to compress valve spring (3). 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.

6. Remove Tooling (A).

7. Repeat Step 4 thorough Step 6 for the remaining valves.

8. Place the cylinder head on a suitable support. Ensure that the heads of the valves are not obstructed. Gently strike the top of the valves with a soft hammer to ensure that valve keepers (1) are properly installed.

End By:

a. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i07676477

Engine Oil Line - 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.

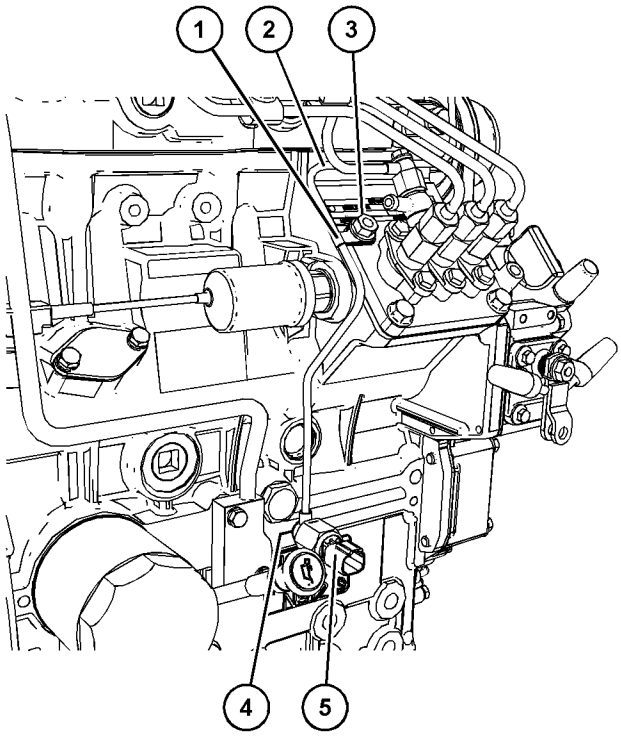

Illustration 103 g06274739
Typical example

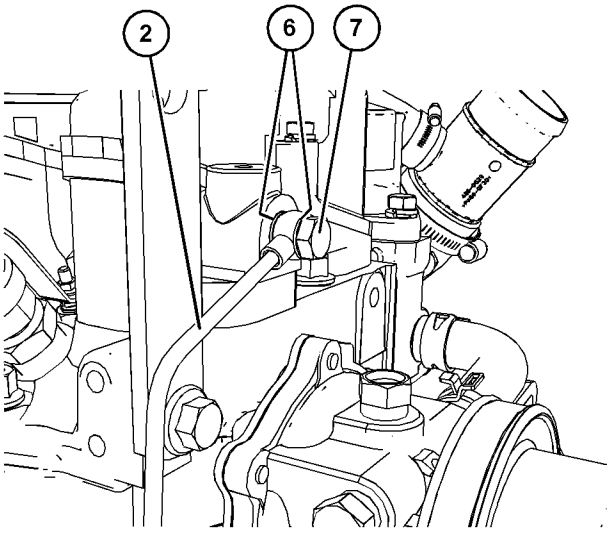

Illustration 104 g06274743
Typical example

1. Loosen nut (3) that attaches clip (1) on engine oil line (2) to the fuel injection pump.

2. Disconnect the Original Equipment Manufacture (OEM) harness assembly from engine oil pressure switch (5). Refer to the OEM for the correct procedure.

3. Remove engine oil pressure switch (5) from engine oil line (2). Remove sealing washers (4) (not shown).

4. Remove banjo bolt (7) from engine oil line (2). Remove washers (6) (not shown).

5. Remove engine oil line (2) from the engine.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the all components are free from wear, damage, or restriction. If necessary, replace any component that is not free from wear, damage, or restriction.

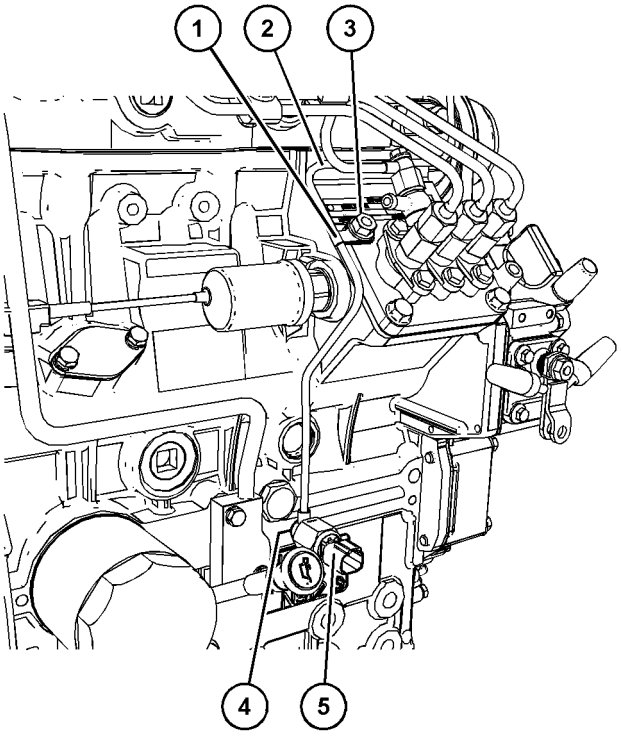

Illustration 105 g06274739
Typical example

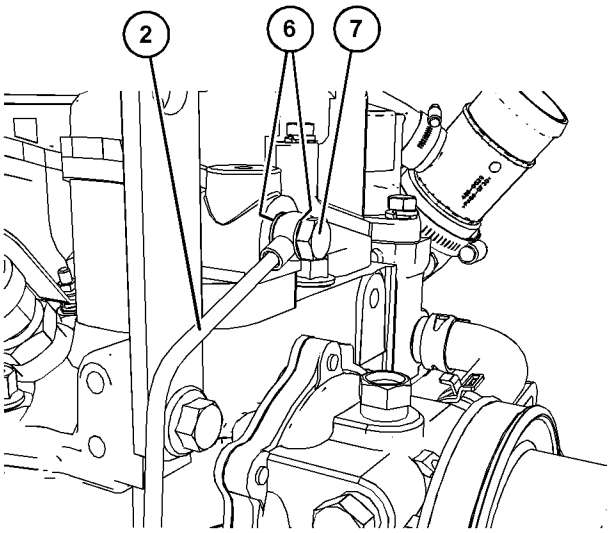

Illustration 106 g06274743
Typical example

2. Place engine oil line (2) onto the engine. Ensure that clip on (1) on the engine oil line is located below nut (2). Install the nut finger tight.

3. Install a new sealing washer (6) to banjo bolt (3). Install the banjo bolt into engine oil line (2) and install the remaining sealing washer. Tighten the banjo bolts finger tight.

4. Install a new sealing washer (4) (not shown) to engine oil pressure switch (5). Install the banjo bolt to engine oil line (2) and install remaining sealing washer. Tighten the engine oil pressure switch finger tight.

5. Tighten banjo bolts (7) to a torque of 12 N·m (106 lb in). Ensure that engine oil line (2) is not strained as the banjo bolt is tightened.

6. Tighten engine oil pressure switch (5) to a torque of 23 N·m (204 lb in). Ensure that engine oil line (2) is not strained as the engine oil pressure switch is tightened.

7. Connect the OEM harness assembly to engine oil pressure switch (5). Refer to the OEM for the correct procedure.

8. Tighten nut (3) that attaches clip (1) on engine oil line (2) to the fuel injection pump.

For 402F-05 and 403F-07 engines. Tighten nut (3) to a torque of 6 N·m (53 lb in).

For 403F-11, 403F-15 engines. Tighten nut (3) to a torque of 15 N·m (133 lb in).

i07676481

Engine Oil Relief Valve - 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.

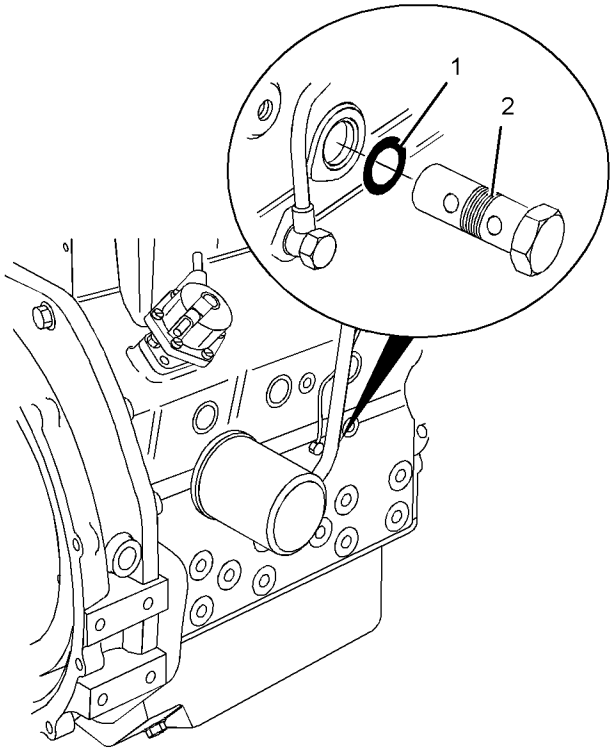

Illustration 107 g01316066
Typical example

1. Remove engine oil relief valve (2) from the cylinder block.
2. Remove O-ring seal (1) from engine oil relief valve (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 or damage. If necessary, replace any component that is worn or damaged.

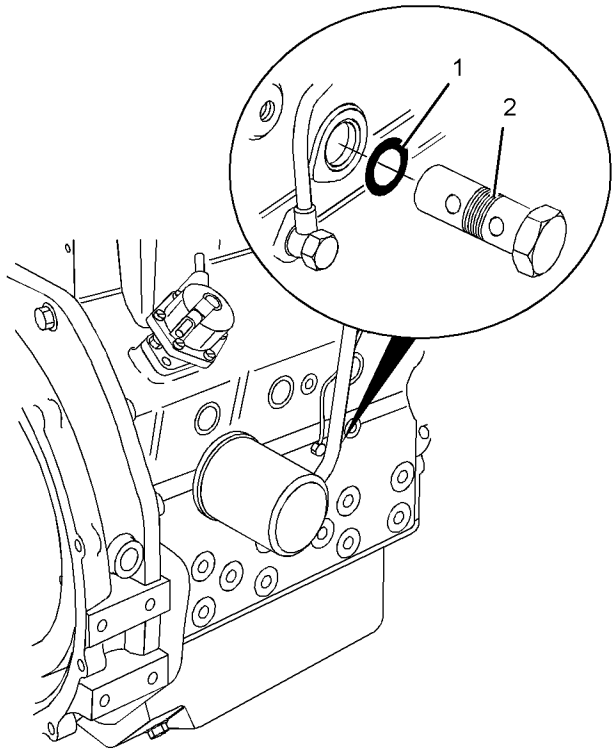

Illustration 108 g01316066
Typical example

2. Install a new O-ring seal (1) to engine oil relief valve (2).
3. Lubricate engine oil relief valve (2) with clean engine oil.

4. Install engine oil relief valve (2) into the cylinder block. Tighten the engine oil relief valve to a torque of 64 N·m (47 lb ft).

i08536458

Engine Oil Pump - Remove (403F-11, and 403F-15 Engines)

Method One for Removal of Idler Hub

Table 12

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T418753	Hub Removal Tool	1
B	27610311	Slide Hammer Puller Gp	1

Start By:

a. Set the engine to top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, "Finding Top Center Position for No. 1 Piston" 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.

c. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct 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.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

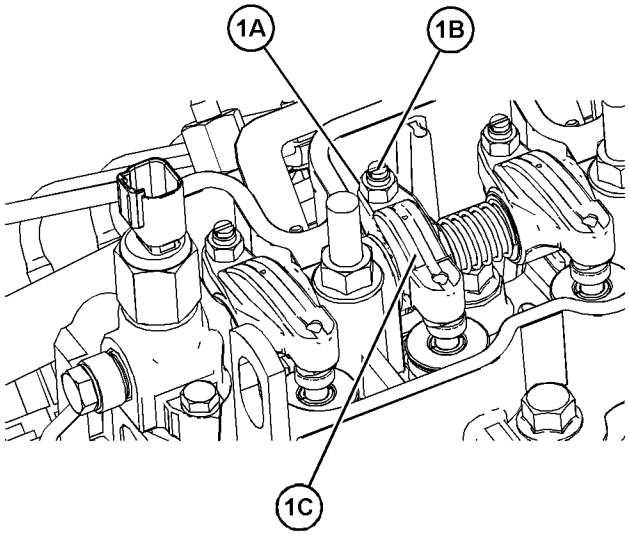

Illustration 109 g06655304
Typical Example

1. Loosen nuts (1A) on all rocker arms (1C). Unscrew adjusters (1B) on all the rocker arms until all valves are fully closed.

Note: Do **NOT** rotate the engine once all the rocker arm adjusters are loosened.

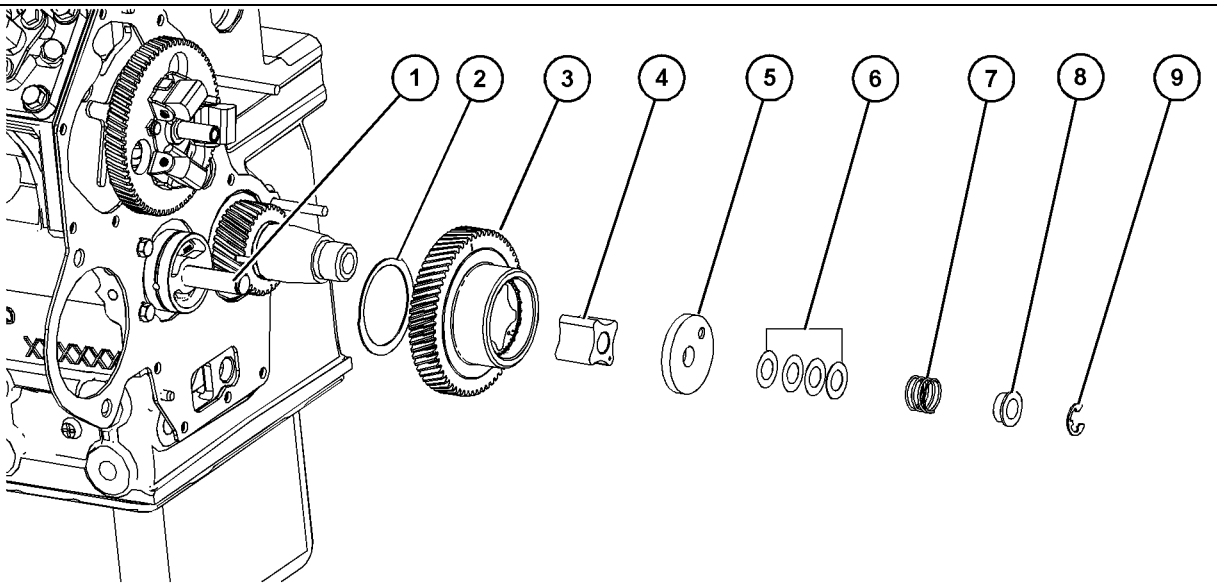

Illustration 110 g06653875

Older Engine Oil Pump Design

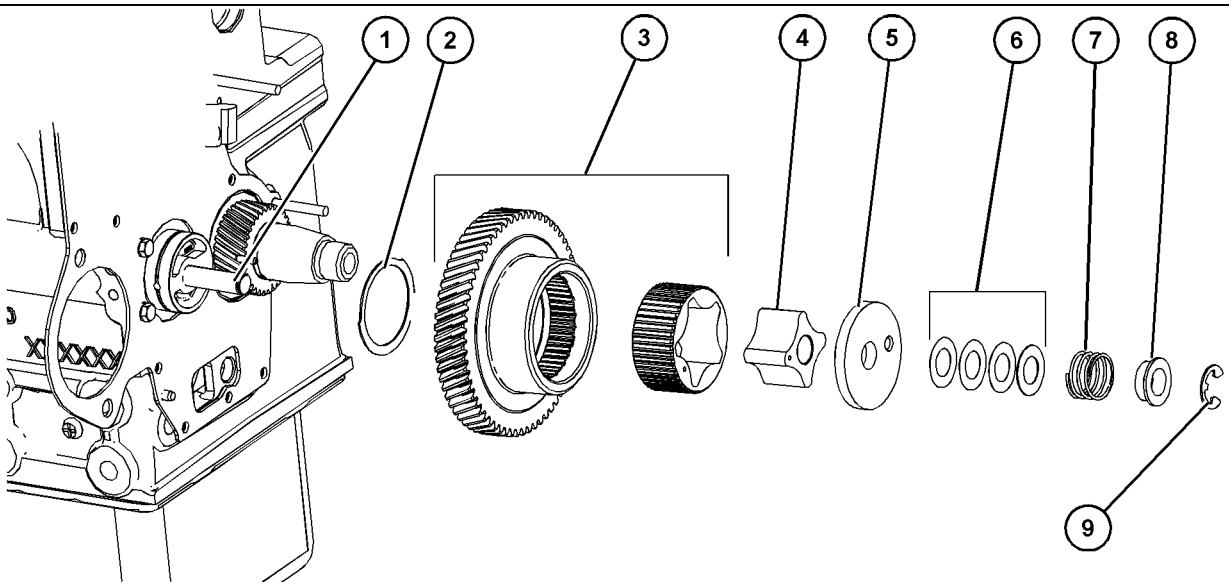

Illustration 111 g06703446

Later Engine Oil Pump Design

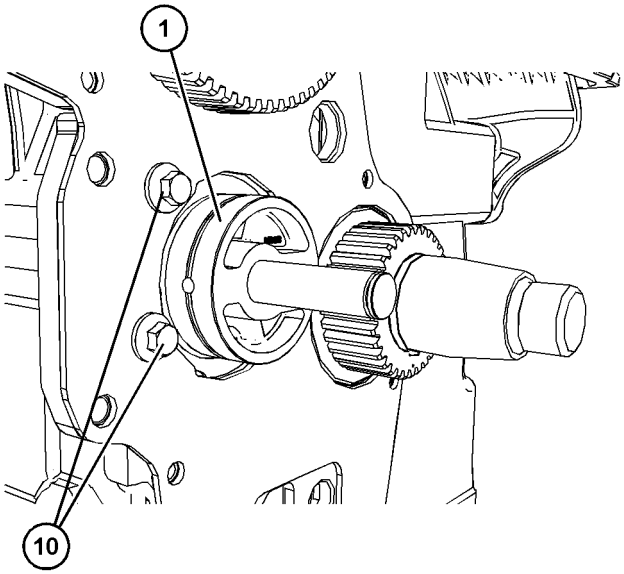

Illustration 112 g06653878
Typical Example

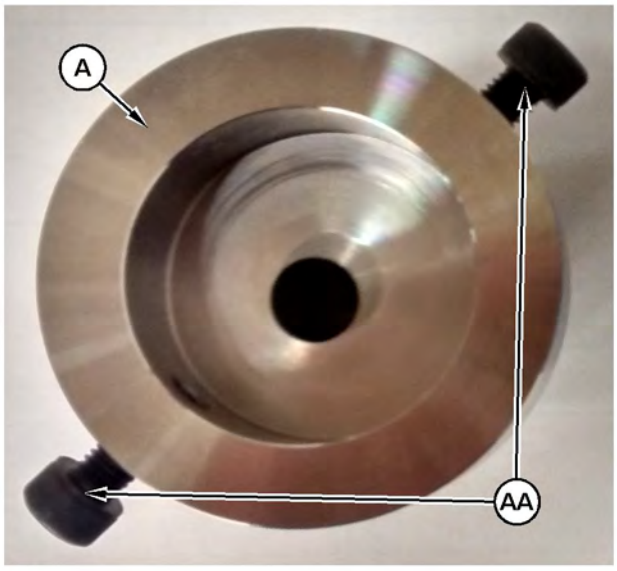

Illustration 113 g06276009

⚠ 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.

2. Remove C-clip (9) that retains idler gear (3) onto idler hub (1).

3. Remove the following components from idler hub (1) collar (8), spring (7), shims (6), and oil pump cover (5).

4. Remove idler gear (3) from idler hub (1).

5. Remove inner rotor (4) from idler hub (1).

6. Remove thrust washer (2) from idler hub (1).

7. Remove bolts (10).

8. Install Tooling (A) to idler hub (1). Securely tighten Allen Head Bolt (AA) on Tooling (A).

9. Install Tooling (B) onto Tooling (A). Use Tooling (B) and Tooling (A) to remove idler hub (1) from the cylinder block.

Method Two for Idler Hub Removal

Start By:

a. Set the engine to top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, "Finding Top Center Position for No. 1 Piston" 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.

c. Remove the front housing and back plate. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct 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.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

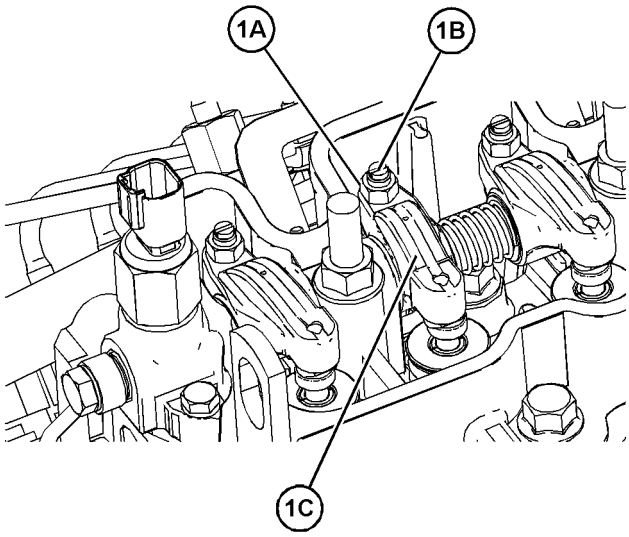

Illustration 114 g06655304

Typical Example

1. Loosen nuts (1A) on all rocker arms (1C). Unscrew adjusters (1B) on all the rocker arms until all valves are fully closed.

Note: Do **NOT** rotate the engine once all the rocker arm adjusters are loosened.

2. Remove the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” for the correct procedure.

3. Remove the camshaft and the back plate. Refer to Disassembly and Assembly, “Camshaft - Remove” for the correct procedure.

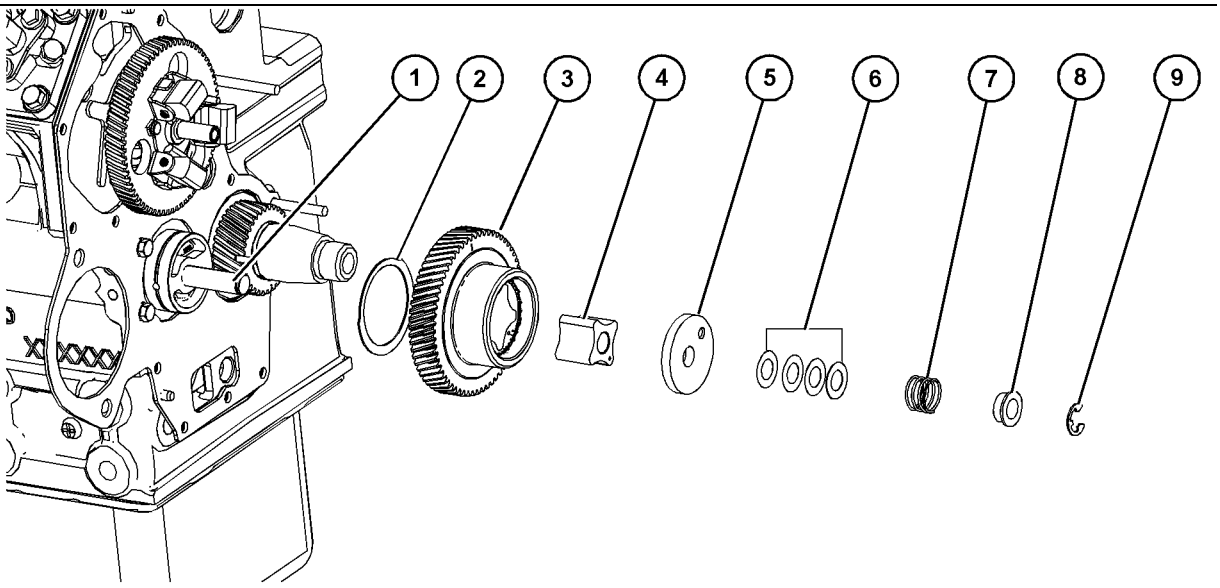

Illustration 115 g06653875

Older Engine Oil Pump Design

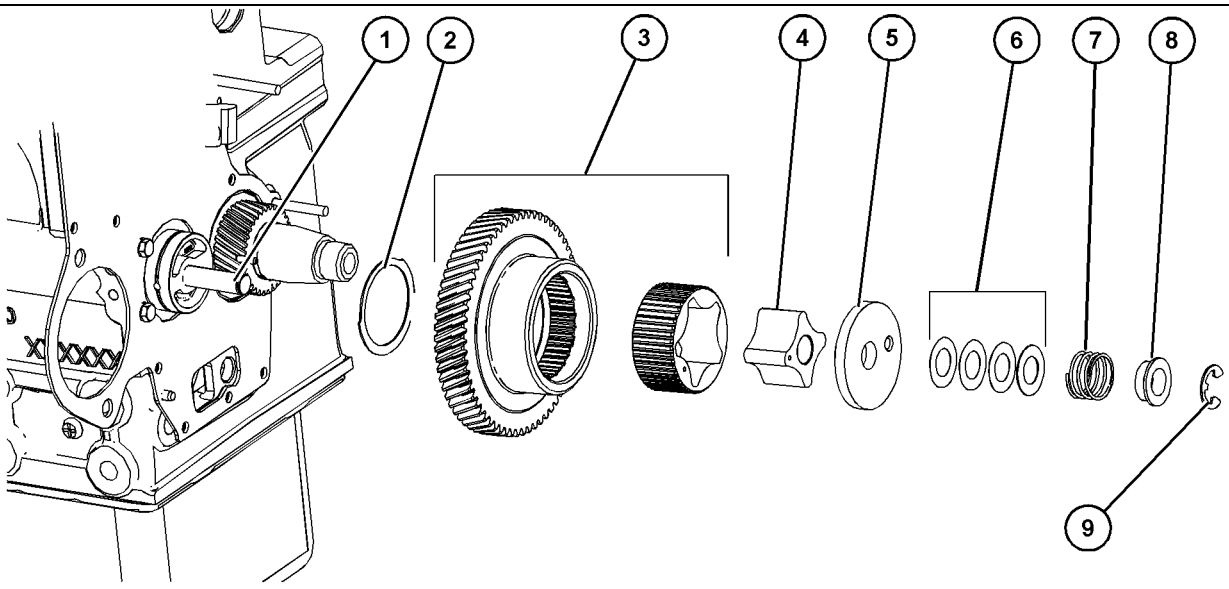

Illustration 116 g06703446

Later Engine Oil Pump Design

⚠ 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.

4. Remove C-clip (9) that retains idler gear (3) onto idler hub (1).
5. Remove the following components from idler hub (1) collar (8), spring (7), shims (6), and oil pump cover (5).
6. Remove idler gear (3) from idler hub (1).
7. Remove inner rotor (4) from idler hub (1).
8. Remove thrust washer (2) from idler hub (1).

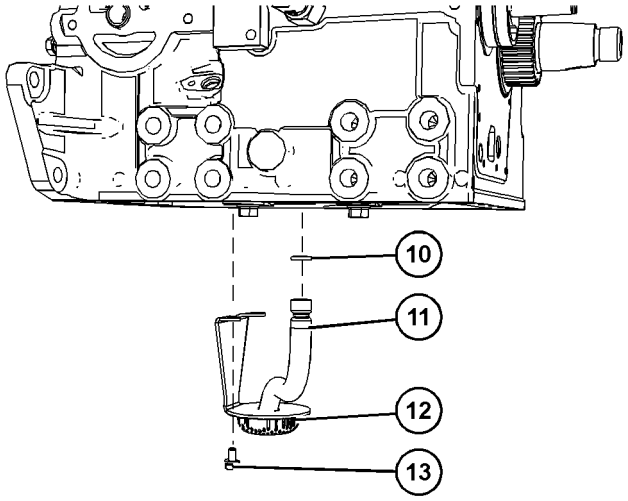

Illustration 117 g06276023

9. Follow Step 9a through Step 9c to remove oil strainer (13) and suction pipe (11).

a. Remove bolts (13) and oil strainer (12) from the cylinder block.

b. Remove suction pipe (11) from the cylinder block.

c. Remove O-ring seal (10) from suction pipe (11).

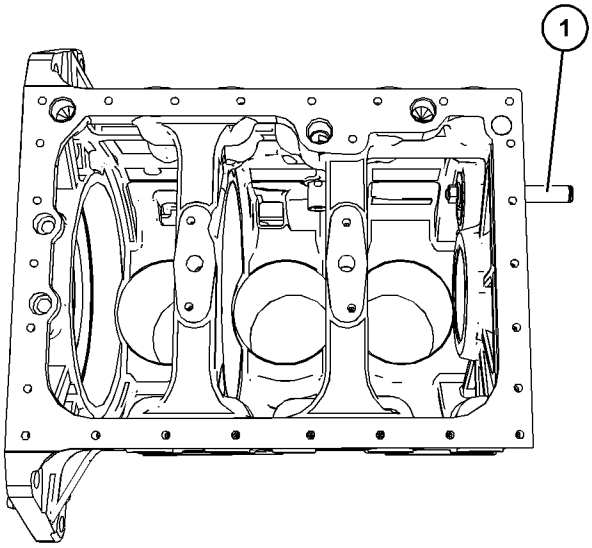

Illustration 118 g06276025

10. Use suitable tooling to driver idler hub (1) from the cylinder block. **Ensure that the cylinder block is not damaged as the idler hub is removed.**

i08536473

Engine Oil Pump - Remove (402F-05 and 402F-07 Engines)

Method One for Removal of Idler Hub

Table 13

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	T418755	Hub Removal Tool	1
B	27610311	Slide Hammer Puller Gp	1

Start By:

a. Set the engine to top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, "Finding Top Center Position for No. 1 Piston" 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.

c. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct 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.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

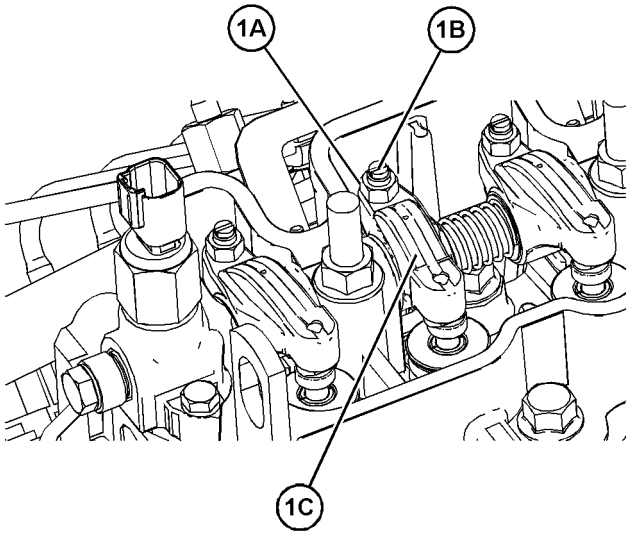

Illustration 119 g06655304
Typical Example

1. Loosen nuts (1A) on all rocker arms (1C). Unscrew adjusters (1B) on all the rocker arms until all valves are fully closed.

Note: Do **NOT** rotate the engine once all the rocker arm adjusters are loosened.

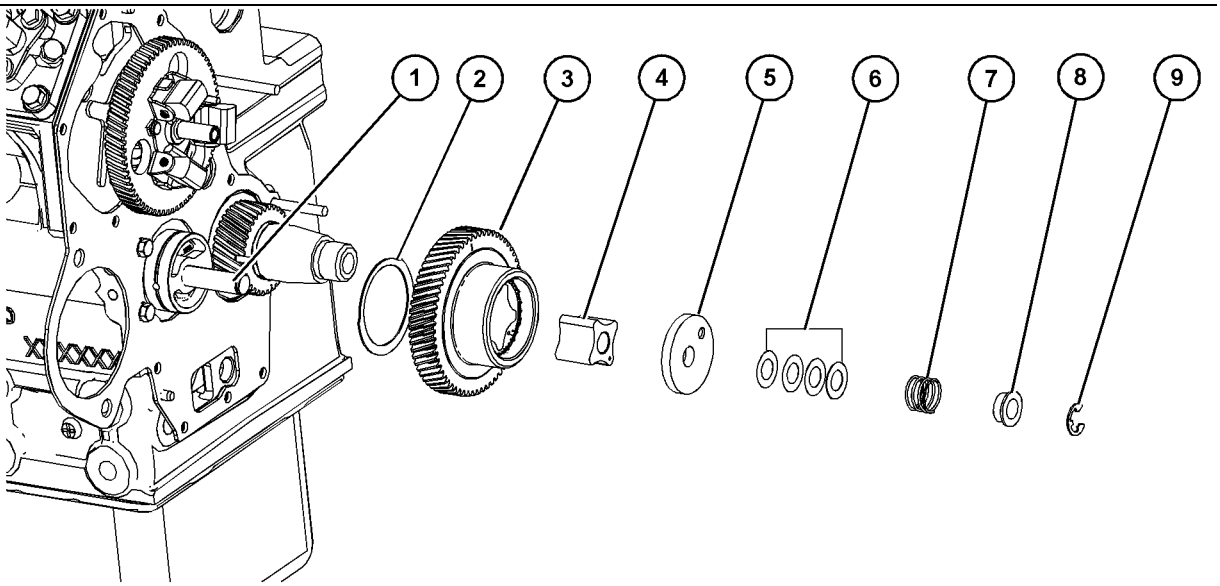

Illustration 120 g06653875

Older Engine Oil Pump Design

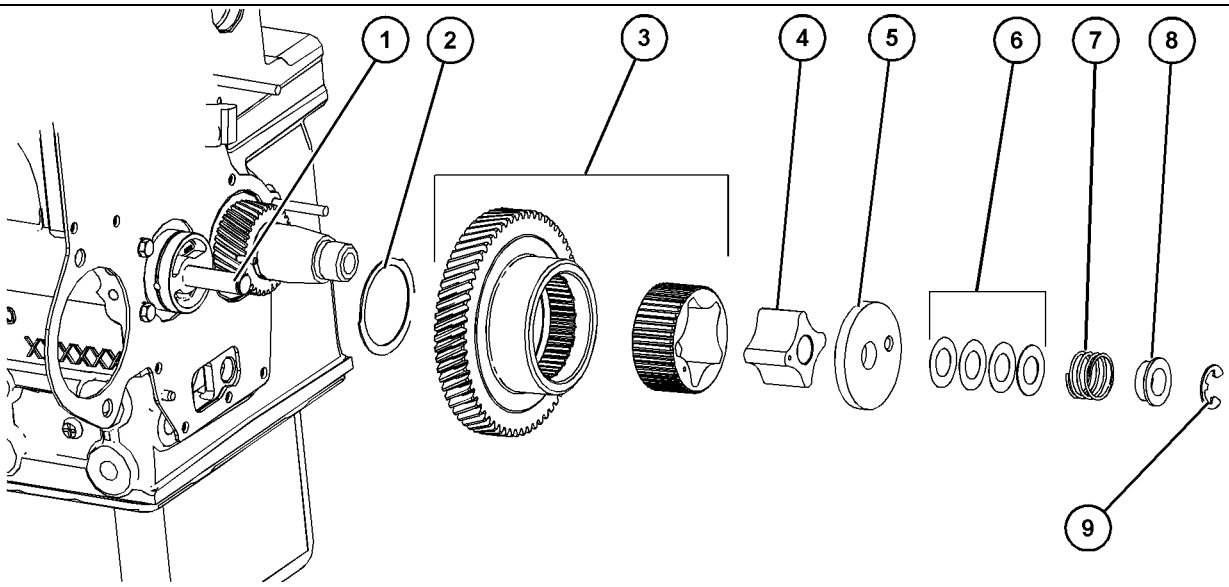

Illustration 121 g06703446

Later Engine Oil Pump Design

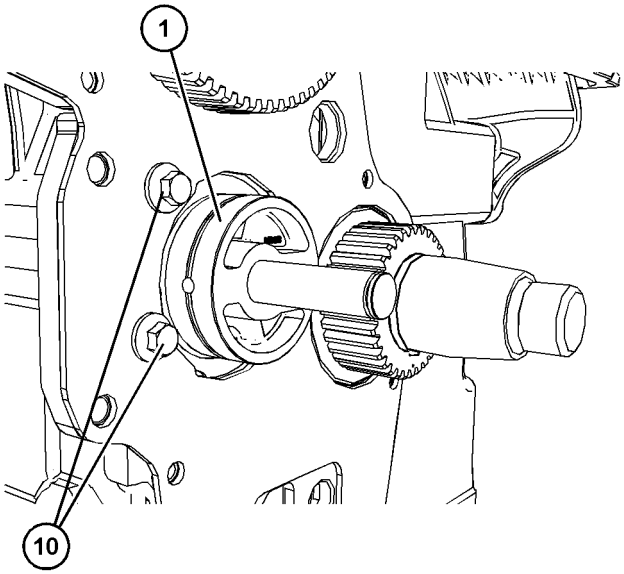

Illustration 122 g06653878

Typical Example

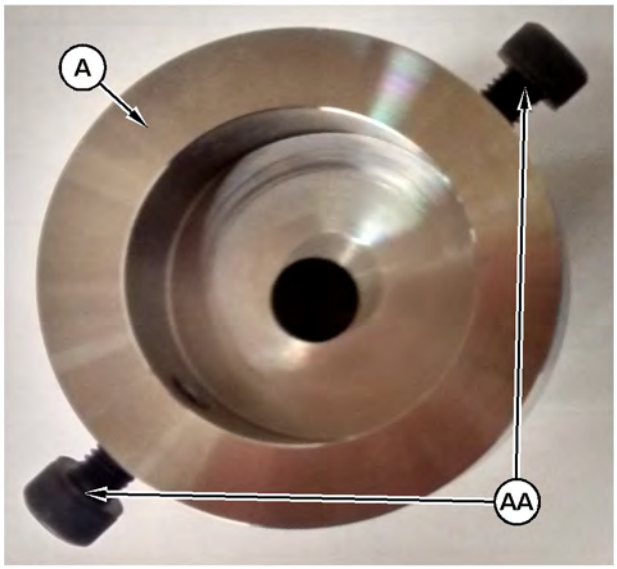

Illustration 123 g06276009

Typical example

⚠ 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.

2. Remove C-clip (9) that retains idler gear (3) onto idler hub (1).

3. Remove the following components from idler hub (1) collar (8), spring (7), shims (6), and oil pump cover (5).

4. Remove idler gear (3) from idler hub (1).

5. Remove inner rotor (4) from idler hub (1).

6. Remove thrust washer (2) from idler hub (1).

7. Install Tooling (A) to idler hub (1). Securely tighten Allen Head Bolt (AA) on Tooling (A).

8. Install Tooling (B) onto Tooling (A). Use Tooling (B) and Tooling (A) to remove idler hub (1) from the cylinder block.

Method Two for Removal of Idler Hub

Start By:

a. Set the engine to top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, "Finding Top Center Position for No. 1 Piston" 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.

c. Remove the front housing and back plate. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct 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.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

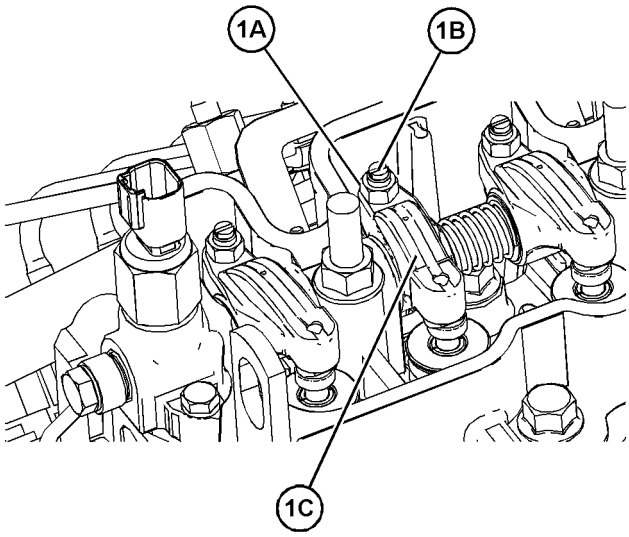

Illustration 124 g06655304

Typical Example

1. Loosen nuts (1A) on all rocker arms (1C). Unscrew adjusters (1B) on all the rocker arms until all valves are fully closed.

Note: Do **NOT** rotate the engine once all the rocker arm adjusters are loosened.

2. Remove the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” for the correct procedure.

3. Remove the camshaft and the back plate. Refer to Disassembly and Assembly, “Camshaft - Remove” for the correct procedure.

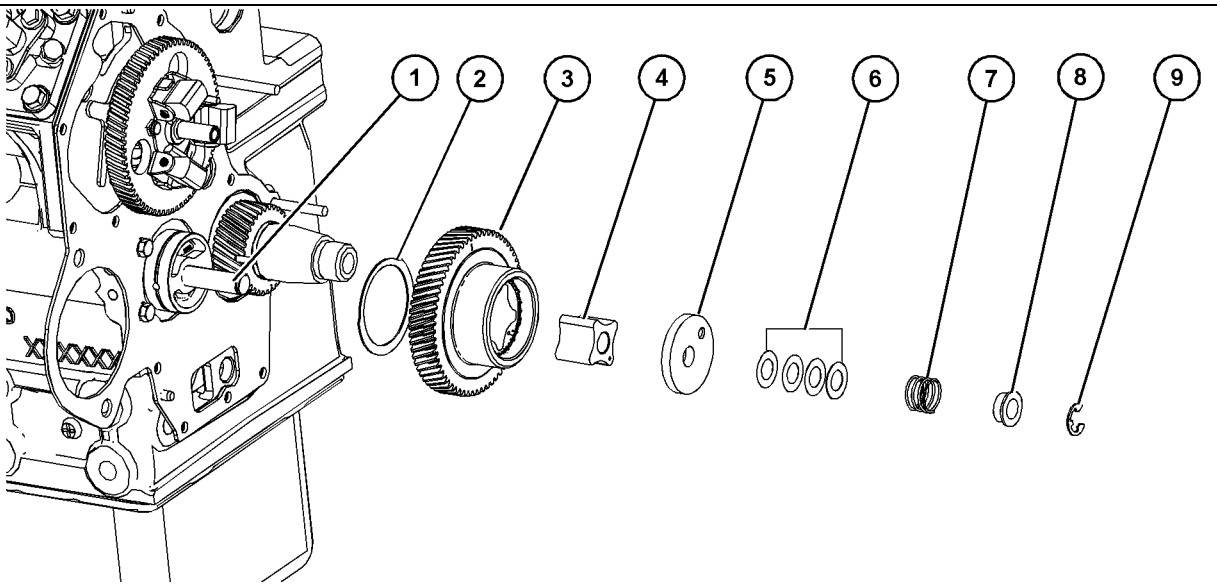

Illustration 125 g06653875

Older Engine Oil Pump Design

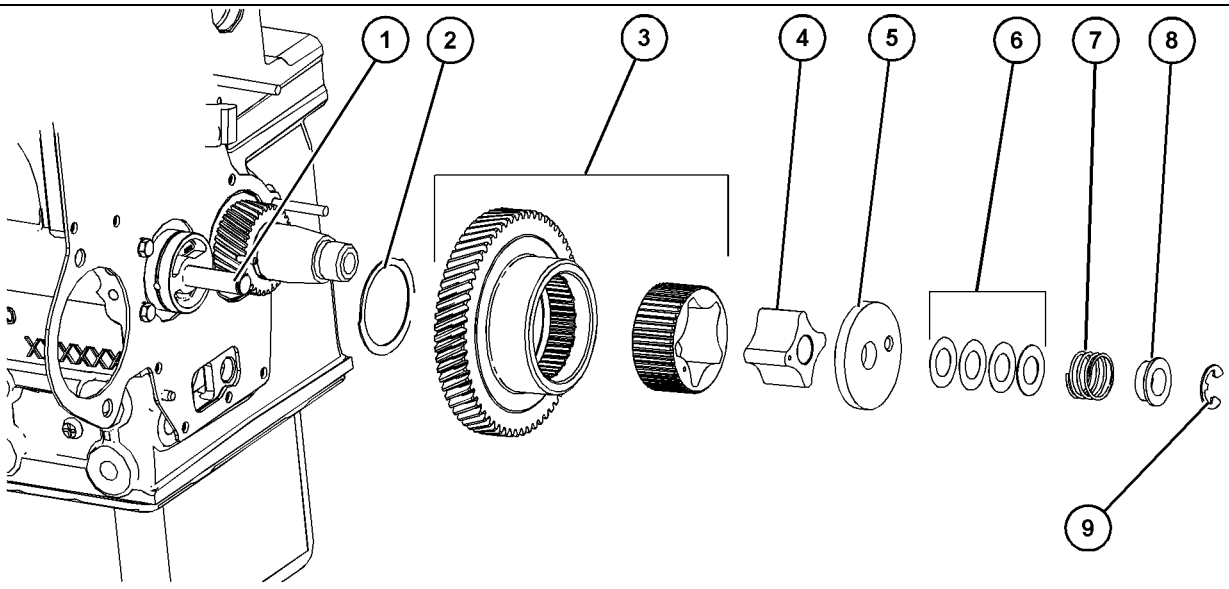

Illustration 126 g06703446

Later Engine Oil Pump Design

⚠ 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.

4. Remove C-clip (9) that retains idler gear (3) onto idler hub (1).
5. Remove the following components from idler hub (1) collar (8), spring (7), shims (6), and oil pump cover (5).
6. Remove idler gear (3) from idler hub (1).
7. Remove inner rotor (4) from idler hub (1).
8. Remove thrust washer (2) from idler hub (1).

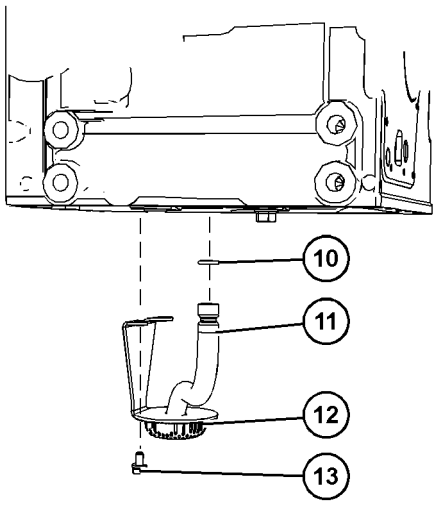

Illustration 127 g06276461

9. Follow Step 9a through Step 9c to remove oil strainer (13) and suction pipe (11).

a. Remove bolts (13) and oil strainer (12) from the cylinder block.

b. Remove suction pipe (11) from the cylinder block.

c. Remove O-ring seal (10) from suction pipe (11).

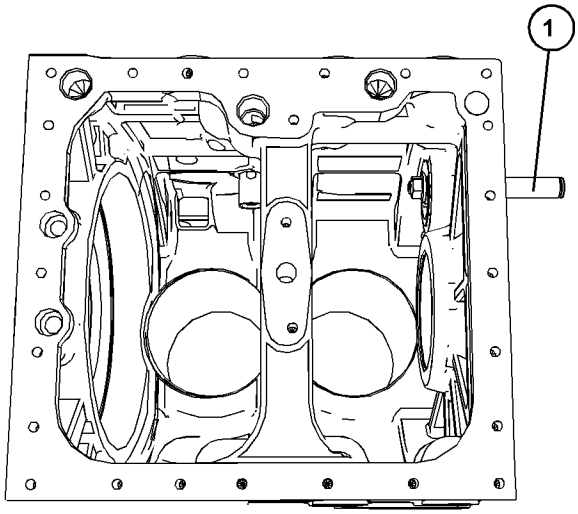

Illustration 128 g06276468

10. Use suitable tooling to driver idler hub (1) from the cylinder block. **Ensure that the cylinder block is not damaged as the idler hub is removed.**

i08536490

Engine Oil Pump - Install (403F-11, 403F-15 Engines)

Method One for Installation of Idler Hub

Table 14

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	21825625	Alignment Tool	1
A(2)	21825627	Alignment Tool	1
B	-	Multipurpose Grease	1

(1) 403F-11 engines
(2) 403F-15 engines

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

1. If the idler hub for the engine oil pump **was** removed from the cylinder block, the engine oil pump assembly and the idler hub must be replaced as an assembly.

2. If the idler hub for the engine oil pump **was not** removed from the cylinder block. Ensure that all components of the engine oil pump are free from wear and damage. If any component is not free from wear or damage, the engine oil pump should be replaced as an assembly.

3. Ensure that the engine is at top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, “Finding Top Center Position for No. 1 Piston” for the correct procedure.

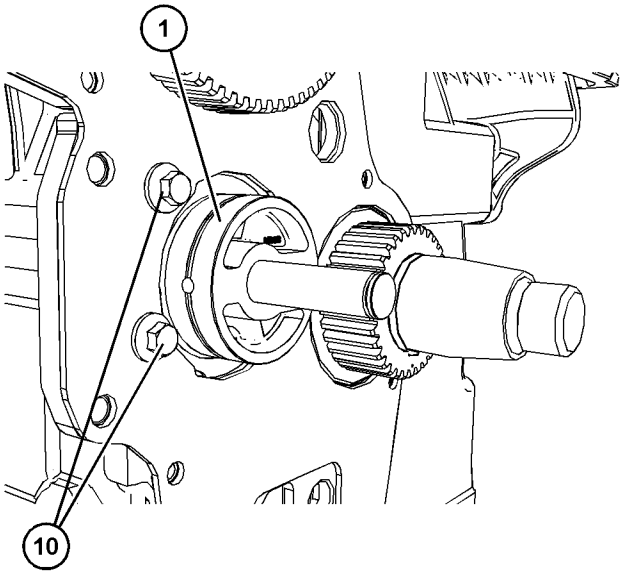

Illustration 129 g06653878

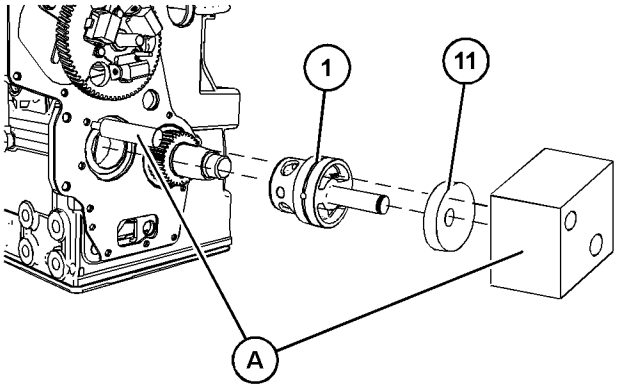

Illustration 130 g06276058
Typical example

4. Install the pin of Tooling (A) to the cylinder block.

5. Install a suitable 6 mm (0.236 inch) washer (11) to the recess of Tooling (A).

Note: The installation of a suitable washer to the recess of Tooling (A) will compensate for the thickness of the back plate.

6. Install idler hub (1) into the Tooling (A). Align Tooling (A) with pin of Tooling (A).

7. Use a soft face hammer to drift Tooling (A) and drive idler hub (1) fully into the cylinder block.

8. Remove Tooling (A) and spacer (11).

9. Install bolts (10). Tighten the bolts to a torque of 10 N·m (89 lb in).

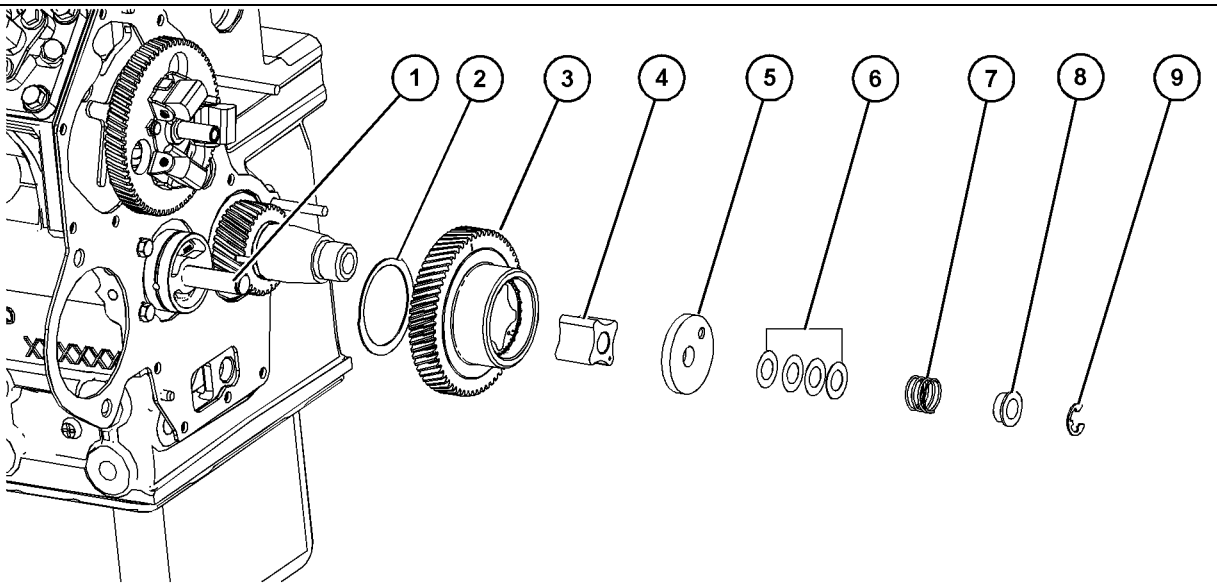

Illustration 131 g06653875

Older Engine Oil Pump Design

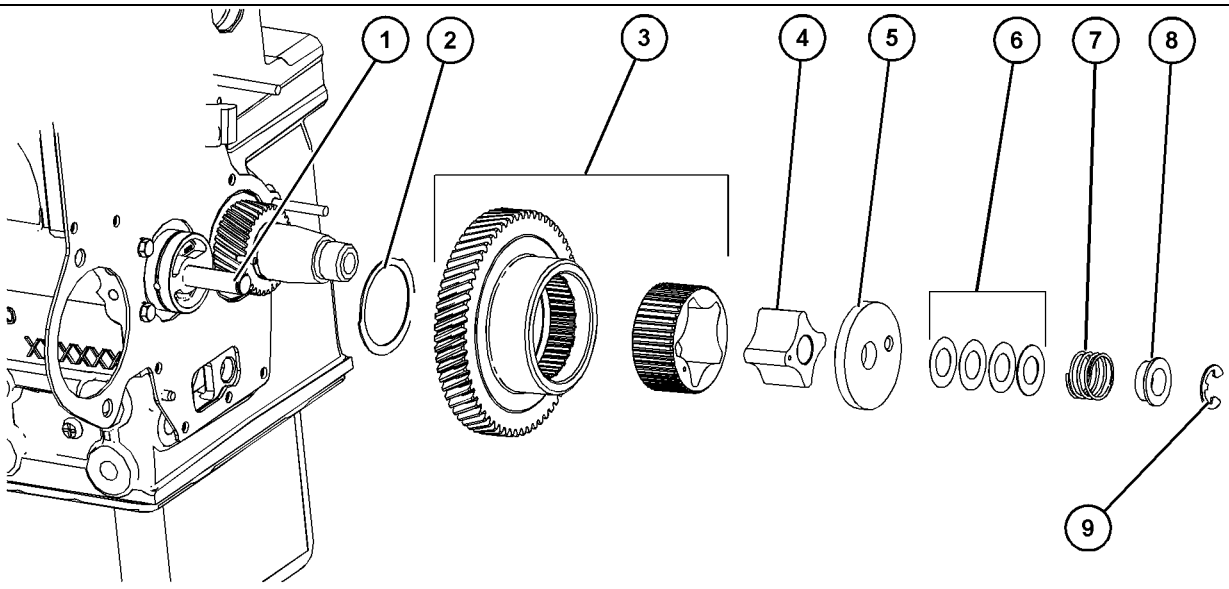

Illustration 132 g06703446

Later Engine Oil Pump Design

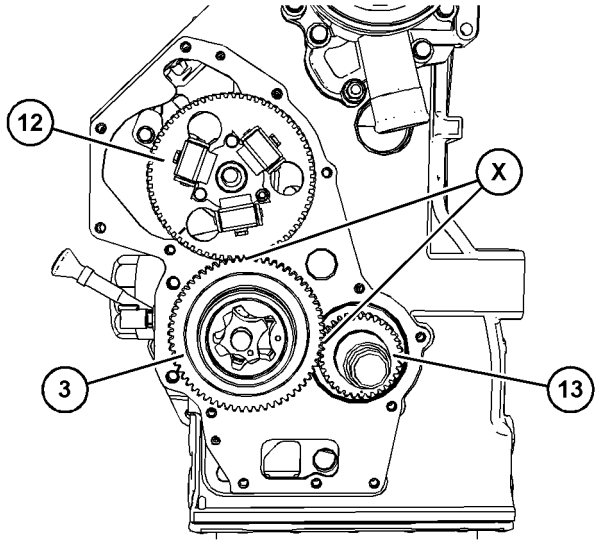

Illustration 133 g06276065
Typical example

10. Lubricate thrust washer (2) with clean engine oil. Install the thrust washer.

⚠ 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.

Note: On later engines the outer rotor of the oil pump may be a spline type and may be removed.

11. Apply Tooling (B) to the faces of inner rotor (4) and to the vanes of idler gear (3).

12. Align timing Marks (X) on idler gear (3) with the respective timing marks on camshaft gear (12) and crankshaft gear (13). Install the idler gear onto idler hub (1).

13. Install inner rotor (4) to idler gear (3).

⚠ WARNING

Personal injury can result from the release of the spring force.

The drive shaft, the piston, and the drive gear are under spring force.

Use a press to slowly release the spring force before the components are removed.

14. Install the following items to idler hub (1) :

- Oil pump cover (5)
- Shim (6)
- Spring (7)
- Collar (8)

Refer to Illustration 131 .

15. Install C-clip (9) to the shaft of idler hub (1).

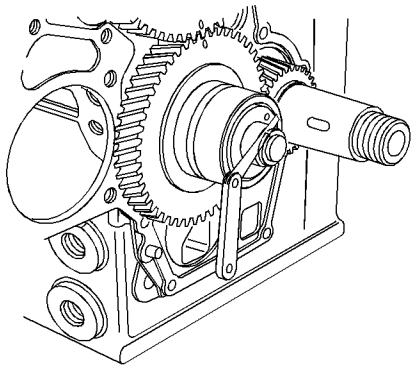

Illustration 134 g01320625
Checking end play by using a feeler gauge

16. Use a feeler gauge to measure the end play of the engine oil pump. Refer to Specifications, “Engine Oil Pump” for further information.

Method Two for Installation of Idler Hub

Table 15

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	21825625	Alignment Tool	1
A(2)	21825627	Alignment Tool	1
B	-	Multipurpose Grease	1

(1) 403F-11 engines
(2) 403F-15 engines

1. If the idler hub for the engine oil pump **was** removed from the cylinder block, the engine oil pump assembly and the idler hub must be replaced as an assembly.

2. If the idler hub for the engine oil pump **was not** removed from the cylinder block. Ensure that all components of the engine oil pump are free from wear and damage. If any component is not free from wear or damage, the engine oil pump should be replaced as an assembly.

3. Ensure that the engine is at top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, “Finding Top Center Position for No. 1 Piston” for the correct procedure.

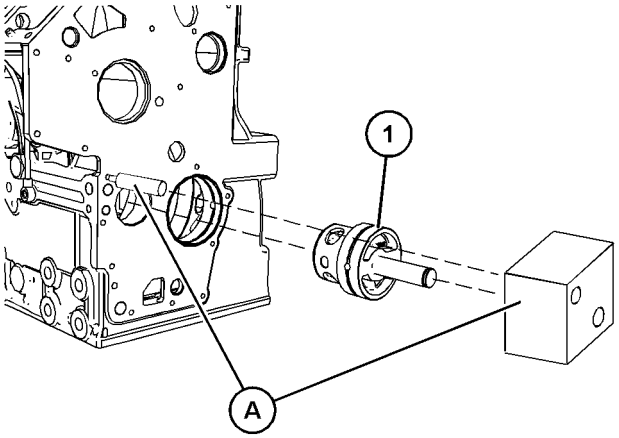

Illustration 135 g06276123
Typical example

4. Install the pin of Tooling (A) to the cylinder block.

5. Install idler hub (1) into the Tooling (A). Align Tooling (A) with pin of Tooling (A).

6. Use a soft face hammer to drift Tooling (A). Drive idler hub (1) into the cylinder block until fully installed.

7. Remove Tooling (A).

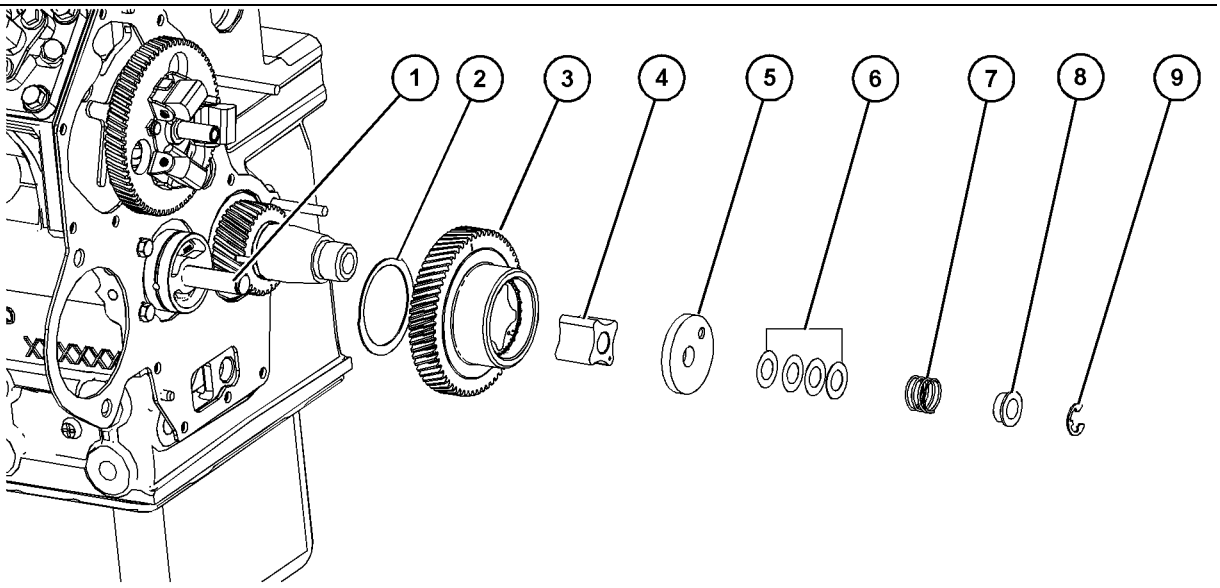

Illustration 136 g06653875

Older Engine Oil Pump Design

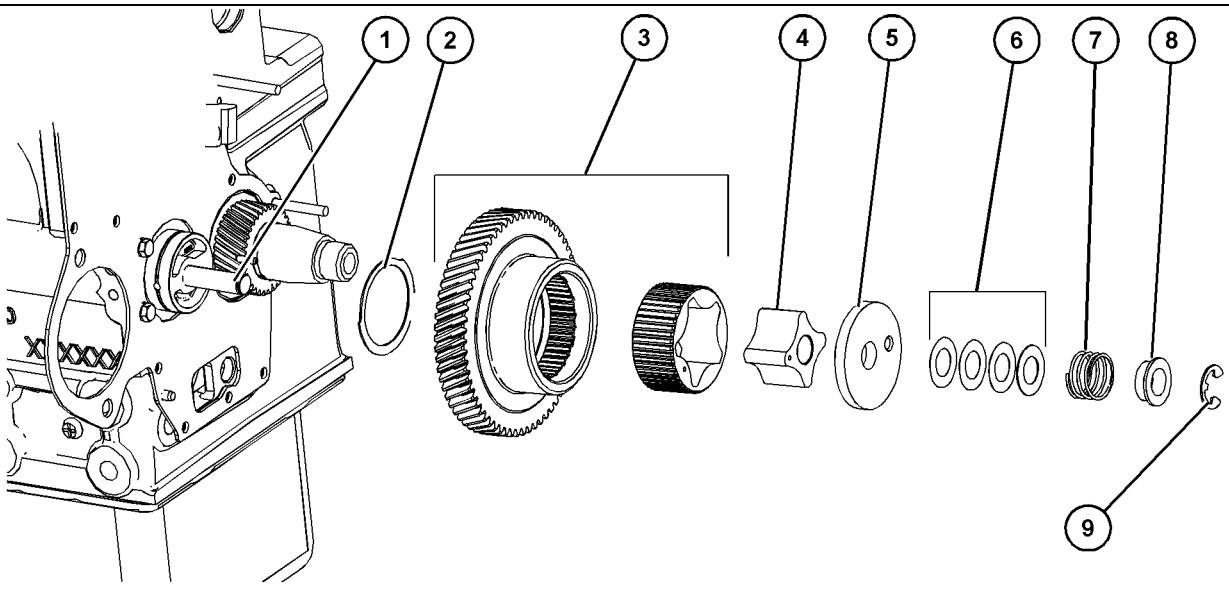

Illustration 137 g06703446

Later Engine Oil Pump Design

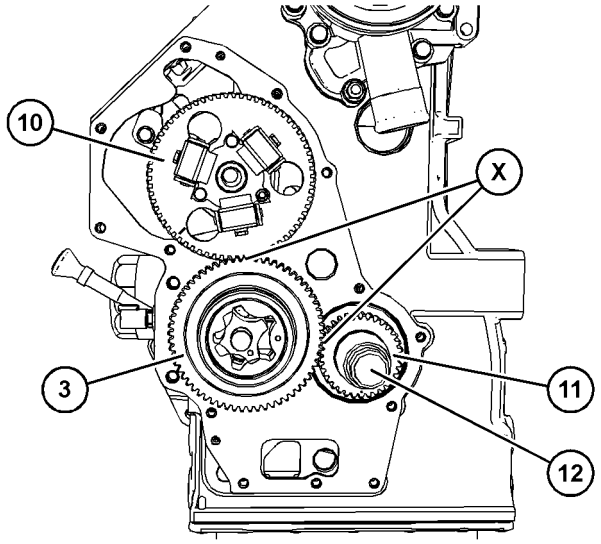

Illustration 138 g06276126
Typical example

8. Install crankshaft (12). Refer to Disassembly and Assembly, “Crankshaft - Install” for the correct procedure.

9. Install the back plate and camshaft (10). Refer to Disassembly and Assembly, “Camshaft - Install” for the correct procedure.

10. Lubricate thrust washer (2) with clean engine oil. Install the thrust washer.

⚠ 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.

Note: On later engines the outer rotor of the oil pump may be a spline type and may be removed.

11. Apply Tooling (B) to the faces of inner rotor (4) and to the vanes of idler gear (3).

12. Align timing Marks (X) on idler gear (3) with the respective timing marks on camshaft gear (12) and crankshaft gear (13). Install the idler gear onto idler hub (1).

13. Install inner rotor (4) to idler gear (3).

⚠ WARNING

Personal injury can result from the release of the spring force.

The drive shaft, the piston, and the drive gear are under spring force.

Use a press to slowly release the spring force before the components are removed.

14. Install the following items to idler hub (1) :

- Oil pump cover (5)
- Shim (6)
- Spring (7)
- Collar (8)

Refer to Illustration 136 .

15. Install C-clip (9) to the shaft of idler hub (1).

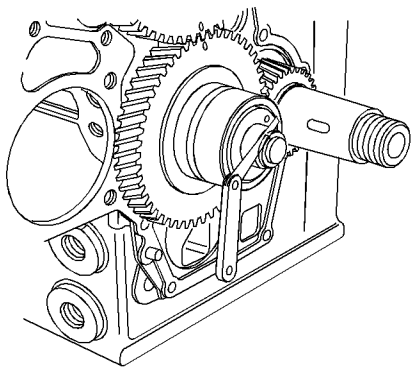

Illustration 139 g01320625
Checking end play by using a feeler gauge

16. Use a feeler gauge to measure the end play of the engine oil pump. Refer to Specifications, “Engine Oil Pump” for further information.

17. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

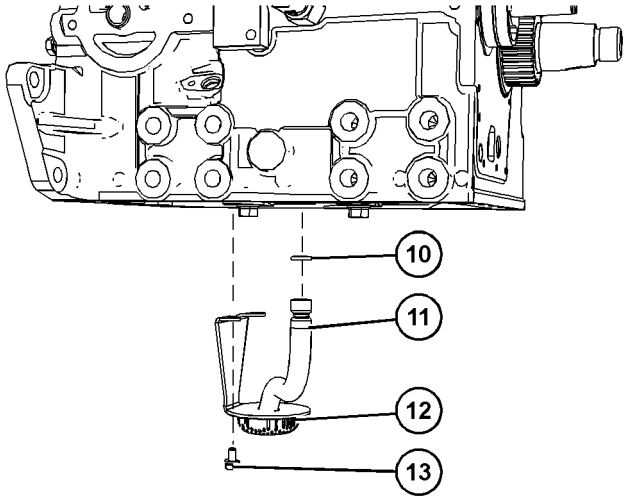

Illustration 140 g06276023

18. Follow Step 18a through Step 18e to install oil strainer (13) and suction pipe (11).

a. Install a new O-ring seal (10) to suction pipe (11).

b. Install suction pipe (11) to the cylinder block.

c. Install oil strainer (12) to the cylinder block. Ensure that suction pipe (11) is correctly positioned onto the suction pipe.

d. Install bolts (13) to oil strainer (12). Tighten the bolts to a torque of 11 N·m (97 lb in).

e. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

i08539077

Engine Oil Pump - Install (402F-05 and 402F-07 Engines)

Method One for Installation of Idler Hub

Table 16

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	21825624	Alignment Tool	1
B	-	Multipurpose Grease	1

(1) 402F-05 and 403F-07 engines

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

1. If the idler hub for the engine oil pump **was** removed from the cylinder block, the engine oil pump assembly and the idler hub must be replaced as an assembly.

2. If the idler hub for the engine oil pump **was not** removed from the cylinder block. Ensure that all components of the engine oil pump are free from wear and damage. If any component is not free from wear or damage, the engine oil pump should be replaced as an assembly.

3. Ensure that the engine is at top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, “Finding Top Center Position for No. 1 Piston” for the correct procedure.

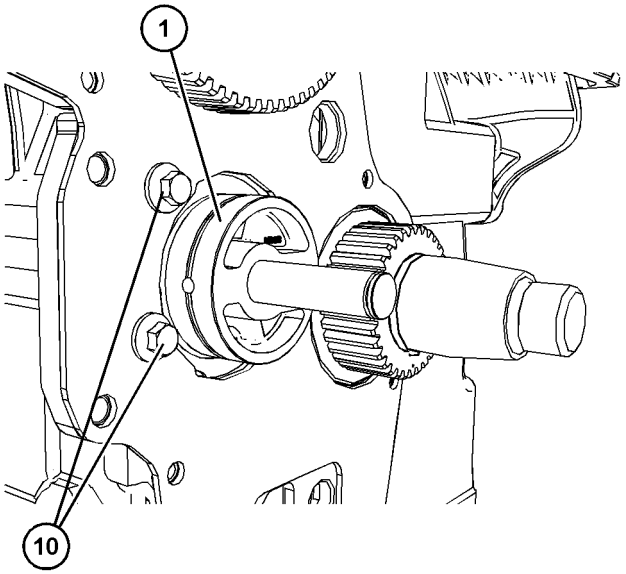

Illustration 141 g06653878

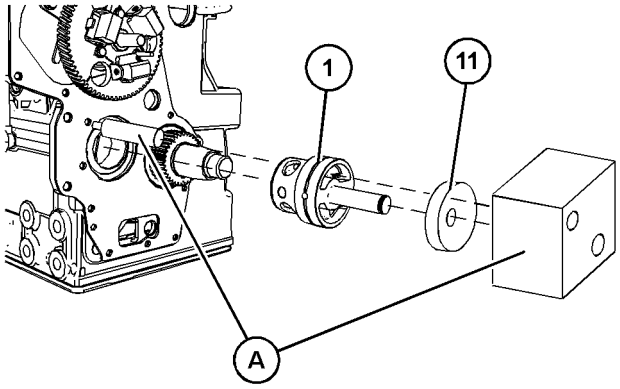

Illustration 142 g06276058
Typical example

4. Install the pin of Tooling (A) to the cylinder block.

5. Install a suitable 6 mm (0.236 inch) washer (11) to the recess of Tooling (A).

Note: The installation of a suitable washer to the recess of Tooling (A) will compensate for the thickness of the back plate.

6. Install idler hub (1) into the Tooling (A). Align Tooling (A) with pin of Tooling (A).

7. Use a soft face hammer to drift Tooling (A) and drive idler hub (1) fully into the cylinder block.

8. Remove Tooling (A) and spacer (11).

9. Install bolts (10). Tighten the bolts to a torque of 10 N·m (89 lb in).

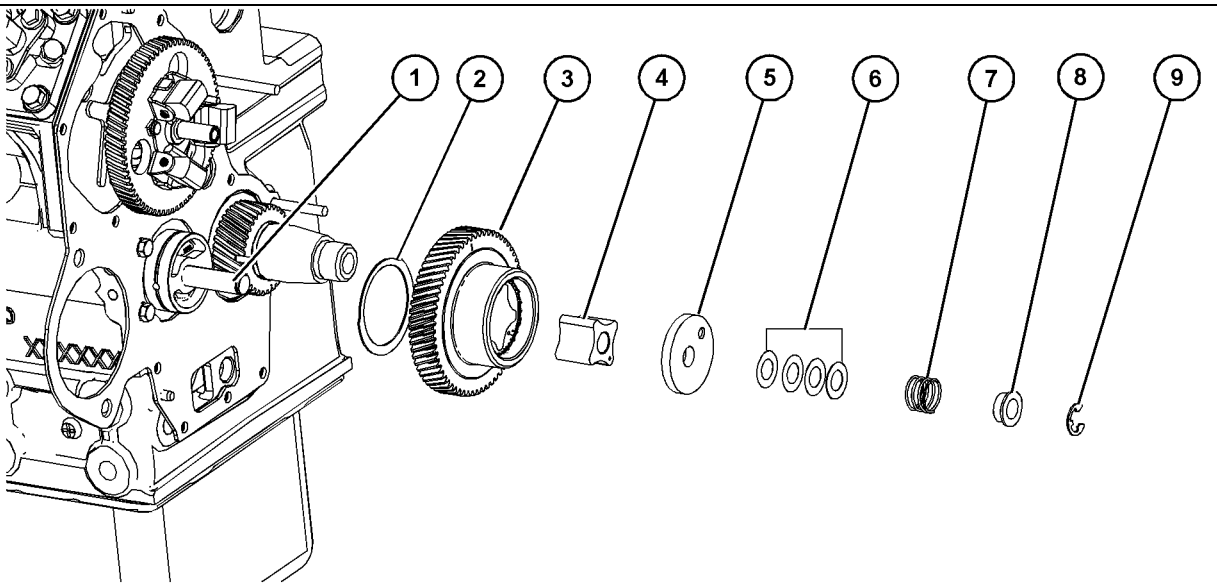

Illustration 143 g06653875

Older Engine Oil Pump Design

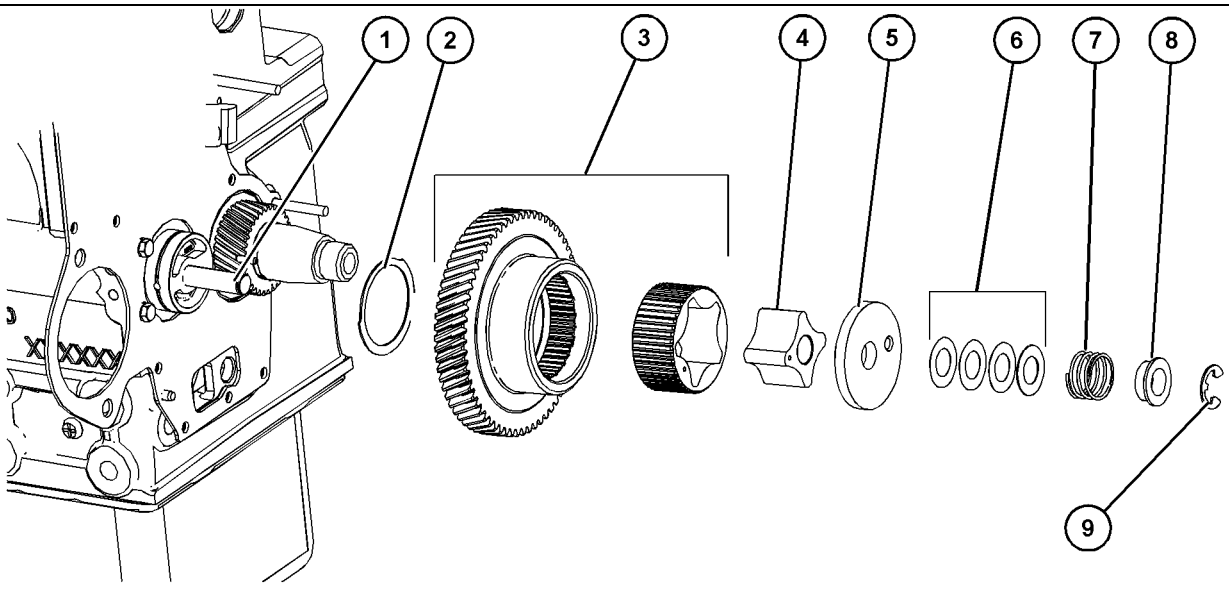

Illustration 144 g06703446

Later Engine Oil Pump Design

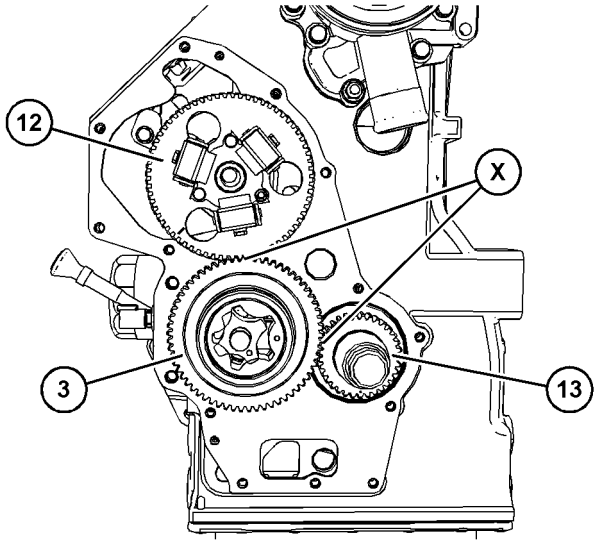

Illustration 145 g06276065
Typical example

10. Lubricate thrust washer (2) with clean engine oil. Install the thrust washer.

⚠ 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.

Note: On later engines the outer rotor of the oil pump may be a spline type and may be removed.

11. Apply Tooling (B) to the faces of inner rotor (4) and to the vanes of idler gear (3).

12. Align timing Marks (X) on idler gear (3) with the respective timing marks on camshaft gear (12) and crankshaft gear (13). Install the idler gear onto idler hub (1).

13. Install inner rotor (4) to idler gear (3).

⚠ WARNING

Personal injury can result from the release of the spring force.

The drive shaft, the piston, and the drive gear are under spring force.

Use a press to slowly release the spring force before the components are removed.

14. Install the following items to idler hub (1) :

- Oil pump cover (5)
- Shim (6)
- Spring (7)
- Collar (8)

Refer to Illustration 143 .

15. Install C-clip (9) to the shaft of idler hub (1).

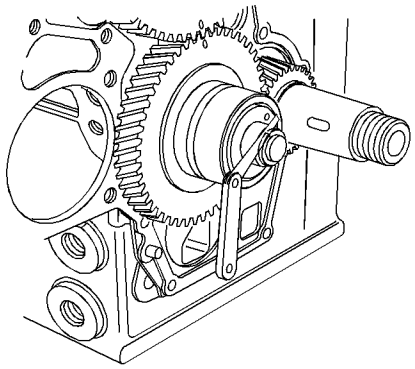

Illustration 146 g01320625
Checking end play by using a feeler gauge

16. Use a feeler gauge to measure the end play of the engine oil pump. Refer to Specifications, “Engine Oil Pump” for further information.

Method Two for Installation of Idler Hub

Table 17

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	21825626	Alignment Tool	1
B	-	Multipurpose Grease	1

(1) 402F-05 and 403F-07 engines

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

1. If the idler hub for the engine oil pump **was** removed from the cylinder block, the engine oil pump assembly and the idler hub must be replaced as an assembly.

2. If the idler hub for the engine oil pump **was not** removed from the cylinder block. Ensure that all components of the engine oil pump are free from wear and damage. If any component is not free from wear or damage, the engine oil pump should be replaced as an assembly.

3. Ensure that the engine is at top center position for No. 1 piston. Refer to Systems Operation Testing and Adjusting, “Finding Top Center Position for No. 1 Piston” for the correct procedure.

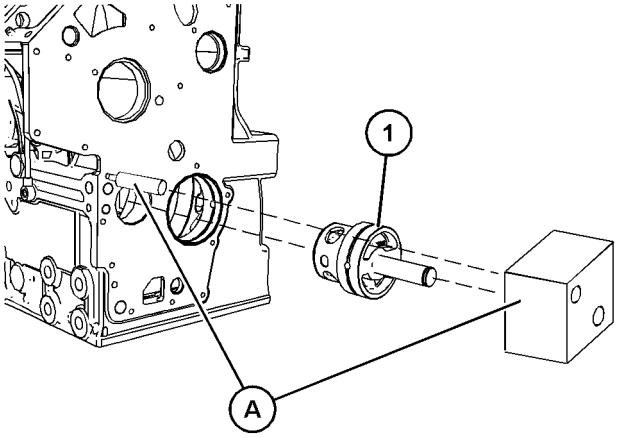

Illustration 147 g06276123
Typical example

4. Install the pin of Tooling (A) to the cylinder block.

5. Install idler hub (1) into the guide plate of Tooling (A). Align the guide plate of Tooling (A) with pin of Tooling (A).

6. Use a soft face hammer to drift Tooling (A) and idler hub (1) into the cylinder block until Tooling (A) contacts the front of the cylinder block.

7. Remove Tooling (A).

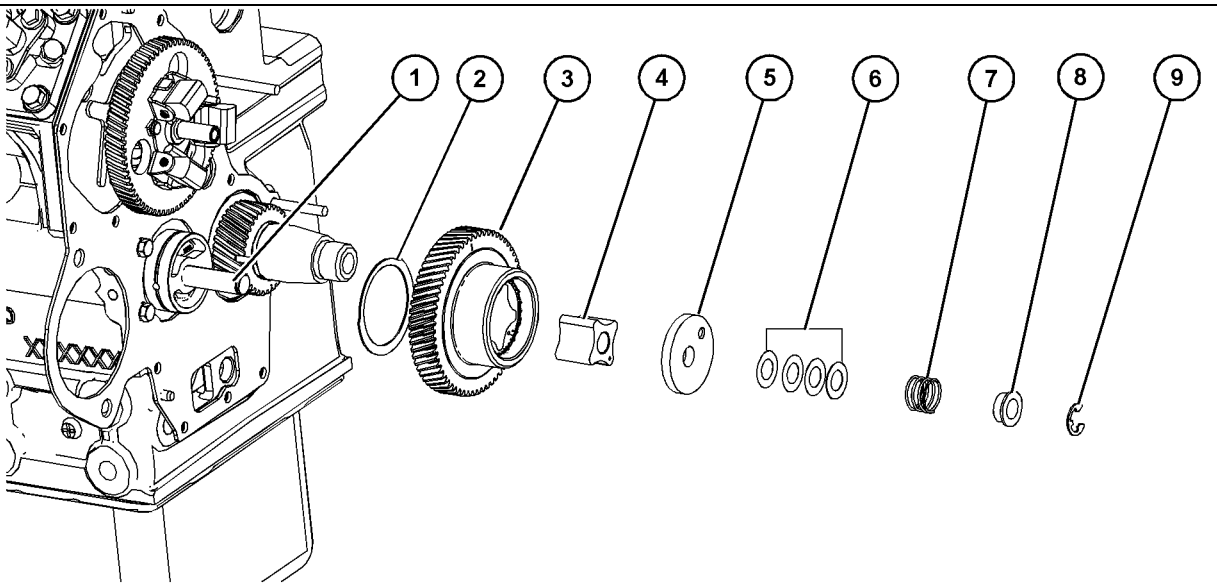

Illustration 148 g06653875

Older Engine Oil Pump Design

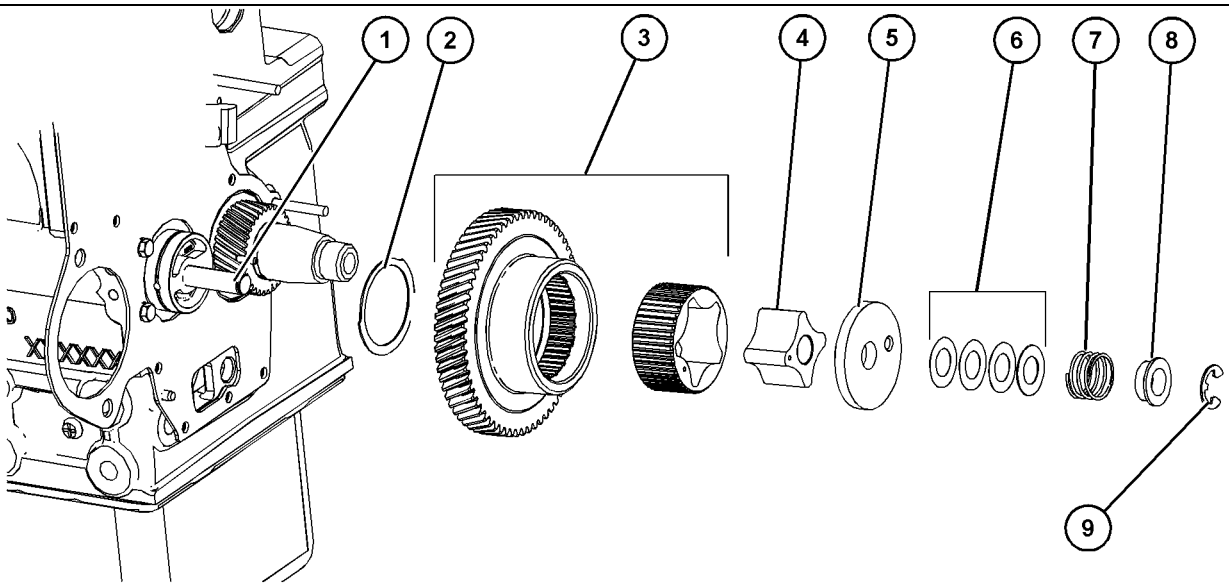

Illustration 149 g06703446

Later Engine Oil Pump Design

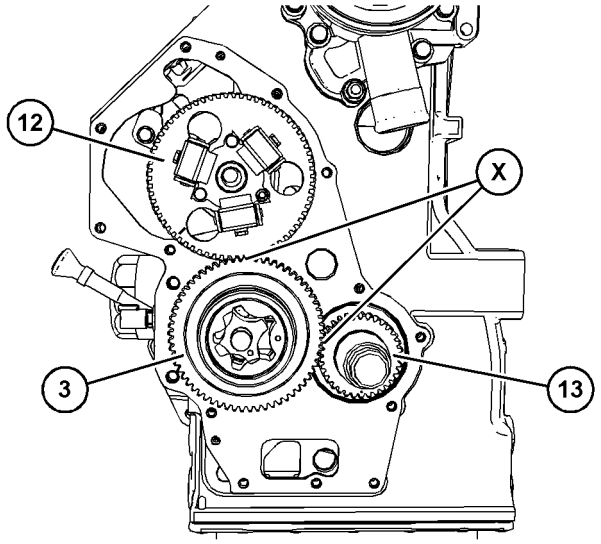

Illustration 150 g06276065
Typical example

8. Install the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” for the correct procedure.

9. Install the back plate and the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove” for the correct procedure.

10. Lubricate thrust washer (2) with clean engine oil. Install the thrust washer.

⚠ 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.

Note: On later engines the outer rotor of the oil pump may be a spline type and may be removed.

11. Apply Tooling (B) to the faces of inner rotor (4) and to the vanes of idler gear (3).

12. Align timing Marks (X) on idler gear (3) with the respective timing marks on camshaft gear (12) and crankshaft gear (13). Install the idler gear onto idler hub (1).

13. Install inner rotor (4) to idler gear (3).

⚠ WARNING

Personal injury can result from the release of the spring force.

The drive shaft, the piston, and the drive gear are under spring force.

Use a press to slowly release the spring force before the components are removed.

14. Install the following items to idler hub (1) :

- Oil pump cover (5)
- Shim (6)
- Spring (7)
- Collar (8)

Refer to Illustration 148 .

15. Install C-clip (9) to the shaft of idler hub (1).

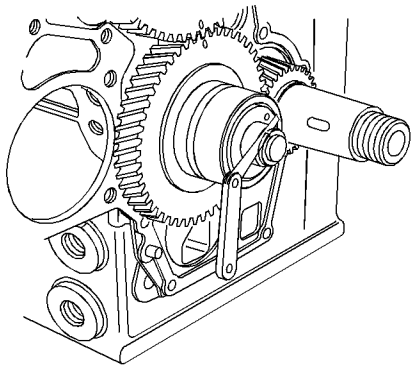

Illustration 151 g01320625
Checking end play by using a feeler gauge

16. Use a feeler gauge to measure the end play of the engine oil pump. Refer to Specifications, “Engine Oil Pump” for further information.

17. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

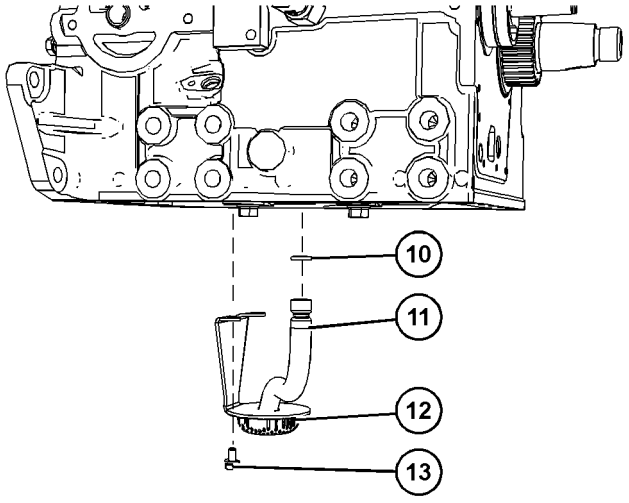

Illustration 152 g06276023

18. Follow Step 18a through Step 18e to install oil strainer (13) and suction pipe (11).

a. Install a new O-ring seal (10) to suction pipe (11).

b. Install suction pipe (11) to the cylinder block.

c. Install oil strainer (12) to the cylinder block. Ensure that suction pipe (11) is correctly positioned onto the suction pipe.

d. Install bolts (13) to oil strainer (12). Tighten the bolts to a torque of 11 N·m (97 lb in).

e. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

i07676507

Water Pump - Remove and Install
(403F-11, and 403F-15 Engines)

Two types of alternator adjusting bracket are installed onto the water pump. Type one has the alternator adjusting bracket installed onto the water pump bracket. Type two has the alternator adjusting bracket secured by the water pump retaining bolts.

Removal Procedure For Type One Water Pump

Start By:

a. Remove the fan. 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 - Drain” for more information.

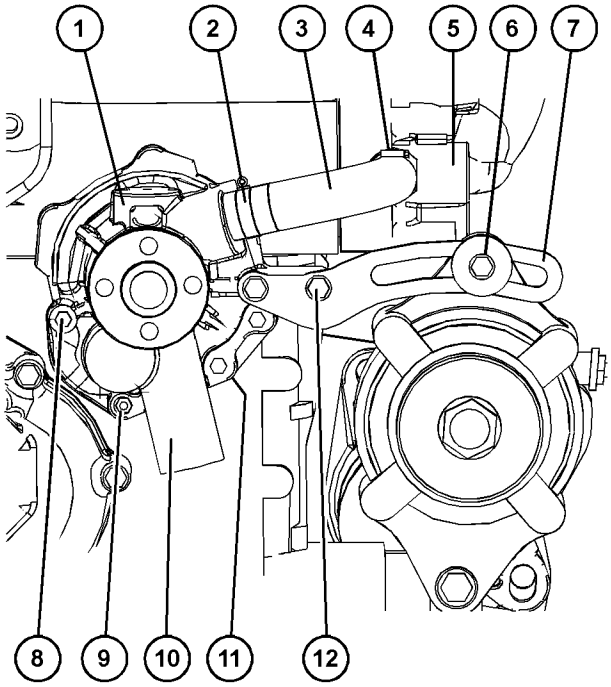

Illustration 153 g06215142
Typical example

2. Loosen the hose clamp and disconnect the coolant hose assembly from inlet connection (10) on water pump (1).

3. Loosen hose clamp (2) and hose clamp (4) for hose assembly (3). Disconnect the hose assembly from water pump (1) and water temperature regulator (5).

4. Remove bolts (12) and bolt and washer (6) from adjusting bracket (7). Remove the adjusting bracket from the alternator.

5. Remove bolts (8) and nut (9) from water pump (1). Support the water pump as the bolts and nut are removed.

6. Remove water pump (1) from the cylinder block.

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

7. Remove gasket (11) (not shown).

Installation Procedure For Type One Water Pump

Table 18

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 242	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the gasket surfaces of the water pump and the cylinder block are clean and free from damage.

2. Ensure that all components of the water pump are free from wear or damage. Replace any components that are worn or damaged.

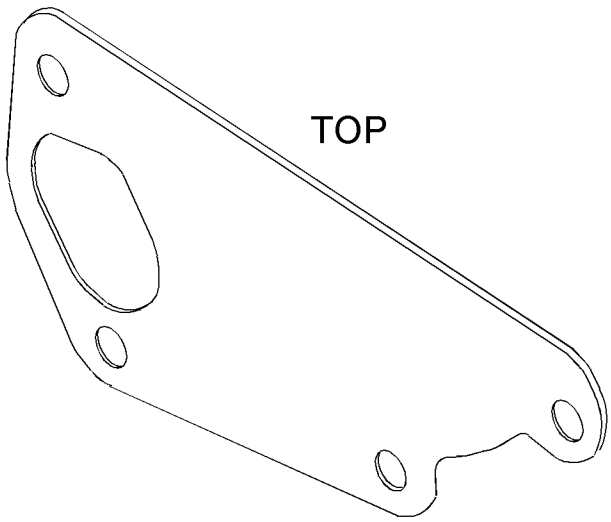

Illustration 154 g06218233
Water pump gasket correct orientation

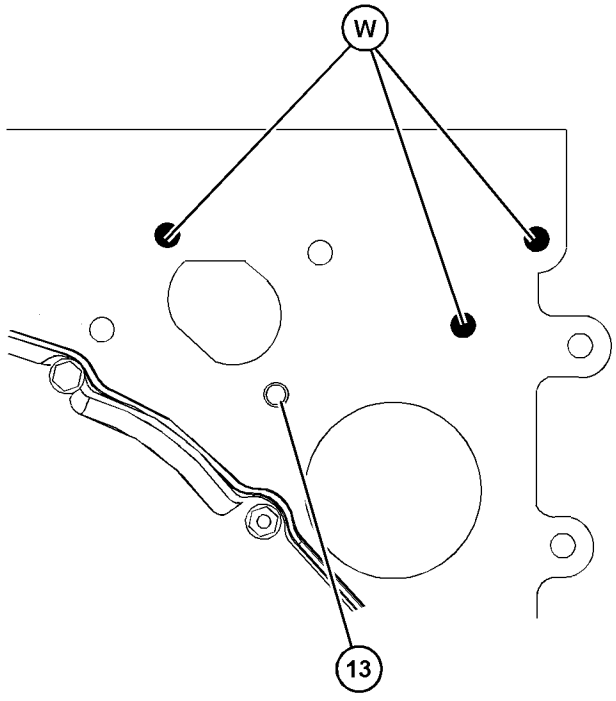

Illustration 155 g06215195

1. Ensure that the bolt holes in Position (W) and stud (13) are clean and free from oil and coolant.

2. Install a new gasket (11) (not shown) over stud (13). Ensure that the gasket is correctly oriented. Refer to Illustration 154 .

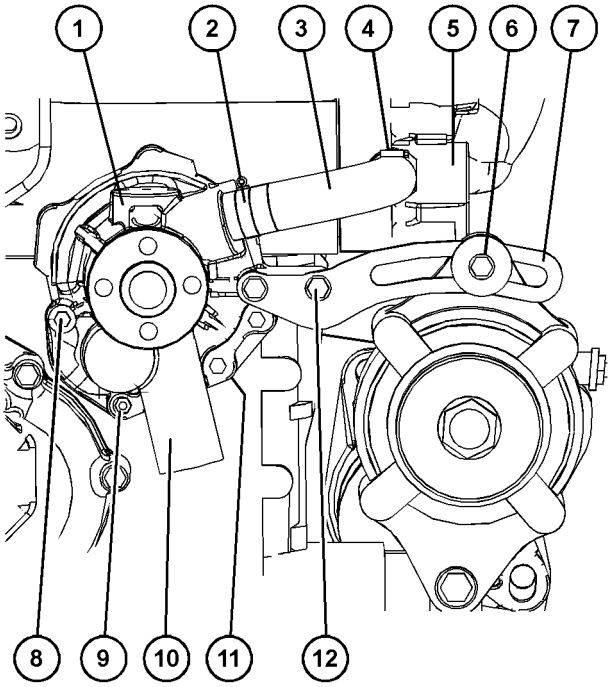

Illustration 156 g06215142

Typical example

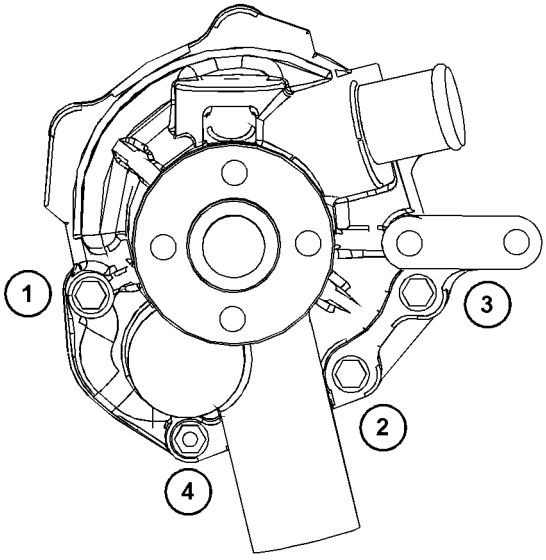

Illustration 157 g06215188

Water pump bolts and nut tightening sequence

3. Apply Tooling (A) to the first two threads of bolts (8) and nut (9).

4. Install water pump (1).

5. Install bolts (8) and nut (9) hand tight. Ensure that gasket (11) (not shown) is correctly positioned.

6. Tighten bolts (8) and nut (9) to a torque of 5 N·m (44 lb in) in the sequence shown in Illustration 157 .

7. Tighten bolts (8) and nut (9) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 157 .

8. Connect the coolant hose assembly to inlet connection (10) on water pump (1). Securely tighten the hose clamp.

9. Connect hose assembly (3) to water pump (1) and water temperature regulator (5). Securely tighten hose clamp (2) and hose clamp (4).

10. Position adjusting bracket (7) onto water pump (1) and the alternator. Install bolts (12) to the water pump and bolt and washer (6) to the adjusting bracket.

11. Tighten bolts (12) to a torque of 22 N·m (195 lb in).

12. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

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

Removal Procedure For Type Two Water Pump

Start By:

a. Remove the fan. 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 - Drain” for more information.

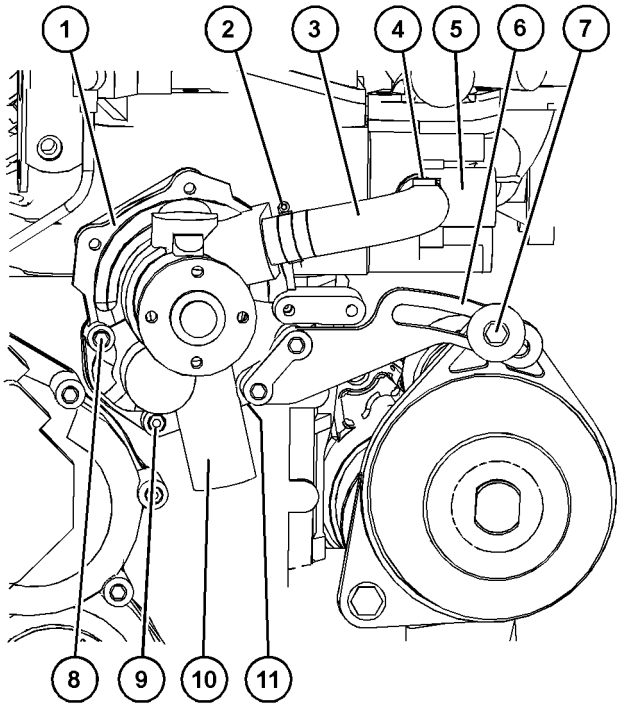

Illustration 158 g06215267
Typical example

2. Loosen the hose clamp and disconnect the coolant hose assembly from inlet connection (10) on water pump (1).
3. Loosen hose clamp (2) and hose clamp (4) for hose assembly (3). Disconnect the hose assembly from water pump (1) and water temperature regulator (5).
4. Remove bolt and washer (7) from adjusting bracket (6).
5. Remove bolts (8) and nut (9) from water pump (1). Support the water pump as the bolts and the nut is removed.

Note: Note position of different length bolts for installation purposes.

6. Remove water pump (1) and adjusting bracket (6) from the cylinder block.

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

7. Remove gasket (11) (not shown).

Installation Procedure For Type Two Water Pump

Table 19

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 242	1

1. Ensure that the gasket surfaces of the water pump and the cylinder block are clean and free from damage.
2. Ensure that all components of the water pump are free from wear or damage. Replace any component the are worn or damaged.

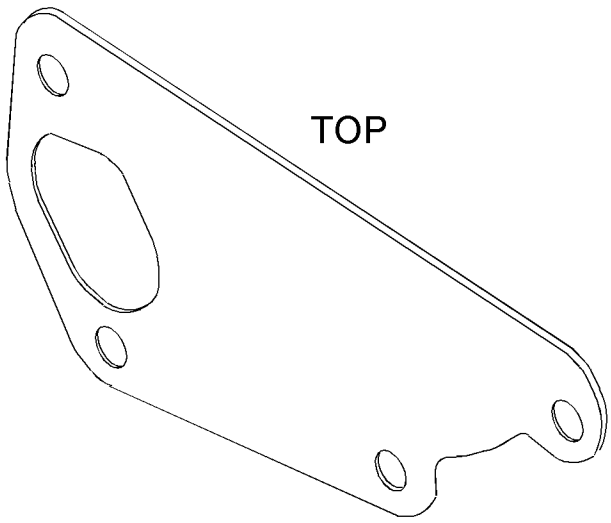

Illustration 159 g06218233
Water pump gasket correct orientation

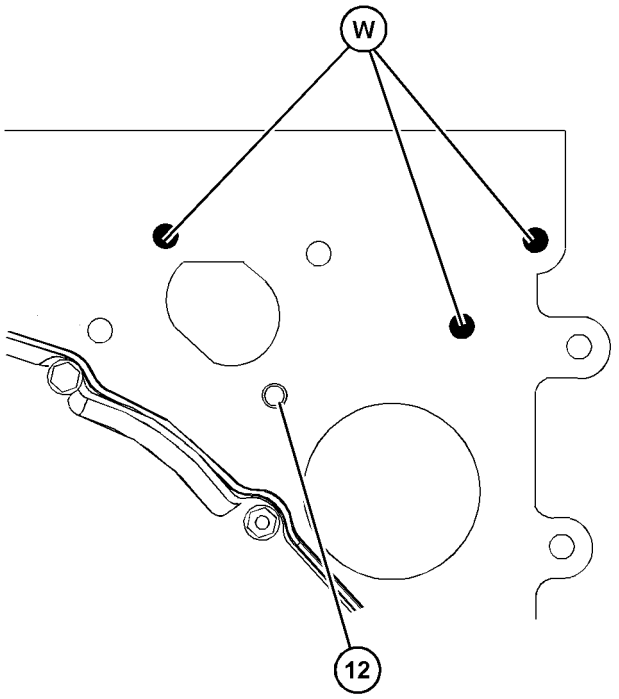

Illustration 160 g06218202

3. Ensure that the bolt holes in Position (W) and stud (12) are clean and free from oil and coolant.

4. Install a new gasket (11) (not shown) over stud (12). Ensure that the gasket is correctly oriented. Refer to Illustration 159 .

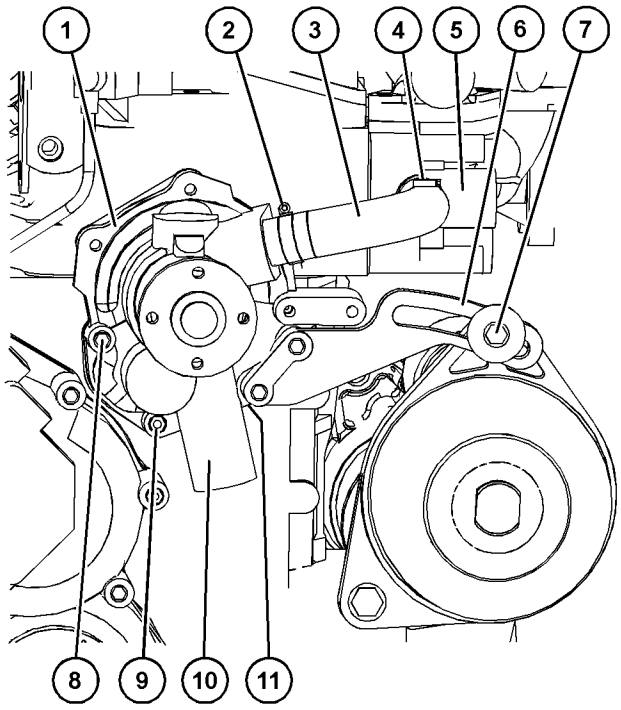

Illustration 161 g06215267

Typical example

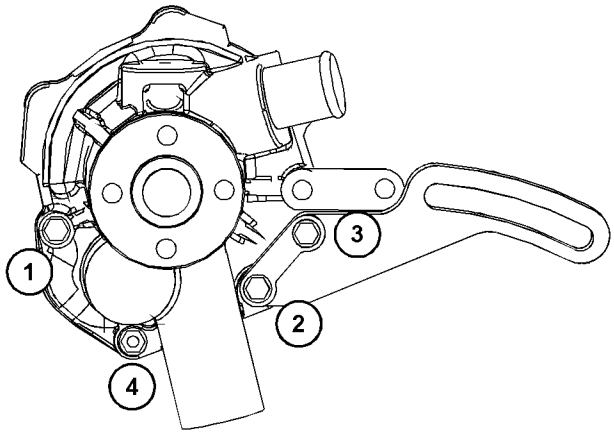

Illustration 162 g06215538

Water pump bolts and nut tightening sequence

5. Apply Tooling (A) to the first two threads of bolts (8) and nut (9).

6. Install water pump (1) and adjusting bracket (6).

7. Install bolts (8) and nut (9) hand tight. Ensure that the gaskets are correctly positioned and the different length bolts are installed into the correct position.

8. Tighten bolts (8) and nut (9) to a torque of 5 N·m (44 lb in) in the sequence shown in Illustration 162 .

9. Tighten bolts (8) and nut (9) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 162 .

10. Connect the coolant hose assembly to inlet connection (10) on water pump (1). Securely tighten the hose clamp.

11. Connect hose assembly (3) to water pump (1) and water temperature regulator (5). Securely tighten hose clamp (2) and hose clamp (4).

12. Install bolt and washer (7) to adjusting bracket (6).

Note: The bolt will be tightened after the alternator belt has been installed.

13. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

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

i07676511

Water Pump - Remove and Install
(402F-05 and 403F-07 Engines)

Removal Procedure

Start By:

a. Remove the fan. 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 - Drain” for more information.

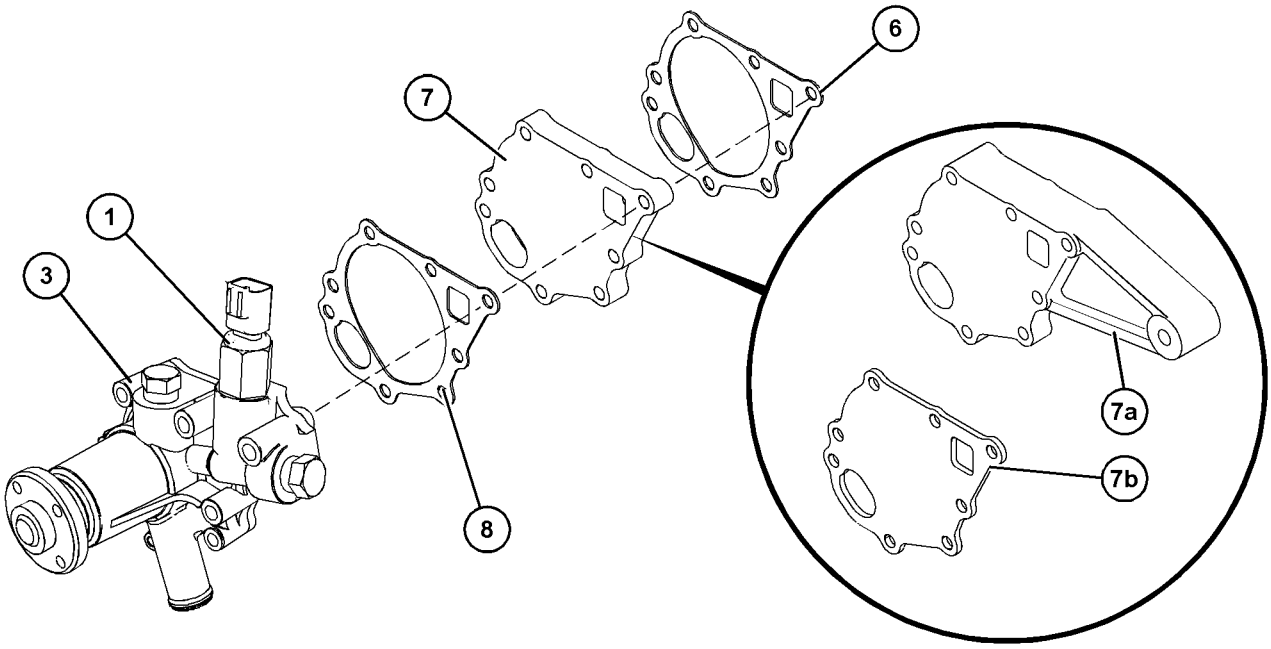

Illustration 163 g06214418

Typical example

Three different types of plate can be installed between the cylinder block and the water pump (3)

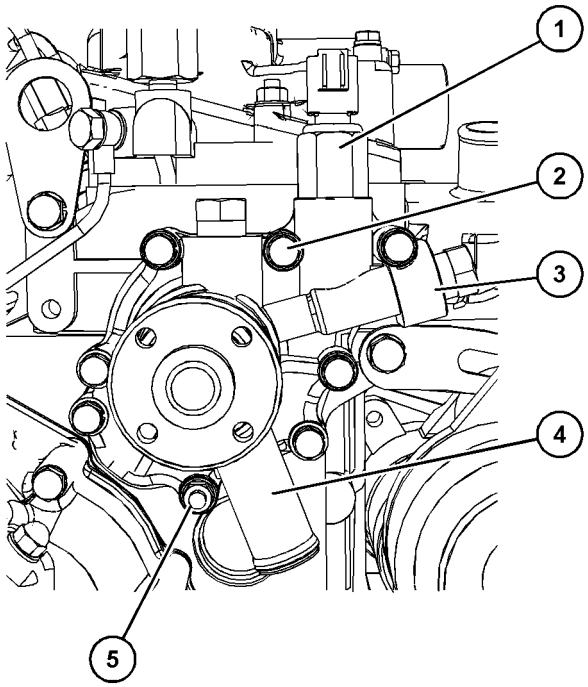

Illustration 164 g06214498
Typical example

2. Loosen the hose clamp and disconnect the coolant hose assembly from inlet connection (4) on water pump (3).

3. Disconnect the harness assembly from coolant temperature sensor (1).

4. Remove bolts (2) and nut (5) from water pump (3). Support the water pump as the bolts and nut are removed.

5. Remove water pump (3) from the cylinder block.

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

6. Remove gasket (6).

7. Water pump (3) could have plate (7), plate (7a), or plate (7b) installed to the water pump.

8. Remove gasket (8).

9. If necessary, remove coolant temperature switch (1) from water pump (3).

Installation Procedure

Table 20

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 242	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the gasket surfaces of the water pump, plate, and the cylinder block are clean and free from damage.

2. Ensure that all components of the water pump are free from wear or damage. Replace any components that are worn or damaged.

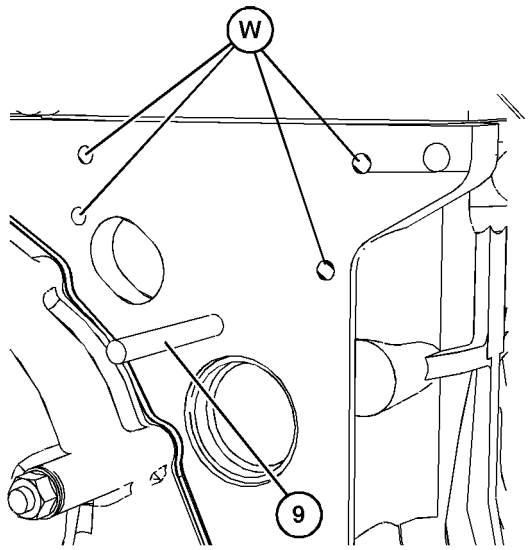

Illustration 165 g06214701

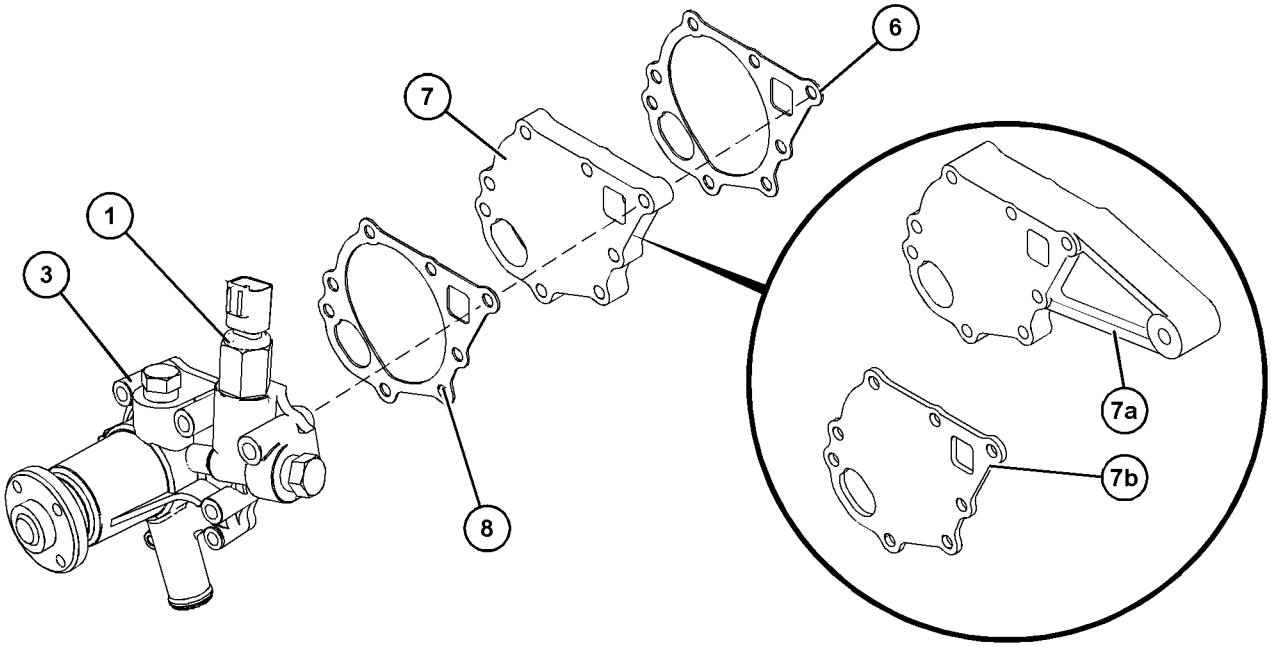

Illustration 166 g06214418

Typical example

Three different types of plate can be installed between the cylinder block and the water pump (3)

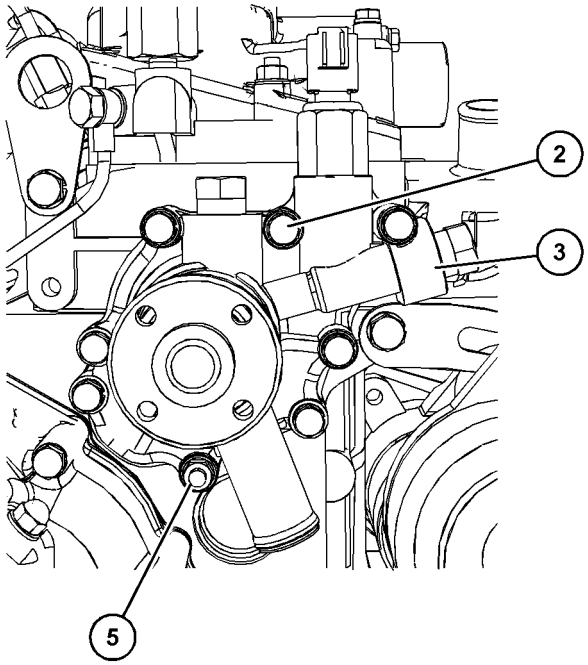

Illustration 167 g06214731

Typical example

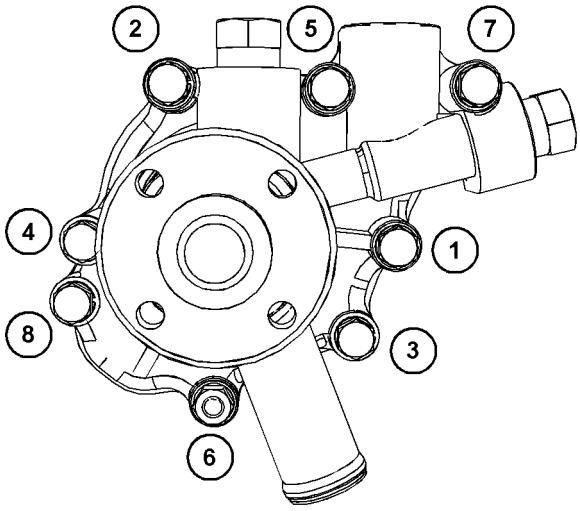

Illustration 168 g06214737

Water pump bolts and nut tightening sequence

3. Ensure that the bolt holes in Position (W) and stud (9) are clean and free from oil and coolant.

4. Install a new gasket (6) over stud (9). Ensure that the gasket is correctly oriented.

5. Install a new gasket (6) over stud (9). Ensure that the gasket is correctly oriented.

6. Install either plate (7), plate (7a), or plate (7b) over stud (9). Ensure that the plate is correctly oriented.

7. Install a new gasket (8) over stud (9). Ensure that the gasket is correctly oriented.

8. Apply Tooling (A) to the first two threads of bolts (2) and nut (5).

9. Install water pump (3).

10. Install bolts (2) and nut (5) hand tight. Ensure that the gaskets are correctly positioned.

11. Tighten the bolts (2) and nut (5) to a torque of 5 N·m (44 lb in) in the sequence shown in Illustration 168 .

12. Tighten bolts (2) and nut (5) to a torque of 10 N·m (89 lb in) in the sequence shown in Illustration 168 .

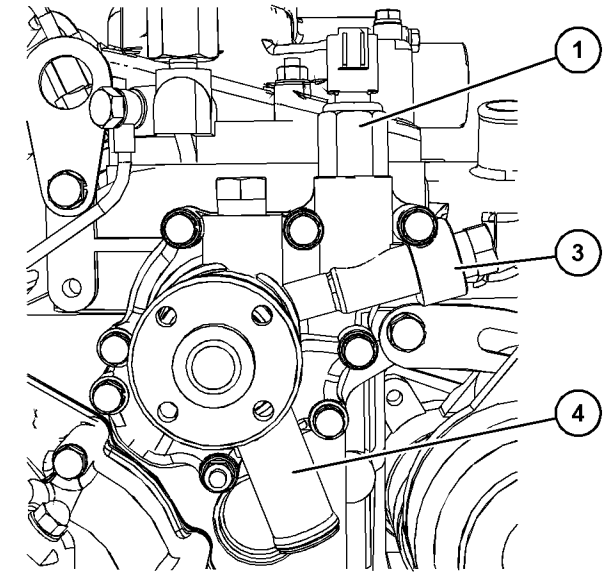

Illustration 169 g06214739

13. If necessary, apply Tooling (A) to the first two threads of coolant temperature switch (1). Install the coolant temperature switch to water pump (3). Tighten the coolant temperature switch to a torque of 27 N·m (239 lb in).

14. Connect the coolant hose assembly to inlet connection (4) on water pump (3). Securely tighten the hose clamp.

15. Connect the harness assembly to coolant temperature sensor (1).

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

End By:

a. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i07676514

Water Temperature Regulator Housing - 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 into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Drain” for more information.

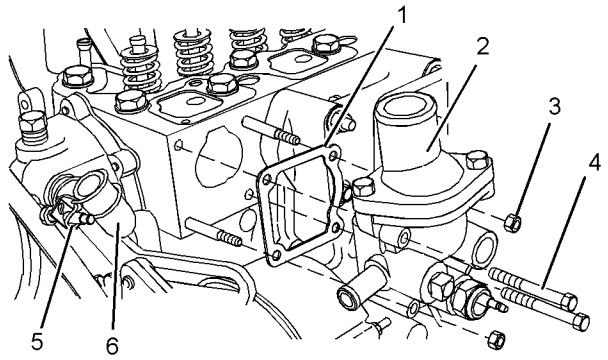

Illustration 170 g01307377
Typical example

2. Loosen hose clamps (5) and disconnect hose (6) from water temperature regulator housing (2).

3. Remove bolts (4) and nuts (3).

4. Remove water temperature regulator housing (2) from the cylinder head.

5. Remove gasket (1) from the cylinder head.

6. If necessary, remove the water temperature regulator. Refer to Disassembly and Assembly, “Water Temperature Regulator - Remove and Install” for the correct procedure.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the gasket surfaces of the cylinder head and the water temperature regulator housing are clean and free from damage.

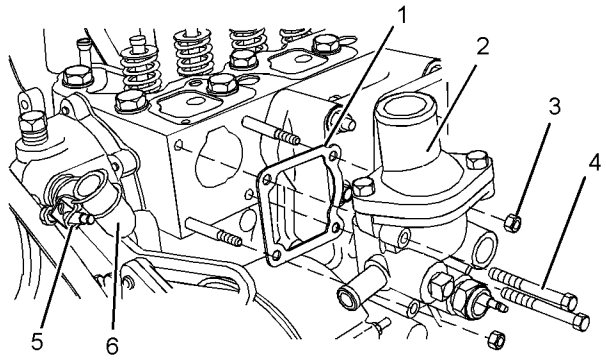

Illustration 171 g01307377
Typical example

2. Install a new gasket (1) to the cylinder head.

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

4. Install bolts (4) and nuts (3). Tighten the fasteners to a torque of 10 N·m (89 lb in).

5. Connect hose (6) to water temperature regulator housing (2). Tighten hose clamps (5).

6. If necessary, install the water temperature regulator. Refer to Disassembly and Assembly, “Water Temperature Regulator - Remove and Install” for the correct procedure.

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

i07676526

Water Temperature Regulator - Remove and Install
(403F-11and 403F-15 Engines.)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

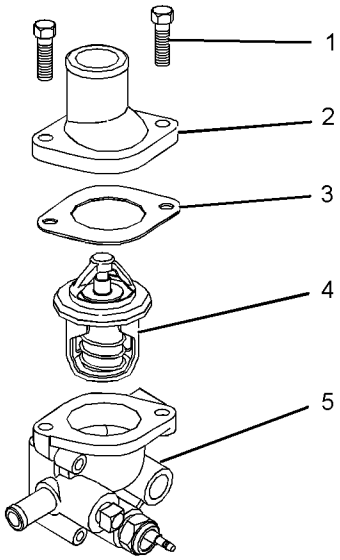

Illustration 172 g01327027
Typical example

2. Remove bolts (1).

3. Remove outlet connection (2).

Note: Identify the orientation of the outlet connection for installation.

4. Remove gasket (3).

5. Remove water temperature regulator (4) from water temperature regulator housing (5).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the water temperature regulator for wear, damage, and correct operation. Refer to Systems Operation, Testing and Adjusting, “Water Temperature Regulator - Test” for more information. If necessary, replace the water temperature regulator.

2. Ensure that the gasket surfaces of the outlet connection and the water temperature regulator housing are clean and free from damage.

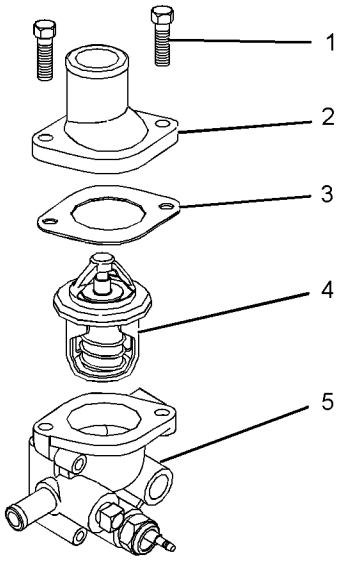

Illustration 173 g01327027
Typical example

3. Install water temperature regulator (4) to water temperature regulator housing (5). Refer to Specifications, “Water Temperature Regulator Housing for 403F-11 and 403F-15 engines” for the correct orientation of the water temperature regulator.

4. Install a new gasket (3).

5. Install outlet connection (2) to water temperature regulator housing (5).

Note: Ensure the correct orientation of the outlet connection.

6. Install bolts (1).

For 403F-11 and 403F-15 engines, tighten the bolts to a torque of 6 N·m (53 lb in).

7. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant -Fill” for more information.

i08106556

Water Temperature Regulator - Remove and Install
(402F-05 and 403F-07 Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

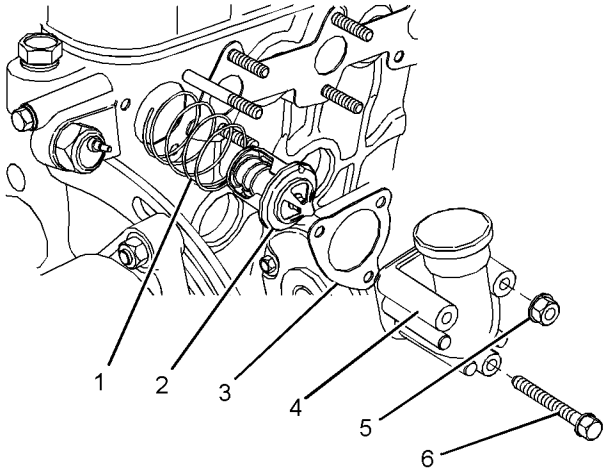

Illustration 174 g01327025
Typical example

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

2. Remove bolts (6) and nuts (5).

3. Remove outlet connection (4).

4. Remove joint (3).

5. Remove water temperature regulator (2) and spring (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the water temperature regulator for wear, damage, and correct operation. Refer to Systems Operation, Testing and Adjusting, “Water Temperature Regulator - Test” for more information. If necessary, replace the water temperature regulator.

2. Ensure that the gasket surfaces of the outlet connection and the cylinder head are clean and free from damage.

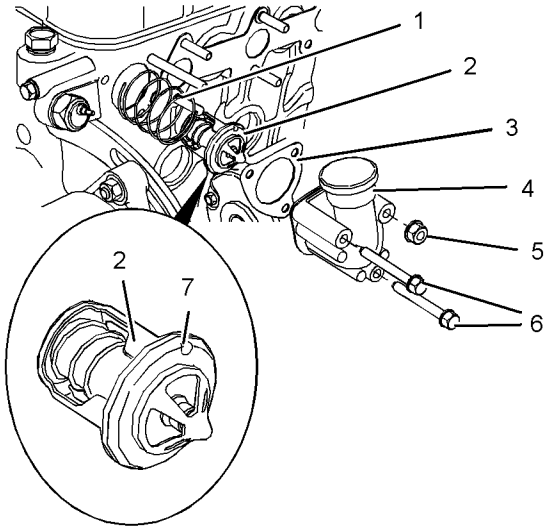

Illustration 175 g01326174
Typical example

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

3. Install spring (1) and water temperature regulator (2) to the cylinder head. Ensure that jiggle pin (7) on water temperature regulator (2) is in the vertically upward position.

4. Install a new joint (3) to the cylinder head.

5. Position outlet connection (4) onto the cylinder head. Install nut (5) and bolts (6) to outlet connection (4). Tighten bolts to a torque of 10 N·m (89 lb in) and nut to a torque of 6 N·m (53 lb in).

6. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Fill” for more information.

i07677771

Flywheel - Remove

Removal Procedure

Table 21

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Bracket	1
B	-	Guide Stud (M10 x 1.25 mm by 80mm)	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.

Note: The two cylinder, and three cylinder engines have different flywheels. The removal procedure is similar for all models.

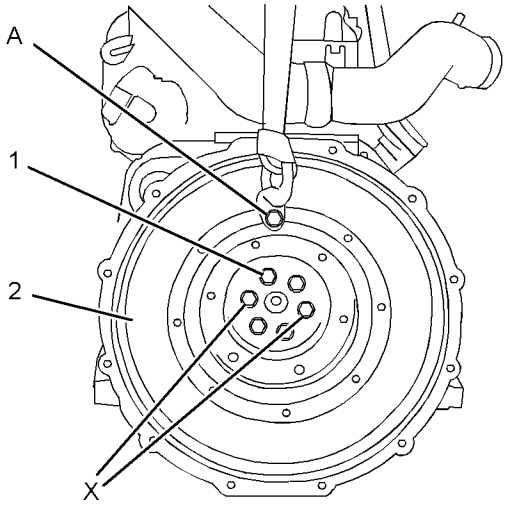

Illustration 176 g01305297
Typical example

1. Install Tooling (A) and a suitable lifting device to flywheel (2). The weight of the flywheel is approximately 42 kg (93 lb).

2. Remove two bolts (1) from positions (X) on the flywheel.

3. Install Tooling (B) in Positions (X) on the flywheel.

4. Remove the remaining bolts (1) and remove flywheel (2).

Note: On some three cylinder engines, a roll pin is located between the crankshaft and the flywheel.

5. Inspect ring gear (3) and flywheel (2) for wear or damage. If the ring gear or the flywheel is worn or damaged, use new parts for replacement.

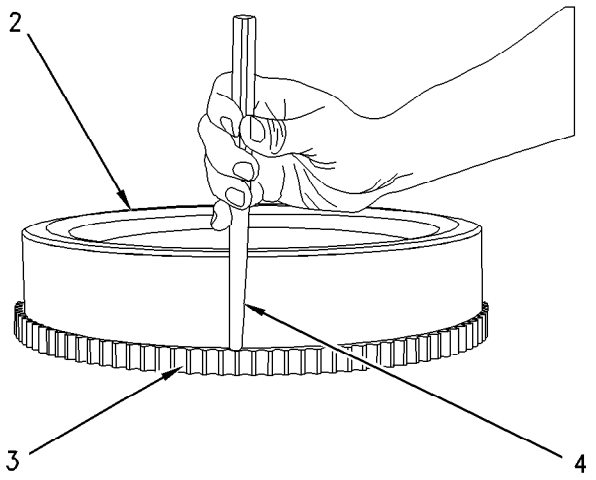

Illustration 177 g00825639
Typical example

6. To remove ring gear (3) from flywheel (2), place the flywheel on a suitable support. Use a hammer (not shown) and a punch (4) to remove the ring gear from the flywheel.

i08095602

Flywheel - Remove (402F-05 - If Equipped)

Removal Procedure

Table 22

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 x 1.25 mm by 80mm)	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.

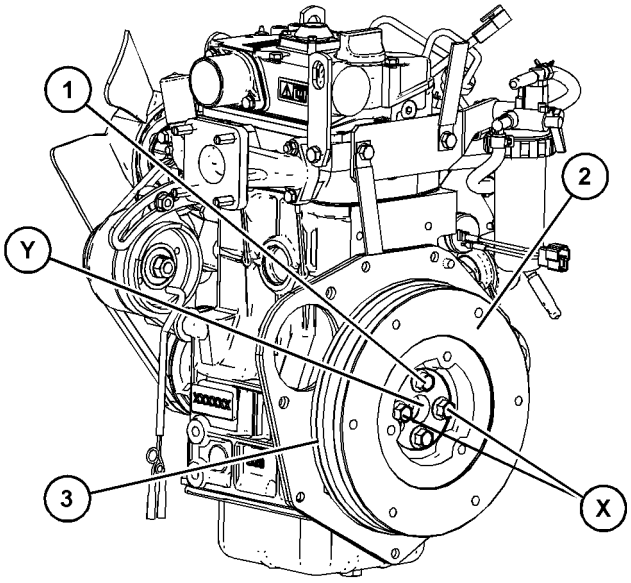

Illustration 178 g06532503
Typical example

1. Remove two bolts (1) from positions (X) on flywheel (2).

2. Install Tooling (A) in Positions (X) on flywheel (2).

3. Remove two remaining bolts (1) from flywheel (2).

4. Position flywheel (2) away from the crankshaft to allow a suitable lifting device to be installed on the flywheel in Position (Y). The weight of the flywheel is approximately 9 kg (20 lb).

5. Inspect ring gear (3) (not shown) and flywheel (2) for wear or damage. If the ring gear or the flywheel is worn or damaged, use new parts for replacement.

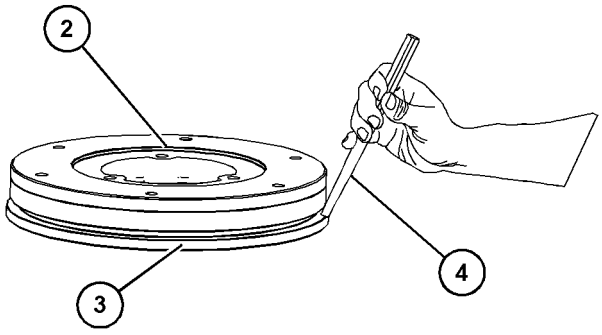

Illustration 179 g06532507
Typical example

6. To remove ring gear (3) from flywheel (2), place the flywheel on a suitable support. Use a hammer (not shown) and a punch (4) to remove the ring gear from the flywheel.

i08097738

Flywheel - Remove
(403F-07 - If Equipped)

Removal Procedure

Table 23

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 x 1.25 mm by 80mm)	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.

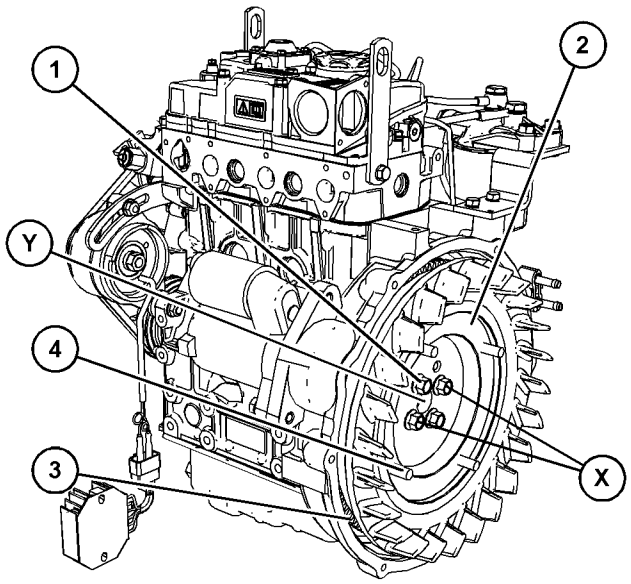

Illustration 180 g06525255
Typical example

1. If necessary, remove studs (4) from flywheel (2).

2. Remove two bolts (1) from positions (X) on flywheel (2).

3. Install Tooling (A) in Positions (X) on flywheel (2).

4. Remove two remaining bolts (1) from flywheel (2).

5. Position flywheel (2) away from the crankshaft to allow a suitable lifting device to be installed on the flywheel in Position (Y). The weight of the flywheel is approximately 18 kg (40 lb).

6. Inspect ring gear (3) (not shown) and flywheel (2) for wear or damage. If the ring gear or the flywheel is worn or damaged, use new parts for replacement.

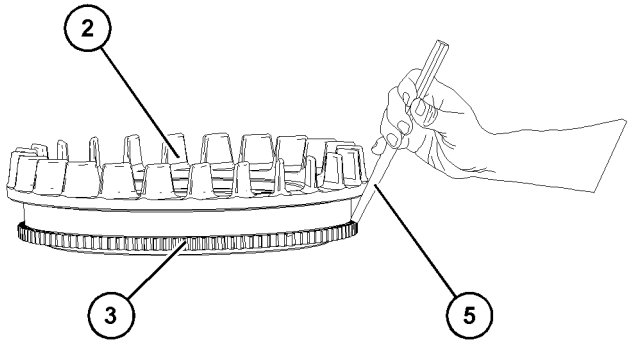

Illustration 181 g06525273
Typical example

7. To remove ring gear (3) from flywheel (2), place the flywheel on a suitable support. Use a hammer (not shown) and a punch (5) to remove the ring gear from the flywheel.

i07677772

Flywheel - Install

Installation Procedure

Table 24

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Lifting Bracket	1
B	-	Guide Stud (M10 x 1.25 mm by 80mm)	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

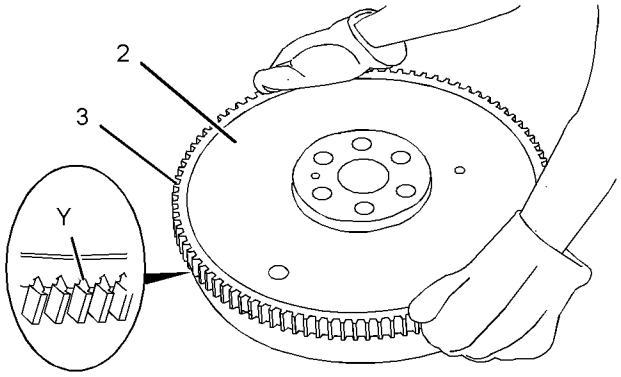

Illustration 182 g01305341
Typical example

1. If the ring gear was removed, follow Steps 1a through 1c to install ring gear (3) to flywheel (2).

a. Identify the orientation of the new ring gear to install the ring gear correctly onto the flywheel.

Note: The chamfered side of gear Teeth (Y) must face toward the starting motor when the flywheel is installed. This chamfer will ensure the correct engagement of the starting motor.

b. Heat ring gear (3) in an oven to a maximum temperature of 150°C (302°F) prior to installation.

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

c. Ensure that the orientation of ring gear (3) is correct and quickly install the ring gear onto flywheel (2).

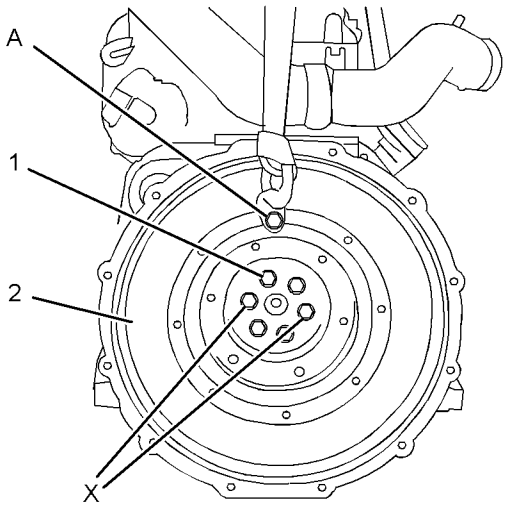

Illustration 183 g01305297
Typical example

2. Thoroughly clean the flywheel housing. Inspect the crankshaft rear seal for leaks. If the crankshaft rear seal is leaking, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

3. Install Tooling (B) to Positions (X) in the crankshaft.

4. Install Tooling (A) and a suitable lifting device to flywheel (2). The weight of the flywheel is approximately 42 kg (93 lb).

5. Position flywheel (2) onto Tooling (B).

On three cylinder engines that have a roll pin, ensure that the roll pin is installed to the crankshaft. Ensure that the roll pin is free from damage. Align the hole in the flywheel with the roll pin in the crankshaft.

6. Install bolts (1) finger tight.

7. Remove Tooling (B) and install the two remaining bolts (1).

8. Use a suitable tool to prevent flywheel (2) from rotating. Tighten bolts (1) to a torque of 74 N·m (54 lb ft).

9. Remove Tooling (A) and the lifting device from the flywheel.

End By:

a. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i08095606

Flywheel - Install
(402F-05 - If Equipped)

Installation Procedure

Table 25

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 x 1.25 mm by 80mm)	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

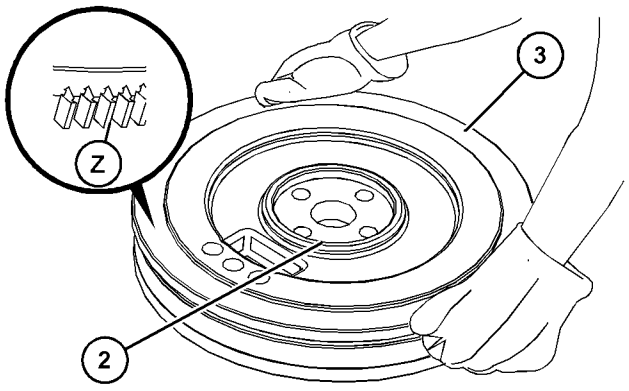

Illustration 184 g06532542
Typical example

1. If the ring gear was removed, follow Steps 1a through 1c to install ring gear (3) to flywheel (2).

a. Identify the orientation of the new ring gear to install the ring gear correctly onto the flywheel.

Note: The chamfered side of gear Teeth (Z) must face toward the starting motor when the flywheel is installed. This chamfer will ensure the correct engagement of the starting motor.

b. Heat ring gear (3) in an oven to a maximum temperature of 150°C (302°F) prior to installation.

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

c. Ensure that the orientation of ring gear (3) is correct and quickly install the ring gear onto flywheel (2).

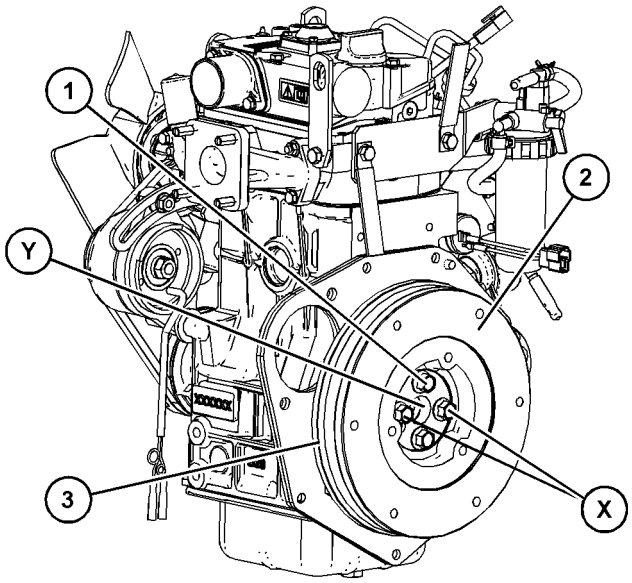

Illustration 185 g06532503
Typical example

2. Thoroughly clean the flywheel housing. Inspect the crankshaft rear seal for leaks. If the crankshaft rear seal is leaking, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

3. Install Tooling (A) to Positions (X) in the crankshaft.

4. Install a suitable lifting device to flywheel (2) in Position (Y). The weight of the flywheel is approximately 9 kg (20 lb).

5. Position flywheel (2) onto Tooling (A), once engaged with the tooling, remove the suitable lifting device.

Ensure that the roll pin is installed to the crankshaft. Ensure that the roll pin is free from damage. Align the hole in the flywheel with the roll pin in the crankshaft.

6. Install bolts (1) finger tight.

7. Remove Tooling (A) and install the two remaining bolts (1).

8. Use a suitable tool to prevent flywheel (2) from rotating. Tighten bolts (1) to a torque of 75 N·m (55 lb ft).

End By:

a. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i08097739

Flywheel - Install
(403F-07 - If Equipped)

Installation Procedure

Table 26

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Guide Stud (M10 x 1.25 mm by 80mm)	2

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

⚠ WARNING

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

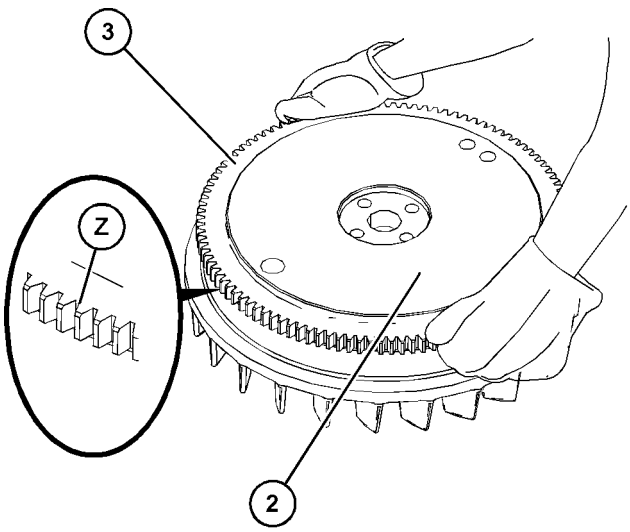

Illustration 186 g06525328
Typical example

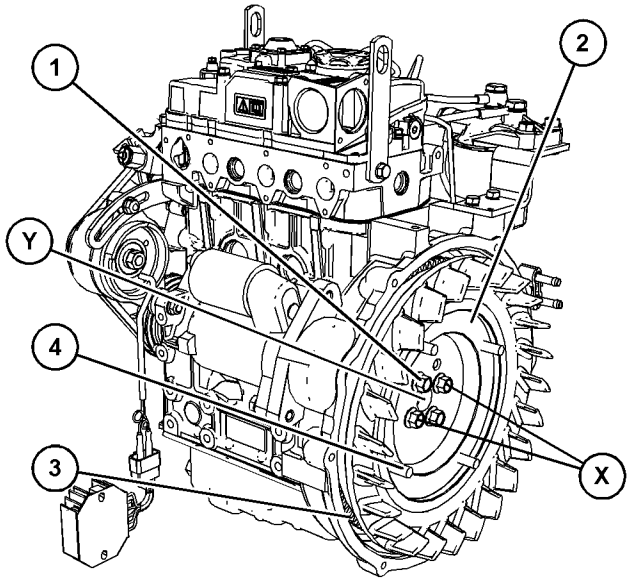

Illustration 187 g06525255
Typical example

1. If the ring gear was removed, follow Steps 1a through 1c to install ring gear (3) to flywheel (2).

a. Identify the orientation of the new ring gear to install the ring gear correctly onto the flywheel.

Note: The chamfered side of gear Teeth (Z) must face toward the starting motor when the flywheel is installed. This chamfer will ensure the correct engagement of the starting motor.

b. Heat ring gear (3) in an oven to a maximum temperature of 150°C (302°F) prior to installation.

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

c. Ensure that the orientation of ring gear (3) is correct and quickly install the ring gear onto flywheel (2).

2. Thoroughly clean the flywheel housing. Inspect the crankshaft rear seal for leaks. If the crankshaft rear seal is leaking, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

3. Install Tooling (A) to Positions (X) in the crankshaft.

4. Install a suitable lifting device to flywheel (2) in Position (Y). The weight of the flywheel is approximately 18 kg (40 lb).

5. Position flywheel (2) onto Tooling (A), once engaged with the tooling, remove the suitable lifting device.

Ensure that the roll pin is installed to the crankshaft. Ensure that the roll pin is free from damage. Align the hole in the flywheel with the roll pin in the crankshaft.

6. Install bolts (1) finger tight.

7. Remove Tooling (A) and install the two remaining bolts (1).

8. Use a suitable tool to prevent flywheel (2) from rotating. Tighten bolts (1) to a torque of 75 N·m (55 lb ft).

9. If necessary, Install studs (4), tighten the studs to a torque of 18 N·m (159 lb in).

End By:

a. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i07677777

Crankshaft Rear Seal - Remove and Install
(Crankshaft Rear Seal with Cast Flywheel Housing)

Removal Procedure

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 two cylinder and three cylinder engines have different configurations for the flywheel housing and the back plate. The removal process is similar for all models.

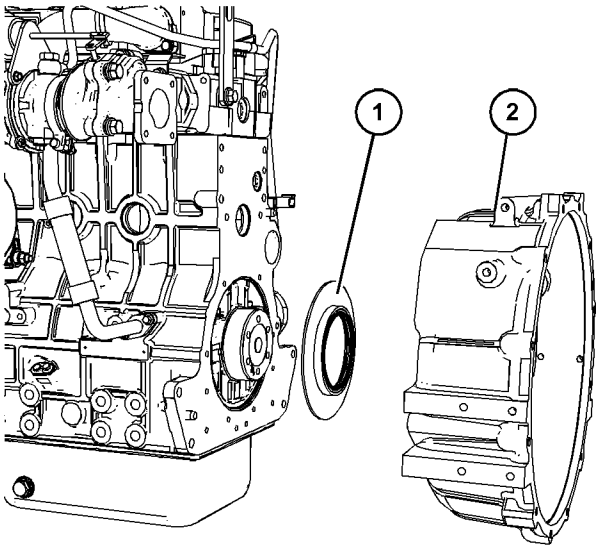

Illustration 188 g06275144
Typical example

1. Remove flywheel housing (2). Refer to Disassembly and Assembly, Flywheel Housing - Remove and Install for the correct procedure.

2. Remove crankshaft rear seal (1) from the cylinder block. Discard the crankshaft oil seal.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

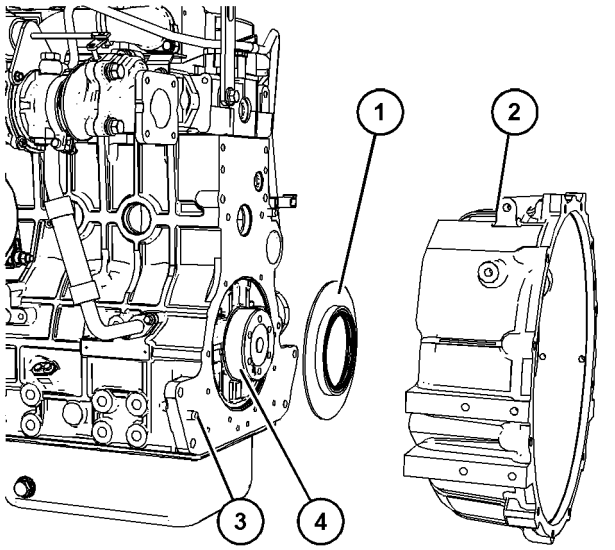

Illustration 189 g06275147
Typical example

1. Inspect dowels (3). If the dowels are damaged, use new parts for replacement.

2. Ensure that crankshaft flange (4) is clean and free from damage. Damaged crankshaft flange can be reclaimed by installing of a wear sleeve. Refer to Disassembly and Assembly, “Crankshaft Wear Sleeve (Rear) - Remove and Install” for more information.

3. Apply clean engine lubricating oil to the flange of crankshaft (4) around the running surface of crankshaft rear seal.

4. Align a new crankshaft rear seal (1) with the flange of crankshaft (4). Carefully install the crankshaft rear seal onto the crankshaft flange. Ensure that the crankshaft rear seal is correctly seated into the recess of cylinder block.

5. Remove flywheel housing (2). Refer to Disassembly and Assembly, Flywheel Housing - Remove and Install for the correct procedure.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i08106558

Crankshaft Rear Seal - Remove and Install
(Crankshaft Rear Seal with Steel Back Plate)

Removal Procedure

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 two cylinder and three cylinder engines have different configurations for the flywheel housing and the back plate. The removal process is similar for all models.

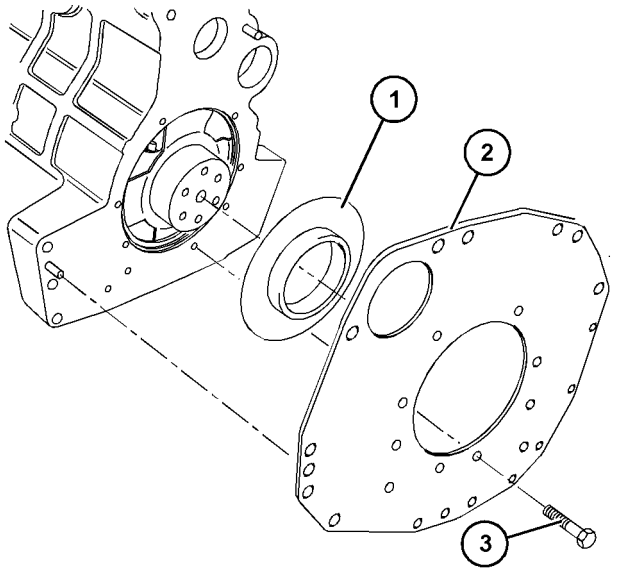

Illustration 190 g06274833

Typical example

1. Remove bolts (3) and remove back plate (2) from the cylinder block.

2. Remove crankshaft rear seal (1) from the cylinder block. Discard the crankshaft oil seal.

Installation Procedure

Table 27

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 5900 Silicone Sealant	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

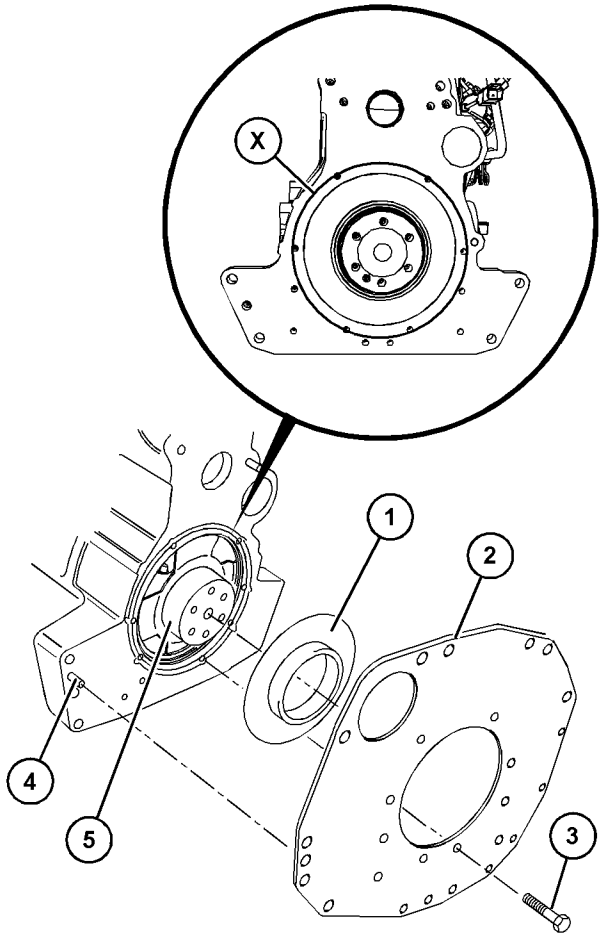

Illustration 191 g06274855

Typical example

1. Ensure that the gasket surfaces of the cylinder block and the back plate (2) are clean and free from damage. Inspect dowels (4). If the dowels are damaged, use new parts for replacement.

2. Ensure that crankshaft flange (5) is clean and free from damage. Damaged crankshaft flange can be reclaimed by installing of a wear sleeve. Refer to Disassembly and Assembly, “Crankshaft Wear Sleeve (Rear) - Remove and Install” for more information.

3. Apply clean engine lubricating oil to the flange of crankshaft (5) around the running surface of crankshaft rear seal.

4. Align a new crankshaft rear seal (1) with the flange of crankshaft (5). Carefully install the crankshaft rear seal onto the crankshaft flange.

5. Apply a continuous bead of Tooling (A) to the rear face of the cylinder block in Position (X).

6. Align back plate (2) to dowels (4). Install the back plate and install bolts (3).

7. Tighten bolts (3).

For 402F-05 and 403F-07 engines. Tighten the bolts to a torque of 25 N·m (221 lb in).

For 403F-11, and 403F-15 engines. Tighten the bolts to a torque of 50 N·m (37 lb ft).

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i07677779

Crankshaft Wear Sleeve (Rear - Remove and Install

Removal Procedure

Start By:

a. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

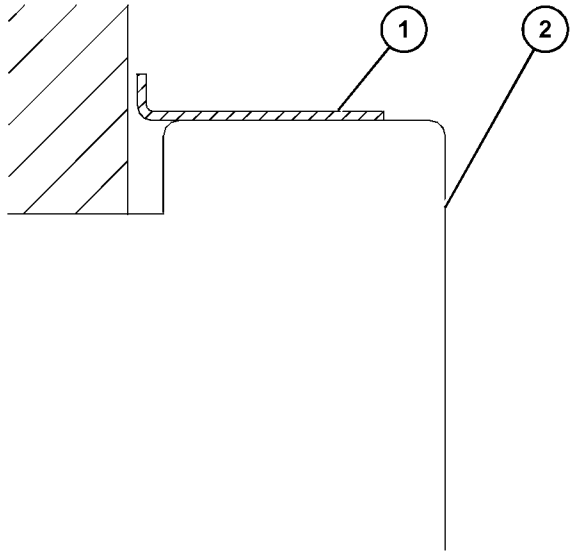

Illustration 192 g06044741
Sectional view of the crankshaft and of the wear sleeve

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

Note: Take care to avoid damaging the crankshaft.

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

3. Remove crankshaft wear sleeve (1) from crankshaft (2).

Installation Procedure

Table 28

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 509	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

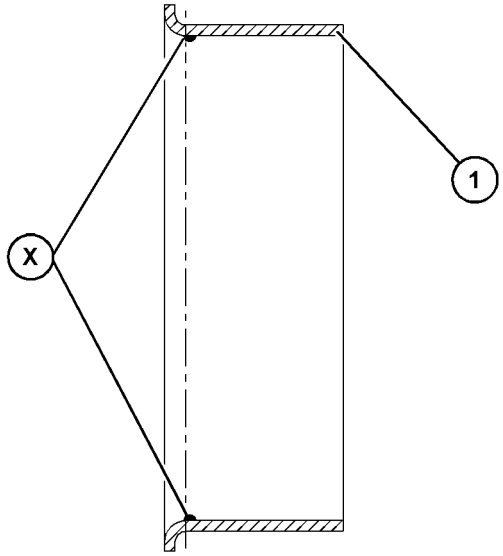

Illustration 193 g06044752

Sectional view of the wear sleeve

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

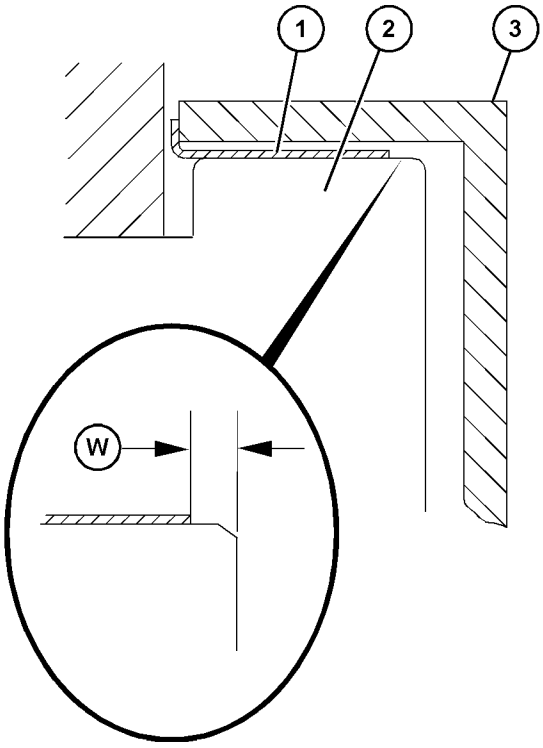

Illustration 194 g06044759

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

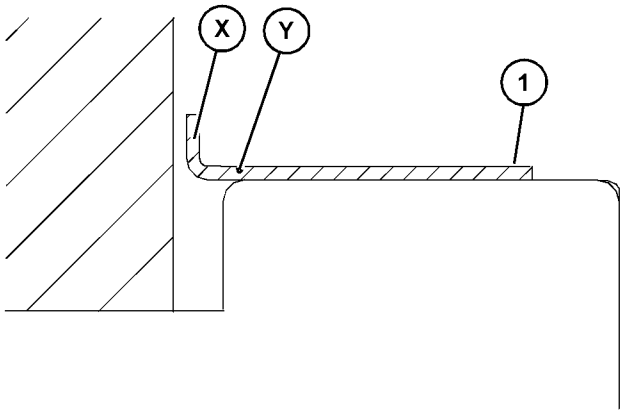

Illustration 195 g06045368

Sectional view of the crankshaft and of the wear sleeve showing tear off groove (Y)

3. Align crankshaft wear sleeve (1) with crankshaft (2). Position installation tool (3) that is provided with the crankshaft wear sleeve over the crankshaft. Use a hammer to drive the crankshaft wear sleeve onto the crankshaft. Ensure that Dimension (W) is 7.5 mm (0.295 inch).

Note: Dimension (W) is the distance from the edge of the crankshaft wear sleeve from the rear face of the crankshaft.

4. Remove installation tool (3).

5. If necessary, cut flange (X) of wear sleeve (1) and use long nose pliers to tear the flange along the tear off Groove (Y).

6. Ensure that crankshaft wear sleeve (1) has no rough edges.

End By:

a. Install a new crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove and Install" for the correct procedure.

i07677782

Flywheel Housing - Remove and Install
(Engines with Flywheel Housing and Back Plate)

Removal Procedure

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.

1. Support the engine.

2. Install a suitable lifting device to the flywheel housing. Support the weight of the housing. The weight of the flywheel housing is approximately 30 kg (66 lb).

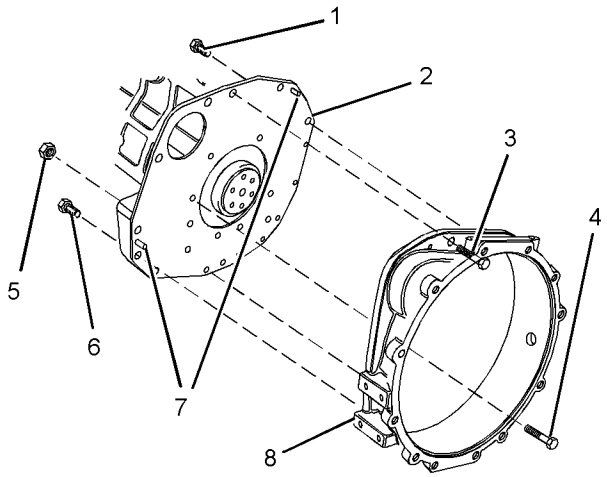

Illustration 196 g01326591

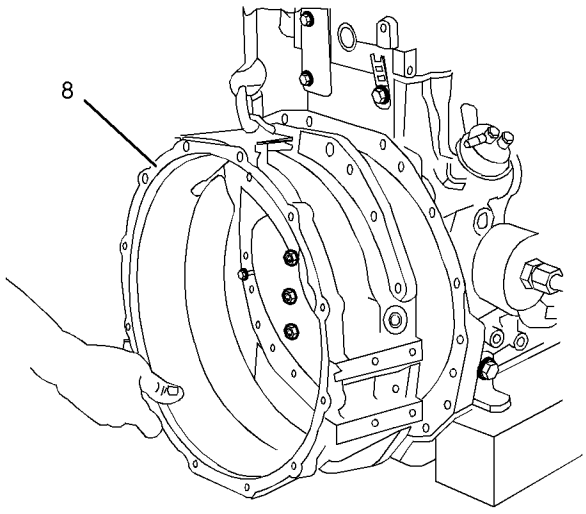

Illustration 197 g01305649
Typical example

3. Remove bolts (3) and (4) that fasten flywheel housing (8) to the cylinder block.

4. Remove bolts (6) on each side of the cylinder block. These bolts fasten flywheel housing (8) to the cylinder block.

5. Remove bolts (1) that fasten back plate (2) to flywheel housing (8).

6. Remove nuts (5) and the bolts (not shown) that fasten back plate (2) to flywheel housing (8).

7. Carefully remove flywheel housing (8) from back plate (2) and dowels (7). Use a suitable lifting device to remove the flywheel housing.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the mating surfaces of back plate (2) and flywheel housing (8) are clean and free from damage. Inspect the crankshaft rear seal (not shown) for leaks. If necessary, replace the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure. Inspect dowels (7) for damage. If the dowels are damaged, use new parts for replacement.

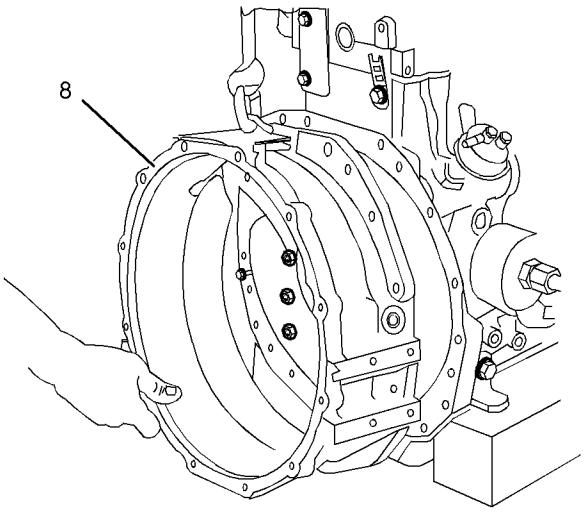

Illustration 198 g01305649

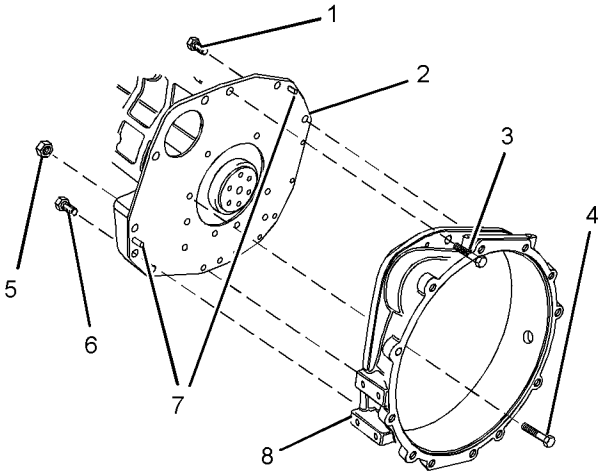

Illustration 199 g01326591
Typical example

2. Use a suitable lifting device to align flywheel housing (8) to dowels (7). The weight of the flywheel housing is approximately 30 kg (66 lb). Install the flywheel housing to the back plate.

3. Install nuts (5) and the bolts (not shown) that fasten back plate (2) to flywheel housing (8).

4. Install bolts (1) that fasten back plate (2) to flywheel housing (8).

5. Install bolts (6) on each side of the cylinder block. These bolts fasten flywheel housing (8) to the cylinder block.

6. Remove the lifting device from the flywheel housing.

7. Install bolts (3) and (4) that fasten flywheel housing (8) to the cylinder block.

8. Tighten the fasteners to a torque of 25 N·m (221 lb in).

End By:

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

i08106568

Flywheel Housing - Remove and Install

Removal Procedure

Start By:

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

b. Remove the flywheel. Refer to Disassembly and Assembly, "Flywheel - Remove" for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

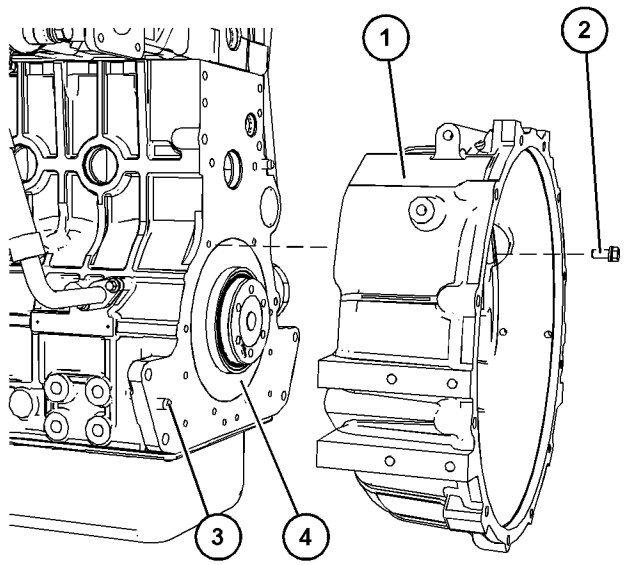

Illustration 200 g06275157

1. Install a suitable lifting device to flywheel housing (1). The weight of the flywheel housing is approximately 30 kg (66 lb).

2. Remove bolts (1) from flywheel housing (2).

3. Use the suitable lifting device to remove flywheel housing (2).

4. Inspect dowels (3). Removal of the dowels that locate the flywheel housing in not necessary unless the dowels are damaged.

5. Inspect crankshaft rear seal (4) for leaks or damage. If necessary, replace the crankshaft rear seal. Refer to Disassembly and Assembly, Crankshaft Rear Seal - Remove and Install for the correct procedure.

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 or damage. If necessary, replace any component that is worn or damage.

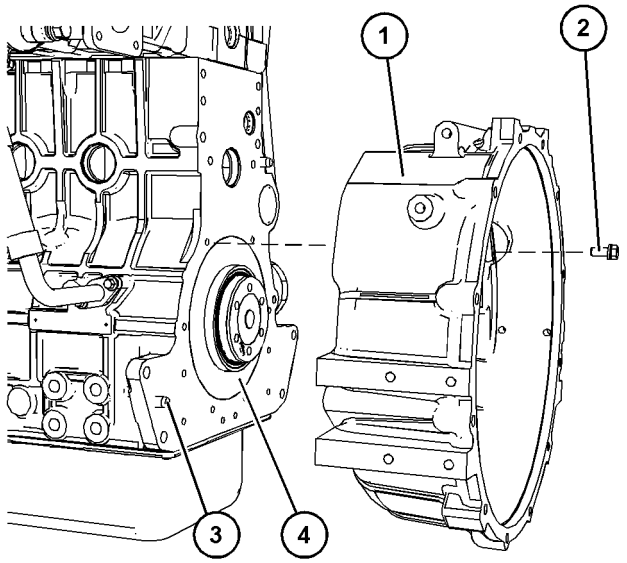

Illustration 201 g06275157

2. Ensure the mating surface of flywheel housing (1) and the cylinder block are clean and free from damage.

3. Attach a suitable lifting device to flywheel housing (1). The weight of the flywheel housing is approximately 30 kg (66 lb).

4. Use a suitable lifting device to align flywheel housing (1) to dowel (3). install the flywheel housing.

5. Install bolts (2) to flywheel housing (1).

6. Tighten bolts (2) to a torque of 25 N·m (221 lb in).

7. Remove the suitable lifting device from flywheel housing (1).

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

b. Install the electric starting motor. Refer to Disassembly and Assembly, “Electric Starting Motor - Remove and Install” for the correct procedure.

i07677785

Crankshaft Pulley - Remove and Install

Removal Procedure

Start By:

a. Remove the V-belt. Refer to Disassembly and Assembly, “V Belts - Remove and Install” for the correct procedure.

Table 29

Required Tools			
Tool	**Part Number**	**Part Number**	**Qty**
A	21825619	Puller	1
	-	Bolt	3

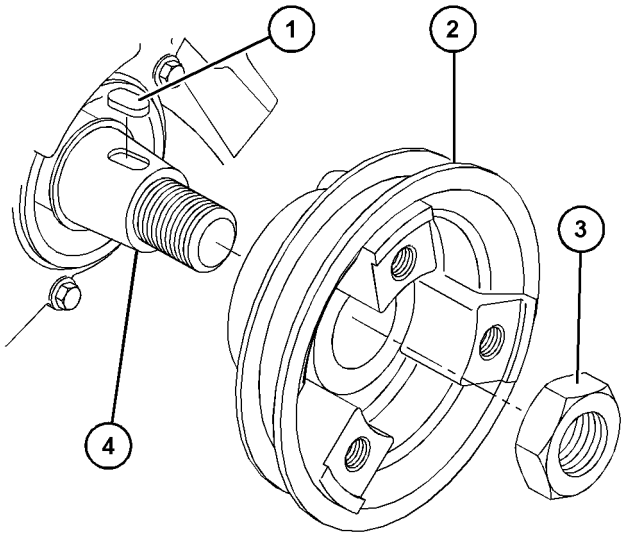

Illustration 202 g06037712

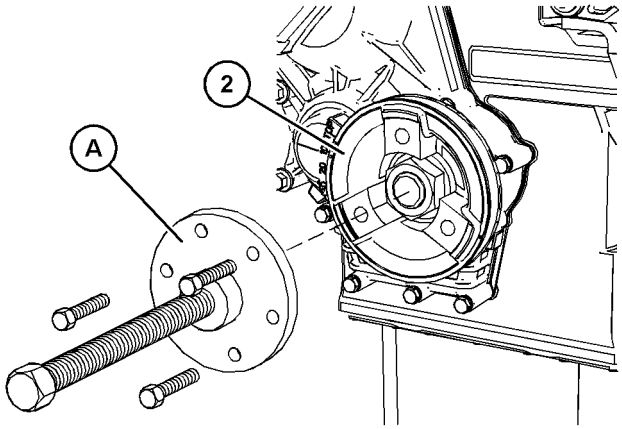

Illustration 203 g06037720

1. Loosen nut (3). Do not remove the nut.

2. Install Tooling (A) to crankshaft pulley (2). Use Tooling (A) to remove crankshaft pulley (2) from crankshaft (4). Remove Tooling (A).

3. Remove nut (3).

4. Remove pulley (2) from crankshaft (4).

5. Remove key (1) from crankshaft (4).

Installation Procedure

1. Ensure that the following components are clean and free from damage: the taper of the crankshaft, the key, and the bore of the crankshaft pulley. Replace any components that are damaged. Ensure that the taper of the crankshaft and the bore of the crankshaft pulley are clean and dry before assembly.

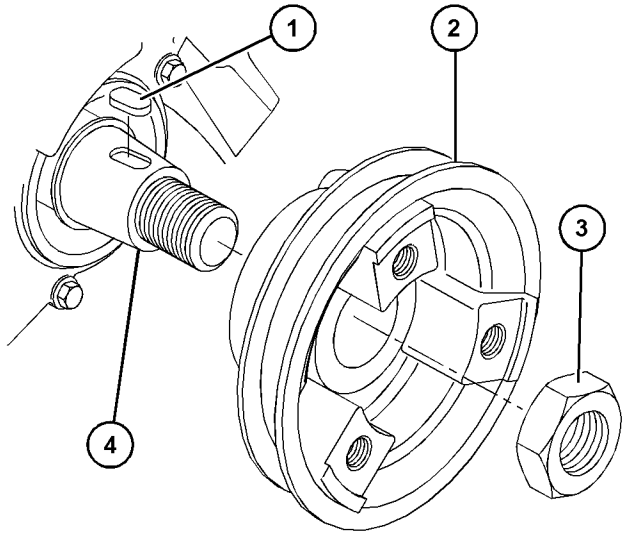

Illustration 204 g06037712

2. Install key (1) to crankshaft (4). Ensure that the key is correctly seated into the crankshaft.

3. Install crankshaft pulley (2) to crankshaft (4). Ensure that the crankshaft pulley is correctly seated onto the key and the crankshaft.

4. Lubricate nut (3) with clean engine oil and install the nut. Tighten the nut to a torque of 304 N·m (224 lb ft).

End By:

a. Install the V-belt to the engine. Refer to Disassembly and Assembly, “V Belts - Remove and Install” for the correct procedure.

i07677787

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 30

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610311	Slide Hammer Puller	1
B	-	Drill Bit 4 mm (0.158 inch)	1

Start By:

a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

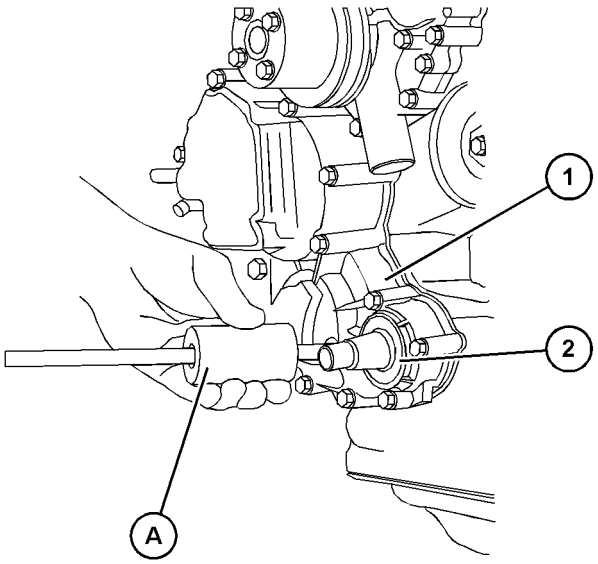

Illustration 205 g06046106
Typical example

1. Use Tooling (B) and a drill to make three holes in crankshaft front seal (2).

NOTICE
Ensure that the main lip is used in order to remove the crankshaft front seal. Do not damage the edge of the housing for the crankshaft front seal.

Note: Do not damage the crankshaft during the removal process of the crankshaft front seal.

2. Use Tooling (A) to remove crankshaft front seal (2). Alternate the position of Tooling (A) from one hole to another hole. Using alternative position will allow you to remove the crankshaft front seal evenly from front housing (1).

Alternative Removal Procedure

Start By:

a. 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.

Note: The alternative removal procedure can be used to remove the crankshaft front seal. This procedure may be used if the front housing has been removed from the engine.

1. Use a suitable mandrel and a press to remove the crankshaft front seal from the front cover. Ensure that the front cover is supported to prevent damage to the cover as the crankshaft front seal is being removed.

Alternative Installation Procedure

1. The alternative installation procedure can be used to install the crankshaft front seal. This procedure may be used if the front housing has been removed from the engine.

2. Ensure that the front cover is free from wear or damage. Ensure that the bore for the crankshaft front seal is free from wear or damage. Replace any component the are not free from wear or damage.

3. Place the front cover on a suitable support to prevent damage to the cover as the oil seal is being installed. Use a suitable mandrel and a press the crankshaft front seal into the front cover.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

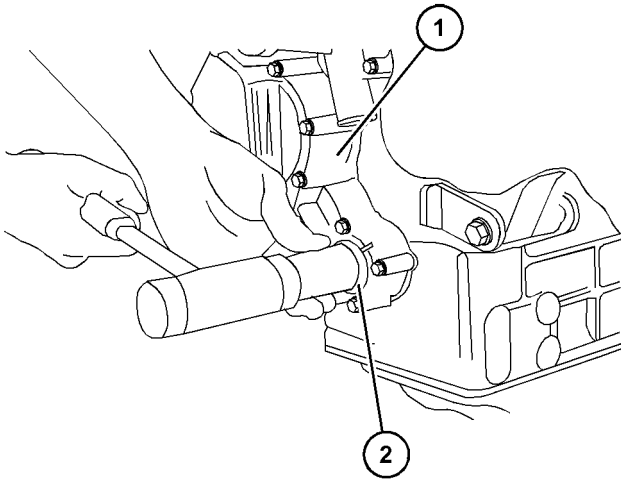

Illustration 206 g06046181
Typical example

1. Ensure that crankshaft front seal (2) bore in front housing (1) and the nose of the crankshaft are clean and free from damage.

2. Lubricate the lip of a new crankshaft front seal (2) with clean engine oil.

3. Position crankshaft front seal (2) in the bore of front housing (1).

NOTICE
Ensure that the lip of the crankshaft front seal that is spring loaded is facing toward the inside of the front housing and that it is square with the bore of the housing for the crankshaft front seal.

4. Use a suitable tool to install crankshaft front seal (2) to front housing (1).

End By:

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

i07677788

Housing (Front) - Remove

Removal Procedure

Start By:

a. Remove the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

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

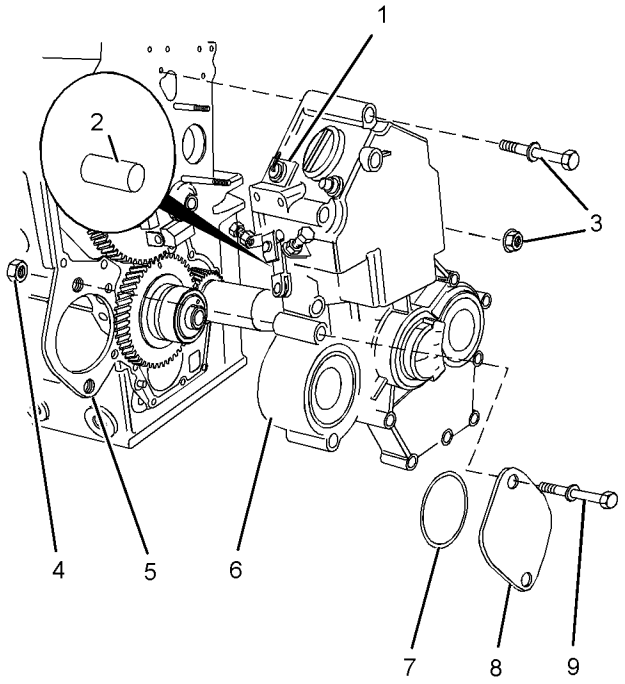

Illustration 207 g01357158

Typical example

1. If the engine is equipped with a turbocharger, disconnect the hose from connection (1).

2. Remove nuts (4) and bolts (9).

3. Remove cover (8) and O-ring seal (7).

4. Remove bolts (3). Identify the position of the different bolts and nuts for installation purpose.

5. Carefully remove front housing (6) from plate (5). Ensure that pin (2) remains in the front housing.

Note: The front housing is aligned to the plate and to the cylinder block with dowels.

6. Remove the gasket.

i07677791

Housing (Front) - Disassemble

Disassembly Procedure

Start By:

a. Record the governor settings. Refer to Systems Operation, Testing and Adjusting, "Governor - Adjust" for the correct procedure.

b. Remove the engine front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct procedure.

⚠ 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
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

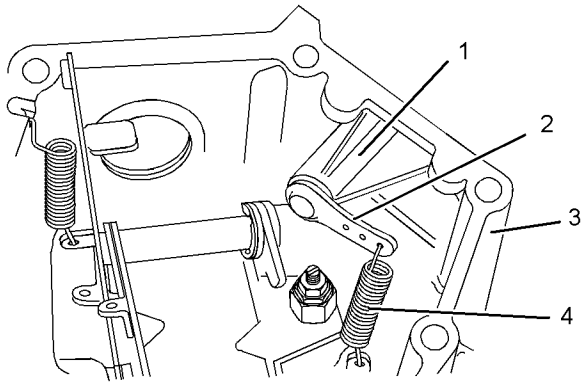

Illustration 208 g01357675

Typical example

1. Remove spring (4) from arm (2) on the assembly of throttle control (1).

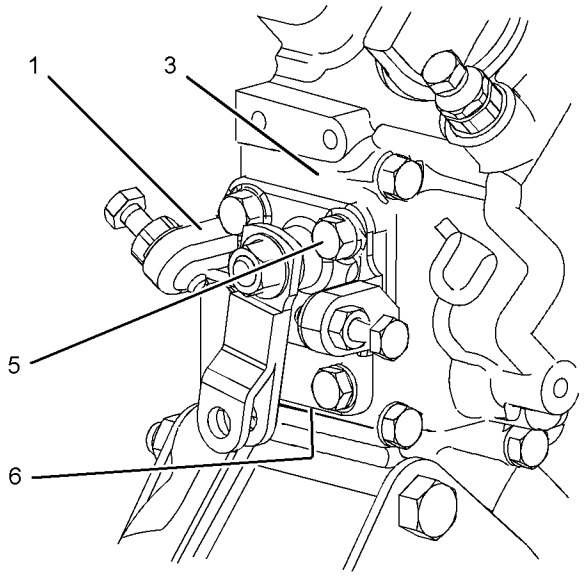

Illustration 209 g01354631

Typical example

2. Remove bolts (5) and remove the assembly of throttle control (1) from front housing (3).

3. Remove joint (6).

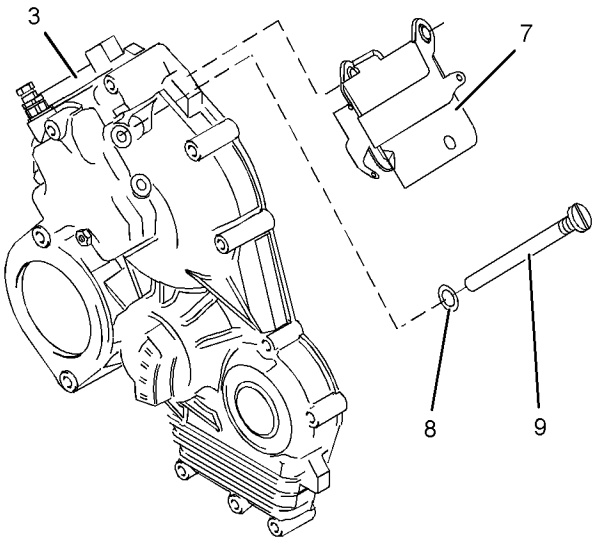

Illustration 210 g01357717

Typical example

4. Remove shaft (9) from front housing (3).

5. Remove lever assembly (7) from front housing (3).

6. Remove sealing washer (8) from shaft (9).

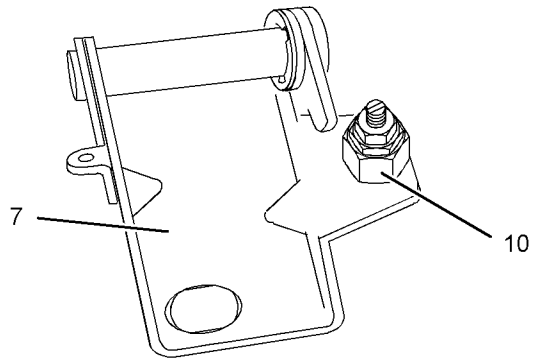

Illustration 211 g01357689

7. If the engine is equipped with an angleich unit, remove angleich unit (10) from lever assembly (7).

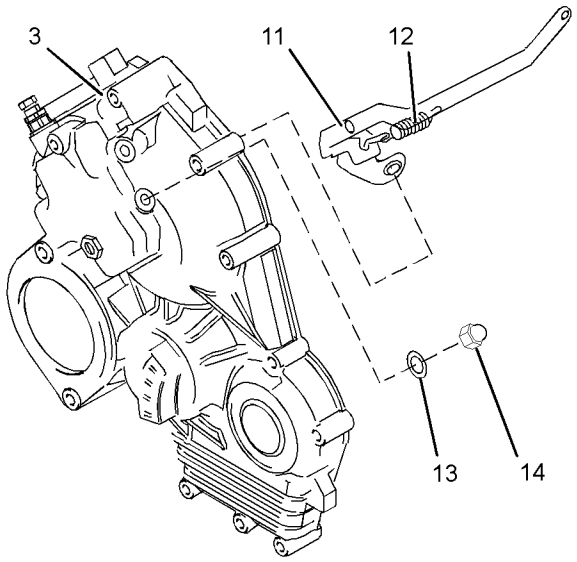

Illustration 212 g01357693

Typical example

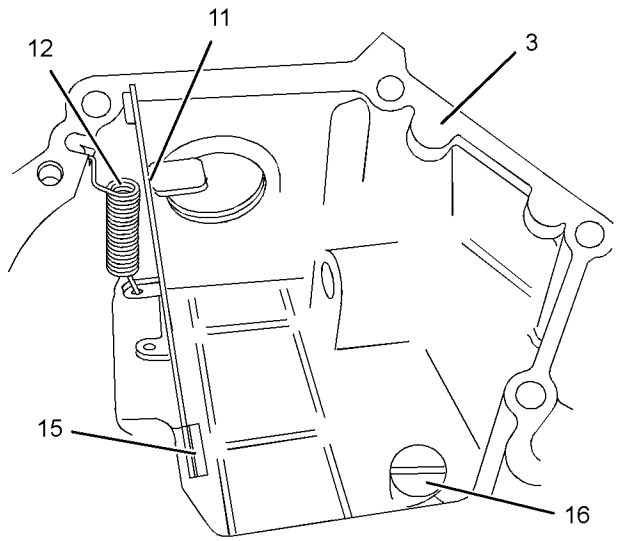

Illustration 213 g01357727
Typical example

8. Disconnect spring (12) from front housing (3).

9. Remove nut (14) and remove sealing washer (13) from front housing (3).

10. Remove shaft (15) and remove lever assembly (11) from front housing (3).

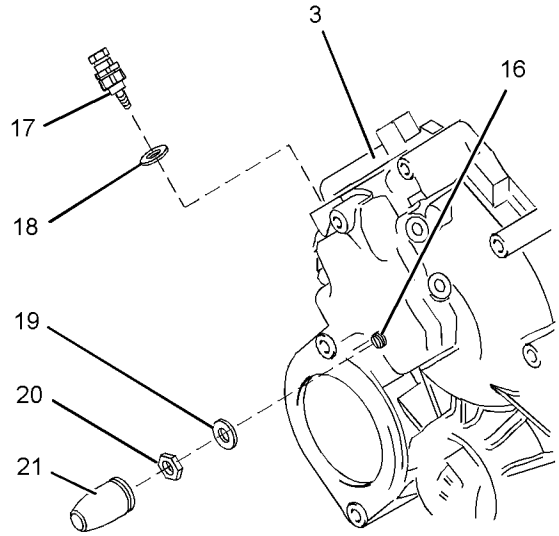

Illustration 214 g01358077
Typical example

11. Remove spring assembly (17) and remove sealing washer (18) from front housing (3).

Note: The position of fuel screw (16) controls the emissions of the engine. Do not remove the fuel screw unless a different front housing will be installed. Do not adjust the fuel screw. Refer to Systems Operation, Testing and Adjusting, "Governor" for further information.

12. If necessary, remove cap (21), locknut ,(20), and sealing washer (19) from front housing (3). Remove fuel screw (16).

i07677790

Housing (Front) - Assemble

Assembly Procedure

Table 31

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 243 Thread Lock	1
B	-	Loctite 275 Thread Lock	1

⚠ 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
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

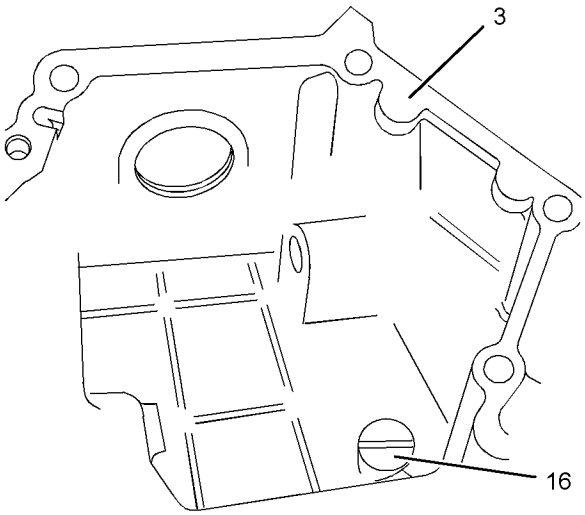

Illustration 215 g01358537
Typical example

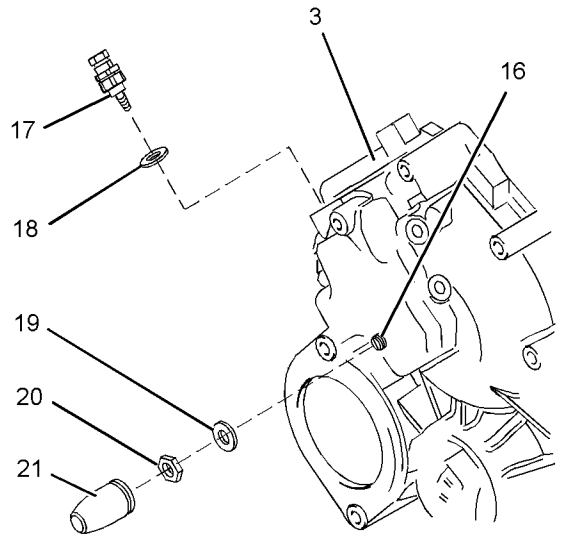

Illustration 216 g01358077
Typical example

Note: The position of stop (16) controls the emissions of the engine. Ensure correct adjustment of the stop.

1. If the original front housing has been replaced by a different item, follow Steps 1a through 1d.

a. Install stop (16) to front housing (3).

b. Install a new sealing washer (19) to stop (16).

c. Loosely install locknut (20) to stop (16). The procedure that is used to set the position of the stop is described in Systems Operation, Testing and Adjusting, “Governor - Inspect”.

d. Install a new emissions label to front housing (3).

2. Install a new sealing washer (18) to spring assembly (17). Loosely install spring assembly (17) to front housing (3).

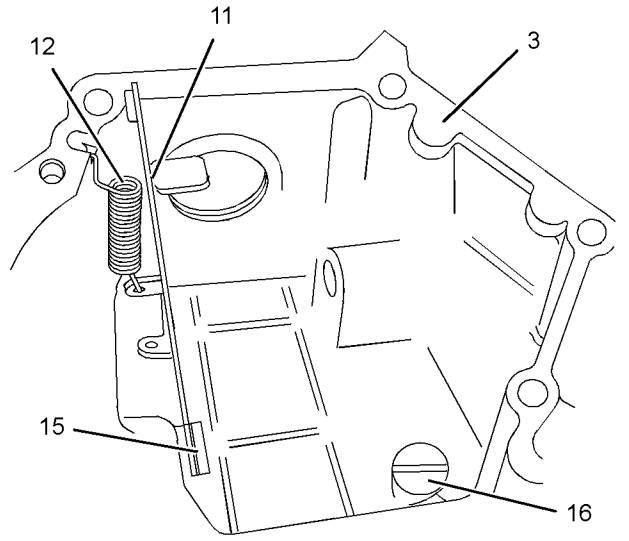

Illustration 217 g01357727
Typical example

3. Place lever assembly (11) in position in front housing (3) and install shaft (15).

Note: Ensure the correct orientation of the lever assembly.

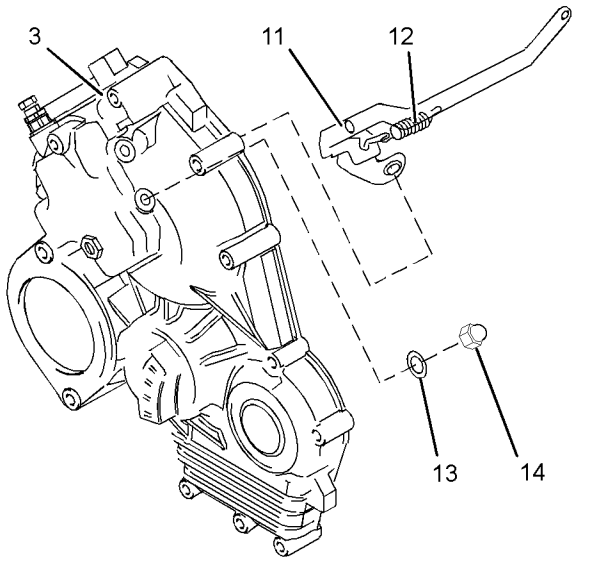

Illustration 218 g01357693

Typical example

4. Install a new sealing washer (13) and nut (14) to front housing (3). Tighten the nut to a torque of 6 N·m (53 lb in).

5. Connect spring (12) to front housing (3). Refer to Illustration 217 .

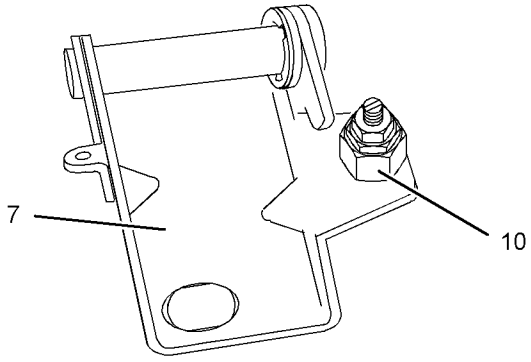

Illustration 219 g01357689

6. If the engine is equipped with an angleich unit, follow Steps 6a and 6b to install the angleich unit.

a. Apply Tooling (B) to the first two threads of angleich unit (10).

b. Install angleich unit (10) to lever assembly (7). Tighten the angleich unit to a torque of 6 N·m (53 lb in).

Note: Ensure that Tooling (A) is not allowed to contaminate the plunger assembly of the angleich unit. Contamination of the plunger assembly will render the angleich unit inoperative.

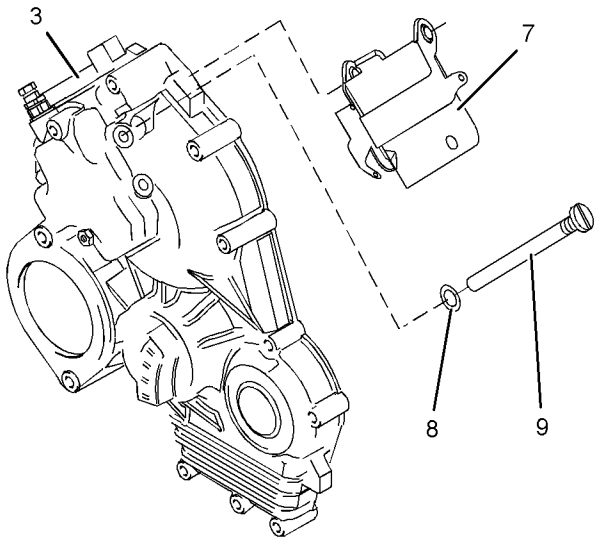

Illustration 220 g01357717

Typical example

7. Install a new sealing washer (8) to shaft (9).

8. Apply Tooling (A) to the first two threads of shaft (9).

9. Place lever assembly (7) in position in front housing (3) and install shaft (9). Tighten the shaft to a torque of 16 N·m (142 lb in).

Note: Ensure the correct orientation of the lever assembly.

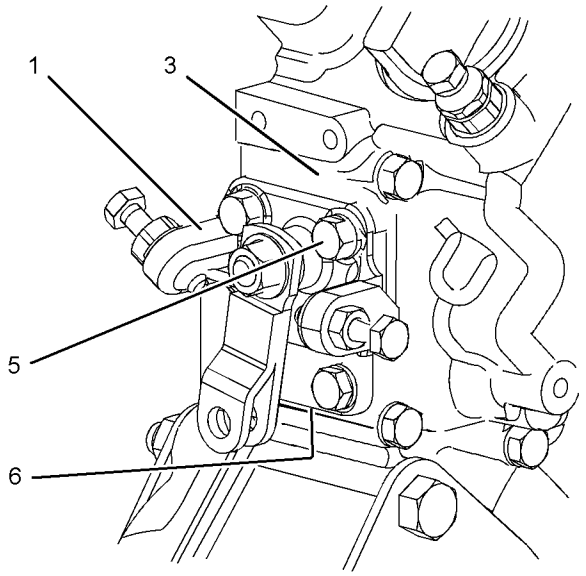

Illustration 221 g01354631

Typical example

10. Position a new gasket (6) and position the assembly of throttle control (1) onto front housing (3).

11. Install bolts (5). Tighten the bolts to a torque of 11 N·m (97 lb in).

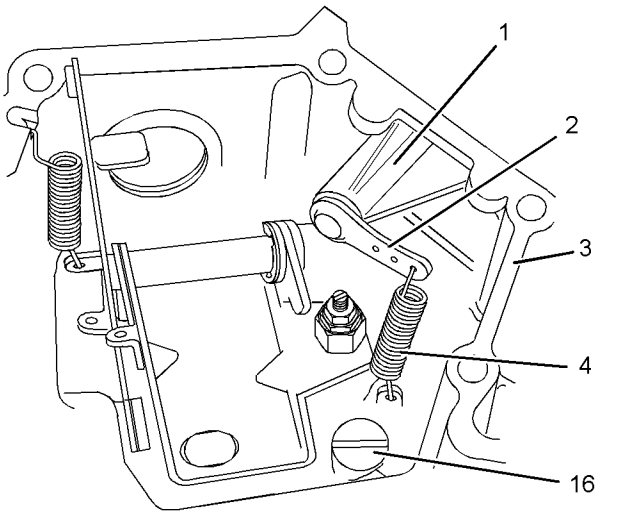

Illustration 222 g01354629

Typical example

12. Install spring (4).

13. If the position of stop (16) has been altered, the stop must be reset. Refer to Systems Operation, Testing and Adjusting, “Governor - Inspect” for the correct procedure.

14. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) Install” for more information.

15. Set the position of the spring assembly (17). Refer to Illustration 216 . The procedure that is used to set the position of the spring assembly is described in Systems Operation, Testing and Adjusting, “Governor - Inspect”. Tighten the spring assembly to a torque of 34 N·m (301 lb in).

16. Install a new cap (21) to nut (20). Refer to Illustration 216 .

i07677795

Housing (Front) - Install

Installation Procedure

Table 32

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A(1)	21825620	Seal Protector	1
A(2)	21825621	Seal Protector	1

(1) 402F-05, 403F-07, and 403F-11 engines
(2) 403F-15 engines

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

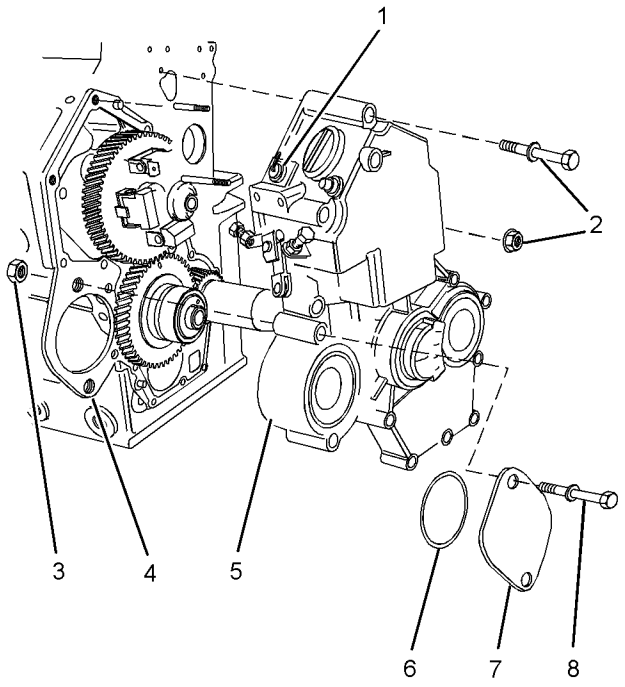

Illustration 223 g01494813
Typical example

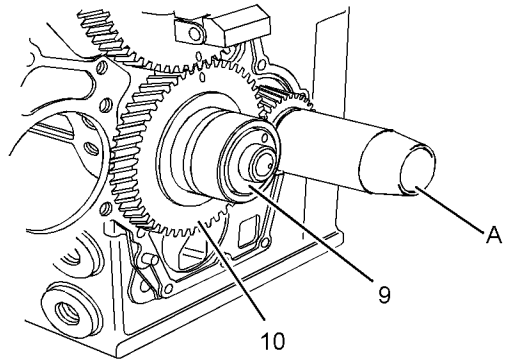

Illustration 224 g01495533
Typical example

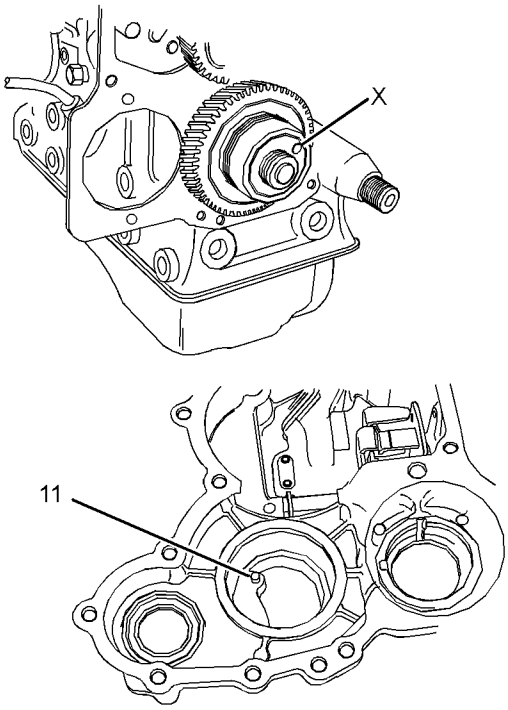

Illustration 225 g01495653
Typical example

1. Ensure that the assembly of front housing (5) and the nose of the crankshaft are clean and free from damage. Clean the gasket surface of plate (4).

2. Install Tooling (A) on the nose of the crankshaft.

3. Align pin (11) with Hole (X) in oil pump cover (9). Ensure that the oil pump cover is concentric to idler gear assembly (10).

4. Install a new gasket to plate (4).

5. Guide the linkage for the fuel injection pump into position so that the link is free to move inside the aperture. Align front housing (5) to the dowels in plate (4). Install front housing (5) to plate (4).

6. Install fasteners (2) and tighten to a torque of 10 N·m (89 lb in).

7. Remove Tooling (A) from the nose of the crankshaft.

8. Install a new O-ring seal (6) to front housing (5). Position cover (7) on front housing (5) and install nuts (3) and bolts (8).

9. Tighten nuts (3) to a torque of 50 N·m (37 lb ft).

10. If the engine is equipped with a turbocharger, connect the hose to connection (1).

End By:

a. Install the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove and Install” for the correct procedure.

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

i07677797

Crankcase Breather - Remove and Install
(Turbocharged Engines)

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.

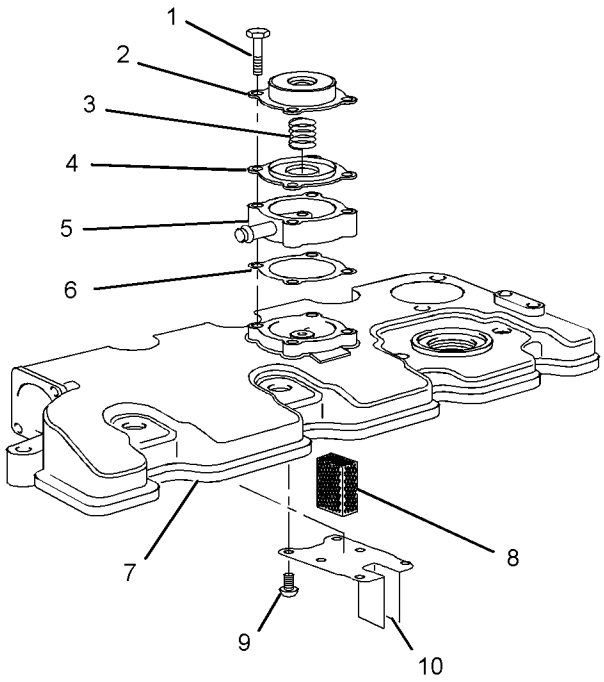

Illustration 226 g01310618
Typical example

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

1. Remove bolts (1) and remove the assembly of cover (2), spring (3), and diaphragm (4). Note the orientation of cover (2).

2. Remove spring (3) and diaphragm (4) from cover (2).

3. Remove adapter (5) and joint (6) from valve mechanism cover (7).

Note: Make a temporary mark to show the orientation of the adapter for installation.

4. If necessary, follow Steps 4a through 4c to remove the gauze for the breather.

a. Remove valve mechanism cover (7). Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

b. Remove screws (9) and carefully remove plate (10).

c. Remove gauze (8) from valve mechanism cover (7).

Installation Procedure

Table 33

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.

NOTICE
Make sure that the components of the breather assembly are installed correctly. Engine damage may occur if the breather assembly is not working properly.

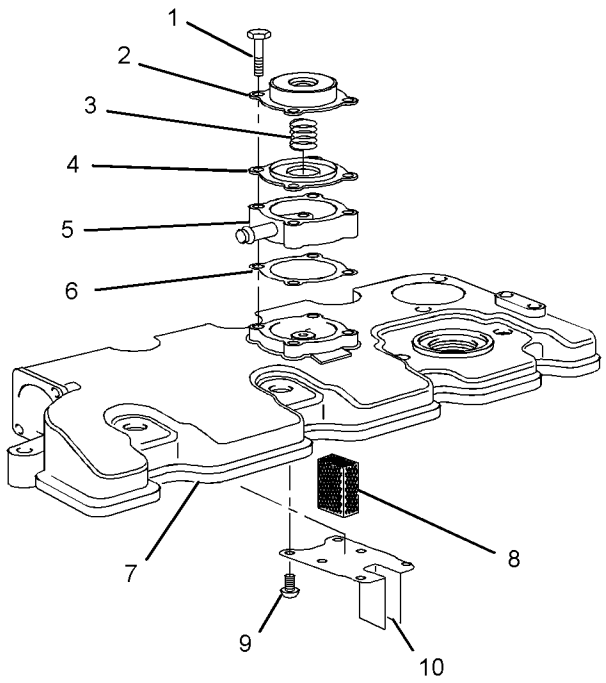

Illustration 227 g01310618
Typical example

1. Clean all parts and inspect all parts. Replace any parts that are worn or damaged. Ensure that the cavity for the breather in the valve mechanism cover is clean. Ensure that vent hole in adapter (5) and the vent hole in cover (2) are free from restriction.

2. If necessary, follow Steps 2a through 2d to install the gauze for the breather.

a. Install gauze (8) to valve mechanism cover (7).

b. Position plate (10) on valve mechanism cover (7) and install screws (9).

c. Tighten screws (9) to a torque of 1.5 N·m (13 lb in).

d. Install valve mechanism cover (7).Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

3. Position a new joint (6) on the valve mechanism cover and install adapter (5).

Note: Ensure the correct orientation of the adapter. The vent hole should face upward.

⚠ 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.

4. Install diaphragm (4) and spring (3) to cover (2).

5. Position the assembly of cover (2), spring (3), and diaphragm (4) onto valve mechanism cover (7).

Note: Ensure the correct orientation of the cover.

6. Install bolts (1). Use Tooling (A) to tighten bolts to a torque of 3 N·m (27 lb in).

i07677798

Crankcase Breather - Remove and Install
(Naturally Aspirated Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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.

The two cylinder, the three cylinder and the four cylinder engines have different crankcase breathers. The removal procedure is similar for all models.

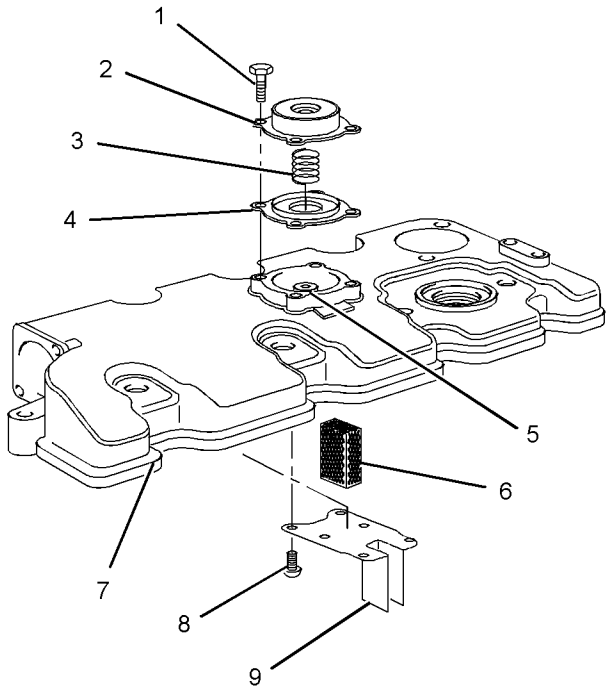

Illustration 228 g01307795
Typical example

⚠ WARNING

Personal injury can result from parts and/or covers under spring pressure.

Spring force will be released when covers are removed.

Be prepared to hold spring loaded covers as the bolts are loosened.

1. Remove bolts (1) and remove the assembly of cover (2), spring (3), and diaphragm (4). Note the orientation of cover (2).

2. Remove spring (3) and diaphragm (4) from cover (2).

3. If necessary, follow Steps 3a through 3c to remove the gauze for the breather.

a. Remove valve mechanism cover (7). Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

b. Remove screws (8) and carefully remove plate (9).

c. Remove gauze (6) from valve mechanism cover (7).

Installation Procedure

Table 34

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.

NOTICE
Make sure that the components of the breather assembly are installed correctly. Engine damage may occur if the breather assembly is not working properly.

The two cylinder, the three cylinder and the four cylinder engines have different crankcase breathers. The installation procedure is similar for all models.

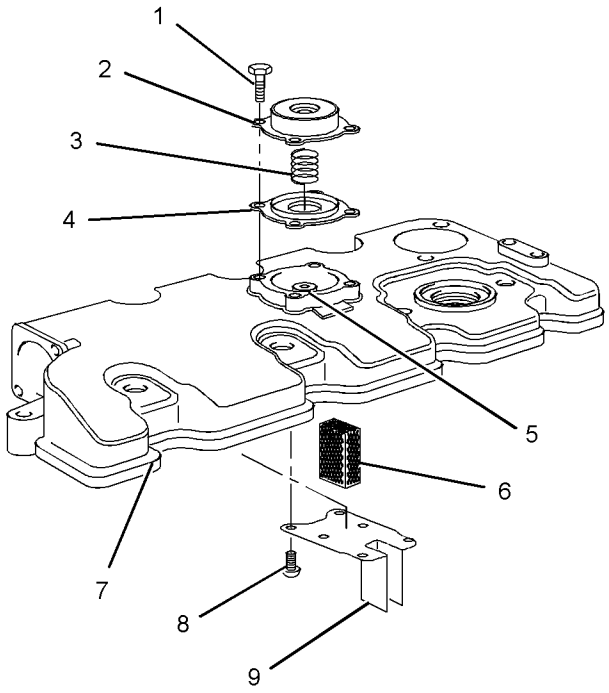

Illustration 229 g01307795
Typical example

1. Clean all parts and inspect all parts. Replace any parts that are worn or damaged. Ensure that the cavity for the breather in the valve mechanism cover is clean. Ensure that vent hole (5) and the vent hole in cover (2) are free from restriction.

2. If necessary, follow Steps 2a through 2d to install the gauze for the breather.

a. Install gauze (6) to valve mechanism cover (7).

b. Position plate (9) on valve mechanism cover (7) and install screws (8).

c. Tighten screws (8) to a torque of 1.5 N·m (13 lb in).

d. Install valve mechanism cover (7).Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

⚠ 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.

3. Install diaphragm (4) and spring (3) to cover (2).

4. Position the assembly of cover (2), spring (3), and diaphragm (4) onto valve mechanism cover (7).

Note: Ensure the correct orientation of the cover.

5. Install bolts (1). Use Tooling (A) to tighten bolts to a torque of 3 N·m (27 lb in).

i07677799

Valve Mechanism Cover - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

Note: The removal procedure is similar for the two cylinder, the three cylinder and the four cylinder engines. The illustrations show the four cylinder engine.

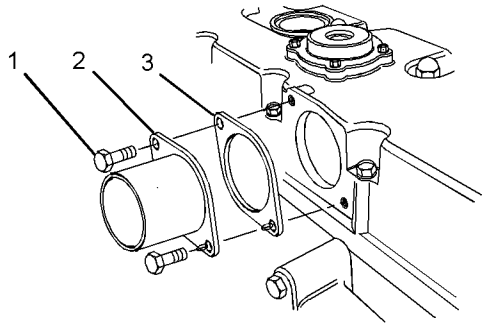

Illustration 230 g01316539
Typical example

1. Loosen the hose clamps and disconnect the hose (not shown) from connection (2).

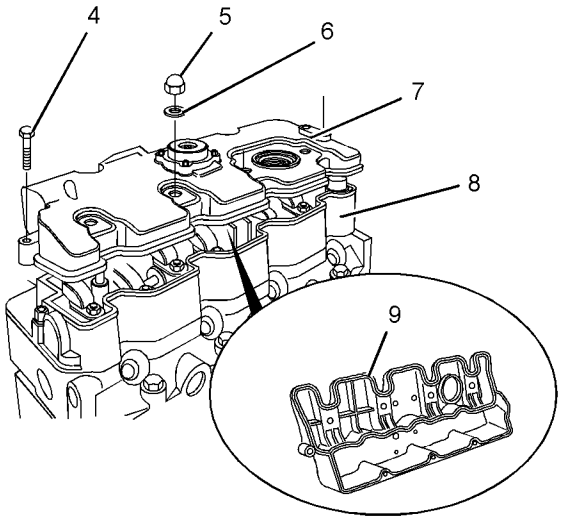

Illustration 231 g01316551
Typical example

2. Remove nuts (5) and washers (6) from valve mechanism cover (7).

3. Remove bolts (4) from valve mechanism cover (7).

Note: Loosen the bolts evenly to avoid distortion of the valve mechanism cover.

4. Remove valve mechanism cover (7) from base (8). Remove seal (9) from valve mechanism cover (7).

5. If necessary, remove bolts (1) and remove connection (2) from valve mechanism cover (7). Remove gasket (2).

6. If necessary, remove the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Remove and Install” for more information.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The installation procedure is similar for the two cylinder, the three cylinder and the four cylinder engines. The illustrations show the four cylinder engine.

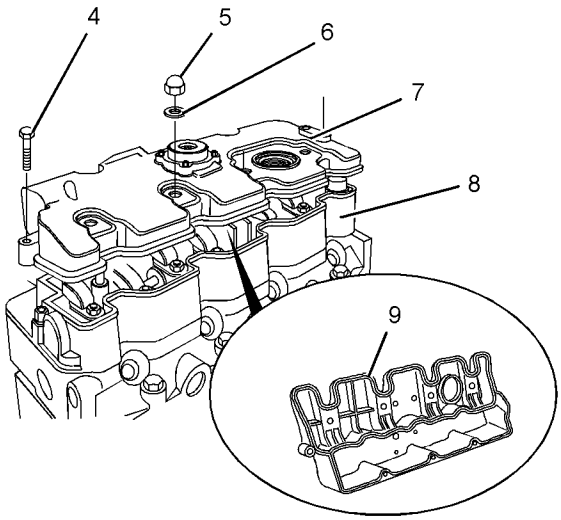

Illustration 232 g01316551
Typical example

1. Ensure that the valve mechanism cover is clean and free from damage. Clean the mating surface of base (8).

2. If necessary, install the crankcase breather. Refer to Disassembly and Assembly, “Crankcase Breather - Remove and Install” for more information.

3. Install a new seal (9) to valve mechanism cover (7).

4. Position valve mechanism cover (7) onto housing (8) and install bolts (4) finger tight.

5. Install new washers (6) and nuts (5) finger tight.

6. For 402F-05, 403F-07, and 403F-11 engines. Evenly tighten bolts (4) to a torque of 10 N·m (89 lb in). Tighten nuts (5) to a torque of 10 N·m (89 lb in).

For 403F-15 engines. Evenly tighten bolts (4) to a torque of 10 N·m (89 lb in). Tighten nuts (5) to a torque of 14 N·m (124 lb in).

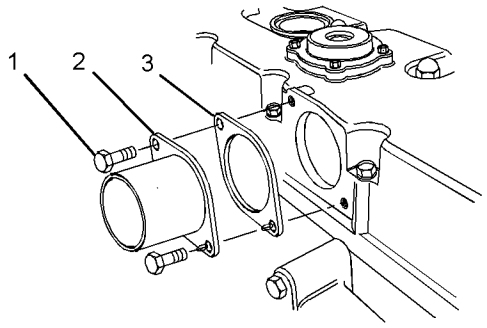

Illustration 233 g01316539
Typical example

7. If necessary, position a new gasket (3) onto valve mechanism cover (7) and install connection (2). Install bolts (1) and tighten to a torque of 14 N·m (124 lb in).

i08154824

Valve Mechanism Cover - Remove and Install
(403F-11 - If Equipped)

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.

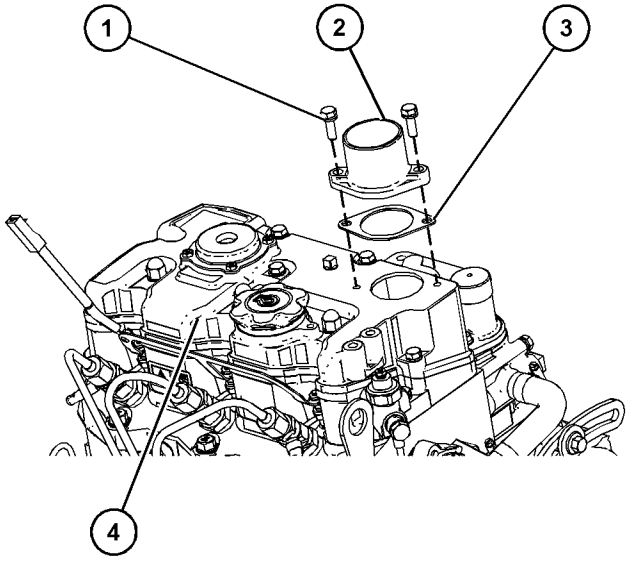

Illustration 234 g06562525
Typical example

1. Loosen the hose clamps and disconnect the hose (not shown) from connection (2).

2. If necessary, follow Step 2a through Step 2c to remove connection (2).

a. Remove bolts (1) from connection (2).

Note: Bolts position for installation purposes.

b. Remove connection (2) from valve mechanism cover (4).

Note: Connection position and orientation for installation purposes.

c. Remove gasket (3) from connection (2).

Note: Gasket orientation for installation purposes.

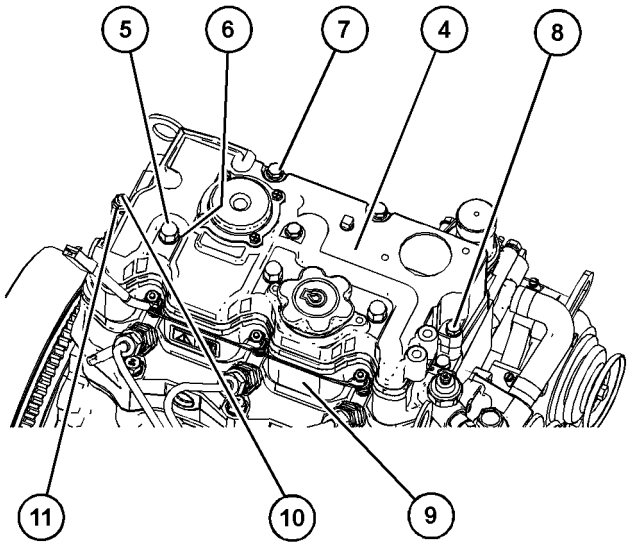

Illustration 235 g06567575
Typical Example

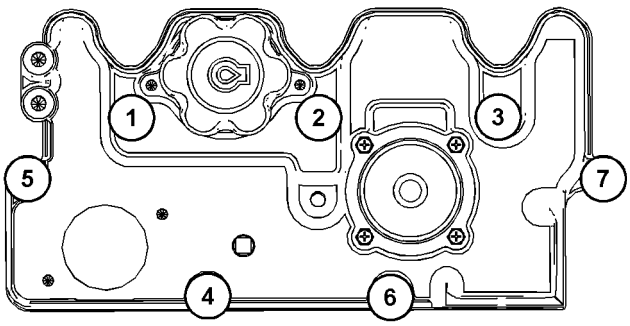

Illustration 236 g06562534
Valve Mechanism Cover Tightening Sequence

3. Remove nuts (5), washers (6) (not shown), bolt (8), bolts (7), and nut (11) from valve mechanism cover (4) in the reverse of the sequence shown in Illustration 236 .

Note: Nuts and bolts positions for installation purposes.

4. Remove valve mechanism cover (4) from base (9).

5. If necessary, remove stud (10) from base (9).

Note: Stud position for installation purposes.

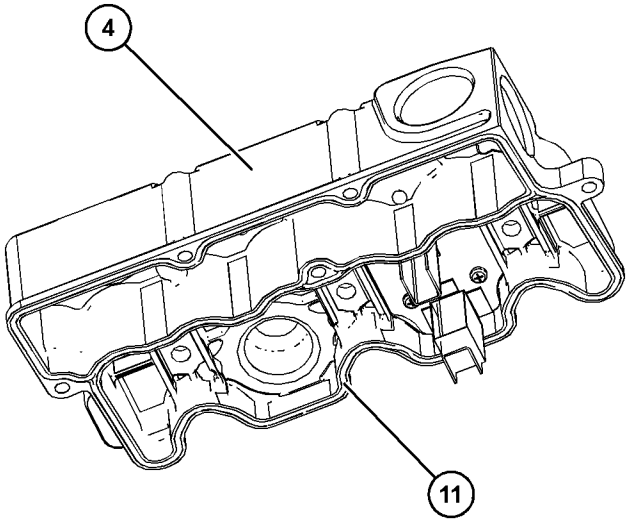

Illustration 237 g06562537
Typical Example

6. Remove O-ring seal (11) from valve mechanism cover (4).

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.

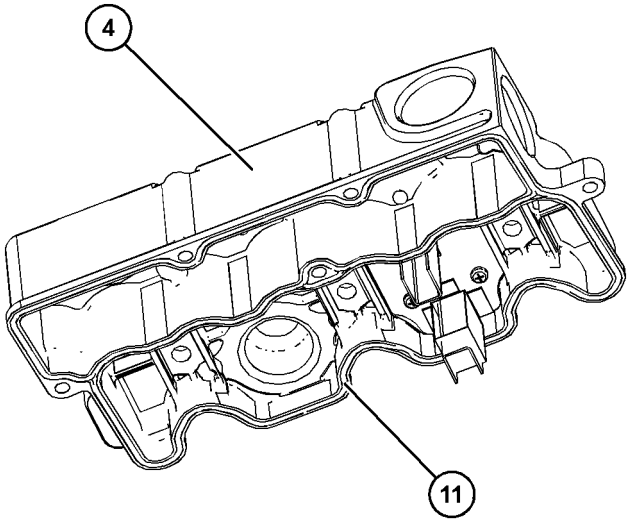

Illustration 238 g06562537
Typical Example

2. Install new O-ring seal (11) to valve mechanism cover (4).

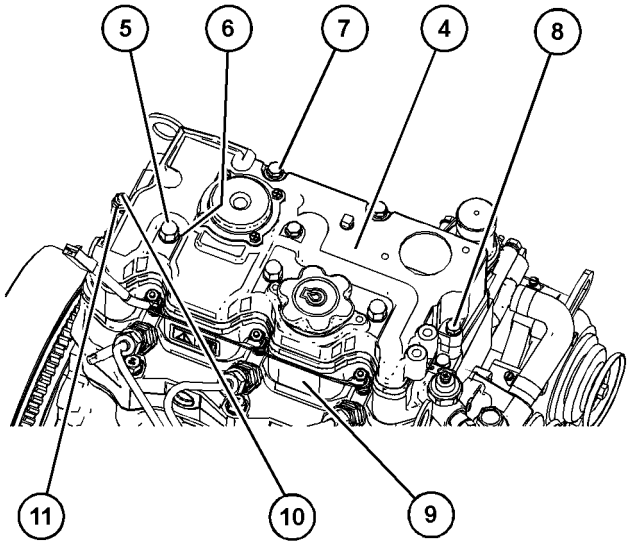

Illustration 239 g06567575
Typical Example

3. If necessary, install new stud (10) into base (9) in the position noted on removal. Tighten the stud to a torque of 6 N·m (53 lb in).

4. Position valve mechanism cover (4) onto base (9) and install bolt (8), bolts (7), and nut (11) finger tight.

5. Install new washers (6) (not shown) and nuts (5) into the positions noted on removal. Tighten the nuts finger tight.

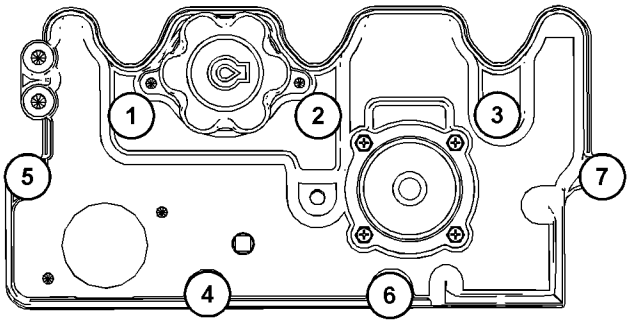

Illustration 240 g06562534
Valve Mechanism Cover Tightening Sequence

6. Follow Step 6a through Step 6d to tighten valve mechanism cover (4), nuts (5), bolt (7), bolts (8), and nut (9).

a. Tighten nuts (5) to a snug torque of 9 N·m (80 lb in) in the numerical sequence 1 to 3 shown in Illustration 240 .

b. Tighten bolt (8), bolts (7), and nut (11) to a snug torque of 5 N·m (44 lb in) in the numerical sequence 4 to 7 shown in Illustration 240 .

c. Tighten nuts (5) to a torque of 18 N·m (159 lb in) in the numerical sequence 1 to 3 shown in Illustration 240 .

d. Tighten bolt (8), bolts (7), and nut (11) to a torque of 10 N·m (89 lb in) in the numerical sequence 4 to 7 shown in Illustration 240 .

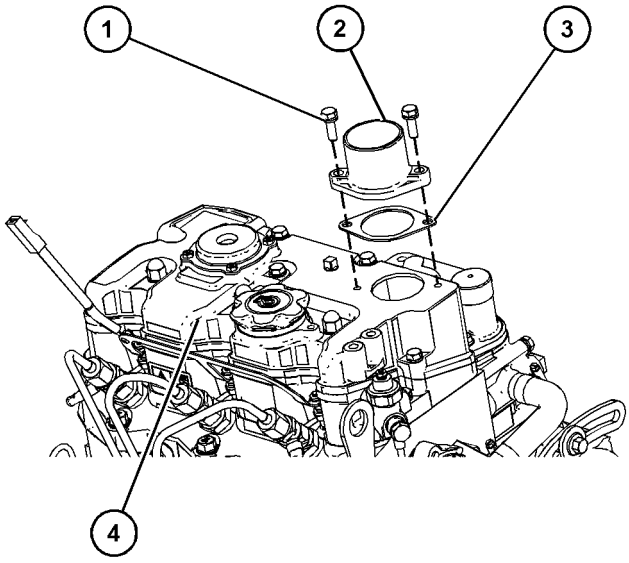

Illustration 241 g06562525

Typical example

7. If necessary, follow Step 7a through Step 7d to install connection (2).

a. Install bolts (1) into connection (2) in the positions noted on removal.

b. Position new gasket (3) onto bolts (1), ensure that the gasket is correctly orientated.

c. Position connection assembly (2) onto valve mechanism cover (4). Install bolts (1) hand tight.

d. Tighten bolts (1) to a torque of 10 N·m (89 lb in).

8. Connect the hose (not shown) to connection (2) and tighten the hose clamps.

i07677803

Rocker Shaft and Pushrod - Remove

Removal Procedure

Start By:

a. Remove the engine oil line. Refer to Disassembly and Assembly, “Engine Oil Line - 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.

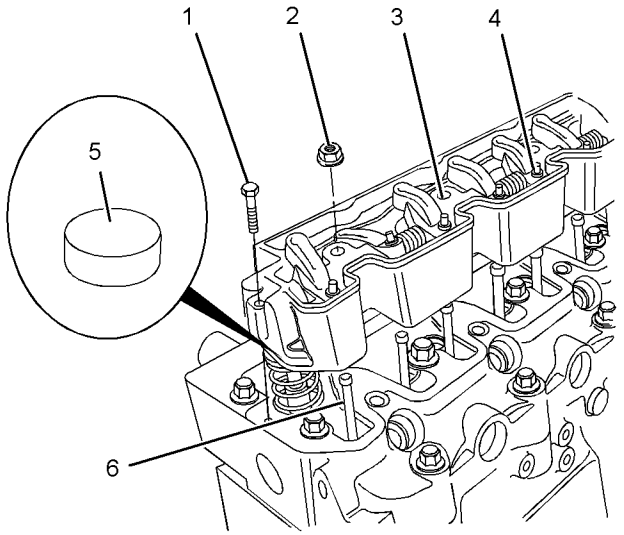

Illustration 242 g01316901

Typical example

1. Loosen the nuts and adjustment screws (4) on all rocker arms.

2. Remove bolts (1) and nuts (2) from rocker shaft assembly (3).

3. Remove rocker shaft assembly (3) from the cylinder head.

4. Place temporary identification marks on caps (5) and pushrods (6).

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

5. Remove pushrods (6) from the cylinder head. Remove caps (5) from the valve stems.

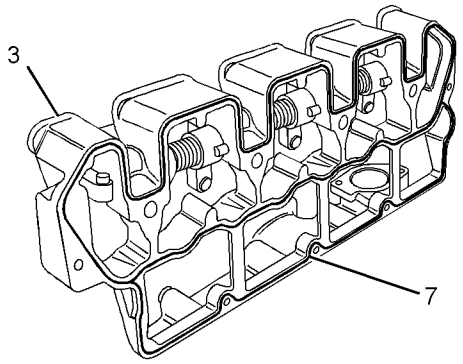

Illustration 243 g01317309

Typical example

6. Remove seal (7) from the base of rocker shaft assembly (3).

i07677805

Rocker Shaft - Disassemble (402F-05, 403F-07, 403F-11, and 403F-15 Engines)

Disassembly Procedure

Start By:

a. Remove the rocker shaft and the pushrods. 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.

1. Make a temporary identification mark on each rocker arm assembly to show the location.

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

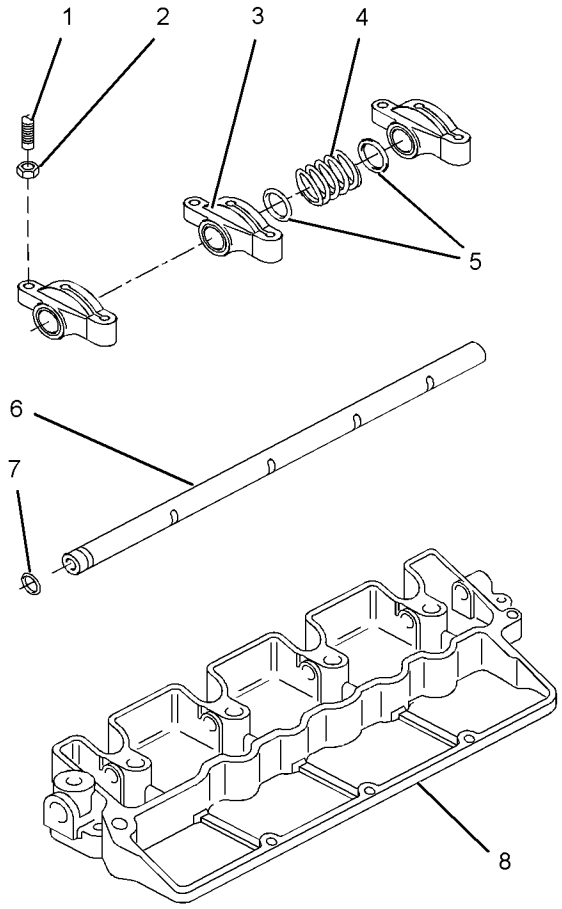

Illustration 244 g01317304

Typical example

2. To remove rocker shaft (6), install a suitable bolt into the end of the rocker shaft. Use the bolt to pull the rocker shaft from base (8).

⚠ 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.

3. Remove rocker arms (3), washers (5), and springs (4).

4. Remove O-ring seal (7) from rocker shaft (6).

5. Remove adjustment screws (1) and nuts (2) from rocker arms (3).

i07677815

Rocker Shaft - Assemble (402F-05, 403F-07, 403F-11, and 403F-15 Engines)

Assembly Procedure

⚠ 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
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

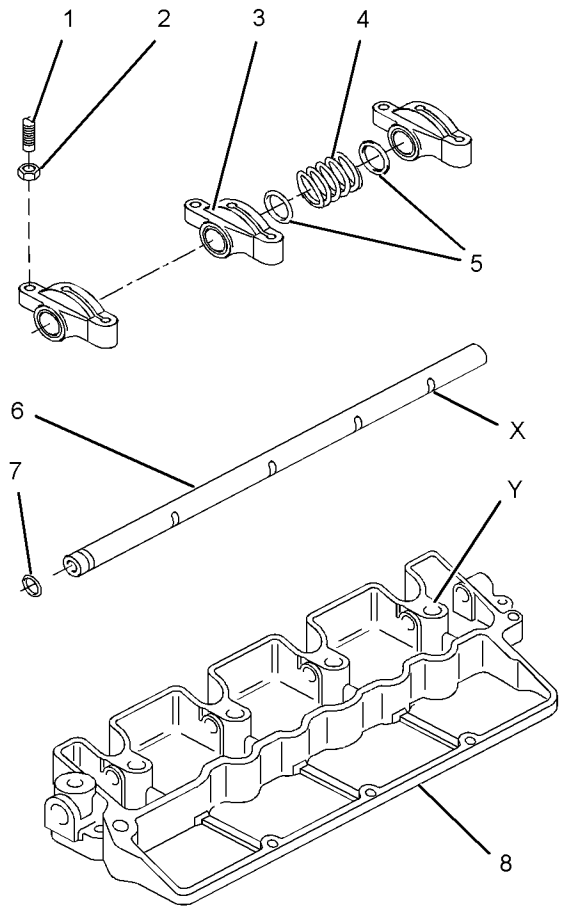

Illustration 245 g01317298
Typical example

2. Lubricate adjustment screw (1) with clean engine oil. Install adjustment screw (1) and nut (2) to rocker arm (3). Repeat the process for the remaining rocker arms.

3. Install a new O-ring seal (7) onto rocker shaft (6). Lubricate the rocker shaft with clean engine oil.

4. Position the end of rocker shaft (6) into the bore in base (8). Align Recesses (X) on the rocker shaft with Holes (Y) in the base.

5. Gradually insert rocker shaft (6) into the base (8). Install rocker arm (3).

6. Continue to insert rocker shaft (6) and install the following components to the rocker shaft:

- Rocker arm (3)
- Washer (5)
- Spring (4)

- Washer (5)
- Rocker arm (3)

7. Repeat Steps 5 and 6 to install the remaining components.

8. Ensure that rocker shaft (6) is fully engaged into base (8). Check that Recesses (X) on the rocker shaft are aligned with Holes (Y) in the base.

End By:

a. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Install" for the correct procedure.

i07677817

Rocker Shaft and Pushrod - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

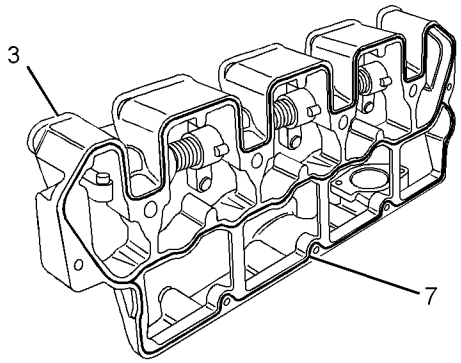

Illustration 246 g01317309
Typical example

2. Install a new seal (7) to the base of rocker shaft assembly (3).

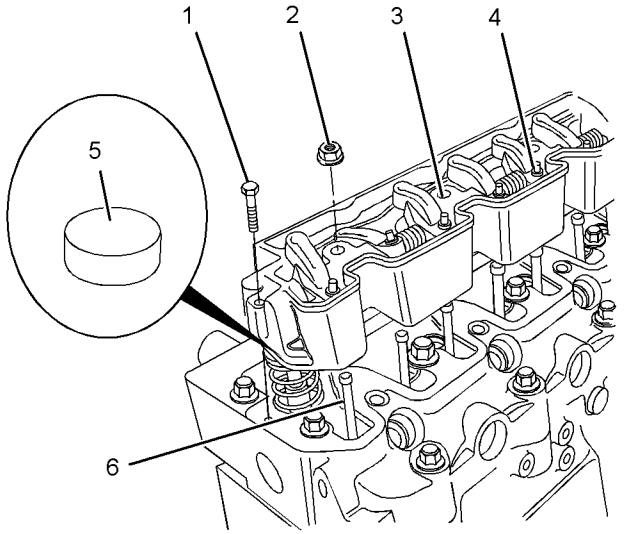

Illustration 247 g01316901
Typical example

3. Apply clean engine lubricating oil to both ends of pushrods (6). Install the pushrods to the engine with the cup upward. Ensure that the pushrods are installed correctly in the socket of the valve lifters.

Note: If the pushrods have been used, ensure that the pushrods are installed in original positions.

4. Lubricate valve stems with clean engine oil. Install caps (5) to the valve stems.

Note: If the caps have been used, ensure that the caps are installed in original positions.

5. Install rocker shaft assembly (3) to the cylinder head.

Note: Ensure that the ends of adjustment screws (4) are correctly seated in ends of pushrods (6).

6. Install nuts (2). Use a deep socket to tighten the nuts. Begin at the center of the rocker shaft and work outward.

For 402F-05 and 403F-07 engines. Tighten nuts (2) to a torque of 10 N·m (88 lb in).

For 403F-11, and 403F-15 engines. Tighten nuts (2) to a torque of 23 N·m (17 lb ft).

7. Install bolts (1) and tighten to a torque of 10 N·m (88 lb in).

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

End By:

a. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

b. Install the engine oil line. Refer to Disassembly and Assembly, “Engine Oil Line- Remove and Install” for the correct procedure.

i07678054

Cylinder Head - Remove (402F-05, 403F-07, 403F-11, and 403F-15)

Removal Procedure

Start By:

a. Remove the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.

b. Remove the fuel filter base. Refer to Disassembly and Assembly, “Fuel filter Base - Remove and Install” for the correct procedure.

c. Remove the fuel injectors. Refer to Disassembly and Assembly, “Fuel Injector - Remove” for the correct procedure.

d. Remove the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs- Remove and Install” for the correct procedure.

e. Remove the rocker shaft and the pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Remove” for the correct procedure.

f. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - 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 - Drain” for the correct draining procedure.

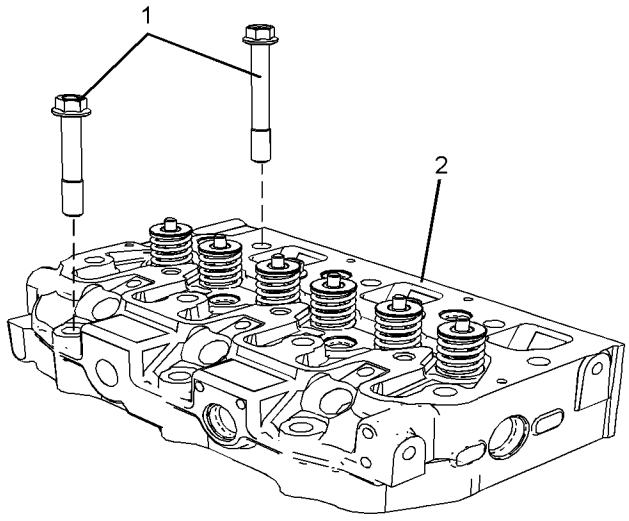

Illustration 248 g06275199
Typical example

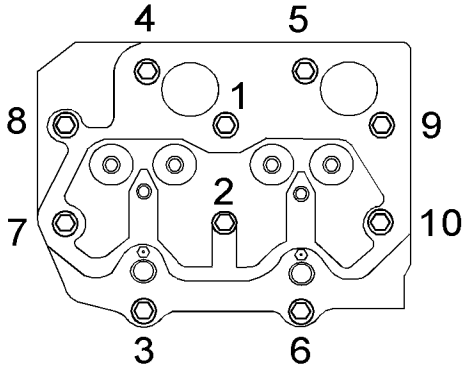

Illustration 249 g01317344
The cylinder head tightening sequence for two cylinder engine

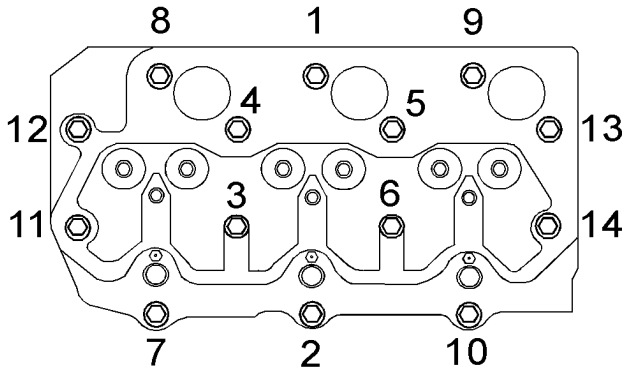

Illustration 250 g01317351

The cylinder head tightening sequence for three cylinder engine

2. Gradually loosen bolts (1) in reverse numerical order. Gradually loosen the bolts in reverse numerical order will prevent distortion of the cylinder head.

For two cylinder engines, loosen the cylinder head bolts in the reverse to the sequence that is shown in Illustration 249 .

For three cylinder engines, loosen the cylinder head bolts in the reverse to the sequence that is shown in Illustration 250 .

3. Remove bolts (1) from cylinder head (2).

4. Attach a suitable lifting device to cylinder head (2). The weight of the cylinder head is approximately 30 kg (66 lb). Carefully lift the cylinder head 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. Avoid contamination of the cylinder bores with coolant or with debris.

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

5. Remove the cylinder head gasket.

Note: The old gasket for the cylinder head should be retained for identification. Gaskets of different thickness are available. Refer to Specifications, “Cylinder Head” for the further information.

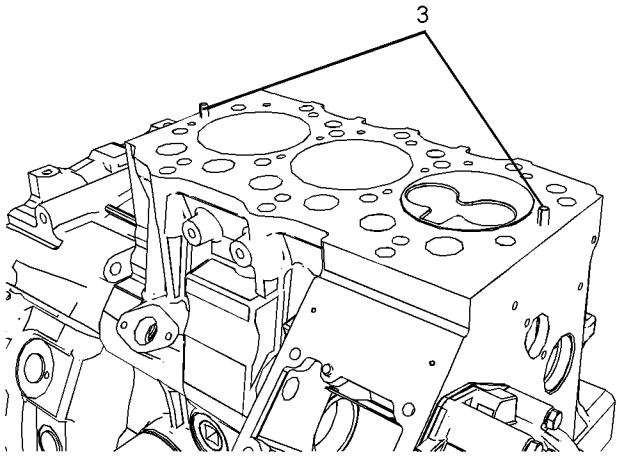

Illustration 251 g06275200

Typical example

6. Note the position of dowels (3) in the cylinder block. Do not remove the dowels unless the dowels are damaged.

7. 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.

i07677829

Cylinder Head - Install (402F-05, 403F-07, 403F-11, and 403F-15)

NOTICE
One of two types of cylinder head bolts can be installed. Type One bolts can be reused if the bolts are serviceable. Refer to Illustration 252 . Type Two bolts must be discarded and new bolts installed. Refer to Illustration 253 .

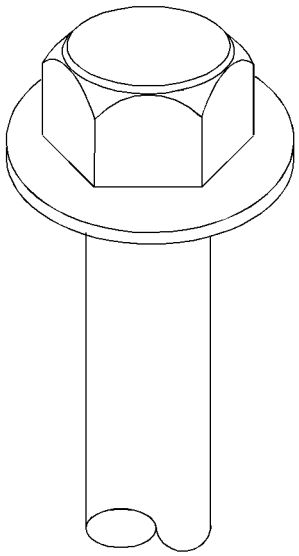

Illustration 252 g06221869

Type One cylinder head bolts

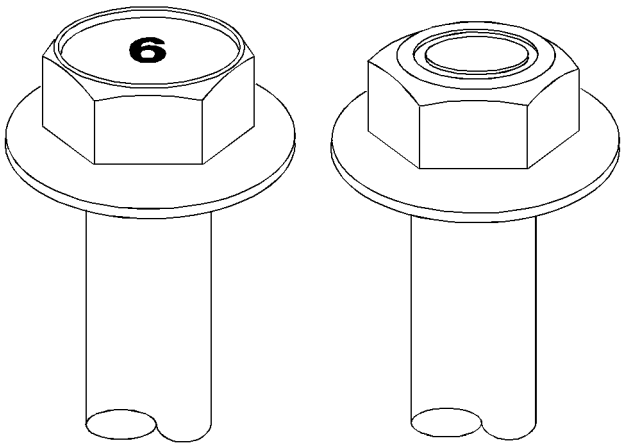

Illustration 253 g06220283

Type Two cylinder head bolts

Installation Procedure for Type One Cylinder Head Bolts

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Table 35

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M11 by 100 mm)	2
B	-	Straight Edge	1

1. Thoroughly clean the gasket surfaces of the cylinder head and the cylinder block. Do not damage the gasket surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.
2. Inspect the gasket surface of the cylinder head for distortion. Refer to Specifications, “Cylinder Head” for more information. If the mating surface of the cylinder head is distorted beyond maximum permitted limits, replace the cylinder head.

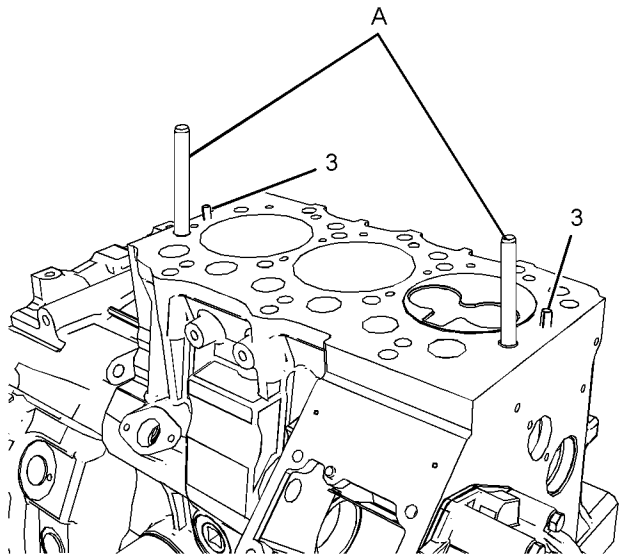

Illustration 254 g06275202

Typical example

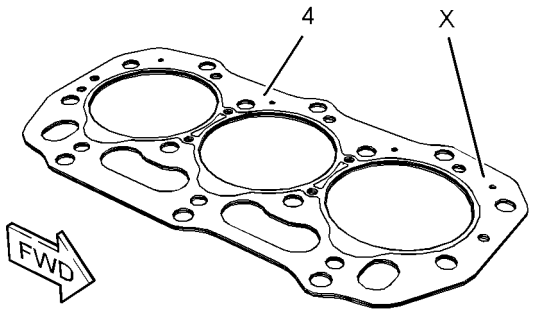

Illustration 255 g06275204
Typical example

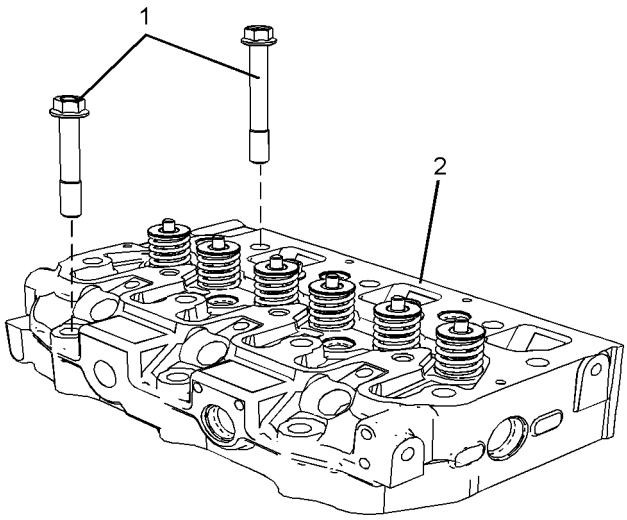

Illustration 256 g06275199
Typical example

3. Inspect dowels (3) for damage. If necessary, replace the dowels in the cylinder block.

4. Install Tooling (A) to the cylinder block. Refer to Illustration 254 .

5. Ensure that the new cylinder head gasket (4) is the same thickness as the cylinder head gasket that was previously removed. The thickness of the cylinder head gasket is indicated by the number that is shown at Position (X). Refer to Specifications, “Cylinder Head” for more information.

6. Align cylinder head gasket (4) with Tooling (A) and with dowels (3). Install the cylinder head gasket onto the cylinder block.

7. Use a suitable lifting device to lift the cylinder head. The weight of the cylinder head is approximately 30 kg (66 lb).

8. Use Tooling (A) to align cylinder head (2) with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned onto dowels (3).

9. Remove Tooling (A).

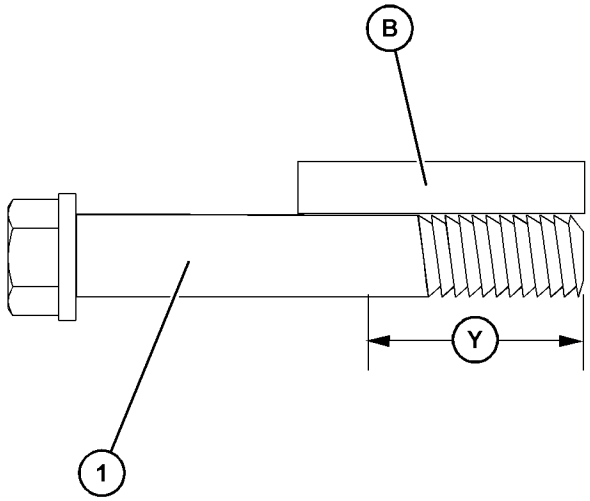

Illustration 257 g06221780

Inspection of Type One cylinder head bolts

10. Clean Type One bolts (1). Follow Step 10a through 10b to inspect the Type One bolts.

a. Check the length of Type One bolts (1).

b. Use Tooling (B) to check the threads of bolts (1). Refer to Illustration 257 . **If any Type One bolts show visual reduction in the diameter of the thread over Length (Y), replace the bolts with a new set of Type Two bolts. If Type One bolts are replaced with a new set of Type Two bolts, refer to the installation procedure for Type Two bolts.**

11. Install bolts (1) to cylinder head (2).

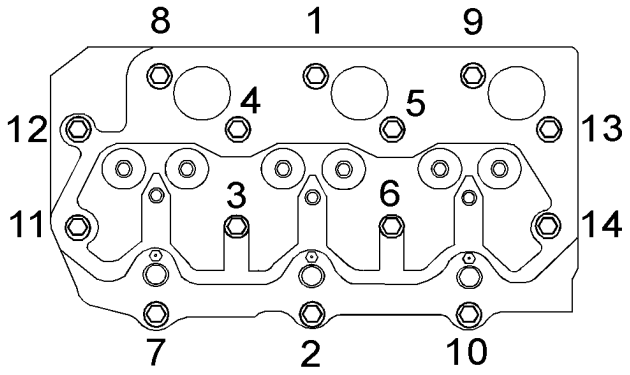

Illustration 258 g01317351

The tightening sequence for a three cylinder engine

12. For three cylinder engines, tighten the bolts to a torque of 101 N·m (75 lb ft). Use the numerical sequence that is shown in Illustration 258 .

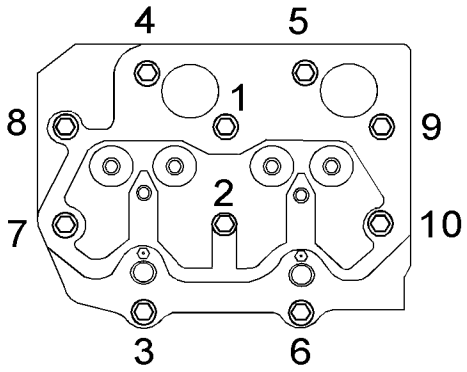

Illustration 259 g01317344

The cylinder head tightening sequence for two cylinder engine

13. For two cylinder engines, tighten the bolts to a torque of 37 N·m (27 lb ft). Use the numerical sequence that is shown in Illustration 259 .

14. If necessary, install the water temperature regulator to the cylinder head. Refer to Disassembly and Assembly, “Water Temperature Regulator- Remove and Install”.

End By:

a. Install the water pump. Refer to Disassembly and Assembly, “Water Pump - Install”.

b. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install”.

c. Install the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install”.

d. Install the fuel injectors. Refer to Disassembly and Assembly, “Fuel Injector - Install”.

e. Install the fuel filter base. Refer to Disassembly and Assembly, “Fuel filter Base - Remove and Install”.

f. Install the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install”.

Installation Procedure for Type Two Cylinder Head Bolts

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Table 36

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Bolt (M11 by 100 mm)	2
B	21825607	Angle Gauge	1

1. Thoroughly clean the gasket surfaces of the cylinder head and the cylinder block. Do not damage the gasket surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.

2. Inspect the gasket surface of the cylinder head for distortion. Refer to Specifications, “Cylinder Head” for more information. If the mating surface of the cylinder head is distorted beyond maximum permitted limits, replace the cylinder head.

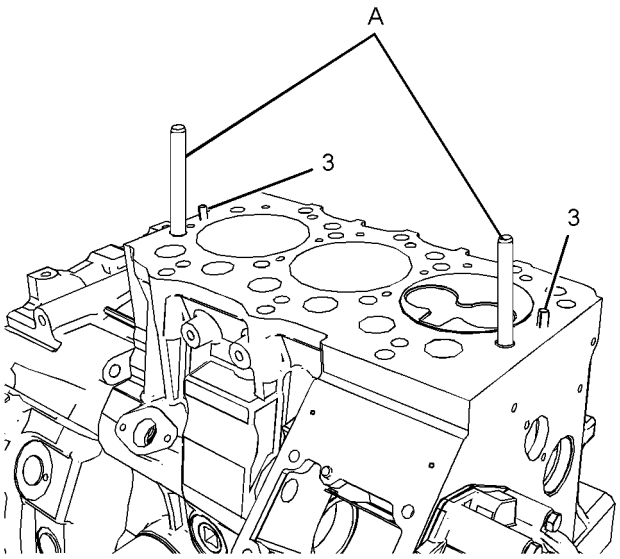

Illustration 260 g06275202
Typical example

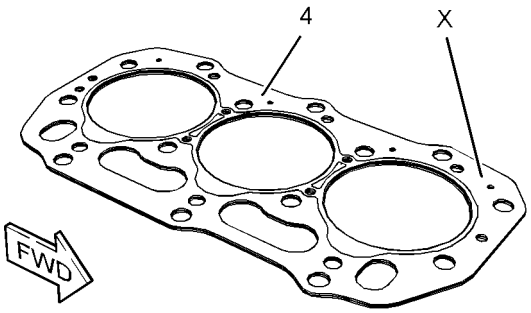

Illustration 261 g06275204
Typical example

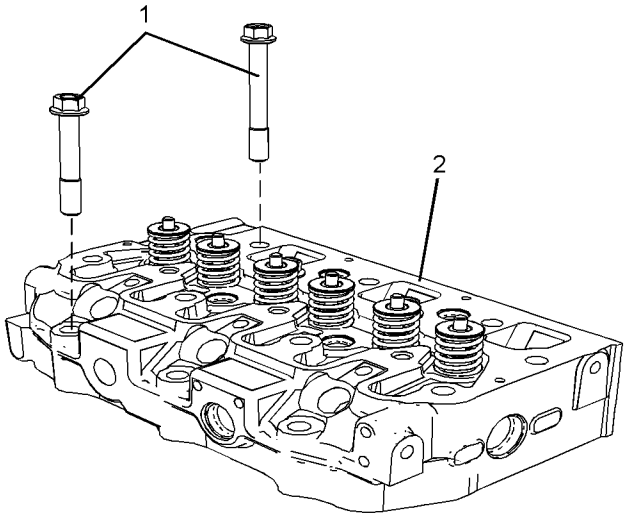

Illustration 262 g06275199
Typical example

3. Inspect dowels (3) for damage. If necessary, replace the dowels in the cylinder block.

4. Install Tooling (A) to the cylinder block. Refer to Illustration 260 .

5. Ensure that the new cylinder head gasket (4) is the same thickness as the cylinder head gasket that was previously removed. The thickness of the cylinder head gasket is indicated by the number that is shown at Position (X). Refer to Specifications, “Cylinder Head” for more information.

6. Align cylinder head gasket (4) with Tooling (A) and with dowels (3). Install the cylinder head gasket onto the cylinder block.

7. Use a suitable lifting device to lift the cylinder head. The weight of the cylinder head is approximately 30 kg (66 lb).

8. Use Tooling (A) to align cylinder head (2) with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned onto dowels (3).

9. Remove Tooling (A).

10. Install new bolts (1) to cylinder head (2).

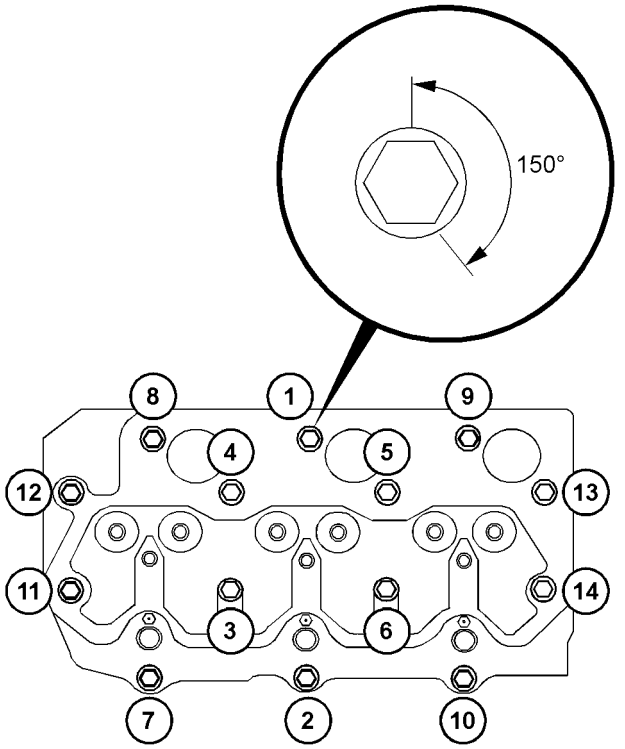

Illustration 263 g06221839

The tightening sequence for a three cylinder engine

11. For three cylinder engines, tighten the bolts to a torque of 50 N·m (37 lb ft). Use the numerical sequence that is shown in Illustration 263 . Use Tooling (B) to turn the bolts a further 150 degrees in the numerical sequence as shown in Illustration 263 .

12. If necessary, install the water temperature regulator to the cylinder head. Refer to Disassembly and Assembly, “Water Temperature Regulator- Remove and Install”.

End By:

a. Install the water pump. Refer to Disassembly and Assembly, “Water Pump - Install”.

b. Install the rocker shaft and the pushrods. Refer to Disassembly and Assembly, “Rocker Shaft and Pushrod - Install”.

c. Install the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install”.

d. Install the fuel injectors. Refer to Disassembly and Assembly, “Fuel Injector - Install”.

e. Install the fuel filter base. Refer to Disassembly and Assembly, “Fuel filter Base - Remove and Install”.

f. Install the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install”.

i07677849

Lifter Group - Remove and Install

Removal Procedure

Table 37

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Telescopic Magnet	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.

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.

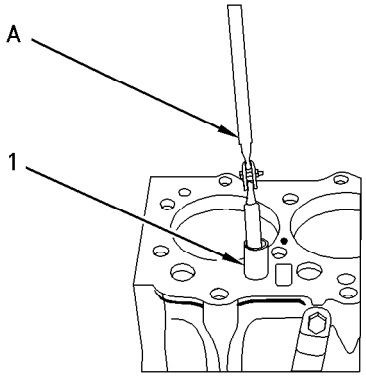

Illustration 264 g00828101

1. Use Tooling (A) to remove lifter (1) from the cylinder block.

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

2. Repeat Step 1 for the remaining lifters.

Installation Procedure

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.

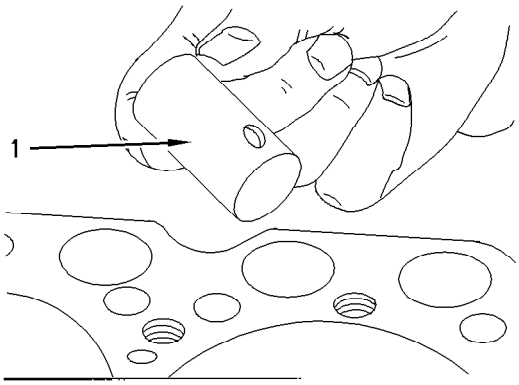

Illustration 265 g00692979

1. Clean lifters (1). Follow Steps 1a through 1c to inspect the lifters. Replace lifters that are worn or damaged.

a. Inspect the seat of the pushrod in the lifter for visual wear or damage. Ensure that oil holes in the lifter are not restricted.

b. Inspect the shank of the lifter for wear or damage. Refer to Specifications, “Lifter Group” for more information.

c. Inspect the face of the lifter that runs on the camshaft for visual wear or damage.

2. Lubricate lifters (1) with clean engine oil.

3. Install lifters (1) into the cylinder block.

Note: The lifters should be free to rotate. If the lifters have been used, ensure that the lifters are installed in the original positions.

End By:

a. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i07677851

Camshaft - Remove

Removal Procedure

Start By:

a. Remove the lifters. Refer to Disassembly and Assembly, “Lifter Group - Remove and Install” 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.

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

Dispose of all fluids according to local regulations and mandates.

1. If the engine is equipped with a mechanical fuel transfer pump, remove the fuel transfer pump. Refer to Disassembly and Assembly, “Fuel Transfer Pump - Remove and Install” for the correct procedure.

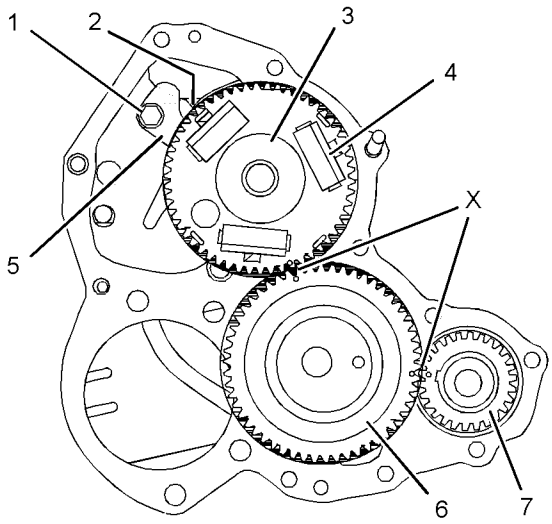

Illustration 266 g01311407

Typical example

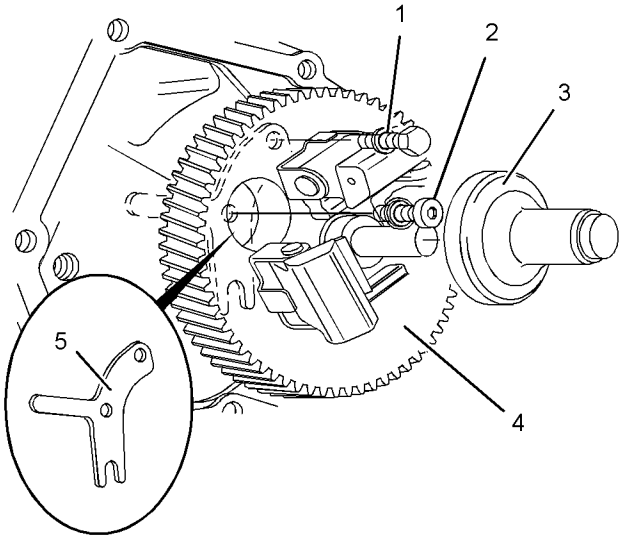

Illustration 267 g01311411

Typical example

2. Remove slider (3) from camshaft gear (4).

Note: 402F-05, 403F-07, 403F-11, and 403F-15 engines have a different camshaft retainer and different fasteners. The removal procedure is similar for all models.

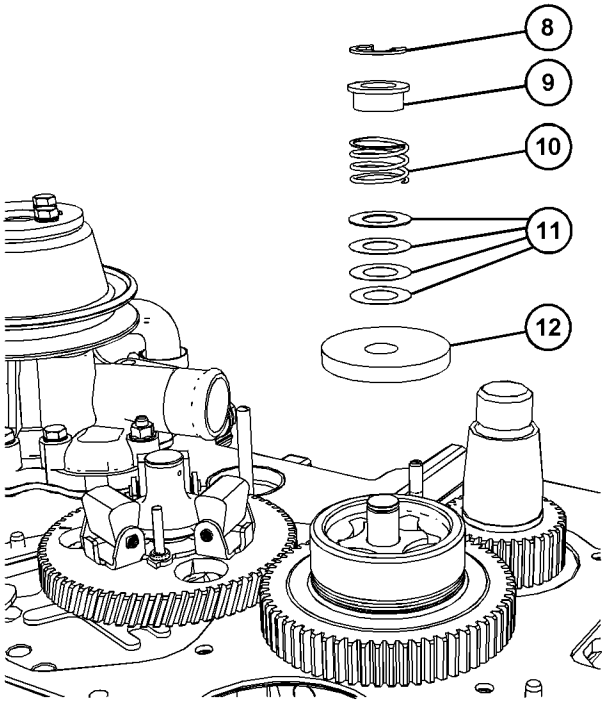

Illustration 268 g06109744

Typical example

3. Before any rotation of gears is performed to align timing Marks (X), remove the following components from the engine oil pump:

- C-clip (8)
- Collar (9)
- Spring (10)
- Shims (11)
- Oil pump cover (12)

Refer to Disassembly and Assembly, Engine Oil Pump - Remove for the correct procedure. Removing the components of the engine oil pump will prevent damage of the oil pump idler hub.

4. Rotate camshaft gear (4) to align the access hole in the camshaft gear with bolt (1). Remove bolt (1).

5. Remove camshaft retainer (5).

6. Rotate the crankshaft until timing Marks (X) are aligned on the following gears:

- Crankshaft gear (7)
- Camshaft gear (4)

- Idler gear (6)

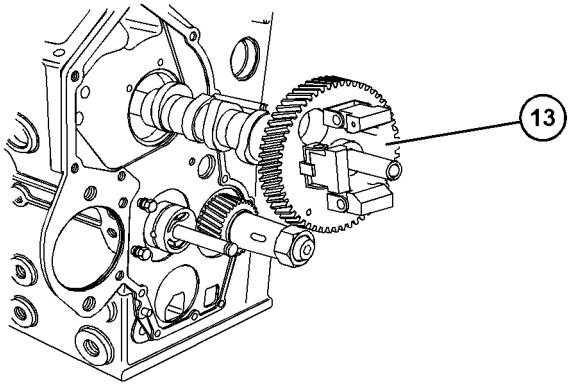

Illustration 269 g06109746
Typical example

7. Carefully remove camshaft assembly (13) from the cylinder block.

Note: Ensure that the lobes of the camshaft and the camshaft bearings are not damaged.

i07677850

Camshaft - Disassemble

Disassembly Procedure

Table 38

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Combination Puller	1

Start By:

a. Remove the camshaft assembly. Refer to Disassembly and Assembly, "Camshaft - Remove" for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

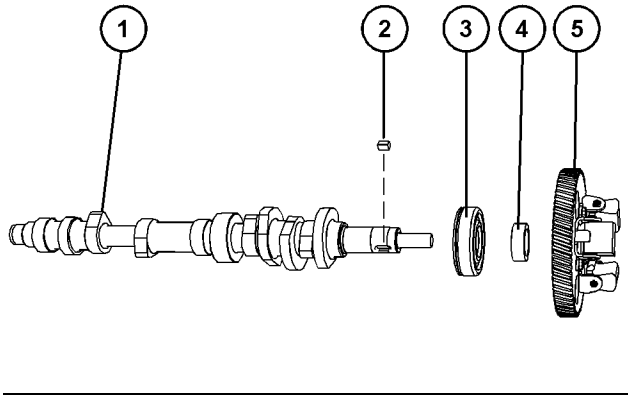

Illustration 270 g06275243

1. Use Tooling (A) to remove gear (5) from camshaft (1).

Note: The gear should be positioned on a suitable support to prevent damage during the disassembly.

2. Remove spacer (3) and key (2) from camshaft (1).

3. Use Tooling (A) to remove bearing (4) from camshaft (1).

Note: Identify the orientation of the bearing for installation.

i07677852

Camshaft - Assemble

Assembly Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of the camshaft assembly are clean and free from damage.

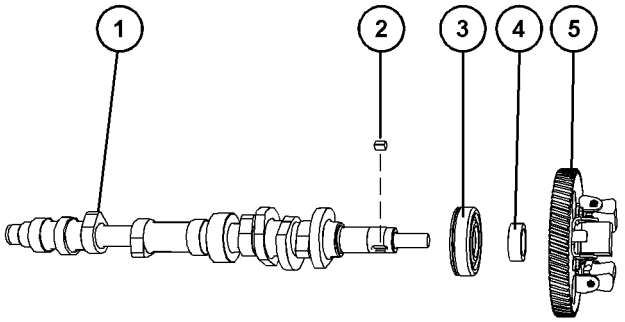

Illustration 271 g06275243
Typical example

2. Lubricate the nose of camshaft (1) with clean engine oil. Use a suitable press to install bearing (3) to the camshaft.

Note: Ensure that the bearing is installed in the correct orientation. The camshaft bearing should be pressed squarely onto the camshaft or damage to the bearing may occur. **Do not press-on the outer race of the bearing.**

3. Install spacer (4) and key (2) to camshaft (1).

4. Align gear (5) with key (2). Use a suitable press to install the gear to the nose of camshaft (1).

Note: The gear should be positioned on a suitable support to prevent damage to the governor flyweights during installation.

End By:

a. Install the camshaft assembly. Refer to Disassembly and Assembly, "Camshaft - Install" for the correct procedure.

i07677853

Camshaft - Install

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the assembly of the camshaft is clean and free from damage.

2. Lubricate the bearings of the camshaft with clean engine oil.

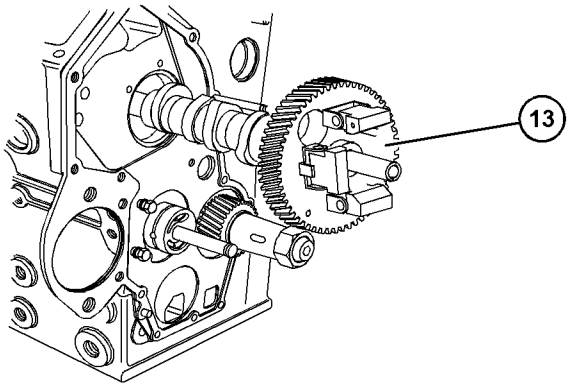

Illustration 272 g06109746
Typical example

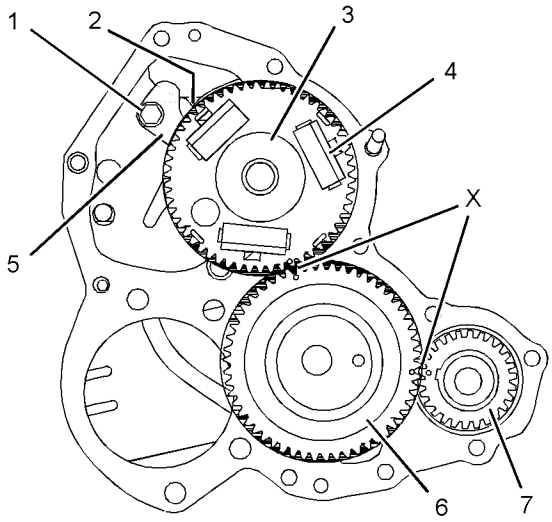

Illustration 273 g01311407
Typical example

3. Carefully install camshaft assembly (13) into the cylinder block. Ensure that timing marks (X) are aligned on the following gears:

- Crankshaft gear (7)
- Camshaft gear (4)
- Idler gear (6)

Note: Do not damage the lobes of the camshaft or the camshaft bearings.

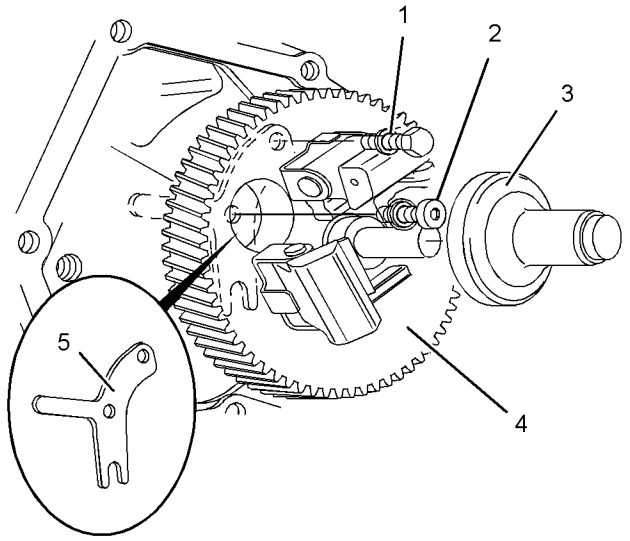

Illustration 274 g01311411

Typical example

Note: 402F-05, 403F-07, 403F-11, and 403F-15 engines have a different camshaft retainer and different fasteners. The installation procedure is similar for all models.

4. Place camshaft retainer (5) in position. Align the holes in the retainer with the holes in the cylinder block.

5. Rotate camshaft gear (4) to align the access hole in the camshaft gear with the hole for fastener (2).

For 402F-05, 403F-07, 403F-11, and 403F-15 engines, install Allen head screw (2) and bolt (1). Tighten fastener (1) and fastener (2) to a torque of 10 N·m (89 lb in).

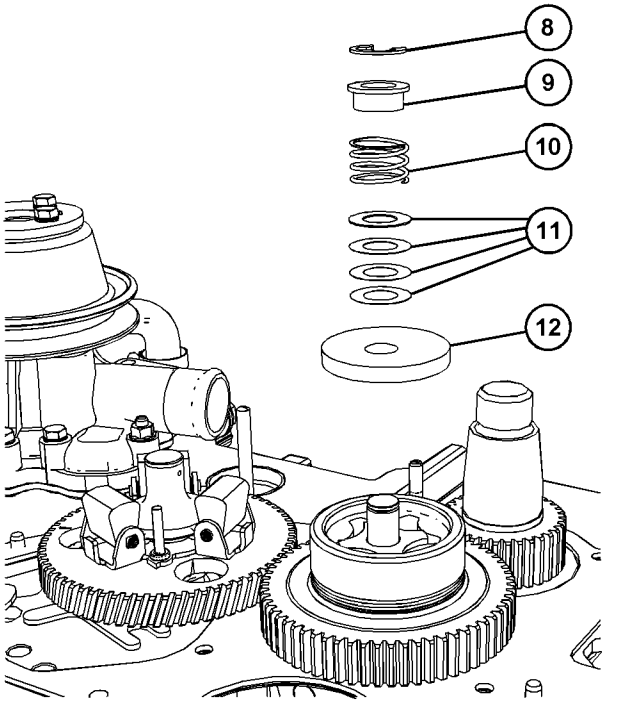

Illustration 275 g06109744

Typical example

6. After the rotation of gears is performed and timing Marks (X) are aligned, install the following components to the engine oil pump:

- C-clip (8)
- Collar (9)
- Spring (10)
- Shims (11)
- Oil pump cover (12)

Refer to Disassembly and Assembly, Engine Oil Pump - Install for the correct procedure.

7. Install slider (3) to camshaft gear (4).

8. If the engine is equipped with a mechanical fuel transfer pump, install the fuel transfer pump. Refer to Disassembly and Assembly, “Fuel Transfer Pump - Remove and Install” for the correct procedure.

End By:

a. Install the lifters. Refer to Disassembly and Assembly, “Lifter Group- Remove and Install” for the correct procedure.

b. Install the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Install” for the correct procedure.

i07677854

Camshaft Bearings - Remove and Install

Removal Procedure

Table 39

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Camshaft Bearing Tool Group	1
	-	Ratchet Wrench	1

Start By:

a. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove” for the correct procedure.

b. Remove the flywheel housing and back plate. Refer to Disassembly and Assembly, “Flywheel Housing - Remove and Install” for the correct procedure.

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

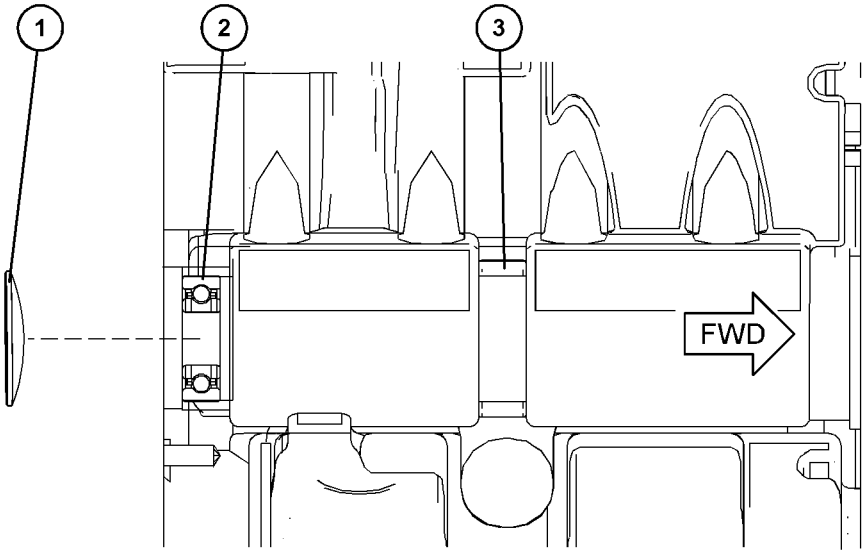

Illustration 276 g06275286

1. Use a suitable tool to remove plug (1) from the cylinder block. Ensure that the surface of the recess is not damaged as the plug is removed.

2. Use Tooling (A) to remove rear ball bearing (2) from the cylinder block.

Note: Take note of the installation depth of the rear ball bearing into the cylinder block for installation purposes.

3. Use Tooling (A) to remove needle bearing (3) from the cylinder block.

Note: Take note of the installation depth of the needle bearing into the cylinder block for installation purposes.

Installation Procedure

Table 40

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Camshaft Bearing Tool Group	1
	-	Ratchet Wrench	1
B	-	Loctite 638	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all the camshaft bearings are free from wear or damage. If necessary, replace any camshaft bearing that is worn or damaged.

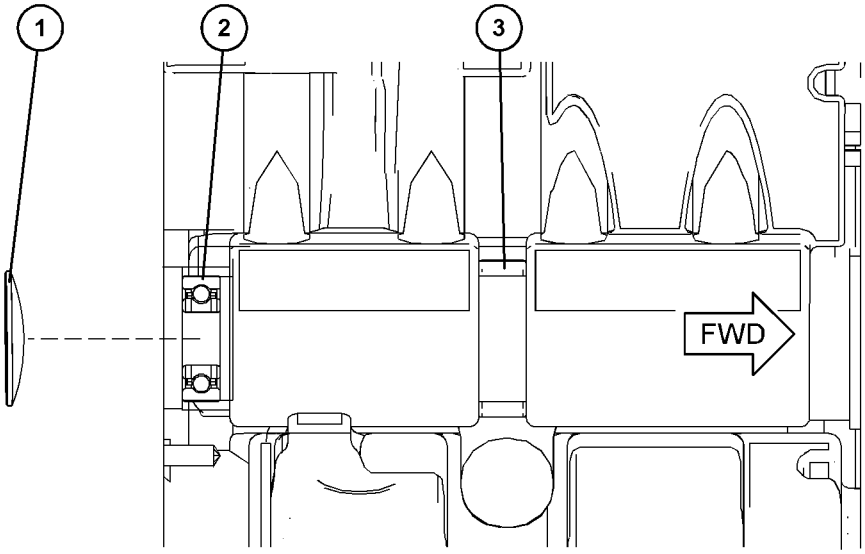

Illustration 277 g06275286

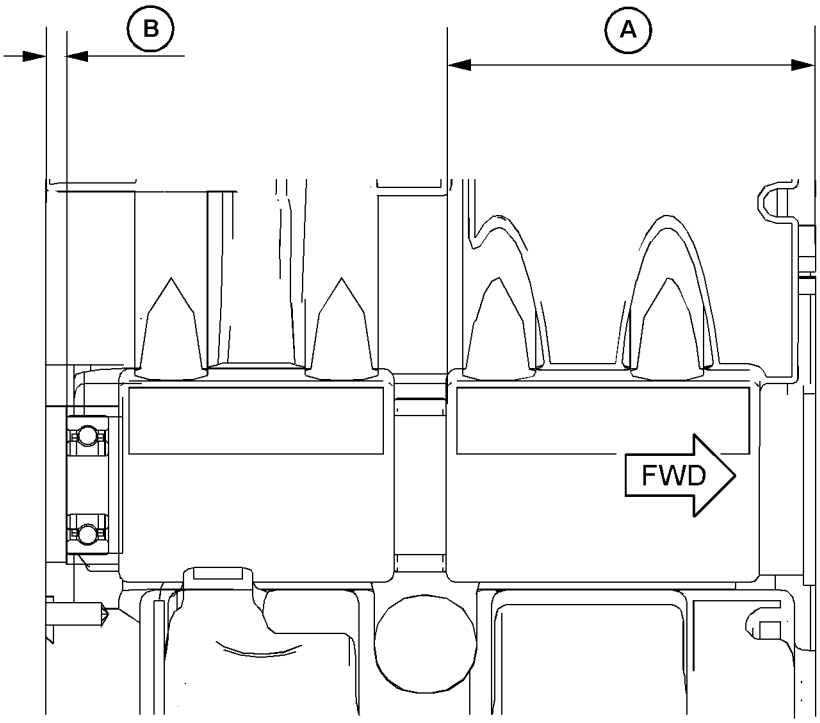

Illustration 278 g06275514

Installation position of camshaft bearings

Position (A) 83 mm (3.268 inch)

Position (B) 5 mm (0.197 inch)

2. Use Tooling (A) to install rear ball bearing (2) into the cylinder block. Refer to Illustration 278 for the correct position.

3. Use Tooling (A) to install needle bearing (3) to the cylinder block. Refer to Illustration 278 for the correct positions.

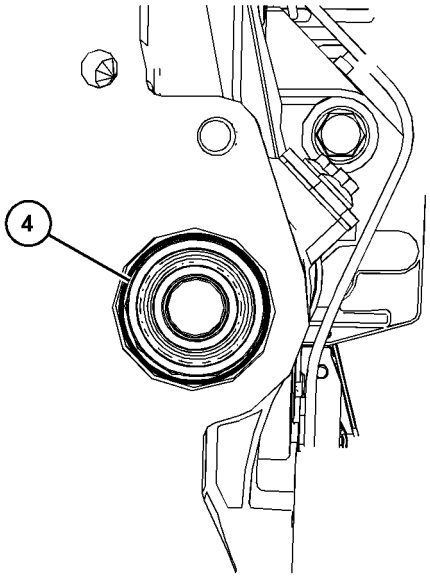

Illustration 279 g06275516

Loctite 638 sealant position

4. Ensure the recess in the cylinder block for plug (1) is clean and free sealant and damage.

5. Apply a bead of Tooling (B) to the recess in the cylinder block for plug (1). Position the plug into the cylinder block and use a suitable tool to depress the center of the plug. Clean away any excess sealant from the plug and the cylinder block.

End By:

a. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Install" for the correct procedure.

b. Install the flywheel housing and back plate. Refer to Disassembly and Assembly, "Flywheel Housing - Remove and Install" for the correct procedure.

i08521002

Engine Oil Pan - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

Note: The two cylinder and three cylinder engines have different engine oil pans. The removal procedure is similar for all models.

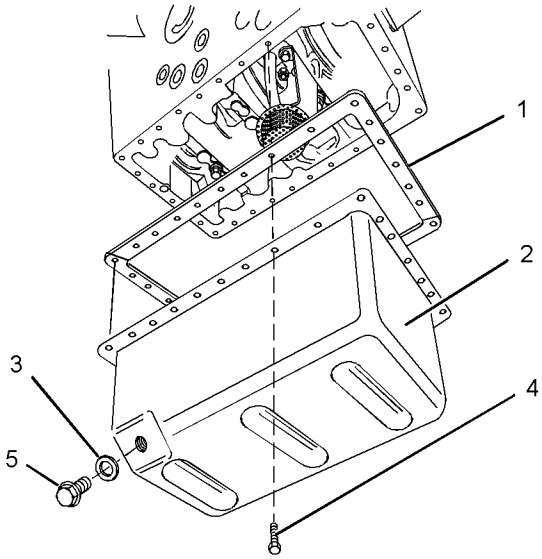

Illustration 280 g01326659

Typical example

1. Remove drain plugs (5) from engine oil pan (2). Drain the engine oil into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Oil Filter Change" for the correct procedure.

2. Remove sealing washers (3) from drain plugs (5).

3. Remove bolts (4) from engine oil pan (2).

4. Remove engine oil pan (2) from the engine.

5. Remove gasket (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The two cylinder and three cylinder engines have different engine oil pans. The installation procedure is similar for all models.

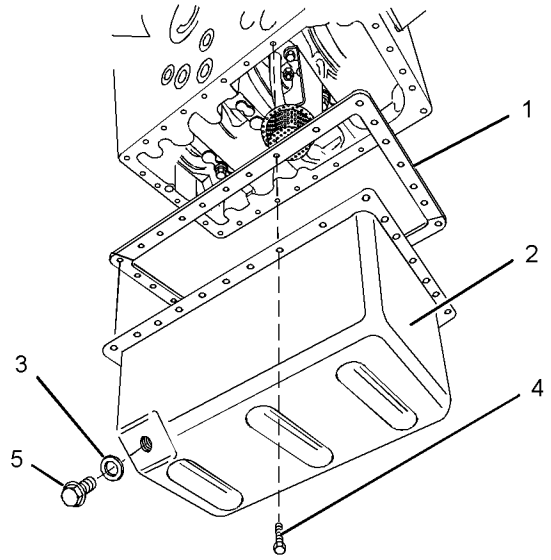

Illustration 281 g01326659

1. Ensure that the engine oil pan is clean and free from damage. Clean the gasket surface of the cylinder block.

2. Install a new gasket (1) and engine oil pan (2) to the engine.

3. Position engine oil pan (2) onto the engine block and install bolts (4) hand tight. Support the engine oil pan as the bolts are installed.

Note: Ensure that gasket (1) is still correctly aligned as the bolts are installed.

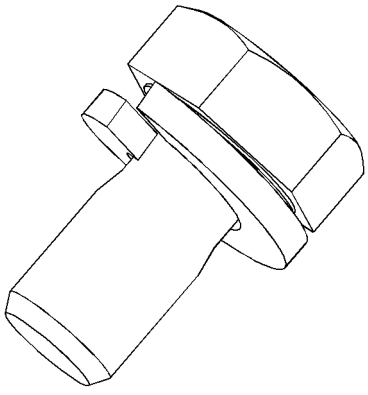

Illustration 282 g06693251

Type 1 Bolt

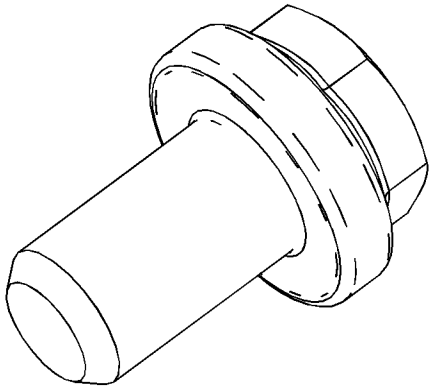

Illustration 283 g06693253

Type 2 Bolt

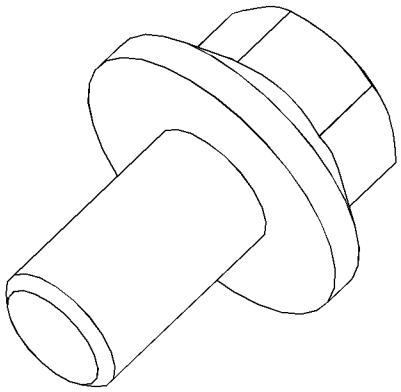

Illustration 284 g06693255

Type 3 Bolt

4. Refer to Illustration 282 . Tighten type 1 bolts (4) to a torque of 10 N·m (89 lb in).

Refer to Illustration 283 and Illustration 284 . Tighten type 2 bolts and type 3 bolts (4) to a torque of 12.5 N·m (111 lb in)

5. Install drain plugs (5) and sealing washers (3) to oil pan (2). Tighten the drain plugs to a torque of 34 N·m (301 lb in).

6. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil Filter Change” for the correct procedure.

i08521008

Engine Oil Pan - Remove and Install
(402F-05 - If Equipped)

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.

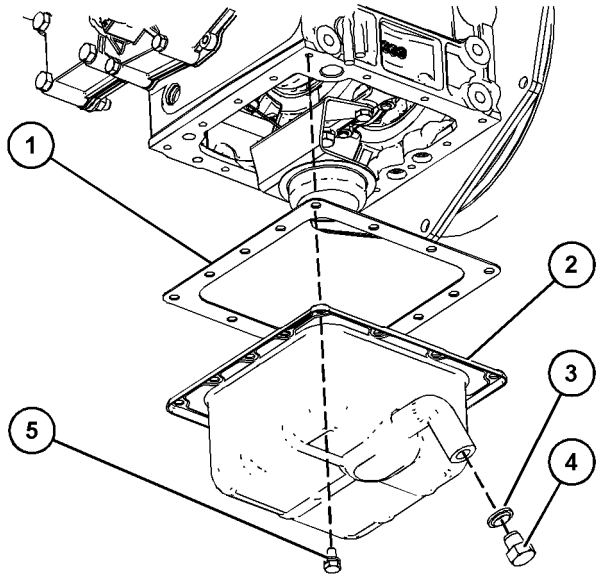

Illustration 285 g06535661
Typical example

1. Remove drain plug (4) from engine oil pan (2). Drain the engine oil into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Oil Filter Change” for the correct procedure.

2. Remove sealing washer (3) from drain plug (4).

3. Remove bolt assemblies (5) from engine oil pan (2).

4. Remove engine oil pan (2) from the cylinder block.

Note: Engine oil pan position and orientation for installation purposes.

5. Remove gasket (1).

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

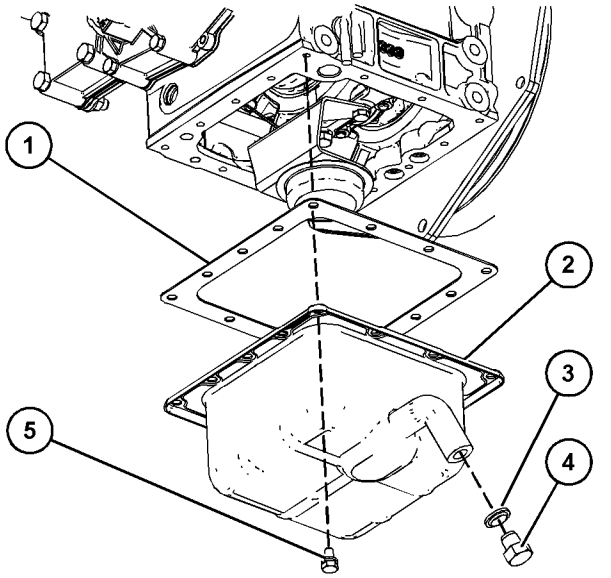

Illustration 286 g06535661
Typical example

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

2. Clean the gasket surface of the cylinder block and engine oil pan (2).

3. Install a new gasket (1) onto engine oil pan (2). Position the engine oil pan onto the cylinder block in the position noted on removal.

4. Position engine oil pan (2) onto the engine block and install bolts (5) hand tight. Support the engine oil pan as the bolts are installed.

Note: Ensure that gasket (1) is still correctly aligned as the bolts are installed.

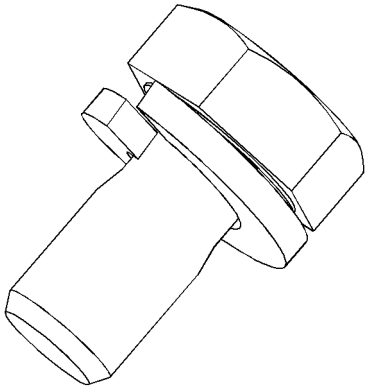

Illustration 287 g06693251

Type 1 Bolt

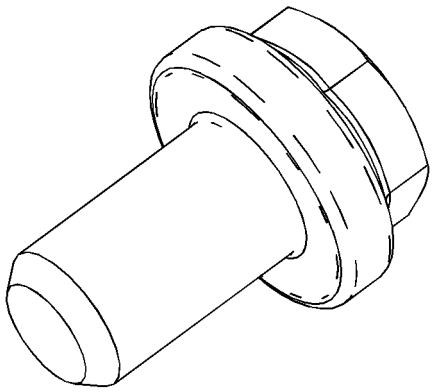

Illustration 288 g06693253

Type 2 Bolt

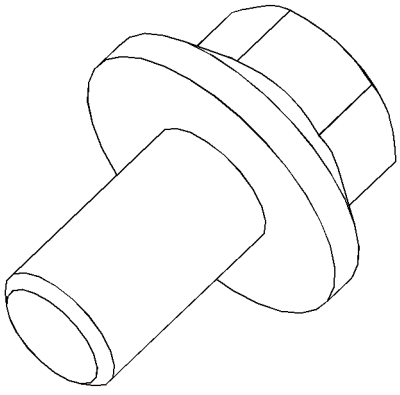

Illustration 289 g06693255

Type 3 Bolt

5. Refer to Illustration 287 . Tighten type 1 bolts (5) to a torque of 10 N·m (89 lb in).

Refer to Illustration 288 and Illustration 289 . Tighten type 2 bolts and type 3 bolts (5) to a torque of 12.5 N·m (111 lb in)

6. Position new washer (3) onto drain plug (4). Install the drain plug assembly to the engine oil pan and tighten the drain plug to a torque of 22.5 N·m (199 lb in)

7. Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil Filter Change” for the correct procedure.

i08521010

Engine Oil Pan - Remove and Install
(403F-07 Engines - If Equipped)

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.

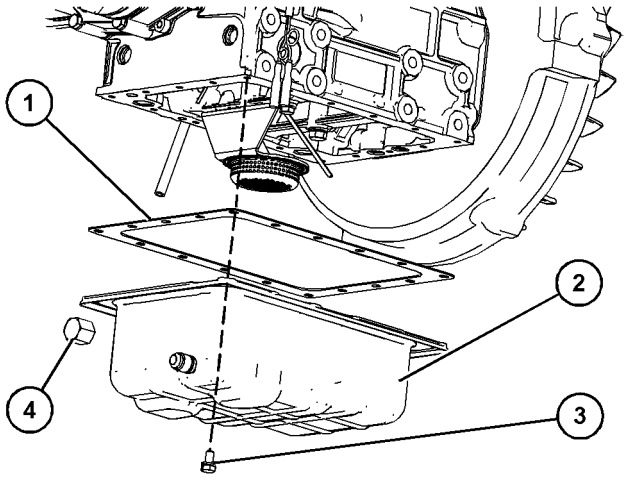

Illustration 290 g06526786
Typical example

1. Remove the drain cap (4) from the engine oil pan (2). Drain the engine oil into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Refill Capacities” for the approximate capacity of the lubricating oil system.

2. Remove bolt assemblies (3) for engine oil pan (2).

3. Remove the engine oil pan (2) from the engine.

4. Remove the gasket (1) from the engine oil pan and the cylinder block. Discard the gasket.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

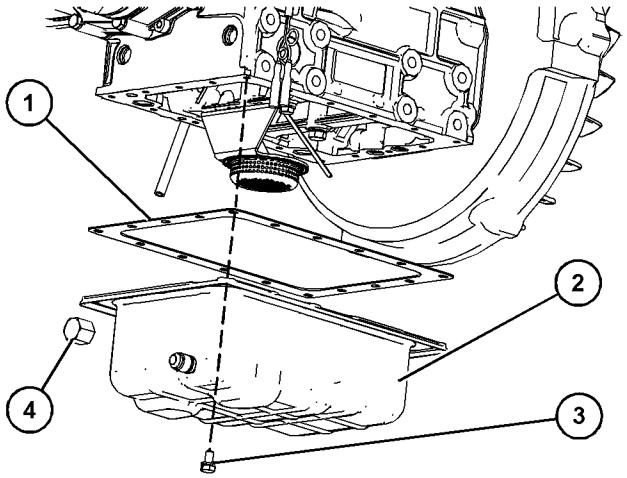

Illustration 291 g06526786
Typical example

1. Clean all surfaces thoroughly.

2. Position a new gasket (1) onto engine oil pan (2).

3. Position engine oil pan (2) onto the engine block and install bolts (3) hand tight. Support the engine oil pan as the bolts are installed.

Note: Ensure that gasket (1) is still correctly aligned as the bolts are installed.

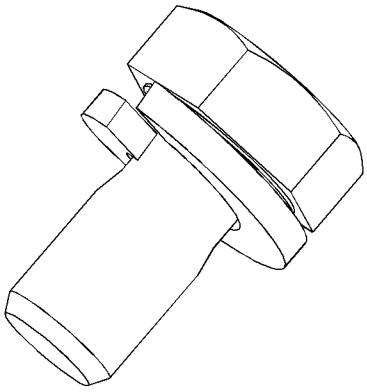

Illustration 292 g06693251
Type 1 Bolt

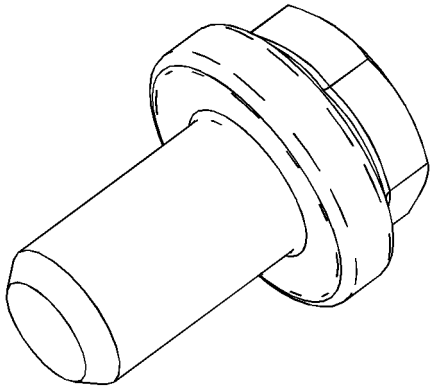

Illustration 293 g06693253

Type 2 Bolt

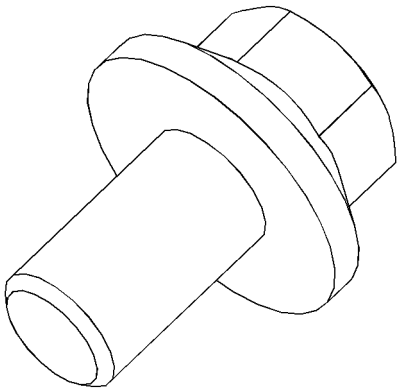

Illustration 294 g06693255

Type 3 Bolt

4. Refer to Illustration 292 . Tighten type 1 bolts (3) to a torque of 10 N·m (89 lb in).

Refer to Illustration 293 and Illustration 294 . Tighten type 2 bolts and type 3 bolts (3) to a torque of 12.5 N·m (111 lb in)

5. Install the drain cap (4) to the oil pan (2). Tighten the drain cap to a torque of 18 N·m (159 lb in).

6. Fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, “Refill Capacities” for more information.

i08521915

Engine Oil Pan - Remove and Install
(403F-11 Engines - If Equipped)

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.

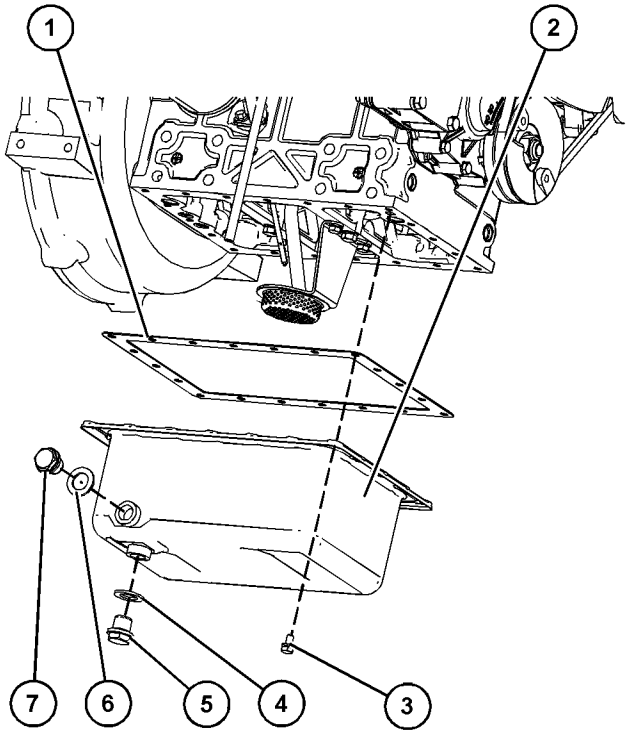

Illustration 295 g06567595

Typical example

1. Remove plug (5) and plug (7) from engine oil pan (2). Drain the engine oil into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Oil Filter Change” for the correct procedure.

2. Remove sealing washer (4) from plug (5) and sealing washer (6) from plug (7).

3. Remove bolt assemblies (3) for engine oil pan (2).

4. Remove the engine oil pan (2) from the engine.

5. Remove gasket (1) from engine oil pan (2) and the cylinder block. Discard the gasket.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

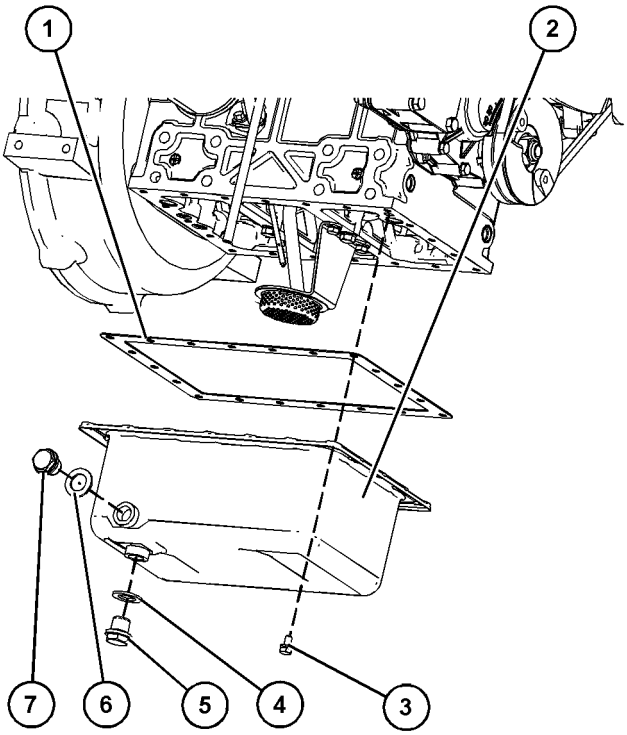

Illustration 296 g06567595
Typical example

1. Ensure that the engine oil pan is clean and free from damage. Clean the gasket surfaces of the cylinder block and the engine oil pan.

2. Position a new gasket (1) onto engine oil pan (2).

3. Position engine oil pan (2) onto the engine block and install bolts (3) hand tight. Support the engine oil pan as the bolts are installed.

Note: Ensure that gasket (1) is still correctly aligned as the bolts are installed.

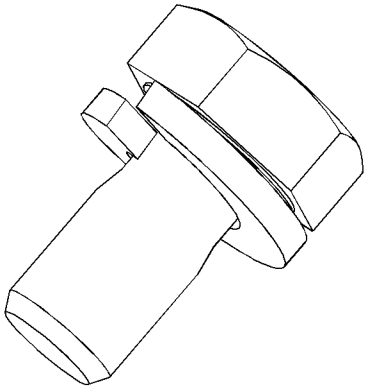

Illustration 297 g06693251
Type 1 Bolt

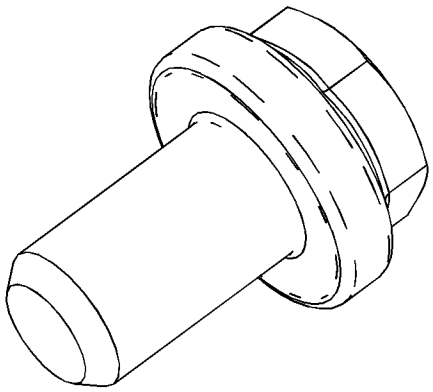

Illustration 298 g06693253
Type 2 Bolt

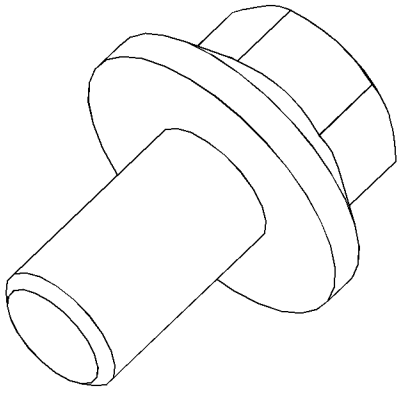

Illustration 299 g06693255
Type 3 Bolt

4. Refer to Illustration 297 . Tighten type 1 bolts (3) to a torque of 10 N·m (89 lb in).

Refer to Illustration 298 and Illustration 299 . Tighten type 2 bolts and type 3 bolts (3) to a torque of 12.5 N·m (111 lb in)

5. Install a new sealing washer (4) onto plug (5) and new sealing washer (6) from plug (7).

6. Install drain plug (5) and drain plug (7) to the oil pan (2). Tighten the drain cap to a torque of 34 N·m (301 lb in).

7. Fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, “Refill Capacities” for more information.

i07677857

Pistons and Connecting Rods - Remove

Removal Procedure

Table 41

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610274	Ridge Reamer	1

Start By:

a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

b. Remove the suction pipe. 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.

1. Position the piston that is being removed in the bottom center position.

2. Use Tooling (A) to remove the carbon from the inner surface of the cylinder bore.

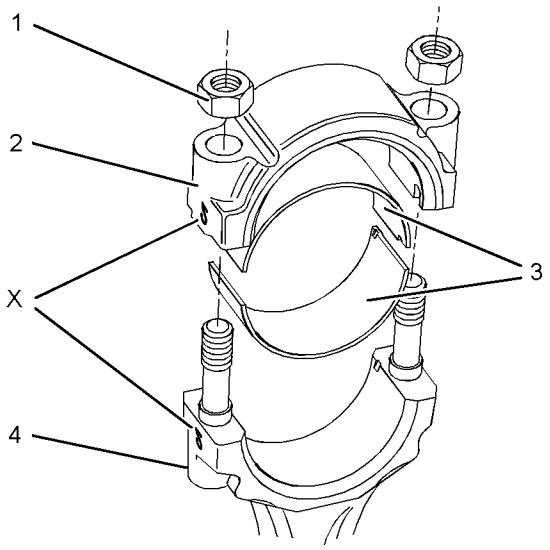

Illustration 300 g01317717

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 (4) 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 to identify the cylinder number.

Note: Do not stamp the connecting rod assembly.

4. Remove nuts (1) and remove connecting rod cap (2) from connecting rod (4).

Note: Use tape or rubber tubing on the threads of the connecting rod bolts to protect the crankshaft journals. The sharp edges of the connecting rod bolts could damage the crankshaft journals.

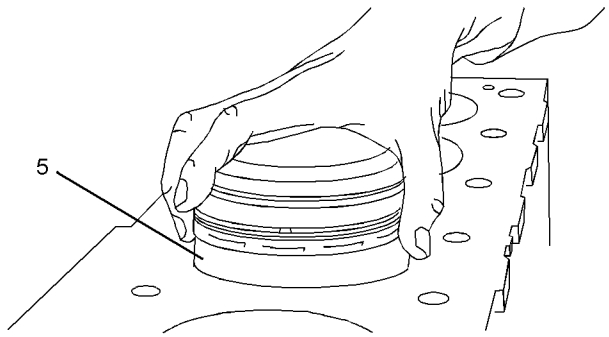

Illustration 301 g01317733
Typical example

5. Carefully push piston (5) and the connecting rod assembly out of the cylinder bore. Lift the piston out of the top of the cylinder block.

Note: Make an identification mark underneath the piston on the pin boss to identify the position on the piston for installation. Always mark the front pin boss.

6. Keep connecting rod bearings (3) with the respective connecting rod (4) and cap (2).

7. Repeat Steps 1 through 6 to remove the remaining pistons and connecting rods.

i07677858

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 42

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Retaining Ring Pliers	1
B	-	Ring Expander	1

Start By:

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

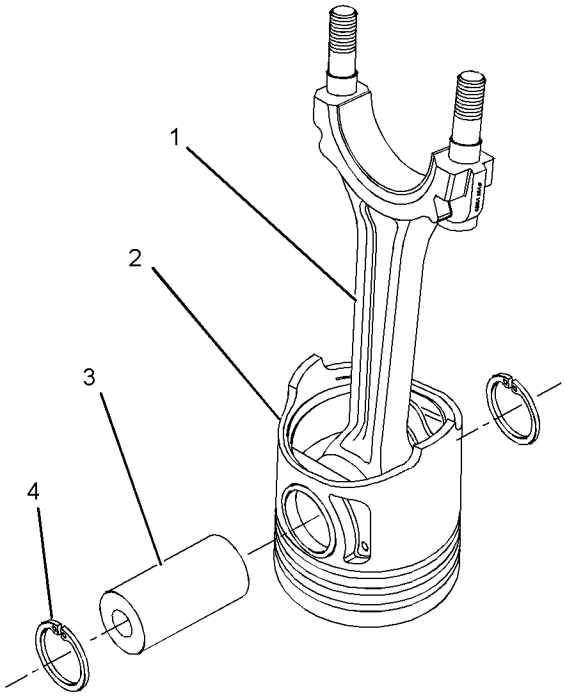

Illustration 302 g01311807
Typical example

2. Place the piston and connecting rod assembly on a suitable surface with the connecting rod upward. Use Tooling (A) to remove retaining rings (4).

3. Remove piston pin (3) and connecting rod (1) from piston (2).

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.

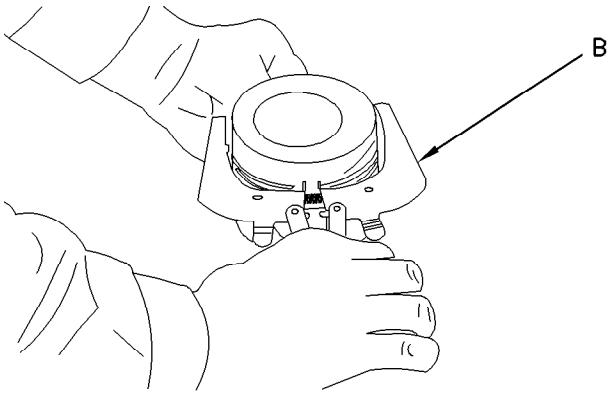

Illustration 303 g00829406
Typical example

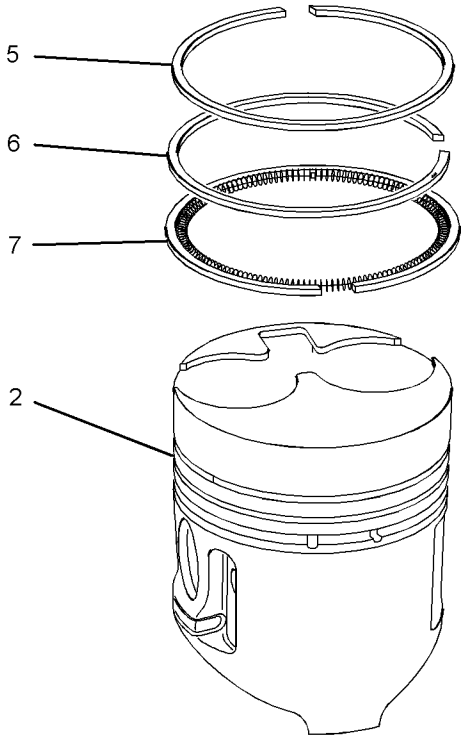

Illustration 304 g01311809

4. Place the piston on a suitable surface with the crown upward. Use Tooling (B) to remove compression ring (5), ring (6), and oil control ring (7) from piston (2).

Note: Identify the orientation of the piston rings for installation.

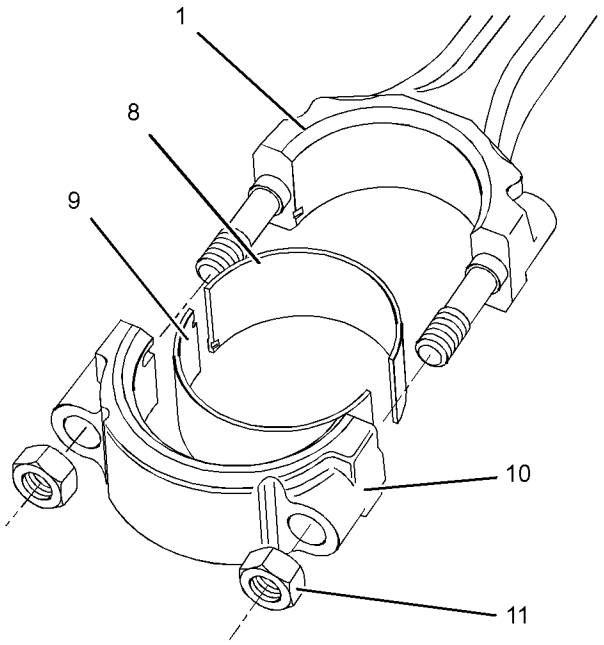

Illustration 305 g01311837
Typical example

5. Remove nuts (11) and connecting rod cap (10) from connecting rod (1).

6. Remove the lower half of connecting rod bearing (9) from connecting rod cap (10). Remove the upper half of connecting rod bearing (8) from connecting rod (1). Keep the bearing shells together.

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

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

i08521918

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 43

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

2. Follow Step 2a through Step 2e to install the piston rings to the piston.

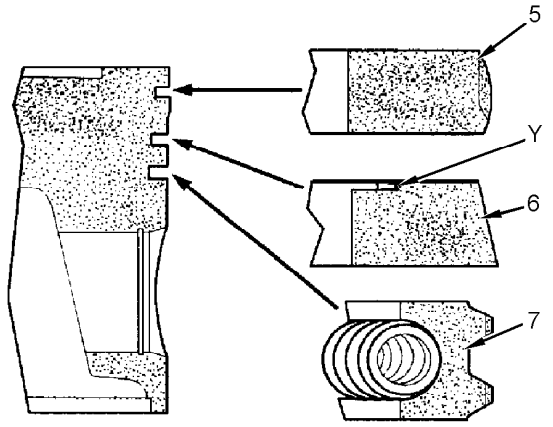

Illustration 306 g01038129

a. Position the spring for oil control ring (7) into the oil ring groove in the piston. The central wire must be located inside the end of the spring.

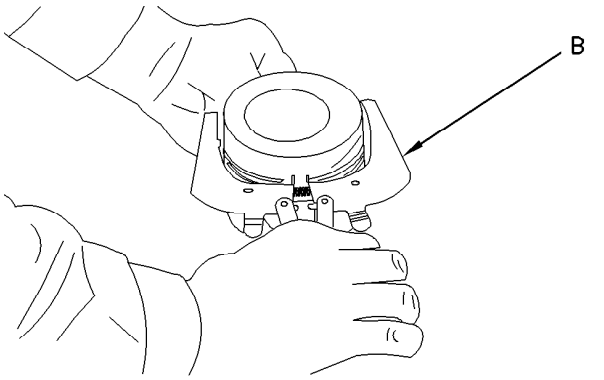

Illustration 307 g00829406
Typical example

b. Use Tooling (B) to install oil control ring (7) over the spring.

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

c. Use Tooling (B) to install intermediate compression ring (6) into the second groove in the piston. The letter “T” and the chamfer (Y) on the inner face of the ring must be upward.

d. Use Tooling (B) to install top compression ring (5) into the top groove in the piston. The letter “T” must be upward.

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

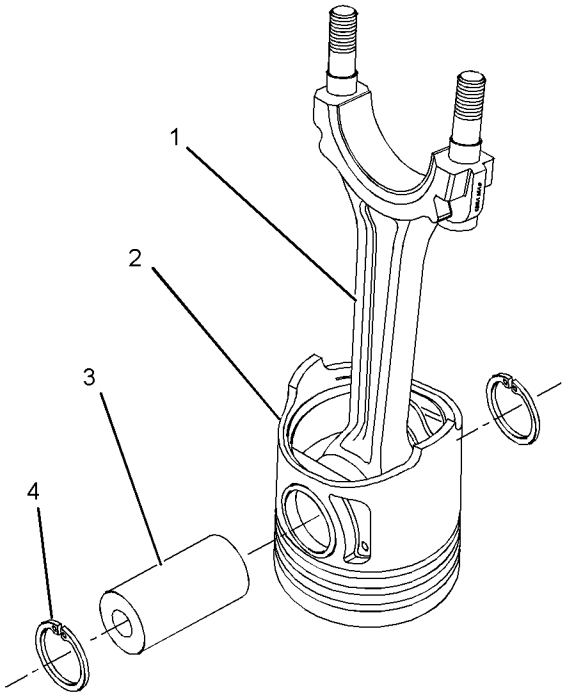

Illustration 308 g01311807
Typical example

3. Lubricate the bush in connecting rod (1) and lubricate the bore for the piston pin in piston (2) with clean engine oil.

4. Place the piston on a suitable surface with the crown downward. Install connecting rod (1) and piston pin (3) to piston (2). The name inside the piston must align with the stamped number on the connecting rod. Ensure the correct orientation of the connecting rod in the piston.

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of 45 ± 5 °C (113 ± 9 °F). Do not use a torch to heat the piston.

5. Use Tooling (A) to install retaining rings (4) to the piston pin bore in piston (2).

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

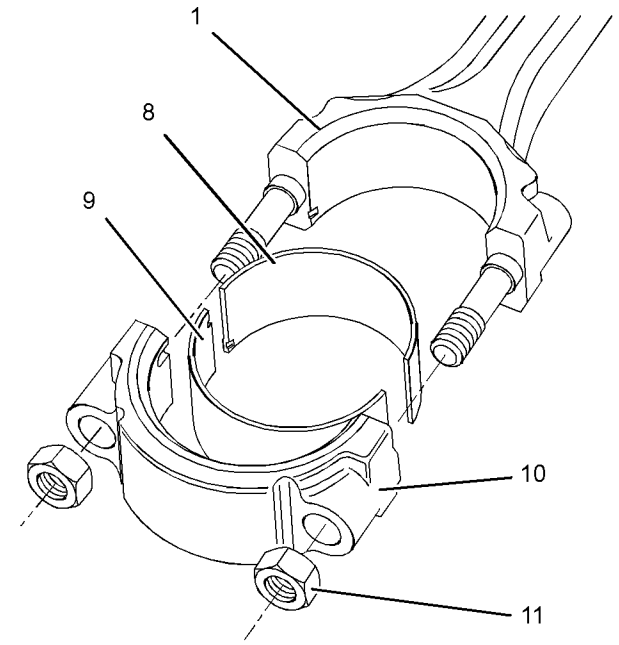

Illustration 309 g01311837
Typical example

6. Install the upper half of connecting rod bearing (8) to connecting rod (1).

7. Install the lower half of connecting rod bearing (9) to connecting rod cap (10).

End By:

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

i07677861

Pistons and Connecting Rods - Install

Installation Procedure

Table 44

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825491	Piston Ring Compressor	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the connecting rod caps were temporarily installed, remove the connecting rod caps. If necessary, thoroughly clean all the components.

2. Apply clean engine oil to the cylinder bore, to the piston rings, to the outer surface of the piston and to the connecting rod bearings.

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

3. Rotate the crankshaft until the crankshaft pin is at the bottom center position. Lubricate the crankshaft pin with clean engine oil.

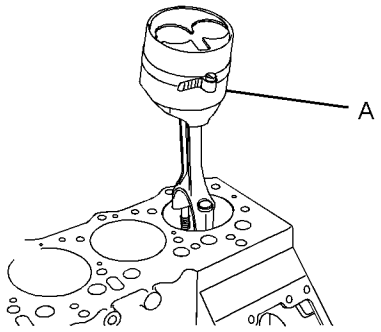

Illustration 310 g01311916
Typical example

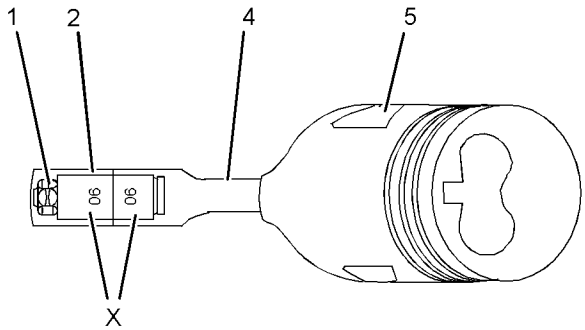

Illustration 311 g01311924
Typical example

4. Ensure that the gaps for the piston rings are at 120 degrees away from each other. Install Tooling (A) onto piston (5). Use tape or rubber tubing on the connecting rod bolts to protect the crankshaft journals.

Note: Ensure that Tooling (A) is installed correctly and that the piston can easily slide from the tool. Ensure that the piston and the connecting rod assembly are installed in the correct cylinder. Align Number (X) on the side of the connecting rod to the right side of the cylinder block. The right-hand side is determined from the flywheel end of the engine.

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

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

6. Install connecting rod cap (2) onto connecting rod (4). Ensure that Number (X) on the connecting rod cap matches Number (X) on the connecting rod. Install nuts (1).

For 402F-05 and 403F-07 engines. Tighten nuts (1) to a torque of 23 N·m (16 lb ft).

For 403F-11, and 403F-15 engines. Tighten nuts (1) to a torque of 32 N·m (24 lb ft).

7. Repeat Step 1 through Step 6 for the remaining pistons and connecting rods.

8. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft to ensure that there is no binding.

End By:

a. Install the suction pipe. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

b. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i07677862

Connecting Rod Bearings - Remove
(Connecting rods in position)

Removal Procedure

Start By:

a. Remove the suction pipe. 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.

Note: If all connecting rod bearings require replacement on a four cylinder engine, 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.

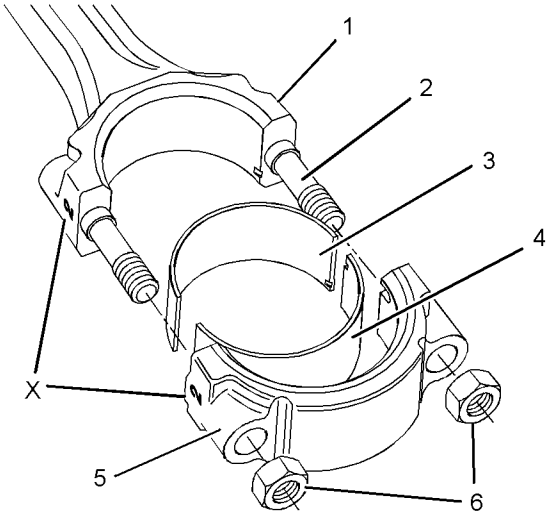

Illustration 312 g01317759
Typical example

Note: The connecting rod and the connecting rod cap should have matching numbers at Position (X). If necessary, make a temporary mark on connecting rod (1) and on connecting rod cap (5).

1. Rotate the crankshaft until the piston is at the bottom center position. Remove nuts (6) and remove connecting rod cap (5) from connecting rod (1).

2. Remove lower connecting rod bearing (4) from connecting rod cap (5).

3. Carefully push connecting rod (1) into the cylinder bore. Remove upper connecting rod bearing (3) from the connecting rod.

Note: Use tape or rubber tubing on connecting rod bolts (2) to protect the crankshaft journals. The sharp edges of the connecting rod bolts could damage the crankshaft journals.

i07677879

Connecting Rod Bearings - Install
(Connecting rods in position)

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the pins of the crankshaft for damage. If the crankshaft is damaged, replace the crankshaft or recondition the crankshaft. Refer to Disassembly and Assembly, “Crankshaft - Remove” and Disassembly and Assembly, “Crankshaft - Install” for the correct procedure. Ensure that the connecting rod bearings are clean and free from wear or damage. If necessary, replace the connecting rod bearings.

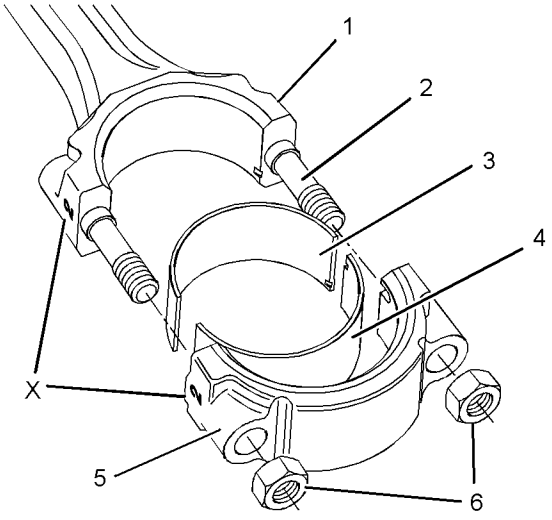

Illustration 313 g01317759
Typical example

2. Clean the bearing surface of connecting rod (1) and connecting rod cap (5). Ensure that Number (X) on connecting rod cap (5) aligns with Number (X) on connecting rod (1).

3. Install upper connecting rod bearing (3) to connecting rod (1). Lubricate the bearing surface of the connecting rod bearing with clean engine oil.

4. Carefully pull connecting rod (1) against the crankshaft pin.

Note: Use tape or rubber tubing on connecting rod bolts (2) to protect the crankshaft journals. The sharp edges of the connecting rod bolts could damage the crankshaft journals.

5. Clean the connecting rod cap. Install lower connecting rod bearing (4) to connecting rod cap (5).

6. Lubricate the pin of the crankshaft and lubricate lower connecting rod bearing (3) with clean engine oil.

NOTICE
When the connecting rod caps are installed, ensure that the identification marks are aligned.

7. Install connecting rod cap (5).

8. Install nuts (4).

For 402F-05 and 403F-07 engines. Tighten nuts (4) to a torque of 23 N·m (16 lb ft).

For 403F-11, and 403F-15 engines. Tighten nuts (4) to a torque of 32 N·m (24 lb ft).

9. Ensure that the installed connecting rod assembly has tactile side play. Carefully rotate the crankshaft to ensure that there is no binding.

Note: If all connecting rod bearings require replacement on a four cylinder engine, 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 - Remove” for more information.

End By:

a. Install the suction pipe. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i07677881

Crankshaft Main Bearings - Remove

Removal Procedure

Start By:

a. Remove the crankshaft assembly. 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.

Crankshaft Main Bearings

1. Ensure that the bearing caps are marked for orientation and the correct position.

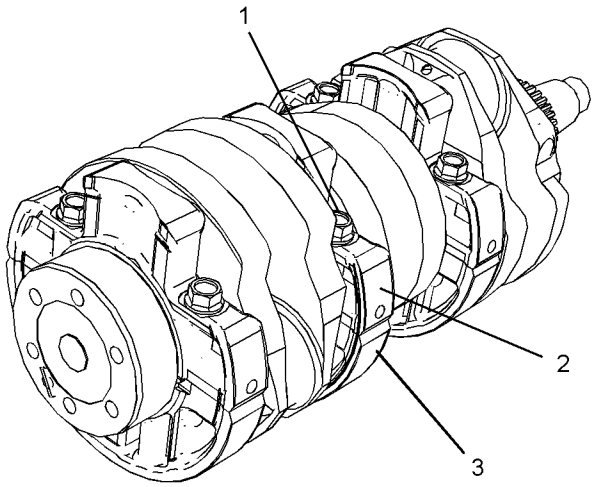

Illustration 314 g06275524

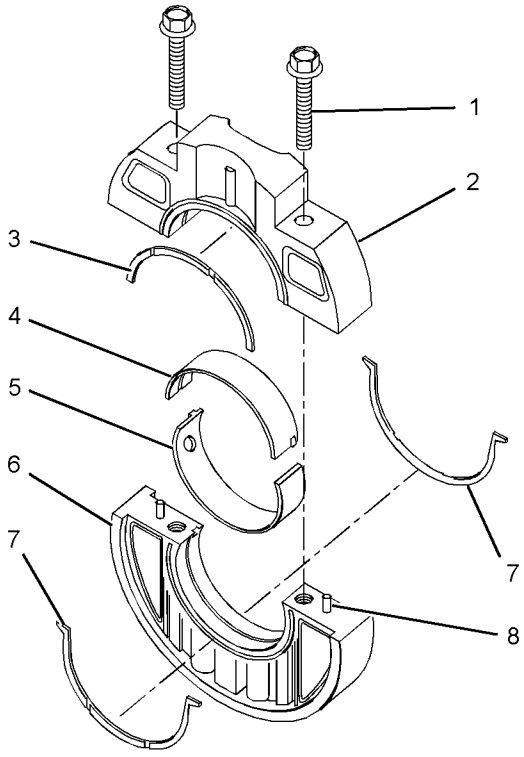

Illustration 315 g01327033
Typical example

2. Remove bolts (1) and upper main bearing cap (2) from lower main bearing cap (6).

3. For 403F-11, and 403F-15 Engines, remove thrust washers (7).

4. Remove main bearing (4) and main bearing (5) from the main bearing caps. Keep the main bearings with the respective bearing caps.

5. Do not remove dowels (8) from the main bearing caps.

Crankshaft Bearing (Front)

Table 45

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610275	Driver	1

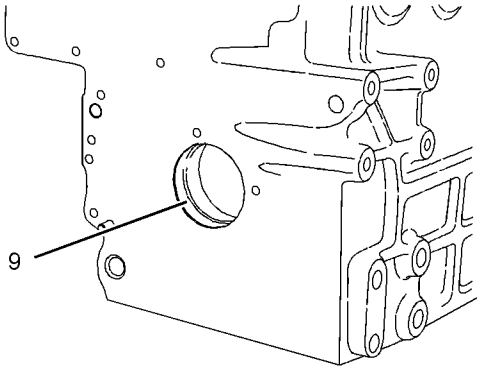

Illustration 316 g01327066

1. Use Tooling (A) to remove crankshaft bearing (9) from the cylinder block.

i07677916

Crankshaft Main Bearings - Install

Installation Procedure

Crankshaft Main Bearings

1. Clean the crankshaft and inspect the crankshaft for wear or damage. Refer to Specifications, “Crankshaft” for more information.

2. Clean the main bearings and the main bearing caps, for 403F-11, and 403F-15 engines, clean the thrust washers. Inspect all components for wear or damage.

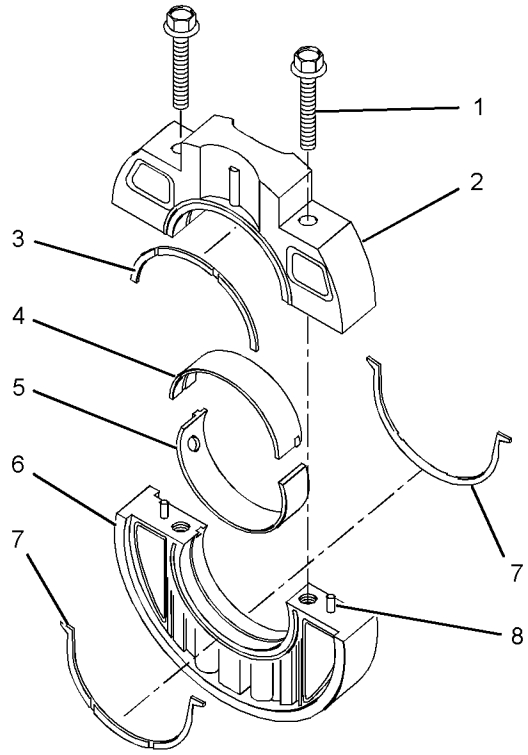

Illustration 317 g01327033
Typical example

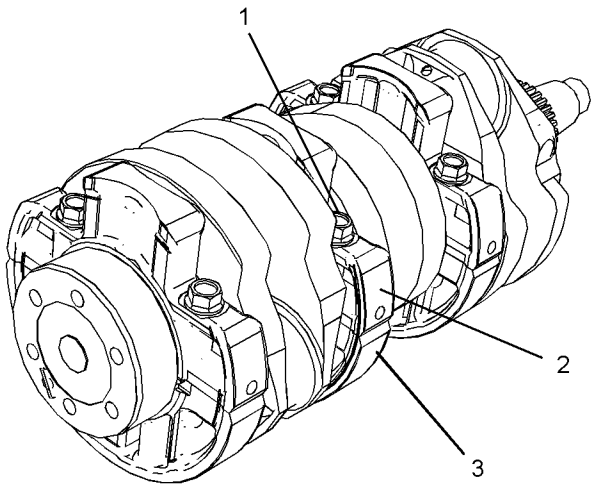

Illustration 318 g06275524
Typical example

3. Install upper main bearing (4) to upper main bearing cap (2). Ensure that the locating tab for the main bearing is seated in the slot in the main bearing cap.

Note: The upper bearing has a groove.

4. Install lower main bearing (5) to lower main bearing cap (6). Ensure that the locating tab for the main bearing is seated in the slot in the main bearing cap.

Note: The lower bearing is a plain bearing that has oil holes.

5. Lubricate main bearing (4) and main bearing (5) with clean engine oil.

6. Position the upper half of main bearing cap (2) in position on the crankshaft. Position the lower half of main bearing cap (6) in position on the crankshaft. Ensure the correct location and orientation of the bearing caps. The locating tabs for the upper and the lower bearings should be on the same side of the engine. Ensure that dowels (8) are in the correct position. The dowels will ensure that the two halves of the main bearing caps are aligned.

For 403F-11, and 403F-15 engines, install thrust washers (7).

Note: Ensure that the thrust washers are aligned correctly and that the oil grooves are facing the crankshaft.

7. Install bolts (1).

For 402F-05, 403F-07, 403F-11, and 403F-15 engines. Tighten the bolts to a torque of 23 N·m (17 lb ft).

Crankshaft Bearing (Front)

Table 46

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	27610275	Driver	1

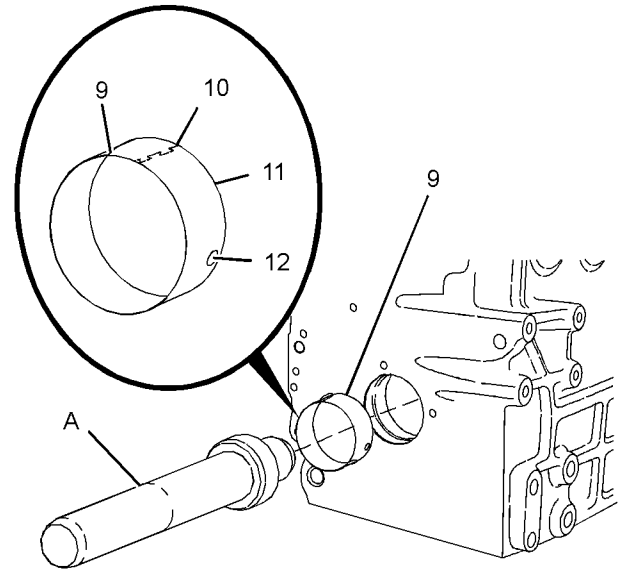

Illustration 319 g01485933

1. Use Tooling (A) to install crankshaft bearing (9) to the cylinder block. Follow Step 1a through Step 1c to install the crankshaft bearing.

a. Ensure that oil supply hole (12) is aligned with the oil gallery in the cylinder block.

b. Ensure that joint (10) is upward.

c. Ensure that chamfer (11) faces toward the cylinder block.

End By:

a. Install the crankshaft assembly. Refer to Disassembly and Assembly, “Crankshaft - Install” for the correct procedure.

i07677923

Crankshaft - Remove

Removal Procedure

Start By:

a. Remove the engine oil relief valve. Refer to Disassembly and Assembly, “Engine Oil Relief Valve - Remove and Install” for the correct procedure.

b. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

c. Remove the engine oil pump and the suction pipe. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

d. Remove the pistons and the 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 in a suitable stand with the rear end upward.

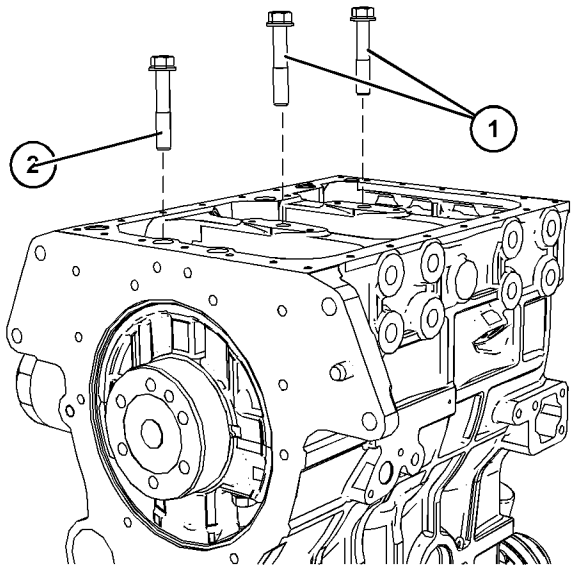

Illustration 320 g06275535
Typical example

2. Remove bolts (1) from the cylinder block.

3. Remove Allen head bolts (2) from the cylinder block.

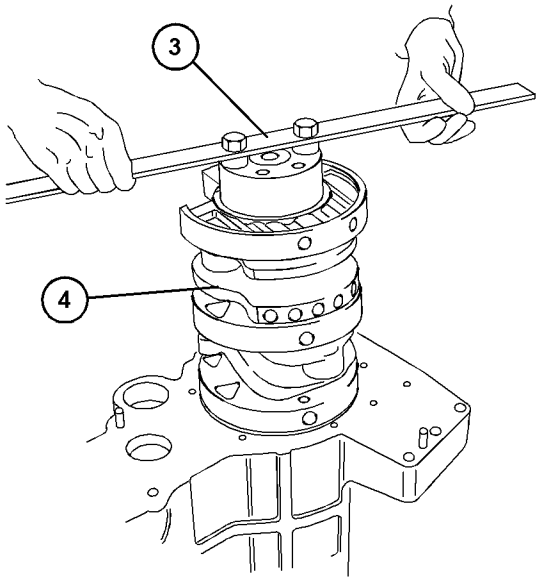

Illustration 321 g06035538
Typical example

4. Attach a suitable lifting device (3) to crankshaft assembly (4).

5. Carefully lift crankshaft assembly (4) from the cylinder block. If necessary, gently tap the nose of the crankshaft with a soft faced hammer.

Note: Install the nut for the crankshaft pulley to protect the nose of the crankshaft. Do not scratch any of the finished surfaces on the crankshaft.

i07677928

Crankshaft - Install

Installation Procedure

Table 47

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1

1. The engine should be mounted in a suitable stand with the rear end upward.

2. Ensure that the crankshaft assembly is clean and free from damage.

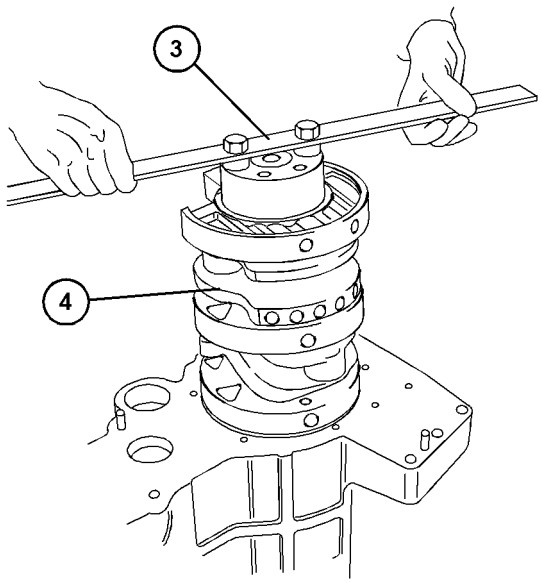

Illustration 322 g06035538

Typical example

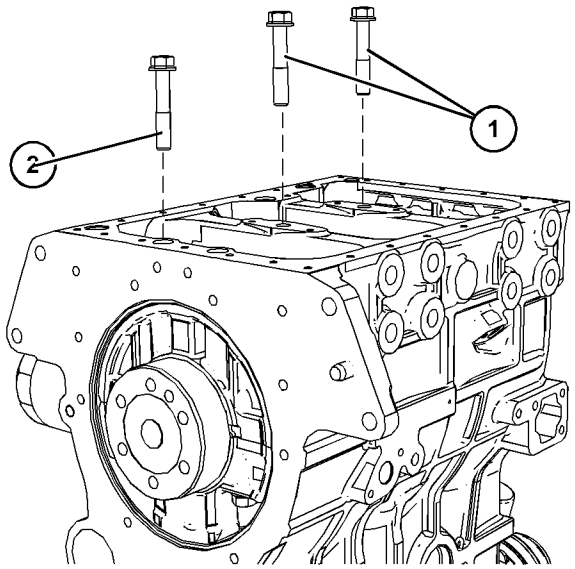

Illustration 323 g06275535

Typical example

3. Attach a suitable lifting device (3) to crankshaft assembly (4). Lubricate the front journal of the crankshaft with clean engine oil.

NOTICE
Ensure that the oil passages in the main bearings align with the oil passages in the cylinder block.

4. Align the holes in crankshaft assembly (4) for bolts (2) with the holes in the cylinder block. If necessary, gently tap the rear of the crankshaft with a soft faced hammer.

5. Align the holes in the crankshaft assembly for Allen head bolts (2) with the holes in the cylinder block. Carefully lower the crankshaft assembly (4) into the cylinder block. If necessary, gently tap the rear of the crankshaft with a soft faced hammer.

6. Remove lifting device (3) from crankshaft assembly (4).

7. Install Allen head bolts (2) finger tight.

8. Install bolts (1) finger tight.

9. Tighten bolts (1) to a torque of 52 N·m (38 lb ft).

10. Tighten Allen head bolts (2) to a torque of 27 N·m (20 lb ft).

11. Rotate the crankshaft to ensure that there is no binding.

12. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (A) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (A) to measure the crankshaft end play. Refer to Specifications, “Crankshaft” for the maximum permissible crankshaft end play.

End By:

a. Install the pistons and the connecting rods. Refer to Disassembly and Assembly, “Pistons and Connecting Rods - Install” for the correct procedure.

b. Install the engine oil pump and the suction pipe. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

c. Install the crankshaft rear seal. Refer to Disassembly and Assembly, “Crankshaft Rear Seal - Remove and Install” for the correct procedure.

d. Install the engine oil relief valve. Refer to Disassembly and Assembly, “Engine Oil Relief Valve - Remove and Install” for the correct procedure.

i07677933

Bearing Clearance - Check

Measurement Procedure

Table 48

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Plastigauge (Green) 0.025 to 0.076 mm (0.001 to 0.003 inch)	1
	-	Plastigauge (Red) 0.051 to 0.152 mm (0.002 to 0.006 inch)	1
	-	Plastigauge (Blue) 0.102 to 0.229 mm (0.004 to 0.009 inch)	1
	-	Plastigauge (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. Checking of the actual clearances of the bearing shells 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 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 324 .

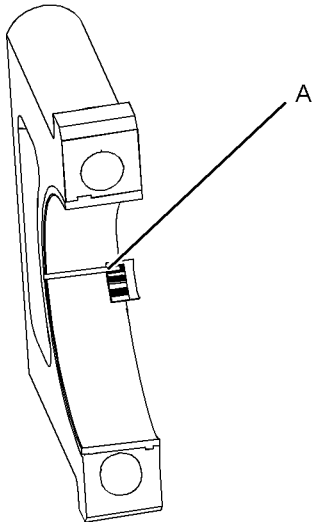

Illustration 324 g01152855
Typical Example

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.

i07677936

Coolant Temperature Switch - Remove and Install
(402F-05 and 403F-07 Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

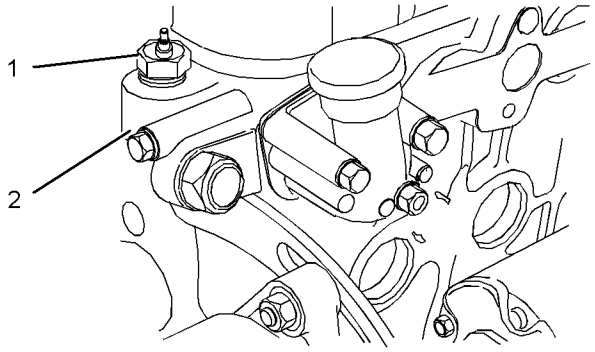

Illustration 325 g01325724
Typical example

2. Disconnect the harness assembly (not shown) from coolant temperature switch (1).

3. Remove coolant temperature switch (1) from water pump (2).

Installation Procedure

Table 49

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 542 Hydraulic Thread Sealant	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the coolant temperature switch for damage and correct operation. Refer to Systems Operation, Testing and Adjusting, “Coolant Temperature Switch - Test” for more information. If necessary, replace the coolant temperature switch.

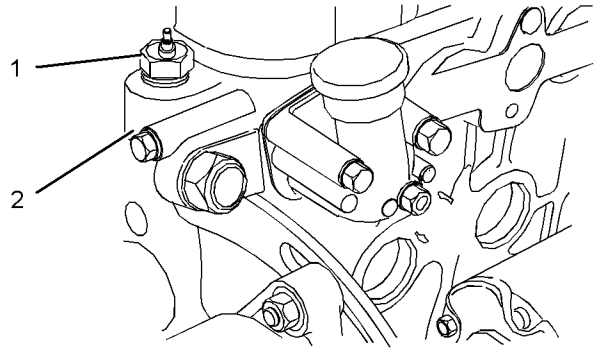

Illustration 326 g01325724
Typical example

2. Install coolant temperature switch (1) to water pump (2). Use a deep socket to tighten the coolant temperature switch to a torque of 27 N·m (20 lb ft).

Note: If a used coolant temperature switch is installed, apply a thin layer of Tooling (A) to the threads of the coolant temperature switch.

3. Connect the harness assembly (not shown) to coolant temperature switch (1).

4. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Fill” for more information.

i07677938

Coolant Temperature Switch - Remove and Install
(403F-11, and 403F-15 Engines)

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

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

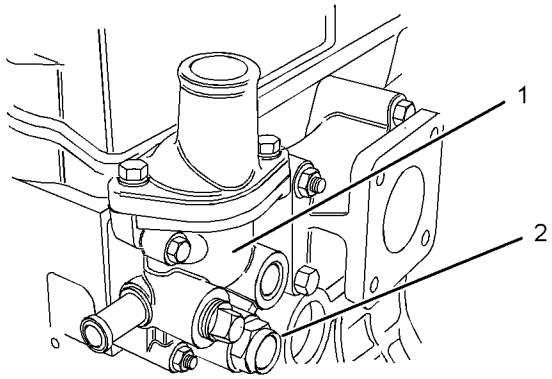

Illustration 327 g01326627
Typical example

2. Disconnect the harness assembly (not shown) from coolant temperature switch (2).

3. Remove coolant temperature switch (2) from water temperature regulator housing (1).

Installation Procedure

Table 50

Required Tools			
Tool	**Part Number**	**Part Description**	**Qty**
A	-	Loctite 542 Hydraulic Thread Sealant	1

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Inspect the coolant temperature switch for damage and correct operation. Refer to Systems Operation, Testing and Adjusting, “Coolant Temperature Switch - Test” for more information. If necessary, replace the coolant temperature switch.

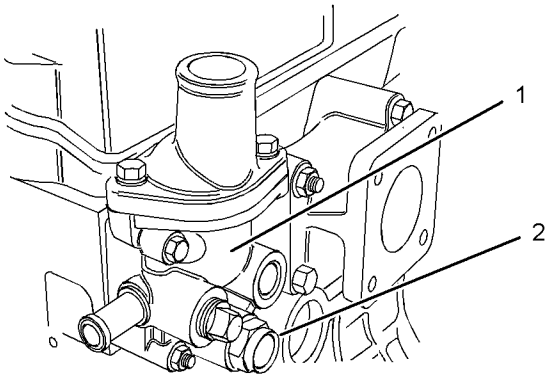

Illustration 328 g01326627
Typical example

2. Install coolant temperature switch (2) to water temperature regulator housing (1). Use a deep socket to tighten the coolant temperature switch to a torque of 27 N·m (20 lb ft).

Note: If a used coolant temperature switch is installed, apply a thin layer of Tooling (A) to the threads of the coolant temperature switch.

3. Connect the harness assembly to coolant temperature switch (2).

4. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Fill” for more information.

i07677949

Engine Oil Pressure Switch - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

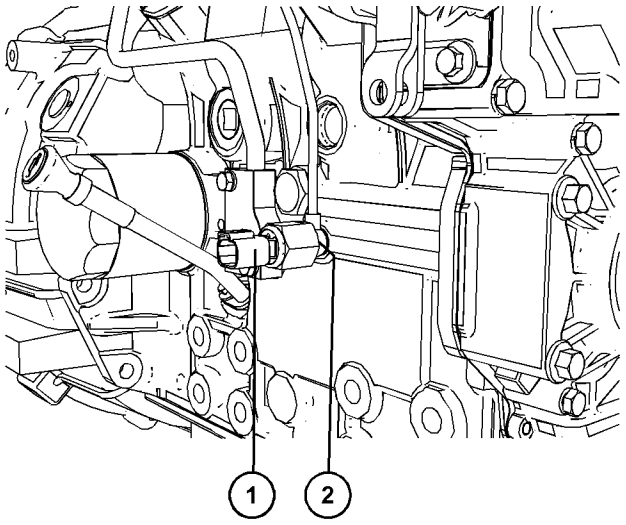

Illustration 329 g06275551

1. Disconnect the Original Equipment Manufacture (OEM) harness assembly from engine oil pressure switch (1).

2. Use a deep socket to remove engine oil pressure switch (1). Remove sealing washers (2) (not shown).

Installation Procedure

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

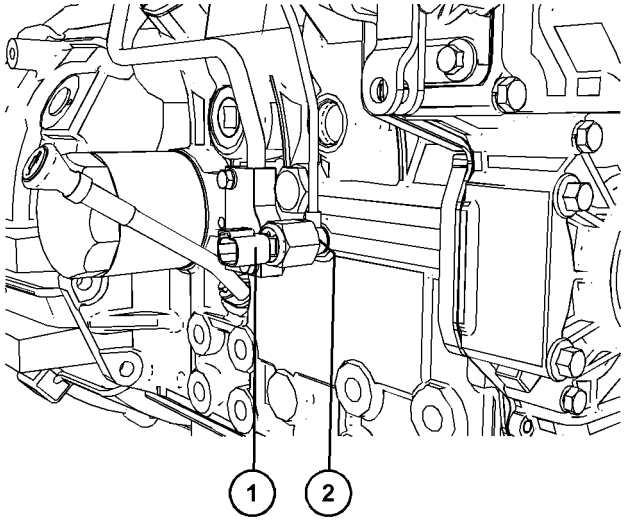

Illustration 330 g06275551

2. Install a new sealing washer (2) (not shown) to engine oil pressure switch (1). Install the engine oil pressure switch and install remaining new sealing washer. Hand tighten the engine oil pressure switch.

3. Use a deep socket to tighten engine oil pressure switch (1) to a torque of 11 N·m (97 lb in).

4. Connect the OEM harness assembly to engine oil pressure switch (1).

i07677953

Glow Plugs - Remove and Install

Removal Procedure

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

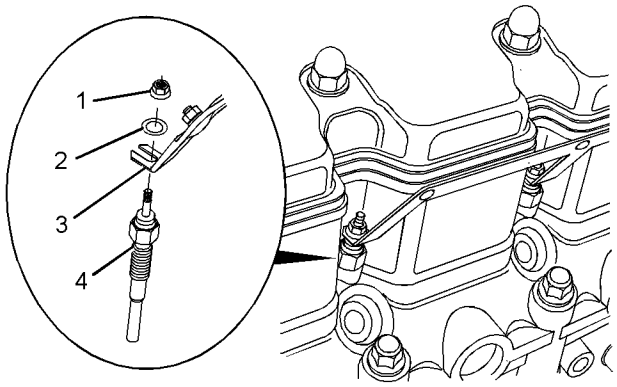

Illustration 331 g01326605
Typical example

2. Remove nuts (1) and washers (2) from bus bar (3).

3. Remove bus bar (3) from glow plugs (4).

4. Remove glow plugs (4) from the cylinder head.

Installation Procedure

Table 51

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

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.

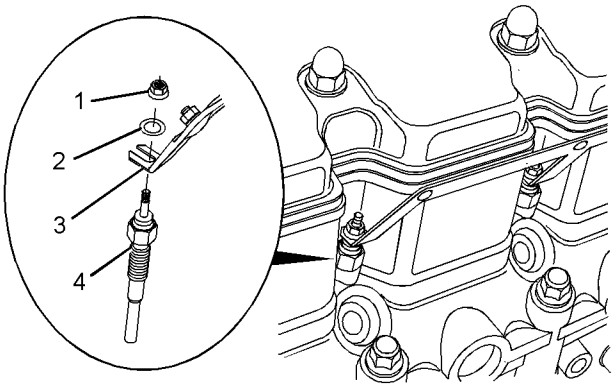

Illustration 332 g01326605
Typical example

2. Install glow plugs (4) into the cylinder head.

For 402F-05,403F-07, 403F-11, and 403F-15 engines. Tighten the glow plugs to a torque of 12 N·m (106 lb in).

3. Position bus bar (3) onto glow plugs (4).

4. Install washers (2) and nuts (1) to glow plugs (4). Use Tooling (A) to tighten the nuts to a torque of 1.2 N·m (10.6 lb in).

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

i07677964

V-Belts - Remove and Install

Removal Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the engine is equipped with fan guards, remove the fan guards.

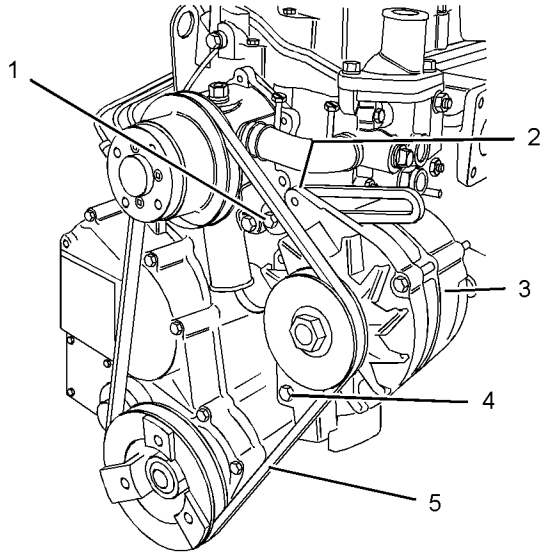

Illustration 333 g01325726
Typical example

2. Loosen bolt (1), bolt (2), and bolt (4).

3. Push alternator (3) toward the engine and remove V-belt (5).

Note: Mark the direction of rotation if the V-belt will be reused.

Installation Procedure

NOTICE
Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

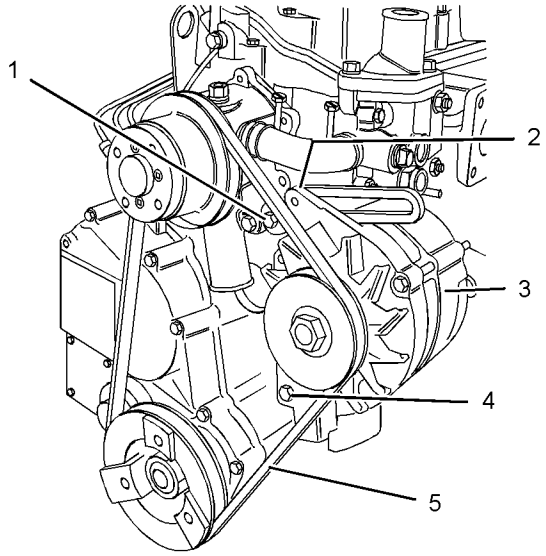

Illustration 334 g01325726

Typical example

1. Check the condition of the V-belt . If the V-belt is worn or damaged, use a new V-belt for replacement.

2. Install V-belt (5) in position on the engine.

Note: A used V-belt should be installed in the original direction of rotation.

3. Slide alternator (3) away from the engine. Refer to Systems Operation, Testing and Adjusting, “Belt Tension Chart” for information on the correct belt tension. Tighten bolt (1), bolt (2), and bolt (4) to a torque of 25 N·m (221 lb in).

4. If the engine is equipped with fan guards, install the fan guards.

i07677971

Fan - Remove and Install

Removal Procedure

Start By:

a. Remove the V-Belt. Refer to Disassembly and Assembly, “V-Belts - Remove and Install” for the correct procedure.

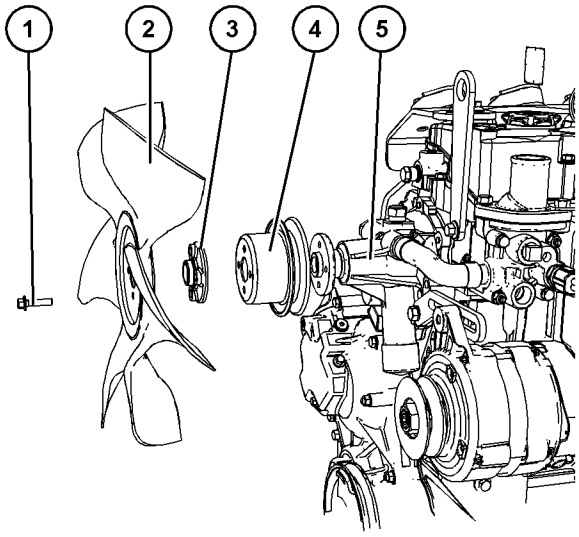

Illustration 335 g06036202

1. Remove bolts (1) and remove fan (2).

Note: Mark the orientation of the fan for installation.

2. Remove spacer (3) and pulley (4) from water pump (5).

Installation Procedure

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

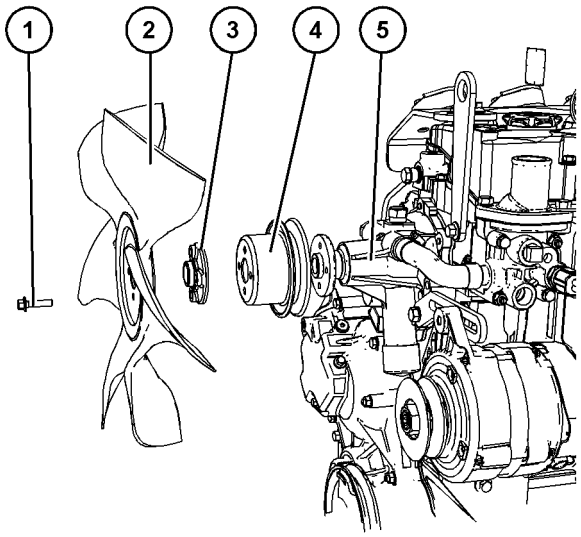

Illustration 336 g06036202

2. Position pulley (4) and spacer (3) on water pump (5). Ensure that the bolt holes are aligned.

3. Install fan (2). Ensure the correct orientation of the fan.

4. Install bolts (1) and tighten to a torque of 11 N·m (97 lb in).

End By:

a. Install the V-Belt. Refer to Disassembly and Assembly, "V-Belts - Remove and Install" for the correct procedure.

i07677974

Alternator - Remove and Install

Removal Procedure

Start By:

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

2. Make temporary identification marks on the connections for the alternator harness assembly.

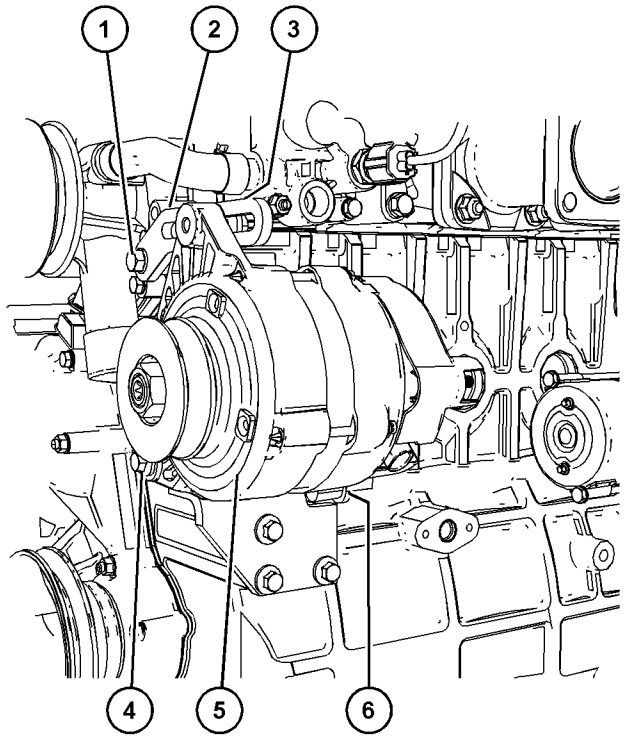

Illustration 337 g06036729

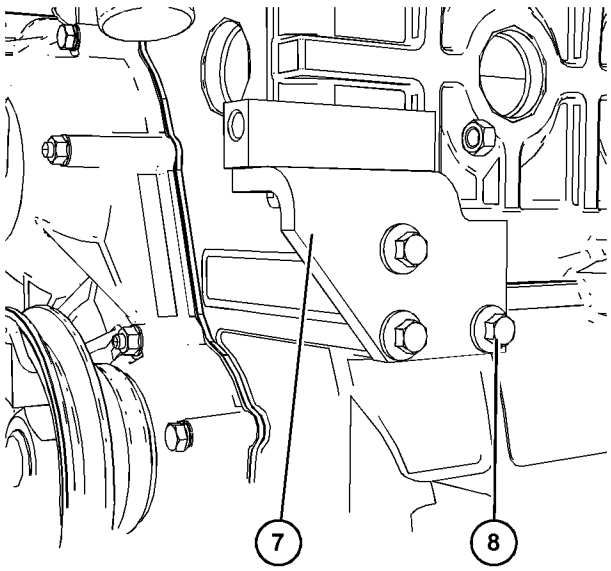

Illustration 338 g06036730

3. Disconnect the harness assembly from alternator (5).

4. Remove bolt and washer (3) (not shown).

5. If necessary, remove bolt (1) and remove link bracket (2).

6. Remove bolt (4) and nut (6) (not shown) from alternator (5).

7. Remove alternator (5) from bracket (7).

8. If necessary, remove bolt (8) and remove bracket (7).

Installation Procedure

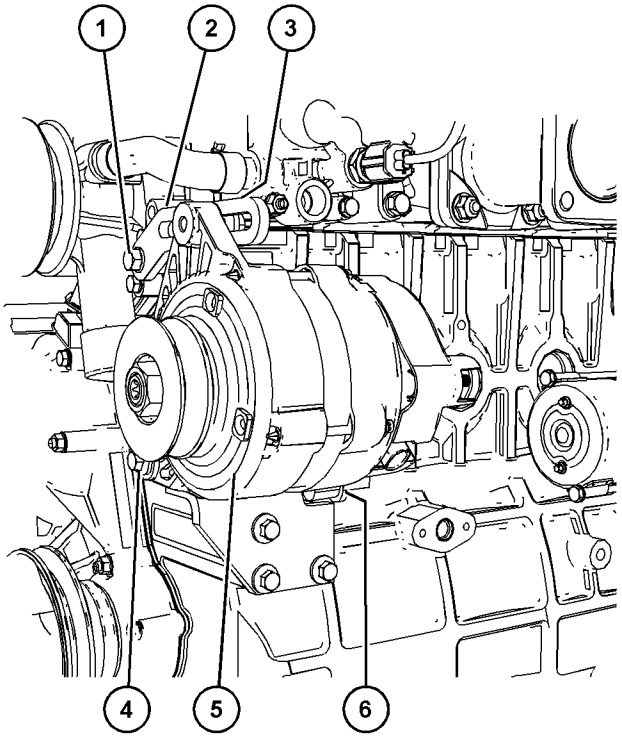

Illustration 339 g06036729

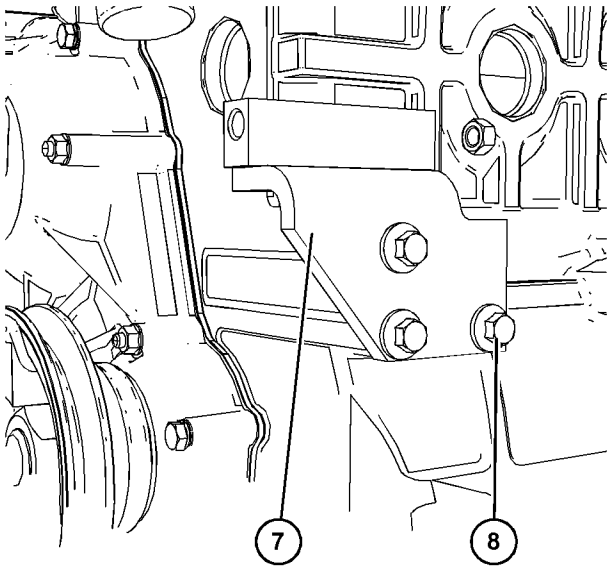

Illustration 340 g06036730

1. If necessary, position bracket (7) onto the cylinder block and install bolts (8). Tighten the bolts to a torque of 28 N·m (248 lb in).

2. If necessary, Install link bracket (2) and install bolt (1).

3. Position alternator (5) onto bracket (7).

4. Install bolt (4) and nut (6) (not shown) to alternator (5).

5. Install bolt and washer (3) (not shown).

6. Install the V-Belt. Refer to Disassembly and Assembly, “V-Belts - Remove and Install” for the correct procedure.

Note: Ensure that the alternator pulley is in alignment with the crankshaft pulley. Ensure that all fasteners are tightened.

7. Connect the harness assembly to alternator (5).

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

i07677981

Alternator - Remove and Install (14 Amp and 15 Amp Alternators)

Removal Procedure

Start By:

a. Remove the V-Belt. Refer to Disassembly and Assembly, “V-Belts - Remove and Install” 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.

2. Make temporary identification marks on the connections of the harness assembly.

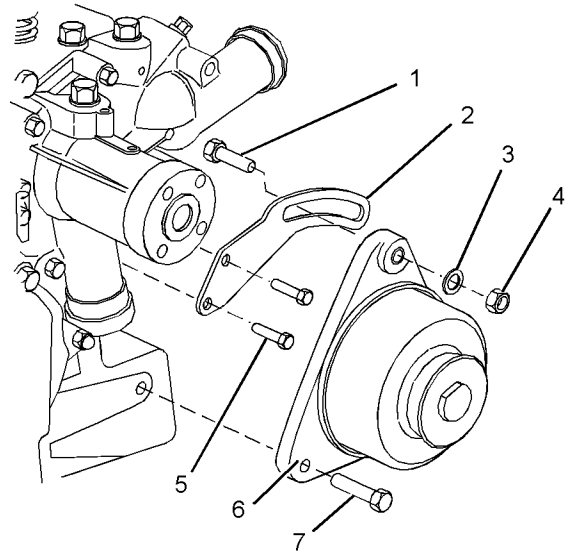

Illustration 341 g01308275
Typical example

3. Disconnect the Original Equipment Manufacture (OEM) from alternator (6).

4. Remove bolt (1), washer (3), and nut (4) from alternator (6).

5. Remove bolt (7) and remove alternator (6) from the engine.

6. If necessary, remove bolts (5) and remove adjusting link (2).

Note: The adjusting link on some engines is secured by one bolt.

Installation Procedure

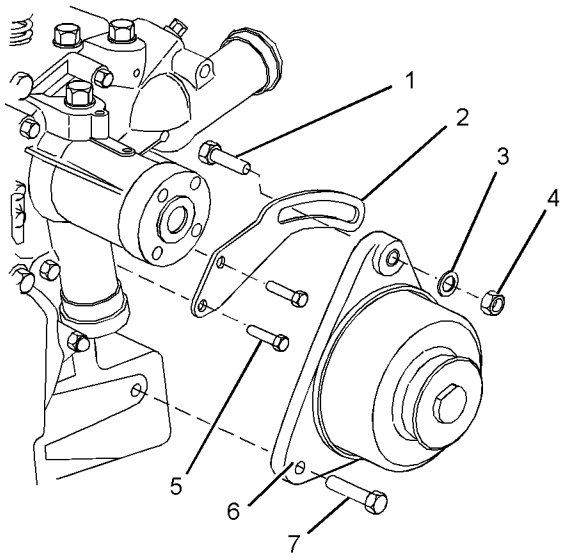

Illustration 342 g01308275
Typical example

1. If necessary, install adjusting link (2) and install bolts (5) finger tight.

Note: The adjusting link on some engines is secured by one bolt.

2. For engines that have an adjusting link that is secured by one bolt, leave bolt (5) loose.

For engines that have an adjusting link that is secured by two bolts, tighten bolts (5) to a torque of 10 N·m (89 lb in).

3. Position alternator (6) on the engine and install bolt (7) finger tight.

4. Install bolt (1), washer (3), and nut (4) finger tight.

5. Install the V-Belt. Refer to Disassembly and Assembly, “V-Belts - Remove and Install” for the correct procedure.

Note: Ensure that the alternator pulley is in alignment with the crankshaft pulley. Ensure that all fasteners are tightened.

6. Connect the OEM harness assembly to the alternator.

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

i08095611

Alternator - Remove and Install (402F-05 - 14 AMP Alternator (If Equipped))

Removal Procedure

Start By:

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

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

Note: Disconnect all electrical connections to the alternator before proceeding. Mark the connections or identify the connections for installation.

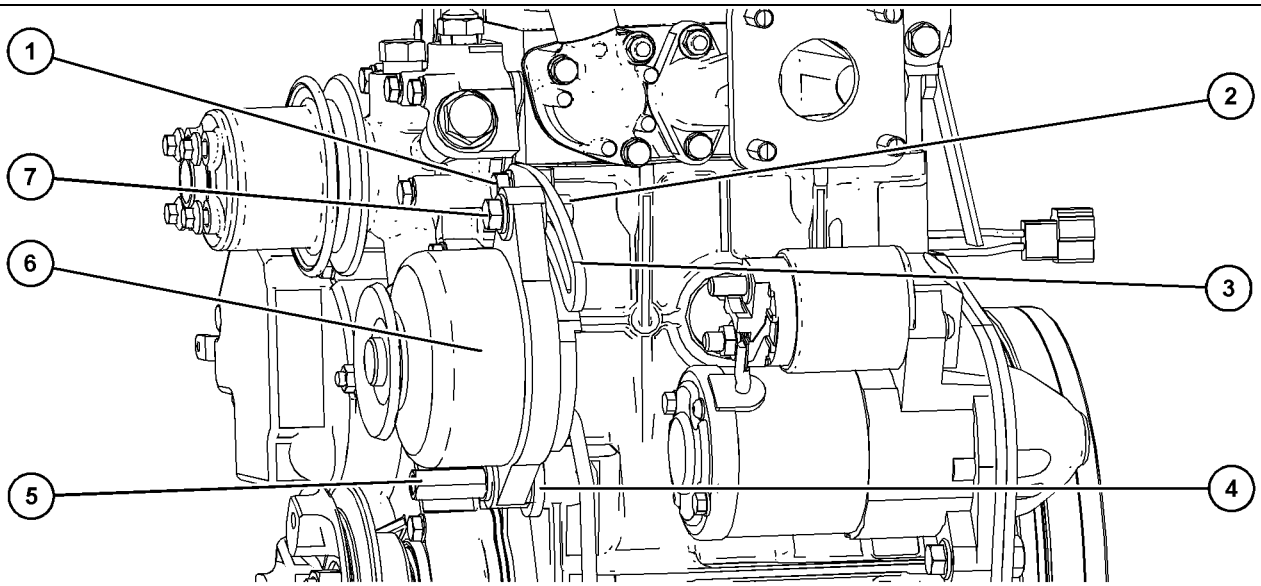

Illustration 343 g06536414
Typical example

2. Remove bolt assembly (7) and nut (2) from the alternator (6).

3. Remove nut (5) that fastens the alternator (6) to the engine.

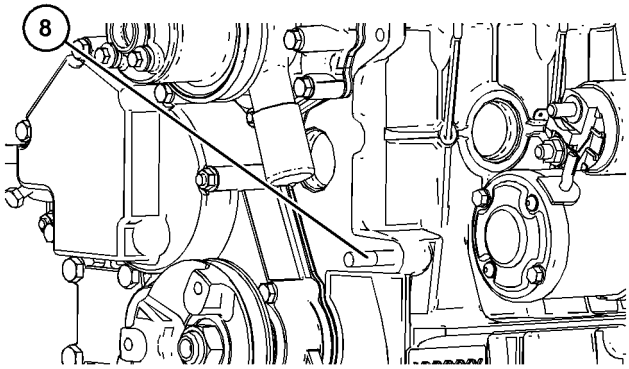

Illustration 344 g06536419
Typical Example

4. Remove alternator (6) and washer (4) from stud (8).

Note: Alternator position and orientation for installation purposes.

5. If necessary, Remove bolt assembly (7) and bracket (3).

Note: Bracket position and orientation for installation purposes.

6. If necessary, remove stud (8).

Note: Stud position for installation purposes.

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.

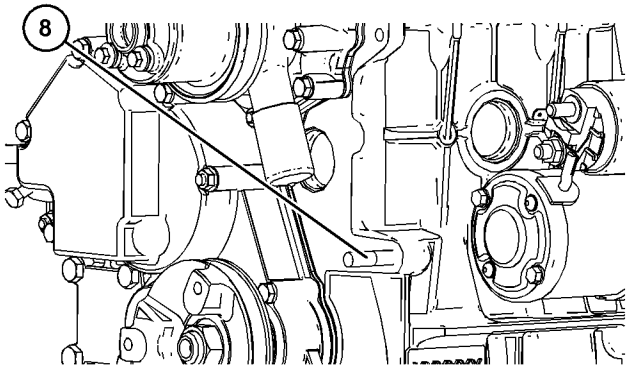

Illustration 345 g06536419
Typical Example

2. If necessary, install stud (8) in the position noted on removal. Tighten the stud to a torque of 11 N·m (97 lb in).

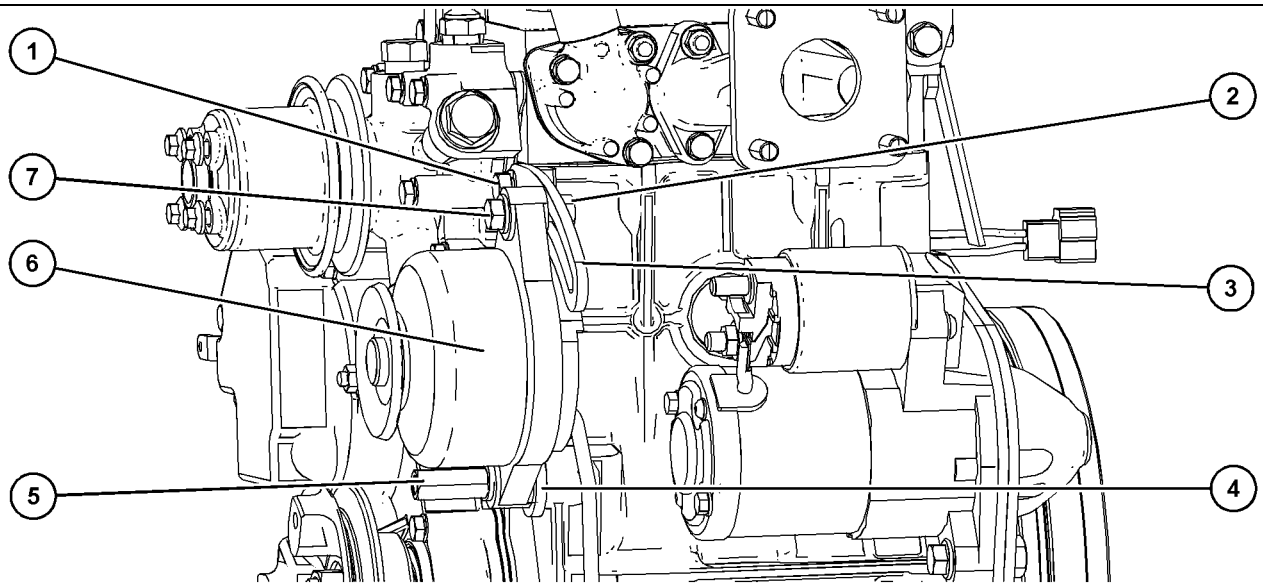

Illustration 346 g06536414
Typical example

3. If necessary, Position bolt assembly (1) into bracket (3). Install the bracket assembly in the position noted on removal finger tight.

4. Position washer (4) onto stud (8). Install alternator (6) and nut assembly (5) onto the stud.

5. Position alternator (6) onto bracket (3), install bolt assembly (5) to the alternator and bracket.

6. Install nut (2) to bolt assembly (5) finger tight.

Note: When you install the alternator, ensure that the alternator pulley is in alignment with the crankshaft pulley within one degree.

7. Check the condition of the V-belt. If the V-belt is worn or damaged, install a new V-belt.

8. Position the V-belt onto alternator (6), the water pump pulley, and the crankshaft pulley. Ensure that the V-belt is correctly positioned onto the alternator pulley, the water pump pulley, and the crankshaft pulley.

Note: A used V-belt should be installed in the original direction of rotation.

9. Slide alternator (6) away from the engine to tighten the V-belt to the correct tension. Refer to the machine Operation and Maintenance Manual for the correct V-belt tension.

10. Tighten bolt (1), nut (5), bolt (7) to a torque of 22 N·m (195 lb in).

11. If the engine is equipped with fan guards, install the fan guards. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

12. Switch the battery disconnect switch to the “ON” position.

Note: Reconnect all electrical connections to the alternator before operating the engine.

i08097740

Alternator - Remove and Install (14 AMP Alternator - 403F-07 - If Equipped)

Removal Procedure

Start By:

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

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

Note: Disconnect all electrical connections to the alternator before proceeding. Mark the connections or identify the connections for installation.

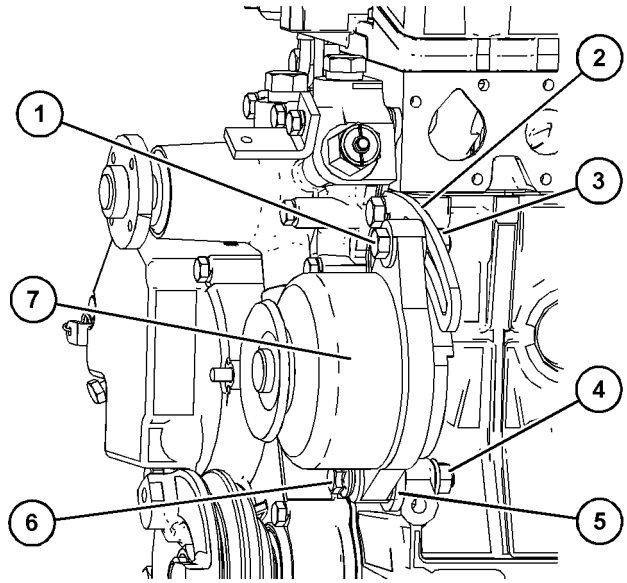

Illustration 347 g06525193
Typical example

2. Remove nut (3), and bolt (1) from alternator (7) and bracket (2). Support the alternator as the bolt is removed.

3. Whilst supporting alternator (7), remove nut (4), bolt assembly (1), and spacer (5) from the alternator. Remove the alternator.

Note: Note alternator orientation for installation purposes.

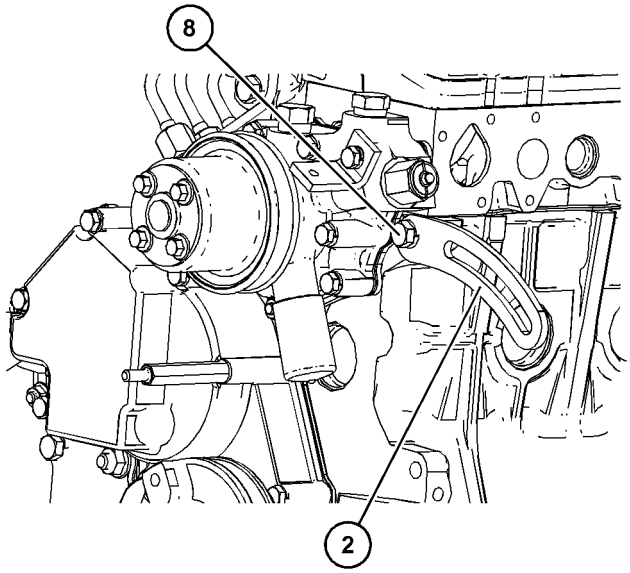

Illustration 348 g06525194
Typical example

4. Remove bolt assembly (8) and remove bracket (2) from the cylinder block.

Note: Note bracket position for installation purposes.

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.

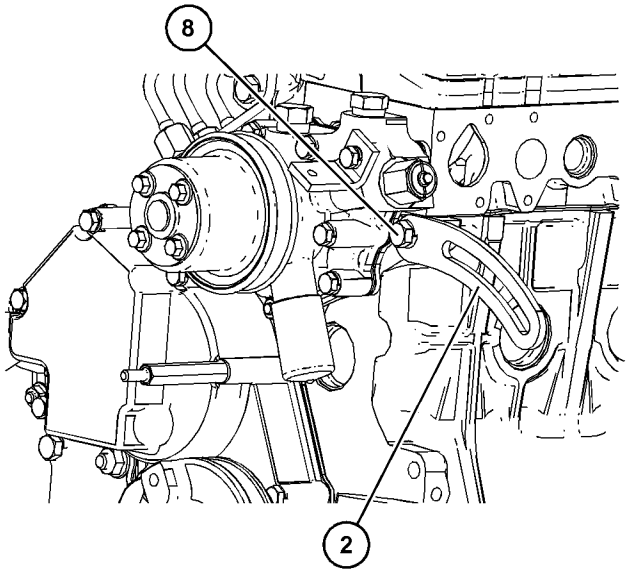

Illustration 349 g06525194
Typical example

2. Position bracket (2) onto the cylinder block and install bolt assembly (8) and tighten the bolt finger tight.

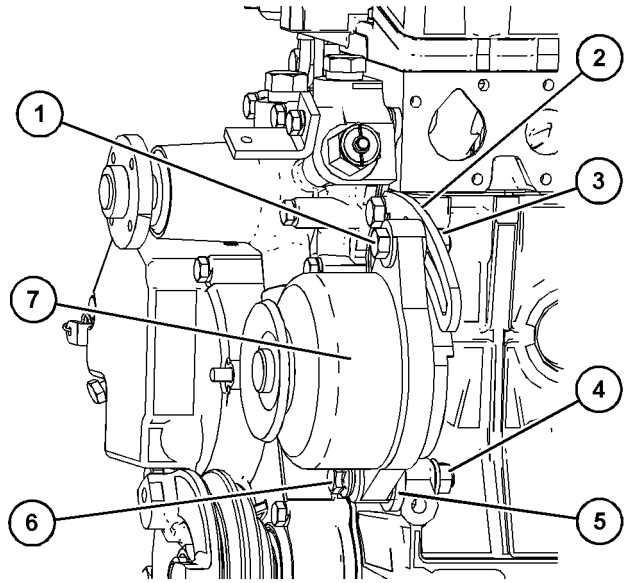

Illustration 350 g06525193

Typical example

3. Follow Step 3a through Step 3c to install alternator (7).

a. Install bolt assembly (6) into alternator (7). Position spacer (5) onto the bolt assembly.

b. Position alternator (7) onto the cylinder block. Support the alternator as nut (4) is installed finger tight.

c. Align alternator (7) and bracket (2). Install bolt (1) and nut (3) finger tight.

4. Check the condition of the V-belt. If the V-belt is worn or damaged, install a new V-belt.

5. Position the V-belt onto alternator (7), the water pump pulley, and the crankshaft pulley. Ensure that the V-belt is correctly positioned onto the alternator pulley, the water pump pulley, and the crankshaft pulley.

Note: A used V-belt should be installed in the original direction of rotation.

6. Slide alternator (7) away from the engine to tighten the V-belt to the correct tension. Refer to the machine Operation and Maintenance Manual for the correct V-belt tension.

7. Tighten bolt (1), nut (3), bolt (6), nut (4), and bolt (8) to a torque of 22 N·m (195 lb in).

8. Tighten nut (4) (not shown) and bolt (5) to a torque of 22 N·m (195 lb in).

9. If the engine is equipped with fan guards, install the fan guards. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

10. Switch the battery disconnect switch to the “ON” position.

Note: Reconnect all electrical connections to the alternator before operating the engine.

i08148438

Alternator - Remove and Install (403F-11 - 40 AMP Alternator (If Equipped)

Removal Procedure

Start By:

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

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

Note: Disconnect all electrical connections to the alternator before proceeding. Mark the connections or identify the connections for installation.

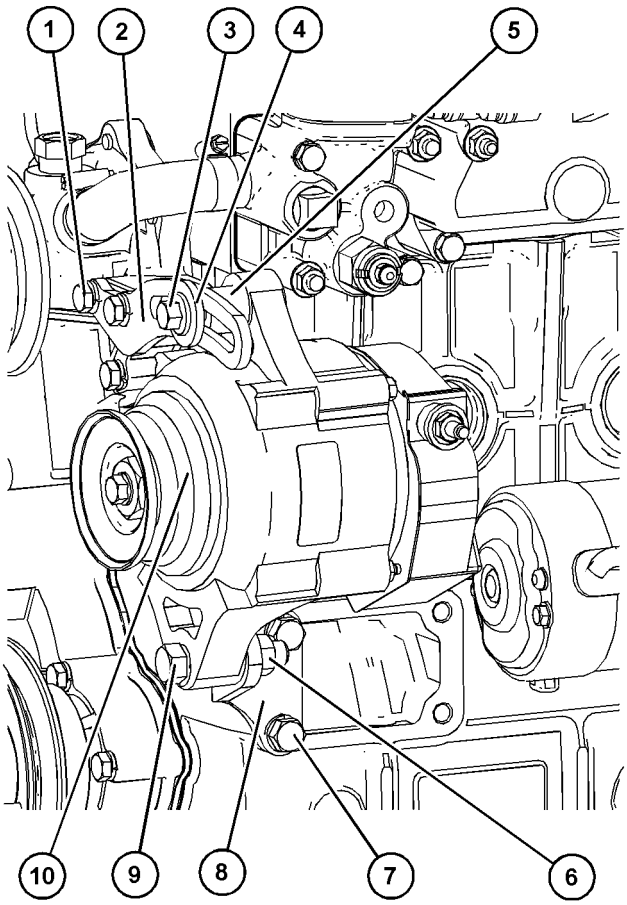

Illustration 351 g06566264

Typical example

2. Remove bolt (3), washer (4), and spacer (5) from alternator (10) and bracket (2). Support the alternator as the bolt is removed.

Note: Note bolt, washer, and spacer position for installation purposes.

3. Whilst supporting alternator (10), remove nut (6) and bolt (9) from the alternator. Remove the alternator.

Note: Note alternator orientation for installation purposes.

4. Remove bolt assemblies (1) and remove bracket (2) from the water pump housing.

Note: Note bracket position for installation purposes.

5. Remove bolt assemblies (7) and remove bracket (8) from the cylinder block.

Note: Note bracket position for installation purposes.

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.

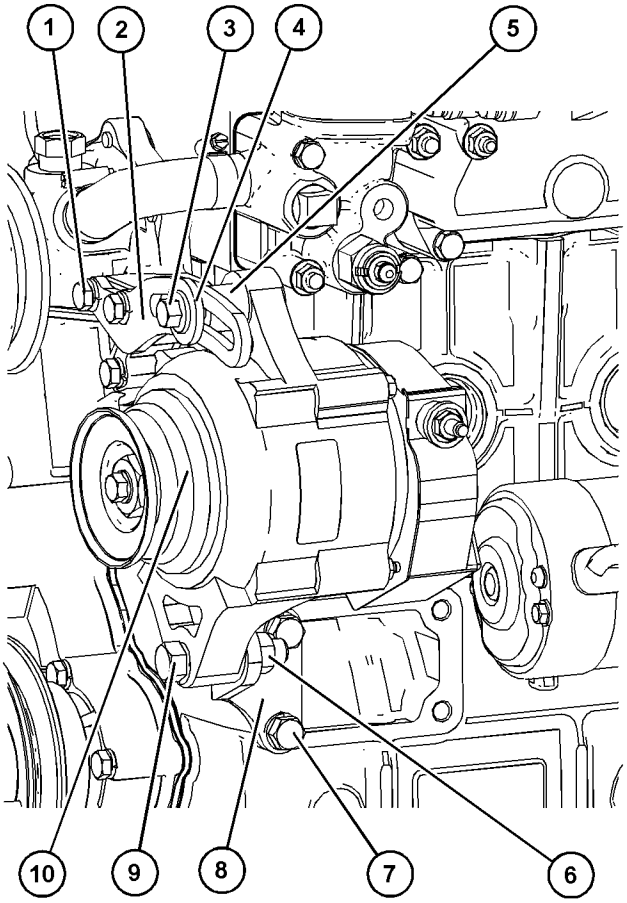

Illustration 352 g06566264

Typical example

2. Position bracket (8) onto the cylinder block and install bolt assemblies (7) finger tight.

3. Tighten bolt assemblies (7) to a torque of 25 N·m (221 lb in).

4. Position bracket (2) onto the water pump housing and install bolt assemblies (1) finger tight.

5. Tighten bolt assemblies (1) to a torque of 10 N·m (89 lb in).

6. Follow Step 6a through Step 6c to install alternator (10).

a. Position alternator (10) onto bracket (8), in the position noted on removal. Install bolt (9) to the alternator and the bracket.

b. Install nut (6) to bolt (9) finger tight.

c. Position washer (4) onto bolt (1). Align alternator (10) with bracket (2). Install the bolt assembly to the alternator, and the bracket. Install spacer (5) between the bracket and alternator as the bolt assembly is installed. Tighten the bolt assembly finger tight.

7. Check the condition of the V-belt. If the V-belt is worn or damaged, install a new V-belt.

8. Position the V-belt onto alternator (10), the water pump pulley, and the crankshaft pulley. Ensure that the V-belt is correctly positioned onto the alternator pulley, the water pump pulley, and the crankshaft pulley.

Note: A used V-belt should be installed in the original direction of rotation.

9. Slide alternator (10) away from the engine to tighten the V-belt to the correct tension. Refer to the machine Operation and Maintenance Manual for the correct V-belt tension.

10. Tighten bolt (3), and bolt (9) to a torque of 25 N·m (221 lb in).

11. If the engine is equipped with fan guards, install the fan guards. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

12. Switch the battery disconnect switch to the “ON” position.

Note: Reconnect all electrical connections to the alternator before operating the engine.

i07677984

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 and to bring the equipment to a zero energy state, disconnect all positive (+) and negative (−) battery cables. Install an appropriate battery cable lockout device and protect the battery posts to prevent accidental contact and shorting.

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. Make temporary identification marks on the harness assemblies that are connected to the electric starting motor.

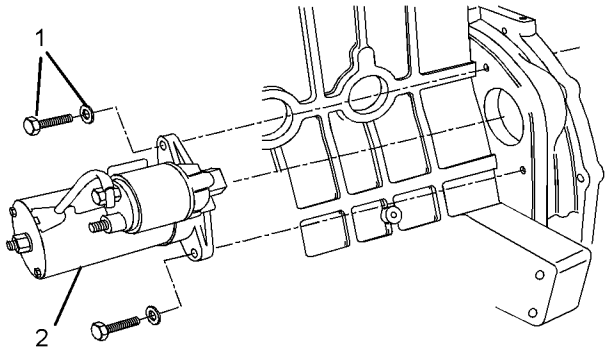

Illustration 353 g01326136

Typical example

3. Disconnect the harness assemblies (not shown) from electric starting motor (2).

4. Remove fasteners (1) that secure electric starting motor (2).

Note: Support the weight of the electric starting motor as the fasteners are removed.

5. Remove electric starting motor (2) from the engine.

Installation Procedure

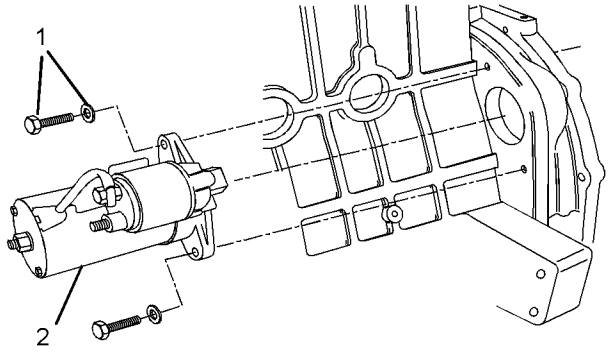

Illustration 354 g01326136

Typical example

1. Install electric starting motor (2) in position on the engine.

2. Install fasteners (1) and tighten to a torque of 50 N·m (37 lb ft).

3. Connect the harness assemblies (not shown) to electric starting motor (2).

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

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