

Disassembly and Assembly

1204F-E44TA and 1204F-E44TTA Industrial Engines

MT (Engine)
MU (Engine)
MW (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.



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.



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.

Table of Contents

Disassembly and Assembly Section

Fuel Priming Pump - Remove and Install (Electric Fuel Lift Pump (EFLP))	5	Flexible Exhaust Pipe - Remove and Install	106
Flow Control Valve - Remove and Install	6	Exhaust Manifold - Remove and Install (Single Turbocharger Exhaust Manifold)	110
Fuel Filter Base - Remove and Install (Single Secondary Fuel Filter)	9	Exhaust Manifold - Remove and Install (Twin Turbochargers Exhaust manifold)	115
Fuel Filter Base - Remove and Install (Twin Secondary Fuel Filter)	13	Exhaust Elbow - Remove and Install (Top Mounted and Side Mounted Turbocharger Exhaust Elbow)	118
Water Separator and Fuel Filter (Primary) - Remove and Install	16	Exhaust Elbow - Remove and Install	119
Fuel Manifold (Rail) - Remove and Install	19	Support and Mounting (CEM) - Remove and Install	120
Relief Valve (Fuel) - Remove and Install	21	Inlet and Exhaust Valve Springs - Remove and Install	122
Fuel Injection Lines - Remove	23	Inlet and Exhaust Valves - Remove and Install	126
Fuel Injection Lines - Install	25	Engine Oil Filter Base - Remove and Install	129
Exhaust Cooler (NRS) - Remove and Install (Twin Turbochargers)	27	Engine Oil Cooler - Remove	130
Exhaust Cooler (NRS) - Remove and Install (Side Mounted Turbocharger)	31	Engine Oil Cooler - Install	131
Exhaust Cooler (NRS) - Remove and Install (Top Mounted Turbocharger)	34	Engine Oil Pump - Remove	132
Inlet Air Control - Remove (NRS Induction Mixer) ..	38	Engine Oil Pump - Install	133
Inlet Air Control - Install (NRS Induction Mixer) ..	40	Water Pump - Remove	135
Fuel Injection Pump - Remove	43	Water Pump - Install	136
Fuel Injection Pump - Install	45	Water Temperature Regulator - Remove and Install	138
Fuel Injection Pump Gear - Remove	47	Flywheel - Remove	139
Fuel Injection Pump Gear - Install	47	Flywheel - Install	140
Electronic Unit Injector - Remove	48	Crankshaft Rear Seal - Remove	141
Electronic Unit Injector - Install	51	Crankshaft Rear Seal - Install	142
Turbocharger - Remove (First Stage Turbocharger)	54	Flywheel Housing - Remove and Install (Standard Housing)	143
Turbocharger - Remove (Second Stage Turbocharger)	56	Flywheel Housing - Remove and Install (Wet Back End Housing)	146
Turbocharger - Remove (Side Mounted Turbochargers)	58	Crankshaft Pulley - Remove and Install	149
Turbocharger - Remove (Top Mounted Turbocharger)	59	Crankshaft Front Seal - Remove and Install (Crankshaft Front Seal for Heavy Duty Front Cover)	150
Turbocharger - Install (First Stage Turbocharger) ..	61	Crankshaft Front Seal - Remove and Install	151
Turbocharger - Install (Top Mounted Turbocharger) ..	64	Front Cover - Remove and Install (Heavy Duty Front Cover)	152
Turbocharger - Install (Second Stage Turbocharger)	66	Front Cover - Remove and Install	154
Turbocharger - Install (Side Mounted Turbochargers)	69	Gear Group (Front) - Remove and Install (Heavy Duty Gear Group (Front))	155
Wastegate Solenoid - Remove and Install	71	Gear Group (Front) - Remove and Install	164
Exhaust Back Pressure Valve - Remove and Install ..	73	Idler Gear - Remove	169
Exhaust Gas Valve (NRS) - Remove and Install	75	Idler Gear - Install	172
Clean Emissions Module - Remove and Install	85	Housing (Front) - Remove (Heavy Duty Housing (Front))	175
Diesel Exhaust Fluid Lines - Remove and Install ..	87	Housing (Front) - Remove	177
Diesel Exhaust Fluid Pump - Remove and Install ..	90	Housing (Front) - Install (Heavy Duty Housing (Front))	179
DEF Injector and Mounting - Remove and Install ..	92	Housing (Front) - Install	182
Diesel Exhaust Fluid Tank - Remove and Install	95	Accessory Drive - Remove and Install (Accessory Drive SAE "A")	184
Manifold (DEF Heater) - Remove and Install	97	Accessory Drive - Remove and Install (Accessory Drive SAE "B")	186
Manifold (DEF Heater) Sensor - Disassemble (Temperature, Level, Quality DEF Manifold Sensor)	101	Crankcase Breather - Remove	189
Manifold (DEF Heater) Sensor - Assemble (Temperature, Level, Quality DEF Manifold Sensor)	102	Crankcase Breather - Install	191
Solenoid Valve (DEF Heater Coolant) - Remove and Install	105	Valve Mechanism Cover - Remove and Install	193
		Rocker Shaft and Pushrod - Remove	195
		Rocker Shaft - Disassemble	198
		Rocker Shaft - Assemble	199
		Rocker Shaft and Pushrod - Install	200
		Cylinder Head - Remove	204
		Cylinder Head - Install	208
		Lifter Group - Remove and Install (Hydraulic Lifter Group)	212

Table of Contents

Camshaft - Remove and Install	214	Idler Pulley - Remove and Install (Grooved Idler Pulley)	292
Camshaft Gear - Remove and Install	216	Belt Tensioner - Remove and Install	293
Camshaft Bearings - Remove and Install	221	Fan - Remove and Install	294
Engine Oil Pan - Remove and Install (Cast Iron Oil Pan)	222	Fan Drive - Remove and Install	295
Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)	226	Electronic Control Module - Remove	296
Balancer - Remove	231	Electronic Control Module - Install	300
Balancer - Install	233	Alternator - Remove	304
Piston Cooling Jets - Remove and Install	235	Alternator - Install	306
Pistons and Connecting Rods - Remove	237	Electric Starting Motor - Remove and Install	309
Pistons and Connecting Rods - Disassemble	238	Air Compressor - Remove and Install (Single Cylinder Air Compressor)	310
Pistons and Connecting Rods - Assemble	240	Air Compressor - Remove and Install (Twin Cylinder Air Compressor)	316
Pistons and Connecting Rods - Install	242		
Connecting Rod Bearings - Remove (Connecting Rods in Position)	243		
Connecting Rod Bearings - Install (Connecting Rods in Position)	245		
Crankshaft Main Bearings - Remove and Install (Crankshaft in Position)	246		
Crankshaft - Remove	251		
Crankshaft - Install	253		
Crankshaft Timing Ring - Remove and Install	257		
Crankshaft Gear - Remove and Install	258		
Crankshaft Gear (Balancer Drive) - Remove and Install	260		
Bearing Clearance - Check	262		
Refrigerant Compressor - Remove and Install	263		
Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor Positioned in Original Equipment Manufacture (OEM) Exhaust Tube Assembly)	266		
Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor on Engine)	267		
Atmospheric Pressure Sensor - Remove and Install	269		
Camshaft Position Sensor - Remove and Install	270		
Crankshaft Position Sensor - Remove and Install	271		
Coolant Temperature Sensor - Remove and Install	272		
Engine Oil Pressure Sensor - Remove and Install	273		
Fuel Pressure Sensor - Remove and Install	274		
Fuel Temperature Sensor - Remove and Install	275		
Ammonia Sensor - Remove and Install (Ammonia Sensor if Equipped)	277		
Soot Antenna - Remove and Install	279		
Temperature Sensor (Exhaust) - Remove and Install (Selective Catalytic Reduction (SCR) Temperature Sensor)	280		
Temperature Sensor (DPF) - Remove and Install	281		
Temperature Sensor (Catalyst Inlet) - Remove and Install	282		
Temperature Sensor (Cooled Exhaust Gas) - Remove and Install	283		
Pressure Sensor (Cooled Exhaust Gas) - Remove and Install (Differential Pressure Sensor and Inlet Pressure Sensor)	284		
Boost Pressure Sensor - Remove and Install	287		
Inlet Manifold Temperature Sensor - Remove and Install	288		
Glow Plugs - Remove and Install	289		
Alternator Belt - Remove and Install	290		
Idler Pulley - Remove and Install (Flat Idler Pulley)	292		

Index Section

Index	324
-------------	-----

Disassembly and Assembly Section

i05981764

Fuel Priming Pump - Remove and Install (Electric Fuel Lift Pump (EFLP))

Removal Procedure

Table 1

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

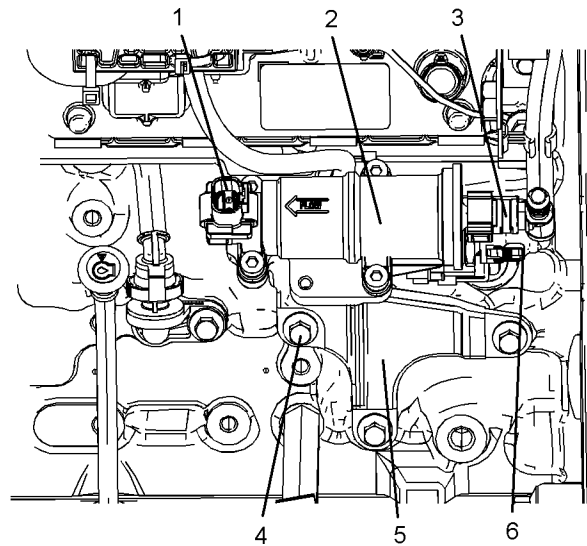


Illustration 1

g03734667

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

Installation Procedure

NOTICE

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

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

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

1. Ensure that the fuel priming pump and the bracket are clean and free from wear and damage. If necessary, replace the fuel priming pump as an assembly.

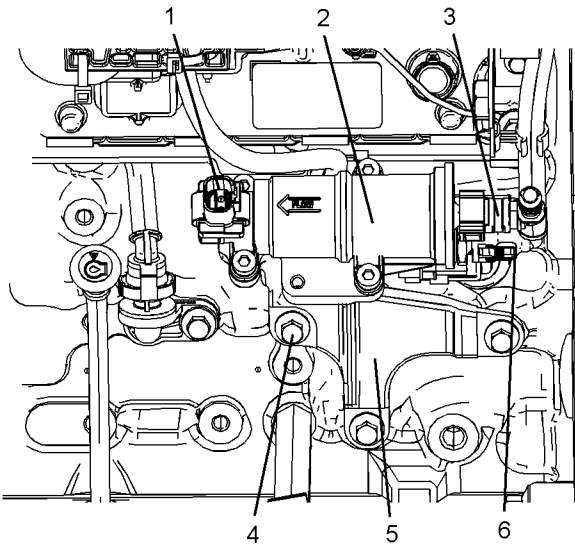


Illustration 2

g03734667

2. Position fuel priming pump (3) and bracket (5) as an assembly onto the cylinder block.
3. Install bolt (4) to bracket (5). Tighten the bolt to a torque of 22 N·m (195 lb in).
4. Remove plugs from plastic tube assembly (3) and plastic tube assembly (5). Remove cap from connections on fuel priming pump (2).
5. Connect plastic tube assembly (3) and plastic tube assembly (5) to fuel priming pump (2).
6. Connect (OEM) wiring harness assembly (1) to fuel priming pump (2).

7. Turn the fuel supply to the ON position.
8. Turn the battery disconnect switch to the ON position.
9. Prime the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for the correct procedure.

i05981747

Flow Control Valve - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankcase breather. Refer to Disassemble and Assemble, "Crankcase Breather - Remove" for the correct procedure.

WARNING

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

NOTICE

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

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

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

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

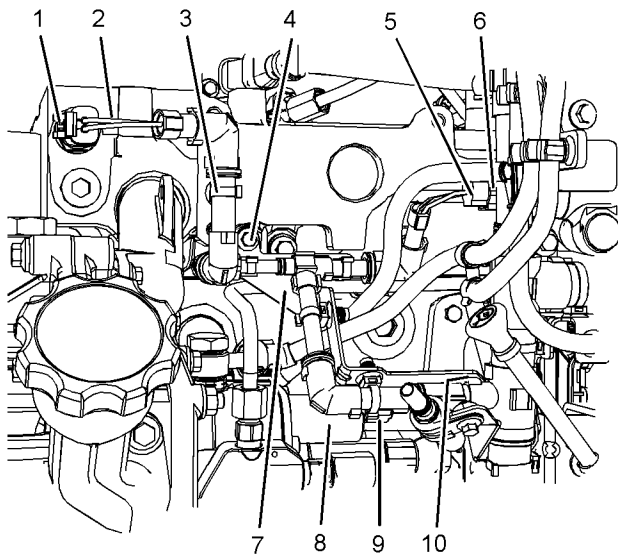


Illustration 3

g02596577

3. Slide locking tab (1) into the unlocked position. Disconnect harness assembly (2) from the coolant temperature sensor.
4. Cut cable strap (3).
5. Disconnect harness assembly (5) from fuel pressure sensor (6).
6. Disconnect assembly (9) from flow control valve (8).
7. Remove bolt (4) and bolt (10) (not shown) from bracket (7).
8. Position bracket (7) and the harness assembly away from the fuel injection pump.

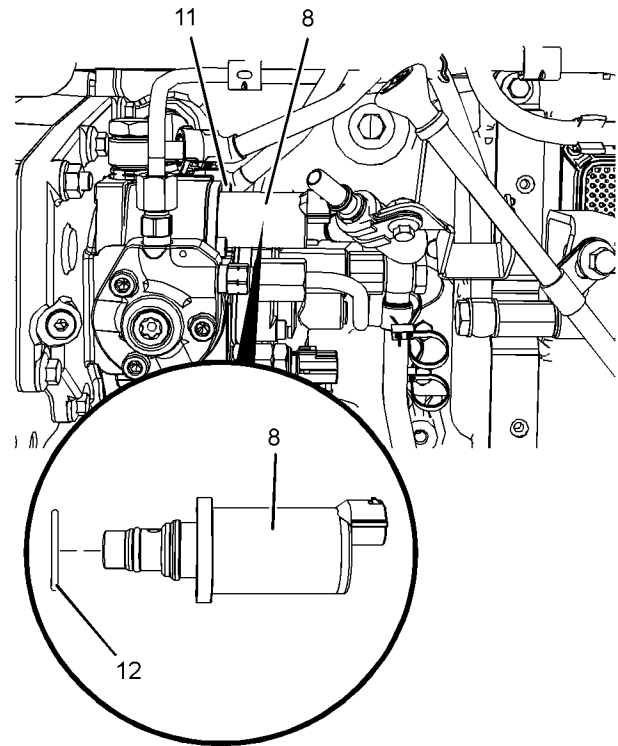


Illustration 4

g02596676

9. Clean the area around flow control valve (8) and fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.
10. Make temporary marks on flow control valve (8) and the fuel injection pump for installation purpose.
11. Remove allen heads screws (11) from flow control valve (8).
12. Remove flow control valve (8) from the fuel injection pump. Remove O-ring seal (12).

Installation Procedure

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

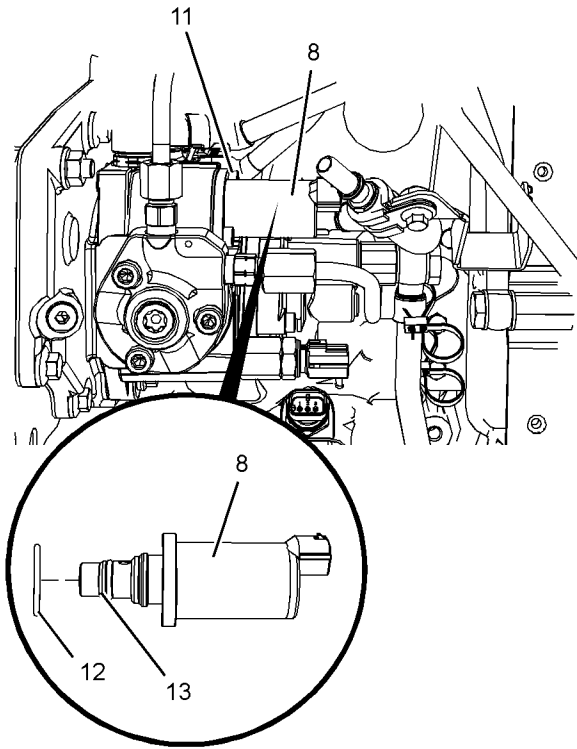


Illustration 5

g02596658

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

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

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

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

5. Lubricate O-ring seal (13) with clean fuel.

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

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

Note: Ensure that the flow control valve is correctly orientated

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

8. Remove guide pins from the fuel injection pump.

9. Install allen head screws (11).

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

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

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

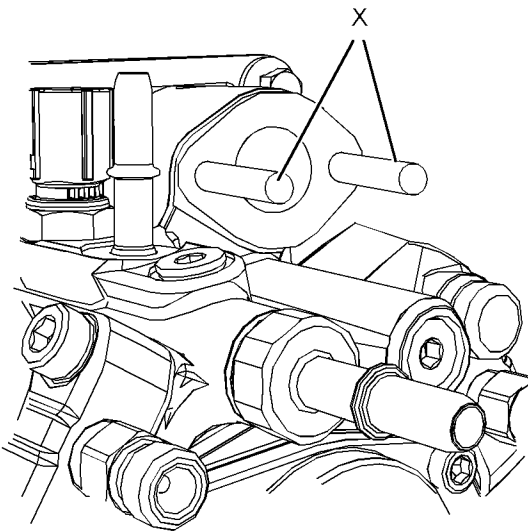


Illustration 6

g02306933

Flow control valve guide pins

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

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

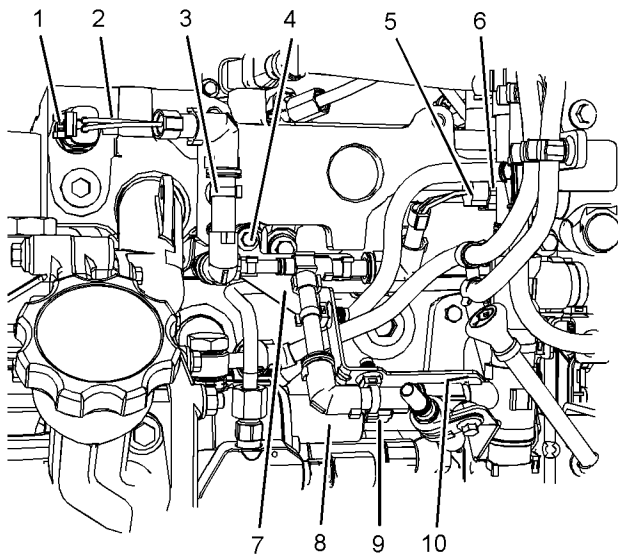


Illustration 7

g02596577

12. Position bracket (7) and harness assembly onto fuel injection pump.
 13. Install bolt (4) and bolt (10) (not shown) to bracket (7). Tighten the bolts to a torque of 9 N·m (80 lb in).
 14. Connect harness assembly (5) to fuel pressure sensor (6).
 15. Connect harness assembly (9) to flow control valve (8).
 16. Connect harness assembly (2) to the coolant temperature sensor. Slide locking tab (1) into the locked position.
 17. Install a new cable strap (3).
- Note:** Ensure that the cable strap meets the Original Equipment Manufactures (OEM) specification.
18. Replace the filters for primary fuel system. Refer to Operation and Maintenance Manual, "Fuel System Primary (Water Separator) Element - Replace" for the correct procedure.
 19. Replace the filters for secondary fuel system. Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.
 20. Turn the fuel supply to the ON position.
 21. Turn the battery disconnect switch to the ON position.
 22. Install the crankcase breather. Refer to Disassemble and Assemble, "Crankcase Breather - Install" for the correct procedure.

23. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for more information.
24. After replacement of the flow control valve, the fuel injection pump must be calibrated. Use the electronic service tool to perform "High Pressure Fuel Pump Calibration".

i05981755

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

Removal Procedure

Table 2

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Turn the fuel supply to the OFF position.
2. Drain the secondary filter. Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

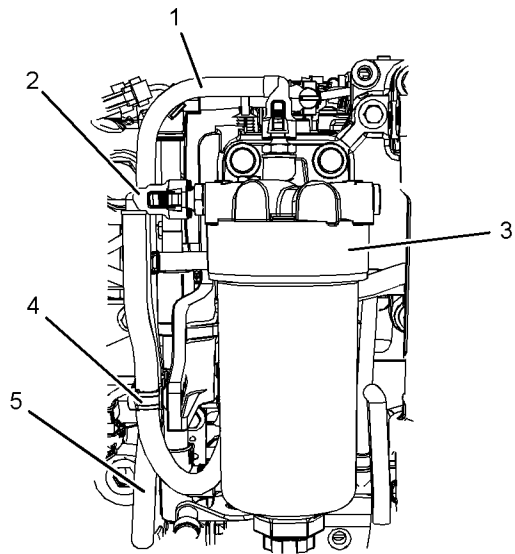


Illustration 8

g02526916

3. Make temporary identification marks on plastic tube assemblies in order to show the correct position of the tube assemblies.
4. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.
5. Disconnect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from the fuel filter base.
6. Remove plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from clips (4).
7. Use Tooling (A) in order to plug the plastic tube assemblies with new plugs. Use Tooling (A) in order to cap the ports in the single secondary fuel filter with new caps.

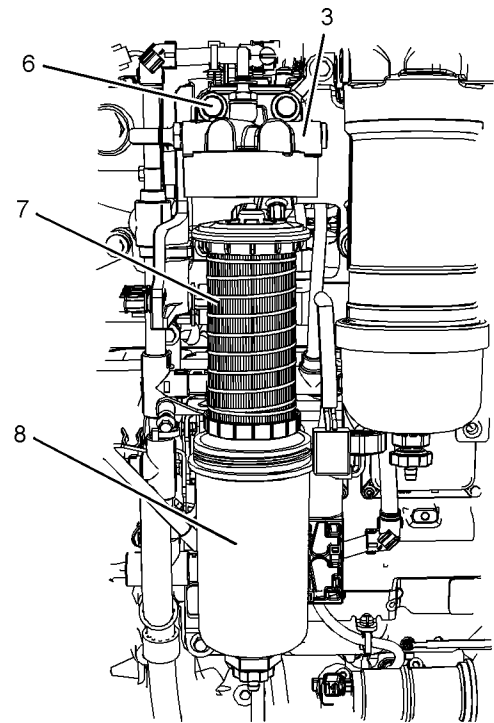


Illustration 9

g02526918

8. Remove canister (8) from fuel filter base (3). Remove secondary filter (7). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.
9. Remove bolts (6) from fuel filter base (3). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

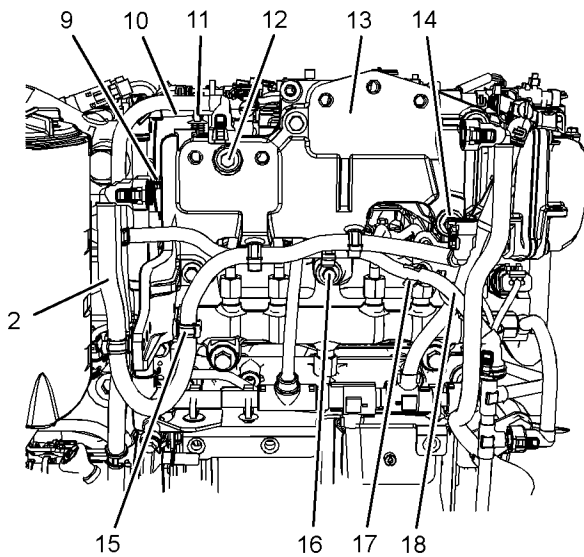


Illustration 10

g02599177

- 10.** If necessary, follow Step 1f through Step 10e in order to remove the bracket for secondary fuel filter.
- Cut cable strap (9) and cable strap (11) from harness assembly (10).
 - Remove plastic tube assembly (2) from clips (15).
 - Remove plastic tube assembly (18) from clips (17).
 - Remove bolts (12), bolts (14) and bolt (16) from fuel filter bracket (13).

Note: Note position of different length bolts.

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

Installation Procedure

NOTICE

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

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

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

NOTICE

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

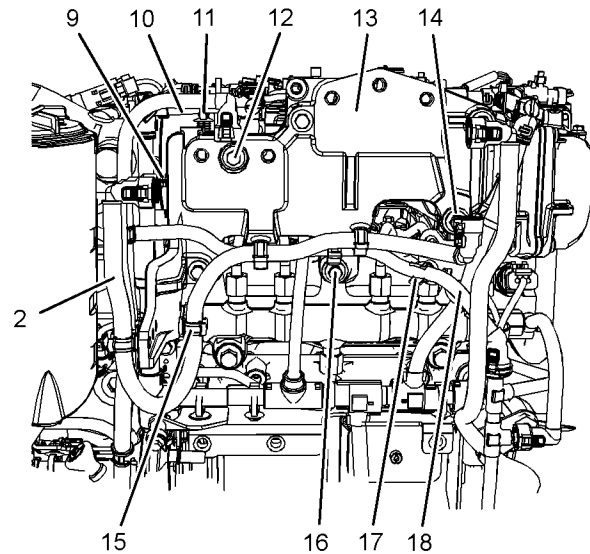


Illustration 11

g02599177

- 1.** If necessary, follow Step 1a through Step 1f in order to install the bracket for secondary fuel filter.
- Position fuel filter bracket (13) onto the NRS induction mixer assembly.
 - Install bolts (12), bolts (14) and bolt (16) to fuel filter bracket (13).
 - Tighten bolts (12), bolts (14) and bolt (16) to a torque of 22 N·m (195 lb in).
 - Install plastic tube assembly (2) to clips (15).
 - Install plastic tube assembly (18) to clips (17).
 - Install new cable strap (9) and cable strap (11) to harness assembly (10).

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

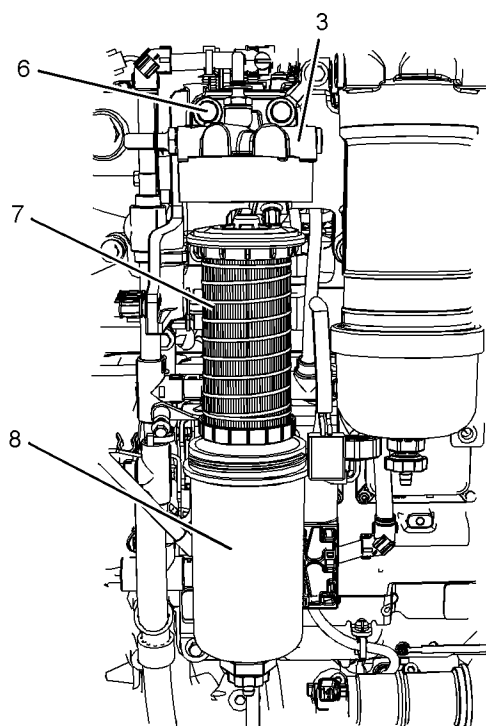


Illustration 12

g02526918

2. Ensure that fuel filter base (3) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.
3. Position fuel filter base (3) on the mounting bracket. Install bolts (6). Tighten the bolts to a torque of 44 N·m (32 lb ft).
4. If necessary, install a new fuel filter (7) to canister (8). Install canister (8) to fuel filter base (3). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

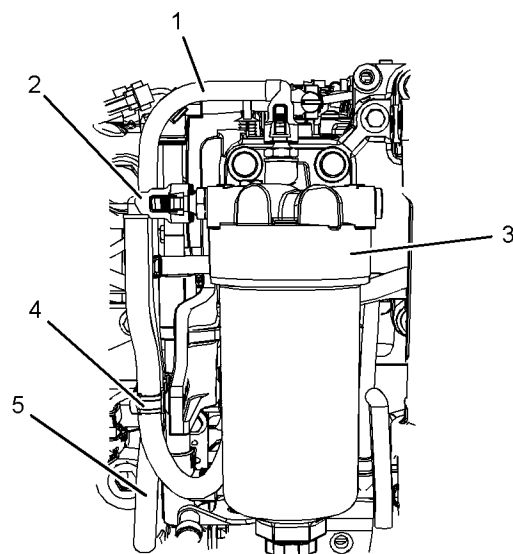


Illustration 13

g02526916

5. Remove the plugs from the plastic tube assemblies. Remove the caps from the ports in the fuel filter base.

NOTICE

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

6. Connect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to the fuel filter base.
7. Install plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to clips (4).
8. Turn the fuel supply to the ON position.

End By:

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

i05981756

Fuel Filter Base - Remove and Install

(Twin Secondary Fuel Filter)

Removal Procedure

Table 3

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Turn the fuel supply to the OFF position.
2. Turn the battery disconnect switch to the OFF position.
3. Drain the secondary filters. Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

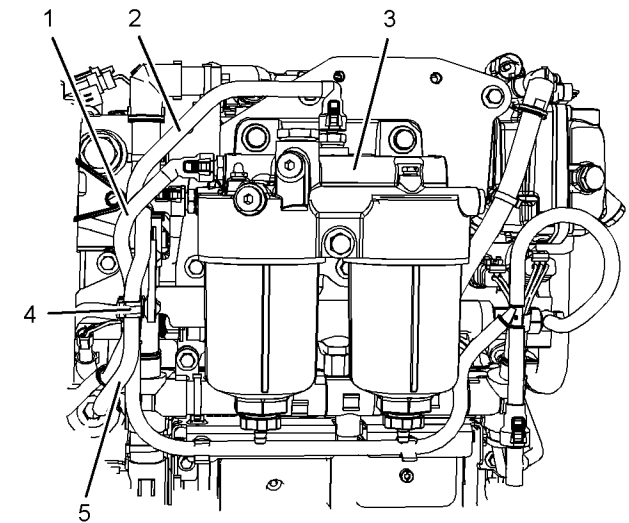


Illustration 14

g02597024

4. Make temporary identification marks on all the plastic tube assemblies in order to show the correct position of the tube assemblies.
5. Place a suitable container below the fuel filter base in order to catch any fuel that might be spilled.
6. Disconnect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from fuel filter base (3).
7. Remove plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) from clips (4).
8. Use Tooling (A) in order to plug the plastic tube assemblies with new plugs. Use Tooling (A) in order to cap the ports in the fuel filter base with new caps.

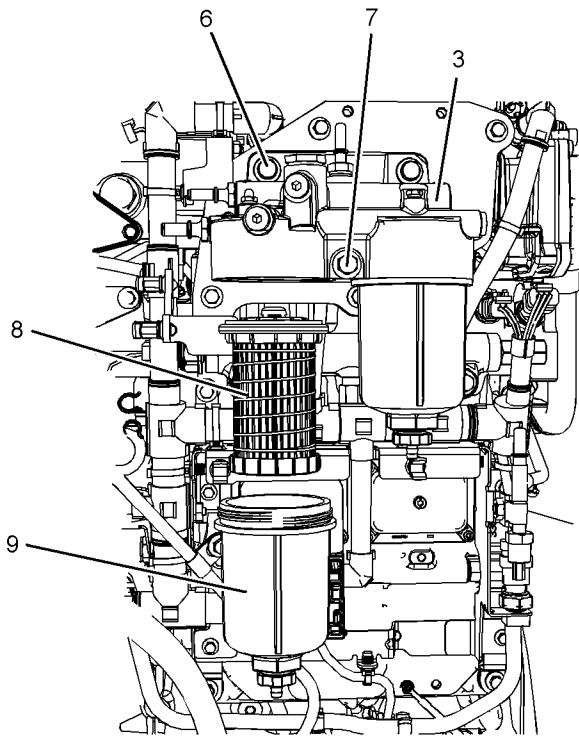


Illustration 15

g02597038

9. Remove secondary filters (8) from canisters (9). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.
10. Remove bolts (6) and bolts (7) from fuel filter base (3). Remove the fuel filter base from the mounting bracket.

Note: Do not disassemble the fuel filter base.

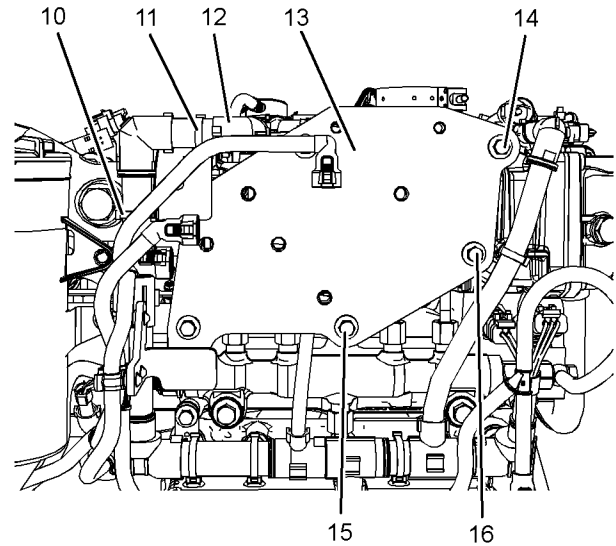


Illustration 16

g02597063

11. If necessary, follow Step 11a through Step 11c in order to remove the bracket for secondary fuel filter.
 - a. Cut cable strap (10) and cable strap (11) from harness assembly (12).
 - b. Remove bolts (11), bolts (12), and bolt (16) from fuel filter bracket (10).
- Note:** Note position of different length bolts.
- c. Remove fuel filter bracket (10) from the NRS induction mixer assembly.

Installation Procedure

NOTICE

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

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

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

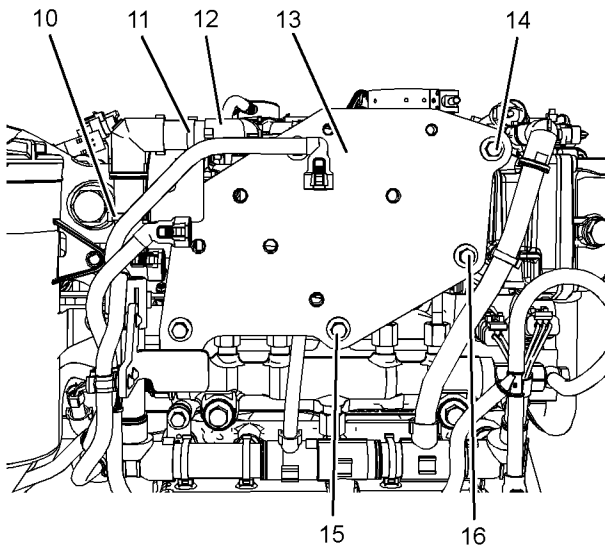


Illustration 17

g02597063

1. If necessary, follow Step 1a through Step 1d in order to install the bracket for secondary fuel filter.
 - a. Position fuel filter bracket (10) onto the NRS induction mixer assembly.
 - b. Install bolts (11), bolts (12) and bolt (16) to fuel filter bracket (10).
 - c. Tighten bolts (11), bolts (12) and bolt (16) to a torque of 22 N·m (195 lb in).
 - d. Install new cable strap (10) and cable strap (11) to harness assembly (12).

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

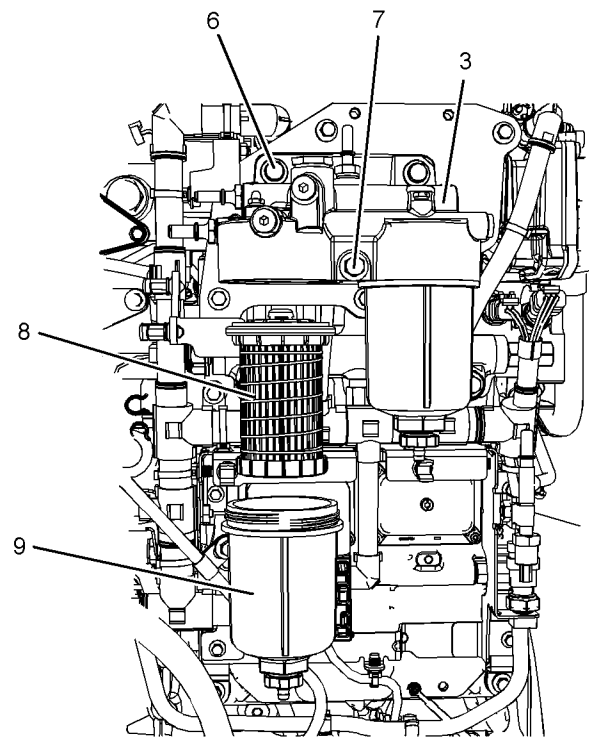


Illustration 18

g02597038

2. Ensure that fuel filter base (3) is clean and free from damage. If necessary, replace the complete fuel filter base and filter assembly.
3. Position fuel filter base (3) on the mounting bracket. Install bolts (6) and bolts (7). Tighten the bolts to a torque of 44 N·m (32 lb ft).
4. If necessary, install new fuel filters (8) to canisters (9). Refer to Operation and Maintenance Manual, "Fuel System Secondary Filter - Replace" for the correct procedure.

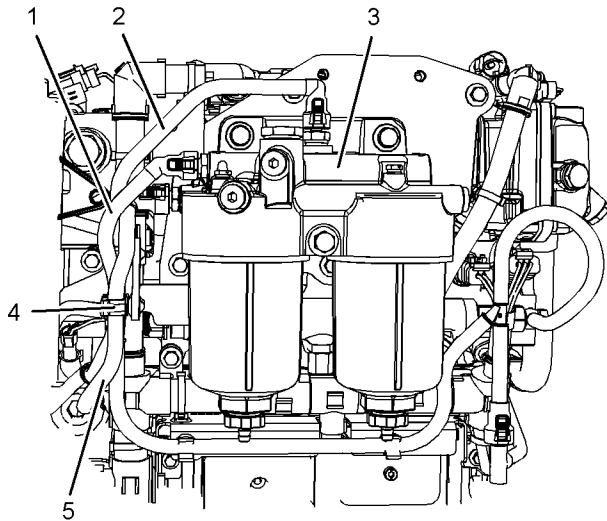


Illustration 19

g02597024

5. Remove the plugs from the plastic tube assemblies. Remove the caps from the ports in the fuel filter base.

NOTICE

Ensure that the plastic tube assemblies are installed in the original positions. Failure to connect the plastic tube assemblies to the correct ports will allow contamination to enter the fuel system. Serious damage to the engine will result if contaminated fuel enters the fuel system.

6. Connect plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to fuel filter base (3).
7. Install plastic tube assembly (1), plastic tube assembly (2), and plastic tube assembly (5) to clips (4).
8. Turn the fuel supply to the ON position.
9. Turn the battery disconnect switch to the ON position.

End By:

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

i05981923

Water Separator and Fuel Filter (Primary - Remove and Install

Removal Procedure

Table 4

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

NOTICE

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

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

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

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

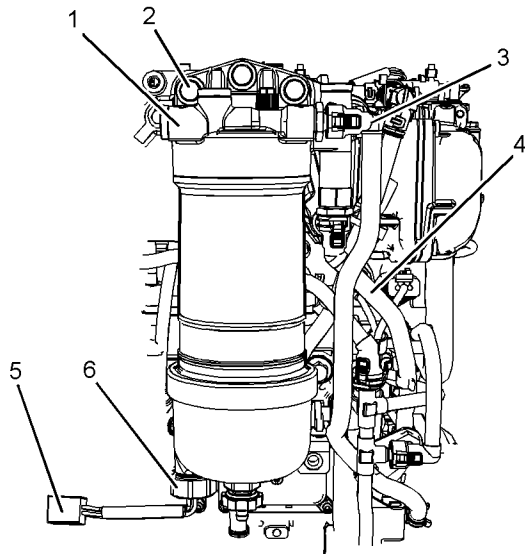


Illustration 20

g02524979

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

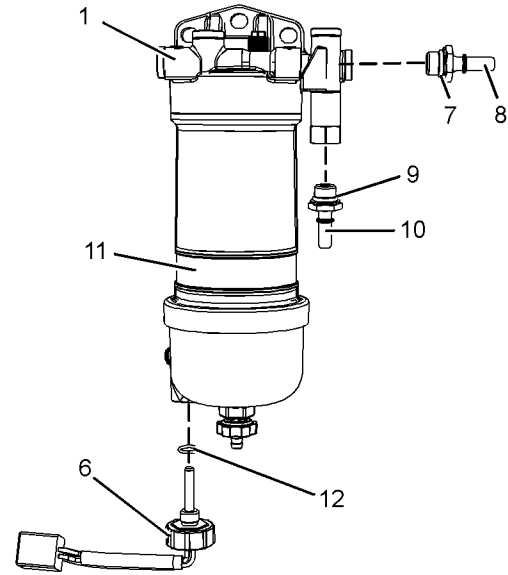


Illustration 21

g02524997

8. If necessary, follow Step 8a through Step 8d in order to disassembly the assembly of primary fuel filter (1).
 - a. Remove connection (7) and remove O-ring seal (8). Use Tooling (A) in order to plug the primary fuel filter (1) with new plug. Use Tooling (A) in order to cap connection (7) with new caps.
 - b. Remove connection (10) and remove O-ring seal (9). Use Tooling (A) in order to plug the primary fuel filter (1) with new plug. Use Tooling (A) in order to cap connection (10) with new caps.
 - c. Remove water in fuel sensor (6) and remove O-ring seal (12).
 - d. Remove the filter element from fuel filter canister (11). Refer to Operation and Maintenance Manual, "Fuel System Primary Filter (Water Separator) Element - Replace" for the correct procedure.

Installation Procedure

NOTICE

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

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

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

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

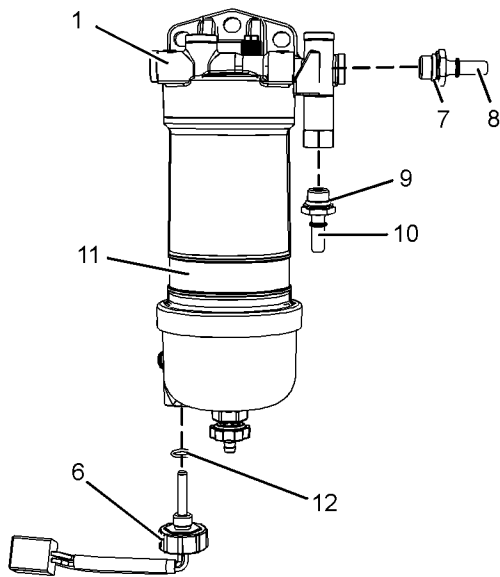


Illustration 22

g02524997

2. If necessary, follow Step 2a through Step 2f in order to assembly primary fuel filter (1).
 - a. Install a new filter element to fuel filter canister (11). Refer to Operation and Maintenance Manual, "Fuel System Primary Filter (Water Separator) Element - Replace" for the correct procedure.
 - b. Remove caps from connection (7). Install a new O-ring seal (8) to connection (7).
 - c. Remove cap from primary fuel filter (1). Install connection (7) to primary fuel filter (1). Tighten the connection to a torque of 20 N·m (177 lb in).

- d. Remove caps from connection (10). Install a new O-ring seal (9) to connection (10).
- e. Remove cap from primary fuel filter (1). Install connection (10) to primary fuel filter (1). Tighten the connection to a torque of 20 N·m (177 lb in).
- f. Install a new O-ring seal (12) to water in fuel sensor (6). Install water in fuel sensor (6) to primary fuel filter (1). Tighten water in fuel sensor (6) hand tight.

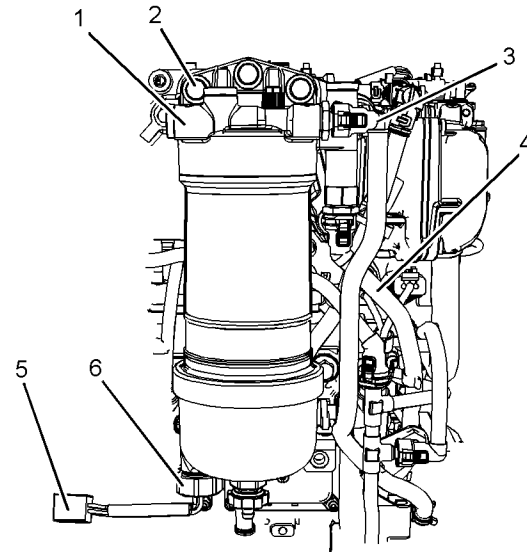


Illustration 23

g02524979

3. Position the assembly of primary fuel filter (1) onto the mounting bracket.
4. Install bolts (2) to the assembly of primary fuel filter (1). Tighten the bolts to a torque of 44 N·m (32 lb ft).
5. Remove the plugs from the plastic tube assemblies. Remove the caps from the connections on the primary fuel filter.

NOTICE

Ensure that the plastic tube assemblies are installed in the original positions. Failure to connect the plastic tube assemblies to the correct ports will allow contamination to enter the fuel system. Serious damage to the engine will result if contaminated fuel enters the fuel system.

6. Connect plastic tube assembly (3) and plastic tube assembly (4) to primary fuel filter (1).
7. Connect the OEM harness assembly to the connection on harness assembly (5) for water in fuel sensor (6).

8. Turn the fuel supply to the ON position.
9. Turn the battery disconnect switch to the ON position.

End By:

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

i05981763

Fuel Manifold (Rail - Remove and Install

Removal Procedure

Table 5

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

Start By:

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

WARNING

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

NOTICE

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

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

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

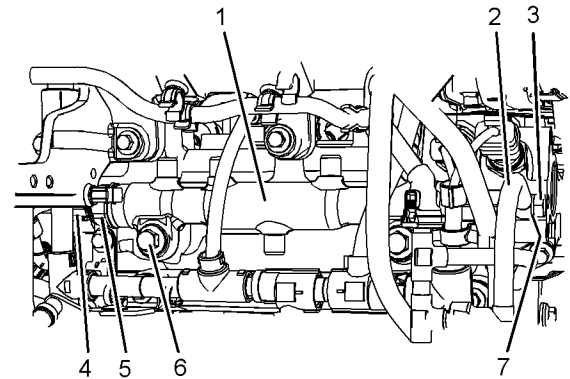


Illustration 24

g02484242

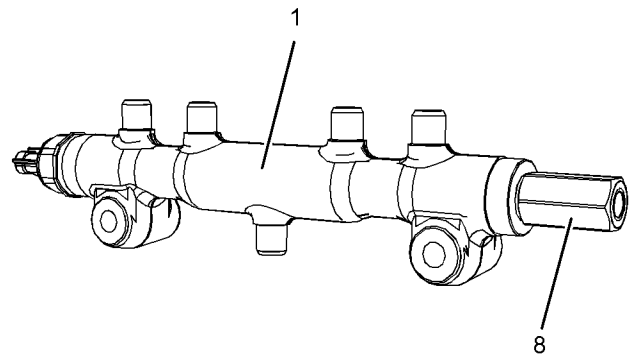


Illustration 25

g02484286

1. Thoroughly clean the area around fuel manifold (1).
2. Disconnect harness assembly (4) from fuel pressure sensor (5).
3. Remove banjo bolt (3) from plastic tube assembly (2). Use Tooling (A) to plug the plastic tube assembly. Remove sealing washers (7) (not shown). Use Tooling (A) to plug fuel manifold (1).
4. Remove bolts (6).
5. Remove fuel manifold (1) from the cylinder block.
6. If necessary, remove fuel pressure relief valve (8) from fuel manifold (1). Ref to Disassembly and Assembly, "Relief Valve (Fuel) - Remove and Install" for the correct procedure.

Installation Procedure

NOTICE

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

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

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

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

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

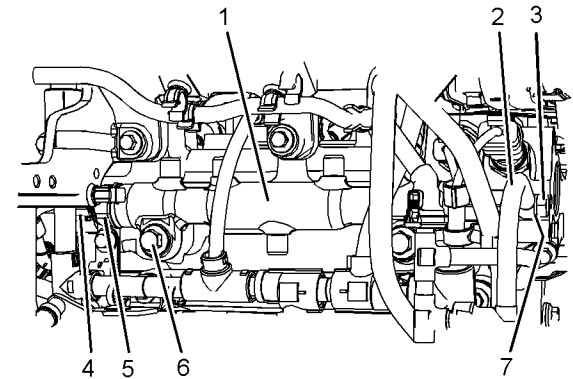


Illustration 26

g02484242

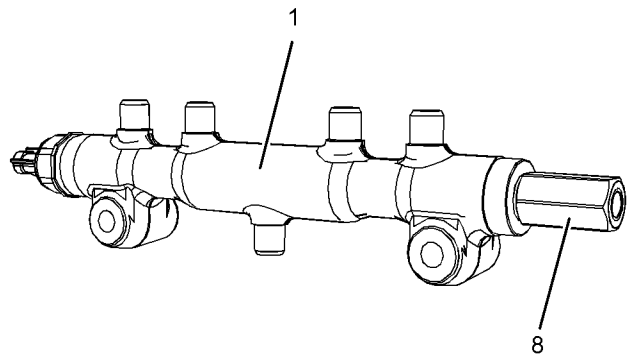


Illustration 27

g02484286

2. If necessary, install fuel pressure relief valve (8) to fuel manifold (1). Ref to Disassembly and Assembly, "Relief Valve (Fuel) - Remove and Install" for the correct procedure.
3. Position fuel manifold (1) onto the cylinder block. Install bolts (6) to fuel manifold (1) finger tight.
4. Install a new set of seals to the electronic unit injectors and a new set of fuel injection lines. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for the correct procedure.
5. Tighten bolts (6) to a torque of 22 N·m (195 lb in).
6. Install a new sealing washer (7) (not shown) to banjo bolt (3).
7. Remove plug from plastic tube assembly (2). Install assembly of banjo bolt (3) to plastic tube assembly (2). Install remaining new sealing washer (7) (not shown) to banjo bolt (3).
8. Install banjo bolt (3) and plastic tube assembly (2) to pressure relief valve (8) finger tight.
9. Tighten banjo bolts (3) to a torque of 15 N·m (133 lb in).

- 10. Connect harness assembly (4) to fuel pressure sensor (5).
- 11. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for the correct procedure.

i07088400

Relief Valve (Fuel - Remove and Install)

Removal Procedure

Table 6

Required Tools			
Tool	Part Number	Part Description	Qty
A	T41 - 0437	Cap Kit	1

WARNING

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

NOTICE

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

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

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

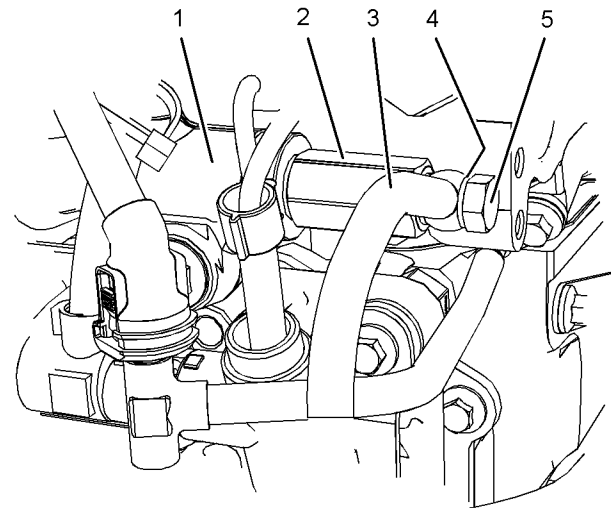


Illustration 28

g02673936

Typical example

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

Installation Procedure

Table 7

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825607	Degree Wheel	1

NOTICE

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

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

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

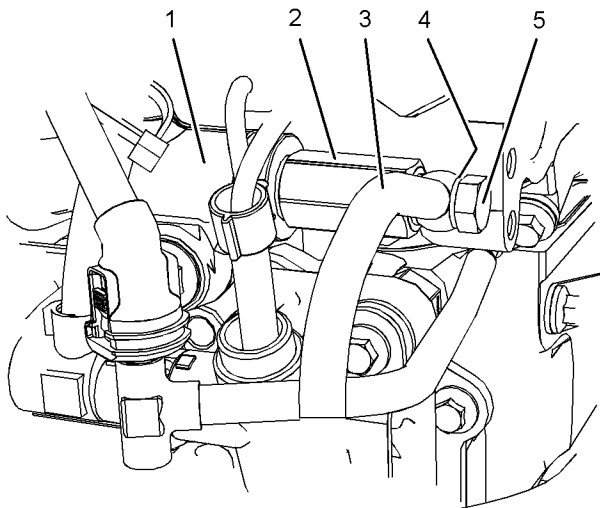


Illustration 29

g02673936

Typical example

1. Follow Step 1a through Step 1f to install the fuel pressure relief valve to the fuel manifold.
 - a. Remove the plug from the port in fuel manifold (1).
 - b. Immediately clean the threads in fuel manifold (1) for fuel pressure relief valve (2). Ensure that the thread is clean and free from debris. Ensure that the thread in the fuel manifold (2) is free from damage.
 - c. Immediately plug the open port in fuel manifold (1) with a new cap after cleaning and inspection.
 - d. Remove the cap from the threaded end of fuel pressure relief valve (2). lubricate the thread of the pressure relief valve with clean fuel.
 - e. Remove the plug from the port of fuel manifold (1). Use a deep socket to install the fuel pressure relief valve (2) into fuel manifold (1) hand tight.
 - f. Tighten fuel pressure relief valve (2) to a snug torque of 30 N·m (266 lb in). Use Tooling (B) to rotate the fuel pressure relief valve in a clockwise direction for another 24 degrees to achieve the final torque.
2. Remove the plug from plastic tube assembly (3).
3. Install a new sealing washer (4) (not shown) onto banjo bolt (5). Position banjo bolt (5) onto plastic tube assembly (3) and install remaining new sealing washer (4) (not shown) onto the banjo bolt.
4. Remove the plug from fuel pressure relief valve (2).
5. Position plastic tube assembly (3) onto fuel pressure relief valve (2). Tighten banjo bolt (5) hand tight.
6. Tighten banjo bolt (5) to a torque of 15 N·m (133 lb in).

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

i05981758

Fuel Injection Lines - Remove

Removal Procedure

Start By:

- Remove crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, “Crankcase Breather - Remove” for the correct procedure.
- Remove secondary fuel filter assembly. Refer to Disassembly and Assembly, “Fuel Filter Base (Single Secondary Fuel Filter) - Remove and Install” for the correct procedure.
- Remove water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
- Remove the Inlet Air Control (NRS Induction Mixer). Refer to Disassembly and Assembly, “Inlet Air Control (NRS Induction Mixer) - Remove” for the correct procedure.

Table 8

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

WARNING

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

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

Disassembly and Assembly Section

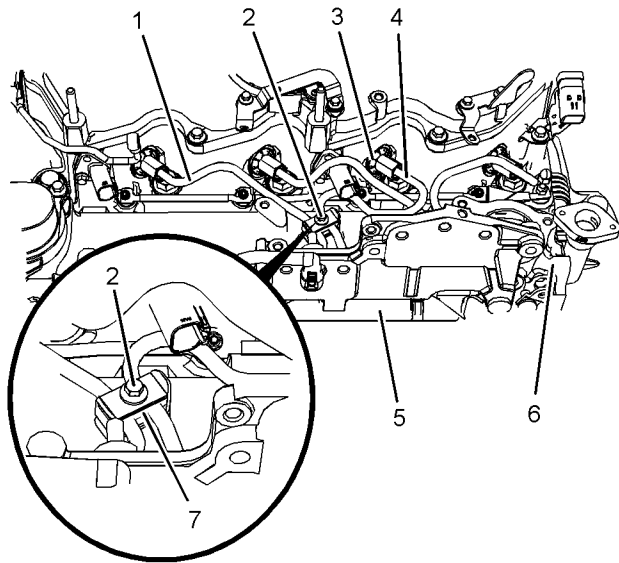


Illustration 30

g02481081

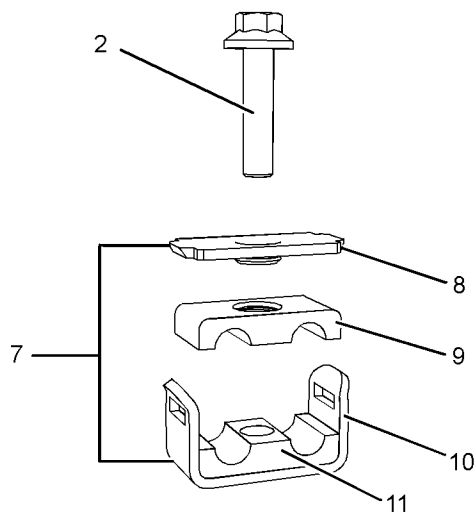


Illustration 31

g02625722

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

7. Use Tooling (A) in order to plug the open port in the electronic unit injector immediately.
8. Remove fuel injection line (1) and fuel injection line (4). **Discard the fuel injection lines.**
9. Remove bracket (10) and isolator (11).
10. Use Tooling (A) in order to plug the open port in fuel manifold (5) immediately.
11. Remove seal (3) from the electronic unit injector and cylinder head (6).
12. Use Tooling (A) in order to plug the open port for the electronic unit injector.
13. Repeat Step 5 through Step 12 in order to remove the remaining fuel injection lines from the fuel manifold to the electronic unit injectors.

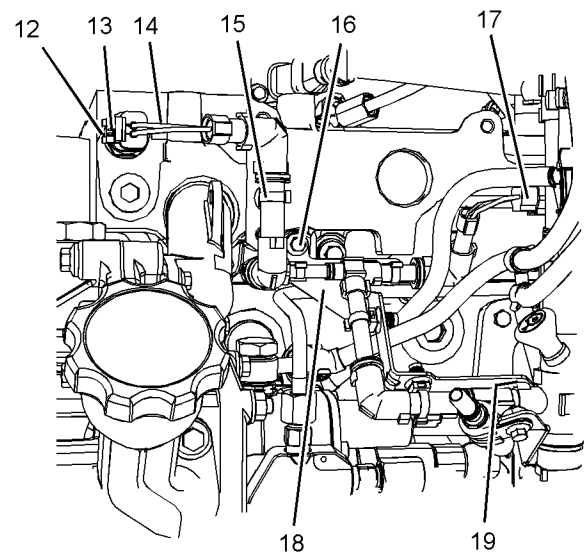


Illustration 32

g02625818

14. Slide locking tab (13) into the unlocked position. Disconnect harness assembly (14) from coolant temperature sensor (12).
15. Disconnect harness assembly (17) from fuel pressure sensor.
16. Cut cable strap (15).
17. Remove bolt (16) and bolt (19) (not shown) from bracket (18).
18. Position bracket (18) and the harness assembly away from the fuel injection pump.

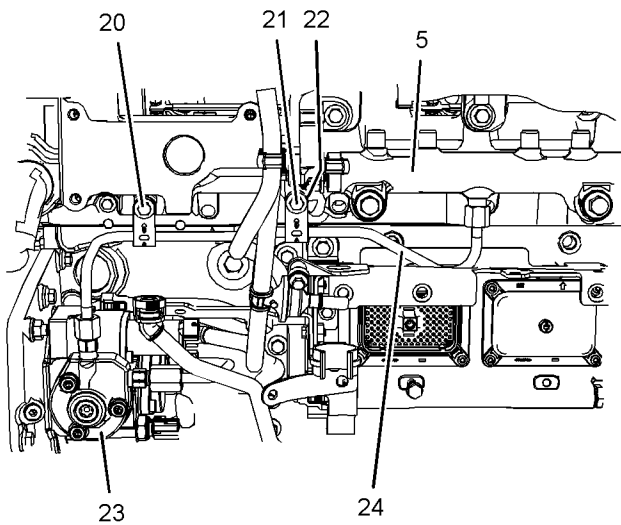


Illustration 33

g02481080

19. Remove bolt (20) from the tube clip.
20. Remove bolt (21) and spacer (22) (not shown) from the tube clip.
21. Disconnect fuel injection line (24) at fuel injection pump (23).
22. Disconnect fuel injection line (24) at fuel manifold (5).
23. Remove fuel injection line (24). **Discard the fuel injection lines.**
24. Use Tooling (A) in order to plug all open ports immediately in fuel manifold (5) and in fuel injection pump (23).

i05981757

Fuel Injection Lines - Install

Installation Procedure

Table 9

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610294	Injector Pipe Nut Tool	1
C	T400030	Wrench	1

NOTICE

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

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

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

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

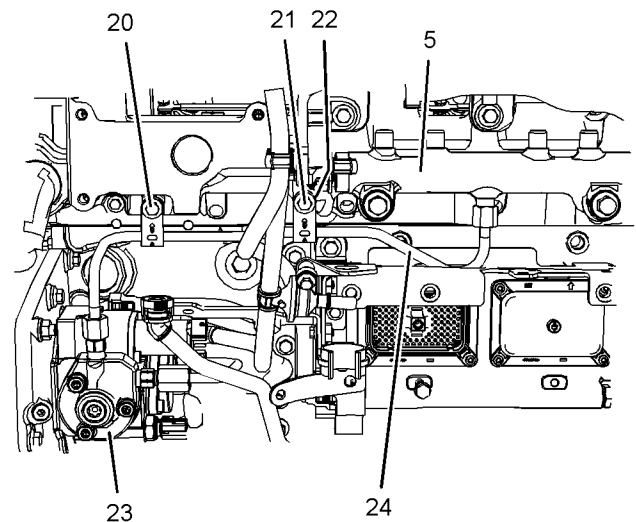


Illustration 34

g02481080

1. Remove plugs from fuel manifold (5) and fuel injection pump (23).
2. Remove the caps from new fuel injection line (24).
3. Position fuel injection line (24) onto fuel injection pump (23) and fuel manifold (5). Loosely install nuts for the fuel injection line onto the fuel manifold and the fuel injection pump.
4. Install bolt (20) to the tube clip finger tight.

Disassembly and Assembly Section

5. Install bolt (21) and spacer (22) to the tube clip finger tight.
6. Use Tooling (C) to tighten the nuts on fuel injection line (24) to a torque of 40 N·m (30 lb ft).
7. Tighten bolt (20) and bolt (21) to a torque of 10 N·m (89 lb in).

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

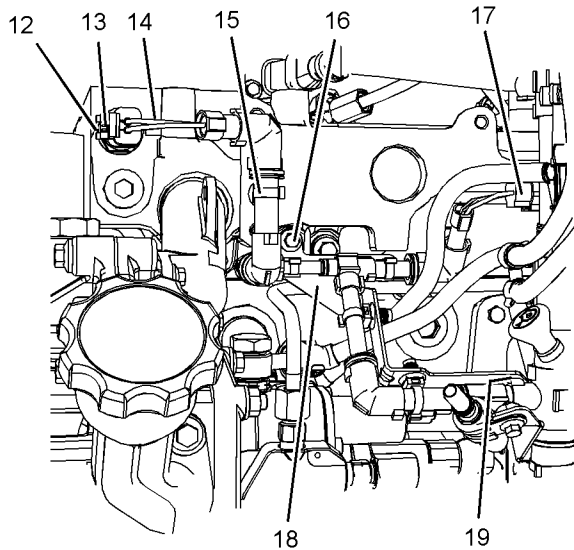


Illustration 35

g02625818

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

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

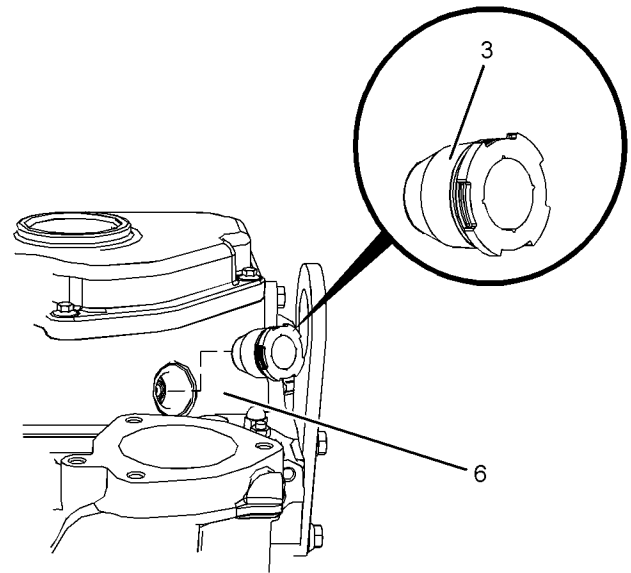


Illustration 36

g02481216

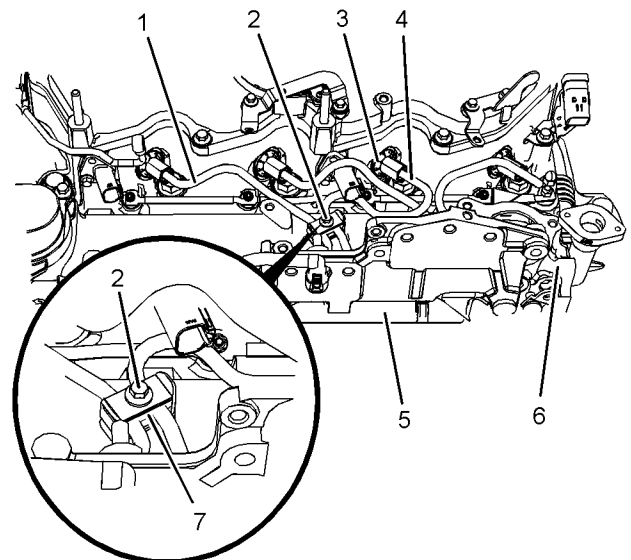


Illustration 37

g02481081

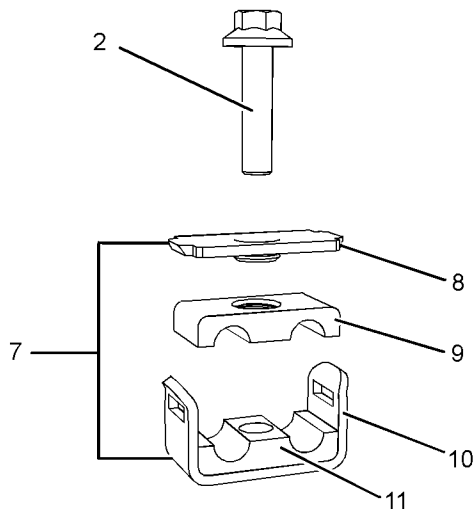


Illustration 38

g02625722

i05981736

13. Install new seals (3) to the electronic unit injector and cylinder head (6). Ensure that the flange on the seal is flush with the cylinder head.
14. Remove the caps from the port of the electronic unit injector and from the appropriate port in fuel manifold (5).
15. Loosely connect the nuts at both ends of fuel injection line (1) and fuel injection line (4), to the electronic unit injector and to the appropriate port in fuel manifold (5). Ensure that the ends of the fuel injection line are correctly seated in the electronic unit injector and in the fuel manifold.
16. Install bracket (10) and isolator (11). Position isolator (9) and clamp plate (8).
17. Use a suitable tool in order to install clamp plate (8) to bracket (10).
18. Install bolt (2) finger tight.
19. Use Tooling (B) to tighten the nuts on fuel injection line (1) and fuel injection line (4) to a torque of 55 N·m (41 lb ft). Ensure that the dust seal is seated correctly against the seal.
20. Tighten bolt (2) to a torque of 10 N·m (89 lb in).
21. Follow Step 13 through Step 20 in order to install the remaining fuel injection lines.
22. Turn the fuel supply to the ON position.
23. Turn the battery disconnect switch to the ON position.
24. Remove the air from the fuel system. Refer to Operations and Maintenance Manual, "Fuel System - Prime" for the correct procedure.

End By:

- a. Install the inlet air control (NRS Induction Mixer). Refer to Disassembly and Assembly, "Inlet Air Control (NRS Induction Mixer) - Install" for the correct procedure.
- b. Install secondary fuel filter assembly. Refer to Disassembly and Assembly, "Fuel Filter Base (Single Secondary Fuel Filter) - Remove and Install" for the correct procedure.
- c. Install water separator and fuel filter (Primary). Refer to Disassembly and Assembly, "Water Separator and Fuel Filter (Primary) - Remove and Install" for the correct procedure.
- d. Install crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.

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

Removal Procedure

Start By:

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

WARNING

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

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

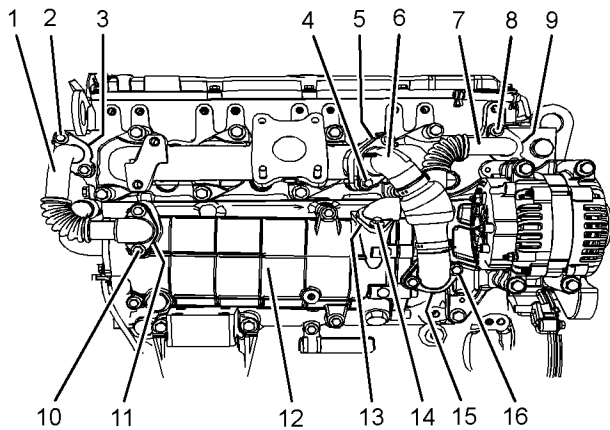


Illustration 39

g02477077

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Remove bolts (2) and bolts (10) from tube assembly (1).
3. Remove tube assembly (1) from exhaust cooler (12) and the cylinder head.
4. Remove gaskets (3) (not shown) and gasket (11) (not shown) from tube assembly (1).
5. Prior to and during removal of bolts (4) and bolts (16) apply releasing fluid to the bolts. Remove bolts (4) and bolts (16) from tube assembly (6).
6. Remove tube assembly (6) from exhaust cooler (12) and the exhaust manifold.
7. Remove gaskets (5) (not shown) and gasket (15) (not shown) from tube assembly (6).
8. Remove bolts (8) and bolt (14) from tube assembly (7).
9. Remove tube assembly (7) from exhaust cooler (12) and the cylinder head.
10. Remove gasket (9) (not shown) and O-ring seal (13) (not shown) from tube assembly (7).

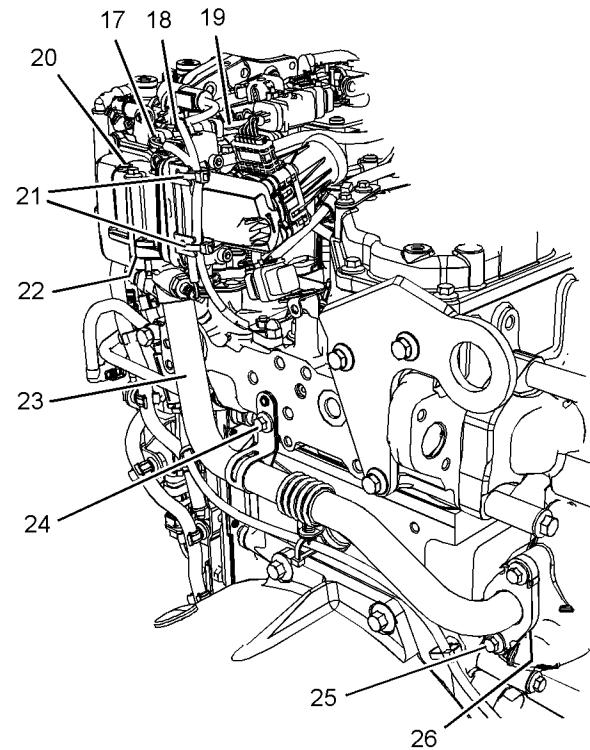


Illustration 40

g02477065

11. Cut cable straps (21) for wiring harness assembly (17). Ensure that all the cable straps are removed from all harness assemblies.
12. Slide locking tab (18) into the unlocked position. Disconnect wiring harness assembly (17) from engine wiring harness assembly (19).
13. Remove bolts (20) from tube assembly (23).
14. Remove bolt (24) from clamp on tube assembly (23).
15. Remove bolts (25) from tube assembly (23).
16. Remove tube assembly (23). Remove gasket (26) (not shown) and gasket (22) (not shown) from tube assembly (23).

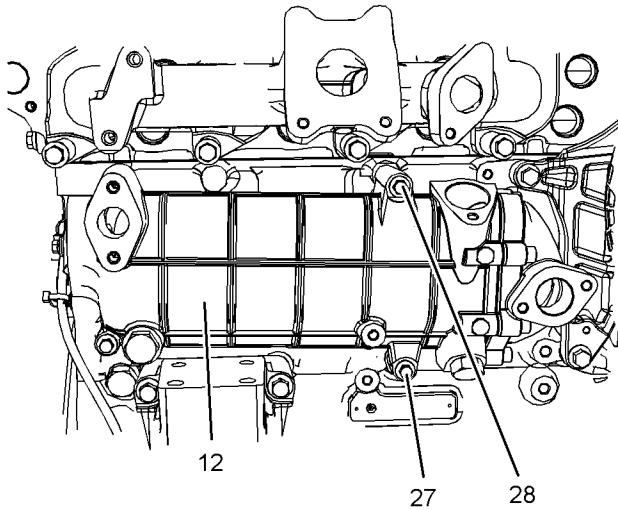


Illustration 41

g02477067

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

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

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

Installation Procedure

NOTICE

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

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

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

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

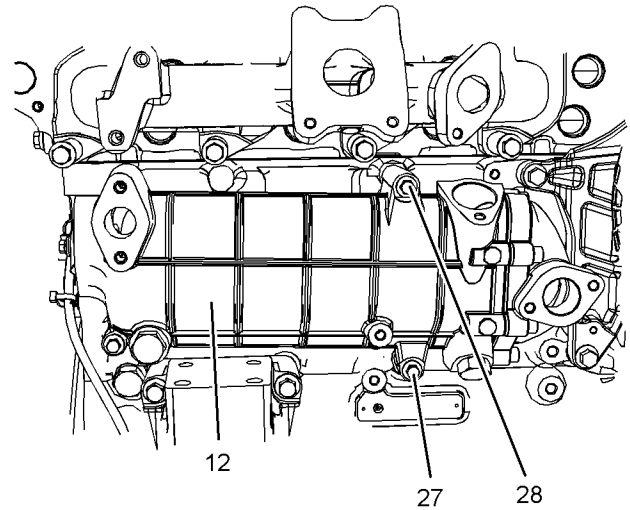


Illustration 42

g02477067

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

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

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

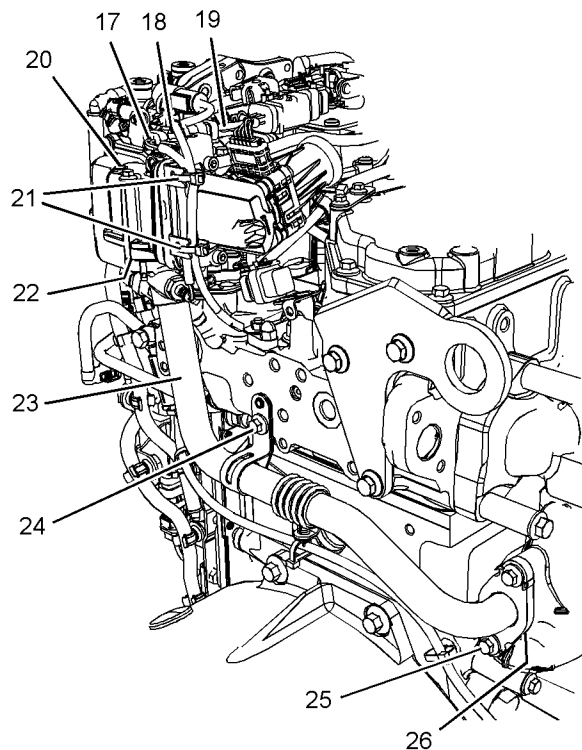


Illustration 43

g02477065

5. Position a new gasket (22) (not shown) and a new gasket (26) (not shown) onto tube assembly (23).
6. Position tube assembly (23) onto the exhaust cooler and the inlet air control. Install bolts (20) and bolts (25) to tube assembly (23).
7. Install bolt (24) to clamp on tube assembly (23).
8. Tighten bolts (20) to a torque of 9 N·m (80 lb in).
Tighten bolts (25) to a torque of 18 N·m (159 lb in).
Tighten bolt (24) to a torque of 22 N·m (195 lb in).
9. Connect wiring harness assembly (17) to engine wiring harness assembly (19). Slide locking tab (18) into the locked position.
10. Install new cable straps (21) to wiring harness assembly (17).

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

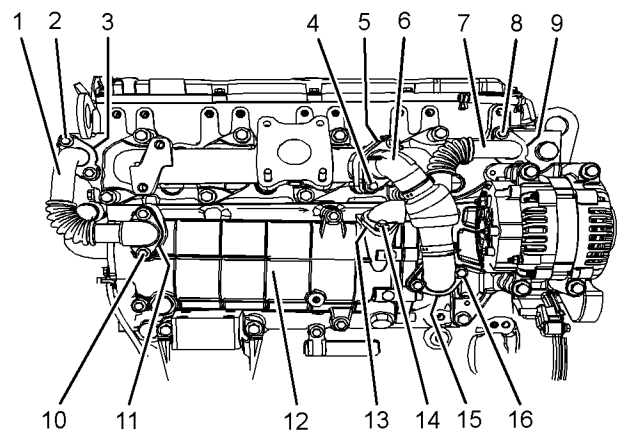


Illustration 44

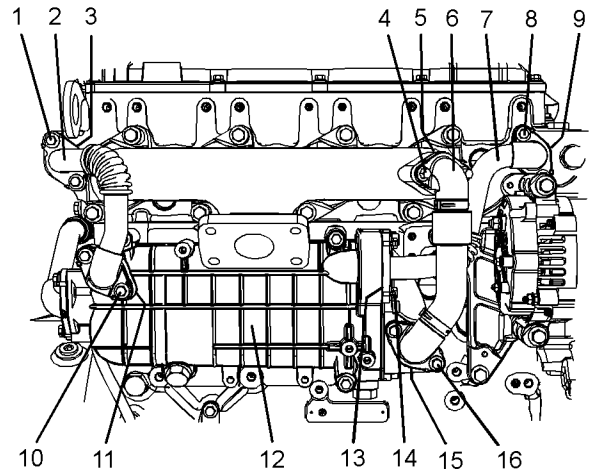
g02477077

11. Position a new gasket (3) (not shown) and a new gasket (11) (not shown) onto tube assembly (1).
 12. Install tube assembly (1) to exhaust cooler (12) and the cylinder head.
 13. Install bolts (2) and bolts (10) to tube assembly (1).
 14. Tighten bolts (10) to a torque of 18 N·m (159 lb in).
Tighten bolt (2) to a torque of 22 N·m (195 lb in).
 15. Position a new gasket (9) (not shown) and install a new O-ring seal (13) (not shown) onto tube assembly (7).
- Note:** Do not lubricate the O-ring seal.
16. Position tube assembly (7) onto exhaust cooler (12) and the cylinder head. Install bolts (8) and bolt (14) to tube assembly (7). Ensure that the tube assembly is correctly positioned into the exhaust cooler.
 17. Tighten bolt (14) to a torque of 18 N·m (159 lb in).
Tighten bolts (8) to a torque of 22 N·m (195 lb in).
 18. Position a new gasket (5) (not shown) and a new gasket (15) (not shown) onto tube assembly (6).
 19. Position tube assembly (6) onto exhaust cooler (12) and the exhaust manifold.
 20. Install new bolts (4) and new bolts (16) to tube assembly (6).

21. Tighten bolts (4) and bolts (16) to a torque of 22 N·m (195 lb in).
22. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

End By:

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



i05981737

Illustration 45

g02619576

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

Removal Procedure

Start By:

- a. Remove the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Remove (Side Mounted Turbocharger)" for the correct procedure.

WARNING

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

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

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Remove bolts (1) and bolts (10) from tube assembly (2).
3. Remove tube assembly (2) from exhaust cooler (12) and the cylinder head.
4. Remove gaskets (3) (not shown) and gasket (11) (not shown) from tube assembly (2).
5. Prior to and during removal of bolts (4) and bolts (16) apply releasing fluid to the bolts. Remove bolts (4) and bolts (16) from tube assembly (6).
6. Remove tube assembly (6) from exhaust cooler (12) and the exhaust manifold.
7. Remove gaskets (5) (not shown) and gasket (15) (not shown) from tube assembly (6).
8. Remove bolts (8) and bolts (14) from tube assembly (7).
9. Remove tube assembly (7) from exhaust cooler (12) and the cylinder head.
10. Remove gasket (9) (not shown) and gasket (13) (not shown) from tube assembly (7).

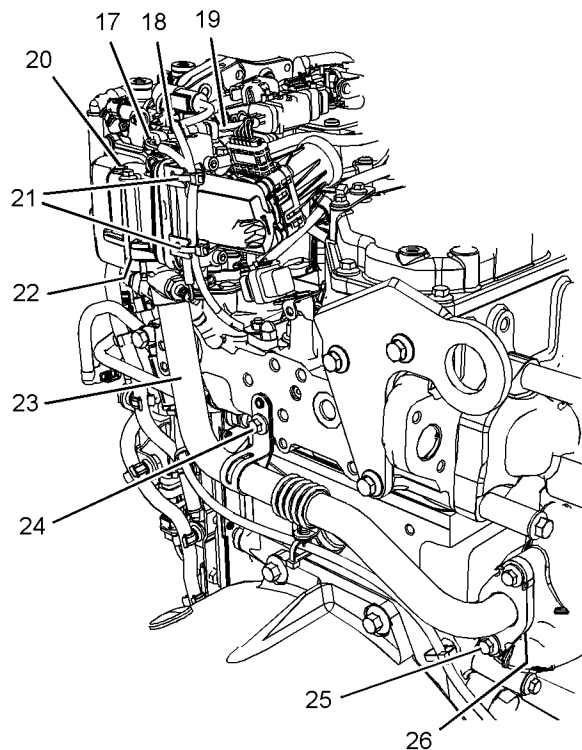


Illustration 46

g02619577

11. Cut cable straps (21) for wiring harness assembly (17). Ensure that all the cable straps are removed from all harness assemblies.
12. Slide locking tab (18) into the unlocked position. Disconnect wiring harness assembly (17) from engine wiring harness assembly (19).
13. Remove bolts (20) from tube assembly (23).
14. Remove bolt (24) from clamp on tube assembly (23).
15. Remove bolts (25) from tube assembly (23).
16. Remove tube assembly (23). Remove gasket (26) (not shown) and gasket (22) (not shown) from tube assembly (23).

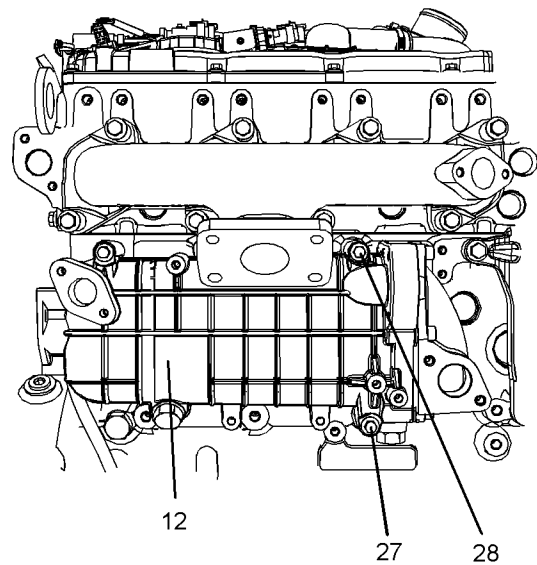


Illustration 47

g02619578

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

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

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

Installation Procedure

NOTICE

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

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

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

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

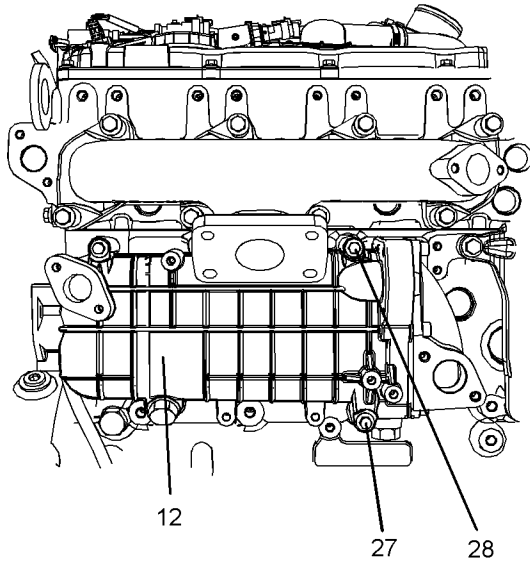


Illustration 48

g02619578

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

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

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

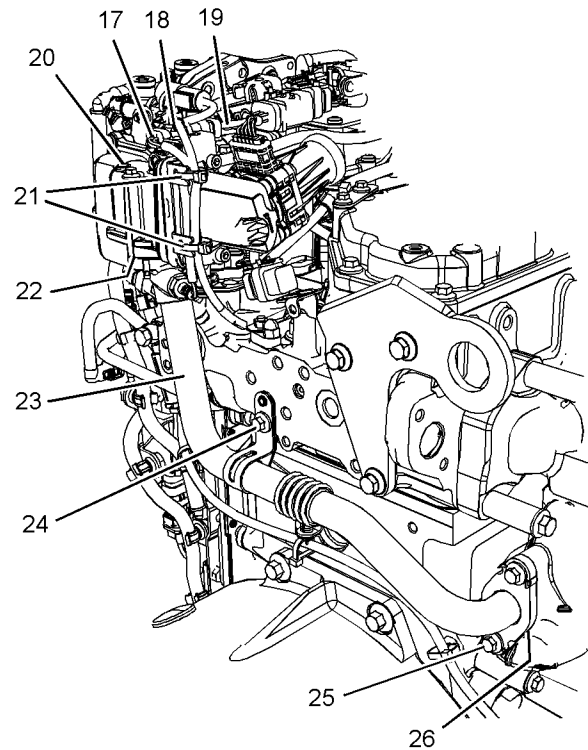


Illustration 49

g02619577

5. Position a new gasket (22) (not shown) and a new gasket (26) (not shown) onto tube assembly (23).
6. Position tube assembly (23) onto the exhaust cooler and the inlet air control. Install bolts (20) and bolts (25) to tube assembly (23).
7. Install bolt (24) to clamp on tube assembly (23).
8. Tighten bolts (20) to a torque of 9 N·m (80 lb in).
Tighten bolts (25) to a torque of 18 N·m (159 lb in).
Tighten bolt (24) to a torque of 22 N·m (195 lb in).
9. Connect wiring harness assembly (17) to engine wiring harness assembly (19). Slide locking tab (18) into the locked position.
10. Install new cable straps (21) to wiring harness assembly (17).

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

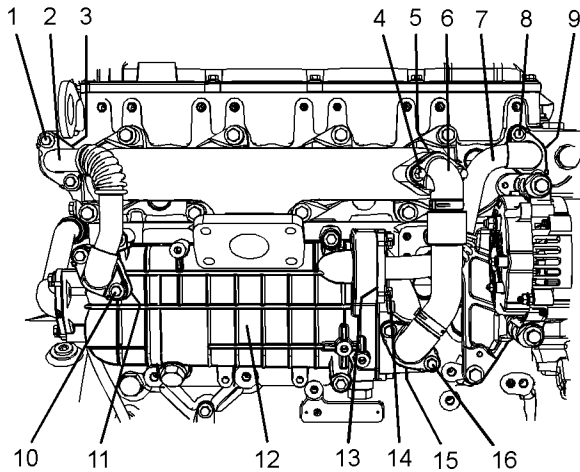


Illustration 50

g02619576

11. Position a new gasket (3) (not shown) and a new gasket (11) (not shown) onto tube assembly (2).
12. Install tube assembly (2) to exhaust cooler (12) and the cylinder head.
13. Install bolts (1) and bolts (10) to tube assembly (2).
14. Tighten bolts (10) to a torque of 18 N·m (159 lb in).
Tighten bolt (2) to a torque of 22 N·m (195 lb in).
15. Position a new gasket (9) (not shown) and install a new gasket (13) (not shown) onto tube assembly (7).
16. Position tube assembly (7) onto exhaust cooler (12) and the cylinder head. Install bolts (8) and bolts (14) to tube assembly (7). Ensure that the tube assembly is correctly positioned into the exhaust cooler.
17. Tighten bolt (14) and bolts (8) to a torque of 22 N·m (195 lb in).
18. Position a new gasket (5) (not shown) and a new gasket (15) (not shown) onto tube assembly (6).
19. Position tube assembly (6) onto exhaust cooler (12) and the exhaust manifold.
20. Install new bolts (4) and new bolts (16) to tube assembly (6).
21. Tighten bolts (4) and bolts (16) to a torque of 22 N·m (195 lb in).

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

End By:

- a. Install the turbocharger. Refer to Disassembly and Assembly, "Turbocharger - Install (Side Mounted Turbocharger)" for the correct procedure.

i05981738

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

Removal Procedure

WARNING

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

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

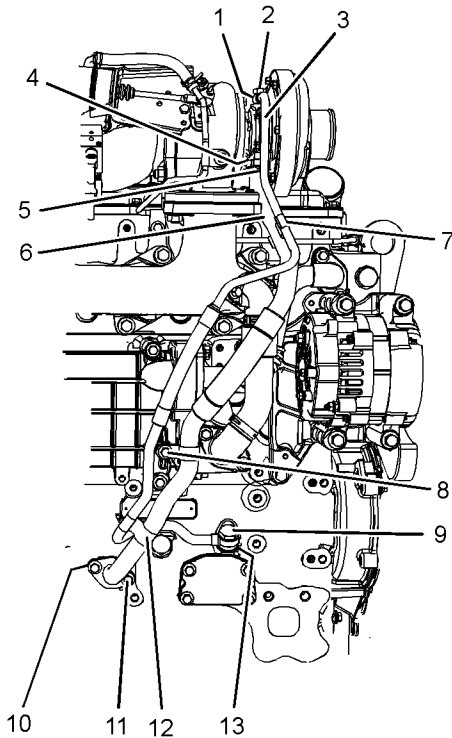


Illustration 51

g02619678

1. Remove clip (7) and clip (12) from tube assembly (3) and tube assembly (6).
2. Remove banjo bolt (2) from tube assembly (3). Remove sealing washers (1) (not shown).
3. Remove banjo bolt (9) from tube assembly (6). Remove sealing washers (13) (not shown).
4. Remove tube assembly (6).
5. remove bolt (8) from clip for tube assembly (6).
6. Remove bolts (5) and bolts (11) from tube assembly (6).
7. Remove tube assembly (6) from the turbo charger and the cylinder block.

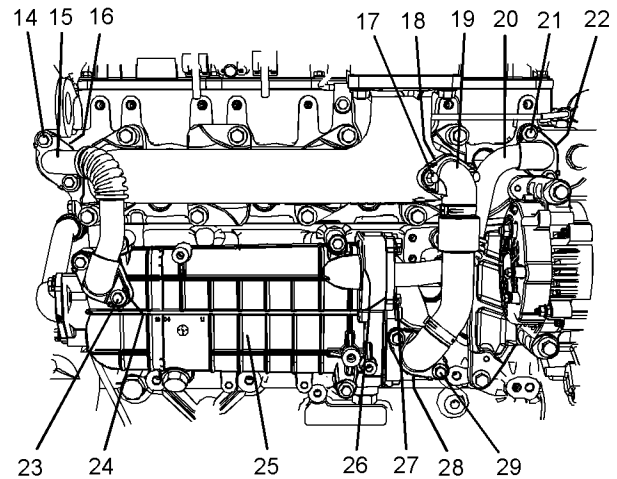


Illustration 52

g02619657

8. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
9. Remove bolts (14) and bolts (23) from tube assembly (15).
10. Remove tube assembly (15) from exhaust cooler (25) and the cylinder head.
11. Remove gaskets (16) (not shown) and gasket (24) (not shown) from tube assembly (15).
12. Prior to and during removal of bolts (17) and bolts (29) apply releasing fluid to the bolts. Remove bolts (17) and bolts (29) from tube assembly (19).
13. Remove tube assembly (19) from exhaust cooler (25) and the exhaust manifold.
14. Remove gaskets (18) (not shown) and gasket (28) (not shown) from tube assembly (19).
15. Remove bolts (21) and bolts (27) from tube assembly (20).
16. Remove tube assembly (20) from exhaust cooler (25) and the cylinder head.
17. Remove gasket (22) (not shown) and gasket (26) (not shown) from tube assembly (20).

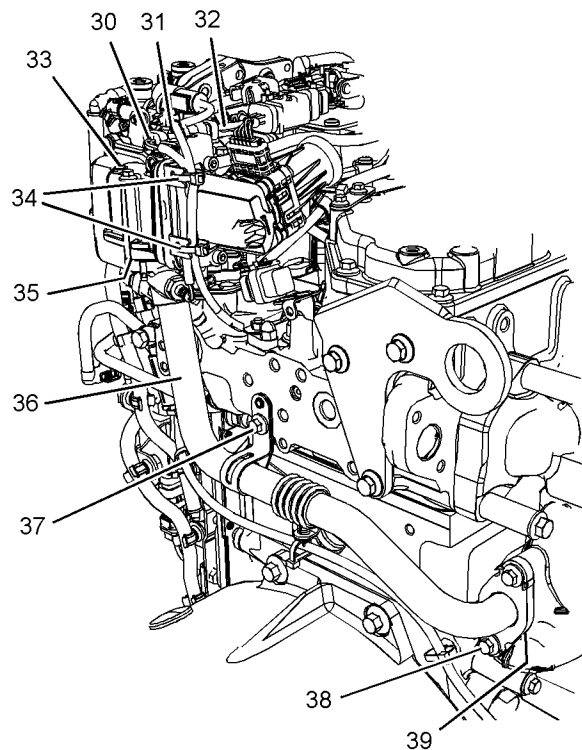


Illustration 53

g02619659

18. Cut cable straps (34) for wiring harness assembly (30). Ensure that all the cable straps are removed from all harness assemblies.
19. Slide locking tab (31) into the unlocked position. Disconnect wiring harness assembly (30) from engine wiring harness assembly (32).
20. Remove bolts (33) from tube assembly (36).
21. Remove bolt (37) from clamp on tube assembly (36).
22. Remove bolts (38) from tube assembly (36).
23. Remove tube assembly (36). Remove gasket (35) (not shown) and gasket (39) (not shown) from tube assembly (36).

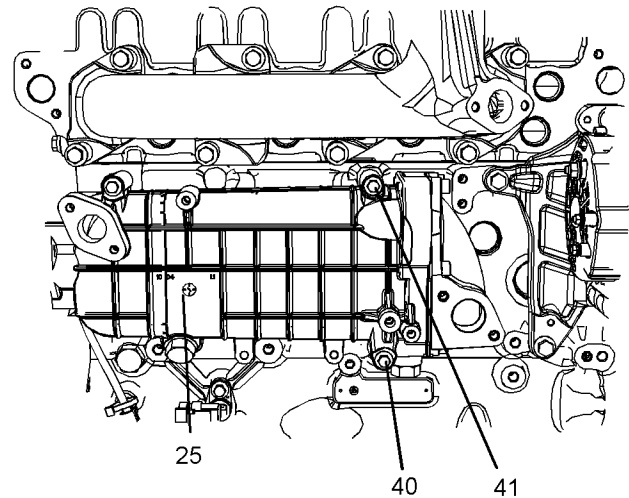


Illustration 54

g02619660

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

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

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

Installation Procedure

NOTICE

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

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

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

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

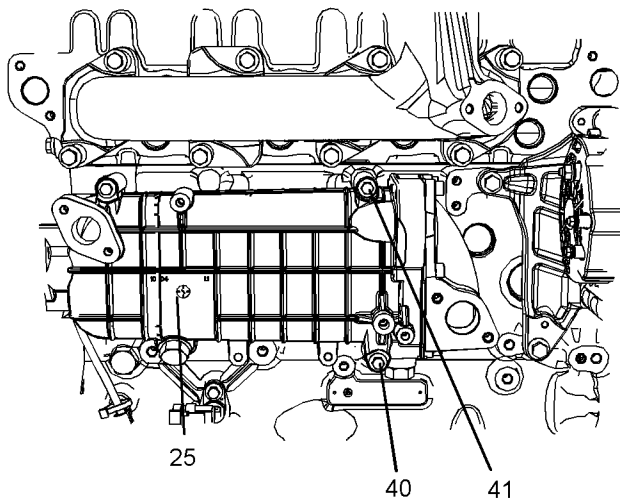


Illustration 55

g02619660

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

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

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

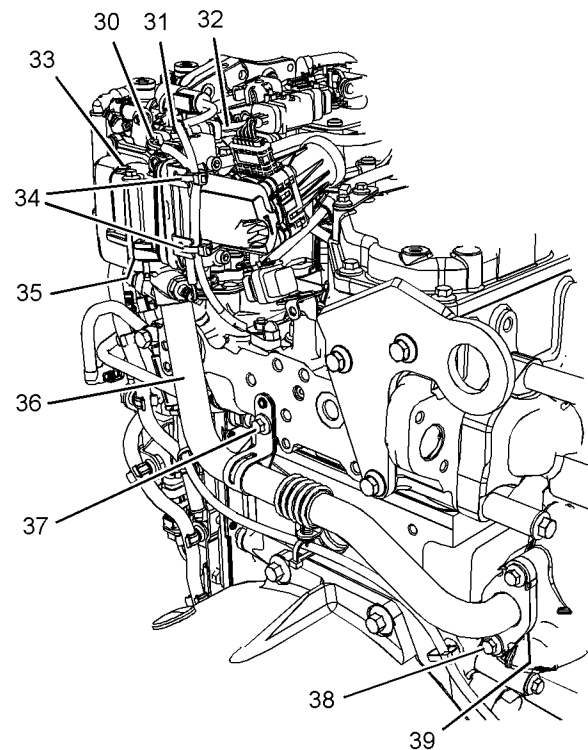


Illustration 56

g02619659

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

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

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

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

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

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

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

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

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

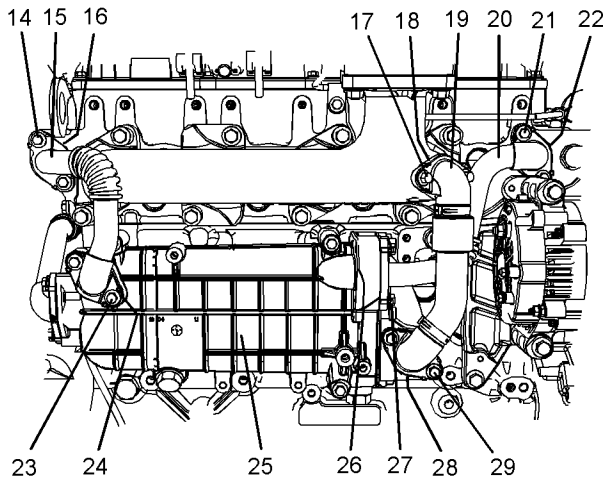


Illustration 57

g02619657

11. Position a new gasket (16) (not shown) and a new gasket (24) (not shown) onto tube assembly (15).
12. Install tube assembly (15) to exhaust cooler (25) and the cylinder head.
13. Install bolts (14) and bolts (23) to tube assembly (15).
14. Tighten bolts (23) to a torque of 18 N·m (159 lb in).
Tighten bolt (14) to a torque of 22 N·m (195 lb in).
15. Position a new gasket (22) (not shown) and install a new gasket (26) (not shown) onto tube assembly (20).
16. Position tube assembly (20) onto exhaust cooler (25) and the cylinder head. Install bolts (21) and bolts (27) to tube assembly (20). Ensure that the tube assembly is correctly positioned into the exhaust cooler.
17. Tighten bolt (21) and bolts (27) to a torque of 22 N·m (195 lb in).
18. Position a new gasket (18) (not shown) and a new gasket (28) (not shown) onto tube assembly (19).
19. Position tube assembly (19) onto exhaust cooler (25) and the exhaust manifold.
20. Install new bolts (17) and new bolts (29) to tube assembly (19).
21. Tighten bolts (17) and bolts (29) to a torque of 22 N·m (195 lb in).

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

i05981790

Inlet Air Control - Remove (NRS Induction Mixer)

Removal Procedure

WARNING

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

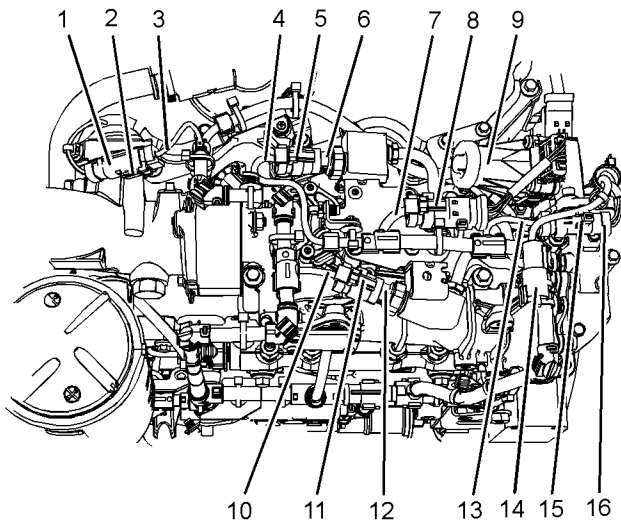


Illustration 58

g02503476

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

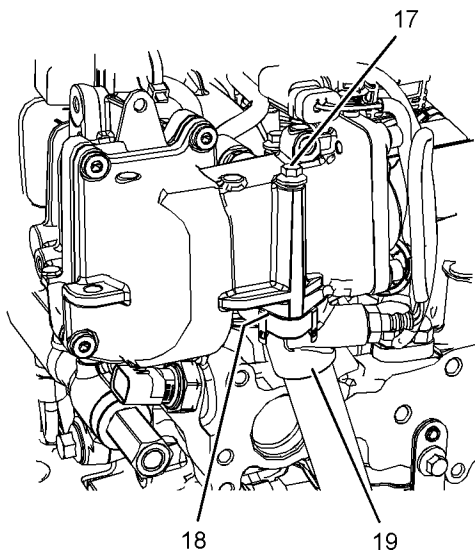


Illustration 59

g02503497

13. Disconnect plastic tube assembly (22) from the valve mechanism cover and the crankcase breather canister. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.
14. Remove bolt from tube assembly (23). Remove banjo bolt (24) and remove sealing washers (25) (not shown).
15. Remove bolts (27) and nut (31) from inlet connection (26).
16. Remove inlet connection (26) and spacer (29). Remove gasket (28) (not shown) and gasket (30) (not shown).
17. Remove bolts (33). Remove the assembly of NRS induction mixer (32) from the cylinder head.
18. Remove gasket (18) from tube assembly (19).
19. Remove gasket (34) (not shown) from assembly of NRS induction mixer (32).

i05981789

Inlet Air Control - Install (NRS Induction Mixer)

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

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

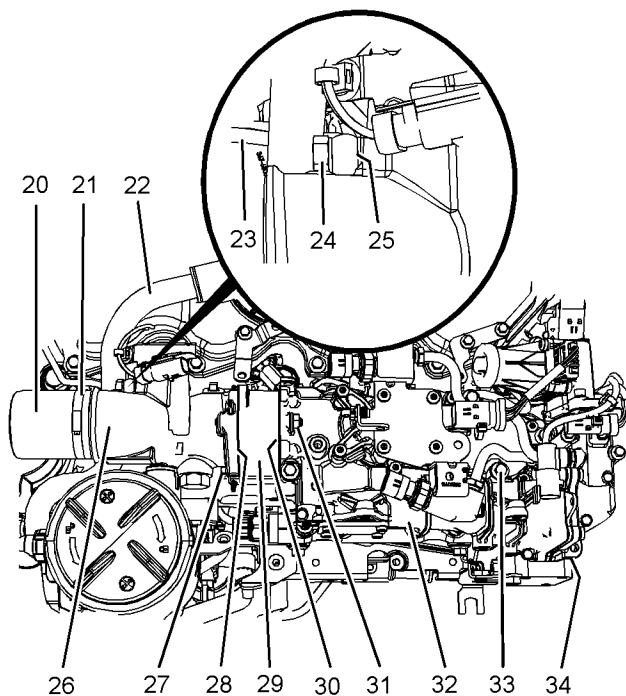


Illustration 60

g02503496

11. Remove bolt (17) from tube assembly (18).
12. Loosen hose clamp (21) on hose assembly (20). Remove hose assembly (20) from the connection of inlet connection (26).

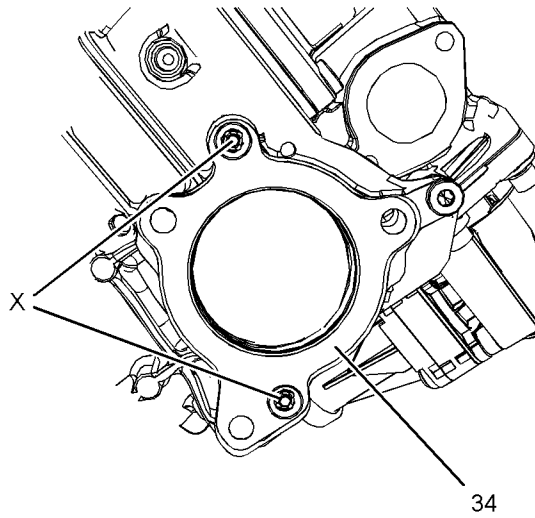


Illustration 61

g02509136

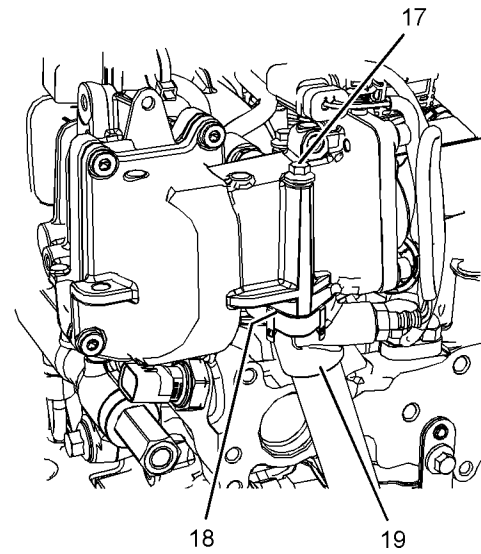


Illustration 63

g02503497

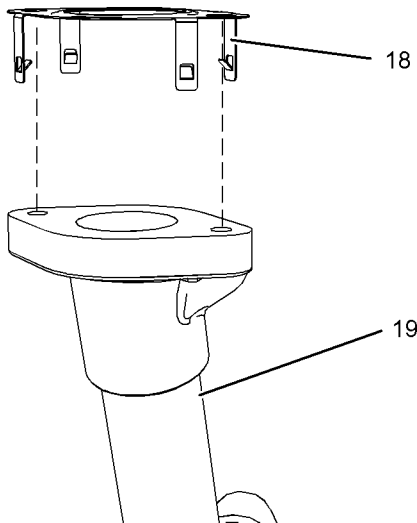


Illustration 62

g02509196

2. Position a new gasket (34) onto locating Pins (X). Ensure that the gasket is correctly orientated onto the NRS induction mixer.
3. Position a new gasket (18) onto tube assembly (19).

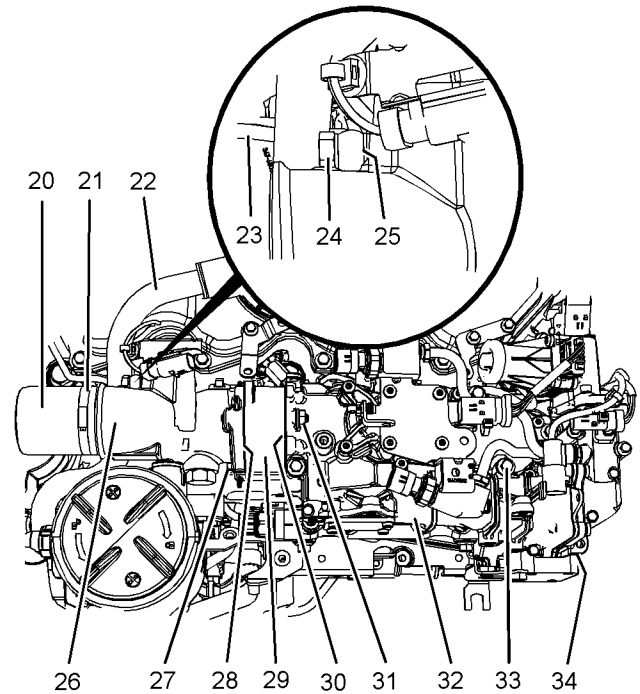


Illustration 64

g02503496

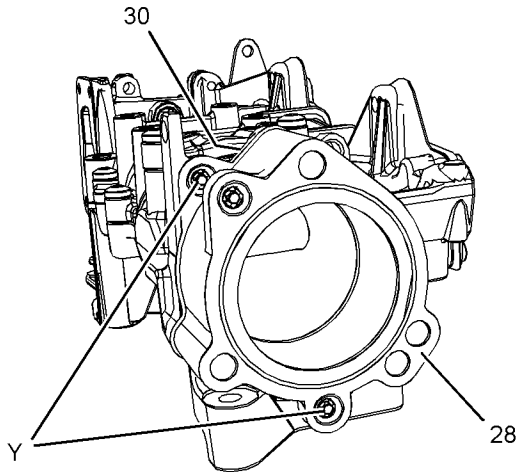


Illustration 65

g02614076

4. Position the assembly of NRS induction mixer (32) onto the cylinder head.
 5. Loosely install bolts (33) to the assembly of NRS induction mixer (32).
 6. Loosely install bolts (17) to tube assembly (18). Ensure that gasket (18) is still correctly located on tube assembly (18).
 7. Tighten bolts (33) to a torque of 22 N·m (195 lb in).
 8. Tighten bolts (17) to a torque of 9 N·m (80 lb in).
 9. Position a new gasket (30) onto NRS induction mixer ensure that the gasket is correctly located onto Pins (Y).
 10. Position a new gasket (28) onto the spacer ensure that the gasket is correctly located onto Pins (Y).
 11. Position spacer (29) onto inlet connection (26).
- Note:** Ensure that the spacer is correctly orientated.
12. Install assembly of inlet connection (26). Install bolts (27) and nut (31).
- Note:** Ensure that the inlet connection is correctly orientated.
13. Tighten bolts (27) and nut (31) to a torque of 22 N·m (195 lb in).
 14. Position a new sealing washer (25) (not shown) onto banjo bolt (24). Install the banjo bolt onto tube assembly (23) and install the remaining new sealing washer (25) (not shown).

15. Tighten banjo bolt (24) to a torque of 15 N·m (133 lb in).
16. Install the bolt for tube assembly (23). Tighten bolts to a torque of 22 N·m (195 lb in).
17. Position hose assembly (20) onto the inlet connection (26). Tighten hose clamp (21) securely.
18. Connect plastic tube assembly (22) to the valve mechanism cover and the crankcase breather canister. Refer to Disassembly and Assembly, "Crankcase Breather - Install" for the correct procedure.

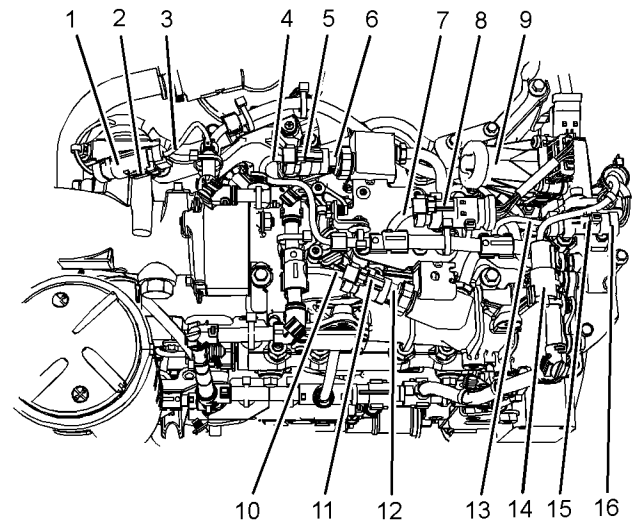


Illustration 66

g02503476

19. If necessary, connect harness assembly (14) for the glow plug.
 20. Position engine harness assembly onto NRS induction mixer. Ensure that the engine harness assembly is correctly routed.
 21. Connect harness assembly (13) to temperature sensor (16) for the NRS induction mixer. Slide locking tab (15) into the locked position.
 22. Install new cable the straps to temperature sensor (16).
- Note:** Ensure that the cable straps meet Original Equipment Manufacturers (OEM) specifications.
23. Connect wiring harness assembly (10) to inlet pressure sensor (12). Slide locking tab (11) into the locked position.
 24. Connect wiring harness assembly (4) to outlet pressure sensor (6). Slide locking tab (5) into the locked position.

- 25.** Connect wiring harness assembly (3) to wiring harness assembly (1) for the wastegate solenoid. Slide locking tab (2) into the locked position.
- 26.** Connect harness assembly (7) to NRS valve (9). Slide locking tab (8) into the locked position.
- 27.** Install new cable straps to the engine wiring harness. Ensure that the engine wiring harness is correctly routed and that all cable straps are correctly positioned.
- Note:** Ensure that the cable straps meet OEM specifications.
- 28.** If necessary, install secondary fuel filter base and bracket. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
- 29.** If necessary, install water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
- 30.** If the Clean Emissions Module (CEM) assembly is mounted on the valve mechanism cover, installation of the DPF assembly will be necessary after the NRS induction mixer has been installed. Refer to Disassembly and Assembly, “Clean Emissions Module - Remove and Install” for the correct procedure.

i05981760

Fuel Injection Pump - Remove

Removal Procedure

Table 10

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	T410437	Plugging Kit	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

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

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

WARNING

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

NOTICE

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

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

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

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

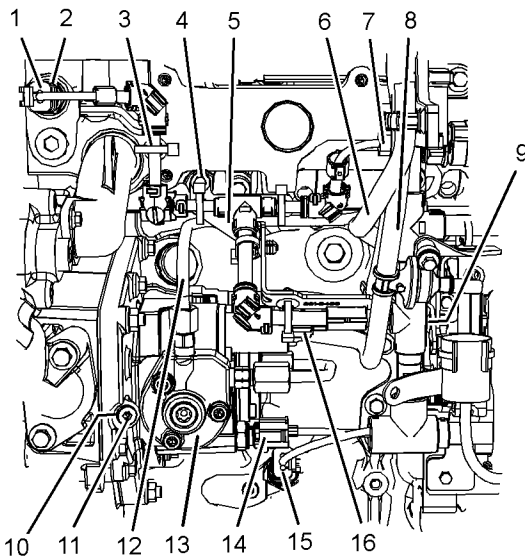


Illustration 67

g02482036

3. Remove plug (11) and remove O-ring seal (10) (not shown).
4. Install Tooling (C) to fuel injection pump (13).
5. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.
6. Use Tooling (B) in order to ensure that the crankshaft is locked with number one piston at top dead center.
7. Cut cable strap (3) from harness assembly (1).
8. Disconnect harness assembly (1) from coolant temperature sensor (2). Refer to Disassembly and Assembly, "Coolant Temperature Sensor - Remove and Install" for the correct procedure.
9. Disconnect harness assembly (7) from the pressure sensor in the fuel manifold.
10. Disconnect harness assembly (16) from the flow control valve.
11. Disconnect harness assembly (14) from the fuel temperature sensor.
12. Disconnect harness assembly (15) from the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install" for the correct procedure.
13. Remove bolt (4) and bolt (9) (not shown) from bracket (5). Remove the bracket and position away from the fuel injection pump.

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

14. Clean fuel injection pump (13) and the area around the fuel injection pump. Ensure that the area is free from contamination before beginning disassembly.
15. Place a suitable container below fuel injection pump (13) in order to catch any fuel that might be spilled.
16. Disconnect plastic tube assembly (6) and plastic tube assembly (8) from fuel injection pump (13). Use Tooling (D) in order to plug the plastic tube assemblies. Cap the connections for plastic tube assemblies on the fuel injection pump.
17. Remove fuel injection line (12) that connects fuel injection pump (13) to the fuel manifold. Refer to Disassembly and Assembly, "Fuel Injection Lines - Remove" for the correct procedure.
18. Use Tooling (D) in order to plug the open ports in the fuel injection pump and in the fuel manifold.
Discard the fuel injection line.

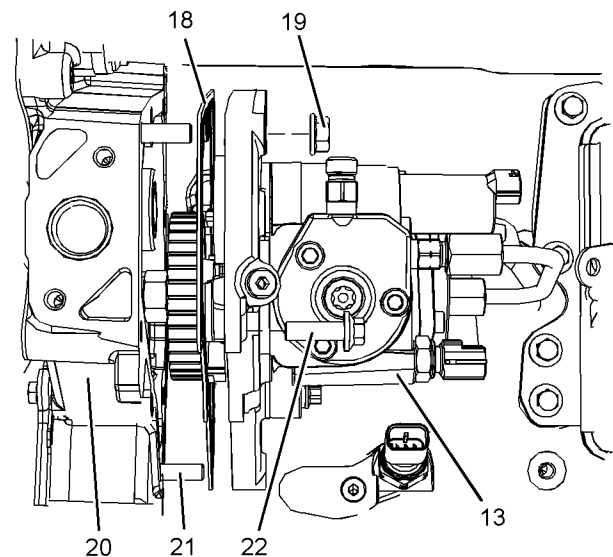


Illustration 68

g02482038

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

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

20. Carefully remove fuel injection pump (13) from front housing (20). Ensure that the bore in front housing (20) is not damaged as the fuel injection pump is removed.
21. Remove gasket (18).
22. If necessary, remove studs (21) from front housing (20).

i05981759

Fuel Injection Pump - Install

Installation Procedure

Table 11

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	
C	T400015	Timing Pin (Fuel Injection Pump)	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

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

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

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

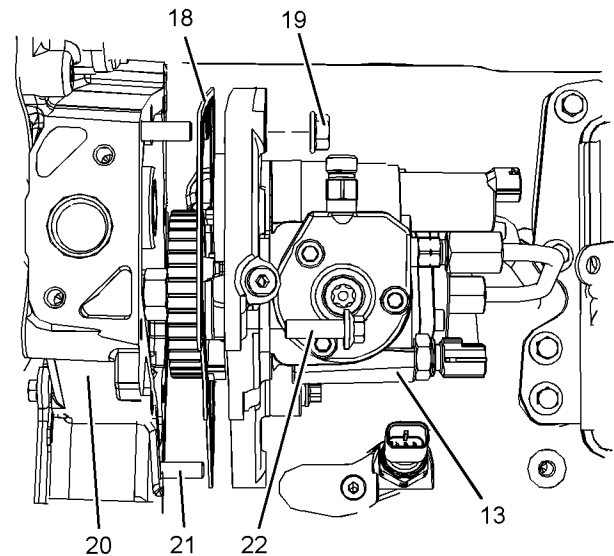


Illustration 69

g02482038

1. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.
 2. Use Tooling (B) in order to lock the crankshaft so that number one piston is at top dead center.
 3. Use Tooling (C) in order to lock fuel injection pump (13) in the correct position. Refer to System Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.
 4. If necessary, install studs (21) from front housing (20). Tighten the studs to a torque of 11 N·m (97 lb in).
 5. Position a new gasket (18) onto front housing (20).
 6. Carefully install fuel injection pump (13) to front housing (20). Ensure that front housing (20) is not damaged as the fuel injection pump is installed.
- Note:** The fuel injection pump should be supported by hand as the bolts are installed.
7. Install nuts (19) to fuel injection pump (13) finger tight.
 8. Install new bolts (22) to fuel injection pump (13). Ensure that the different length bolts are installed in to the correct position.
 9. Tighten bolts (22) to a torque of 22 N·m (195 lb in).
Tighten nut (19) to a torque of 22 N·m (195 lb in).

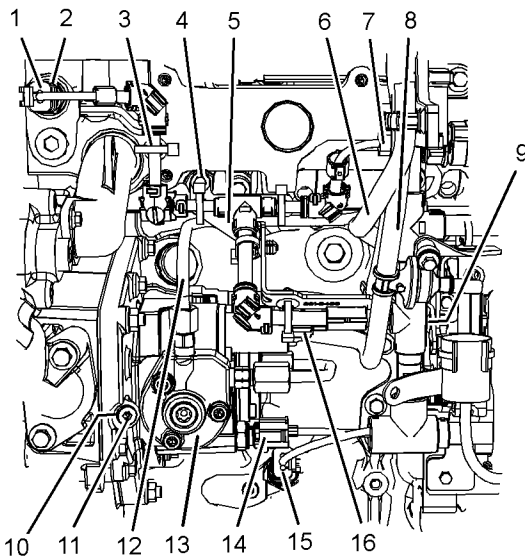


Illustration 70

g02482036

10. Remove Tooling (C) from fuel injection pump (9). Install a new O-ring seal (7) (not shown) to plug (8).
 11. Install plug (8) to fuel injection pump (9). Tighten the plug to a torque of 14 N·m (124 lb in).
 12. Remove the appropriate caps in order to install fuel injection line (1). Install a new fuel injection line (1) to the fuel injection pump and to the fuel manifold. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for the correct procedure.
 13. Position harness assembly (1) and bracket (5) onto the cylinder head. Loosely install bolt (4) and bolt (9) (not shown) to bracket (5).
 14. Connected harness assembly (1) to coolant temperature sensor (2). Refer to Disassembly and Assembly, "Coolant Temperature Sensor - Remove and Install" for the correct procedure.
 15. Install a new cable strap (3) to harness assembly (1).
- Note:** Ensure that the new cable strap meets Original Equipment Manufactures (OEM) specifications.
16. Connected harness assembly (7) to the pressure sensor in the fuel manifold.
 17. Connected harness assembly (16) to the flow control valve.
 18. Connected harness assembly (14) to the fuel temperature sensor. Refer to Disassembly and Assembly, "Fuel Temperature Sensor - Remove and Install" for the correct procedure.

19. Connected harness assembly (15) to the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install" for the correct procedure.
20. Tighten bolt (4) and bolt (9) (not shown) to a torque of 9 N·m (80 lb in).
21. Remove caps from connections for the plastic tube assemblies on fuel injection pump (13). Remove plugs from plastic tube assembly (6) and plastic tube assembly (8).
22. Connect plastic tube assembly (6) and plastic tube assembly (8) to fuel injection pump (13).

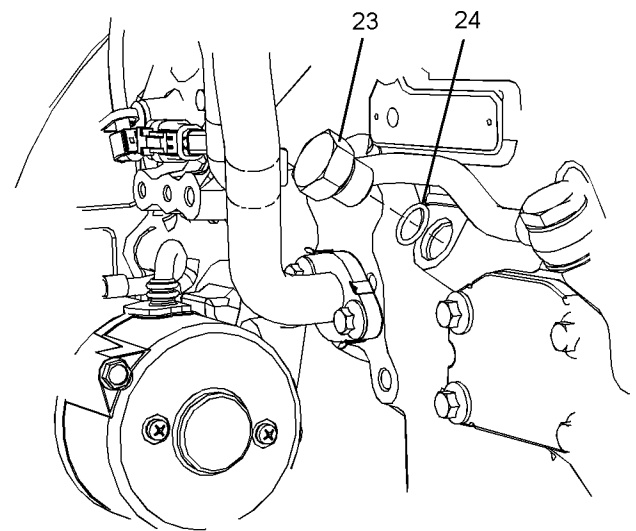


Illustration 71

g02612176

23. Remove Tooling (B) from the cylinder block.
24. Install a new O-ring seal (24) to plug (23). Install the plug into the cylinder block. Tighten plug (23) to a torque of 21 N·m (186 lb in).
25. Turn the fuel supply to the ON position.
26. Turn the battery disconnect switch to the ON position.
27. Install crankcase breather canister and plastic tube assemblies. Refer to Disassembly and Assembly, "Crankcase Breather - Install" for the correct procedure.
28. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for the correct procedure.

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

i05981762

Fuel Injection Pump Gear - Remove

Removal Procedure

Table 12

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Puller (Two Leg)	1

Start By:

- a. Remove the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

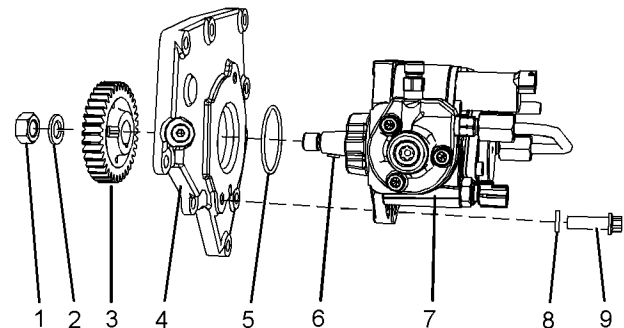


Illustration 72

g02483636

1. Use a suitable tool in order to prevent fuel injection pump gear (3) from rotating. **Ensure that the gear is not damaged as nut (1) is loosened.**

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

2. Remove nut (1) and washer (2).
3. Use Tooling (A) in order to remove gear (3) from the shaft of fuel injection pump (7).
4. Remove key (6) from the shaft of fuel injection pump (7).
5. Remove bolts (9) and washers (8). Remove adapter plate (4) from fuel injection pump (7).
6. Remove O-ring seal (5).

i05981761

Fuel Injection Pump Gear - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

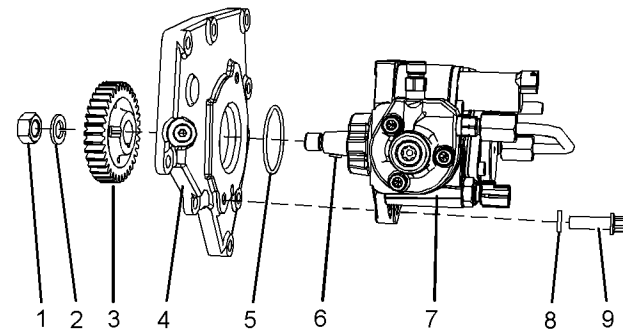


Illustration 73

g02483636

2. Position a new O-ring seal (5) onto fuel injection pump (7).
 3. Position adapter plate (4) onto fuel injection pump (7).
 4. Install new bolts (9) and washer (8). Tighten the bolts to a torque of 22 N·m (195 lb in).
 5. Install key (6) to the shaft of fuel injection pump (7).
 6. Position gear (3) onto the shaft of fuel injection pump (7).
 7. Position a new washer (2) onto the shaft of the fuel injection pump. Install nut (1) and tighten the nut hand tight.
 8. Use a suitable tool in order to prevent fuel injection pump gear (3) from rotating. **Ensure that the gear is not damaged as nut (1) is tightened.**
- Note: Do not use timing pin for the fuel injection in order to prevent the fuel injection pump gear from rotating.**
9. Tighten nut (1) to a torque of 64 N·m (47 lb ft).

End By:

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

i06988000

Electronic Unit Injector - Remove

Removal Procedure

Table 13

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

Start By:

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

WARNING

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

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

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

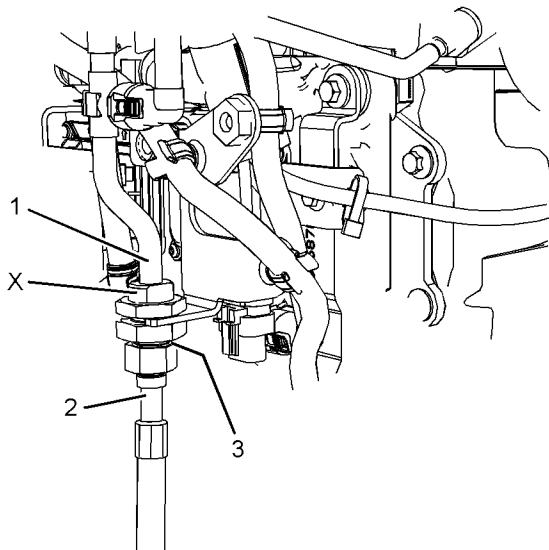


Illustration 74

g02475251

3. Place a suitable container below tube assembly (1) to catch any fuel that might be spilled.
4. Use a suitable tool in Position (X) to hold tube assembly (1) as nut on hose assembly (2) is loosened.
5. Loosen the nut on hose assembly (2) to allow the fuel to drain from tube assembly (1).

6. Remove hose assembly (2) from tube assembly (1). Remove O-ring seal (3) (not shown).
7. Use Tooling (C) to cap the hose assembly immediately. Use Tooling (C) to plug the tube assembly immediately.

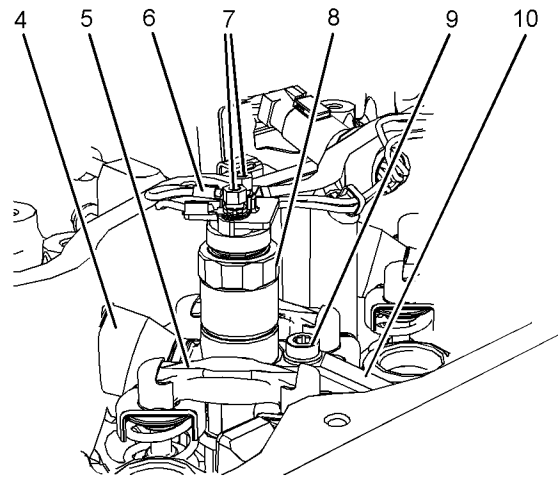


Illustration 75

g01971773

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

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

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

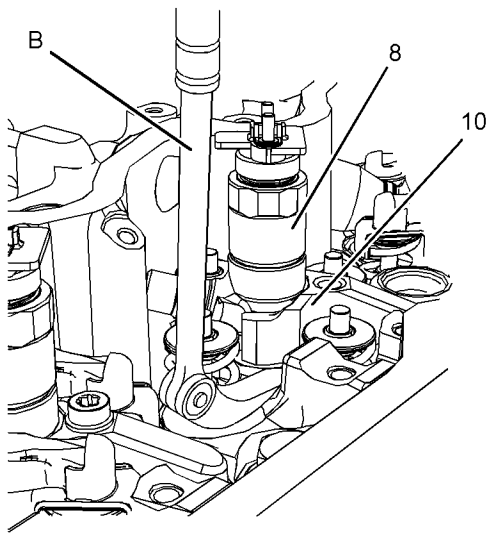


Illustration 76

g01971775

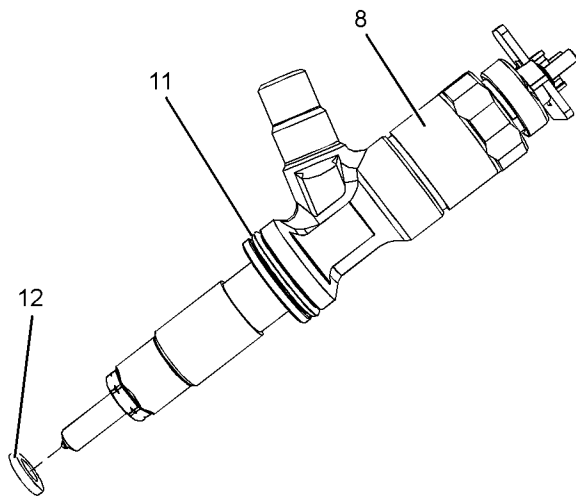


Illustration 77

g01972153

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

Note: Always handle electronic unit injectors with care.

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

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

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

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

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

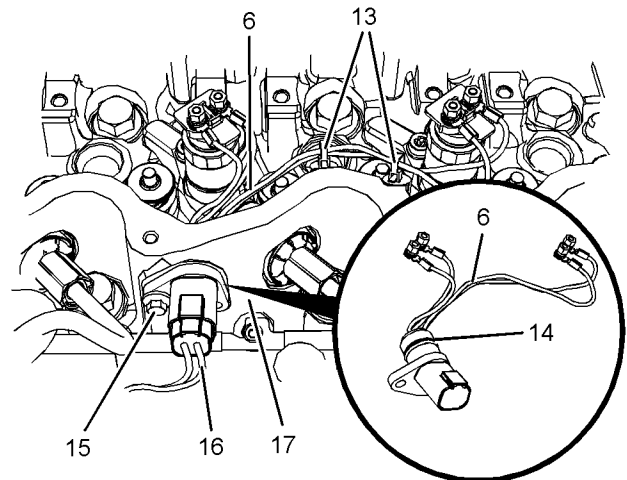


Illustration 78

g02047333

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

- a. Place a temporary identification mark on harness assembly (6) for the electronic unit injectors.
- b. Cut cable straps (13) and remove the remaining sections of the cable straps from the cylinder head.
- c. Disconnect harness assembly (16) from harness assembly (6).
- d. Remove bolt (15) for harness assembly (6).
- e. Withdraw harness assembly (6) from cylinder head (17).
- f. Remove O-ring seal (14) from harness assembly (6).
- g. If necessary, repeat Step 18a through Step 18f to remove the remaining harness assemblies

from the cylinder head.

i06988037

Electronic Unit Injector - Install

Installation Procedure

Table 14

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610307	T40 Torx Socket	1
D	GE50028	Vacuum Pump	1
	GE50046	Fluid Sampling Bottle	1
	GE50030	Tube 7.9 mm (0.31 inch) Outside Diameter	1
E	T400030	Wrench	1
F	27610296	Torque Wrench	1

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

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

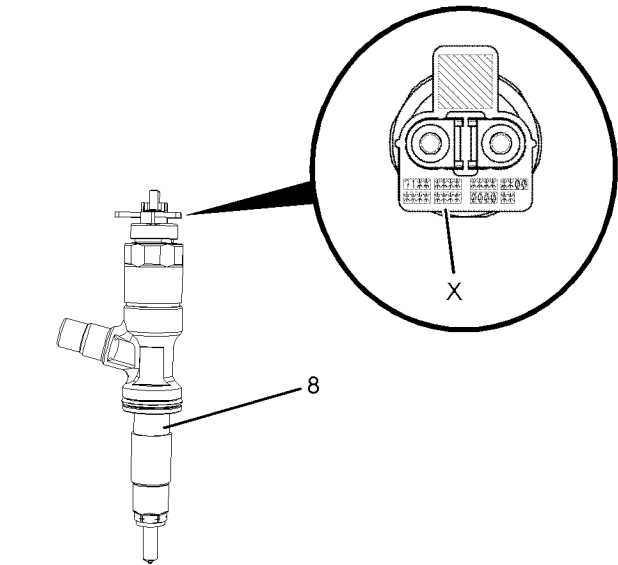


Illustration 79

g01973053

Injector code location

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

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

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

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

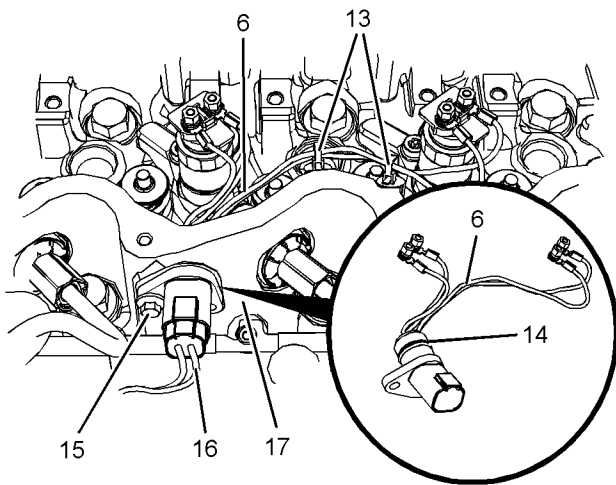


Illustration 80

g02047333

3. If necessary, follow Step 3a through Step 3f to install harness assemblies (6) to cylinder head (17).
 - a. Install a new O-ring seal (14) to harness assembly (6).

Note: Do not lubricate the O-ring seal.

 - b. Install harness assembly (6) to cylinder head (17).
 - c. Install a new bolt (15) to harness assembly (6). Tighten the bolt to a torque of 5.5 N·m (49 lb in).
 - d. Install new assemblies of the cable strap (13) to harness assembly (6).

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

- e. Connect harness assembly (16) to harness assembly (6).
 - f. If necessary, repeat Step 3a through Step 3e to install the remaining harness assemblies to the cylinder head.
4. Ensure that the fuel inlet port of the electronic unit injector is capped. Ensure that the electronic unit injector is clean.

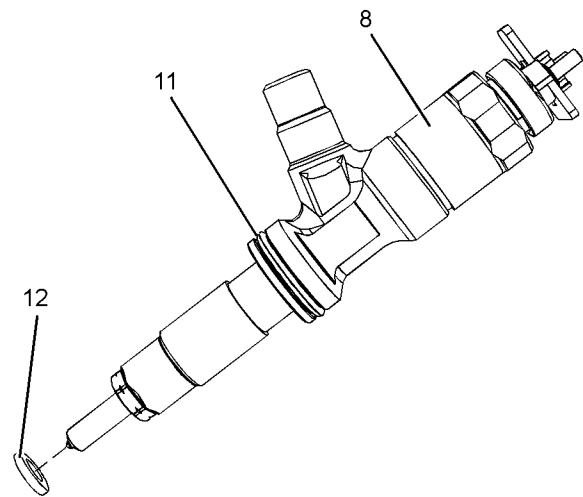


Illustration 81

g01972153

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

Note: Do not lubricate the O-ring seal.
6. Use a suitable tool to install a new sealing washer (12) to electronic unit injector (8).

Note: Ensure that the nozzle for the electronic unit injector is not damaged in any way on installation of the new sealing washer.
7. Ensure that O-ring seal (12) and sealing washer (12) on a new electronic unit injector are not damaged and in place.

Note: Do not lubricate the O-ring seal.
8. Ensure that the seat for the electronic unit injector in the cylinder head is clean and free from damage. Ensure that the sealing washer has been removed from the cylinder head.

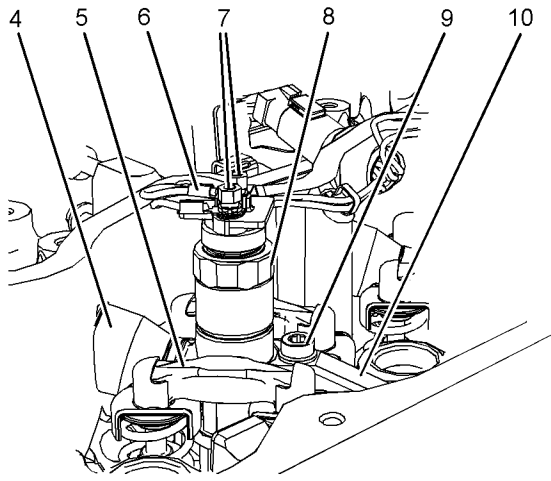


Illustration 82

g01971773

9. Position clamp (10) between the valve springs. Align electronic unit injector (8) to the bore for the electronic unit injector in the cylinder head. Install the clamp to the electronic unit injector. Ensure that the electronic unit injector is pushed firmly against the seat in the cylinder head.
 10. Install a new Torx screw (9) to clamp (10). Tighten the Torx screw finger tight.
 11. Remove the cap from electronic unit injector (8). Install a new seal (4) to electronic unit injector (8) and to the cylinder head. Ensure that the flange on the seal is flush with the cylinder head.
 12. Remove the plugs from the new fuel injection line. Loosely install the fuel injection line. Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for the correct procedure.
- Note:** Ensure that the ends of the fuel injection line are seated in the electronic unit injector and the fuel manifold. Tighten the nuts finger tight.
13. Use Tooling (A) to tighten Torx screw (12) to a torque of 27 N·m (239 lb in).
 14. Use Tooling (E) to tighten the fuel injection line to a torque of 55 N·m (41 lb ft). Refer to Disassembly and Assembly, "Fuel Injection Lines - Install" for the correct procedure.
 15. Use a deep socket to install harness assembly (6) to electronic unit injector (8). Use Tooling (F) to tighten connections (7) to a torque of 2.0 N·m (18 lb in).

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

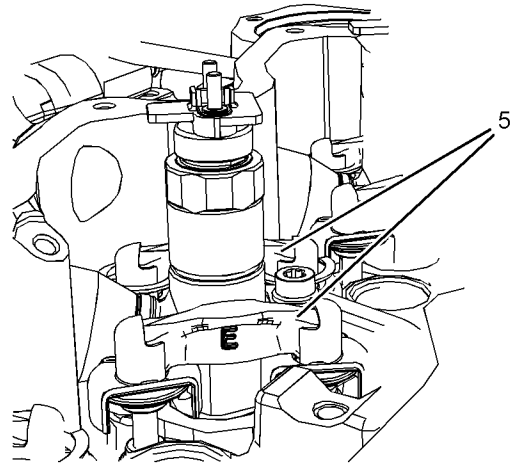


Illustration 83

g01973093

The correct location of valve bridges

NOTICE

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

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

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

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

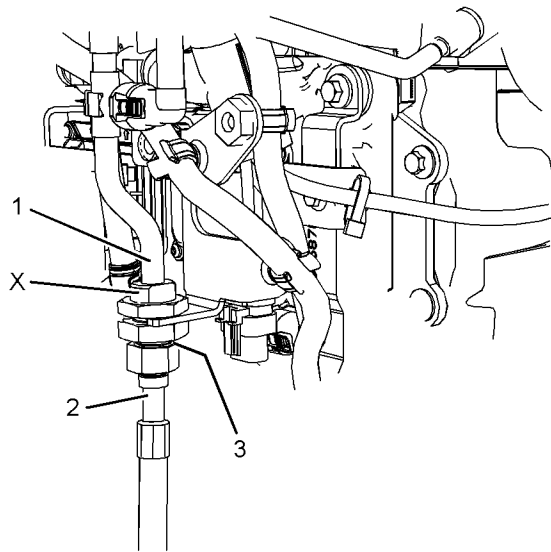


Illustration 84

g02475251

19. Remove cap from tube assembly (1). Install a new O-ring seal (3) (not shown) to tube assembly (1).
20. Remove cap from hose assembly (2). Install hose assembly (2) to tube assembly (1).
21. Use a suitable tool to hold tube assembly (1) in Position (X). Tighten nut for hose assembly (2) to a torque of 43 N·m (32 lb ft).
22. Turn the fuel supply to the ON position.
23. Turn the battery disconnect switch to the ON position.
24. Remove the air from the fuel system. Refer to Operation and Maintenance Manual, "Fuel System - Prime" for the correct procedure.

i05981903

Turbocharger - Remove (First Stage Turbocharger)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

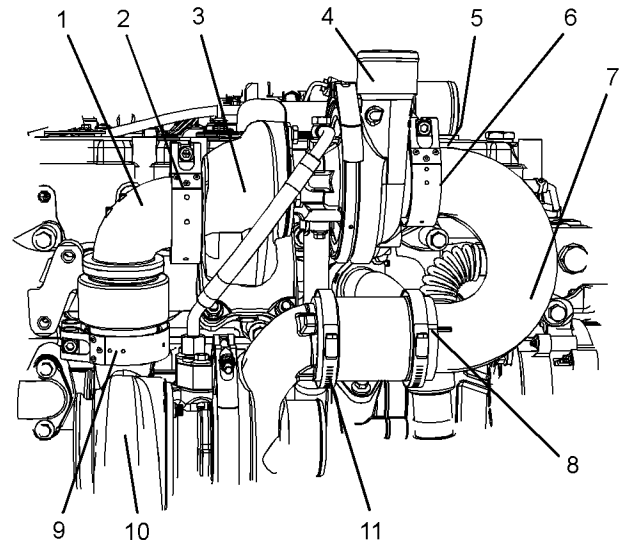


Illustration 85

g02526997

1. Loosen the hose clamp and disconnect hose assembly from air outlet (4) from turbocharger (3).
 2. Slide hose clamp along hose assembly (5). Disconnect hose assembly (5) from the wastegate actuator.
 3. Loosen the allen head bolt on V-band clamp (2) and loosen the allen head bolt on V-band clamp (9) from elbow (1). Remove the V-band clamps from the elbow.
- Note:** If the V-band clamps remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the allen head bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**
4. Remove elbow (1) from turbocharger (3) and turbocharger (10).
 5. Loosen allen head bolt on V-band clamp (6) on air duct (7) and loosen hose clamps (11).

Note: If the V-band clamp remains tight on the flange, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the allen head bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**

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

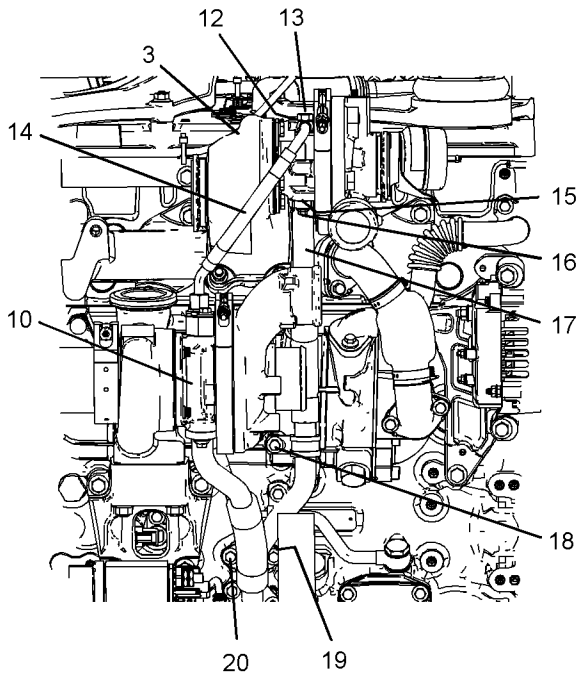


Illustration 86

g03734673

7. Remove banjo bolt (13) from hose assembly (14).
8. Remove sealing washers (12) (not shown).
9. Disconnect hose assembly (14) from the connection on turbocharger (10). Plug and cap the turbocharger. Plug and cap the hose assembly.
10. Remove hose assembly (14).
11. Remove bolt (18) from the clip for tube assembly (17).
12. Remove bolts (16) and bolts (20) from tube assembly (17).
13. Remove tube assembly (17) from turbocharger (3) and the cylinder block.
14. Remove gasket (15) (not shown) and gasket (19) (not shown) from tube assembly (17).

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

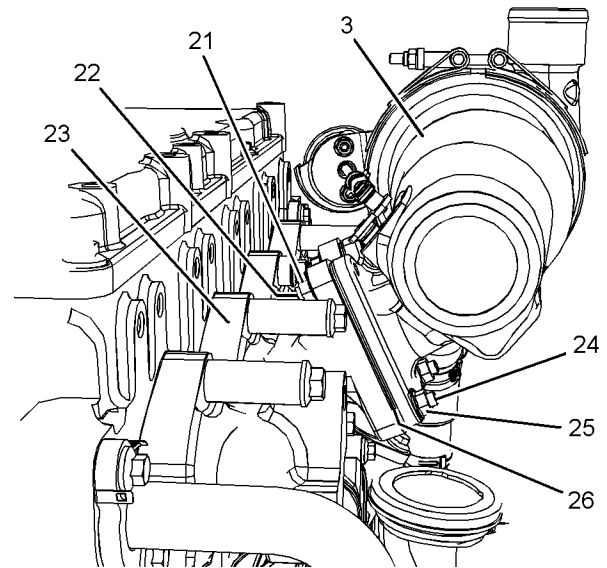


Illustration 87

g02526999

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

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

16. Remove turbocharger (3) from exhaust manifold (23).
17. Remove gasket (26) (not shown).
18. If necessary, remove studs (22) (not shown) from turbocharger (3).

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

i05981907

Turbocharger - Remove (Second Stage Turbocharger)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

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

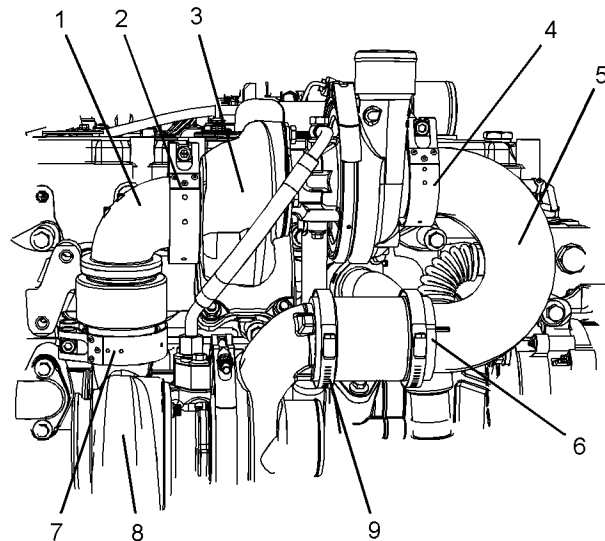


Illustration 88

g02529457

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

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

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

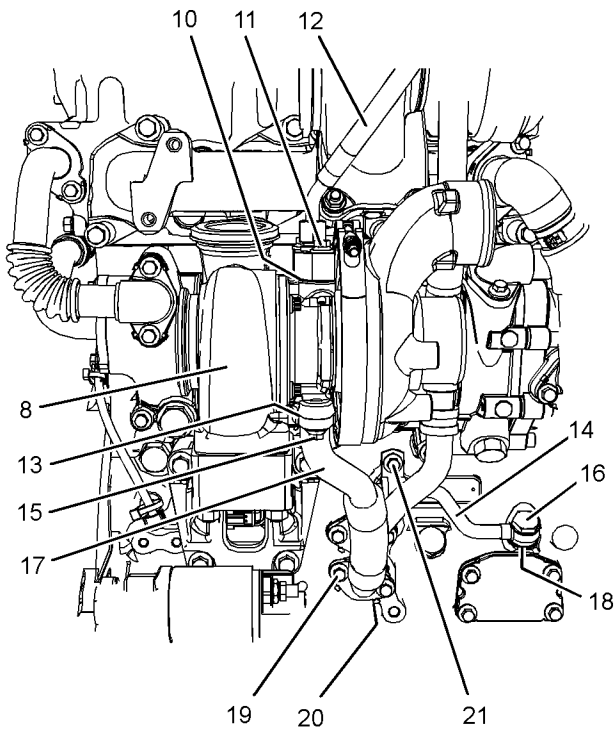


Illustration 89

g02529478

5. Disconnect hose assembly (12) from the connection on turbocharger (8). Plug the connection on the turbocharger. Cap the hose assembly.
6. Remove bolts (11) from tube assembly (14).
7. Remove bolt (21) from clamp for tube assembly (14).
8. Remove banjo bolt (16). Remove sealing washers (18) (not shown).
9. Remove tube assembly (14) from turbocharger (8). Plug the tube assembly. Plug the turbocharger and the cylinder block.
10. Remove gasket (10) (not shown).
11. Remove bolts (15) and bolts (19) from tube assembly (17).
12. Remove tube assembly (17) from turbocharger (8).
13. Remove gasket (13) (not shown) and gasket (20) (not shown).

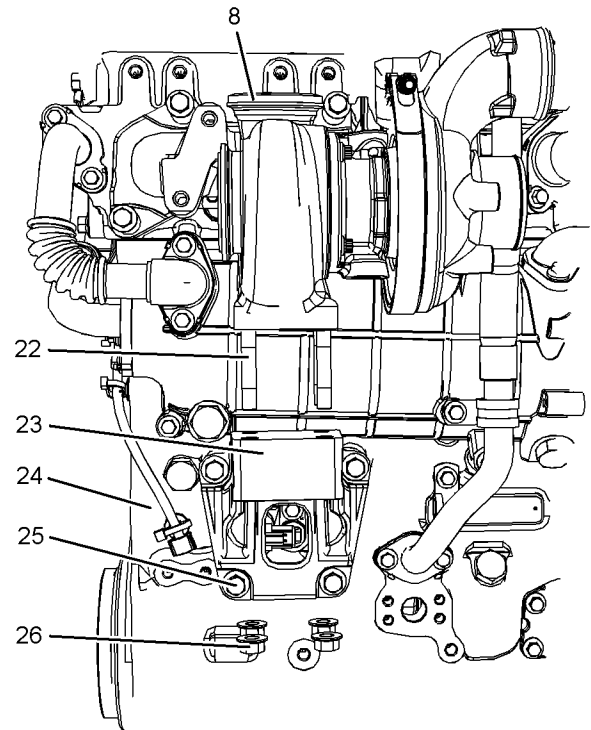


Illustration 90

g02529479

14. Remove nuts (26).
15. Remove turbocharger (8) from bracket (23).
16. If necessary, remove studs (22) from turbocharger (8).
17. If necessary, follow Step 17a through Step 17b in order to remove bracket (23) from cylinder block (24).
 - a. Remove bolts (25).

Note: Support the bracket as the bolts are removed.

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

i05981913

Turbocharger - Remove (Side Mounted Turbochargers)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

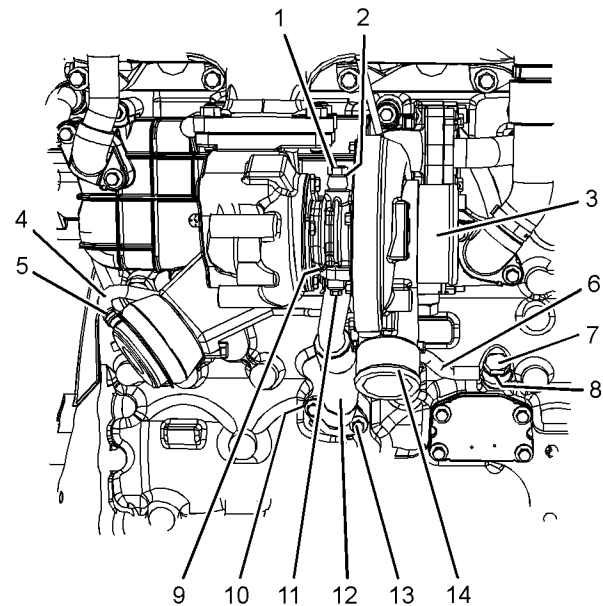
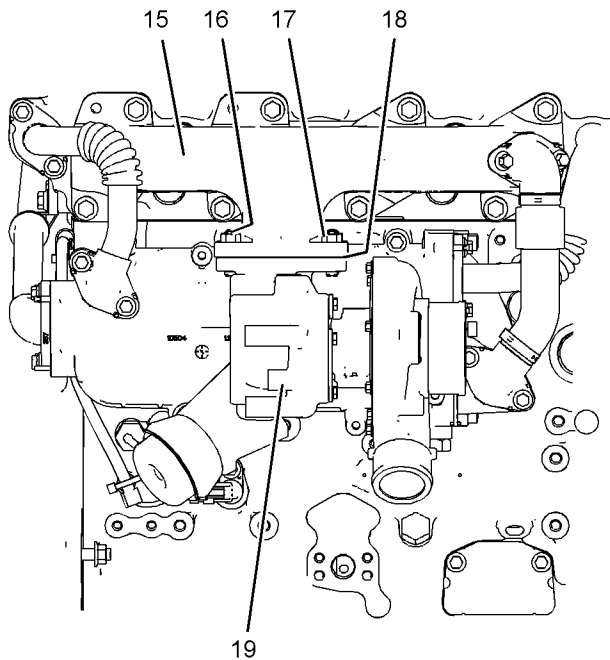


Illustration 91

g03735740

1. Loosen hose clamps and disconnect the hose assemblies from turbocharger inlet (3) and from turbocharger outlet (14).
2. Remove banjo bolt (1) from tube assembly (6). Remove sealing washers (2) (not shown).
3. Remove banjo bolt (7) from tube assembly (6). Remove sealing washers (8) (not shown).
4. Remove tube assembly (6) from the turbocharger and the cylinder block.
5. Slide hose clamp (5) along hose assembly (4). Disconnect hose assembly (4) from the wastegate actuator.
6. Remove bolts (11) and bolts (13). Remove tube assembly (12) from the turbocharger.
7. Remove gasket (9) (not shown) and gasket (10) (not shown).



i05981915

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

Turbocharger - Remove (Top Mounted Turbocharger)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Illustration 92

g03735741

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

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

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

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

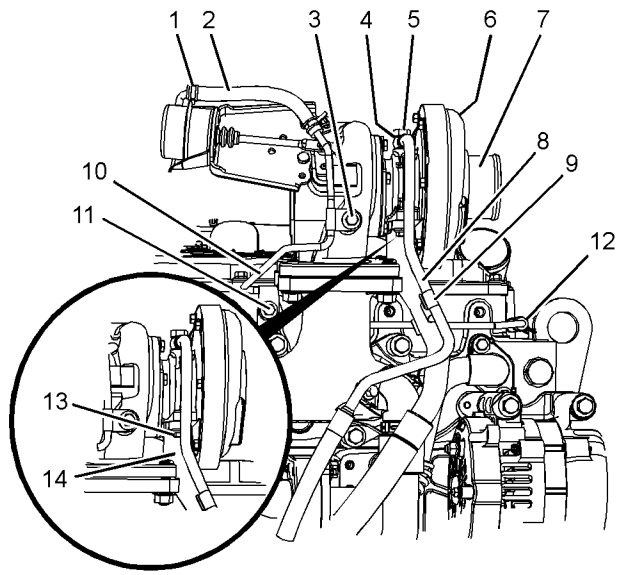


Illustration 93

g02568360

Typical example

1. Loosen hose clamps and disconnect the hose assemblies from turbocharger inlet (7) and from turbocharger outlet (6) (not shown).
2. Remove banjo bolt (5) from tube assembly (8). Remove sealing washers (4) (not shown).
3. Remove clip (9) from tube assembly (8) and tube assembly (14).
4. Slide hose clamp (1) along hose assembly (2). Disconnect hose assembly (2) from the wastegate actuator.
5. Remove bolt (3) and bolt (11) for tube assembly (10).
6. Slide hose clamp (12) along the hose assembly. Remove tube assembly (10).
7. Remove bolts (13) tube assembly (14).

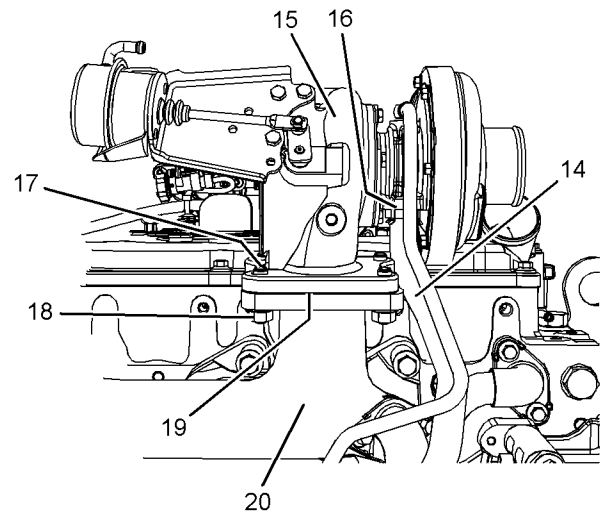


Illustration 94

g03735212

Typical example

8. Remove nuts (18). Remove turbocharger (15) from exhaust manifold (20).
- Note:** Do not use the actuator rod to lift the turbocharger.
9. Remove gasket (19) (not shown).
 10. Remove gasket (16) (not shown) from tube assembly (14).
 11. If necessary, remove the studs (17) (not shown) from turbocharger (15).

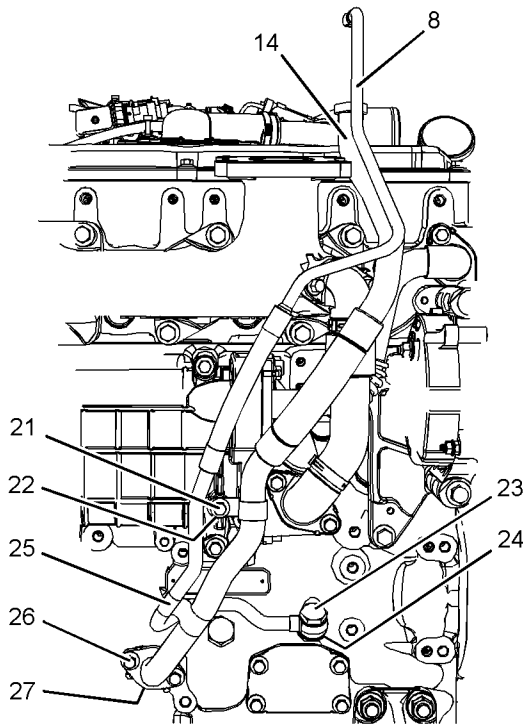


Illustration 95

g02570158

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

- a. Remove clip (25) from tube assembly (8) and tube assembly (14).
- b. Remove banjo bolt (23) from tube assembly (8). Remove sealing washers (24) (not shown).
- c. Remove bolts (21) and spacer (22) (not shown).
- d. Remove tube assembly (8).
- e. Remove bolts (26) and remove tube assembly (14).

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

i05981902

Turbocharger - Install (First Stage Turbocharger)

Installation Procedure

Table 15

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

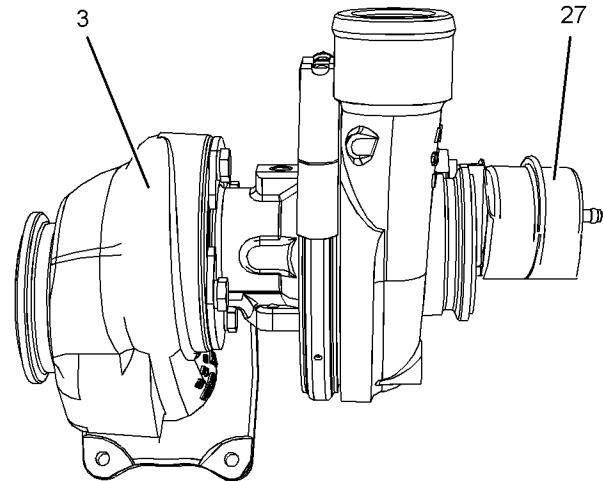


Illustration 96

g03734757

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

Disassembly and Assembly Section

2. Test wastegate actuator (27) for correct operation. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect" for more information. If any part of the wastegate actuator is worn or damaged, the complete turbocharger must be replaced.

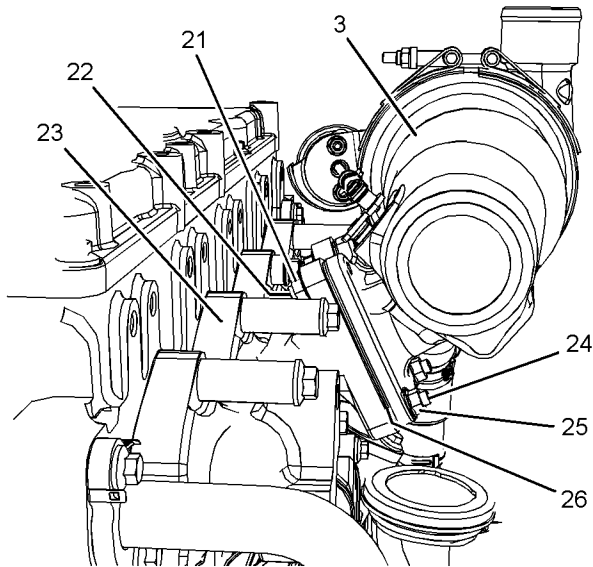


Illustration 97

g02526999

5. If necessary, install studs (24) to exhaust manifold (23). Tighten the studs to a torque of 18 N·m (160 lb in).
6. Install a new gasket (20) (not shown) onto exhaust manifold (23).
7. Position turbocharger (3) onto exhaust manifold (23). Install nuts (21) and nuts (25) finger tight.
8. Apply sufficient pressure in Position (A) to ensure that turbocharger (3) is at the lowest point on studs (22) (not shown) and studs (24). Do not release the pressure on the turbocharger in Position (A) until nuts (21) and nuts (25) have been tightened securely.
9. Tighten nuts (21) and nuts (25) to a torque of 22 N·m (195 lb in).

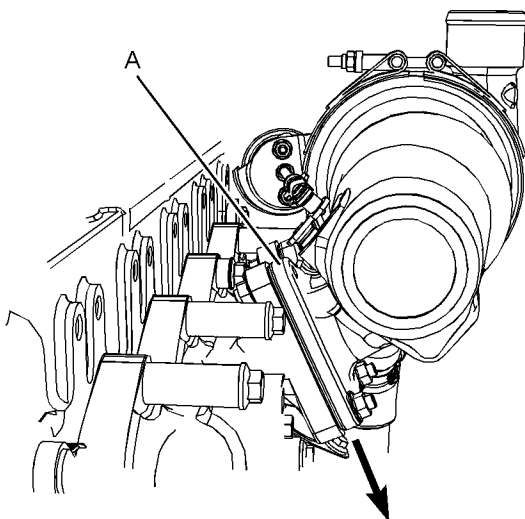


Illustration 98

g02614636

3. Clean the gasket surface of exhaust manifold (23).
4. If necessary, install studs (22) (not shown) to turbocharger (3). Tighten the studs to a torque of 18 N·m (160 lb in).

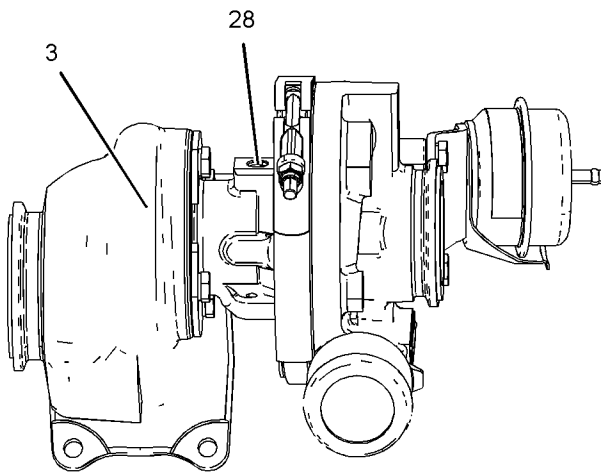


Illustration 99

g03734758

12. Remove plugs from turbocharger (3) and the cylinder block.
13. Position tube assembly (17) onto turbocharger (3) and the cylinder block.
14. Install bolts (16) and bolts (20).
15. Install bolt (18) to the clip for tube assembly (17).
16. Tighten bolts (20) to a torque of 22 N·m (195 lb in).
Tighten bolts (16) to a torque of 9 N·m (80 lb in).
Tighten bolt (18) to a torque of 18 N·m (159 lb in).
17. Remove the plug from oil inlet port (28). Lubricate the turbocharger bearings with clean engine oil through the oil inlet port. Rotate the wheel of the compressor several times in order to lubricate the bearings.
18. Ensure that hose assembly (14) is clean and free from restriction. Replace any damaged components.

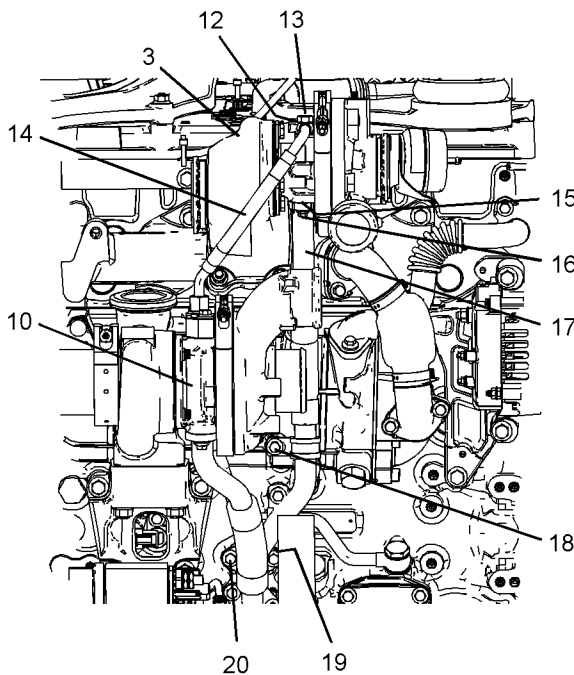


Illustration 100

g03734673

10. Remove plugs from tube assembly (17). Ensure that tube assembly (17) is clean and free from restriction. Replace any damaged components.
11. Position a new gasket (15) (not shown) and a new gasket (19) (not shown) onto tube assembly (17).

19. Remove cap from connection on turbocharger (10). Loosely connect hose assembly (14) to connection on turbocharger (10).
 20. Position a new sealing washer (12) (not shown) onto banjo bolt (13).
 21. Install banjo bolt (13) to hose assembly (14) and position the remaining new sealing washer (12) (not shown) onto banjo bolt (13).
 22. Tighten banjo bolt (13) to a torque of 22 N·m (195 lb in).
- Note:** Ensure that the hose assembly does not come into contact with the turbine housing as the banjo bolt is tightened.
23. Tighten tube nut for hose assembly (14) on turbocharger (10) to a torque of 30 N·m (265 lb in).

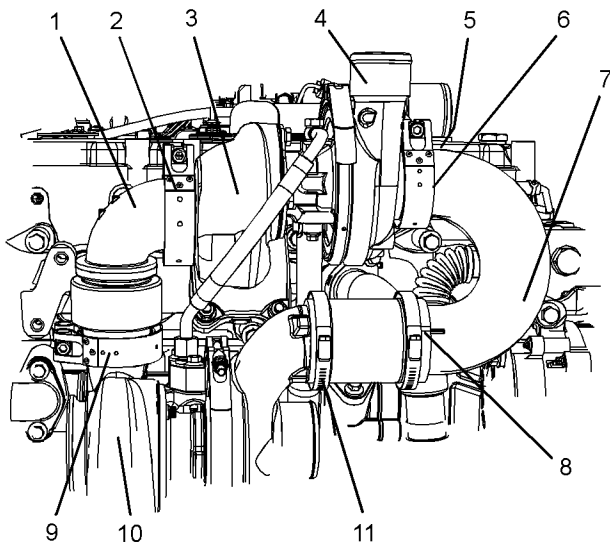


Illustration 101

g02526997

24. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (6). Position V-band clamp (6) onto air duct (7).
25. Position hose assembly (11) and air duct (7) onto the outlet of turbocharger (10) and turbocharger (3). Tighten the allen head bolt for V-band clamp to a torque of 12 N·m (106 lb in).
26. Tighten hose clamps (11) securely.
27. Ensure that elbow (1) is free from wear and damage. If necessary, replace the elbow.
28. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (2). Position V-band clamp (2) onto elbow (1).
29. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (9). Position V-band clamp (9) onto turbocharger (10).
30. Position elbow (1) onto turbocharger (3) and turbocharger (10).
31. Tighten the allen head bolt for V-band clamp (2) and the allen head bolt for V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.
32. Tighten the allen head bolt for V-band clamp (2) and the allen head bolt for V-band clamp (9) to a torque of 12 N·m (106 lb in).
33. Connect hose assembly (5) to the wastegate actuator. Slide hose clamp along hose assembly (5) ensure that hose clamp is correctly positioned.

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

i05981917

Turbocharger - Install (Top Mounted Turbocharger)

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

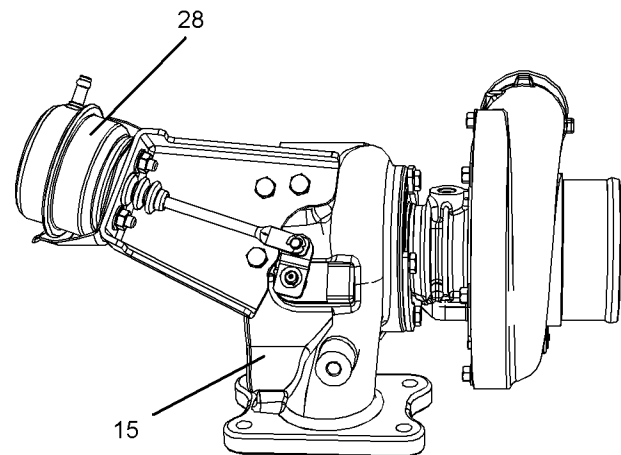


Illustration 102

g03735219

1. Ensure that turbocharger (15) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect" for more information. If the turbocharger is worn, the complete turbocharger must be replaced.
2. Test wastegate actuator (28) for correct operation. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect" for more information. If the wastegate actuator is damaged or the wastegate actuator does not operate within the specified limits, the complete turbocharger must be replaced.

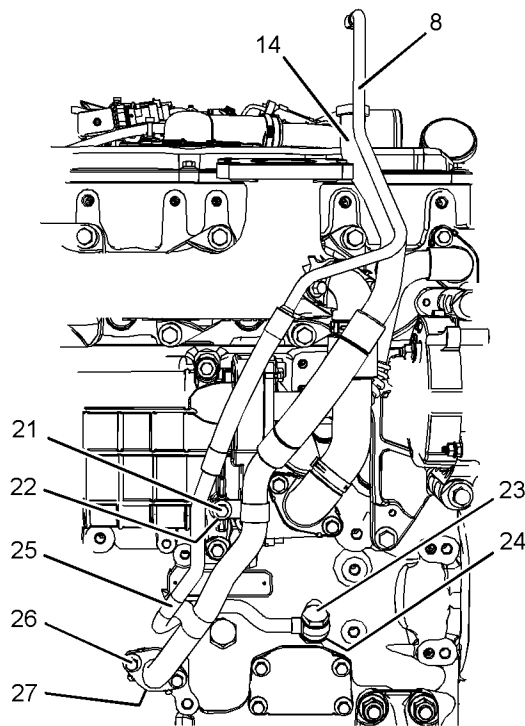


Illustration 103

g02570158

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

- a. Ensure that tube assembly (8) and tube assembly (14) are clean and free from restriction. Clean the gasket surface of the cylinder block.
- b. Position a new gasket (27) (not shown) onto tube assembly (14).
- c. Position tube assembly (14) onto cylinder block. Install bolts (26) finger tight.
- d. Install bolt (21) and spacer (22) (not shown) finger tight.
- e. Tighten bolts (26) to a torque of 22 N·m (195 lb in).
Tighten bolt (21) to a torque of 18 N·m (159 lb in).
- f. Position a new sealing washer (24) (not shown) onto banjo bolt (23). Install banjo bolt (23) to tube assembly (8) and install remaining new sealing washer (24) (not shown) onto banjo bolt (23).
- g. Position tube assembly (8) onto cylinder block. Tighten banjo bolt (23) finger tight.

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

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

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

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

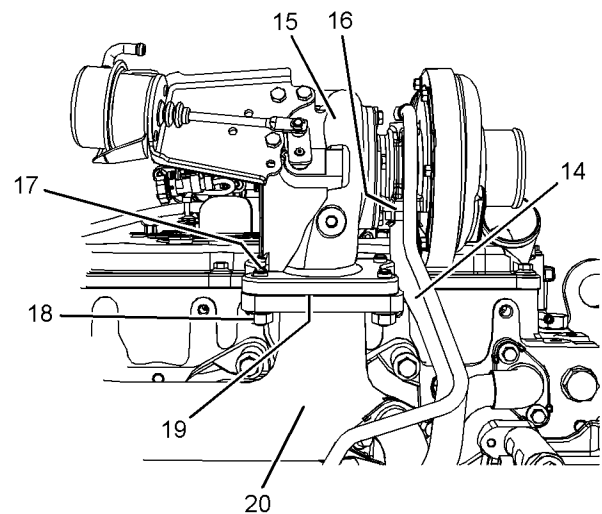


Illustration 104

g03735212

Typical example

4. Clean the gasket surfaces of the exhaust manifold (20). If necessary, install studs (17) (not shown) to the turbocharger (15). Tighten the studs to a torque of 18 N·m (13 lb ft).
 5. Position a new gasket (16) (not shown) onto tube assembly (14).
 6. Position a new gasket (16) (not shown) onto exhaust manifold (20).
 7. Position turbocharger (15) on exhaust manifold (20).
- Note:** Do not use the actuator rod to lift the turbocharger.
8. Install nuts (18). Tighten the nuts to a torque of 44 N·m (32 lb ft).

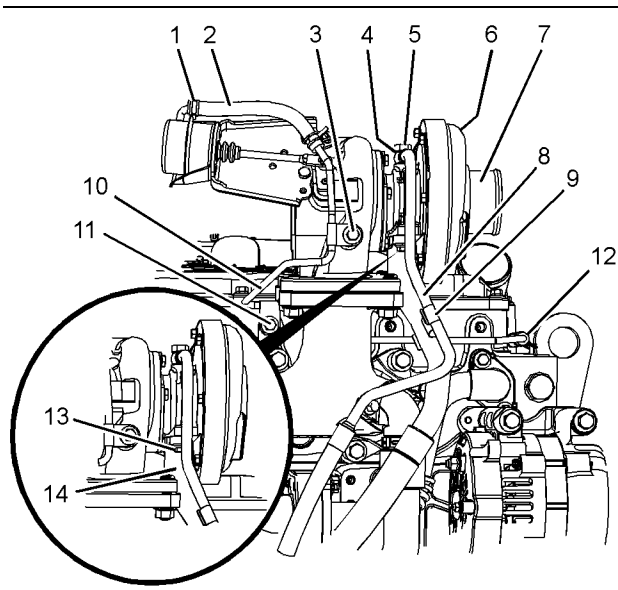


Illustration 105

g02568360

Typical example

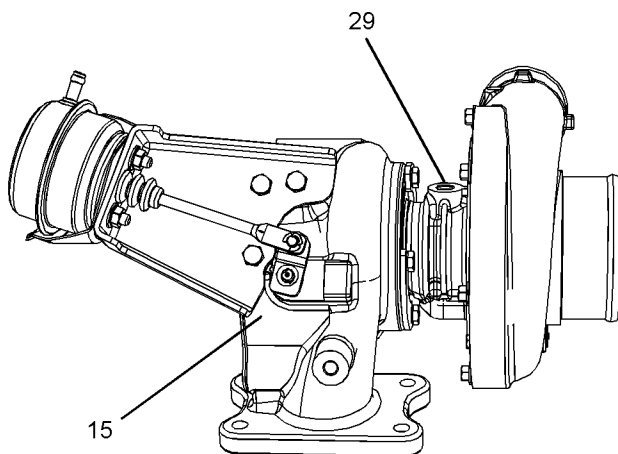


Illustration 106

g03735218

9. Install bolts (13) to tube assembly (14).
10. Tighten bolts (13) to a torque of 9 N·m (80 lb in).
11. Lubricate the bearings of turbocharger (15) with clean engine oil through oil inlet port (29). Rotate the shaft of the turbocharger in order to distribute the lubricant.
12. Position a new sealing washer (4) (not shown) onto banjo bolt (5). Install banjo bolt (5) onto tube assembly (8) and install remaining new sealing washer (4) (not shown) to banjo bolt (5).

13. Tighten banjo bolt (5) to a torque of 15 N·m (133 lb in).
14. Install clip (9) from tube assembly (8) and tube assembly (14).
15. Position tube assembly (10) onto turbocharger. Install bolt (3) and bolt (11) finger tight.
16. Connect hose assembly (2) to the wastegate actuator. Slide hose clamp (12) along the hose assembly.

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

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

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

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

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

End By:

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

i07088438

Turbocharger - Install (Second Stage Turbocharger)

Installation Procedure

Table 16

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

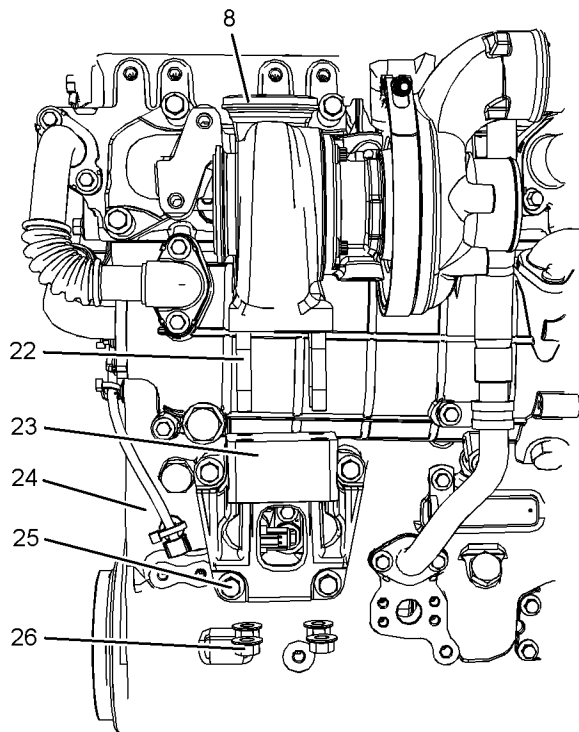


Illustration 107

g02529479

1. Ensure that turbocharger (8) is clean and free from damage. Inspect the turbocharger for wear. Refer to System Operation, Testing and Adjusting, "Turbocharger Inspect" for more information. If any part of the turbocharger is worn or damaged, the complete turbocharger must be replaced.
2. If necessary, follow Step 2a through Step 2b to install bracket (23) onto cylinder block (24).
 - a. Position bracket (23) onto cylinder block (24). Install bolts (25).

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

 - b. Tighten bolts (25) to a torque of 44 N·m (32 lb ft).
3. If necessary, install studs (22) to turbocharger (8). Tighten the studs to a torque of 18 N·m (159 lb in).
4. Install turbocharger (6) onto bracket (23).
5. Install nuts (26) and hand tighten the nuts.
6. Tighten the nuts to a torque of 44 N·m (32 lb ft).

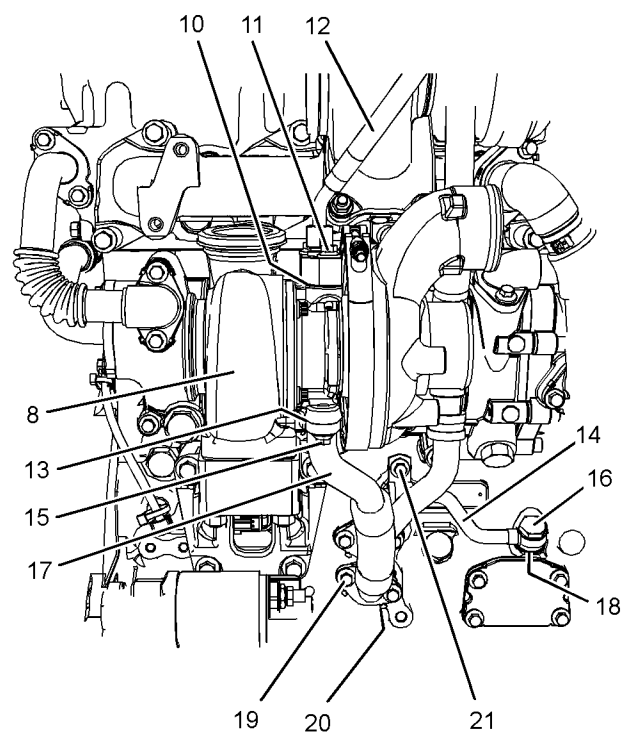


Illustration 108

g02529478

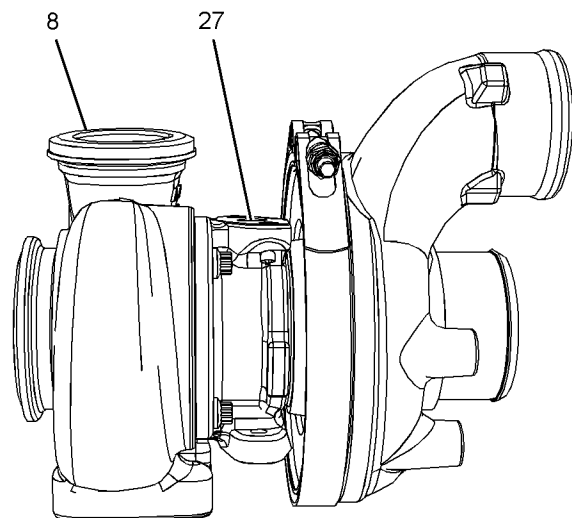


Illustration 109

g02529636

7. Position a new gasket (13) (not shown) and a new gasket (20) (not shown) onto tube assembly (17).
8. Position tube assembly (17) onto turbocharger (8) and the cylinder block.
9. Install bolts (15) and bolts (19).

Disassembly and Assembly Section

10. Tighten bolts (15) and bolts (19) to a torque of 22 N·m (195 lb in).
11. Remove the plug from oil inlet port (27). Lubricate the turbocharger bearings with clean engine oil through the oil inlet port. Rotate the wheel of the compressor several times to lubricate the bearings.
12. Remove plugs from tube assembly (14). Ensure that tube assembly (14) is clean and free from restriction. Replace any damaged components.
13. Position a new gasket (10) (not shown) onto turbocharger (8).
14. Position tube assembly (14) onto turbocharger (8) and the cylinder block. Loosely install bolts (11) to the tube assembly.
15. Position a new sealing washer (18) (not shown) onto banjo bolt (16).
16. Install banjo bolt (16) to hose assembly (14). Install the remaining new sealing washer (18) (not shown) to banjo bolt (16).
17. Install bolt (21) to clamp for hose assembly (14).
18. Tighten banjo bolt (16) to a torque of 40 N·m (29 lb ft).
Tighten bolts (11) to a torque of 22 N·m (195 lb in).
Tighten bolts (21) to a torque of 22 N·m (195 lb in).
19. Remove plug from hose assembly (12) and connection on turbocharger (8). Ensure that hose assembly (12) and connection are clean and free from restriction. Replace any damaged components.
20. Connect hose assembly (12) from the connection on turbocharger (8). Tighten tube nut for hose assembly (12) on turbocharger (8) to a torque of 30 N·m (265 lb in).

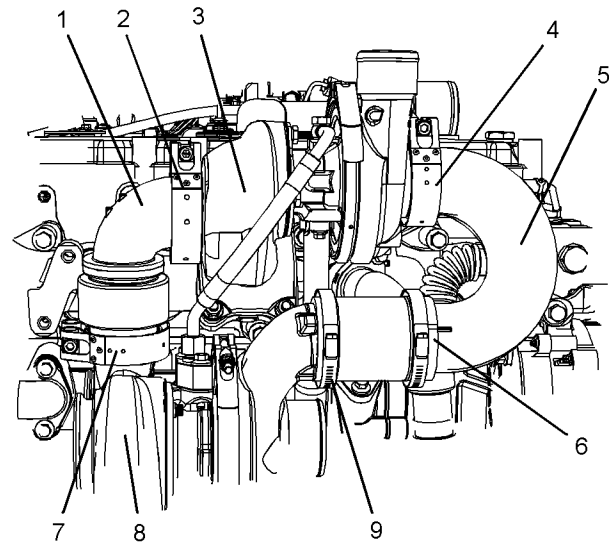


Illustration 110

g02529457

21. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (4). Position V-band clamp (4) onto air duct (5).
22. Position hose assembly (6) and air duct (5) onto the outlet of turbocharger (8) and turbocharger (3). Tighten the allen head bolt V-band clamp to a torque of 12 N·m (106 lb in).
23. Tighten hose clamps (9) securely.
24. Ensure that elbow (1) is free from wear and damage. If necessary, replace the elbow that is worn or damaged.
25. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (2). Position V-band clamp (2) onto elbow (1).
26. Use Tooling (A) to lubricate the allen head bolt for V-band clamp (7). Position V-band clamp (7) onto turbocharger (8).
27. Position elbow (1) onto turbocharger (3) and turbocharger (8).
28. Tighten V-band clamp (2) and V-band clamp (7) finger tight. Ensure that the V-band clamps are seated correctly onto the turbochargers.
29. Tighten allen head bolt for V-band clamp (2) and allen head bolt for V-band clamp (7) to a torque of 12 N·m (106 lb in).
30. Connect the air inlet hose to the turbocharger and tighten the hose clamp securely.

End By:

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

i07088466

Turbocharger - Install (Side Mounted Turbochargers)

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

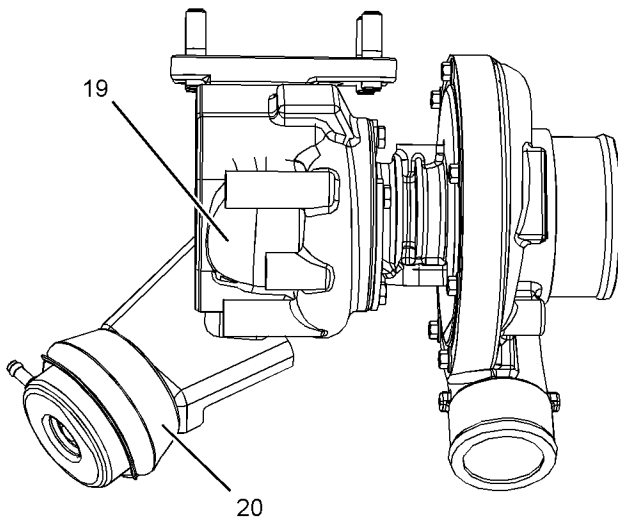


Illustration 111

g03735742

1. Ensure that turbocharger (19) is clean and free from damage. Inspect the turbocharger for wear. Refer to Systems Operation, Testing and Adjusting, "Turbocharger - Inspect" for more information. If the turbocharger is worn, the complete turbocharger must be replaced.
2. Test actuator (20) for correct operation. Refer to Systems Operation, Testing and Adjusting, "Turbocharger - Inspect" for more information. If the actuator is damaged or the actuator does not operate within the specified limits, the complete turbocharger must be replaced.

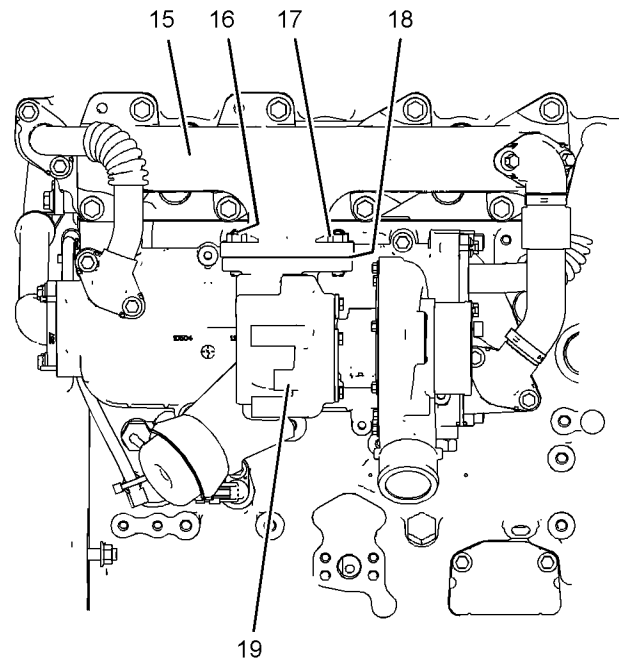


Illustration 112

g03735741

3. Clean the gasket surfaces of exhaust manifold (15). If necessary, install studs (16) (not shown) to turbocharger (19). Tighten the studs to a torque of 18 N·m (13 lb ft).
4. Install a new gasket (18) (not shown) to the exhaust manifold.
5. Position turbocharger (19) onto exhaust manifold (15) and install nuts (17). Tighten the nuts to a torque of 44 N·m (32 lb ft).

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

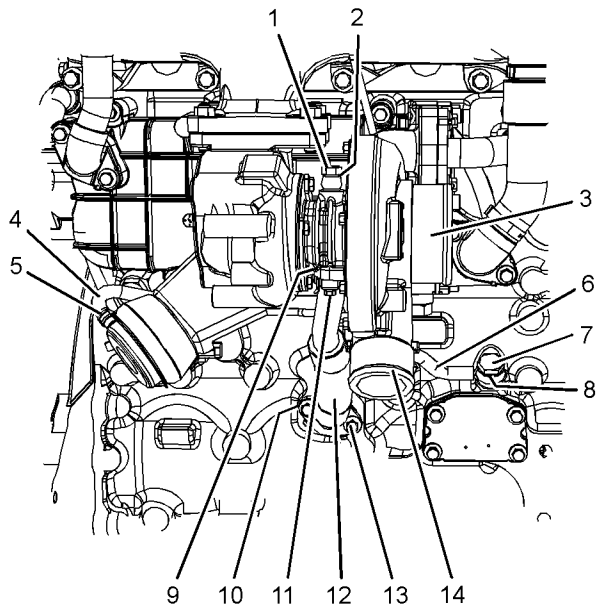


Illustration 113

g03735740

6. Position a new gasket (9) (not shown) and a new gasket (10) (not shown) onto tube assembly (12).
7. Install tube assembly (12) onto the turbocharger and the cylinder block.
8. Install bolts (11) and bolts (13) finger tight.
9. Tighten bolts (11) to a torque of 9 N·m (80 lb in). Tighten bolts (13) to a torque of 22 N·m (16 lb ft).

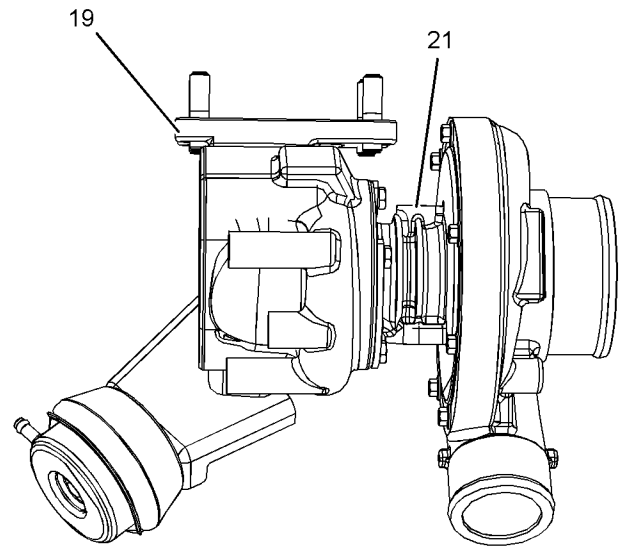


Illustration 114

g03735744

10. Lubricate the bearings of turbocharger (19) with clean engine oil through oil inlet port (21). Rotate the shaft of the turbocharger to distribute the lubricant.
 11. Position a new sealing washer (2) (not shown) onto banjo bolt (1). Install banjo bolt (1) into tube assembly (6) and install remaining new sealing washer (2) (not shown) to banjo bolt (1).
 12. Position tube assembly (6) onto the turbocharger. Loosely tighten banjo bolt (1).
 13. Position a new sealing washer (8) (not shown) onto banjo bolt (7). Install banjo bolt (7) to tube assembly (6) and install remaining new sealing washer (8) (not shown). Loosely tighten banjo bolt (6).
 14. Tighten banjo bolt (7) to a torque of 40 N·m (30 lb ft). Tighten banjo bolt (1) to a torque of 15 N·m (133 lb in).
- Note:** Ensure that the tube assembly does not come into contact with any other engine component.
15. Connect hose assembly (4) to wastegate actuator. Slide hose clamp (5) along hose assembly (4).
- Note:** Ensure that hose clamp is correctly positioned on the hose assembly.
16. Connect the hose assemblies to turbocharger inlet (3) and for turbocharger outlet (14). Securely tighten the hose clamps.

End By:

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

i05981920

Wastegate Solenoid - Remove and Install

Removal Procedure

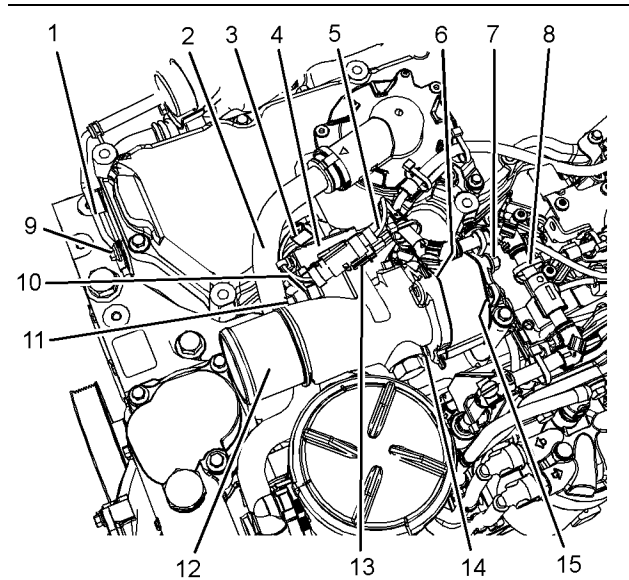


Illustration 115

g02522557

1. If the Diesel Particulate Filter (DPF) assembly is mounted on the valve mechanism cover, removal of the DPF assembly will be necessary in order to access the wastegate solenoid. Refer to Disassembly and Assembly, "Diesel Particulate Filter - Remove" for the correct procedure.
2. Loosen hose clamps and remove hose assembly from connection (12).
3. Remove plastic tube assembly (2) from the valve mechanism cover and the crankcase breather canister.
4. Slide locking tab (13) into the unlocked position. Disconnect harness assembly (5) from the harness assembly for wastegate solenoid (3).
5. Slide the harness assembly for wastegate solenoid (3) from bracket (4).
6. Remove bolts (9) from tube assembly (1).

7. Remove banjo bolt (11) and remove sealing washers (10) (not shown).
8. Cut cable straps (8) from harness assembly (5). Position harness assembly (5) away from NRS induction mixer.
9. Remove nut (7) and bolts (14).
10. Remove the assembly of inlet connection (12) from the NRS induction mixer assembly.
11. Remove gasket (6) (not shown) and gasket (15) (not shown).

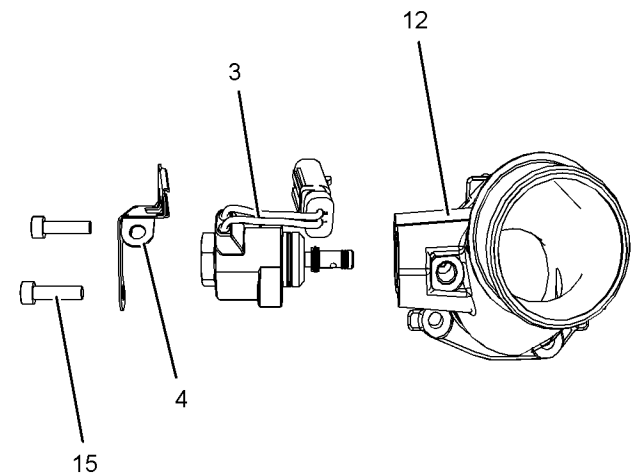


Illustration 116

g02522558

12. Remove allen head bolts (15) from wastegate solenoid (3). Remove bracket (4).
13. Remove wastegate solenoid (3) from inlet connection (12).
14. Plug inlet connection (12) and cap wastegate solenoid (3) with new plugs and caps.

Installation Procedure

Table 17

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Delphi Lockheed Rubber Grease	1

NOTICE

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

Disassembly and Assembly Section

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

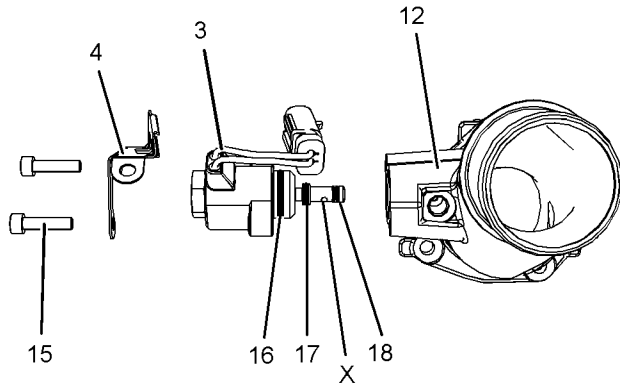


Illustration 117

g02522577

2. Ensure that O-ring seal (16), O-ring seal (17), and O-ring seal (18) on wastegate solenoid (3) are free from damage and wear.
 3. If the O-ring seals are damaged or worn, the wastegate solenoid should be replaced as an assembly.
 4. Ensure that the ports in Position (X) are clean and free from restriction.
 5. Remove the cap from wastegate solenoid (3) and remove plug from inlet connection (12).
 6. Use Tooling (A) in order to lubricate O-ring seal (16), O-ring seal (17), and O-ring seal (18) on wastegate solenoid (3).
 7. Install wastegate solenoid (3) to inlet connection (12).
 8. Position bracket (4) onto wastegate solenoid (3).
- Note:** Ensure that the bracket is correctly orientated.
9. Install allen head bolts (15) to wastegate solenoid (3). Tighten the allen head bolts to a torque of 9 N·m (80 lb in).

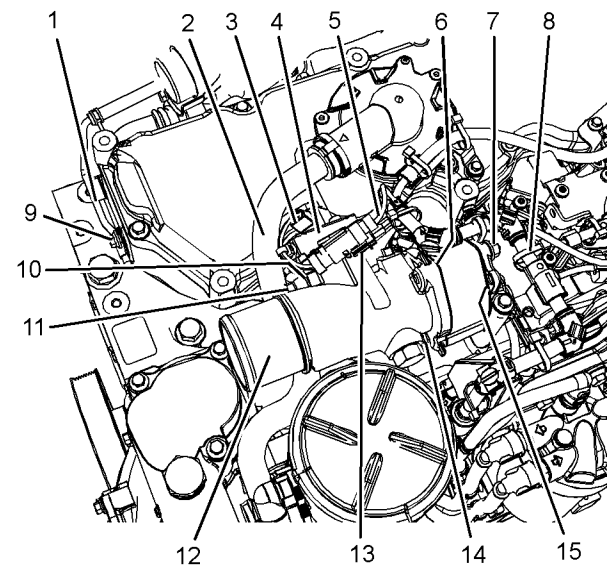


Illustration 118

g02522557

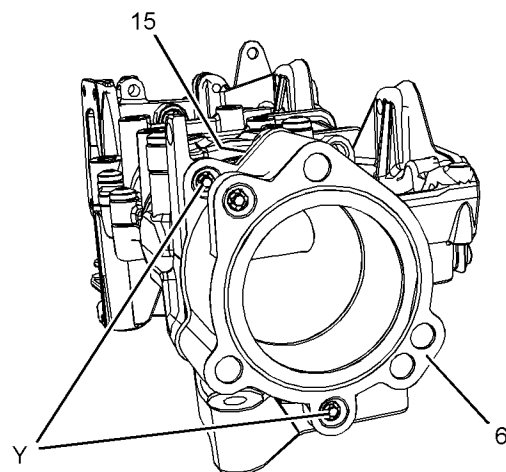


Illustration 119

g02524456

10. Position a new gasket (6) and a new gasket (15) (not shown) onto the NRS induction mixer assembly. Ensure that gasket (6) and gasket (15) (not shown) is correctly located on Pins (Y).
11. Position the assembly on inlet connection (12) onto the NRS induction mixer assembly.
12. Install nut (7) and bolts (14).
13. Tighten nut (7) and bolts (14) to a torque 22 N·m (195 lb in).

14. Position a new sealing washer (10) (not shown) onto banjo bolt (11). Install banjo bolt (11) to tube assembly (1) and install the remaining new sealing washer (10) (not shown) onto the banjo bolt. Tighten the banjo bolt finger tight
 15. Install bolts (9) to tube assembly (1). Tighten the bolts to a torque 22 N·m (195 lb in).
 16. Tighten banjo bolt (11) to a torque 15 N·m (133 lb in).
 17. Slide the harness assembly for wastegate solenoid (3) onto bracket (4).
 18. Position harness assembly (5) onto NRS induction mixer. Install new cable straps (8) to harness assembly (5).
- Note:** Ensure that the cable straps meet the Original Equipment Manufactures (OEM) specification.
19. Connect harness assembly (5) to the harness assembly for wastegate solenoid (3). Slide locking tab (13) into the locked position.
 20. Install plastic tube assembly (2) to the valve mechanism cover and the crankcase breather canister.
 21. Install hose assembly onto connection (12). Tighten hose clamps securely.

22. If the Clean Emissions Module (CEM) assembly was mounted on the valve mechanism cover, installation of the DPF assembly will be necessary after the installation of the wastegate solenoid. Refer to Disassembly and Assembly, "Clean Emissions Module - Remove and Install" for the correct procedure.

i05981735

Exhaust Back Pressure Valve - Remove and Install

Removal Procedure

Start By:

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

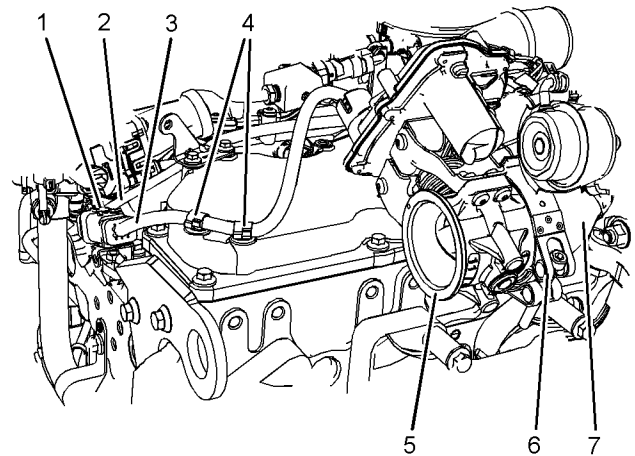


Illustration 120

g02476753

Typical example

1. Unclip retaining clips (4) for exhaust back pressure valve wiring harness (3). Slide locking tab (1) into the unlocked position.
2. Disconnect exhaust back pressure valve wiring harness (3) from assembly of engine wiring harness (2).
3. Loosen allen head bolt on V-band clamp (6).

Note: If the V-band clamp (6) remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**

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

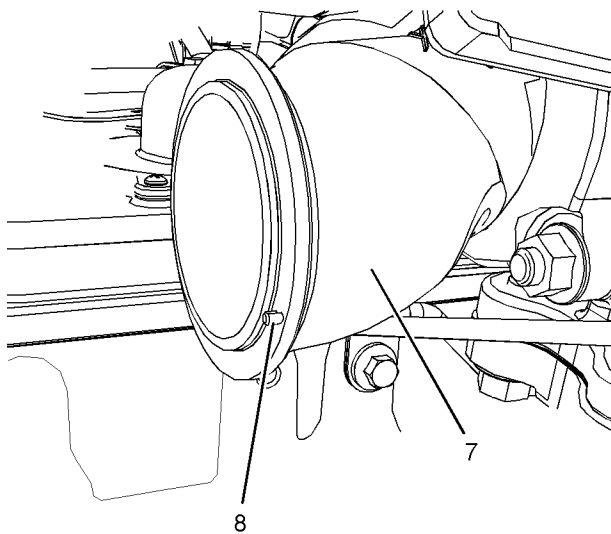


Illustration 121

g02476738

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

Installation Procedure

Table 18

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

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

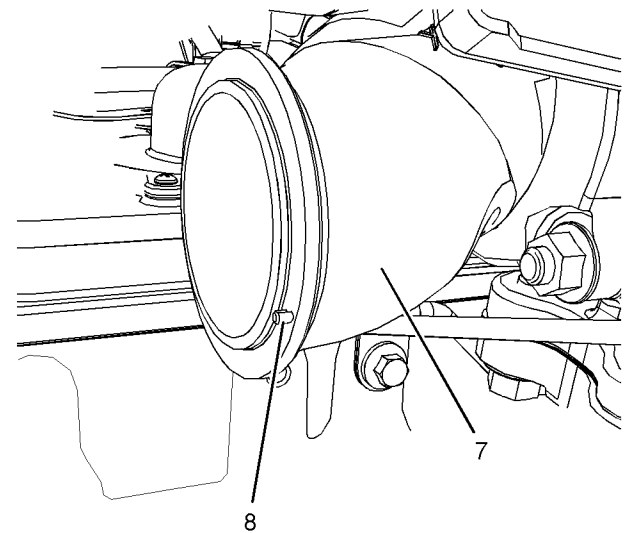


Illustration 122

g02476738

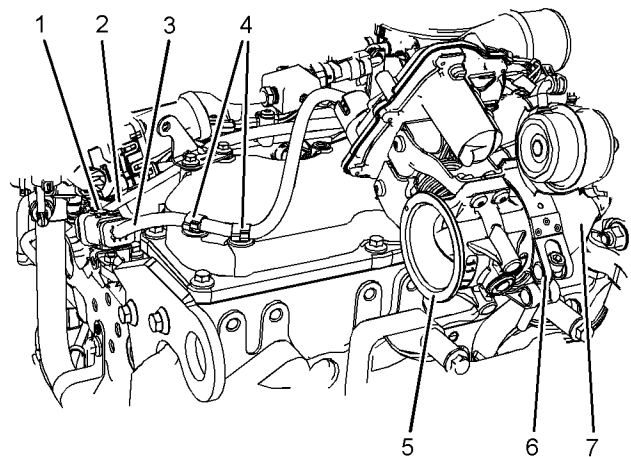


Illustration 123

g02476753

Typical example

2. Ensure that dowel (8) is free from damage and is correctly positioned in exhaust elbow (7).
3. Use Tooling (A) to lubricate the threads of the allen head bolt for V-band clamp (6).
4. Position V-band clamp (6) onto exhaust elbow (7).
5. Install exhaust back pressure valve (5) onto exhaust elbow (7). Ensure that the exhaust back pressure valve is correctly located onto dowel (8) on the exhaust elbow.

6. Ensure that V-band clamp (6) is seated onto exhaust back pressure valve (5) and exhaust elbow (7). Tighten the allen head bolt for the V-band clamp hand tight.
7. Tighten the allen head bolt for V-band clamp (6) to a torque of 12 N·m (106 lb in).
8. Connect exhaust back pressure valve wiring harness (3) to the assembly of engine wiring harness (2).
9. Slide locking tab (1) into the locked position. Clip retaining clips (4) for exhaust back pressure valve wiring harness (3).

End By:

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

i07991771

Exhaust Gas Valve (NRS - Remove and Install

Note: There are two service options for this procedure, choose the method that is most suited to your engine.

Removal Procedure

Method 1

Start By:

- a. If necessary, remove the clean emissions module. Refer to Disassembly and Assembly, “Clean Emissions Module - Remove and Install” for the correct procedure.

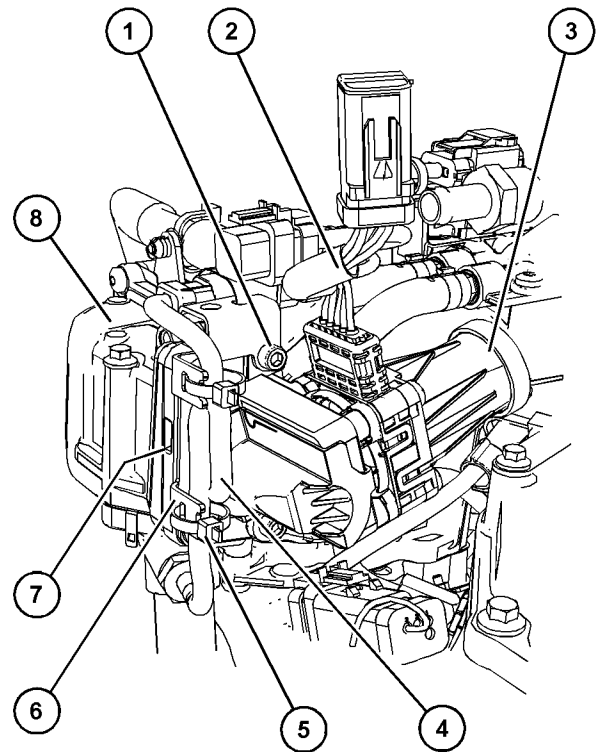


Illustration 124

g06515069

1. Disconnect harness assembly (2).
2. Cut cable straps (5) and position harness assembly (4) away from bracket (6).
3. Remove Allen bolts (1) and bracket (6) from exhaust gas valve (3).
4. Remove exhaust gas valve (3) from exhaust gas valve elbow (8).
5. Remove O-ring seal (7) (not shown).

Method 2

Start By:

- a. If necessary, remove the clean emissions module. Refer to Disassembly and Assembly, "Clean Emissions Module - Remove and Install" for the correct procedure.

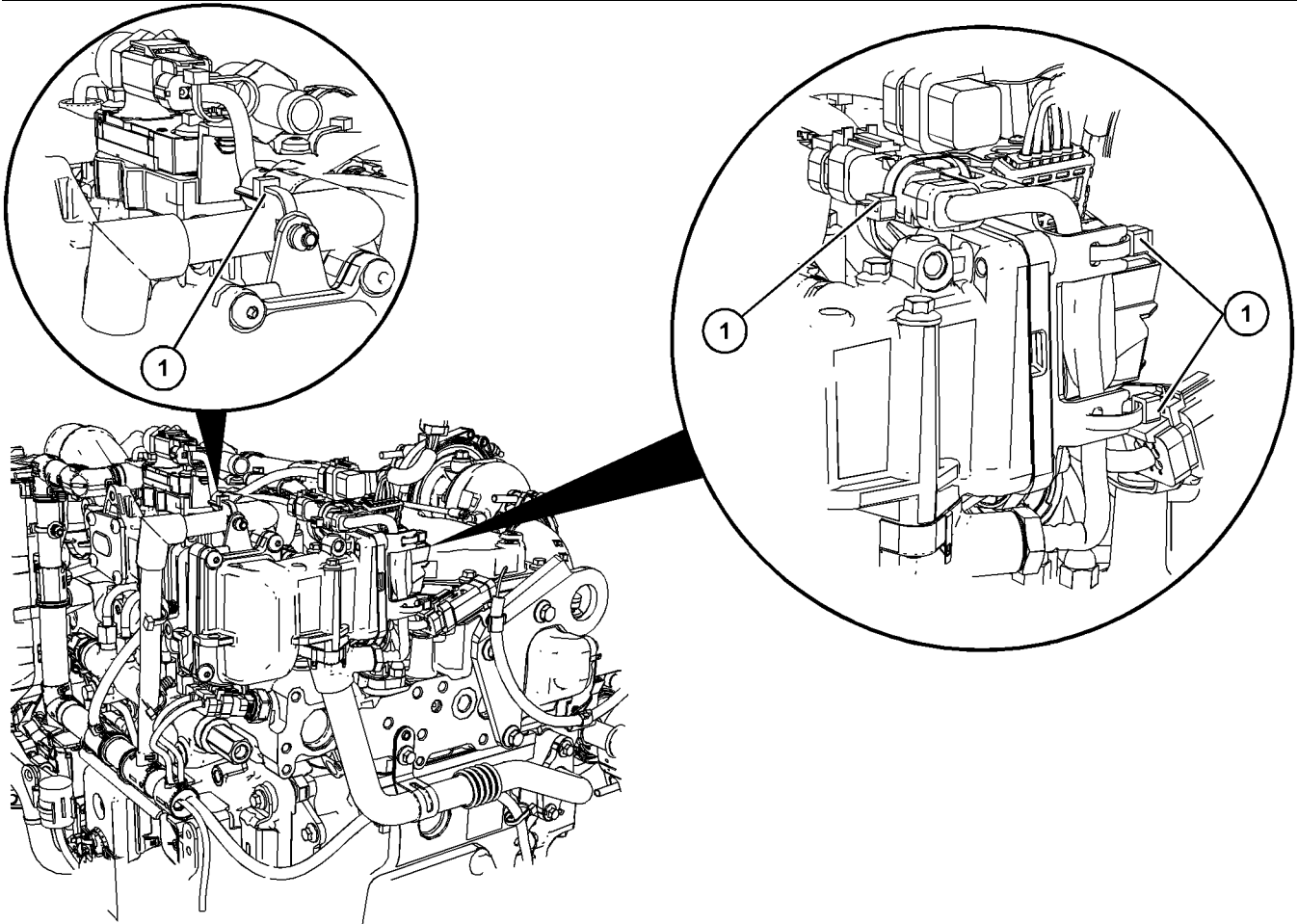


Illustration 125

g06500848

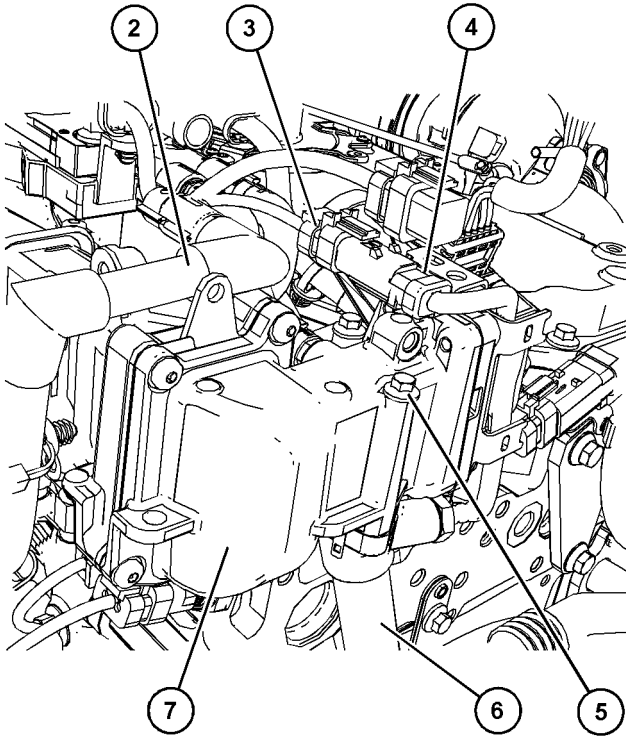


Illustration 126

g06500885

1. Remove cable straps (1) from harness assembly (2), harness assembly (3), and harness assembly (4).
2. Slide the locking tab into the unlocked position and disconnect harness assembly (3) from harness assembly (4).

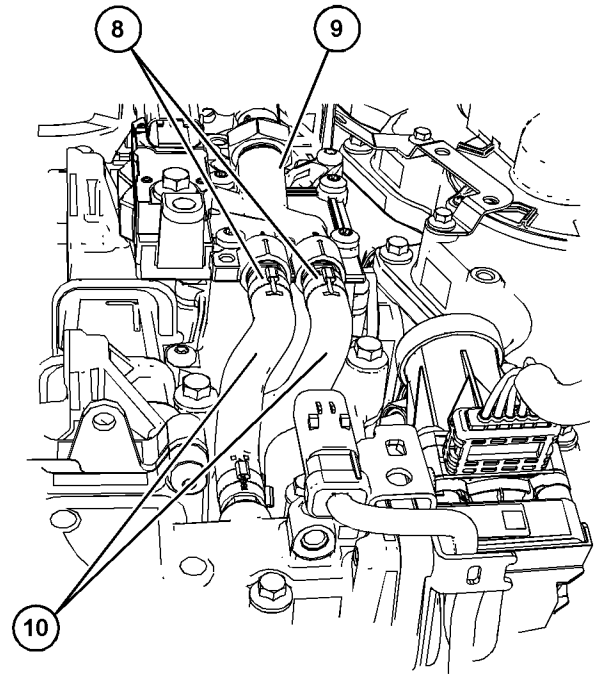


Illustration 127

g06500910

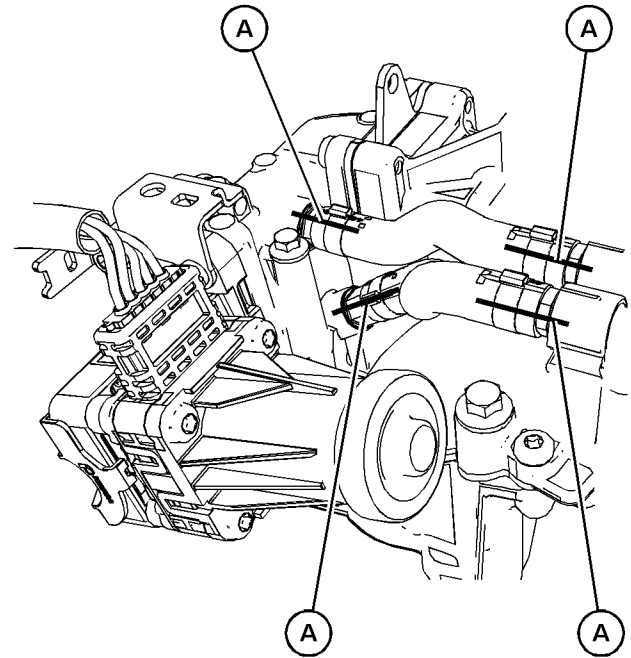


Illustration 128

g06514124

Temporary alignment marks (A)

Disassembly and Assembly Section

3. Make temporary alignment marks on both ends of hoses (10) in Positions (A) for installation purposes.
4. Use a suitable tool to remove hose clamps (8) from hoses (10) taking care not to damage the hoses. Disconnect hoses (10) from pressure sensor manifold (9).
5. Remove bolts (5) from tube assembly (6) and exhaust gas valve elbow (7).

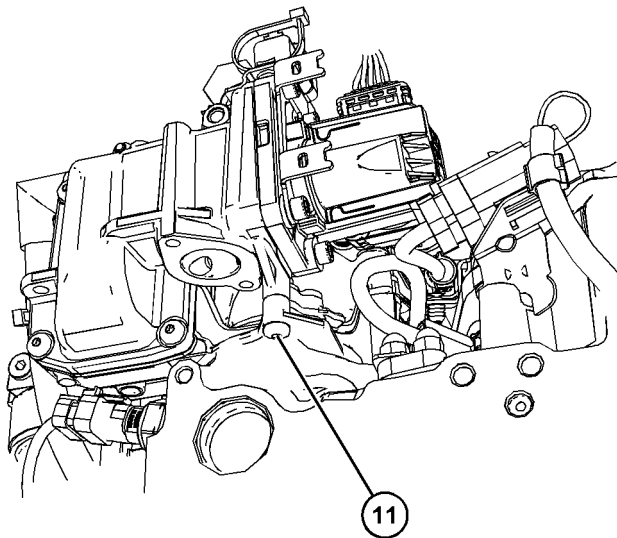


Illustration 129

g06500982

6. Remove tube assembly (6). Refer to Disassembly and Assembly, "Exhaust Cooler (NRS) - Remove and Install" for the correct procedure.
7. Remove Torx bolt (11) from exhaust gas valve elbow (7).

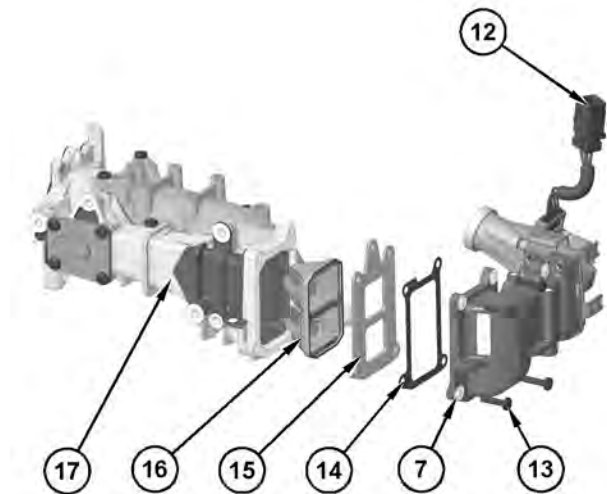


Illustration 130

g06500949

8. Disconnect harness assembly (12)
9. Support exhaust gas valve elbow (7) and remove Torx bolts (13).
10. Remove exhaust gas valve elbow (7) from exhaust gas valve main body (17).
11. Remove gasket (14). If necessary, remove baffle plate (15) from exhaust gas valve main body (17). Ensure that reed valve (16) is not dislodged during baffle plate (15) removal.

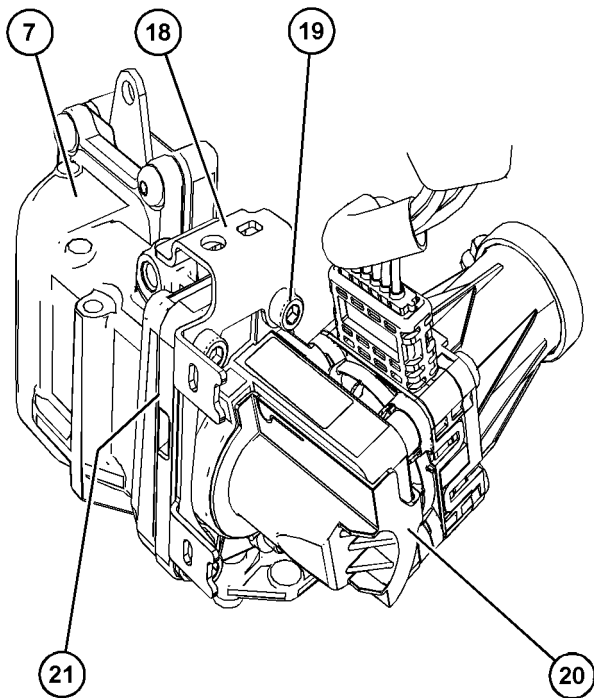


Illustration 131

g06502099

12. Remove Allen head bolts (19) and bracket (18) from exhaust gas valve (20).

13. If necessary, remove exhaust gas valve (20) from exhaust gas valve elbow (7).

Note: Do not twist the exhaust gas valve as the exhaust gas valve is removed from the exhaust gas valve elbow.

14. Remove gasket (21) (not shown) from exhaust gas valve (20).

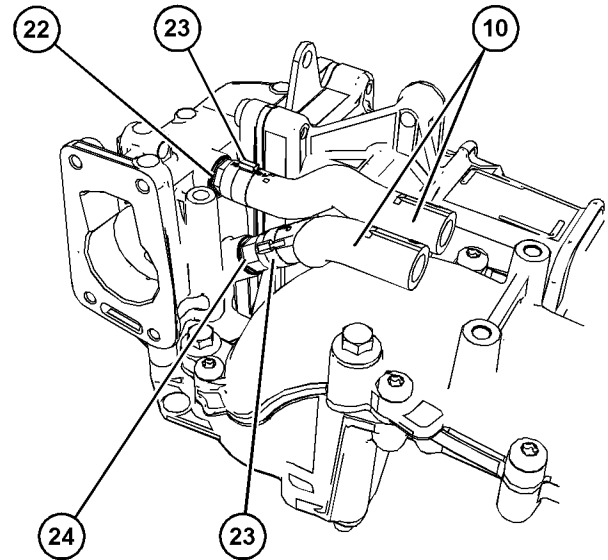


Illustration 132

g06514975

15. Use a suitable tool to remove hose clamps (23) from hoses (10) taking care not to damage the hoses. Disconnect hoses (10) from union (22) and union (24).

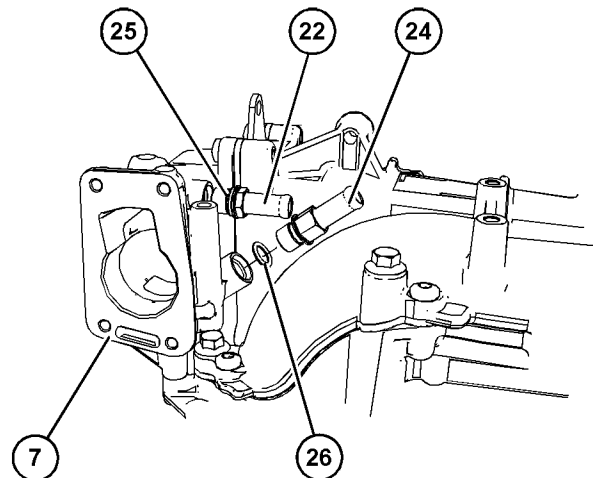


Illustration 133

g06515022

16. Remove union (22) and union (24) from exhaust gas valve elbow (7).

Note: Identify the unions positions as the unions are not interchangeable and must be reinstalled in the original positions.

17. Remove O-ring seal (25) and O-ring seal (26) from the unions. Discard the O-rings.

Installation Procedure

Method 1

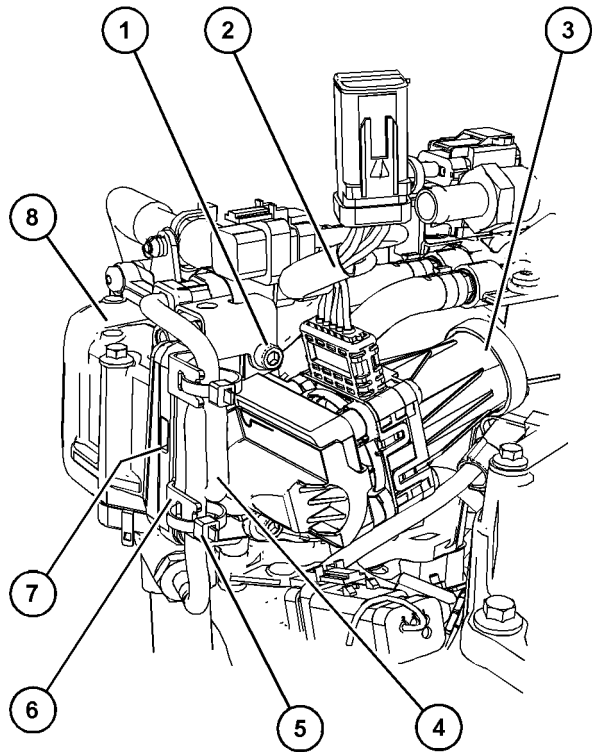


Illustration 134

g06515069

1. Install new O-ring seal (7) (not shown) to exhaust gas valve (3).
2. Install exhaust gas valve (3) to exhaust gas valve elbow (8).
3. Position bracket (6) onto the exhaust gas valve and install Allen bolts (1). Tighten the Allen bolts to a torque of 9 N·m (80 lb in).
4. Position harness (4) onto bracket (6) and install cable straps (5).

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

5. Connect harness assembly (2) and slide the locking tab into the locked position.

End By:

- a. If necessary, install the clean emissions module. Refer to Disassembly and Assembly, "Clean Emissions Module - Remove and Install" for the correct procedure.

Method 2

Table 19

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Loctite Dri-Loc 2015 (Orange)	1
B	-	Guide Stud M6 x 70mm	2

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

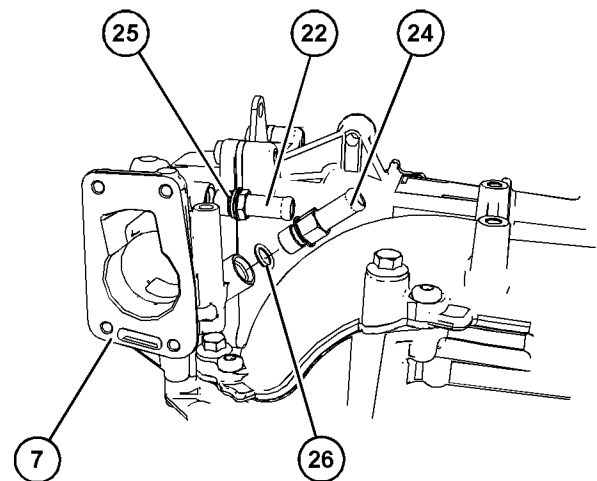


Illustration 135

g06515022

2. Install new O-ring seal (26) to union (24).
3. Apply Tooling (A) to the threads of union (24). Install the union and tighten the union to a torque of 15 N·m (132.76 lb in).
4. Install new O-ring seal (25) to union (22).
5. Apply Tooling (A) to the threads of union (22). Install the union and tighten the union to a torque of 15 N·m (132.76 lb in).

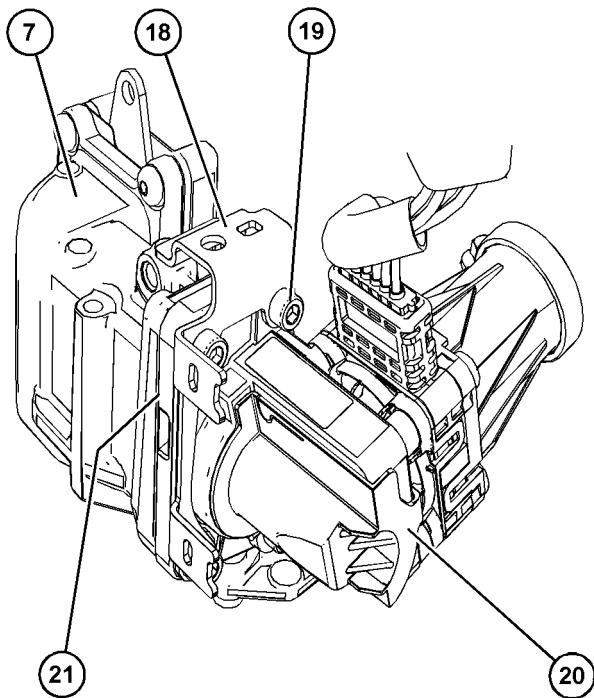


Illustration 136

g06502099

6. Ensure that the bore in exhaust gas valve elbow (7) for exhaust gas valve (20) is clean and free from damage. If necessary, replace the exhaust gas valve elbow and exhaust gas valve.
7. If the original exhaust gas valve (20) is to be installed, ensure that the sealing surfaces are clean and free from damage.
8. Install new gasket (21) (not shown) to the exhaust gas valve.
9. Lightly lubricate the surfaces of the exhaust gas valve with clean engine oil.
10. Install the exhaust gas valve to exhaust gas valve elbow (7).
11. Position bracket (18) onto the exhaust gas valve and install Allen head bolts (19). Tighten Allen head bolts to a torque of 9 N·m (80 lb in).

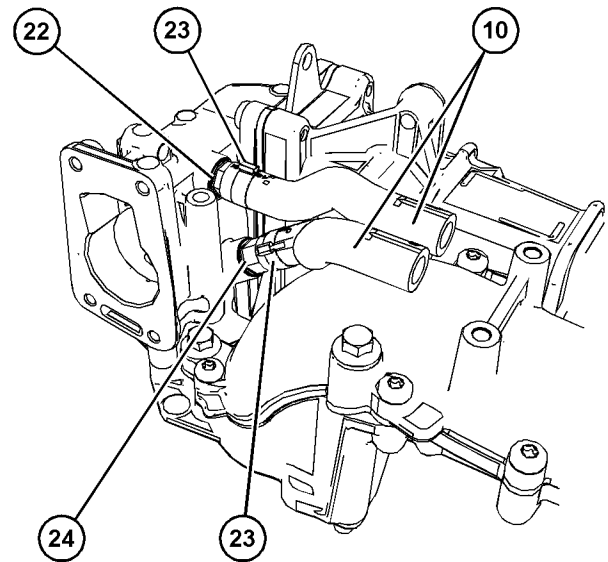


Illustration 137

g06514975

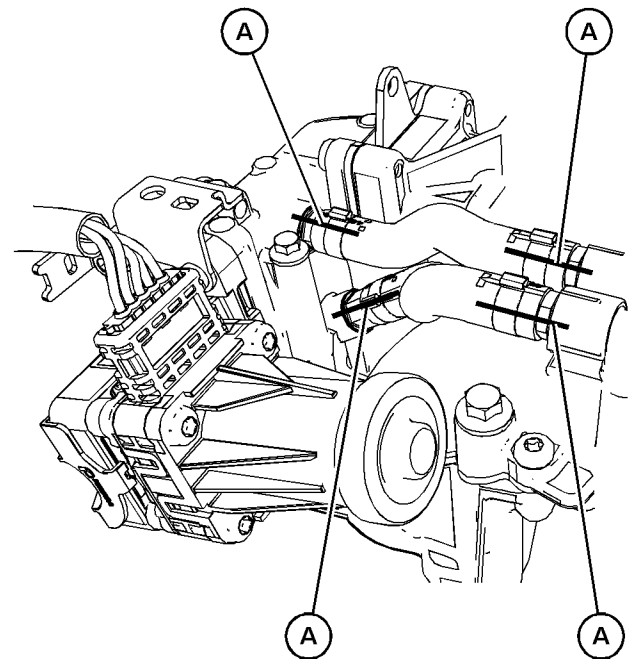


Illustration 138

g06514124

Temporary hose alignment marks (A)

12. Install new worm drive hose clamps (23) onto hoses (10). Install the hoses onto unions (22) and (24). Align the temporary marks in Positions (A) made during the disassembly procedure.

Disassembly and Assembly Section

Tighten worm drive hose clamps (23) to a torque of 4.5 N·m (39.83 lb in).

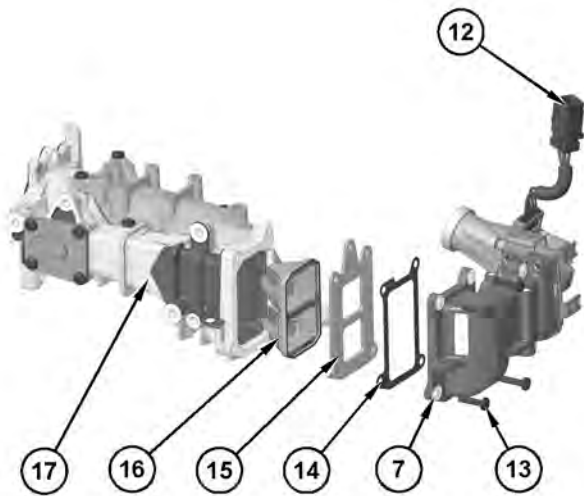


Illustration 139

g06500949

13. Install Tooling (B) to exhaust gas valve main body (17).

14. If necessary, install baffle plate (15) to exhaust gas valve main body (17).

Note: Ensure that reed valve (16) is not dislodged during the assembly process.

15. Position gasket (14) onto exhaust gas valve main body (17).

16. Position the exhaust gas valve elbow onto exhaust gas valve main body (17) and install two Torx bolts (13).

Remove Tooling (B) and install the remaining Torx bolts .

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

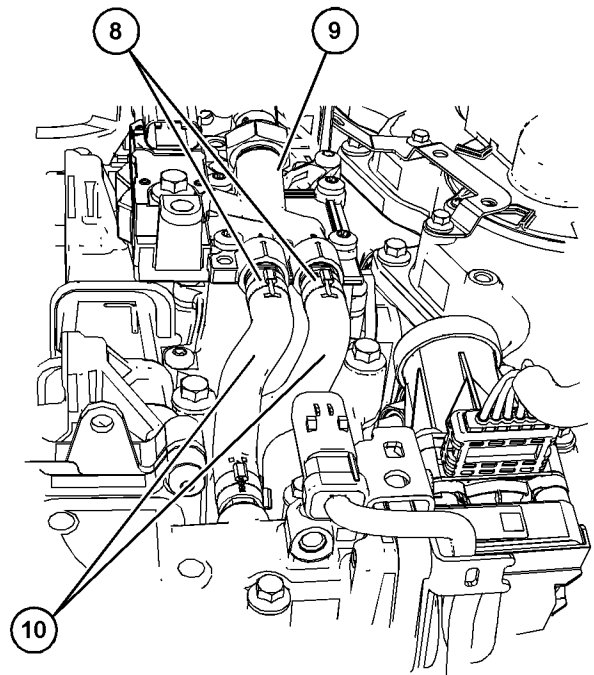


Illustration 140

g06500910

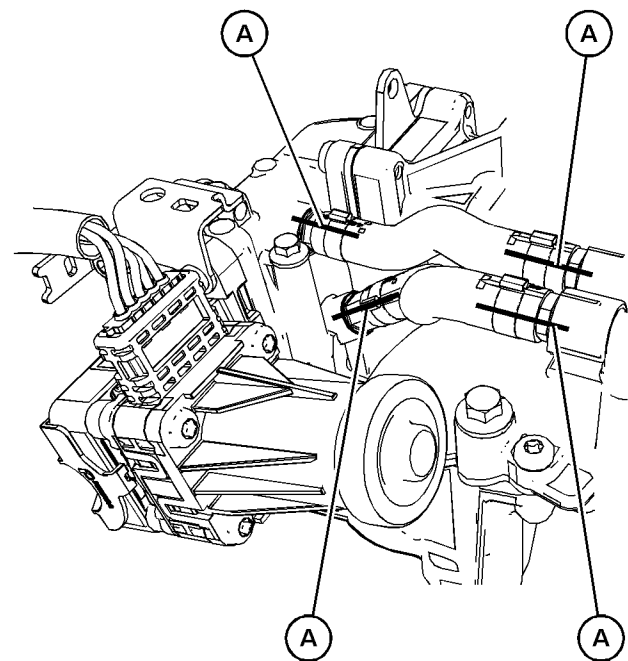


Illustration 141

g06514124

Temporary hose alignment marks (A)

- 17.** Install new worm drive hose clamps (8) onto hoses (10). Install the hoses onto pressure sensor manifold (9). Align the temporary marks in Positions (A) made during the disassembly procedure on the hoses.

Tighten worm drive hose clamps (8) to a torque of 4.5 N·m (39.83 lb in).

- 18.** Connect harness assembly (12) and slide the locking tab into the locked position.

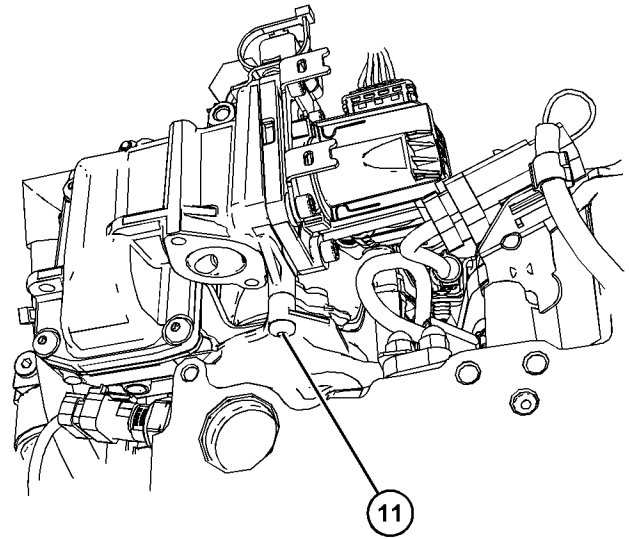


Illustration 142

g06500982

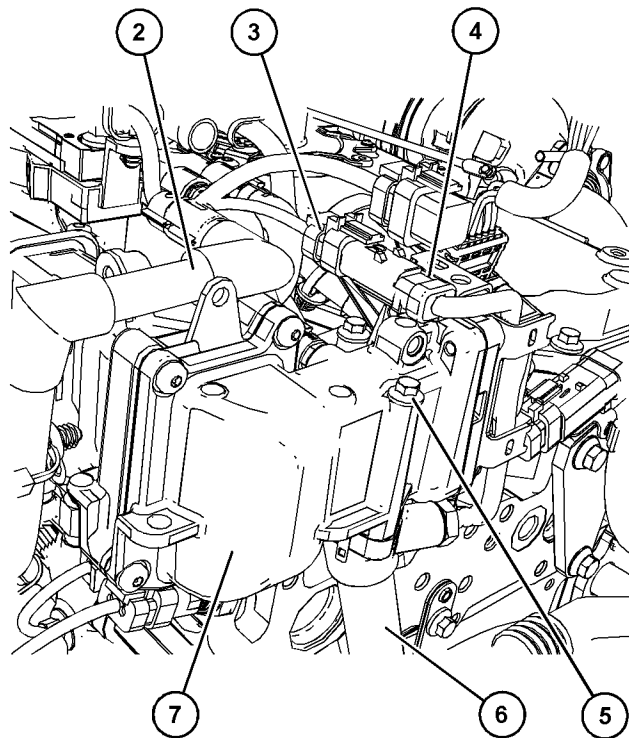


Illustration 143

g06500885

- 19.** Install Torx bolt (11) to exhaust gas valve elbow (7). Tighten the Torx bolt to a torque of 9 N·m (80 lb in).

Disassembly and Assembly Section

20. If necessary, install tube assembly (6). Refer to Disassembly and Assembly, "Exhaust Cooler (NRS) - Remove and Install" for the correct procedure.
21. Install bolts (5) to exhaust gas valve elbow (7) and tube assembly (6). Tighten the bolts to a torque of 9 N·m (80 lb in).
22. Connect harness assembly (3) to harness assembly (4) and slide the locking tab into the locked position.

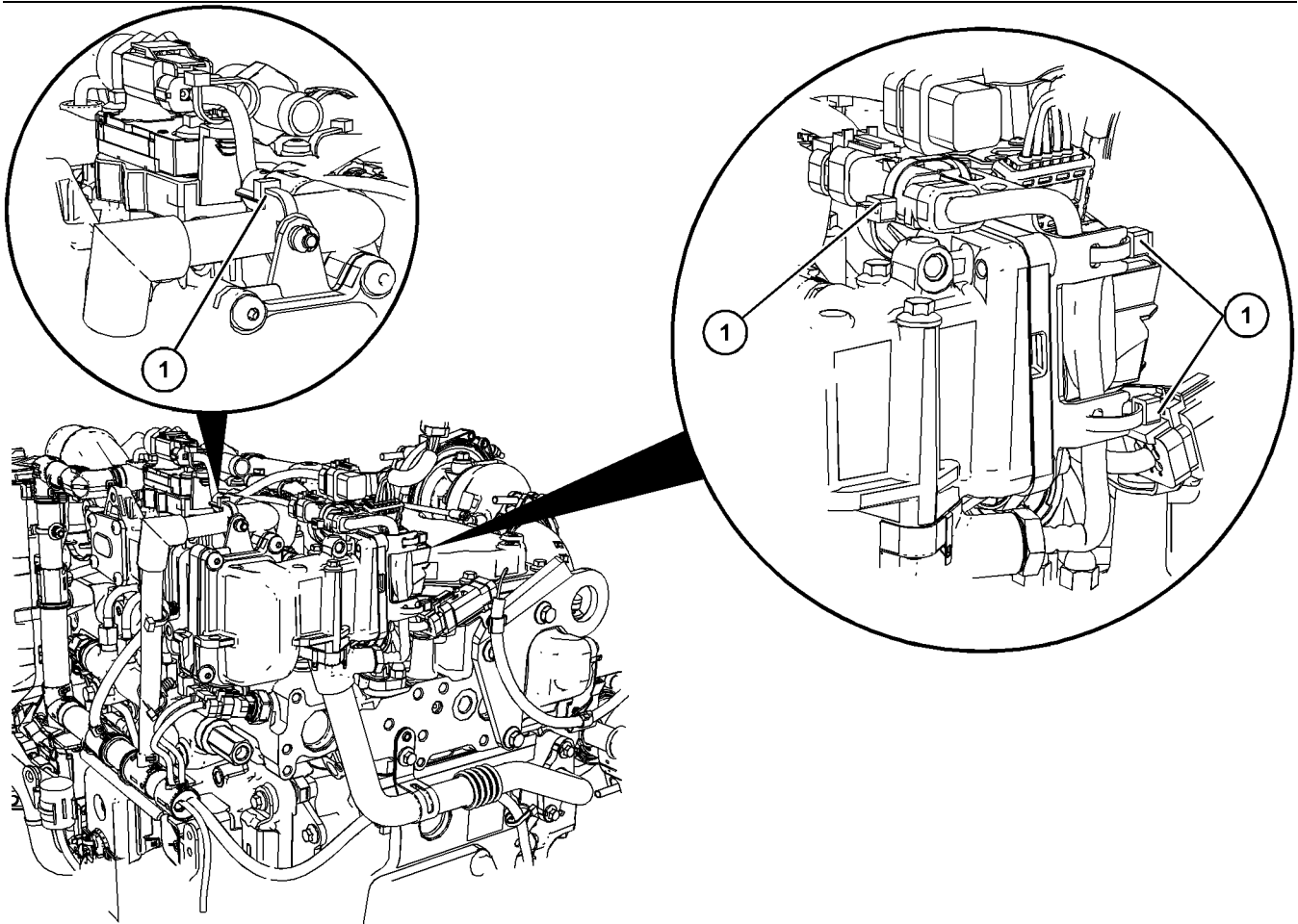


Illustration 144

g06500848

23. Install new cable straps (1) to harness assembly (2), harness assembly (3), and harness assembly (4).

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

End By:

- a. If necessary, install the clean emissions module. Refer to Disassembly and Assembly, "Clean Emissions Module - Remove and Install" for the correct procedure.

i08468503

Clean Emissions Module - Remove and Install

Removal Procedure

Table 20

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400921	Capping Kit	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, "Battery Disconnect Switch" for further information.

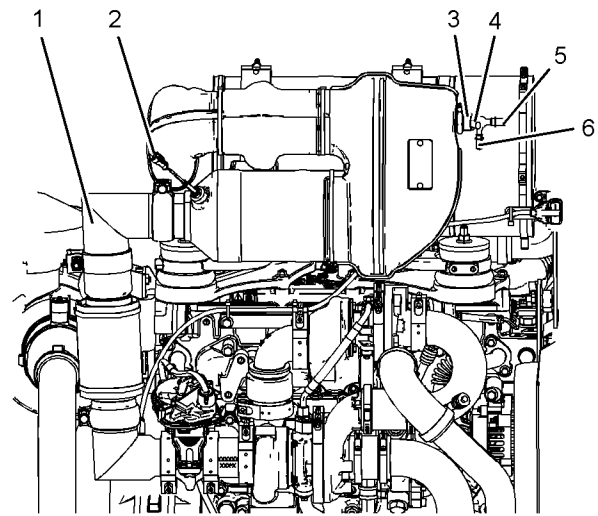


Illustration 145

g03726978

2. Remove flexible exhaust pipe (1). Refer to Disassembly and Assembly, "Flexible Exhaust Pipe - Remove and Install" for the correct procedure.
3. Disconnect the harness assembly from exhaust temperature sensor (2).
4. Disconnect harness assembly (4) from Diesel Emission Fluid (DEF) injector(3). Use Tooling (A) to cap the harness assembly and the DEF injector.
5. Remove Diesel Emission Fluid (DEF) line (5) and diesel emission fluid line (6) from the DEF injector (3). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
6. Use Tooling (A) to caps DEF injector (3).
7. Use Tooling (A) plug diesel emission fluid line (5) and diesel emission fluid line (6).

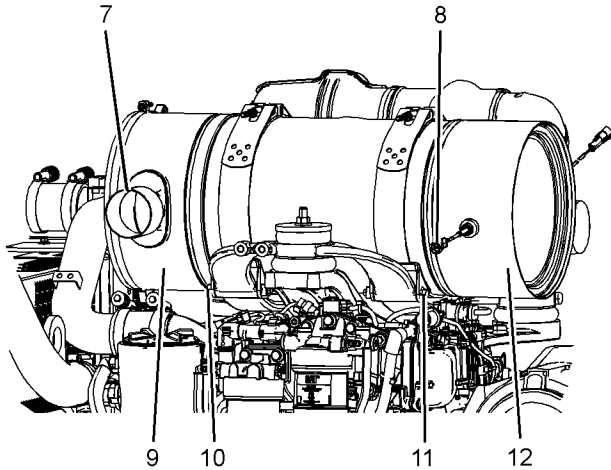


Illustration 146

g03726980

8. Remove the Original Equipment Manufacture (OEM) exhaust tube assembly (7) from Clean Emissions Module (CEM) (12). Refer to the OEM for the correct procedure.
9. Disconnect the harness assembly from exhaust temperature sensor (8).
10. Attach a suitable lifting device to the assembly of CEM (12).
11. Remove bolts (10) and bolts (11) from CEM (12). Use the suitable lifting device to remove the CEM from the bracket.

Installation Procedure

1. Ensure that all components are clean and free from wear and damage. If necessary, replace the CEM as an assembly. The assembly of the CEM will be supplied with mounting brackets. **The orientation of the CEM to the brackets will be preset. The clamps retaining the CEM to the bracket should not be loosened or removed.**

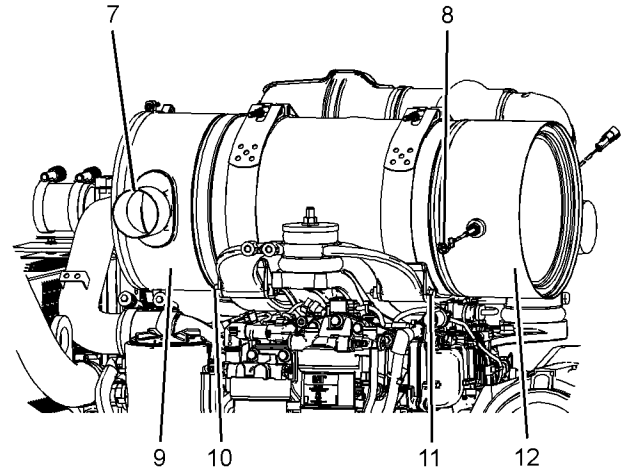


Illustration 147

g03726980

2. Attach a suitable lifting device to the assembly of CEM (12).
3. Use the suitable lifting device to install CEM (12) to the bracket. Install bolts (10) and bolts (11) to CEM (12). Tighten the bolts to a torque of 44 N·m (32 lb ft).
4. Remove the suitable lifting device from CEM (12).
5. Connect the harness assembly to exhaust temperature sensor (8).
6. Install the Original Equipment Manufacture (OEM) exhaust tube assembly (7) to Clean Emissions Module CEM (12). Refer to the OEM for the correct procedure.

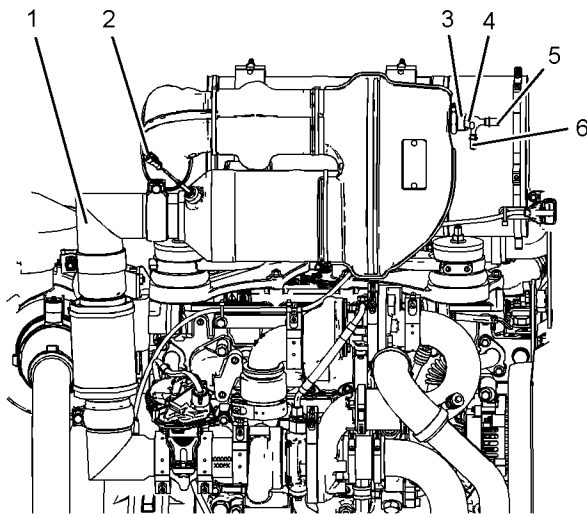


Illustration 148

g03726978

7. Install flexible exhaust pipe (1). Refer to Disassembly and Assembly, "Flexible Exhaust Pipe - Remove and Install" for the correct procedure.
8. Connect the harness assembly to exhaust temperature sensor (2).
9. Remove the cap the harness assembly (4) and DEF injector (3). Connect the harness assembly to the DEF injector.
10. Remove the caps from DEF injector (3) and diesel emission fluid line (5) and diesel emission fluid line (6). Connect the diesel emission fluid lines to the DEF injector. Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.

i08468505

Diesel Exhaust Fluid Lines - Remove and Install

Removal Procedure

Table 21

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400921	Capping Kit	1
B	-	De-ionized Water	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, "Battery Disconnect Switch" for further information.

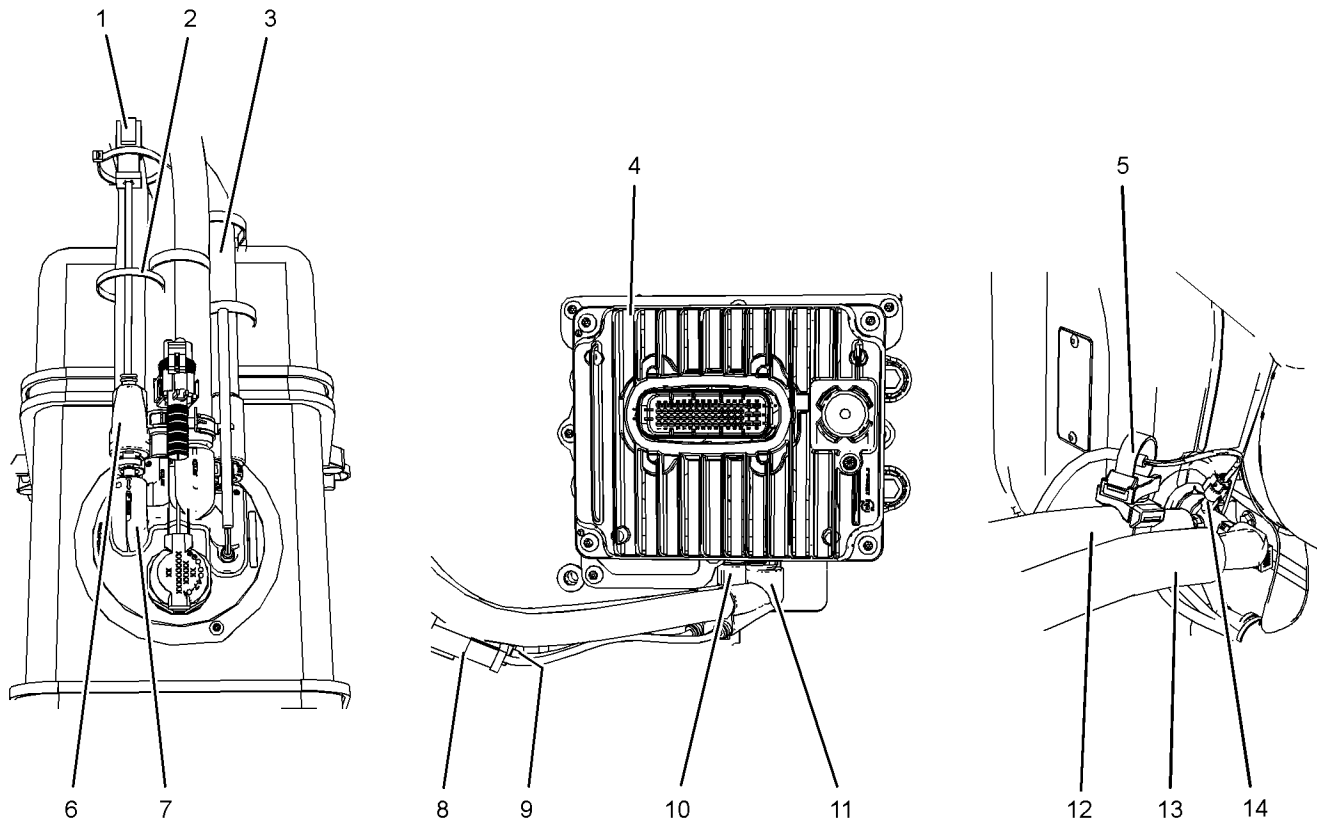


Illustration 149

g03732131

Typical examples

2. Ensure that the area around Manifold (DEF Heater) (7), Diesel Exhaust Fluid (DEF) pump (4), Diesel Exhaust Fluid injector (14) and Diesel Exhaust Fluid (DEF) line (3) and Diesel Exhaust Fluid (DEF) line (6) is clean and free dirt and debris. If necessary, use Tooling (B) and a suitable tool to clean the area around the DEF component.
3. Refer to the Original Equipment Manufacture (OEM) for the correct location of the Manifold (DEF Heater) (7), Diesel Exhaust Fluid (DEF) pump (4), and Diesel Exhaust Fluid injector (14). Refer to the OEM for the correct routing of the diesel exhaust fluid lines.
4. Ensure that the area around manifold DEF heater (7), DEF pump (4), and DEF injector (14) are clean and free dirt and debris. If necessary, clean the area around the manifold DEF heater, DEF pump, and DEF injector.
5. Disconnect the Original Equipment Manufacture (OEM) harness assemblies from harness assembly (1), harness assembly (8), and harness assembly (9) for the Diesel Exhaust Fluid (DEF) lines.
6. Make temporary marks on cable straps for installation purposes. Cut cable straps (2) and cable straps (5). Ensure that all cable straps are removed.
7. Disconnect diesel exhaust fluid line (6) and diesel exhaust fluid line (3) from manifold DEF heater (7).
8. Use Tooling (A) to cap manifold DEF heater (7). Use Tooling (A) to plug diesel exhaust fluid line (6) and diesel exhaust fluid line (3).
9. Disconnect diesel exhaust fluid line (10) and diesel exhaust fluid line (11) from DEF pump (4).
10. Use Tooling (A) to cap DEF pump (4). Use Tooling (A) to plug diesel exhaust fluid line (10) and diesel exhaust fluid line (11).

11. Disconnect diesel exhaust fluid line (12) and diesel exhaust fluid line (13) from DEF injector (14).
12. Use Tooling (A) to cap DEF injector (14). Use Tooling (A) to plug diesel exhaust fluid line (12) and diesel exhaust fluid line (14).

Installation Procedure

Table 22

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	De-ionized Water	1

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

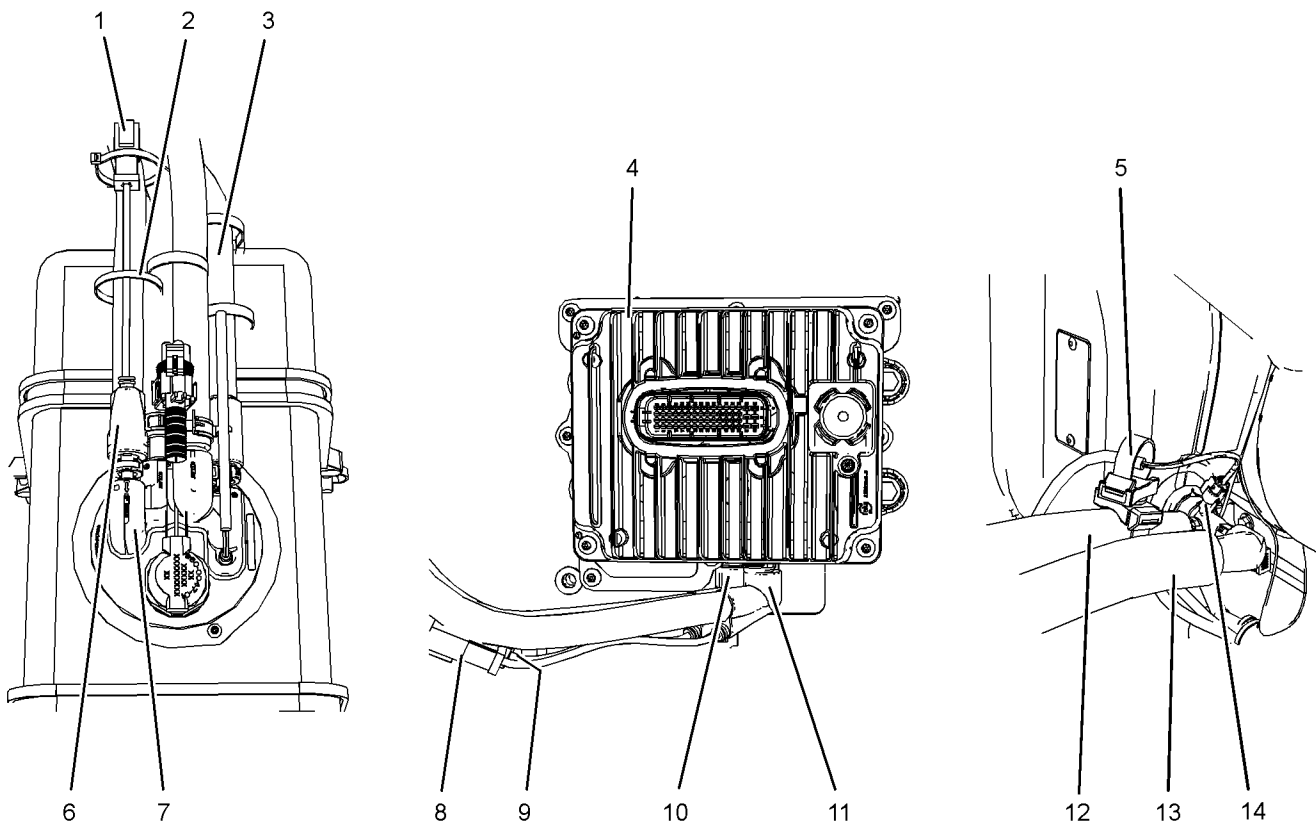


Illustration 150

g03732131

Typical examples

2. Remove caps manifold DEF heater (7) and plug from DEF line (6) and DEF line (3).
3. Connect DEF line (6) and DEF line (3) to manifold DEF heater (7).

4. Connect the OEM harness assemblies to harness assembly (1), harness assembly (8), and harness assembly (9) for the Diesel Exhaust Fluid (DEF) lines.

5. Install new cable straps (2). Ensure that all cable straps are replaced.

Note: Ensure that the cable straps meet OEM specification.

6. Remove caps from DEF pump (4) and plugs from DEF line (10) and DEF line (11).

7. Connect DEF line (10) and DEF line (11) to DEF pump (4).

8. Install new cable straps (5). Ensure that all cable straps are replaced.

Note: Ensure that the cable straps meet OEM specification.

9. Remove cap from DEF injector (14) and plugs from DEF line (13). Connect the DEF line to the DEF injector.

10. Prior to the installation of DEF supply line (12), follow Step 10a through Step 10h in order to flush the DEF supply line.

- a. Turn the battery disconnect switch to the ON position.
- b. Connect the electronic service tool. Refer to Troubleshooting, “Electronic Service Tools” for the correct procedure.
- c. Remove cap from the DEF supply line. Place the open end of the DEF supply line in a suitable container, with a capacity greater than 2 L (0.44 Imp gal).
- d. Select the DEF dosing system accuracy test. Refer to Troubleshooting, “DEF Dosing System Accuracy Test” for the correct procedure.
- e. Hold the DEF supply line above the suitable container. Run the DEF dosing system accuracy test for maximum of 90 second.
Ensure that the DEF supply line is not immersed in the DEF fluid in the suitable container.
- f. Turn the battery disconnect switch to the OFF position.
- g. Use Tooling (B) to clean any DEF fluid from the end of the DEF supply line.
- h. Remove the caps from DEF injector (14). Connect DEF supply line to the DEF injector.

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

12. Use the electronic service tool to perform a pressure test on the DEF system and check for leaks. Refer to Troubleshooting, “DEF Dosing System Verification Test” for further information.

13. Turn the battery disconnect switch to the OFF position. Disconnect the electronic service tool.

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

i08468506

Diesel Exhaust Fluid Pump - Remove and Install

Removal Procedure

Table 23

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400921	Capping Kit	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, “General Hazard” for safety information.

NOTICE

Care must be taken to ensure that Diesel Emission Fluid (DEF) for the system 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. Refer to the Original Equipment Manufacture (OEM) for the location of the DEF pump.
2. **Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, “Battery Disconnect Switch” for further information.**

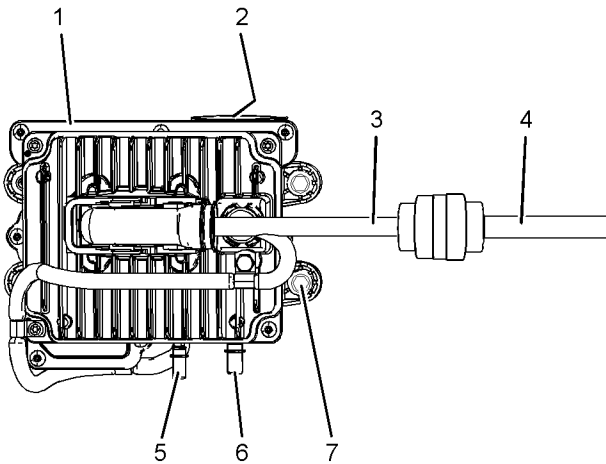


Illustration 151

g03727625

3. Ensure that the area around DEF fluid pump (1) is clean and free dirt and debris. If necessary, clean the area around the DEF injector. **Clean the area around the DEF fluid pump with Tooling (B) and a suitable tool.**
4. Disconnect harness assembly (3) from Original Equipment Manufacture (OEM) harness assembly (4).
5. Make temporary marks on DEF lines for installation purposes. Remove the DEF line from connection (5) and the DEF line from connection (6) from DEF fluid pump(1). Refer to Disassembly and Assembly, “Diesel Exhaust Fluid Lines - Remove and Install” for the correct procedure.
6. Use Tooling (A) to plug the DEF lines. Tooling (A) to cap connection (5) and connection (6).
7. Remove bolts (7) from DEF pump (1). Support the weight of the DEF pump as the bolts are removed. Remove the DEF pump.
8. If necessary, remove DEF filter (2) (not shown). Refer to Operation and Maintenance Manual, “Diesel Exhaust Fluid Filter - Clean/Replace” for the correct procedure.

Installation Procedure

Table 24

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	De-ionized Water	1

1. Ensure that the DEF pump is free from wear or damage. Replace the DEF pump as an assembly if any component of the DEF pump is not free from wear or damage.

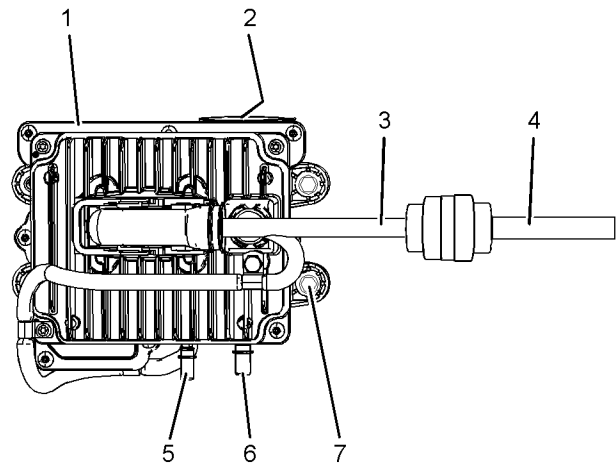


Illustration 152

g03727625

2. If necessary, install a new DEF filter (2) (not shown). Refer to Operation and Maintenance Manual, “Diesel Exhaust Fluid Filter - Clean/ Replace” for the correct procedure.
 3. Install DEF pump (1) and install bolts (7) to diesel exhaust fluid pump. Support the weight of the DEF pump as the bolts are installed. Tighten the bolts to a torque of 16 N·m (142 lb in).
 4. Remove plugs from the DEF lines. Remove the caps from connection (5) and connection (6).
 5. Install the DEF line to connection (5) and the DEF line to connection (6). Refer to Disassembly and Assembly, “Diesel Exhaust Fluid Lines - Remove and Install” for the correct procedure.
- Note:** Ensure that the DEF lines are connected into the correct positions.
6. Connect harness assembly (3) to OEM harness assembly (4).

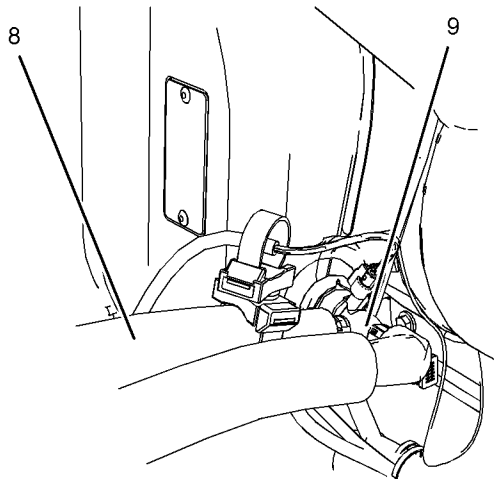


Illustration 153

g03741895

Typical example

7. After the installation of the DEF lines on to the DEF pump. Follow Step 7a through Step 7k in order to flush DEF supply line (8) at DEF injector (9).

- a. Ensure that the area around DEF injector (9) is clean and free dirt and debris. If necessary, clean the area around the DEF injector. **Clean the area around the DEF injector with Tooling (B) and a suitable tool.**
- b. Disconnect DEF line (8) from DEF injector (9).
- c. Use Tooling (A) to cap DEF injector (9) and DEF line (8).
- d. Turn the battery disconnect switch to the ON position.
- e. Connect the electronic service tool. Refer to Troubleshooting, "Electronic Service Tools" for the correct procedure.
- f. Remove cap from the DEF supply line. Place the open end of the DEF supply line in a suitable container, with a capacity greater than 2 L (0.44 Imp gal).
- g. Select the DEF dosing system accuracy test. Refer to Troubleshooting, "DEF Dosing System Accuracy Test" for the correct procedure.
- h. Hold the DEF supply line above the suitable container. Run the DEF dosing system accuracy test for maximum of 90 second. **Ensure that the DEF supply line is not immersed in the DEF fluid in the suitable container.**

- i. Turn the battery disconnect switch to the OFF position.
- j. Use Tooling (B) to clean any DEF fluid from the end of the DEF supply line.
- k. Remove the caps from DEF injector (9). Connect DEF supply line (8) to the DEF injector.

8. Turn the battery disconnect switch to the ON position.
9. Use the electronic service tool to perform a pressure test on the DEF system and check for leaks. Refer to Troubleshooting, "DEF Dosing System Verification Test" for further information.
10. Turn the battery disconnect switch to the OFF position. Disconnect the electronic service tool.
11. Turn the battery disconnect switch to the ON position.

i08468507

DEF Injector and Mounting - Remove and Install

Removal Procedure

Table 25

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400921	Capping Kit	1
B	-	De-ionized Water	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, "Battery Disconnect Switch" for further information.

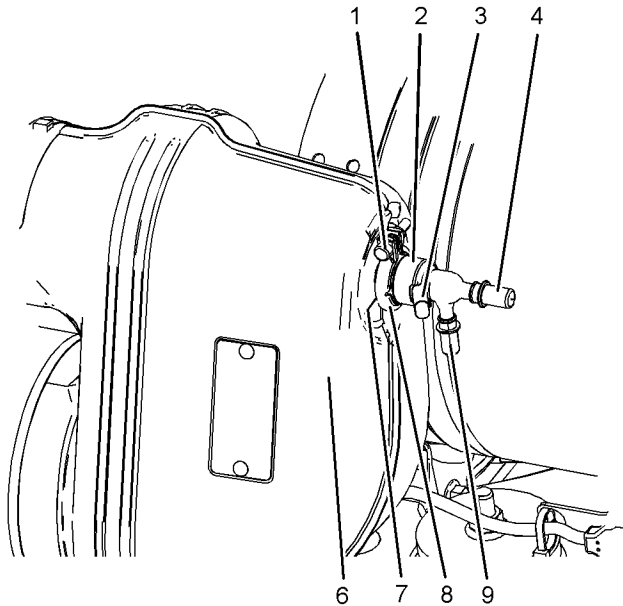


Illustration 154

g03727382

2. Ensure that the area around Diesel Emission Fluid (DEF) injector (2) is clean and free dirt and debris. If necessary, clean the area around the DEF injector. **Clean the area around the DEF injector with Tooling (B) and a suitable tool.**
3. Disconnect the harness assembly from connection (4) on DEF injector (2). Use Tooling (A) to cap the harness assembly and the DEF injector.
4. Remove the Diesel Emission Fluid (DEF) line from connection (4) on the DEF injector (2). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
5. Use Tooling (A) to cap connection (4) on DEF injector (2) and the DEF line.
6. Remove the DEF line from connection (9) on DEF injector (2). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.

7. Use Tooling (A) to cap connection (9) on DEF injector (2) and the DEF line.
8. Make temporary marks on DEF injector (2) and Clean Emissions Module (CEM) (6) for installation purposes.
9. Sufficiently loosen allen head bolt (1) for V-band clamp (8) and remove DEF injector (2) and the V-band clamp from CEM (6).
10. Remove gasket (7) (not shown).

Installation Procedure

Table 26

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	De-ionized Water	1

1. Ensure that the DEF injector and the CEM are free from wear or damage. Replace any component that is worn or damaged.

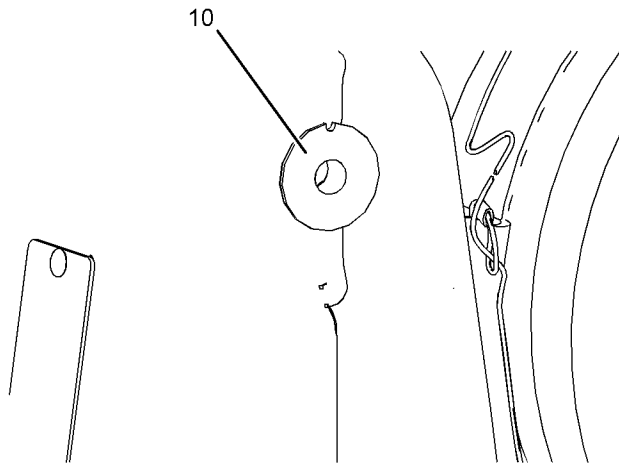


Illustration 155

g03736256

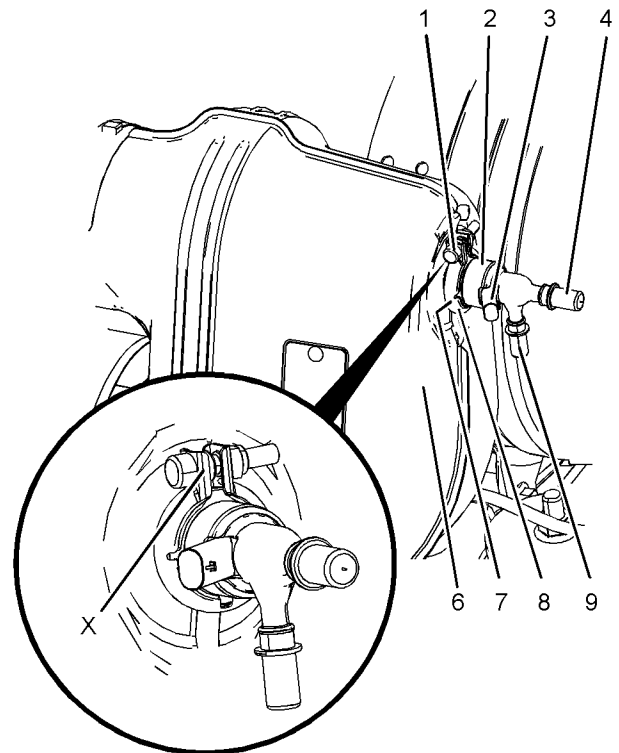


Illustration 156

g03729714

2. Ensure that gasket surface (10) for DEF injector (2) is clean and free from damage and wear.
3. Install a new gasket (7) (not shown) onto DEF injector (2).

4. Position V-band clamp (8) onto DEF injector (2). Ensure that the V-band clamp is correctly orientated in Position (X).
5. Install DEF injector (2) and align with the temporary marks. Tighten allen head bolt (1) hand tight. Ensure that the DEF injector and the clamp are correctly seated onto the CEM. Ensure that the DEF injector and V-band clamp is free to rotate.
6. Remove the caps from the harness assembly and connection (4) on DEF injector(2). Connect harness assembly to the connection on the DEF injector.
7. Prior to the installation of the DEF supply line, follow Step 7a through Step 7h in order to flush the DEF supply line.
 - a. Turn the battery disconnect switch to the ON position.
 - b. Connect the electronic service tool. Refer to Troubleshooting, "Electronic Service Tools" for the correct procedure.
 - c. Remove cap from the DEF supply line. Place the open end of the DEF supply line in a suitable container, with a capacity greater than 2 L (0.44 Imp gal).
 - d. Select the DEF dosing system accuracy test. Refer to Troubleshooting, "DEF Dosing System Accuracy Test" for the correct procedure.
 - e. Hold the DEF supply line above the suitable container. Run the DEF dosing system accuracy test for maximum of 90 second. **Ensure that the DEF supply line is not immersed in the DEF fluid in the suitable container.**
 - f. Turn the battery disconnect switch to the OFF position.
 - g. Use Tooling (B) to clean any DEF fluid from the end of the DEF supply line.
 - h. Remove the caps from DEF injector (2). Connect DEF supply line to connection (9) on DEF injector (2).
8. Remove the caps from connection (4) on DEF injector (2). Connect the DEF return line to the DEF injector. Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure. If necessary, loosen allen head bolt (1) for clamp (8) in order to ensure that the diesel emission fluid lines are not strained on installation.

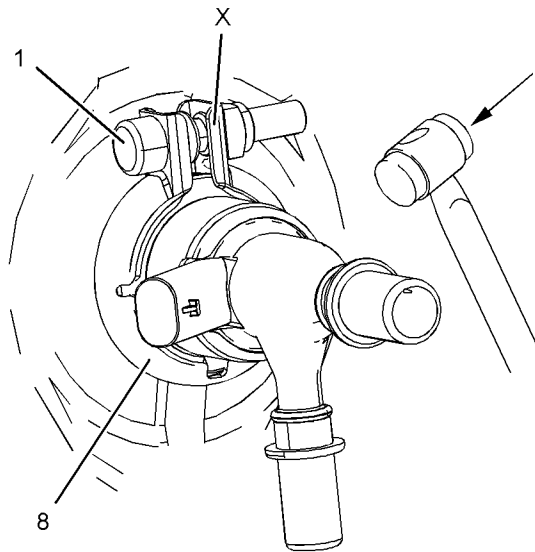


Illustration 157

g03736268

9. Tighten allen head bolt (1) for V-band clamp (8) to a torque of 4 N·m (35 lb in). Ensure that the clamp remains in Position (X).
10. Lightly tap the full circumference of the V-band clamp with a soft faced hammer in order to correctly seat the V-band clamp. Repeat Step 9 until the allen head bolt reaches the correct torque value.
11. Turn the battery disconnect switch to the ON position.
12. Use the electronic service tool to perform a pressure test on the DEF system and check for leaks. Refer to Troubleshooting, “DEF Dosing System Verification Test” for further information.
13. Turn the battery disconnect switch to the OFF position. Disconnect the electronic service tool.

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

i08468510

Diesel Exhaust Fluid Tank - Remove and Install

Removal Procedure

Table 27

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400921	Capping Kit	1
B	-	De-ionized Water	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, “General Hazard” for safety information.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, “Battery Disconnect Switch” for further information.
2. Refer to the Original Equipment Manufacture (OEM) for the location of the diesel exhaust fluid tank.
3. Drain the coolant from the cooling system to a level below the solenoid valve, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct draining procedure.

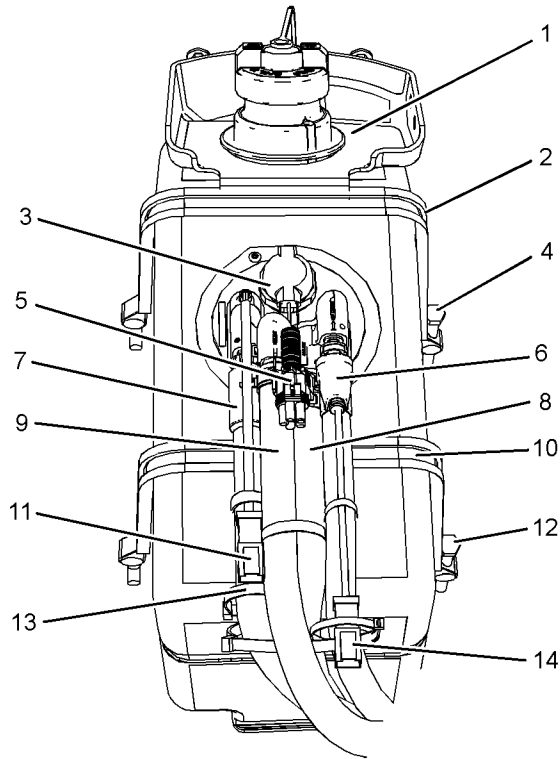


Illustration 158

g03732064

Typical example

4. Ensure that the area around manifold DEF heater (3) is clean and free dirt and debris. If necessary, clean the area around the manifold DEF heater. **Clean the area around the manifold DEF heater with Tooling (B) and a suitable tool.**
5. Make temporary mark on cable straps (13) for installation purposes. Cut the cable straps from the harness assemblies and the diesel emission fluid lines.
6. Disconnect the Original Equipment Manufacture (OEM) harness assemblies from harness assembly (5), harness assembly (11), and harness assembly (14). Use Tooling (A) to cap the harness assemblies.
7. Remove diesel emission fluid line (7) and diesel emission fluid line (6) from manifold DEF heater (3). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
8. Loosen the hose clamps and disconnect the hose assembly (8) and hose assembly (9) from manifold DEF heater (3). Use Tooling (A) to cap hose assemblies and the manifold DEF heater.

9. Remove bolt (4) and bolt (12) for strap (2) and strap (10). Remove the straps from diesel exhaust fluid tank (1).
10. Remove diesel exhaust fluid tank (1) from the mounting bracket.

Installation Procedure

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

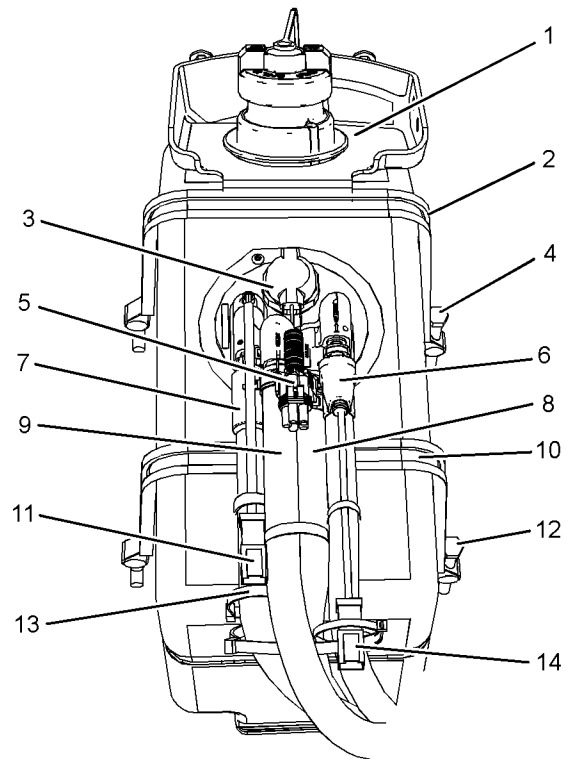


Illustration 159

g03732064

Typical example

2. Install diesel exhaust fluid tank (1) onto the mounting bracket.
3. Install strap (2) and strap (10) onto diesel exhaust fluid tank (1). Ensure that the straps are correctly installed onto the diesel exhaust fluid tank.
4. Install bolt (4) and bolt (12) for strap (2) and strap (10). Hand tighten the bolts. Ensure that the straps are correctly located onto the diesel exhaust fluid tank.
5. Tighten bolt (4) and bolt (12) to strap (2). Refer to the OEM for the correct torque procedure and the correct value.

6. Install diesel emission fluid line (7) and diesel emission fluid line (6) to manifold DEF heater (3). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
 7. Remove the caps from hose assembly (8) and hose assembly (9) to manifold DEF heater (3). Connect the hose assemblies to the manifold DEF heater. Ensure that the hose assemblies are installed into the correct positions. Tighten the hose clamps. Refer to the OEM for the correct torque value.
 8. Remove the caps from harness assembly (5), harness assembly (11), and harness assembly (14). Connect the OEM harness assemblies to the harness assemblies. Ensure that the harness assemblies are installed into the correct position.
 9. Install new cable straps (13) to the harness assemblies and the diesel emission fluid lines. Ensure that the cable straps are install in the original position.
- Note:** Ensure that the cable straps meet OEM specifications.
10. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Check" and Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.
 11. Turn the battery disconnect switch to the ON position.

i08601567

Manifold (DEF Heater - Remove and Install

Removal Procedure

Table 28

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400291	Capping Kit	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. **Ensure that the purge process for the DEF system is completed before turning the battery disconnect switch to the OFF position. Refer to the Operation and Maintenance Manual, "Battery Disconnect Switch" for further information.**
2. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

Disassembly and Assembly Section

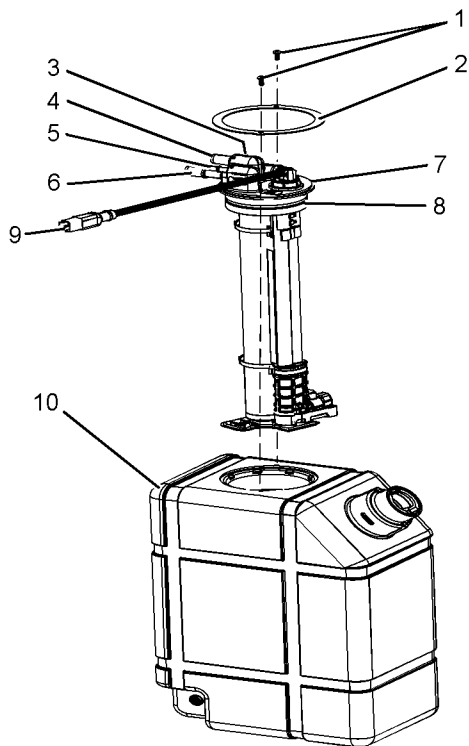


Illustration 160

g03730127

3. Remove the Diesel Emission Fluid (DEF) line from connection (3) (not shown) from manifold Diesel Exhaust Fluid (DEF) heater (7). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
4. Remove the diesel emission fluid line from connection (6) from manifold DEF heater (7). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
5. Use Tooling (A) to cap connection (6) and connection (3) (not shown).
6. Use Tooling (A) to plug the DEF lines.
7. Loosen the hose clamps on the hose assemblies. Disconnect the hose assemblies from connection (4) and connection (5) from manifold DEF heater (7).
8. Use Tooling (A) to cap connection (4) and connection (5).
9. Use Tooling (A) to plug the hose assemblies.
10. Disconnect the harness assembly from harness assembly (9).

11. Remove Torx screws (1) from ring (2). Remove the ring from manifold DEF heater (7).
12. Remove manifold DEF heater (7) from DEF tank (10).
13. Remove O-ring seal (8) from manifold DEF heater (7).

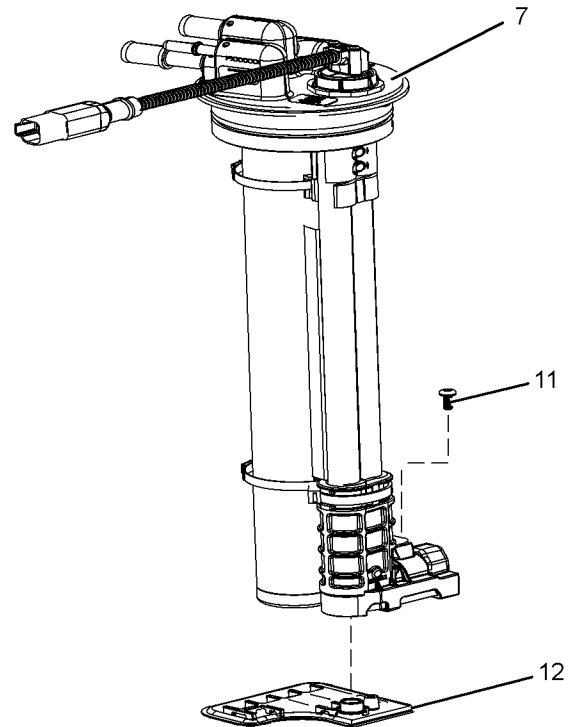


Illustration 161

g03730136

14. If necessary, follow Step 4a through Step 5 to remove filter (12) from manifold DEF heater (7).
 - a. Remove Torx screw from filter (12).
 - b. Remove filter (12).

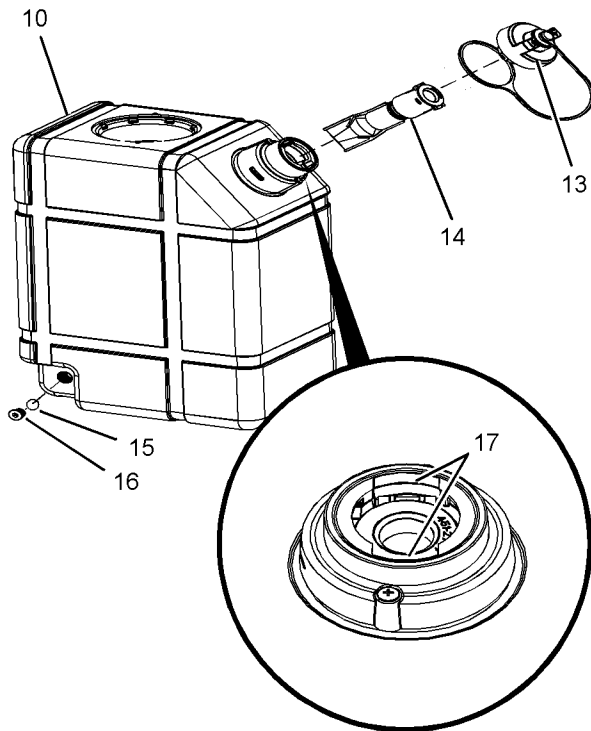


Illustration 162

g03730140

15. If necessary, follow Step 15a through Step 15d to disassemble DEF tank (10).
 - a. Ensure that the area around cap on the DEF tank is clean. Drain DEF tank (10). Refer to Operation and Maintenance Manual, “Diesel Exhaust Fluid Tank - Flush” the correct procedure.
 - b. Remove plug (16) from DEF tank (10). Remove O-ring seal (15) from the plug.
 - c. Remove filler cap (13) from DEF tank (10).
 - d. Use a suitable tool, to press locking tabs (17) and remove filter screen (14) from the neck of DEF tank (10).

Installation Procedure

Table 29

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610296	Torque Wrench	1
C	-	T15 Torx 1/4" Hexagon Drive	1
D	-	T25 Torx 1/4" Hexagon Drive	1

1. Ensure that the manifold DEF heater, DEF tank, filter, and filter screen are free from wear, damage, clean, and free from restriction. Replace any component that is not free from wear, damage, and free from restriction.
2. If necessary, clean DEF filler screen. Refer to Operation and Maintenance Manual, “DEF Filler Screen - Clean” the correct procedure.

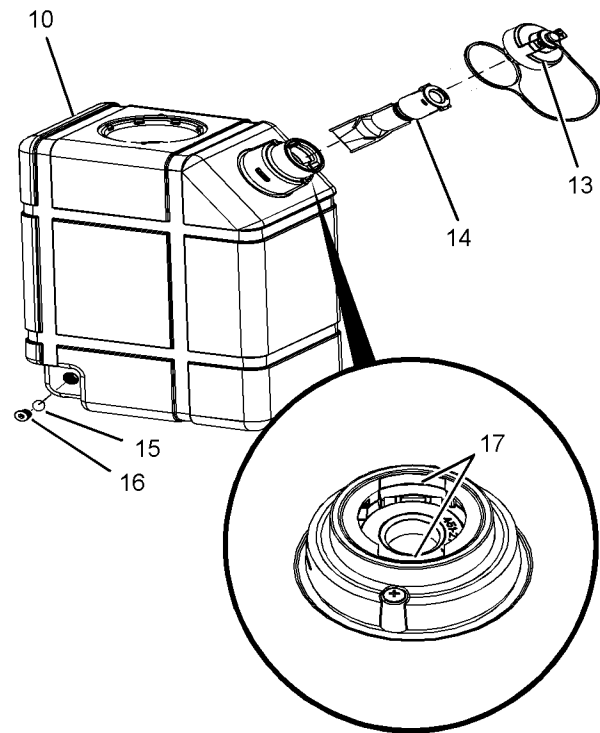


Illustration 163

g03730140

3. If necessary, follow Step 3a through Step 3c to assemble DEF tank (10).
 - a. Install a new O-ring seal (15) to plug (16). Install the plug to DEF tank (10). Tighten the plug to a torque of 6 N·m (53 lb in).
 - b. Install filter screen (14) to the neck of DEF tank (10). Ensure that locking tabs (17) are correctly engaged into the neck of DEF tank.
 - c. Install filler cap (13) to DEF tank (10).

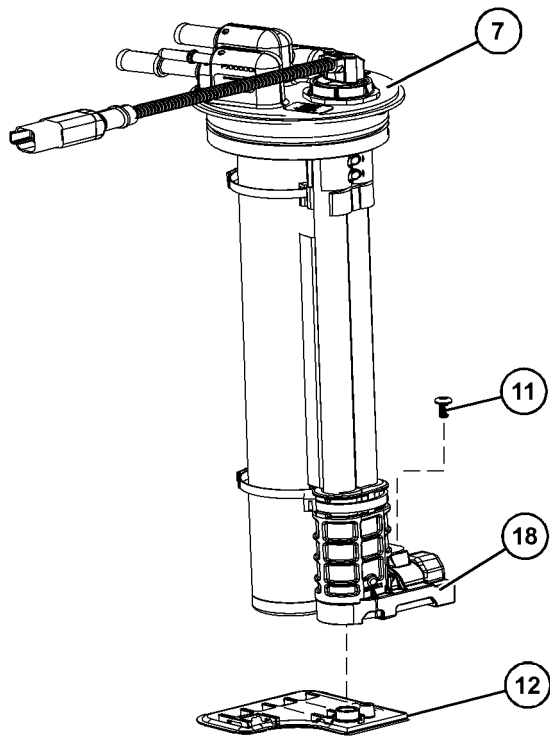


Illustration 164

g06719333

Typical Example

4. If necessary, follow Step 4a through Step 4b to install filter (12) to manifold DEF heater (7).
 - a. Install filter (12) to manifold DEF heater (7). Ensure that the filter is correctly positioned onto the manifold DEF heater.
 - b. Install Torx screw to filter (12). Use Tooling (B) and Tooling (C) to tighten the Torx screw to a torque of 1.24 N·m (11 lb in).

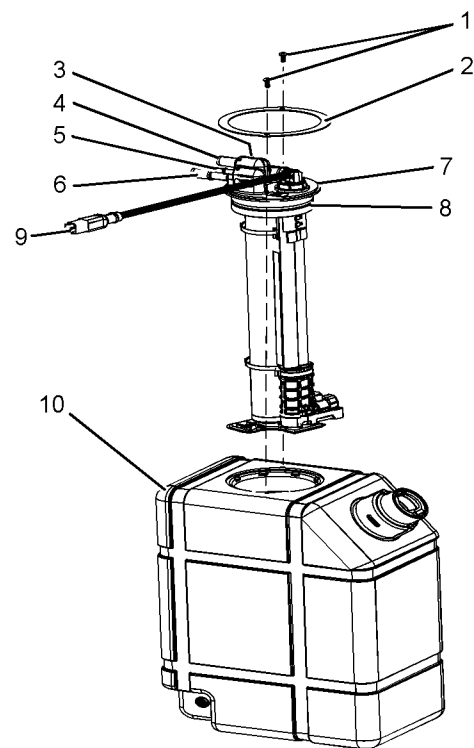


Illustration 165

g03730127

5. Install a new O-ring seal (8) to manifold DEF heater (7).
 6. Ensure that the DEF tank (10) has a minimum level of 50% DEF solution in the DEF tank.
 7. Insert manifold DEF heater (7) to DEF tank (10). Agitate the manifold DEF heater in the DEF solution by moving it up and down, side to side for 60 seconds to expel air from sensor unit protective boot (18). Ensure that the unit is then correctly seated into the DEF tank.
- Note:** failure to remove trapped air from the protective boot of a new sensor, may result in fault codes being displayed.
8. Install manifold DEF heater (7) to DEF tank (10). Ensure that the manifold DEF heater is correctly seated into DEF tank.
 9. Install ring (2) to manifold DEF heater (7). Ensure that the ring is correctly orientated and correctly seated onto the manifold DEF heater.
 10. Install new Torx screws (1) to ring (2). Use Tooling (B) and Tooling (D) to tighten Torx screws to a torque of 2.8 N·m (25 lb in).
 11. Remove the caps from the connections on the manifold DEF heater. Remove caps from DEF lines.

12. Install the DEF line to connection (3) (not shown) on manifold DEF heater (7). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
13. Install the diesel emission fluid line to connection (6) on manifold DEF heater (7). Refer to Disassembly and Assembly, "Diesel Exhaust Fluid Lines - Remove and Install" for the correct procedure.
14. Remove the cap connection (4) and connection (5).
15. Connect the hose assemblies to connection (4) and connection (5) on manifold DEF heater (7). Tighten the hose clamps to a torque of 7 N·m (62 lb in).
16. Connect the harness assembly to harness assembly (9).
17. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
18. Turn the battery disconnect switch to the ON position.

i07989455

Manifold (DEF Heater Sensor - Disassemble

(Temperature, Level, Quality DEF Manifold Sensor)

Disassemble Procedure

Table 30

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Deionized water	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

Care must be taken to ensure that Diesel Emission Fluid (DEF) for the system 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.

Start By:

- a. Remove the manifold DEF heater. Refer to Disassembly and Assembly, "Manifold (DEF Heater) - Remove and Install" for the correct procedure.

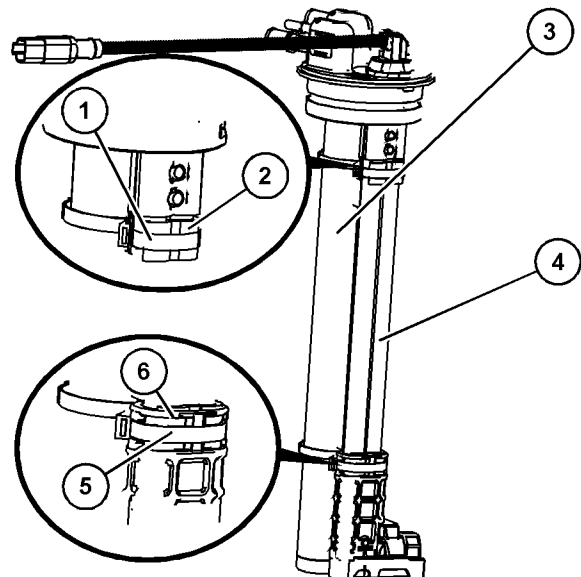


Illustration 166

g06496948

Typical example

1. If necessary, use Tooling (A) to clean the Diesel Exhaust Fluid (DEF) deposits from manifold DEF heater (3) and DEF sensor (4)
2. Using a suitable tool cut cable strap (1) and cable strap (5), remove the cable straps.

Note: Note cable strap positions for installation purposes.

Note: Discard cable straps once removed.

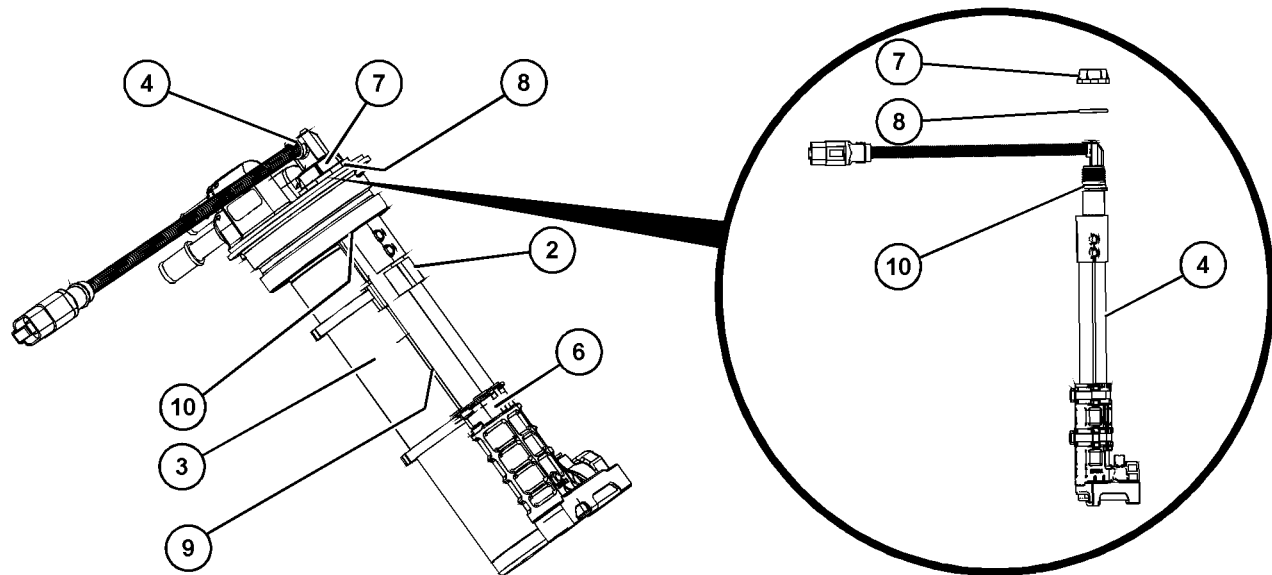


Illustration 167

g06499816

Typical example

3. Place the DEF heater (3) in a suitable support, using a suitable tool loosen nut (7) on DEF sensor (4).
4. Remove nut (7) and O-ring seal (8) from DEF sensor (4).

Note: Ensure that the O-ring seal is removed from the upper sealing face of the DEF header.

5. If necessary, use a suitable tool to remove DEF sensor (4) from clamp (2) and clamp (6), ensure that the clamps are not damaged. Whilst removing the DEF sensor from the DEF header. Ensure spacer (9) is supported as the DEF sensor is removed from the DEF header.

Note: Note DEF sensor orientation for installation purposes.

Note: Note spacer position and orientation for installation purposes.

6. Ensure O-ring seal (10) is removed from the lower sealing face of the DEF header.

i07989519

Manifold (DEF Heater Sensor - Assemble (Temperature, Level, Quality DEF Manifold Sensor)

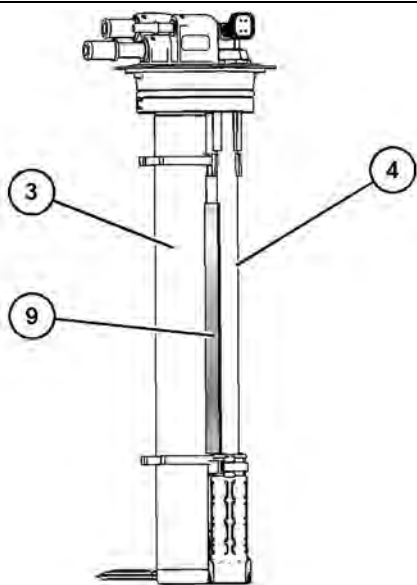


Illustration 168

g06501321

Typical example

Assembly Procedure

Table 31

Required Tools			
Tool	Part Number	Part Description	Qty

(continued)

(Table 31, contd)

A	-	Cable Strap Tension Tool	1
B	-	Deionized Water	1
C	-	Loctite LB8104	1

NOTICE

Ensure that all adjustments and repairs that are carried out to the Diesel Emission Fluid (DEF) system are performed by authorized personnel that have the correct training.

Before beginning ANY work on the DEF system, refer to Operation and Maintenance Manual, "General Hazard" for safety information.

NOTICE

Care must be taken to ensure that Diesel Exhaust Fluid (DEF) for the system 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 free from damage and wear. Replace any component that is worn or damaged.

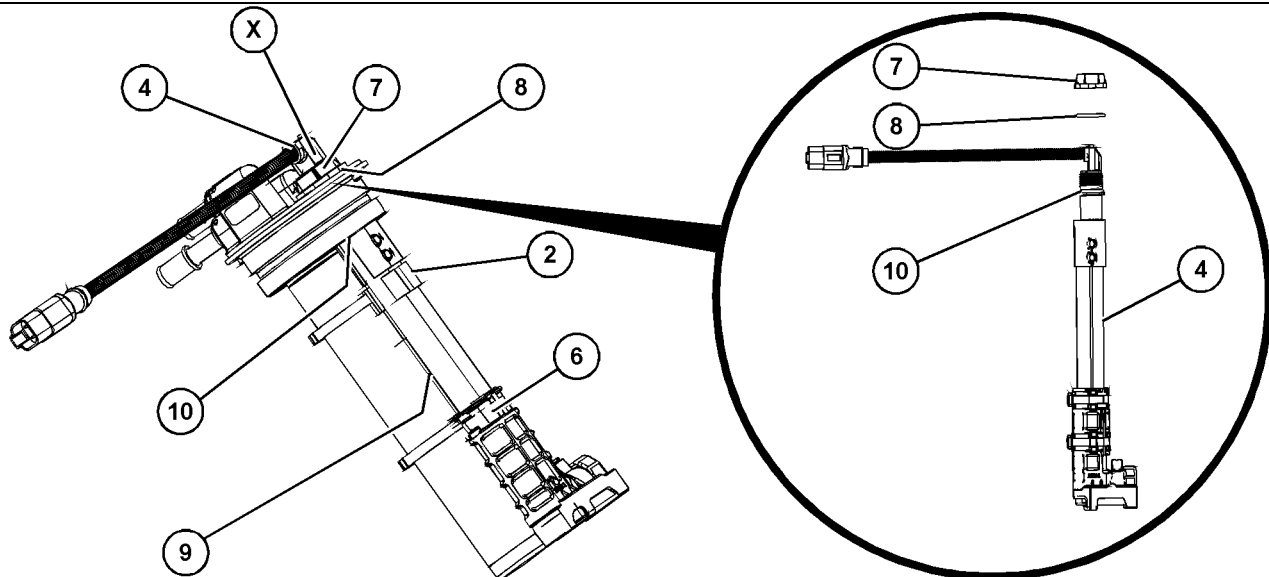


Illustration 169

g06499866

Typical example

2. Ensure new O-ring (10) is installed to new DEF sensor (4). Apply Tooling (C) to the new O-ring seal.

Note: Do not use hydrocarbon-based lubricant.

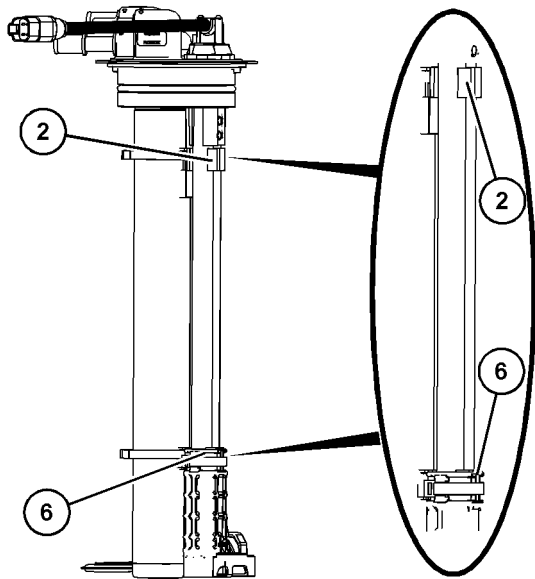


Illustration 170

g06501315

Typical example

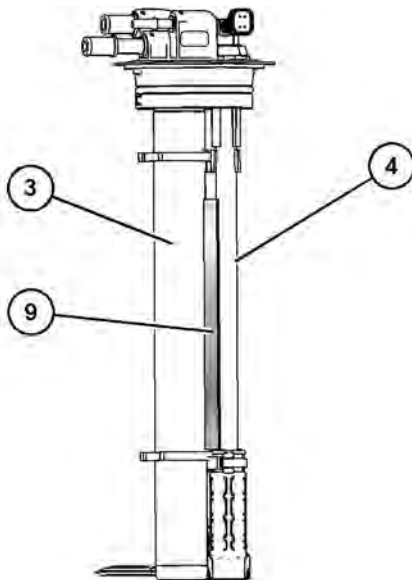


Illustration 171

g06501321

Typical example

- Place DEF heater (3) in a suitable support. Install DEF sensor (4) to the DEF header in Position (X) in the orientation noted on removal. Ensure that the DEF sensor locates into clamp (2) and clamp (6) as the DEF sensor is installed. Install spacer (9) between DEF heater (3) and DEF sensor (4) in the position and orientation noted on removal.

- Ensure new O-ring (8) is located in new nut (7) and apply Tooling (C) to the new O-ring seal. Install the new nut to DEF sensor (4) and tighten the nut finger tight.

Note: Do not use hydrocarbon-based lubricant.

- Using suitable tool tighten nut (7) to a torque of 4.5 N·m (40 lb in)

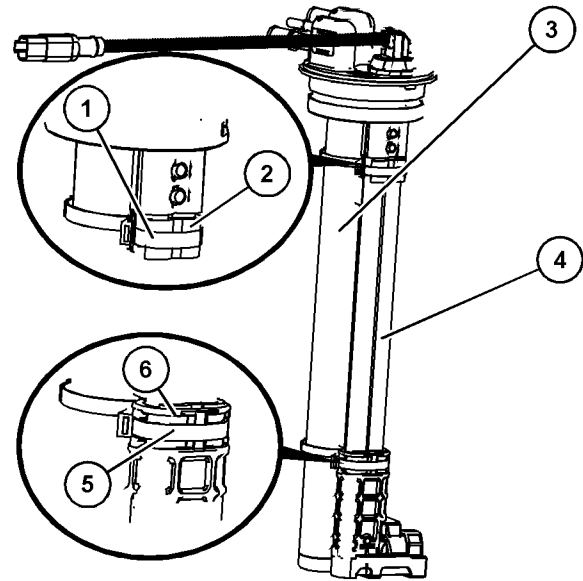


Illustration 172

g06496948

Typical example

- Install new cable tie (1) to clamp (2) and new cable tie (5) to clamp (6) in the positions noted on removal. Use Tooling (A) to tighten the new cable ties to 222 N (50 lb).

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

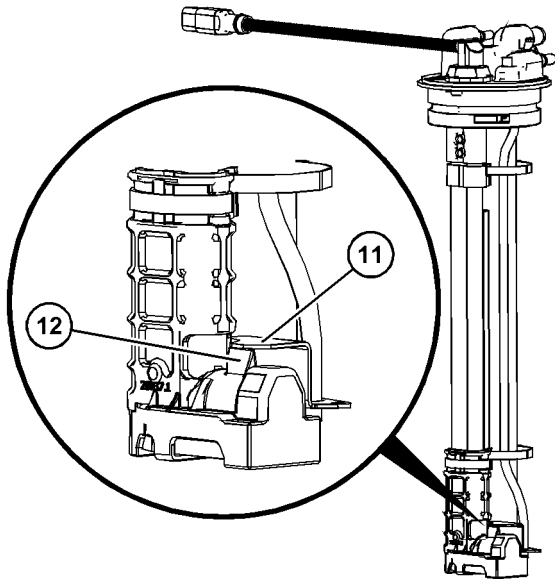


Illustration 173

g06496977

7. Ensure that there is an air gap between gas bubble evacuation port (12) on the DEF sensor (4) and bracket (11). If necessary, adjust bracket (11) to achieve 5 mm (0.2 inch) gap between the gas bubble evacuation port and the bracket.
8. Using Tooling (B) clean any excess assembly lubricant from the DEF sensor prior to installing the DEF heater to the DEF tank.

End By:

- a. **Install the manifold DEF heater. Refer to Disassembly and Assembly, "Manifold (DEF Heater) - Remove and Install" for the correct procedure.**

i05981816

Solenoid Valve (DEF Heater Coolant) - Remove and Install

Removal Procedure

1. Turn the battery disconnect switch to the OFF position.
2. Refer to the Original Equipment Manufacture (OEM) for the location of the solenoid valve.
3. Drain the coolant from the cooling system to a level below the solenoid valve, into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.

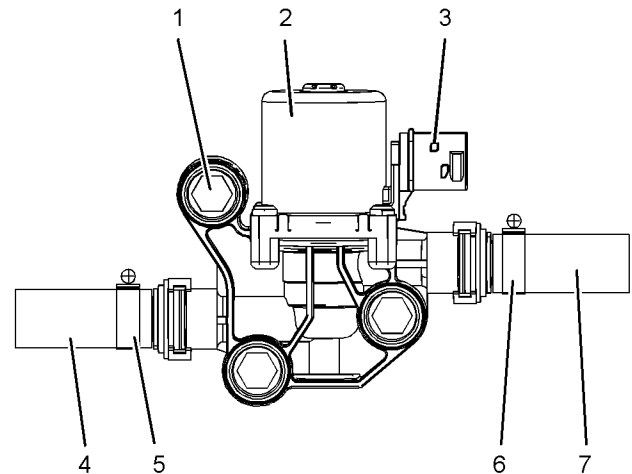


Illustration 174

g03727977

4. Disconnect the harness assembly from connection (3) on solenoid valve (2).
5. Loosen hose clamp (5) and remove hose assembly (4) from solenoid valve (2).
6. Loosen hose clamp (6) and remove hose assembly (7) from solenoid valve (2).
7. Remove bolts (1) and remove solenoid valve (2).

Installation Procedure

1. Ensure that the solenoid valve is free from wear or damage. Replace the solenoid valve as an assembly if any component of the solenoid valve is not free from wear or damage.

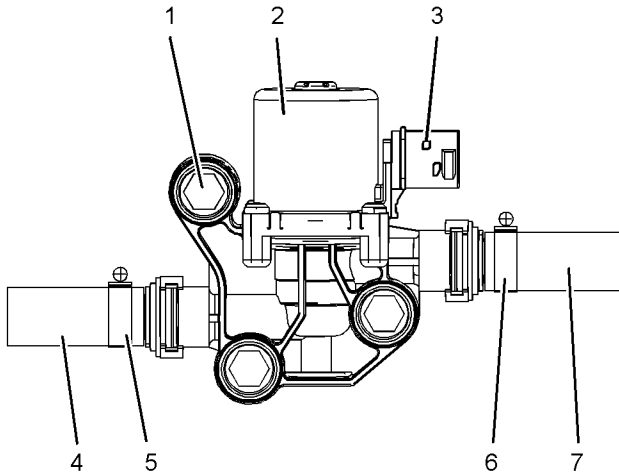


Illustration 175

g03727977

2. Install solenoid valve (2) and install bolts (1). Tighten the bolts to a torque of 22 N·m (195 lb in).
3. Install hose assembly (4) to solenoid valve (2). Tighten hose clamp (5) to a torque of 7 N·m (62 lb in).
4. Install hose assembly (7) to solenoid valve (2). Tighten hose clamp (6) to a torque of 7 N·m (62 lb in).
5. Connect the harness assembly to connection (3) on solenoid valve (2).
6. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Check" and Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.
7. Turn the battery disconnect switch to the ON position.

i05981746

Flexible Exhaust Pipe - Remove and Install

Removal Procedure for the Flexible Exhaust Pipe as an Assembly



The ends of the bellows are very sharp. Injury could occur if the bellows are not handled properly. Handle the bellows by the convolutions.

NOTICE

The bellows must be supported at all times when the bellows are not installed in the application. Failure to support the bellows adequately could result in the failure of the bellows. Do not use power tools in order to disassemble or assemble any part of the flexible exhaust system.

The alignment of the bellows is important. Incorrect alignment may lead to premature failure of the bellows. Misalignment can be identified by visually inspecting the uniformity of the spacing between the convolutions on the bellows.

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. If there is any difficulty in installation after the repair, discard the bellows.

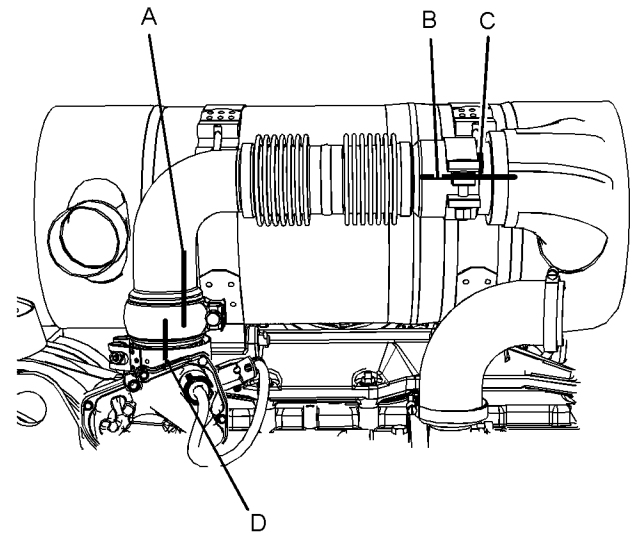


Illustration 176

g02478857

Typical example

1. The lateral alignment of the bellows is critical. All the components must be assembled in the same alignment as prior to disassembly. The components that require correct lateral alignment are shown at Positions (A, B, C, and D).

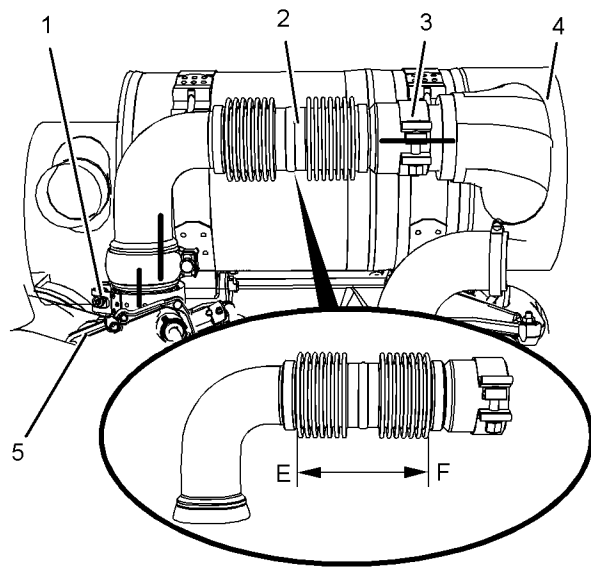


Illustration 177

g02478858

Typical example

2. Follow Steps 2a through Step 2d in order to remove the flexible exhaust as an assembly from the Clean Emission Module (CEM) and the turbocharger.
 - a. Use suitable material in order to encase flexible exhaust pipe (2). Encasing the flexible exhaust pipe will prevent damage of the bellows. Encase bellows for the flexible exhaust pipe (2) between Position (E) and Position (F). Use cable straps in order to retain the suitable material.

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

- b. Loosen clamp (3) on the flexible exhaust pipe assembly.
- c. Loosen the bolt for V-band clamp (1).

Note: If V-band clamp (1) remain tight on the flanges, apply releasing fluid on the V-band clamp. Lightly tap the bolt on the V-band clamp with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamp.**

- d. Remove the assembly of the flexible exhaust pipe from the CEM (4) and exhaust back pressure valve (5).

Note: Ensure that the assembly of the flexible exhaust pipe is supported as the clamps are removed.

Disassembly Procedure for the Flexible Exhaust Pipe Assembly

1. If any part of the flexible exhaust pipe assembly is damaged. Refer to Special Instruction, REHS5014, "Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines" for more information.

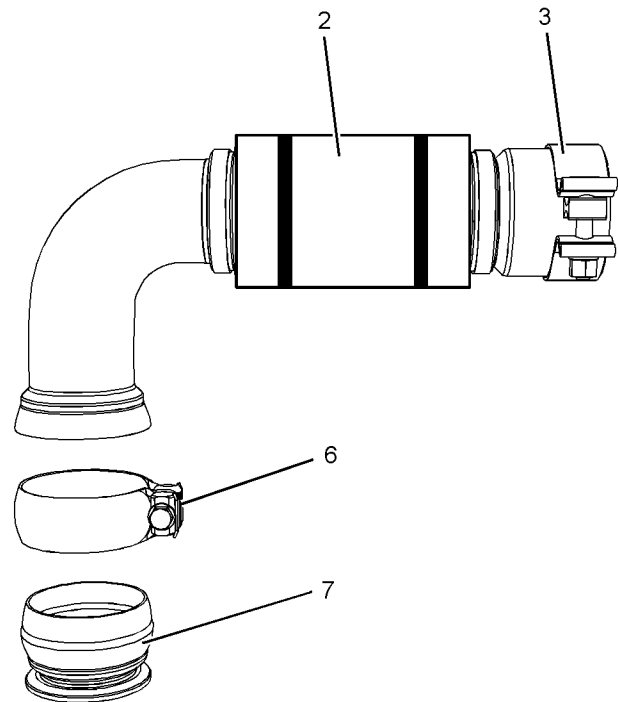


Illustration 178

g02478996

Typical example

2. If necessary, follow Step 2a through Step 2b in order to disassemble the flexible exhaust pipe assembly.
 - a. Loosen ball clamp (6) and remove the ball clamp.
 - b. Remove the assembly of bellows (2) from the adapter (7).

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

Assembly Procedure for the Flexible Exhaust Pipe Assembly

Table 32

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

1. Ensure that all components of the flexible exhaust pipe assembly are clean and free from wear and damage. If necessary, replace any components of the flexible exhaust pipe assembly that are worn or damaged. Refer to Special Instruction, REHS5014, "Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines" for more information.

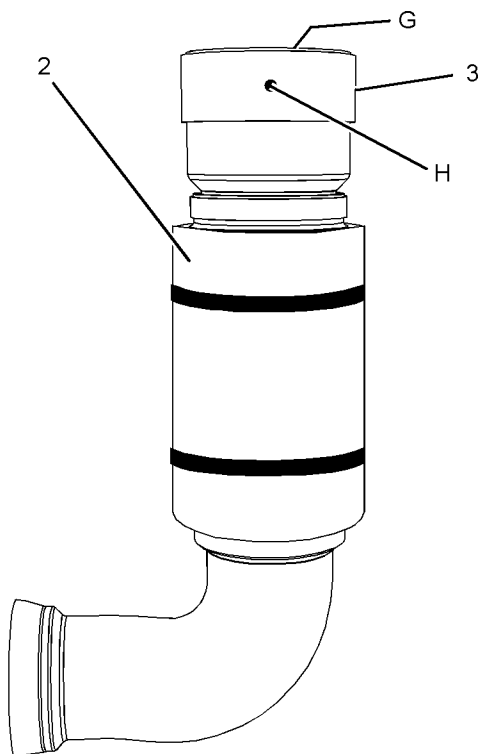


Illustration 179

g02478998

Typical example

2. If the flexible exhaust pipe assembly was previously disassembled. Follow Step 2a through Step 2h in order to assemble the flexible exhaust pipe assembly.

NOTICE

Use the correct personal protective equipment when removing the clamp.

- a. If original bellows are to be reinstalled, place the internal area in Position (G) (not shown) of the bellows on a suitable support. Use Tooling (A) in order to drill a pilot hole through the spot weld in Position (H) on clamp (3).

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

- b. Use Tooling (B) in order to drill out spot weld in Position (H) on clamp (3). Remove clamp (3) from the bellows.
- c. Remove all burrs from the internal and external areas of bellows (3). **Ensure that debris does not enter bellows.**

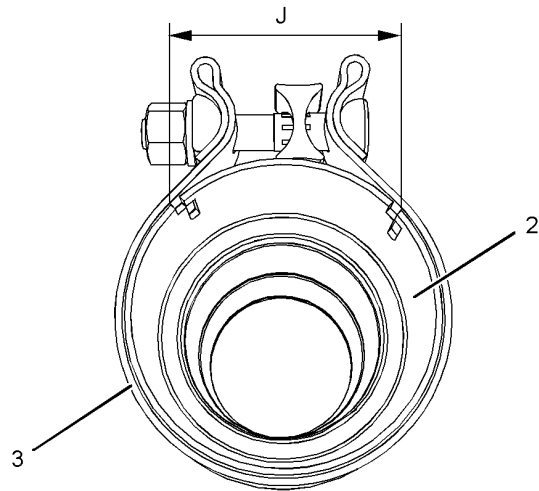


Illustration 180

g02479478

e. If new bellows (2) are installed, clamp (3) will be pre-installed to the bellows.

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

f. Position a new ball clamp (6) onto adapter (7).

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

h. Tighten ball clamp (6) hand tight.

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

Installation Procedure for the Flexible Exhaust Pipe as an Assembly

NOTICE

Inspect the bellows for damage prior to installation. If there is any damage to the convolutions, discard the bellows. If there is any difficulty in installation after the repair, discard the bellows.

1. Check the flexible exhaust pipe assembly for damage. Refer to Special Instruction, REHS5014, "Reuse Guideline for the Flexible Exhaust Pipe Group on Tier 4 Engines" for more information.

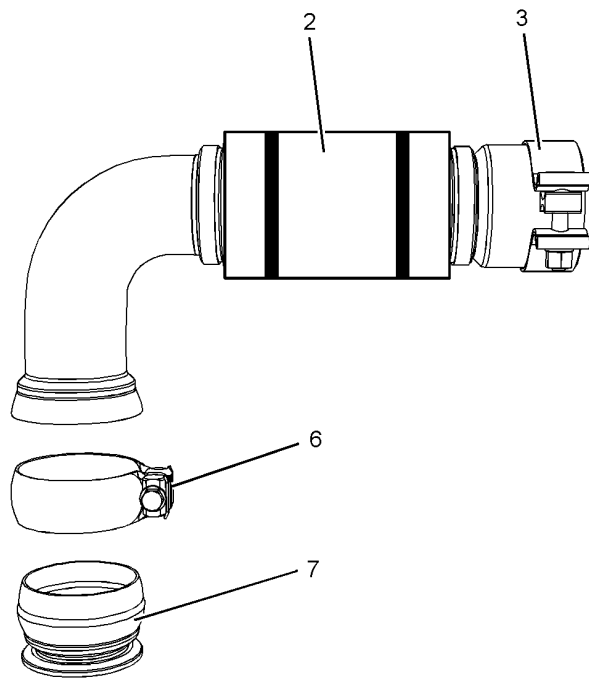


Illustration 181

g02478996

Typical example

- d. Position a new clamp (3) onto bellows (2). Hand tighten clamp (3). Ensure that the center of the clamp is central to Slots (J) on the bellows. The clamp must be flush with the end of the bellows (2).

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

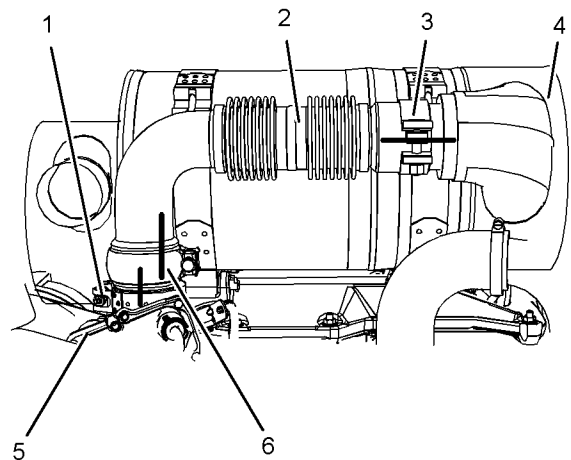


Illustration 182

g02479539

Typical example

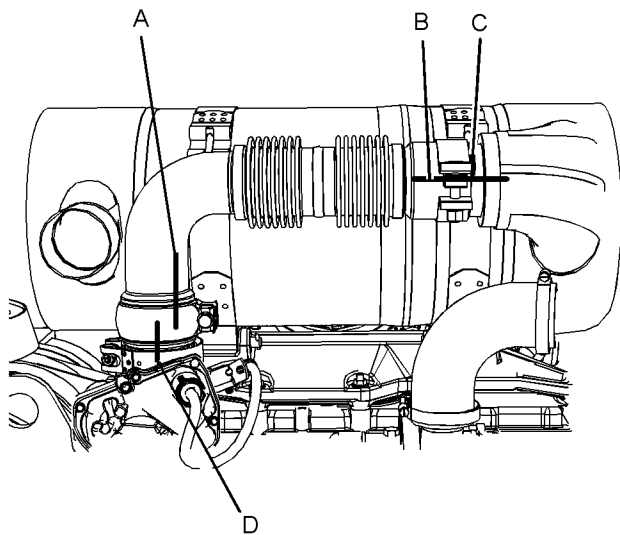


Illustration 183

g02479541

Typical example

2. Install V-band clamp (1) onto exhaust back pressure valve (5).
3. Install assembly of the flexible exhaust pipe onto CEM (4) and exhaust back pressure valve (5).

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

4. Position V-band clamp (1) onto adapter.
5. Tighten V-band clamp (1) hand tight.

NOTICE

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

6. Align the assembly of the flexible exhaust pipe with the temporary marks. Ensure that bellows (2) are not subjected to any undue stress.
7. If a new bellows assembly has been installed, ensure that all components of the flexible exhaust pipe are not subjected to any undue stress and are correctly aligned.
8. Tighten clamp (3) to a torque of 55 N·m (40 lb ft).
9. Tighten ball clamp (6) to a torque of 35 N·m (26 lb ft).
10. Tighten V-band clamp (1) to a torque of 12 N·m (106 lb in).

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

i05981741

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

Removal Procedure

Start By:

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

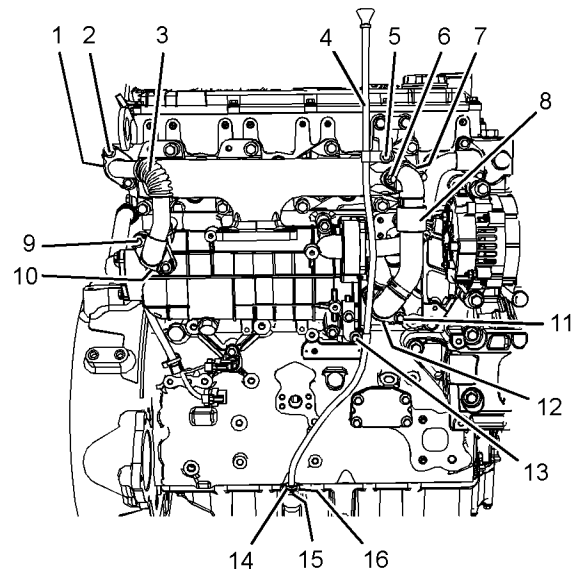


Illustration 184

g02478716

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.
2. Remove bolts (2) and bolt (9) from tube assembly (3).

3. Remove tube assembly (3) from the cylinder head and the exhaust cooler.
4. Remove gasket (1) (not shown) and gasket (10) (not shown) from tube assembly (3).
5. Prior to and during removal of bolts (6) and bolts (11) apply releasing fluid to the bolts. Remove bolts (6) and bolts (11) from tube assembly (8).
6. Remove tube assembly (8) from the exhaust cooler and the exhaust manifold.
7. Remove gasket (7) (not shown) and gasket (12) (not shown) from tube assembly (8).
8. Remove bolt (5) and bolt (13) from dipstick tube assembly (4).
9. Loosen nut (14) on dipstick tube assembly (4). Remove the dipstick tube assembly.
10. Remove O-ring seal (15) (not shown) and seal (16) (not shown) from the dipstick tube assembly.

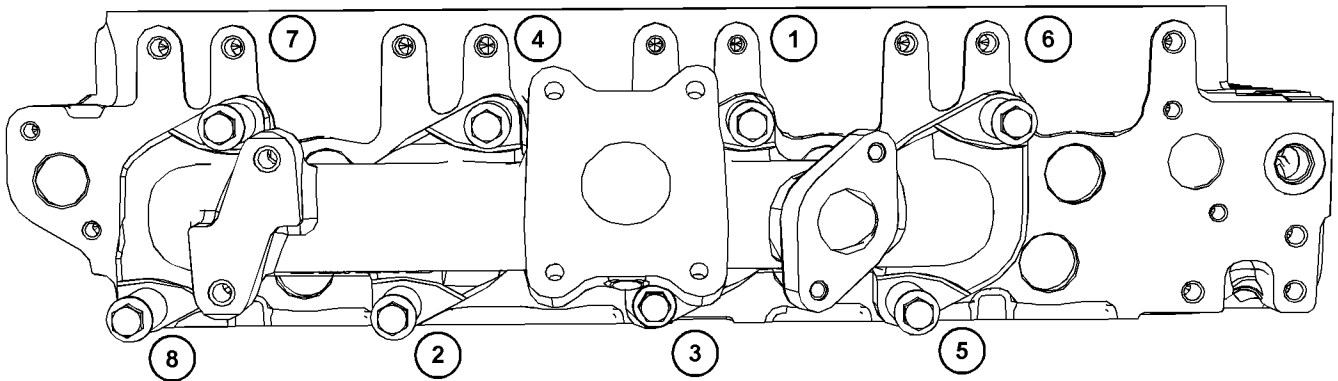


Illustration 185

Tighten sequence of exhaust manifold

g02477641

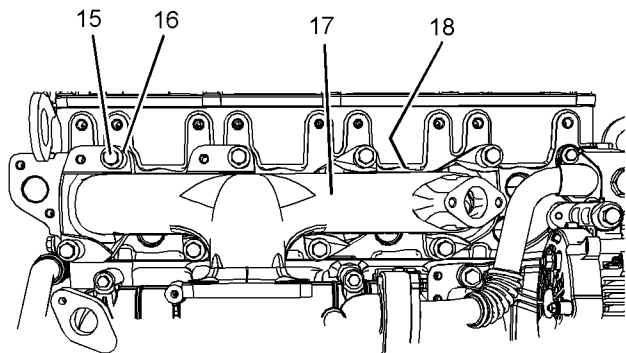


Illustration 186

g02478717

- 11.** Loosen bolts (15) in reverse numerical order.
Refer to Illustration 185 .

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

- 12.** Remove bolts (15) and spacers (16) from exhaust manifold (17). Note position of the different length spacer.

Note: Support the manifold as the bolts are removed.

- 13.** Remove exhaust manifold (17).

- 14.** Remove exhaust manifold gasket (18) (not shown).

Installation Procedure

Table 33

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400020	Manifold Alignment Pins	2
B	T400019	Manifold Alignment Pins	1
C ⁽¹⁾	-	Loctite 575	1
⁽²⁾ D	-	Loctite 565	1

⁽¹⁾ If Loctite 575 is not available, install new bolts

⁽²⁾ If Loctite 565 is not available, install new bolts

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

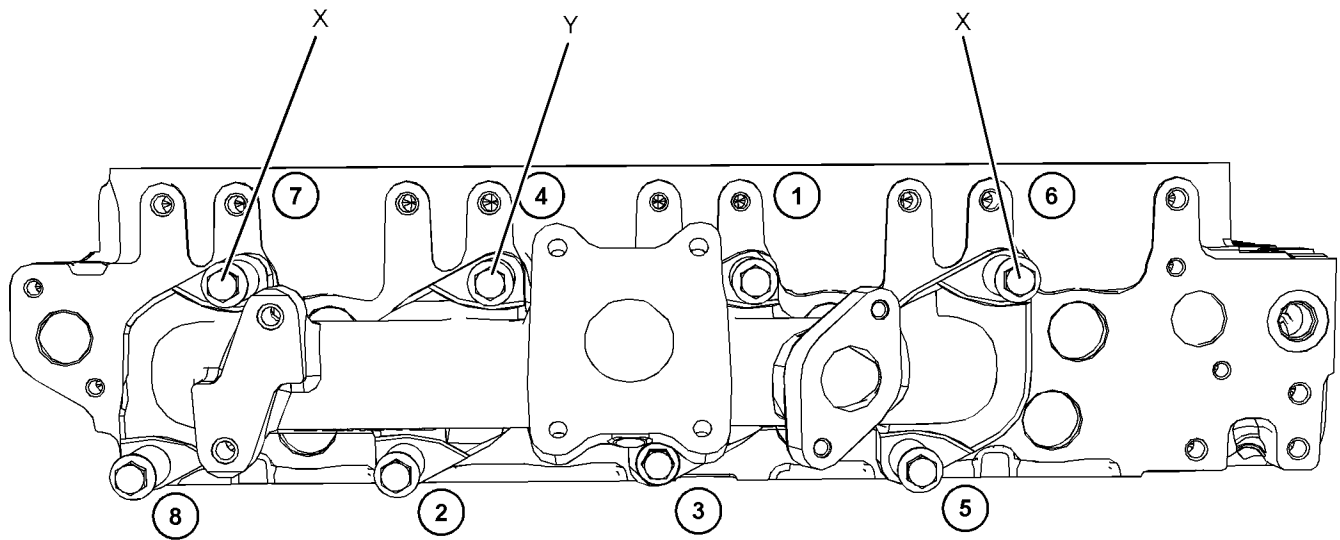


Illustration 187

g02477697

Tighten sequence of exhaust manifold and Tooling position

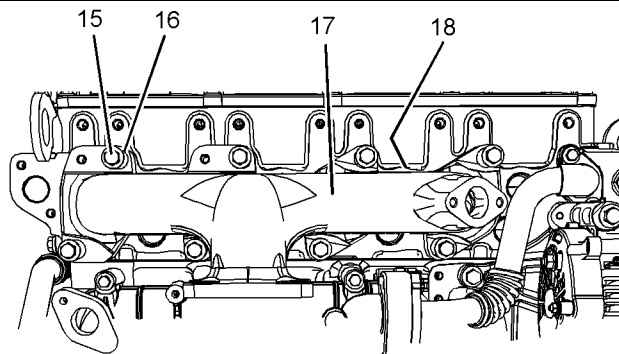


Illustration 188

g02478717

2. Position a new exhaust manifold gasket (18) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Tooling (B) in Positions (Y). Refer to Illustration 187 .

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

3. Align exhaust manifold (17) with Tooling (A) and Tooling (B). Install the exhaust manifold to the cylinder head.
4. If bolts (15) have been previously used, thoroughly clean the bolts. Tooling (C) or Tooling (D) should be applied to the first two threads of the bolts. **If Tooling (C) or Tooling (D) is not available, new bolts should be installed.**

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

5. Install bolts (15) and spacers (16) hand tight. Ensure that the different length spacer is installed into the correct position.
6. Remove Tooling (A) and Tooling (B). Install remaining bolts (15) and spacers (16) hand tight.
7. Tighten bolts (15) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 187 .

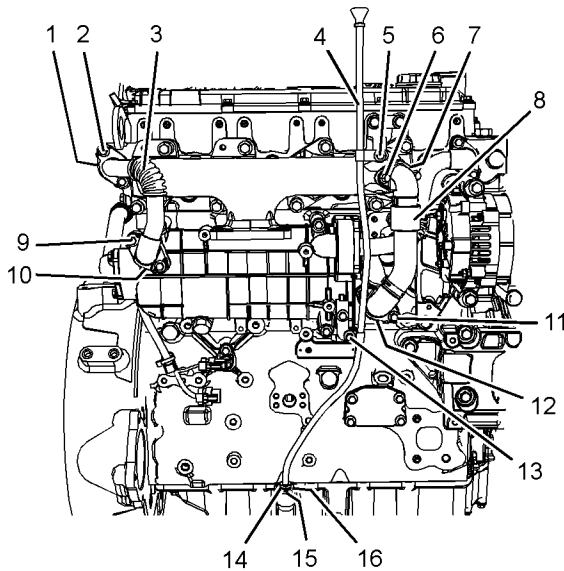


Illustration 189

g02478716

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

- 8.** Ensure that all tube assemblies are free from restriction and damage.
- 9.** Position a new gasket (7) (not shown) and a gasket (12) (not shown) onto tube assembly (8).
- 10.** Install tube assembly (8) onto the exhaust cooler and the exhaust manifold.
- 11.** Install bolts (6) and bolts (11) to tube assembly (8). Tighten the bolts to a torque of 22 N·m (195 lb in).
- 12.** Position a new gasket (1) (not shown) a new gasket (10) (not shown) onto tube assembly (3).
- 13.** Install tube assembly (3) onto the cylinder head and the exhaust cooler.
- 14.** Install bolts (2) and bolt (9) to tube assembly (3).
- 15.** Tighten bolt (9) to a torque of 18 N·m (159 lb in).
Tighten bolts (2) to a torque of 22 N·m (195 lb in).
- 16.** Install a new O-ring seal (15) (not shown) and a new seal (16) (not shown) to the dipstick tube assembly. Loosely install nut (14) for dipstick tube assembly (4).
- 17.** Install bolt (5) and bolt (13) to dipstick tube assembly (4).
- 18.** Tighten nut (14) to a torque of 18 N·m (159 lb in).
Tighten bolts (5) and bolt (13) to a torque of 22 N·m (195 lb in).

End By:

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

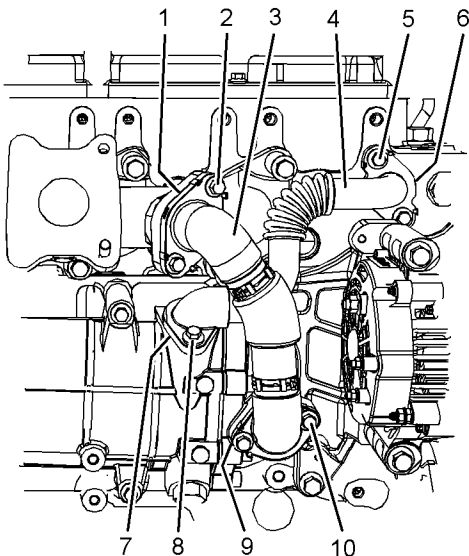
i05981742

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

Removal Procedure**Start By:**

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

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct procedure.
2. Prior to and during removal of bolts (2) and bolts (10) apply releasing fluid to the bolts. Remove bolts (2) and bolts (10) from tube assembly (3).
3. Remove tube assembly (3) from the exhaust cooler and the exhaust manifold.
4. Remove gasket (1) (not shown) and gasket (9) (not shown) from tube assembly (3).
5. Remove bolts (5) and bolt (8) from tube assembly (4).
6. Remove tube assembly (4) from the cylinder head and the exhaust cooler.
7. Remove gasket (6) (not shown) and O-ring seal (9) (not shown) from tube assembly (4).



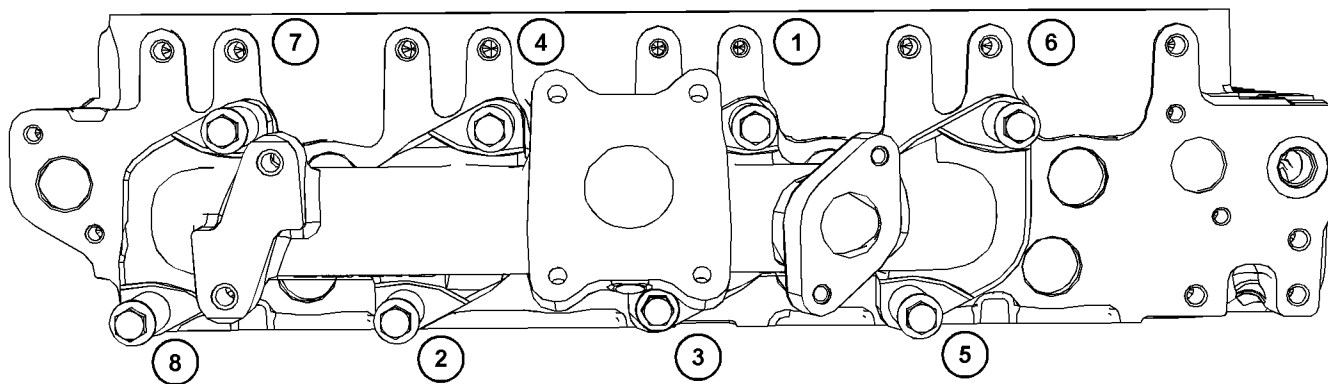


Illustration 191

g02477641

Tighten sequence of exhaust manifold

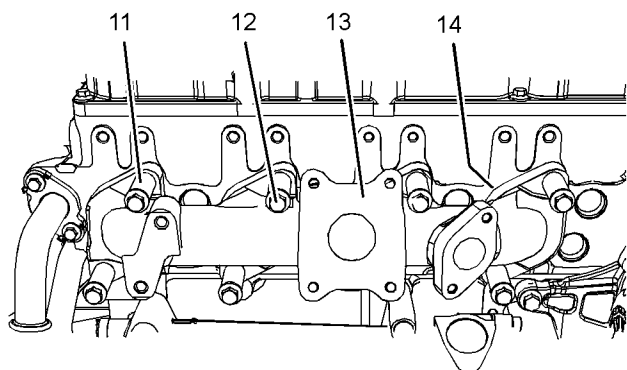


Illustration 192

g02477643

8. Loosen bolts (12) in reverse numerical order. Refer to Illustration 191 .

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

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

Note: Support the manifold as the bolts are removed.

10. Remove exhaust manifold (13).

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

Installation Procedure

Table 34

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400020	Manifold Alignment Pins	2
B	T400019	Manifold Alignment Pins	1
C ⁽¹⁾	-	Loctite 575	1
⁽²⁾ D	-	Loctite 565	1

⁽¹⁾ If Loctite 575 is not available, install new bolts

⁽²⁾ If Loctite 565 is not available, install new bolts

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

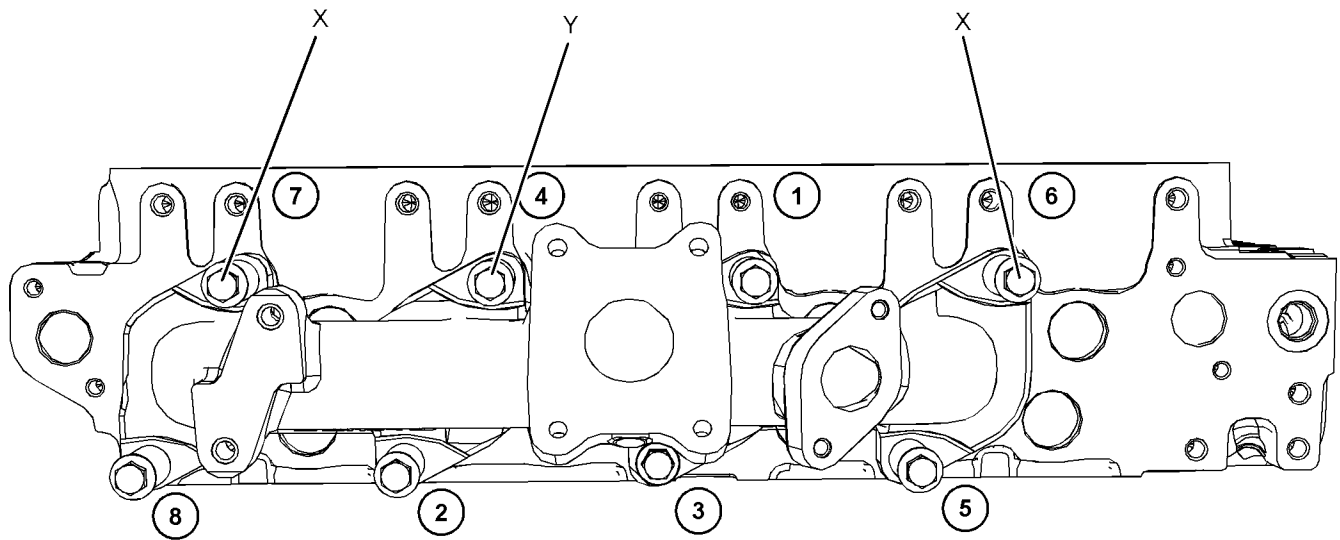


Illustration 193

g02477697

Tighten sequence of exhaust manifold and Tooling position

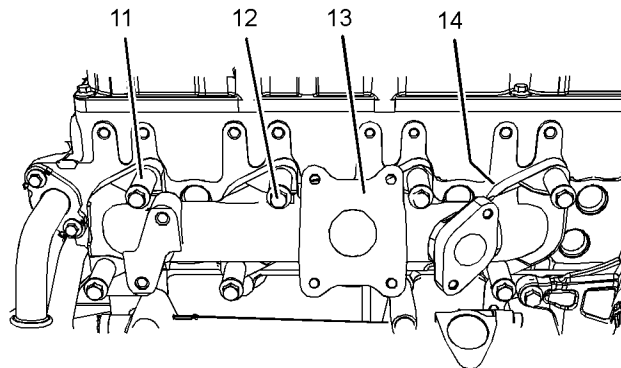


Illustration 194

g02477643

2. Position a new exhaust manifold gasket (14) (not shown) onto the cylinder head. Install Tooling (A) in Positions (X) and Tooling (B) in Positions (Y). Refer to Illustration 193 .

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

3. Align exhaust manifold (13) with Tooling (A) and Tooling (B). Install the exhaust manifold to the cylinder head.
4. If bolts (12) have been previously used, thoroughly clean the bolts. Tooling (C) or Tooling (D) should be applied to the first two threads of the bolts. **If Tooling (C) or Tooling (D) is not available, new bolts should be installed.**

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

5. Install bolts (12) and spacers (11) hand tight. Ensure that the different length spacer is installed into the correct position.
6. Remove Tooling (A) and Tooling (B). Install remaining bolts (12) and spacers (11) hand tight.
7. Tighten bolts (12) to a torque of 44 N·m (32 lb ft). Tighten the bolts in the sequence that is shown in Illustration 192 .

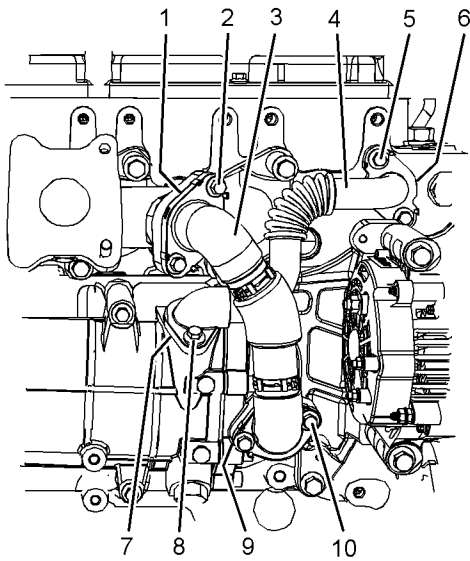


Illustration 195

g02477639

8. Position a new gasket (6) (not shown) and a new O-ring seal (9) (not shown) onto tube assembly (4).
 9. Install tube assembly (4) to the cylinder head and the exhaust cooler.
- Note:** Ensure that the tube assembly is correctly installed into the exhaust cooler.
10. Install bolts (5) and bolt (8) to tube assembly (4).
 11. Tighten bolt (8) to a torque of 18 N·m (159 lb in).
Tighten bolts (5) to a torque of 22 N·m (195 lb in).
 12. Position a new gasket (1) (not shown) and a new gasket (9) (not shown) to tube assembly (3).
 13. Install tube assembly (3) to the exhaust cooler and the exhaust manifold.
 14. Install new bolts (2) and new bolts (10) to tube assembly (3). Tighten the bolts to a torque of 22 N·m (195 lb in).

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

End By:

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

i05981739

Exhaust Elbow - Remove and Install

(Top Mounted and Side Mounted Turbocharger Exhaust Elbow)

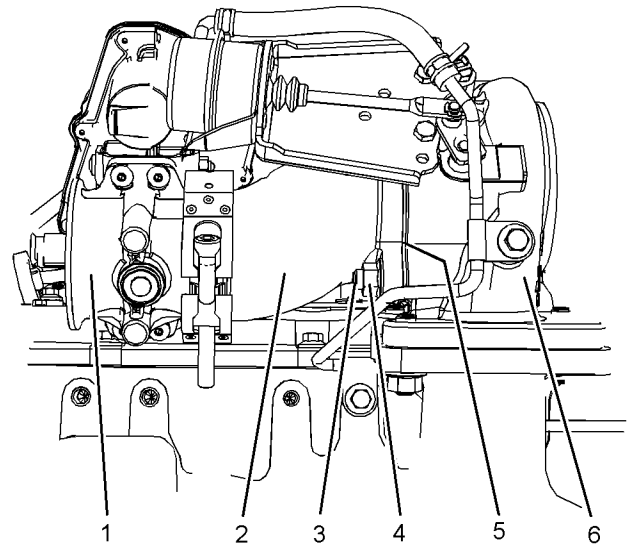
Removal Procedure

Illustration 196

g02476645

Typical example

1. If necessary, remove exhaust back pressure valve (1) from exhaust elbow (2). Refer to Disassembly and Assembly, "Exhaust Back Pressure Valve - Remove and Install" for the correct procedure.
2. Remove nuts (4) from turbocharger (6).
3. Make temporary marks on exhaust elbow (2) and turbocharger (6) to show correct orientation. Remove exhaust elbow (2) from turbocharger (6).

4. Remove gasket (5) (not shown) from turbocharger (6).
5. If necessary, remove studs (3) from turbocharger (6).

Installation Procedure

Table 35

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

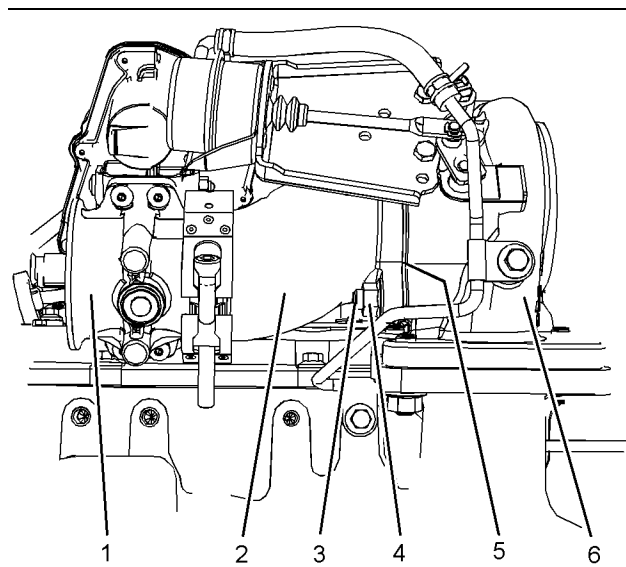


Illustration 197

g02476645

Typical example

1. Ensure that the exhaust elbow and the outlet of the turbocharger are free from damage. Replace any components that are damaged.
2. If necessary, install studs (3) to turbocharger (6). Use Tooling (A) to lubricate the threads of studs (3). Tighten the studs to a torque of 18 N·m (159 lb in).
3. Position a new gasket (6) (not shown) onto turbocharger (6).
4. Install exhaust elbow (2) onto turbocharger (6). Ensure that the exhaust elbow is correctly orientated.
5. Use Tooling (A) to lubricate the threads of nuts (4). Install nuts (4) onto turbocharger (6). Tighten the nuts to a torque of 44 N·m (33 lb ft).

6. If necessary, install exhaust back pressure valve (1) to exhaust elbow (2). Refer to Disassembly and Assembly, "Exhaust Back Pressure Valve - Remove and Install" for the correct procedure.

i05981740

Exhaust Elbow - Remove and Install

Removal Procedure

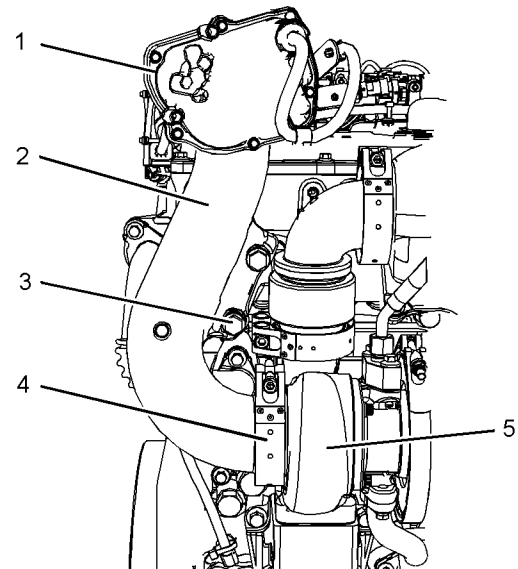


Illustration 198

g02476565

1. If necessary, remove exhaust back pressure valve (1) from exhaust elbow (2). Refer to Disassembly and Assembly, "Exhaust Back Pressure Valve - Remove and Install" for the correct procedure.

2. Loosen allen head bolt on V-band clamp (4).

Note: If the V-band clamp (4) remain tight on the flanges, apply releasing fluid on the V-band clamps in order to assist removal. Lightly tap the bolts on the V-band clamps with a soft faced hammer in order to assist removal. **Do not use a prybar in order to remove V-band clamps.**

3. Remove V-band clamp (4) from turbocharger (5) and exhaust elbow (2).

4. Remove bolts (3) and spacers. Remove exhaust elbow (2) from turbocharger (5).

Note: Support the weight of the exhaust elbow as the bolts are removed.

Installation Procedure

Table 36

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

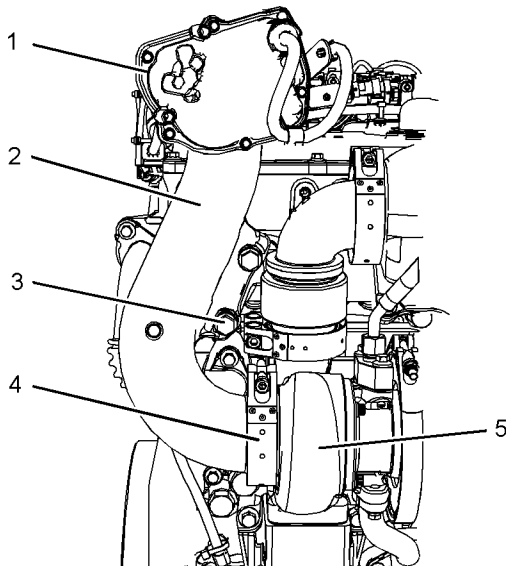


Illustration 199

g02476565

1. Ensure that the exhaust elbow and the outlet of the turbocharger are free from damage. Replace any components that are damaged.
 2. Use Tooling (A) to lubricate the threads of the allen head bolt for V-band clamp (4).
 3. Loosely position V-band clamp (4) onto turbocharger (5).
 4. Position exhaust elbow (2) onto turbocharger (5). Install V-band clamp (4) onto exhaust elbow (2) and hand tighten the allen head bolt on the V-band clamp.
- Note:** Support the weight of the exhaust elbow as the V-band clamp is installed.
5. Install the spacers and bolts (3) hand tight. Ensure that exhaust elbow (2) is correctly positioned onto turbocharger (5) and is correctly aligned.
 6. Tighten the allen head bolt for V-band clamp (4) to a torque of 12 N·m (106 lb in).
 7. Tighten bolts (3) to a torque of 44 N·m (32 lb ft).

8. If necessary, install exhaust back pressure valve (1) to exhaust elbow (2). Refer to Disassembly and Assembly, "Exhaust Back Pressure Valve - Remove and Install" for the correct procedure.

i05981818

Support and Mounting (CEM - Remove and Install

Removal Procedure

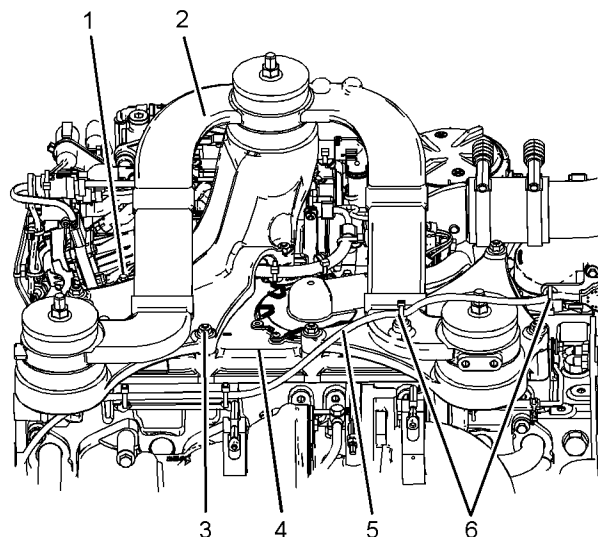


Illustration 200

g03729120

1. Cut cable straps (6) from harness assembly (5).
2. Remove bolt (1) and nuts (3) from bracket assembly (2). Support the bracket assembly as the bolt and the nuts are removed.
3. Remove bracket assembly (2) from valve mechanism cover (4).

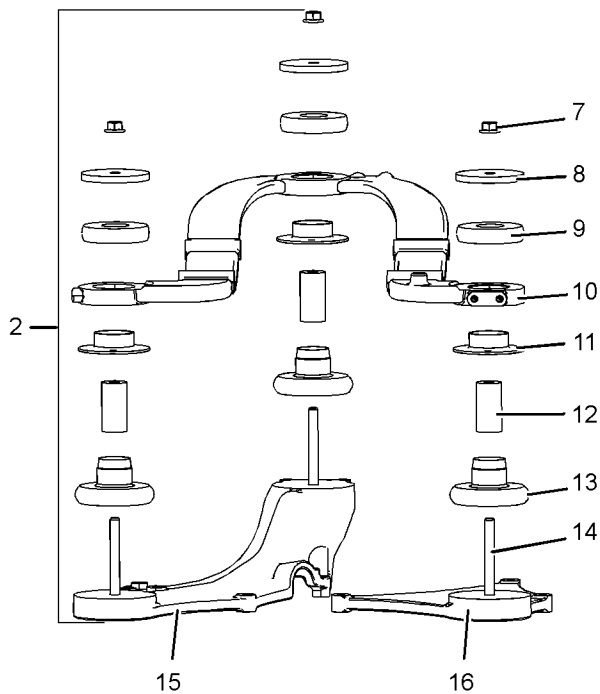


Illustration 201

g03729121

4. If necessary, follow Step 4a through Step 4e in order to disassemble bracket assembly (2).
 - a. Remove nuts (7) and remove washers (8).
 - b. Remove mounts (9) from upper bracket (10).
 - c. Remove upper bracket (10) from rear bracket (15) and front bracket (16).
 - d. Remove flanges (11), sleeves (12), and mounts (13).
 - e. If necessary, remove studs (14) from rear bracket (15) and front bracket (16).
5. When bracket assembly (2), is removed from valve mechanism cover (4). Replacement of the valve mechanism cover gasket is recommended. Refer to Disassembly and Assembly, "Valve Mechanism Cover - Remove and Install" for the correct procedure.

Installation Procedure

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

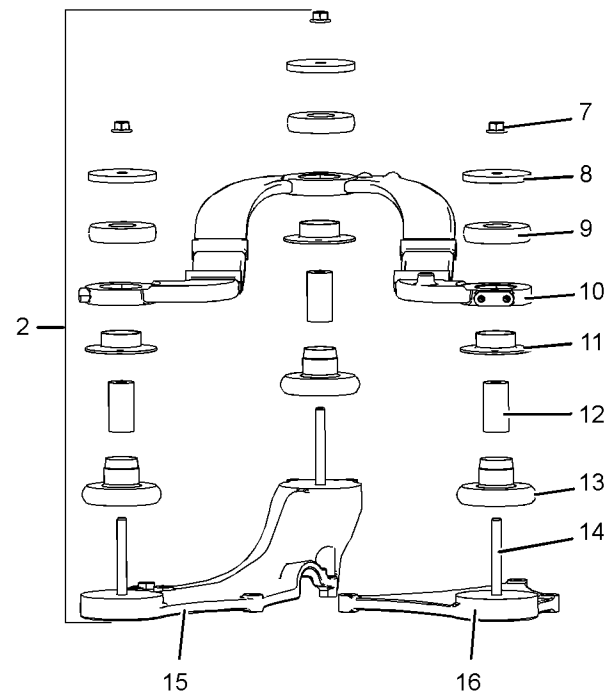


Illustration 202

g03729121

2. If necessary, follow Step 2a through Step 2e in order to assemble bracket assembly (2).
 - a. If necessary, install studs (14) from rear bracket (15) and front bracket (16). Tighten the studs to a torque of 25 N·m (221 lb in).
 - b. Install mounts (13), sleeves (12), and flanges (11) onto studs (14) of rear bracket (15) and front bracket (16). Ensure that the flanges are correctly seated onto the mounts and the sleeves into the mounts.
 - c. Install upper bracket (10) to rear bracket (15) and front bracket (16). Ensure that the brackets are correctly orientated.
 - d. Install mounts (9) to upper bracket (10).
 - e. Install washers (8) and nuts (7) hand tight

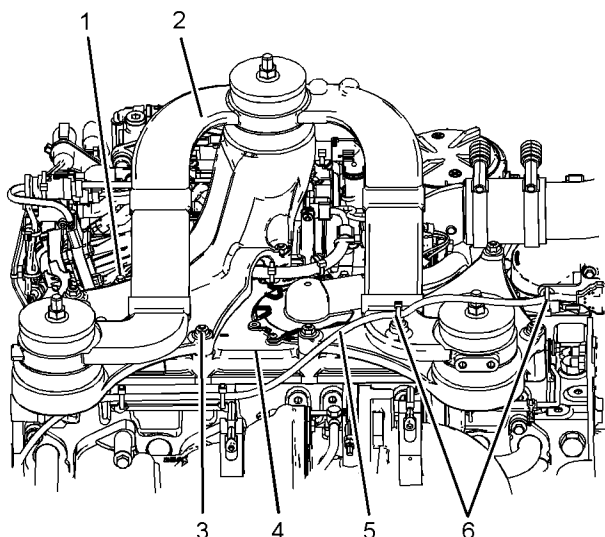


Illustration 203

g03729120

3. Install bracket assembly (2) onto valve mechanism cover (4).
4. Install bolt (1) and nuts (3) to bracket assembly (2). Support the bracket assembly as the bolt and the nuts are installed.
5. Tighten bolt (1) and nuts (3) to a torque of 22 N·m (195 lb in).
6. If necessary, tighten the nuts for the mountings on bracket assembly (2) to a torque of 78 N·m (58 lb ft). Refer to Illustration 202 .
7. Install new cable straps (6) to harness assembly (5).

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

i05981791

Inlet and Exhaust Valve Springs - Remove and Install

Removal Procedure

Table 37

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

(continued)

(Table 37, contd)

	27610235	Adapter	1
	27610295	Head	1
B ⁽¹⁾	T400011	Crankshaft Turning Tool	1
B ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

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

WARNING

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

Make sure to wear all necessary protective equipment.

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

NOTICE

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

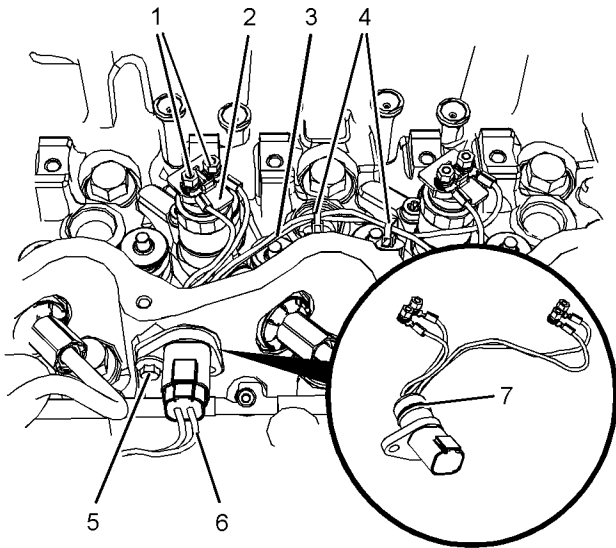


Illustration 204

g01978813

1. Follow Step 1a through Step 1h in order to remove the harness assemblies for the electronic unit injectors.
 - a. Place a temporary identification mark on connections (1) for harness assembly (3) for electronic unit injectors (2).
 - b. Use a deep socket to remove connections (1) from electronic unit injectors (2).
 - c. Cut cable straps (4) and remove the remaining sections of the cable straps from the cylinder head.
 - d. Disconnect plug (6) from harness assembly (3).
 - e. Remove bolt (5) from harness assembly (3).
 - f. Withdraw harness assembly (3) from the cylinder head.
 - g. Remove O-ring seal (7) from harness assembly (3).
 - h. Repeat Step 1a through Step 1g in order to remove the remaining harness assemblies.

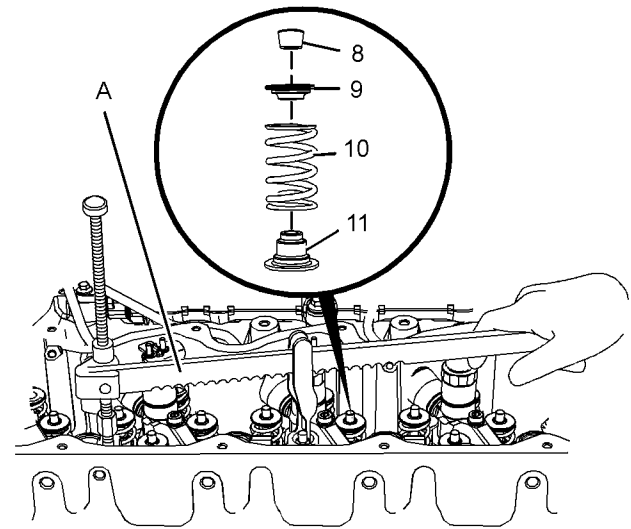


Illustration 205

g02501157

NOTICE

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

2. Follow Step 2a through Step 2d in order to position the appropriate piston at top dead center.
 - a. Install Tooling (A) in position on the cylinder head in order to compress a valve spring (10) for the appropriate piston.
 - b. Use Tooling (A) in order to compress valve spring (10) and open the valve slightly.

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

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

Note: Do not use excessive force to turn the crankshaft. The use of force can result in bent valve stems.

- d. **Continue to rotate the crankshaft and gradually release the pressure on Tooling (A) until the piston is at the top dead center position. The valve is now held in a position that allows the valve spring to be safely removed.**

Disassembly and Assembly Section

Note: Valve springs must be replaced in pairs for the inlet valve or the exhaust valve of each cylinder. If all valve springs require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. Ensure that all of the valve springs are installed before changing from one pair of cylinders to another pair of cylinders.

NOTICE

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

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

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

Remove valve keepers (9).

4. Slowly release pressure on Tooling (A).
5. Remove valve spring retainer (9) and remove valve spring (10).
6. If necessary, remove valve stem seals (11).
7. Repeat Step 3 through Step 6 in order to remove the remaining valve springs from the appropriate cylinder.
8. Remove Tooling (A).

Installation Procedure

Table 38

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1
B ⁽¹⁾	T400011	Crankshaft Turning Tool	1
B ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
C	27610289	Torque Wrench	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

NOTICE

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

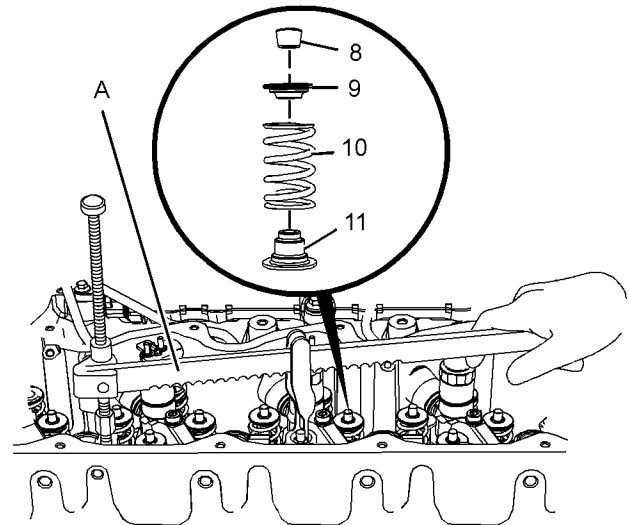


Illustration 206

g02501157

1. Inspect valve springs (10) for damage and for the correct length. Refer to Specifications, "Cylinder Head Valves" for further information.
2. If necessary, install a new valve stem seal (11) onto the valve guide.

Note: The outer face of the valve guide must be clean and dry before installing the valve stem seal.

3. Install valve spring (10) onto the cylinder head. Position valve spring retainer (9) on valve spring (10).

WARNING

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

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

NOTICE

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

4. Install Tooling (A) in the appropriate position on the cylinder head in order to compress valve spring (10).

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

Note: Do not compress the spring so that valve spring retainer (9) touches valve stem seal (11).

6. Install valve spring keepers (8).

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

8. Repeat Step 2 through Step 7 for the remaining valves.

WARNING

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

9. Remove Tooling (A).

Note: If all valve springs require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following cylinders. 1 and 4 and 2 and 3. Remember that the crankshaft must not be turned while the valve springs are removed. Ensure that all of the valve springs are installed before changing from one pair of cylinders to the other pair of cylinders. If all valve springs do not require replacement, the springs must be replaced in pairs.

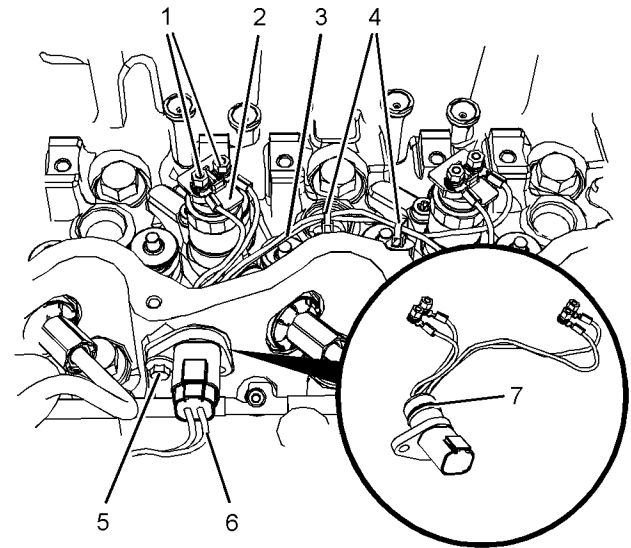


Illustration 207

g01978813

10. Follow Step 10a through Step 10g in order to install the harness assemblies for electronic unit injectors (2).

- a. Ensure that harness assembly (3) for the electronic unit injectors is clean and free from damage. Replace any damaged components.
- b. Install a new O-ring seal (7) onto harness assembly (3) for electronic unit injectors (2).

Note: Do not lubricate the O-ring seal.

- c. Push harness assembly (3) into the cylinder head.
- d. Install a new bolt (5) and tighten the bolt to a torque of 5.5 N·m (49 lb in).
- e. Connect plug (6) from harness assembly (3).
- f. Use a deep socket to install connections (1) to electronic unit injectors (2). Use Tooling (C) to tighten the connections to a torque of 2.0 N·m (18 lb in).
- g. Install new assemblies of the cable straps (4) to harness assembly (3).

Note: Ensure that the cable straps meet the OEM specification. Ensure that the assemblies of the cable straps are correctly installed into the cylinder head.

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

End By:

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

i05981792

Inlet and Exhaust Valves - Remove and Install

Removal Procedure

Table 39

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Clean the bottom mating surface of the cylinder head. Check the depth of the valves below the face of the cylinder head before the valve springs are removed. Refer to Specifications, “Cylinder Head Valves” for the correct dimensions.
2. Place a temporary identification mark on the heads of the valves in order to identify the correct position.

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

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

Note: Ensure that the cylinder head is kept on a clean, soft surface in order to prevent damage to the machined face.

WARNING

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

Make sure to wear all necessary protective equipment.

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

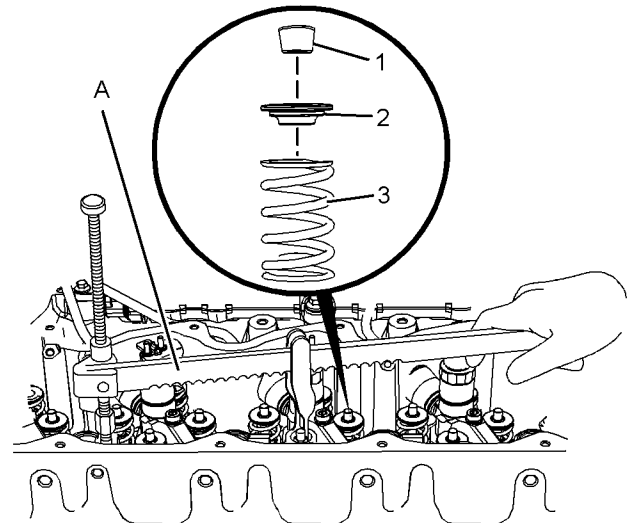


Illustration 208

g02511756

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

NOTICE

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

5. Apply sufficient pressure to Tooling (A) in order to remove valve keepers (1).

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

6. Slowly release pressure on Tooling (A).

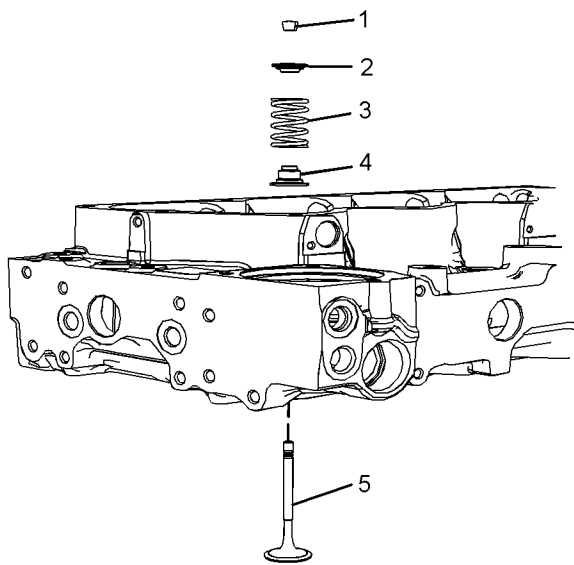


Illustration 209

g02511676

7. Place a temporary identification mark on valve spring (3) in order to identify the correct position.
8. Remove valve spring retainer (2). Remove valve spring (3).
9. Repeat Step 4 through Step 8 for the remaining valves.
10. Remove Tooling (A).
11. Remove valve stem seals (4).
12. Use a suitable lifting device in order to carefully turn over the cylinder head.
13. Remove valves (5).

Installation Procedure

Table 40

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825739	Valve Spring Compressor	1
	27610235	Adapter	1
	27610295	Head	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The valves have a hard surface finish. Grinding compound must not be used on the valves. Grinding compound will damage the hard surface finish of the valves.

1. Clean all components of the cylinder head assembly. Ensure that all ports, all coolant passages, and all lubrication passages in the cylinder head are free from debris. Follow Step 1a through Step 1d in order to inspect the components of the cylinder head assembly. Replace any components that are worn or damaged.
 - a. Inspect the cylinder head for wear and for damage. Refer to System Operation, Testing and Adjusting, "Cylinder Head Inspect" for the correct procedure.
 - b. Inspect the valve seats for wear and for damage. Refer to Specifications, "Cylinder Head Valves" for further information.
 - c. Inspect the valve guides for wear and for damage. Refer to Specifications, "Cylinder Head Valves" and System Operation, Testing and Adjusting, "Valve Guide - Inspect" for further information.
 - d. Inspect the valves for wear and for damage. Refer to Specifications, "Cylinder Head Valves" for further information.
 - e. Inspect valve springs (3) for damage and for the correct length. Refer to Specifications, "Cylinder Head Valves" for further information.

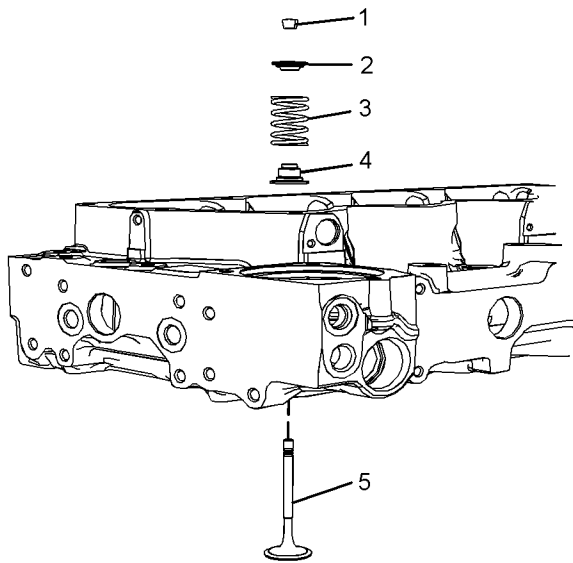


Illustration 210

g02511676

2. Lubricate the stems of valves (5) with clean engine oil. Install valves (5) in the appropriate positions in the cylinder head. Check the depth of the valves below the face of the cylinder head. Refer to System Operation, Testing and Adjusting, "Valve Depth - Inspect" for more information.
3. Use a suitable lifting device in order to carefully turn over the cylinder head. The weight of the cylinder head is approximately 65 kg (143 lb).

Note: Ensure that all of the valves remain in place.

4. Install new valve stem seals (4) onto each of the valve guides.

Note: The outer face of the valve guides must be clean and dry before installing valve stem seals (4).

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

WARNING

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

Make sure to wear all necessary protective equipment.

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

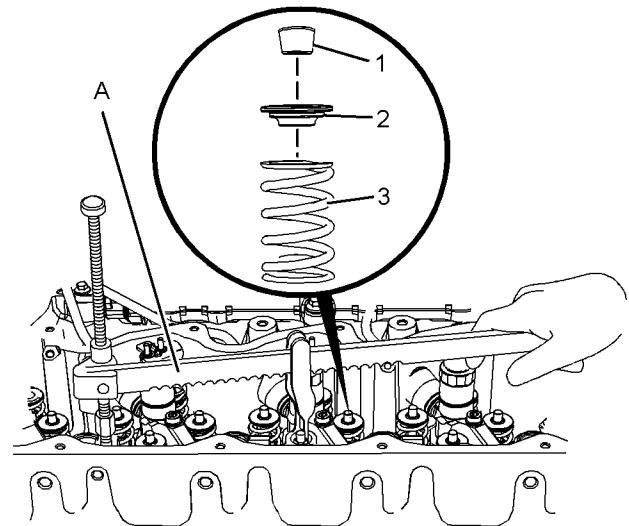


Illustration 211

g02511756

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

NOTICE

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

7. Apply sufficient pressure to Tooling (A) in order to install valve keepers (1).

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

WARNING

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

8. Carefully release the pressure on Tooling (A).
9. Repeat Step 5 through Step 8 for the remaining valves.
10. Remove Tooling (A) from the cylinder head.

End By:

- a. Install the cylinder head. Refer to **Disassembly and Assembly, "Cylinder Head - Install"** for the correct procedure.

i05980781

Engine Oil Filter Base - Remove and Install

Removal Procedure

Table 41

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

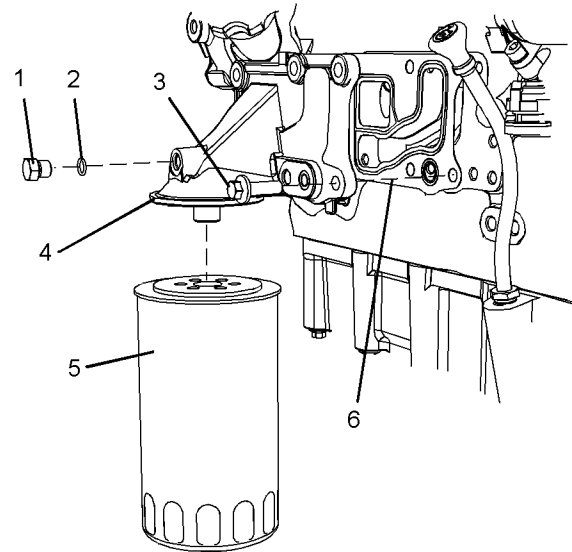


Illustration 212

g02475535

1. Place a suitable container below engine oil filter base (5) in order to catch any oil that might be spilled.
2. Use Tooling (A) to remove engine oil filter (5). Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for the correct procedure.
3. Remove bolts (3).
4. Remove engine oil filter base (4).
5. Remove gasket (6).
6. If necessary, remove plug (1) from engine oil filter base (4). Remove O-ring seal (2) from plug (1).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

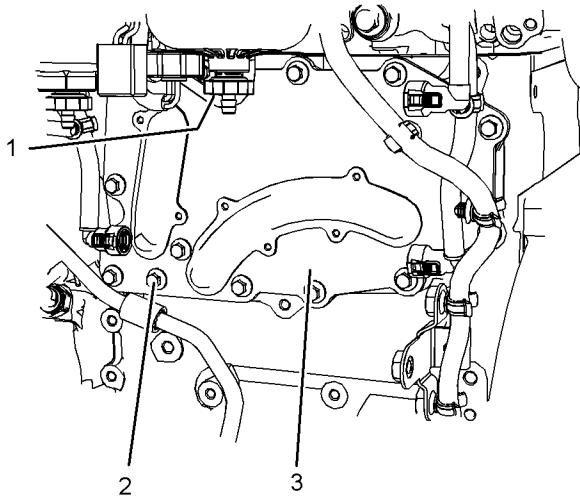


Illustration 214

g03701812

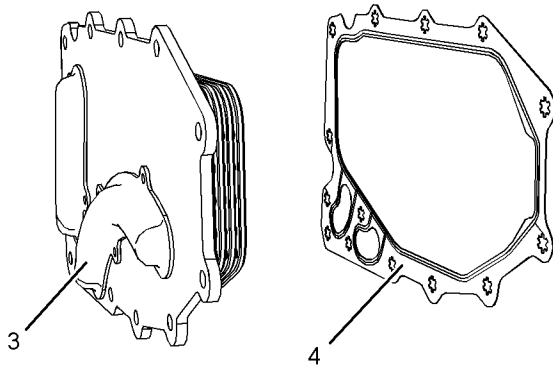


Illustration 215

g02475493

2. Remove spacer (1) (not shown) from the cylinder block.
3. Remove bolt (2) from the assembly of engine oil cooler (3).

Note: Support the engine oil cooler as the bolts are removed.

4. Remove the assembly of engine oil cooler (3) from the cylinder block.

5. Remove gasket (4) from engine oil cooler (3).

i05980761

Engine Oil Cooler - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

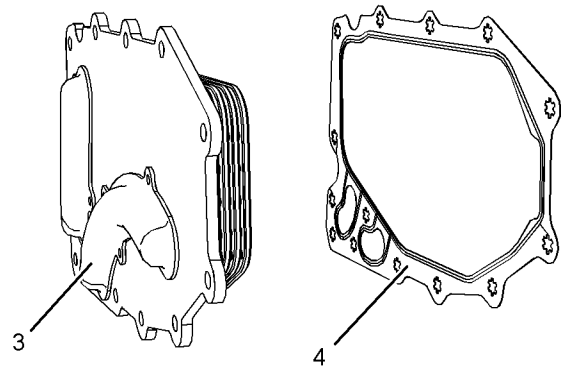


Illustration 216

g02475493

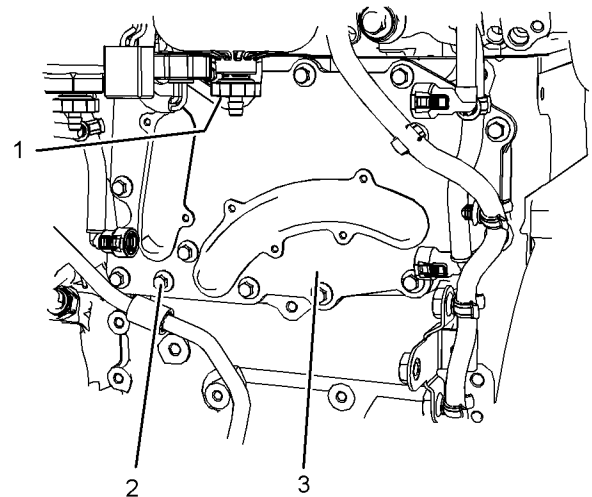


Illustration 217

g03701812

1. Ensure that engine cooler (3) is clean and free from damage. Ensure that the engine oil cooler is free from restriction.

Disassembly and Assembly Section

2. Clean the gasket surfaces of the cylinder block.
3. Position a new gasket (4) onto engine oil cooler (3).
4. Push bolts (1) through the holes in the gasket.

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

5. Position engine oil cooler (3) onto the cylinder block. Hand tighten bolts (2). Support the engine oil cooler as the bolts are installed.

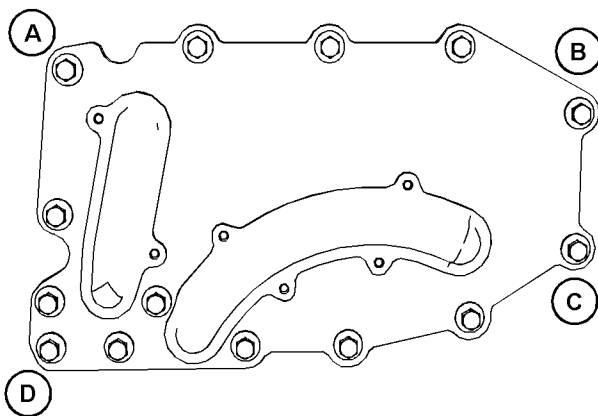


Illustration 218

g03741794

Snug torque tightening sequence for the engine oil cooler

6. Tighten the bolts to a snug torque of 7.5 N·m (66) in the sequence that is shown in Illustration 218 .

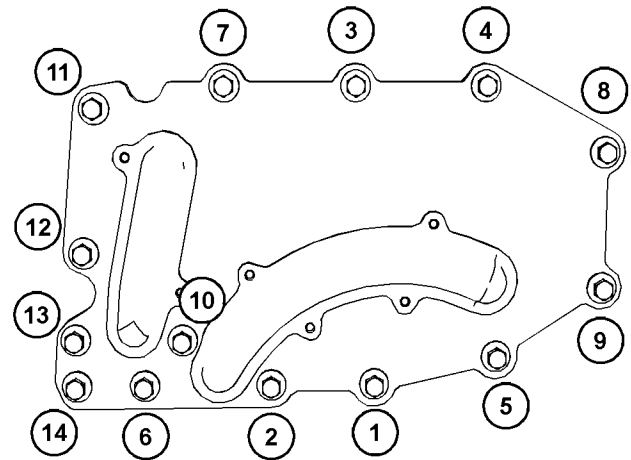


Illustration 219

g03736218

Tightening sequence for the engine oil cooler

7. Tighten the bolts to a torque of 26 N·m (230 lb in) in the sequence that is shown in Illustration 219 .
8. Install spacer (1) (not shown). Tighten the bolts to a torque of 44 N·m (32 lb ft). Refer to Illustration 217

End By:

- a. **Install the Electronic Control Module (ECM). Refer to Disassembly and Assembly, "Electronic Control Module - Install" for the correct procedure.**

i05981734

Engine Oil Pump - Remove

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

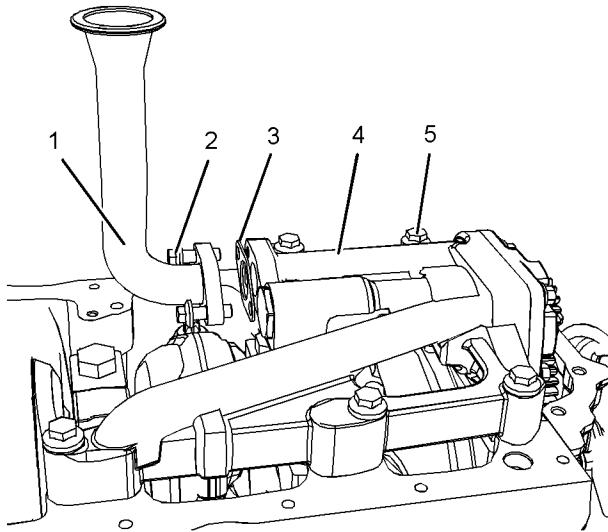


Illustration 220

g02476517

1. Remove bolts (2). Remove suction pipe (1) from engine oil pump (4).
2. Remove gasket (3).
3. Remove bolts (5) and remove the assembly of engine oil pump (4) from the cylinder block.

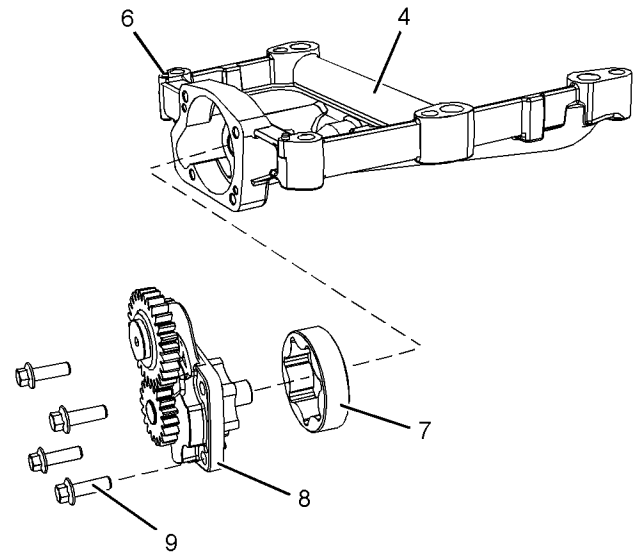


Illustration 221

g02476518

4. If necessary, follow Step 4a through Step 4d in order to disassembly engine oil pump (4).
 - a. Remove bolts (9) from front cover assembly (8).
 - b. Remove front cover assembly (8) from the housing of the engine oil pump (4).
 - c. Remove outer rotor (7) from the housing of engine oil pump (4).
 - d. Do not remove dowel (6) from the housing of engine oil pump (4) unless the dowels are damaged.

i05981733

Engine Oil Pump - Install

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Disassembly and Assembly Section

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

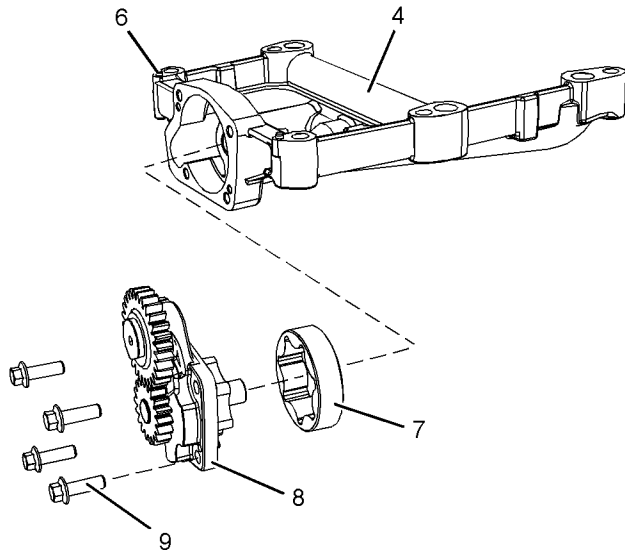


Illustration 222

g02476518

2. If necessary, follow Step 2a through Step 2f in order to assembly engine oil pump (4).
 - a. Lubricate the internal components for the assembly of engine oil pump (4) with clean engine oil.
 - b. Install outer rotor (7) to the housing of engine oil pump (4).
 - c. Install front cover assembly (8) to the housing of the engine oil pump (4).
 - d. Install bolts (9) to front cover assembly (8). Tighten the bolts finger tight.
 - e. Tighten bolts (9) to a torque of 24 N·m (212 lb in).
 - f. Ensure that dowels (6) are correctly located in the housing of engine oil pump (4).

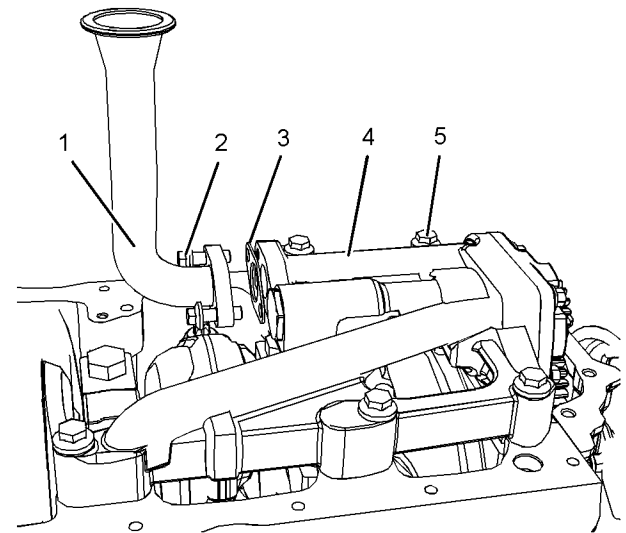


Illustration 223

g02476517

3. Position the assembly of engine oil pump (4) onto the cylinder block.

Note: Ensure that the dowels in the housing of the engine oil pump are aligned with the holes in the cylinder block.

4. Install bolts (5). Tighten the bolts to a torque of 44 N·m (32 lb ft).
5. Check the backlash between idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for further information.
6. Position a new gasket (3) onto suction pipe (1). Install the assembly of suction pipe (1) onto the assembly of engine oil pump (4).
7. Install bolts (2) finger tight. Tighten the bolts to a torque to 22 N·m (195 lb in).

End By:

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

i05981922

Water Pump - Remove**Removal Procedure****Start By:**

- a. Remove the fan and the fan pulley. Refer to **Disassembly and Assembly, "Fan - Remove and Install"** for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system into a suitable container for storage or disposal. Refer to **Operation and Maintenance Manual, "Cooling System Coolant - Change"** for the correct procedure.
2. Loosen the hose clamps and remove the hose from the water pump inlet.

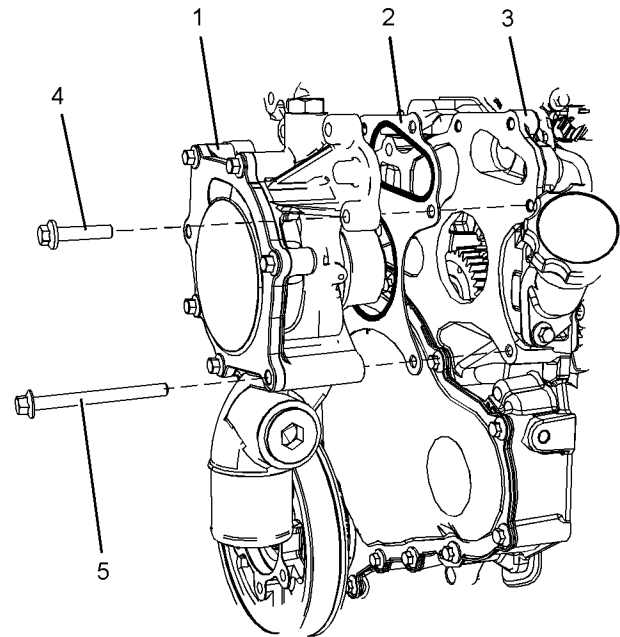


Illustration 224

g02524476

3. Remove bolts (4) and bolts (5).
 4. Remove water pump (1) from housing (3).
- Note:** If necessary, tap the water pump with a soft faced hammer in order to loosen the water pump.
5. Remove gasket (2).

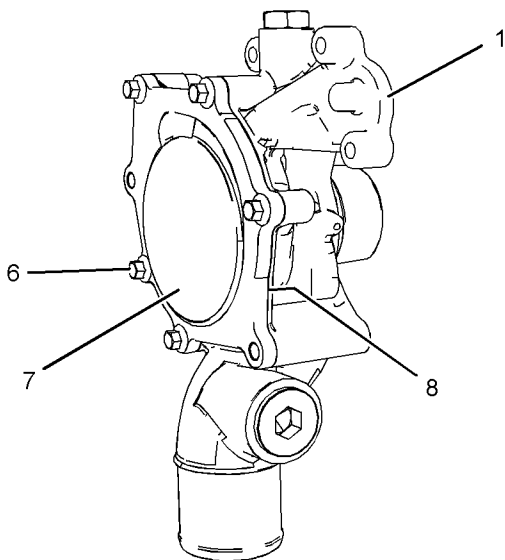


Illustration 225

g02524477

6. If necessary, remove cover (7) from the water pump. Follow Step 6a through Step 6c in order to remove the cover.

- a. Remove bolts (6).
- b. Remove cover (7).
- c. Remove O-ring seal (8) (not shown).

i05981921

Water Pump - Install

Installation Procedure

Table 42

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M8 by 90 mm	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

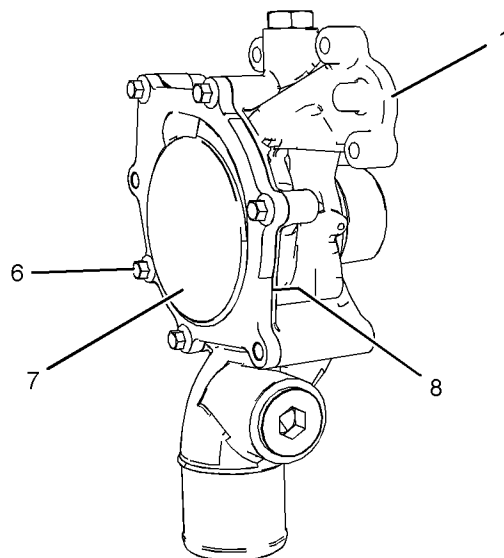


Illustration 226

g02524477

2. If necessary, install cover (7) to water pump (1). Follow Step 2a through Step 2d in order to install the cover.

- a. Clean the gasket surface of cover (7).
- b. Position a new O-ring seal (8) (not shown) onto water pump (1).
- c. Install cover (7) to water pump (1).
- d. Install bolts (6) to cover (7). Tighten the bolts to a torque of 22 N·m (195 lb in).

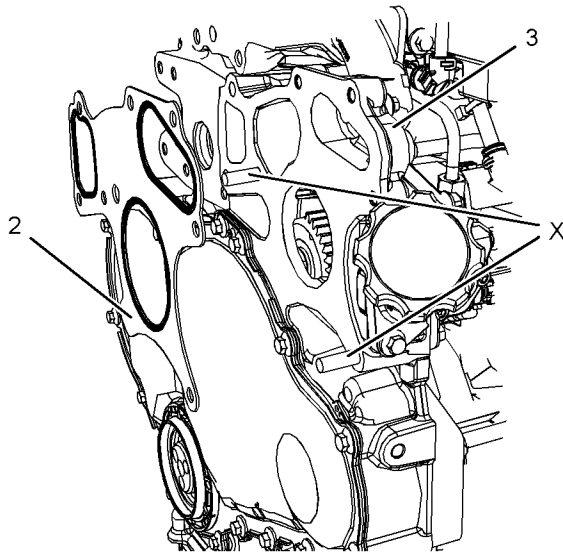


Illustration 227

g02524518

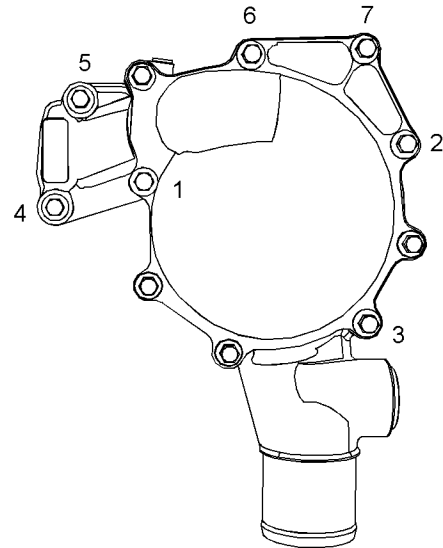


Illustration 229

g01985813

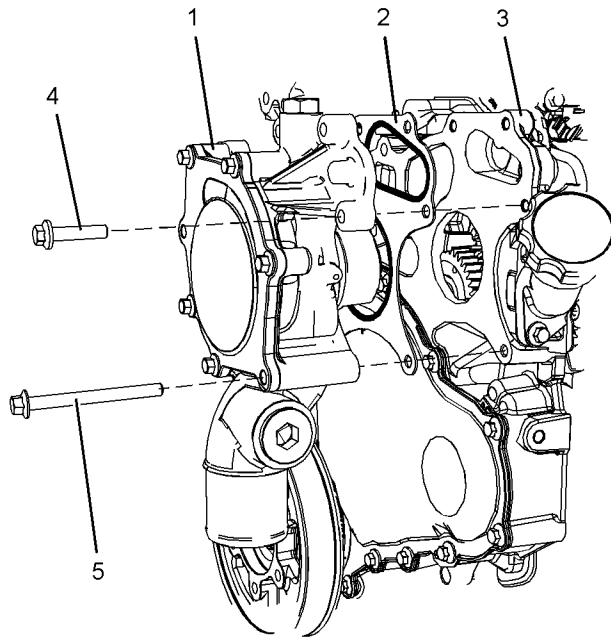


Illustration 228

g02524516

3. Clean the gasket surface of housing (3).
 4. Install Tooling (A) in Position (X).
 5. Use Tooling (A) in order to align new gasket (2) to housing (3). Install the gasket onto the housing.
 6. Align water pump (1) to Tooling (A). Install the water pump to housing (1).
- Note:** Ensure that the gear of the water pump and the gear of the fuel injection pump mesh.
7. Install bolts (4) and bolts (5). Refer to Illustration 228 . Tighten the bolts finger tight.
 8. Remove Tooling (A) and install remaining bolts (4) and bolts (5).
 9. Tighten bolts (4) and bolts (5) in the sequence that is shown in Illustration 229 to a torque of 22 N·m (195 lb in).
 10. Install the hose to the water pump inlet. Tighten the hose clamps.
 11. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct procedure.

End By:

- a. Install the fan and the fan pulley. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i05981925

Water Temperature Regulator - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

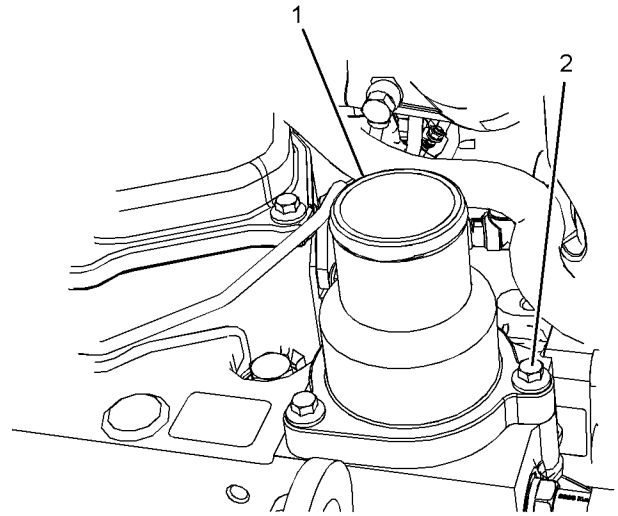


Illustration 230

g02524799

2. Loosen the hose clamps from the upper radiator hose and disconnect the upper radiator hose from water temperature regulator housing (1).
3. Remove bolts (2) from water temperature regulator housing (1).
4. Remove water temperature regulator housing (1) from the cylinder head.

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components of water temperature regulator housing (2) are clean and free of wear and damage. Check the water temperature regulator for correct operation. Refer to System Operation, Testing and Adjusting, “Water Temperature Regulator - Test” for the correct procedure to test the water temperature regulator. If any components of the water temperature regulator housing are worn or damaged, the complete assembly must be replaced.

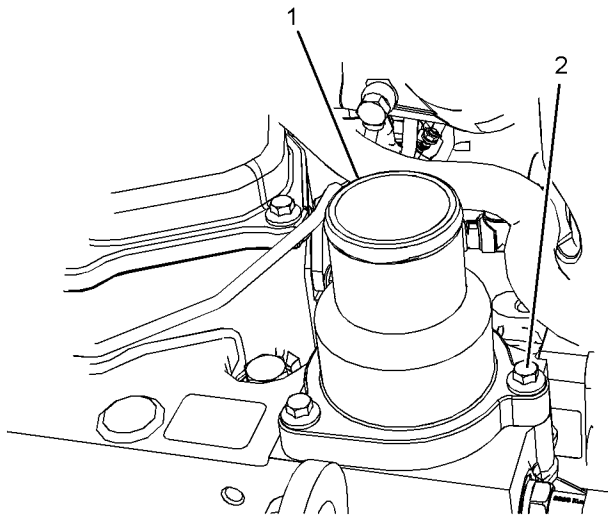


Illustration 231 g02524799

Typical example

2. If the original water temperature regulator (1) is to be installed. Ensure that the seal is not damaged and is correctly positioned in water temperature regulator housing (2).
3. Install water temperature regulator housing (1) to the cylinder head.

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

4. Install bolts (2). Tighten the bolts to a torque of 22 N·m (195 lb in).
5. Connect the upper radiator hose and tighten the hose clamps.
6. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Check" and Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct filling procedure.

i05981749

Flywheel - Remove

Removal Procedure

Table 43

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs 1/2 inch - UNF by 4 inch	2

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

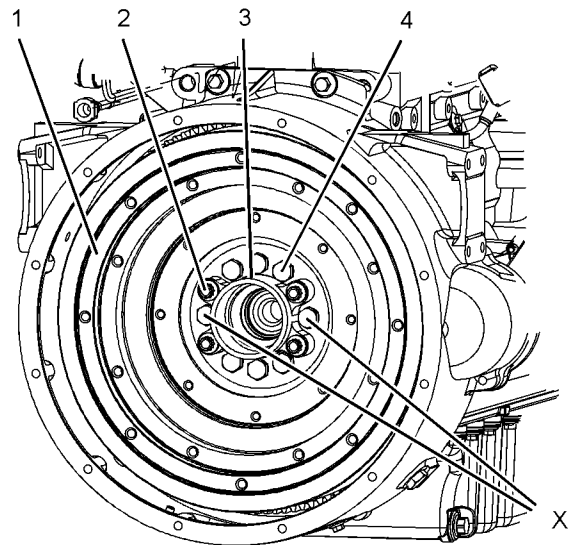


Illustration 232 g01336668

Typical example

1. Remove bolts from Position (X) on flywheel (1).
2. Install Tooling (A) in Position (X) on flywheel (1).
3. Install a suitable lifting device on flywheel (1). Support the weight of the flywheel. The flywheel can weigh 71 kg (156 lb).
4. If necessary, remove bolts (2) that secure the housing for pilot bearing (3) to flywheel (1). Remove the housing for pilot bearing (3).
5. Remove remaining bolts (4).
6. Use the lifting device to remove the flywheel from the engine.

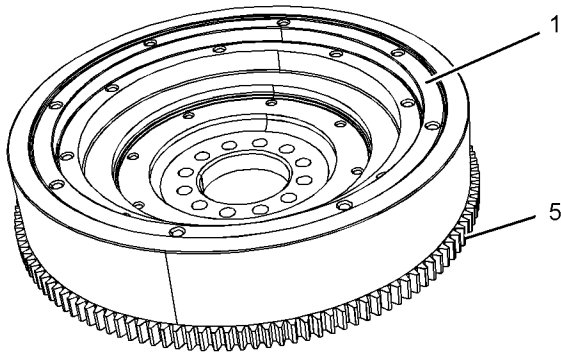


Illustration 233

g01336669

Typical example

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

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

i05981748

Flywheel - Install

Installation Procedure

Table 44

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs 1/2 inch - UNF by 4 inch	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

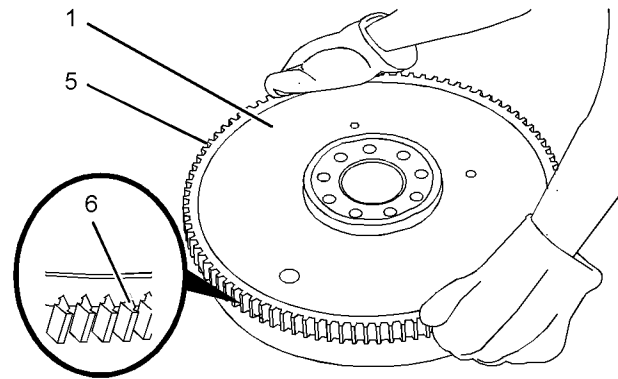


Illustration 234

g01336671

Typical example

WARNING

Always wear protective gloves when handling parts that have been heated.

1. If the flywheel ring gear was removed, follow Step 1a through Step 1c in order to install ring gear (5) to flywheel (1).
 - a. Identify the orientation of teeth (6) on new ring gear (5).

Note: The chamfered side of ring gear teeth (6) must face toward the starting motor when the flywheel is installed. The chamfered on ring gear teeth will ensure the correct engagement of the starting motor.

- b. Heat flywheel ring gear (5) in an oven to a maximum temperature of 250 °C (482 °F) prior to installation.

Note: Do not use a torch to heat the ring gear.

- c. Ensure that the orientation of ring gear (5) is correct and quickly install the ring gear onto flywheel (1).

2. Inspect the crankshaft rear seal for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" for the correct procedure.

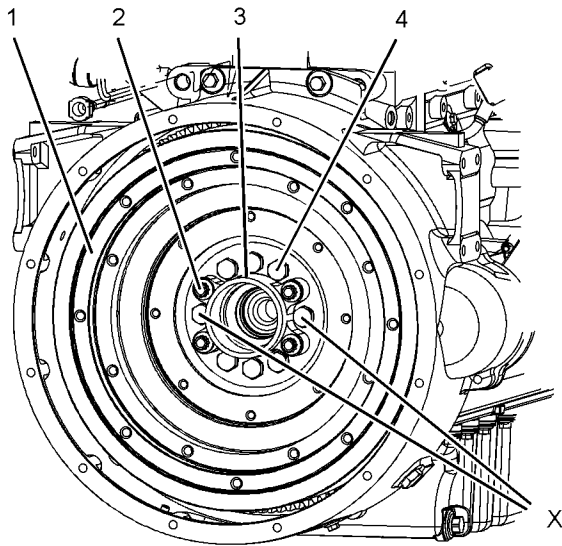


Illustration 235

g01336668

Typical example

3. Install a suitable lifting device on flywheel (1). The flywheel can weigh 71 kg (156 lb).
4. Install Tooling (A) in Position (X) on the crankshaft.
5. Use the lifting device to position flywheel (1) onto Tooling (A).
6. If necessary, install pilot bearing (3) and bolts (2) to flywheel (1).
7. Install bolts (4) to flywheel (1).
8. Remove Tooling (A) and install remaining bolts (4) to flywheel (1).
9. Use a suitable tool to prevent the flywheel from rotating. Tighten bolts (2) and (4) to a torque of 140 N·m (103 lb ft).
10. Remove the lifting device from flywheel (1).
11. Check the run out of the flywheel. Refer to Specifications, "Flywheel" for further information.

End By:

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

i05980600

Crankshaft Rear Seal - Remove

Removal Procedure

Table 45

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: The crankshaft rear seal and the housing are manufactured as a one-piece assembly. The assembly is not serviceable. If the crankshaft rear seal is removed, the assembly must be replaced.

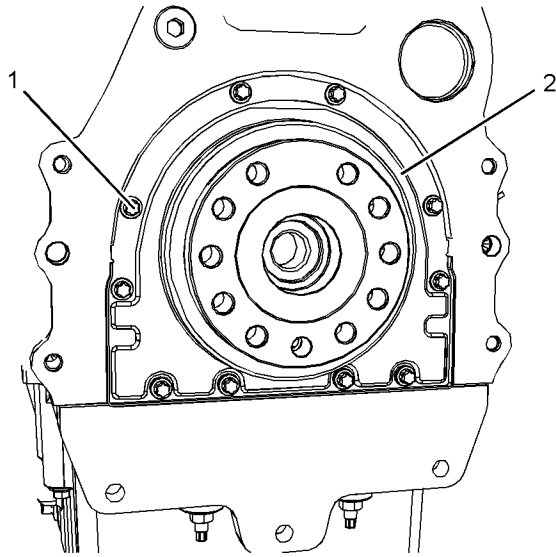


Illustration 236

g02449936

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

i05980590

Crankshaft Rear Seal - Install

Installation Procedure

Table 46

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	E10 Torx Socket	1
B	27610306	Alignment Tool	1

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

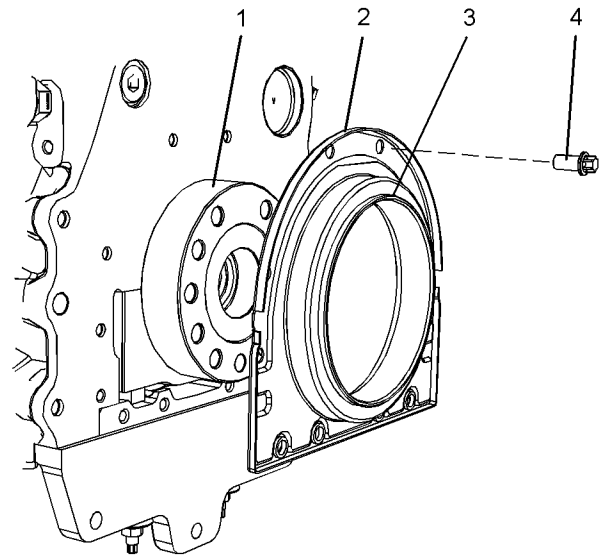


Illustration 237

g02450219

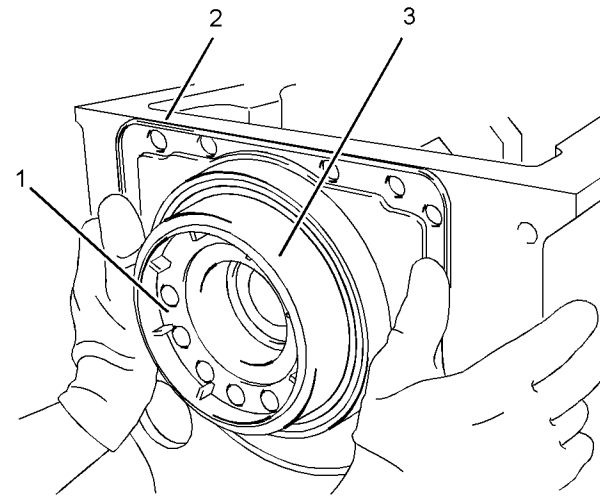


Illustration 238

g02450222

1. Ensure that crankshaft flange (1) is clean, dry, and free from damage.
2. Ensure that the face of the cylinder block and the bridge piece are clean and dry.
3. A new crankshaft rear seal is supplied with a plastic sleeve (3). Ensure that the plastic sleeve is squarely installed within crankshaft rear seal (2).

Note: The plastic sleeve is included in order to protect the lip of the seal as the seal is pushed over the crankshaft flange.

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

4. Align plastic sleeve (3) with crankshaft flange (1). Ensure that the plastic sleeve is engaged onto the crankshaft flange. Push new crankshaft rear seal (2) squarely onto the crankshaft flange.

During this process, the plastic sleeve will be forced out of the crankshaft rear seal. Discard the plastic sleeve.

5. Align the two molded locators on crankshaft rear seal (2) with the holes in the cylinder block. Ensure that the crankshaft rear seal is seated against the cylinder block.

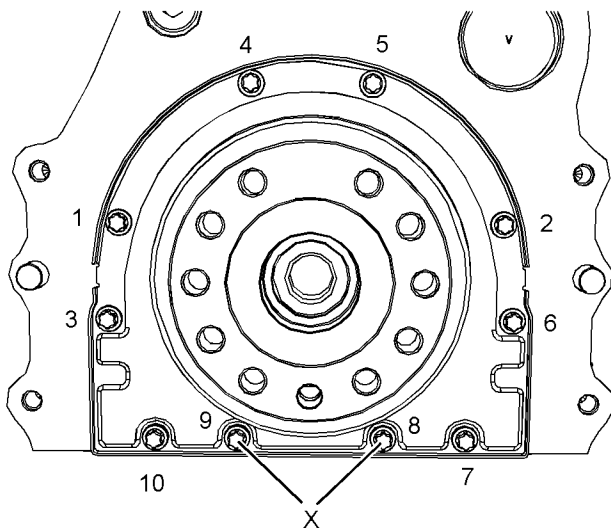


Illustration 239

g02451996

6. Install torx screws (4) finger tight.

Tightening sequence for the crankshaft rear seal

Note: Do not install torx screws to Positions (X) at this stage.

7. Install Tooling (B) to crankshaft rear seal (2) and to crankshaft flange (1).
8. Use Tooling (A) in order to tighten torx screws (4) to a torque of 22 N·m (16 lb ft). Tighten torx screws (4) in the sequence that is shown in Illustration 239.
9. Remove Tooling (B).
10. Install remaining torx screws (4) to Positions (X). Use Tooling (A) in order to tighten the torx screws to a torque of 22 N·m (16 lb ft). Refer to Illustration 239.

End By:

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

i05981751

Flywheel Housing - Remove and Install (Standard Housing)

Removal Procedure

Table 47

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M10 by 100 mm	2

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

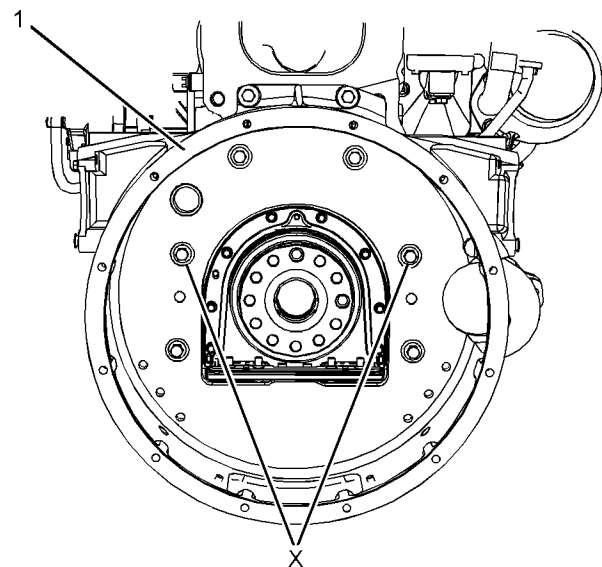


Illustration 240

g01983516

Typical example

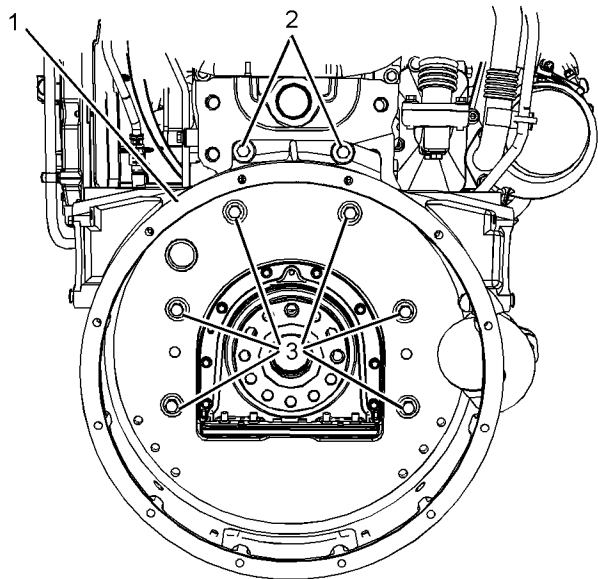


Illustration 241

g01981253

1. Remove the bolts from Position (X) from flywheel housing (1).
2. Install Tooling (A) into Position (X) on flywheel housing (1).
3. Install a suitable lifting device to the flywheel housing in order to support the flywheel housing. The flywheel housing can weigh 40 kg (88 lb).
4. Remove bolts (2) and remaining bolts (3) from flywheel housing (1).
5. Use a suitable lifting device in order to remove flywheel housing (1) from the cylinder block.

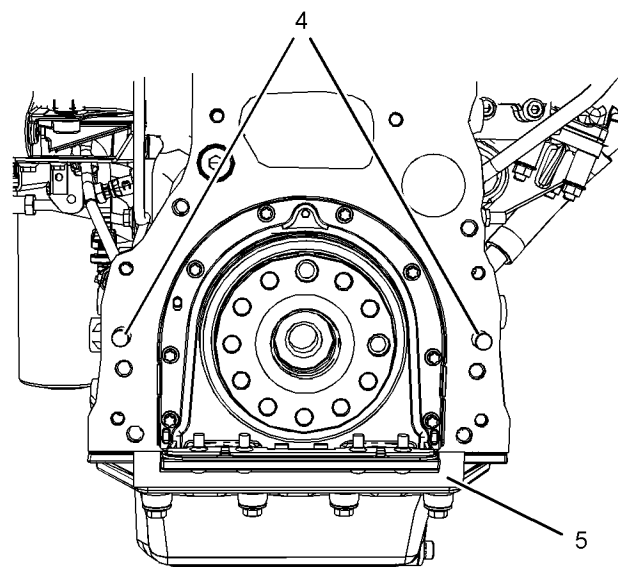


Illustration 242

g01983533

Typical example

6. Remove dust seal (5).
7. If necessary, remove dowels (4) from the cylinder block.

Installation Procedure (Standard Housing)

Table 48

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M10 by 100 mm	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

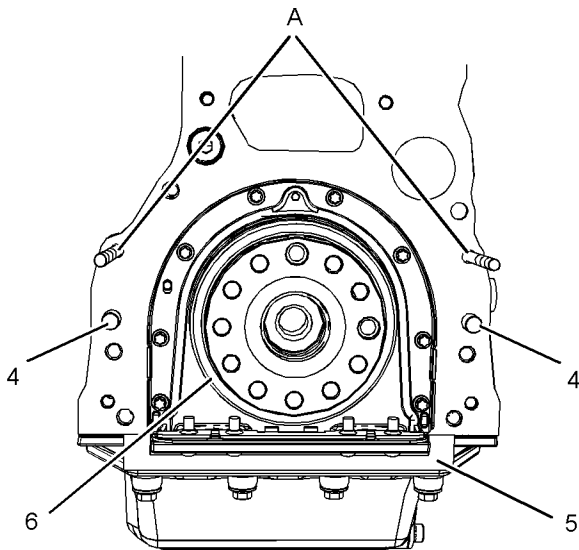


Illustration 243

g01983535

Typical example

2. Inspect crankshaft rear seal (6) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install" for the correct procedure.
3. Clean the rear face of the cylinder block. If necessary, install dowels (4) to the cylinder block.
4. Install Tooling (A) to the cylinder block.
5. Install dust seal (5).

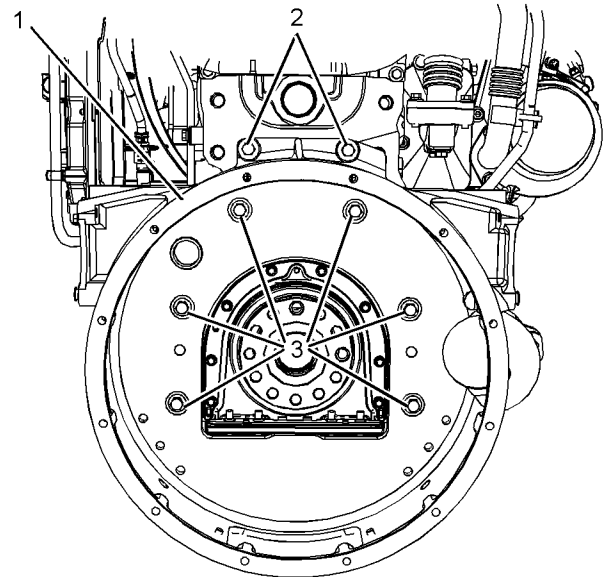


Illustration 244

g01981253

Typical example

6. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 40 kg (88 lb).
7. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.
8. Install bolts (2) and bolts (3).
9. Remove Tooling (A). Install remaining bolts (3).

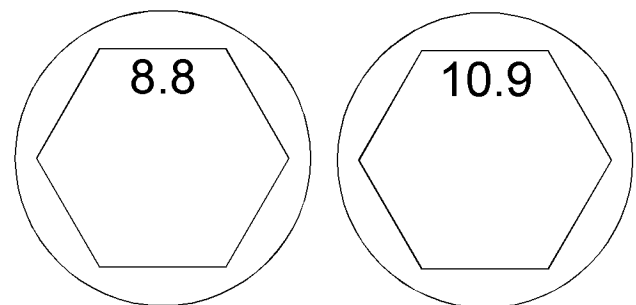


Illustration 245

g01984554

Identification of the bolt Grade.

10. When 8.8 Graded bolts are installed, follow Step 10a through Step 10b.
 - a. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).
 - b. Tighten bolts (2) to a torque of 78 N·m (58 lb ft).

11. When 10.9 Graded bolts are installed follow Step 11a through Step 11b.

- a. Tighten bolts (3) to a torque of 115 N·m (85 lb ft).
- b. Tighten bolts (2) to a torque of 190 N·m (140 lb ft).

12. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, “Flywheel Housing - Inspect” for the correct procedure.

End By:

a. Install the flywheel. Refer to Disassembly and Assembly, “Flywheel - Install” for the correct procedure.

i05981752

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

Removal Procedure

Table 49

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

Start By:

a. Remove the flywheel. Refer to Disassembly and Assembly, “Flywheel - Remove” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The wet back end flywheel housing may be installed on standard engines. When the wet back-end flywheel housing is installed, to a standard engine a seal will not be installed to the flywheel housing.

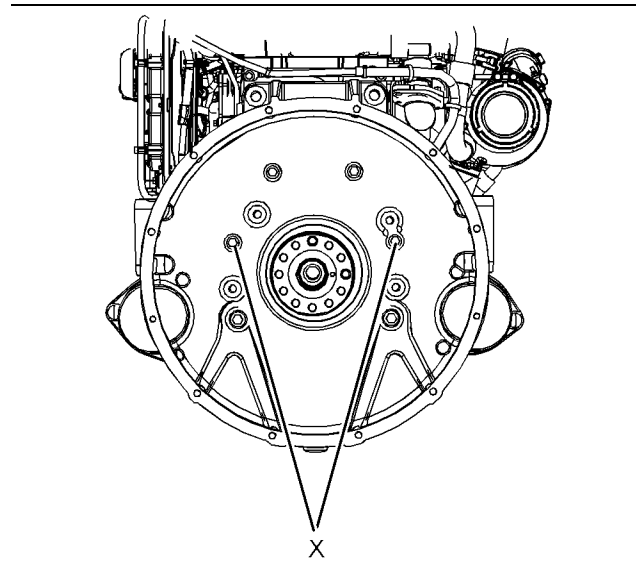


Illustration 246

g01986178

Typical example

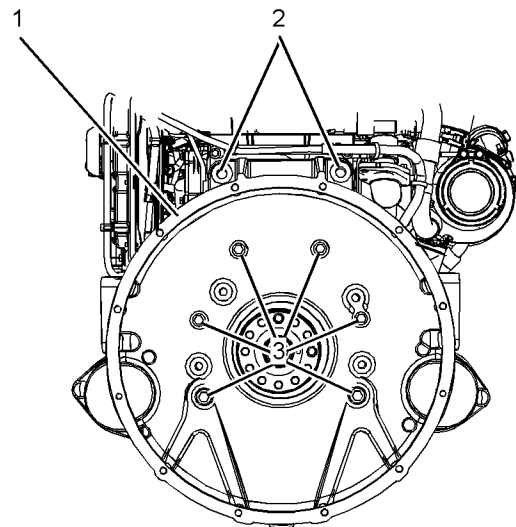


Illustration 247

g01988515

1. Remove the bolts from Position (X) from flywheel housing (1).
2. Install Tooling (A) into Position (X) on flywheel housing (1).
3. Install a suitable lifting device to the flywheel housing in order to support the flywheel housing. The flywheel housing can weigh 40 kg (88 lb).
4. Remove bolts (2) and remaining bolts (3) from flywheel housing (1).

5. Use the lifting device in order to remove flywheel housing (1) from the cylinder block.

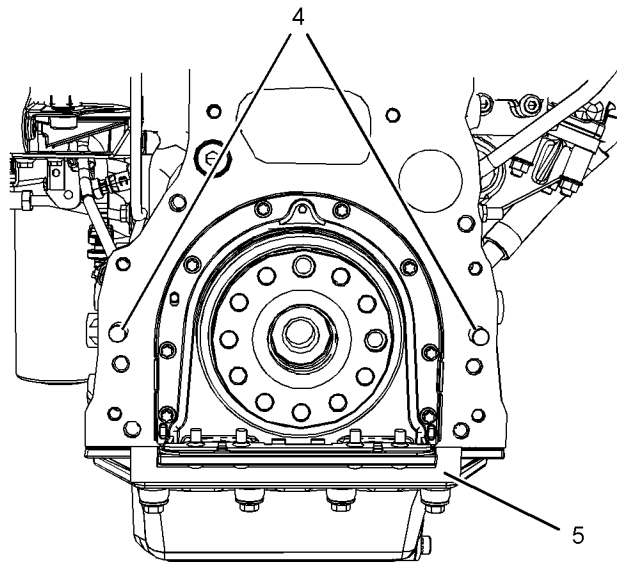


Illustration 248 g01988534

Typical example

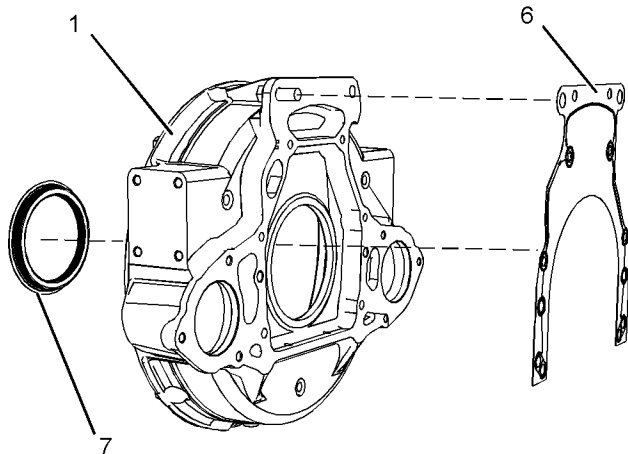


Illustration 249 g01988535

Typical example

- 6. Remove dust seal (5).
- 7. Remove gasket (6).
- 8. If necessary, remove dowels (4) from the cylinder block.
- 9. Remove oil seal (7) from flywheel housing (1).

Installation Procedure (Wet Back End Housing)

Table 50

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M10 by 100 mm	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

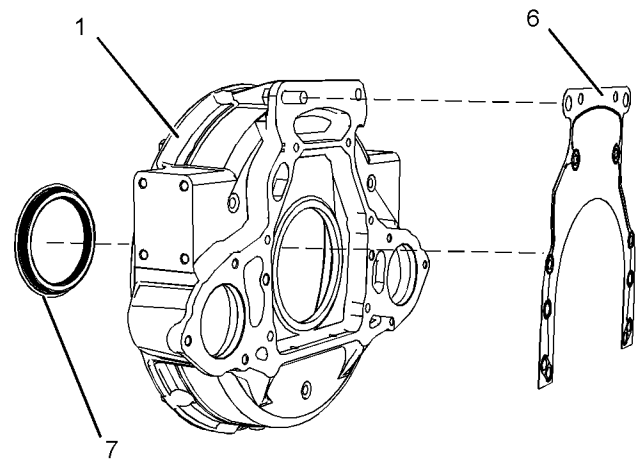


Illustration 250 g01988676

Typical example

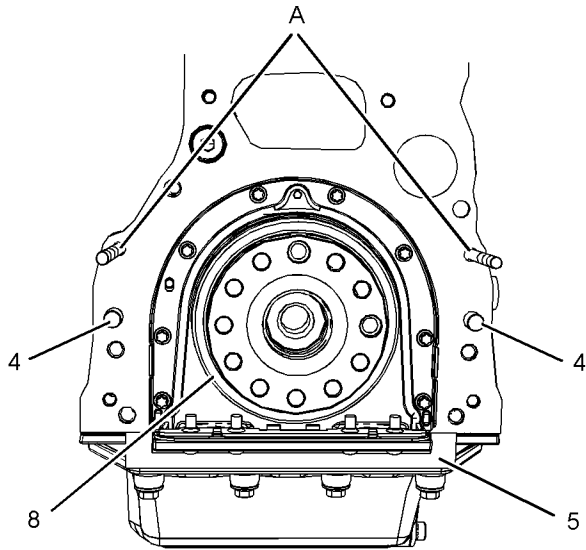


Illustration 251

g01988677

Typical example

2. Ensure that the bolts are clean and free from oil or grease. Ensure that all threaded holes in the cylinder block are clean and free from oil or grease.

3. Install a new oil seal (7) to flywheel housing (1).

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

4. Inspect crankshaft rear seal (8) for leaks. If there are any oil leaks, replace the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" and refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install" for the correct procedure.

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

6. Install Tooling (A) to the cylinder block.

7. Align a new gasket (6) with Tooling (A). Install the gasket to the cylinder block.

8. Install dust seal (5).

9. Install a suitable lifting device to the flywheel housing. The flywheel housing can weigh 40 kg (88 lb).

10. Use the lifting device to align flywheel housing (1) with Tooling (A). Install the flywheel housing to the cylinder block.

11. Install bolts (2) and bolts (3).

12. Remove Tooling (A). Install remaining bolts (3).

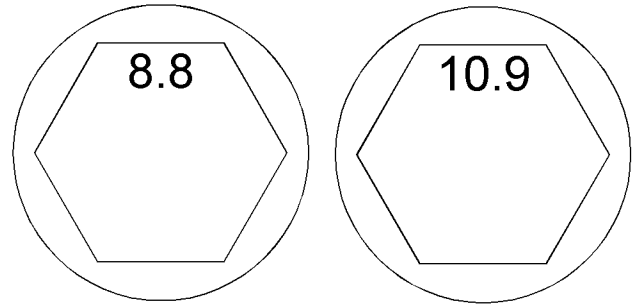


Illustration 252

g01984554

Identification of the bolt Grade.

13. When 8.8 Graded bolts are installed, follow Step 13a through Step 13b.

- a. Tighten bolts (3) to a torque of 63 N·m (46 lb ft).
- b. Tighten bolts (2) to a torque of 78 N·m (58 lb ft).

14. When 10.9 Graded bolts are installed, follow Step 14a through Step 14b.

- a. Tighten bolts (3) to a torque of 115 N·m (85 lb ft).
- b. Tighten bolts (2) to a torque of 190 N·m (140 lb ft).

15. Check the alignment of flywheel housing (1) with the crankshaft. Refer to System Operation, Testing and Adjusting, "Flywheel Housing - Inspect" for further information.

End By:

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

i05982959

Crankshaft Pulley - Remove and Install

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

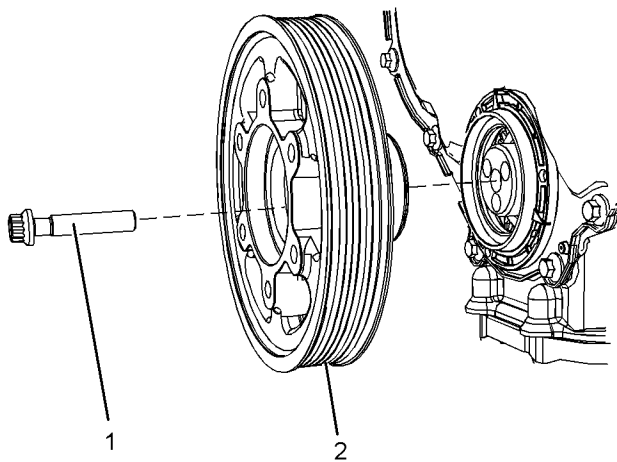


Illustration 253

g02449658

1. Use a suitable tool in order to prevent the crankshaft from rotating. Remove bolts (1).
2. Remove crankshaft pulley (2) from the crankshaft.

Installation Procedure

Table 51

Required Tools			
Tool	Part Number	Part Description	Qty
A	21825607	Degree Wheel	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the pulley is clean and free from damage. Replace any components that are damaged.

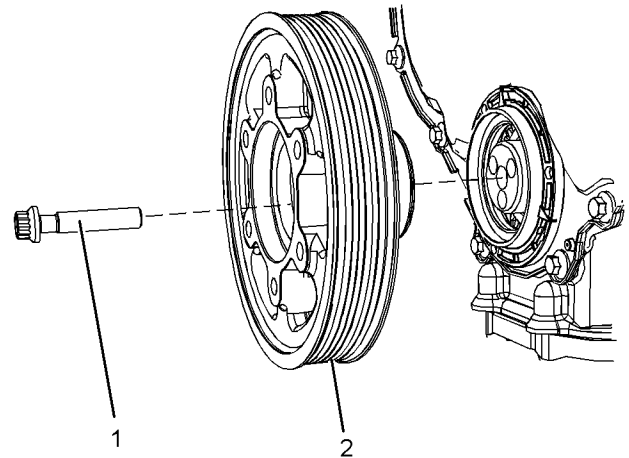


Illustration 254

g02449658

2. Install a new front seal to the front cover. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install" for the correct procedure.
3. Install crankshaft pulley (2) to the crankshaft.

Note: Do not lubricate the front seal or the seal face of the crankshaft pulley.

4. Install bolts (1).
5. Use a suitable tool in order to prevent the crankshaft from rotating. Tighten the bolts to a torque of 22 N·m (195 lb in).
6. Use tooling (A) in order to turn bolts (1) through an additional 120 degrees.

End By:

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

i05980464

Crankshaft Front Seal - Remove and Install

(Crankshaft Front Seal for Heavy
Duty Front Cover)

Removal Procedure

Table 52

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

Start By:

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley- Remove and Install" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

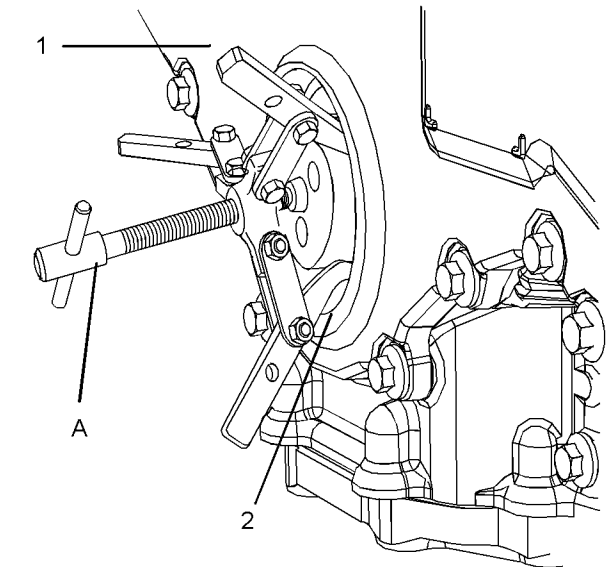


Illustration 255

g02443718

1. Install the legs of Tooling (A) behind crankshaft front seal (2). Install a suitable spacer between Tooling (A) and the crankshaft.
2. Use Tooling (A) in order to pull crankshaft front seal (2) out of front cover (1).

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

Installation Procedure

Table 53

Required Tools			
Tool	Part Number	Part Description	Qty
B	21825577	Front Seal Installer	1
	21825578	Plate	1
	21825580	Anchor Plate	1
	27610284	Seal Installer Tool	1
	21825579	Sleeve	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the bore for the crankshaft front oil seal in the front cover is clean and free from damage.

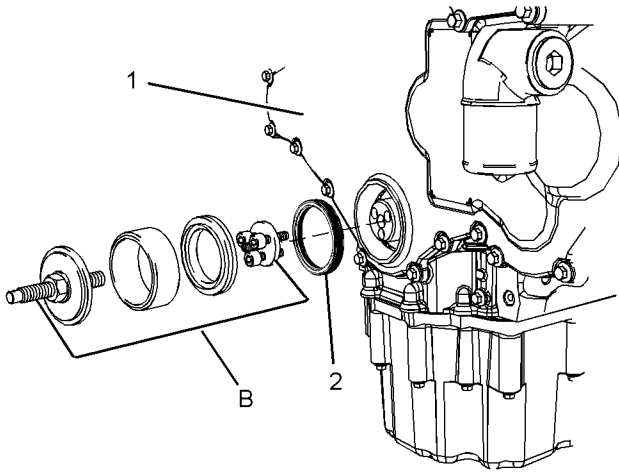


Illustration 256

g02443719

2. Assemble Tooling (B).
3. Correctly position a new crankshaft front seal (2) to front cover (1).

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

4. Use Tooling (B) to install crankshaft front seal (2) to front cover (1). Ensure that the front face of the crankshaft front seal is installed to a depth of $6.5 \pm 0.2 \text{ mm}$ ($0.256 \pm 0.008 \text{ inch}$).
5. Remove Tooling (B) from the crankshaft.

End By:

- a. **Install the crankshaft pulley.** Refer to Disassembly and Assembly, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

i07911123

Crankshaft Front Seal - Remove and Install

Removal Procedure

Table 54

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400016	Oil seal removal & installation tool	1

Start By:

- a. **Remove the crankshaft pulley.** Refer to Disassembly and Assembly, “Crankshaft Front Pulley- Remove and Install” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

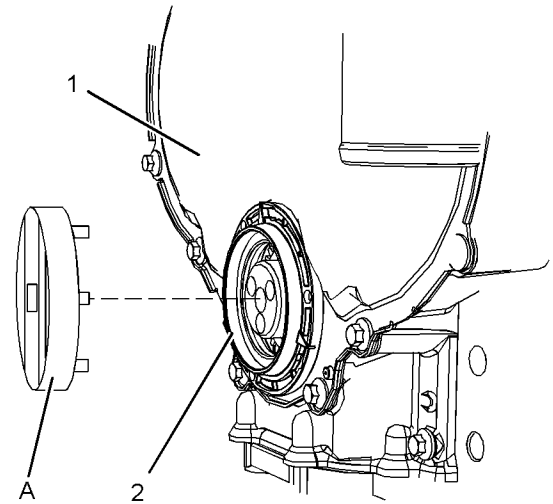


Illustration 257

g02445196

1. Align Tooling (A) onto crankshaft front seal (2).
2. Turn Tooling (A) in a counterclockwise direction and remove crankshaft front seal (2) from front cover (1).

Installation Procedure

Table 55

Required Tools			
Tool	Part Number	Part Description	Qty
A	T400016	Oil seal removal & installation tool	1
B	-	P-80 Emulsion Lubricant	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the front cover is clean and free from damage.

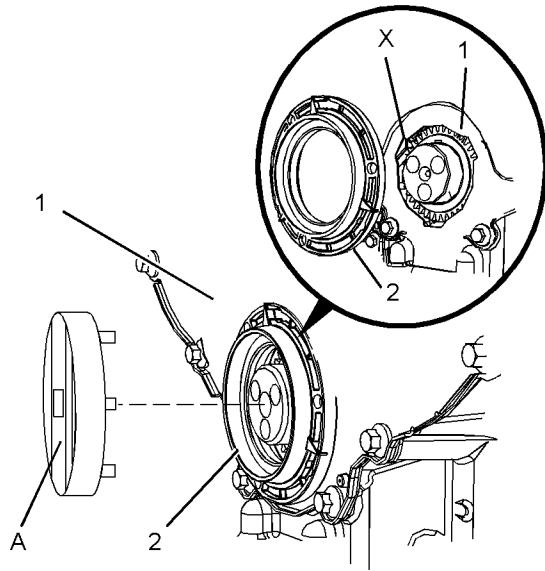


Illustration 258

g02445197

2. Apply Tooling (B) to the seal on new crankshaft front seal (2).
3. Correctly position a new crankshaft front seal (2) in Position (X) onto front cover (1).
4. Position Tooling (A) onto crankshaft front seal (2).
5. Use Tooling (A) to turn crankshaft front seal (2) in clockwise direction.
6. If it is necessary to apply a torque greater than 50 N·m (37 lb ft) to install crankshaft front seal (2). Remove crankshaft front seal (2). Inspect the crankshaft front seal and the front cover for faults or damage.
7. If necessary repeat Step 2 through Step 6 to install crankshaft front seal (2).

End By:

- a. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Front Pulley- Remove and Install" for the correct procedure.

i05981753

Front Cover - Remove and Install (Heavy Duty Front Cover)

Removal Procedure**Start By:**

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install" for the correct procedure.
- b. If the engine has a fan, remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.

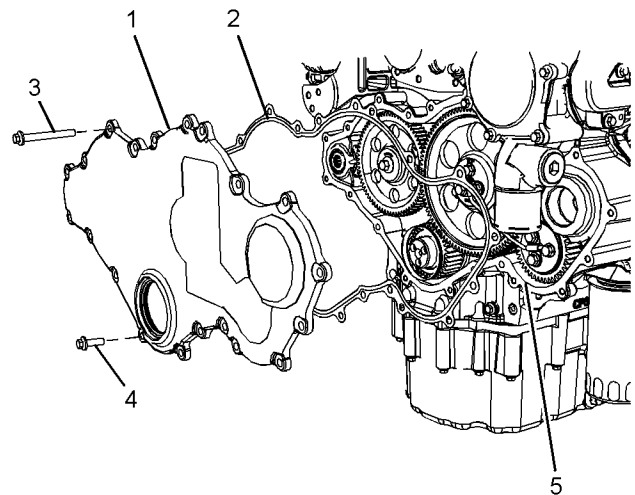


Illustration 259

g02480997

1. Remove the front seal from the front cover. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install" for the correct procedure.
2. Remove bolts (3) and bolts (4). Identify the positions of bolts of different length.
3. Remove front cover (1) from front housing (5).
4. Remove gasket (2).

Installation Procedure

Table 56

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M8 by 70 mm	2
B	T400023	Front Cover Alignment Tool	1

9. Remove Tooling (A) and install the remaining bolts.

10. Tighten bolts (3) and bolts (4) to a torque of 22 N·m (195 lb in).

11. Remove Tooling (B).

12. Install a new front seal to the front cover. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install" for the correct procedure.

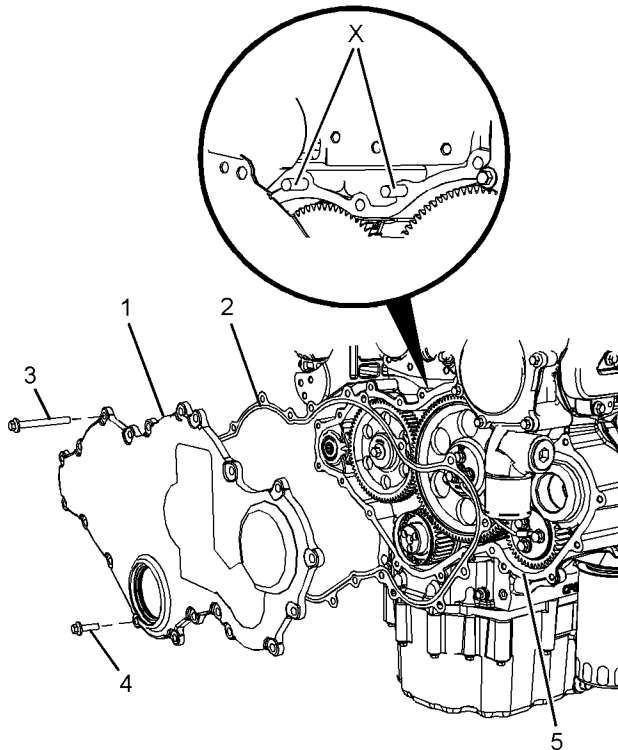


Illustration 260

g02480998

1. Ensure that all components are clean and free from damage. Replace any damaged components.
2. Thoroughly clean the gasket surface of front housing (5).
3. Thoroughly clean front cover (1).
4. Install Tooling (A) into Holes (X) in front housing (5).
5. Install a new gasket (2) onto Tooling (A).
6. Install front cover (1) onto Tooling (A).
7. Install bolts (3) and bolts (4) finger tight. Ensure that the bolts of different length are installed in the correct positions.
8. Use Tooling (B) to align the front cover assembly.

End By:

- a. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install" for the correct procedure.
- b. If the engine has a fan, install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.

i05981754

Front Cover - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install" for the correct procedure.
- b. If the engine has a fan, remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.

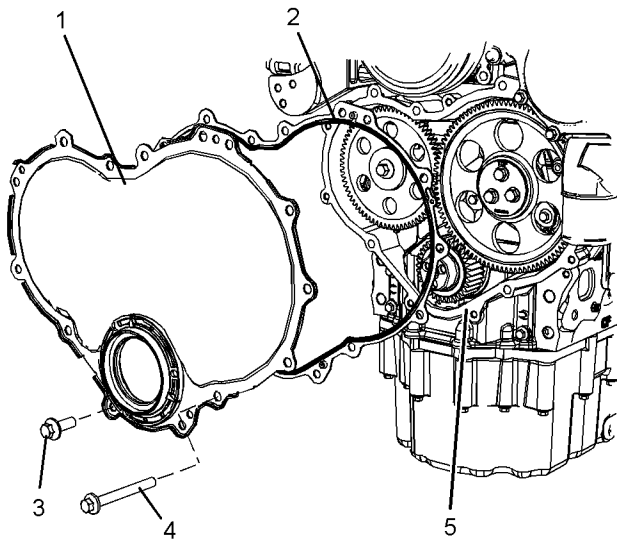


Illustration 261

g02481028

1. Remove the front seal from the front cover. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install" for the correct procedure.
2. Remove bolts (3) and bolts (4). Identify the positions of bolts of different length.

3. Remove front cover (1) from front housing (5).
4. Remove gasket (2).

Installation Procedure

Table 57

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M8 by 70 mm	2
B	T400054	Front Cover Alignment Tool	1

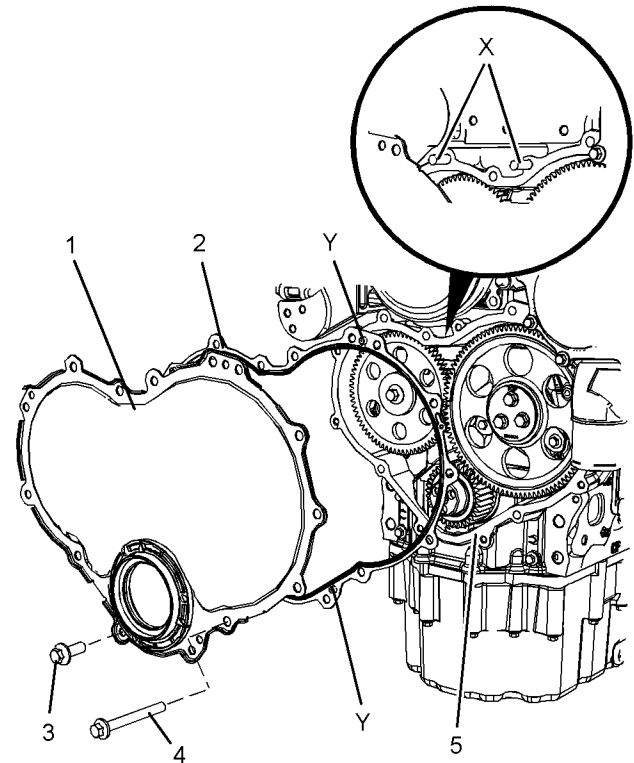


Illustration 262

g02481030

1. Thoroughly clean the gasket surface of the front housing.
2. If the original front cover is installed, follow Step 2a through Step 2b.
 - a. Thoroughly clean front cover (1).
 - b. Install a new gasket (2) to front cover (1). Engage Locators (Y) into the holes in the front cover.
3. Install Tooling (A) into Holes (X) in front housing (5).
4. Use Tooling (A) in order to position the front cover assembly onto the front housing.

5. Install bolts (3) and bolts (4) finger tight. Ensure that the bolts of different length are installed in the correct positions.
6. Install a new front seal to the front cover. Refer to Disassembly and Assembly, "Crankshaft Front Seal - Remove and Install" for the correct procedure.
7. Use Tooling (B) in order to align the front cover.
8. Remove Tooling (A) and install the remaining bolts.
9. Tighten bolts (3) and bolts(4) to a torque of 22 N·m (195 lb in).
10. Remove Tooling (B) from the front cover.

End By:

- a. **Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install" for the correct procedure.**
- b. **If the engine has a fan, install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.**

i05981766

Gear Group (Front - Remove and Install)

(Heavy Duty Gear Group (Front))

Removal Procedure

Table 58

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the front gear group. Carefully follow the procedure in order to remove the gear group.

1. If the air compressor is equipped with a hydraulic pump, remove the hydraulic pump. Refer to Original Equipment Manufactures (OEM) for the correct procedure.
2. If the engine is equipped with an air compressor, remove the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Remove" for the correct procedure.
3. If the engine is equipped with only a hydraulic pump, remove the hydraulic pump. Refer to OEM for the correct procedure.
4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.

Note: Do not use excessive force to install Tooling (D). Do not use Tooling (D) to hold the crankshaft during repairs.

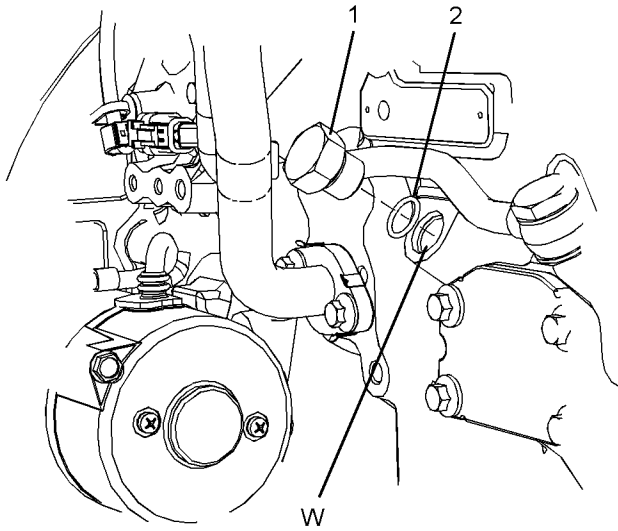


Illustration 263

g02486477

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
6. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.
7. Remove Tooling (D).
8. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

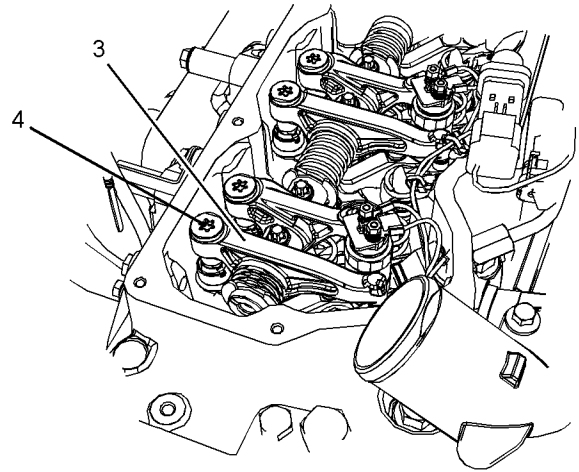


Illustration 264

g03706901

9. Use Tooling (E) in order to loosen threaded inserts (4) on all rocker arms (3). Unscrew threaded inserts (4) on all rocker arms (3) until all valves are fully closed.

Note: Ensure that ALL threaded inserts are fully unscrewed.

10. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to Illustration 279 .

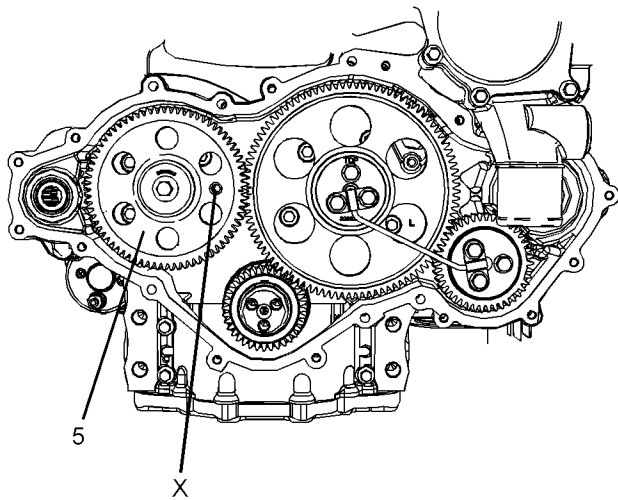


Illustration 265

g03706903

- 11.** Install Tooling (B) through Hole (X) in camshaft gear (5) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
- 12.** Use Tooling (C) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

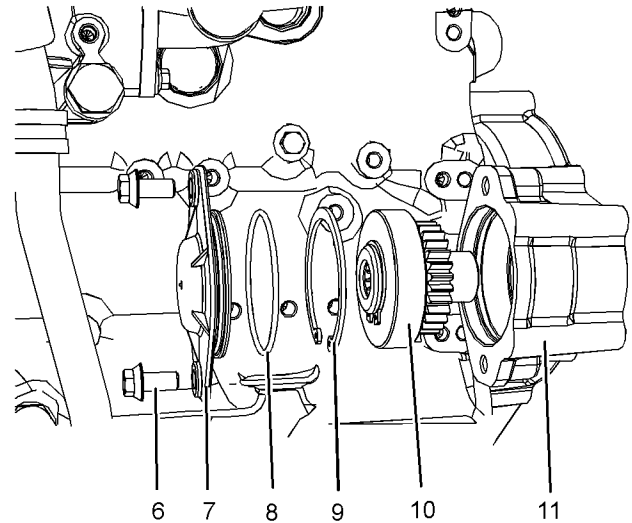


Illustration 266

g03706905

- 13.** If the right-hand side of the engine is equipped with a hydraulic pump, remove the hydraulic pump. Refer to OEM for the correct procedure.
- 14.** If necessary, remove bolts (6) from plate (7). Remove plate (7) and remove O-ring seal (8).
- 15.** Remove circlip (9) and remove gear assembly (10) from front housing (11).

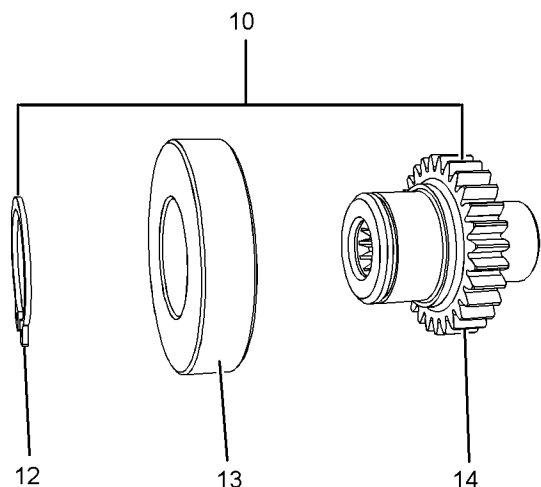


Illustration 267

g03706906

- 16.** If necessary, follow Step 16a through Step 16b in order to disassemble gear assembly (10).
 - a. Remove circlip (12) from gear assembly (10).

b. Place gear assembly (10) on a suitable support. Press bearing (13) from gear (14).

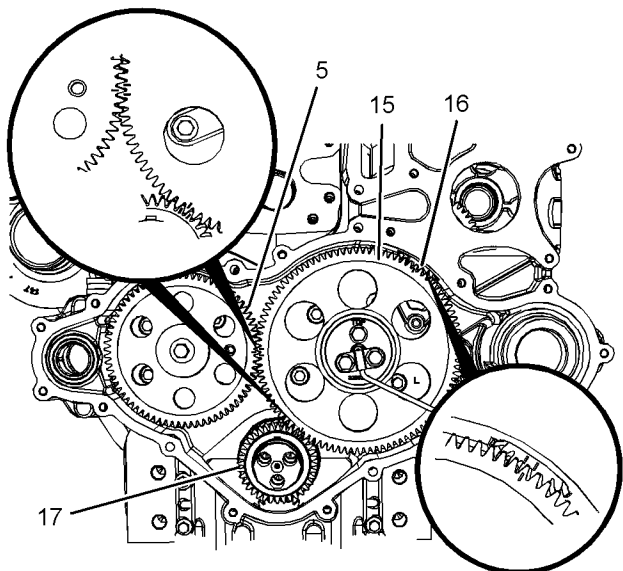


Illustration 268

g03706907

17. Mark gear (5), gear (15), gear (16) and gear (17) in order to show alignment. Refer to Illustration 268 .

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

18. Remove camshaft gear (6). Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

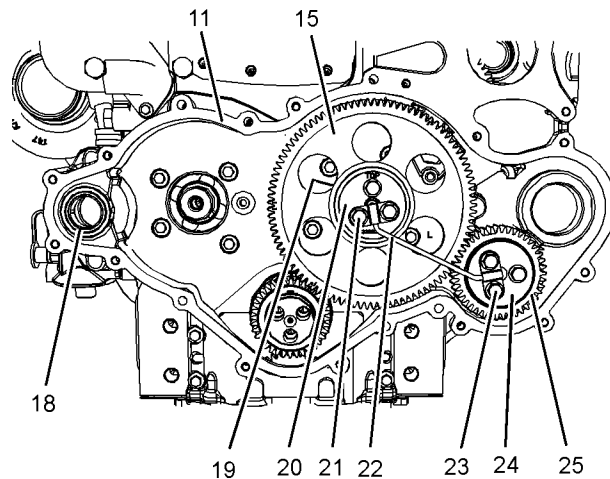


Illustration 269

g03706909

- 19. Remove bolts (21) and bolts (23).
- 20. Remove tube assembly (22) from idler gear (15) and idler gear (25).
- 21. Remove plate (20).
- 22. Remove idler gear (15) from hub (19) (not shown).
- 23. Remove idler gear (25) and idler gear hub (24) from front housing (11).
- 24. Remove hub (19) (not shown) from front housing (11).
- 25. If necessary, remove bearing (18) from front housing (11). Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

Installation Procedure

Table 59

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1

(continued)

(Table 59, contd)

D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1
F	-	Delphi Lockheed Rubber Grease	1
G	-	Loctite 609 Bearing Mount Compound	1
H	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

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

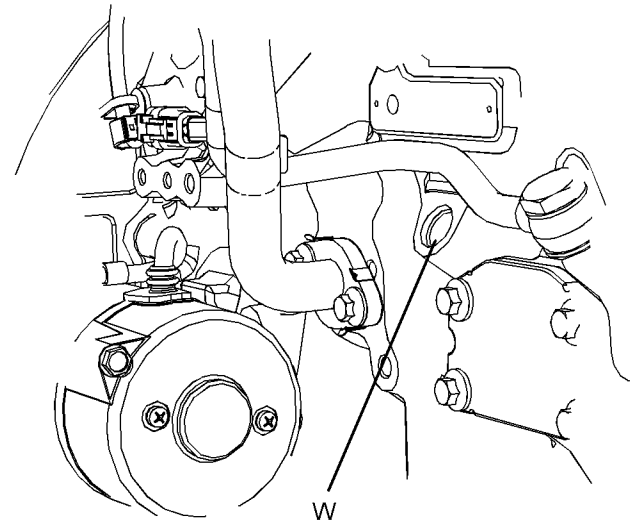


Illustration 270

g02488176

2. If necessary, install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.

Note: Do not use excessive force to install Tooling (D). Do not use Tooling (D) to hold the crankshaft during repairs.

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

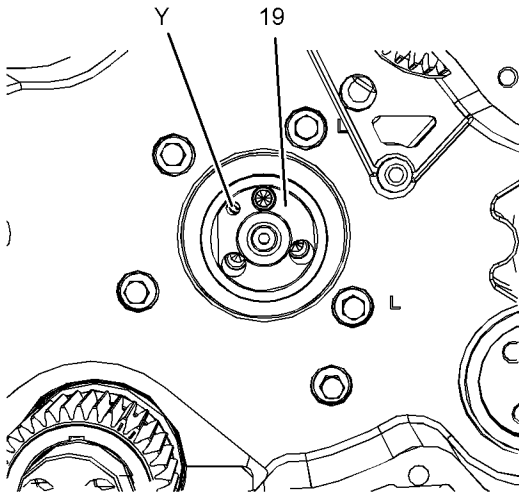


Illustration 271

g03706911

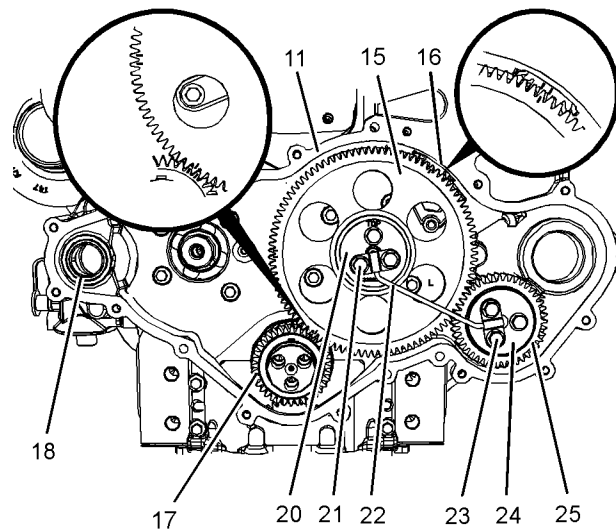


Illustration 272

g03706914

4. If necessary, Install bearing (18) to front housing (11). Refer to Disassembly and Assembly, "Housing (Front) - Install" for the correct procedure.
5. Install hub (19) to the recess of front housing (11). Ensure that the oil Hole (Y) is to the top of the hub.
6. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install" for the correct procedure.

7. Lubricate idler hub (19) with clean engine lubricating oil. Install idler gear (15) to the idler hub. Ensure that the timing marks are toward the front of the idler gear. Align timing marks on idler gear (15) with gear (17) and gear (16).
8. Lubricate idler gear hub (24) with clean engine lubricating oil and install idler gear (25) to the idler gear hub. Install the assembly for idler gear (25) to front housing (11).

Note: Ensure that the idler gear hub and the idler gear are correctly aligned.

9. Position plate (20) onto idler gear (15).

Note: Ensure that the identification mark TOP is upward.

10. Position tube assembly (22) onto idler gear (15) and idler gear (24). Install bolts (21) and bolts (23).

Note: Ensure that the tube is correctly positioned on the hubs of the idler gears.

11. Tighten bolts (21) and bolts (23) to a torque of 44 N·m (32 lb ft).

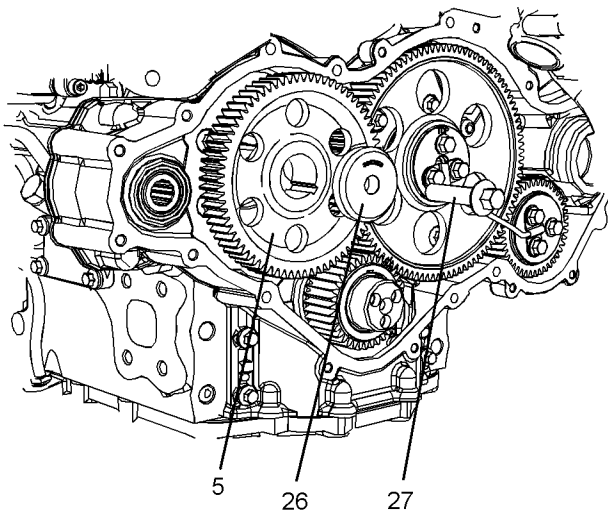


Illustration 273

g03706915

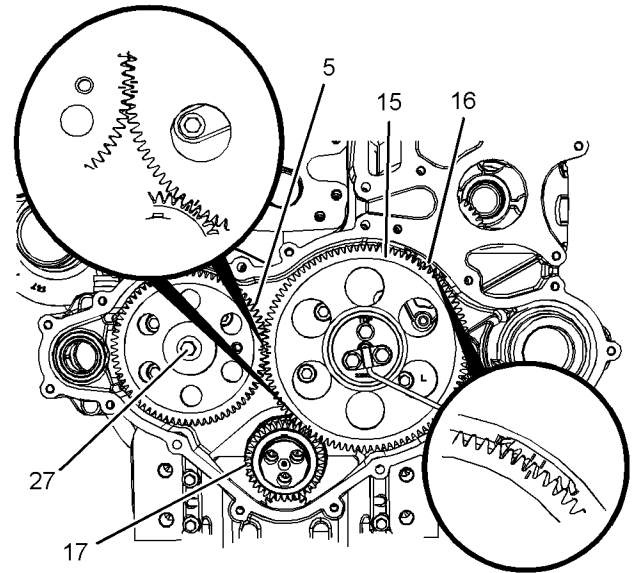


Illustration 275

g03706922

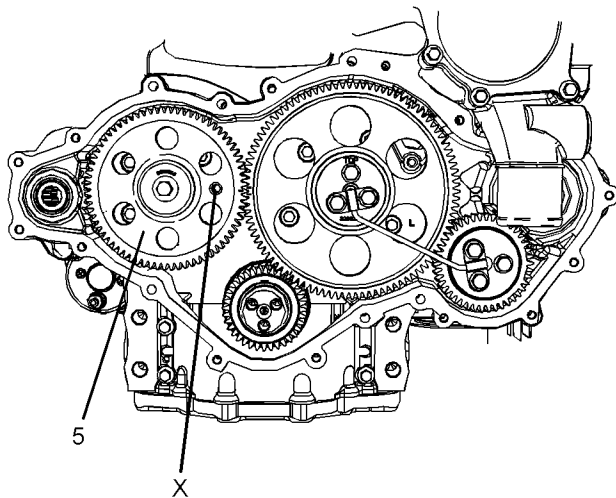


Illustration 274

g03706903

12. Install camshaft gear (5). Ensure that the camshaft gear and the idler gear timing marks are correctly aligned.
13. Install Tooling (B) through Hole (X) in camshaft gear (6) into the front housing.
14. Loosely install bolt (27) and washer (26) for the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install" for the correct procedure.

15. Ensure that the timing marks on gear (5), gear (15), gear (16) and gear (17) are in alignment and that the mesh of the gears is correct.

16. Remove Tooling (B), Tooling (C), and Tooling (D).

17. When bolt (27) is a 8.8 Grade. Tighten bolt (27) for camshaft gear (5) to a torque of 95 N·m (70 lb ft).

When bolt (27) is a 10.9 Grade. Tighten bolt (27) to a torque of 120 N·m (89 lb ft).

18. Use Tool (H) in order to check the end play of the camshaft gear. Refer to Specifications, "Camshaft" for more information.

19. Use Tool (H) in order to check the end play of the idler gears. Refer to Specifications, "Gear Group (Front)" and refer to Disassembly and Assembly, "Idler Gear - Remove and Install" for further information.

20. Use Tooling (H) in order to measure the backlash for gear (5), gear (15), gear (16) and gear (17). Refer to Specifications, "Gear Group (Front)" for further information.

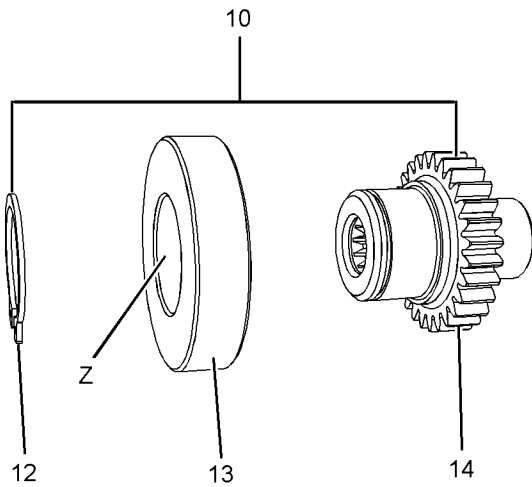


Illustration 276

g03706923

- 21.** If necessary, follow Step 21a through Step 21c in order to assemble gear assembly (10).
- Apply a small continuous bead of Tooling (G) to inner Surface (Z) of bearing (13). Place the inner race of bearing (13) onto a suitable support. Press the shaft of gear (14) into bearing (13) until the shoulder of the gear is against the bearing. Remove any excess bearing mount compound.
 - Install circlip (12) to gear assembly (10).
 - Lightly lubricate bearing (13) and gear assembly (10) with clean lubricating oil.

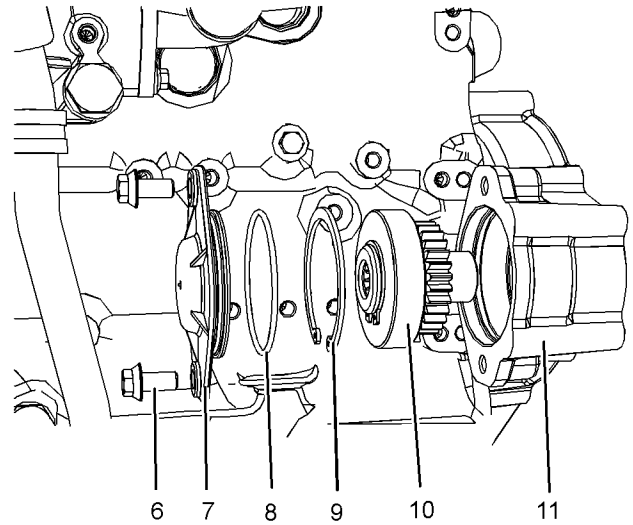


Illustration 277

g03706905

- 22.** Install gear assembly (10) to front housing (11). Ensure that the shaft of gear assembly (10) is correctly aligned with the bearing in front housing (11).
- 23.** Install circlip (9) to front housing (11).
- Note:** Ensure that the circlip is correctly located in the front housing.
- 24.** Ensure that there is tactile backlash between the camshaft gear and the accessory drive gear.
- 25.** If the right-hand side of the engine is equipped with a hydraulic pump, install the hydraulic pump. Refer to OEM for the correct procedure.
- 26.** If necessary, lightly lubricate a new O-ring seal (8) with Tooling (F). Install new O-ring seal (8) to plate (7). Install plate (7) to front housing (11).
- 27.** Install bolts (6) to plate (7). Tighten the bolts to a torque of 10 N·m (88 lb in).
- 28.** Lubricate each gear with clean engine oil.

NOTICE

Failure to ensure that the crankshaft is positioned at the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

29. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

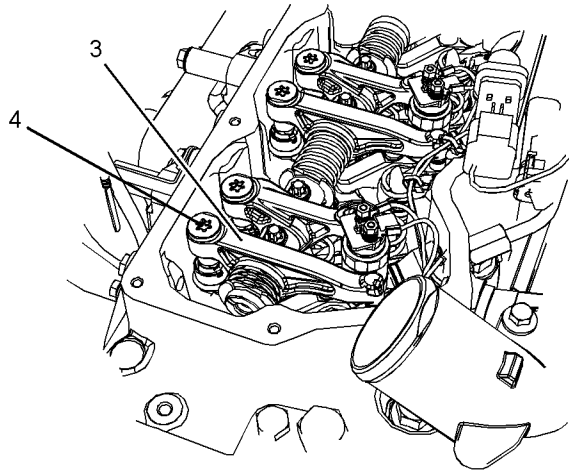


Illustration 278

g03706901

30. Use Tooling (E) in order to tighten threaded inserts (4) on all rocker arms (3). Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be correctly seated into the cup for the pushrod.

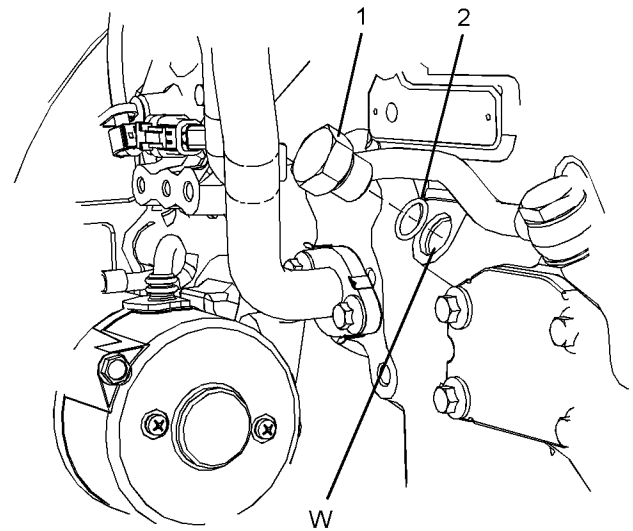


Illustration 279

g02486477

31. Install a new O-ring seal (1) to plug (2). Install the plug into Hole (W) in the cylinder block. Tighten plug (2) to a torque of 21 N·m (186 lb in).

32. If the engine is equipped with an air compressor, install the air compressor. Refer to Disassembly and Assembly, "Air Compressor - Install" for the correct procedure.

33. If the air compressor is equipped with a hydraulic pump, install the hydraulic pump. Refer to OEM for the correct procedure.

34. If the engine is equipped only with a hydraulic pump, install the hydraulic pump. Refer to OEM for the correct procedure.

35. The engine should not be operated for a period 45 minutes after the threaded inserts on all the rocker arms have been tightened. This period of time will allow the hydraulic lifters to purge off excessive engine oil from the hydraulic lifters.

End By:

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

i05981767

Gear Group (Front - Remove and Install)

Removal Procedure

Table 60

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the front gear group. Carefully follow the procedure in order to remove the gear group.

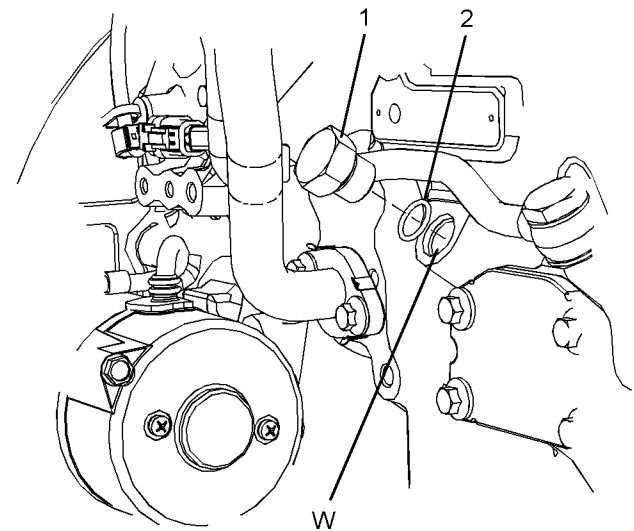


Illustration 280

g02485936

1. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
2. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.
3. Remove Tooling (D).
4. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

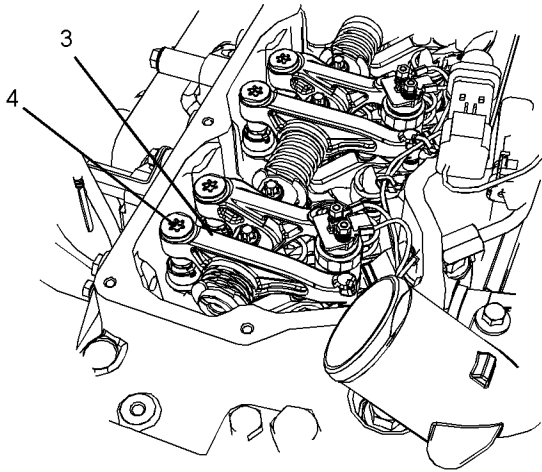


Illustration 281

g03707478

5. Use Tooling (E) in order to loosen threaded inserts (4) on all rocker arms (3). Unscrew threaded inserts (4) on all rocker arms (3) until all valves are fully closed.

Note: Ensure that ALL threaded inserts are fully unscrewed.

6. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to Illustration 280 .

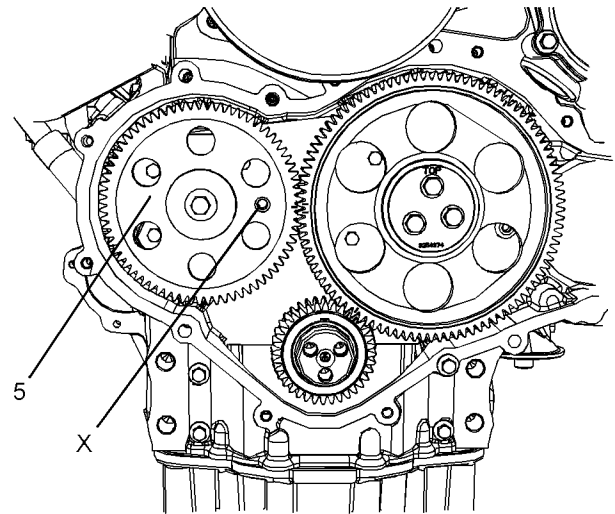


Illustration 282

g03707479

7. Install Tooling (B) through Hole (X) in camshaft gear (5) into the front housing. Use Tooling (B) in order to lock the camshaft in the correct position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
 8. Install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
- Note:** Do not use excessive force to install Tooling (D). Do not use Tooling (D) to hold the crankshaft during repairs.
9. Use Tooling (C) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

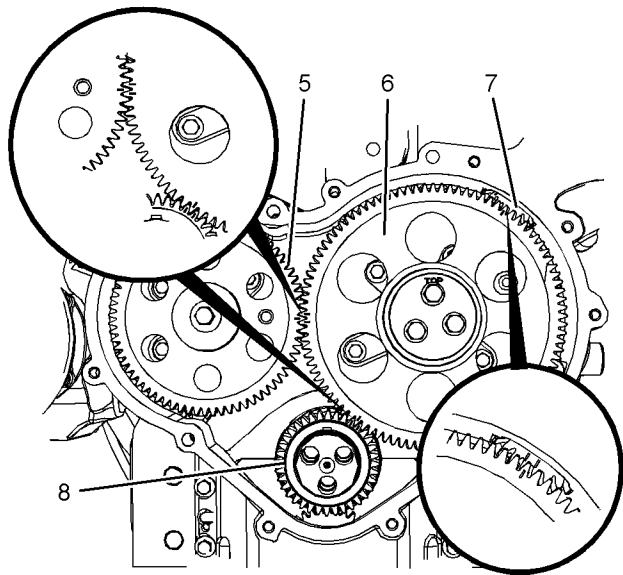


Illustration 283 g03707480

Alignment of timing marks

10. Mark gear (5), gear (6), gear (7) and gear (8) in order to show alignment. Refer to Illustration 283 .

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

11. Remove camshaft gear (5). Refer to Disassembly and Assembly, “Camshaft Gear - Remove and Install” for the correct procedure.

12. Remove idler gear (6). Refer to Disassembly and Assembly, “Idler Gear - Remove and Install” for the correct procedure.

Installation Procedure

Table 61

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610212	Timing Pin (Camshaft)	1
C	T400015	Timing Pin (Fuel Injection Pump)	1
D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1
F	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

Note: The fuel injection pump must remain locked until the procedure instructs you to unlock the fuel injection pump.

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

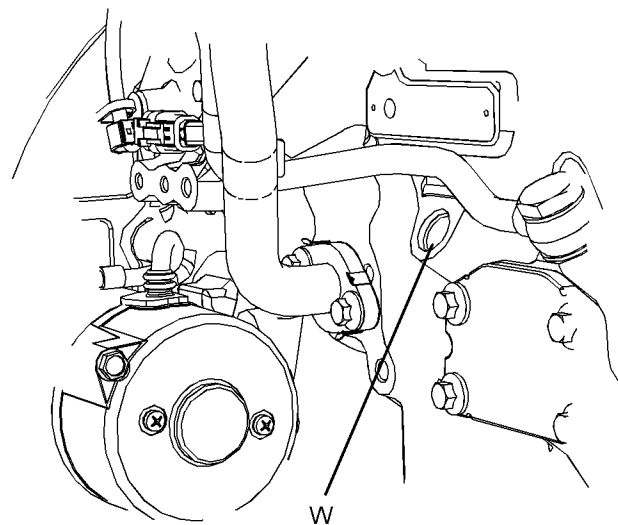


Illustration 284 g02485938

2. If necessary, install Tooling (D) into Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, “Finding Top Center Position for No.1 Piston” for the correct procedure.

Note: Do not use excessive force to install Tooling (D). Do not use Tooling (D) to hold the crankshaft during repairs.

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

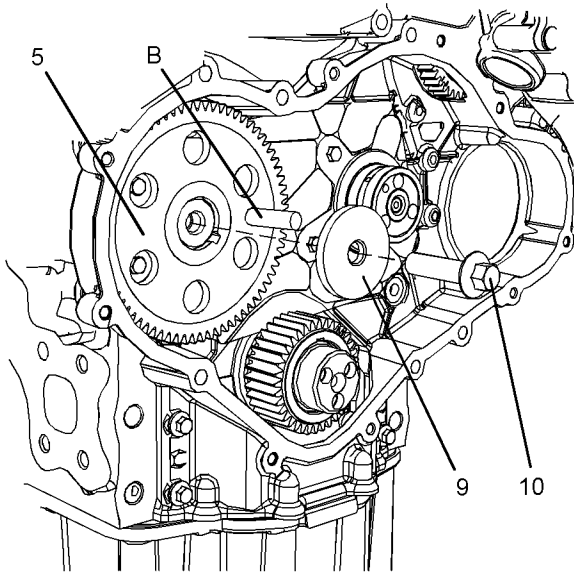


Illustration 285

g03707481

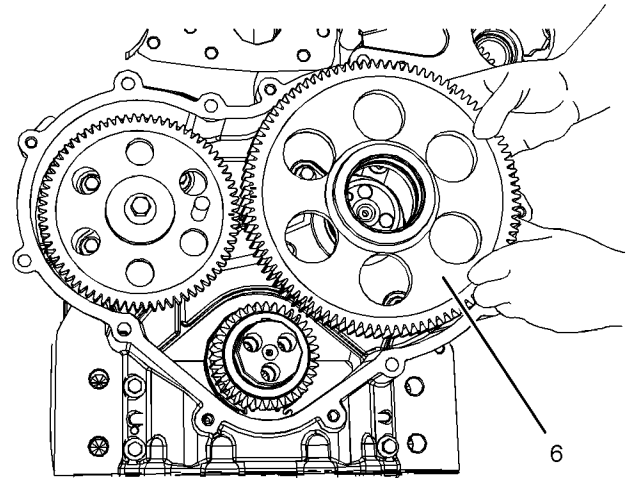


Illustration 287

g03707482

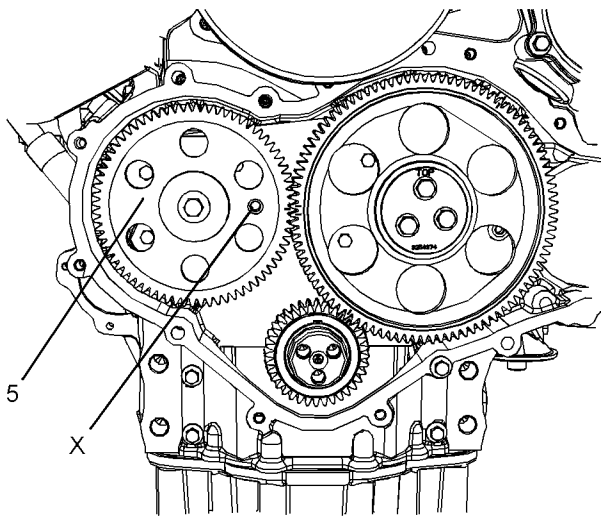


Illustration 286

g03707479

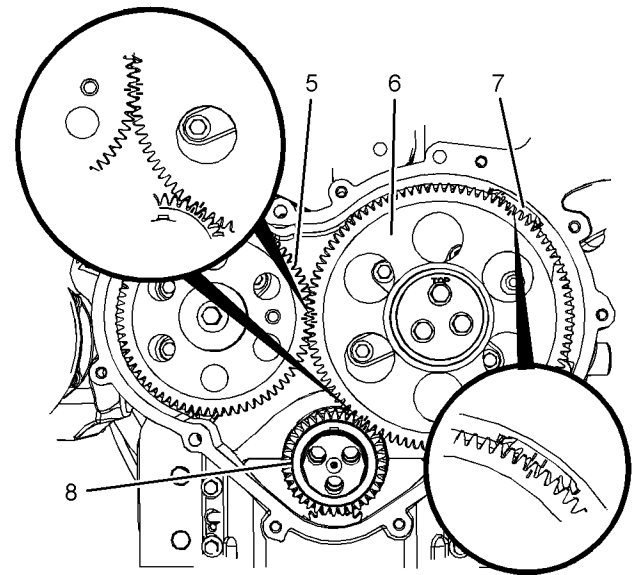


Illustration 288

g03707480

4. Install camshaft gear (5). Loosely install bolt (10) and washer (9) for the camshaft gear. Refer to Disassembly and Assembly, "Camshaft Gear - Remove and Install" for more information.
5. Install Tooling (B) through Hole (X) in camshaft gear (5) into the front housing.

Alignment of timing marks

6. Install idler gear (6). Ensure that the timing marks on gear (5), gear (6), gear (7) and gear (8) are in alignment and that the mesh of the gears is correct. Refer to Disassembly and Assembly, "Idler Gear - Remove and Install" for the correct procedure.
7. Use Tooling (F) in order to check the end play of the idler gear. Refer to Specifications, "Gear Group (Front)" and refer to Disassembly and Assembly, "Idler Gear - Remove and Install" for further information.

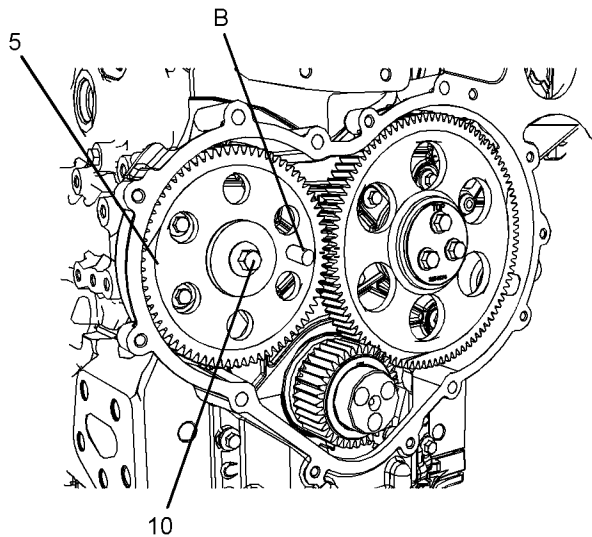


Illustration 289

g03707483

8. Ensure that the fuel injection pump is locked in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install" for the correct procedure.
9. Remove Tooling (B) and Tooling (C).
10. When bolt (10) is a 8.8 Grade. Tighten bolt (10) for camshaft gear (5) to a torque of 95 N·m (70 lb ft).
When bolt (10) is a 10.9 Grade. Tighten bolt (10) for camshaft gear (5) to a torque of 120 N·m (89 lb ft).
11. Use Tooling (F) in order to check the end play of the camshaft gear. Refer to Specifications, "Camshaft" for more information.

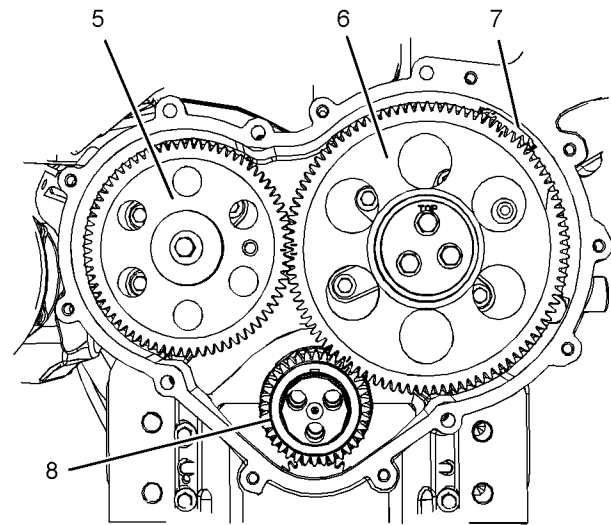


Illustration 290

g03707484

12. Use Tooling (F) in order to measure the backlash for gear (5), gear (6), gear (7) and gear (8). Refer to Specifications, "Gear Group (Front)" for further information.
13. Lubricate each gear with clean lubricating engine oil.
14. If necessary, use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure. If necessary, use Tooling (D) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.
15. Remove Tooling (D).

NOTICE

Failure to ensure that the crankshaft is positioned at the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

16. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

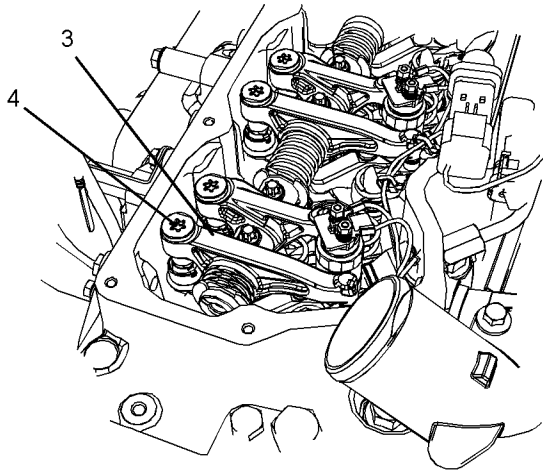


Illustration 291

g03707478

17. Use Tooling (E) in order to tighten threaded inserts (4) on all rocker arms (3). Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be correctly seated into the cup for the pushrod.

18. The engine should not be operated for a period 45 minutes after the threaded inserts on all the rocker arms have been tightened. This period of time will allow the force from the valve springs to purge off excessive engine oil from the hydraulic lifters.

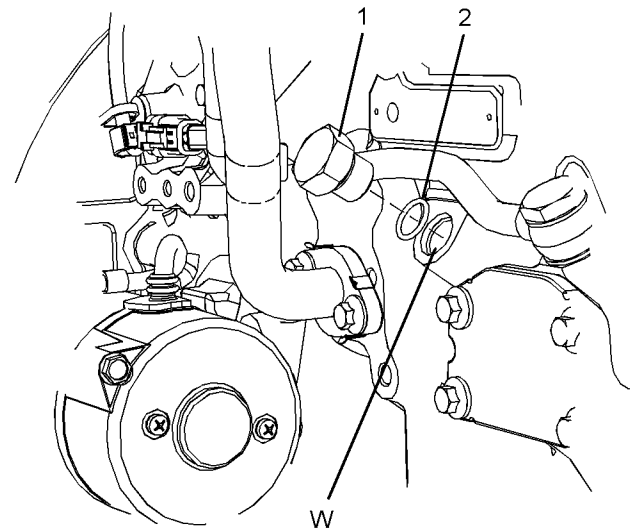


Illustration 292

g02485936

19. Install a new O-ring seal (1) to plug (2). Install the plug into Hole (W) in the cylinder block. Tighten plug (2) to a torque of 21 N·m (186 lb in).

End By:

- a. **Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.**
- b. **Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.**

i05981781

Idler Gear - Remove

Removal Procedure

Table 62

Required Tools			
Tool	Part Number	Part Description	Qty
(1)A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	T400015	Timing Pin (Fuel Injection Pump)	1
C	27610212	Timing Pin (Camshaft)	1

(continued)

Disassembly and Assembly Section

(Table 62, contd)

D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1

(1) This Tool is used in the aperture for the electric starting motor.

Start By:

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

Note: Care must be taken in order to ensure that the fuel injection pump timing is not lost during the removal of the fuel pump gear. Carefully follow the procedure in order to remove the fuel pump gear.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

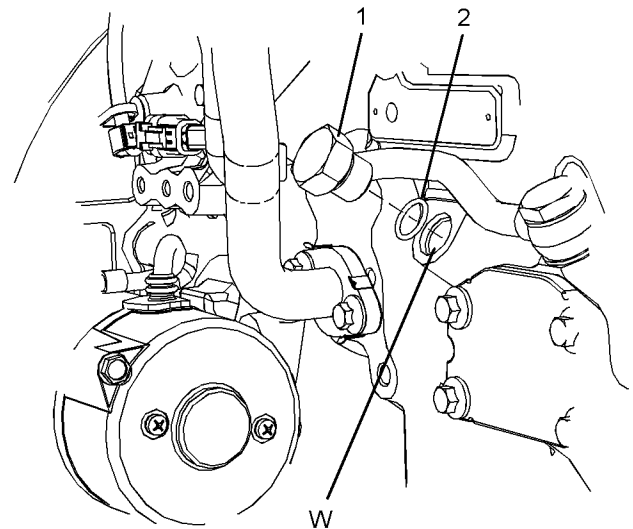


Illustration 293

g02485936

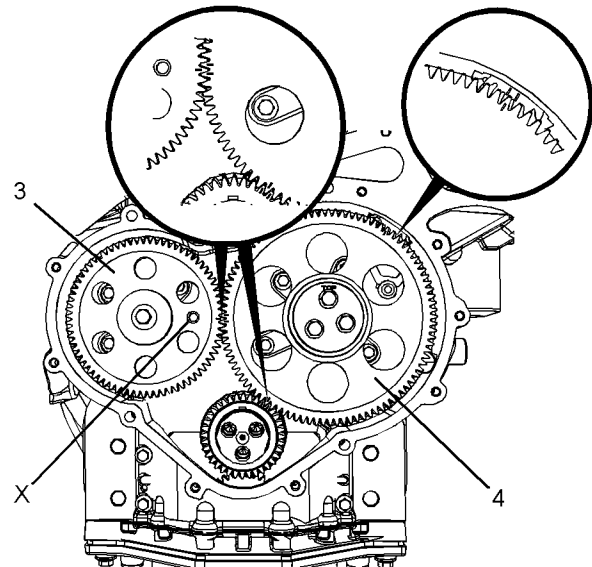


Illustration 294

g01994553

1. Remove plug (1) from the cylinder block and remove O-ring seal (2) from the plug.
2. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at top dead center on the compression stroke. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
3. Install Tooling (D) through Hole (W) in order to lock the crankshaft so that number one piston is at top dead center on the compression stroke.

4. Ensure that Tooling (C) is installed into Hole (X) in camshaft gear (3). Use Tooling (C) in order to lock the camshaft in the correct Position.

Note: Ensure that the gears are marked in order to show alignment. Refer to Illustration 294 .

5. Use Tooling (B) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

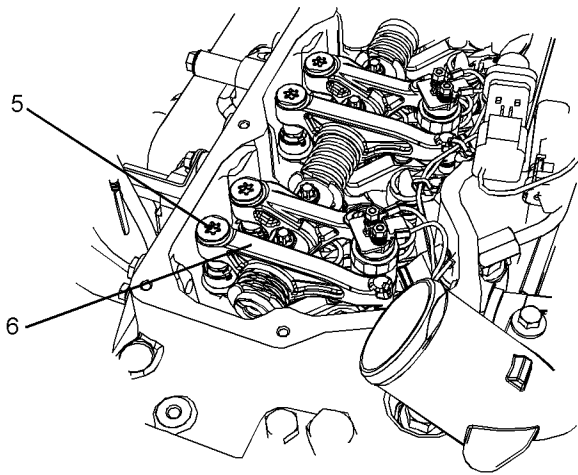


Illustration 295

g01994556

6. Use Tooling (E) in order to loosen threaded inserts (5) on all rocker arms (6). Unscrew threaded inserts (5) on all rocker arms (6) until all valves are fully closed.

Note: Failure to ensure that ALL threaded inserts are fully unscrewed can result in contact between the valves and pistons.

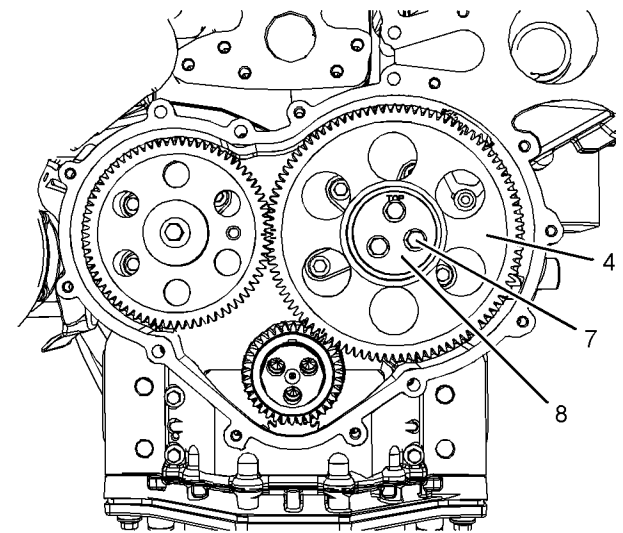


Illustration 296

g01994576

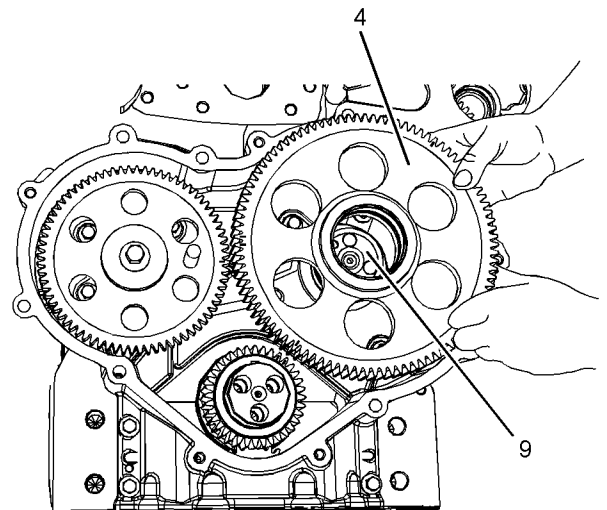


Illustration 297

g01994557

7. Mark plate (8) in order to show orientation.

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

8. Remove bolts (7).

9. Remove plate (8).

10. Remove the assembly of idler gear (4).

11. Remove hub (9) from the recess in the front housing.

i05981780

Idler Gear - Install

Installation Procedure

Table 63

Required Tools			
Tool	Part Number	Part Description	Qty
(1)A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	T400015	Timing Pin (Fuel Injection Pump)	1
C	27610212	Timing Pin (Camshaft)	1
D	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
E	27610307	T40 Torx Socket	1
F	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1

(1) This Tool is used in the aperture for the electric starting motor.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

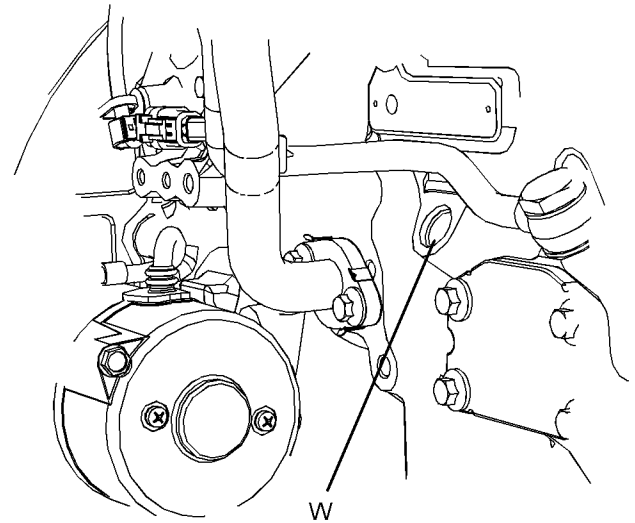


Illustration 298

g02491276

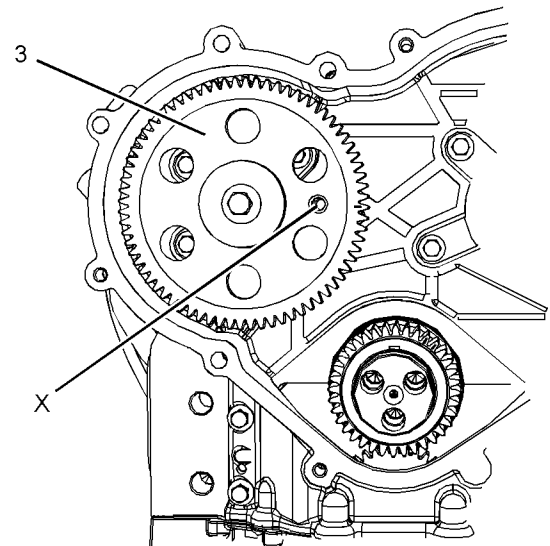


Illustration 299

g01996475

2. Ensure that Tooling (D) is installed in Hole (W) in the cylinder block. Use Tooling (D) in order to lock the crankshaft in the correct Position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
3. Ensure that Tooling (C) is installed into Hole (X) in camshaft gear (3).
4. Use Tooling (B) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

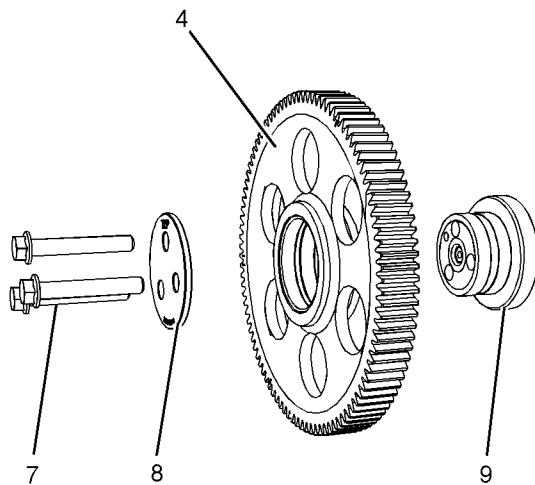


Illustration 300

g01996477

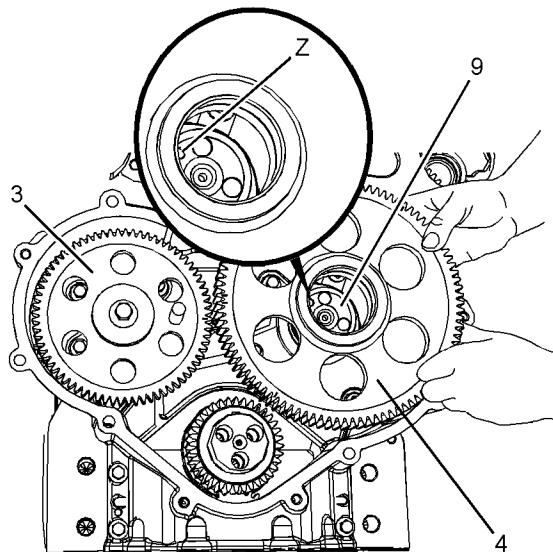


Illustration 301

g01996478

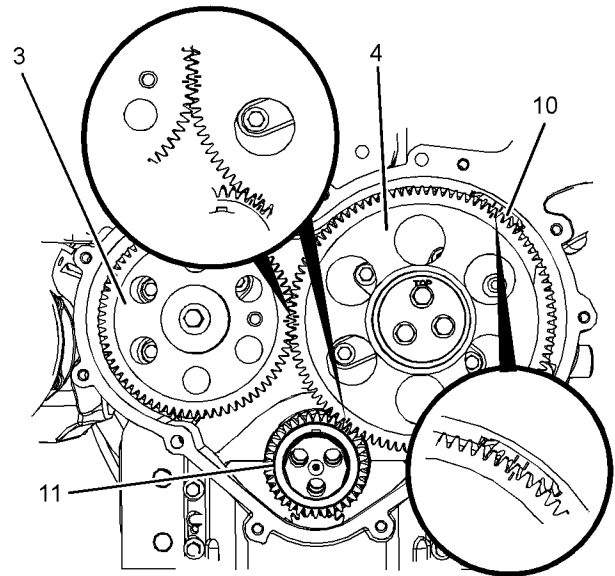


Illustration 302

g01996576

5. Clean idler gear (4) and inspect the idler gear for wear and damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the idler gear.
 6. Clean hub (9) and inspect the hub for wear and damage. Refer to Specifications, "Gear Group (Front)" for more information. If necessary, replace the hub.
 7. Lubricate hub (9) with clean engine oil. Install hub (9) into the recess in the front housing. Ensure that oil Hole (Z) is to the top of the hub.
 8. Install idler gear (4) onto hub (9). Ensure that the timing marks are toward the front of the idler gear.
 9. Align the timing mark on idler gear (4) with the timing mark on camshaft gear (3), fuel injection pump gear (10) and crankshaft gear (11). Refer to the Illustration 302 . Install the assembly of idler gear (4) to hub (9).
 10. Clean plate (8) and inspect the plate for wear and damage. If necessary, replace the plate.
 11. Lubricate plate (8) with clean engine oil. Align the holes in plate (8) with the holes in hub (9). Install the plate in the original orientation.
- Note:** Ensure that the identification mark TOP is upward.
12. Install bolts (7). Tighten the bolts to a torque of 44 N·m (32 lb ft).
 13. Remove Tooling (B), Tooling (C), and Tooling (D).

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

14. Use Tooling (F) in order to check the end play for the idler gear. Refer to Specifications, "Gear Group (Front)" for more information.
15. Use Tooling (F) in order to check the backlash between the idler gear and the camshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
16. Use Tooling (F) in order to check the backlash between the idler gear and the crankshaft gear. Refer to Specifications, "Gear Group (Front)" for more information.
17. Use Tooling (F) in order to check the backlash between the idler gear and the fuel injection pump gear. Refer to Specifications, "Gear Group (Front)" for more information.
18. Lightly lubricate all of the gears with clean engine oil.

NOTICE

Failure to ensure that the crankshaft is set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

19. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

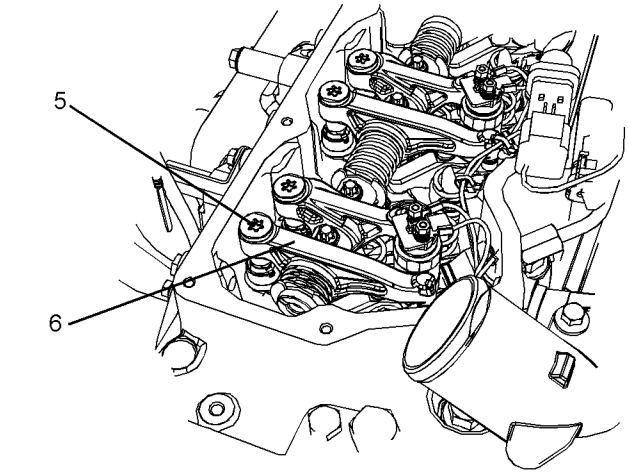


Illustration 303

g01994556

20. Ensure that the guides for the pushrods are correctly positioned on the threaded inserts (5). Use Tooling (E) in order to tighten threaded inserts (5) on all rocker arms (6). Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly into the cup for the pushrod.

21. The engine should not be operated for a period 45 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force of the valve springs to purge off excessive engine oil from the hydraulic lifters.

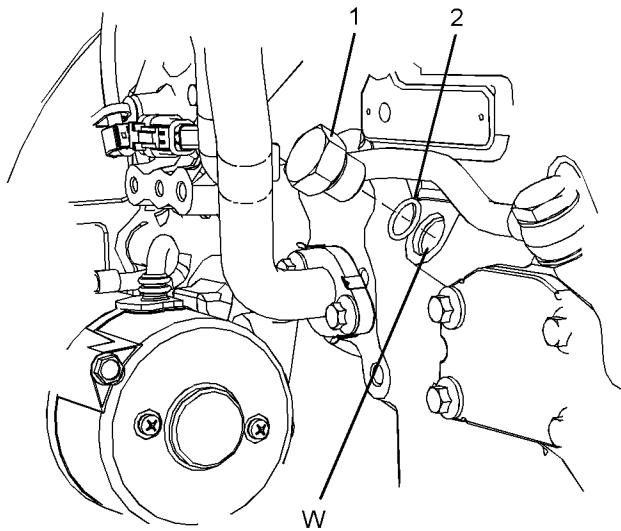


Illustration 304

g02485936

- 22.** Position a new O-ring seal (2) onto plug (1). Install the plug to the cylinder block and tighten the plug to a torque of 21 N·m (186 lb in).

End By:

- a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i05981774

Housing (Front - Remove (Heavy Duty Housing (Front))

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.
- b. Remove the crankshaft pulley. Refer to Disassembly and Assembly, “Crankshaft Pulley - Remove” for the correct procedure.
- c. Remove the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove” for the correct procedure.
- d. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, “Accessory Drive - Remove and Install” for the correct procedure.
- e. Remove the water pump. Refer to Disassembly and Assembly, “Water Pump - Remove” for the correct procedure.
- f. Remove the timing gears. Refer to Disassembly and Assembly, “Gear Group (Front) - Remove and Install” for the correct procedure.
- g. Remove the fuel injection pump. Refer to Disassembly and Assembly, “Fuel Injection Pump - Remove” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

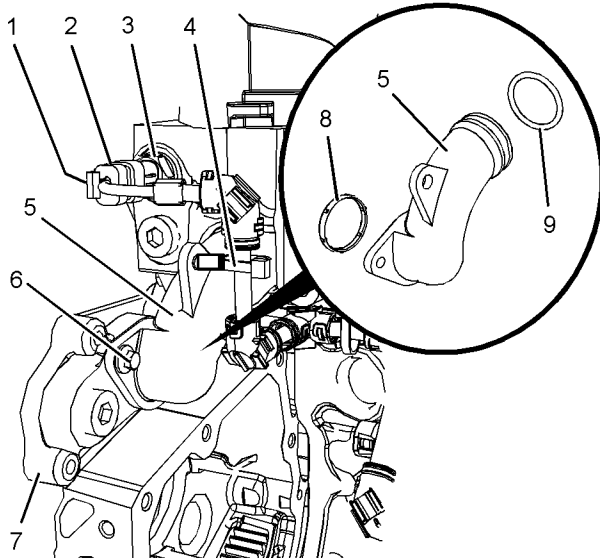


Illustration 305

g02490356

1. Slide locking tab (1) (not shown) into the unlocked position.
2. Disconnect harness assembly (2) from coolant temperature sensor (3).
3. Cut cable strap (4) and remove harness assembly (2) from bypass tube (5).
4. Remove bolts (6) that secure bypass tube (5) to front housing (7).
5. Remove bypass tube (5) from the cylinder head. Remove O-ring seal (8) and O-ring seal (9) from bypass tube (5).

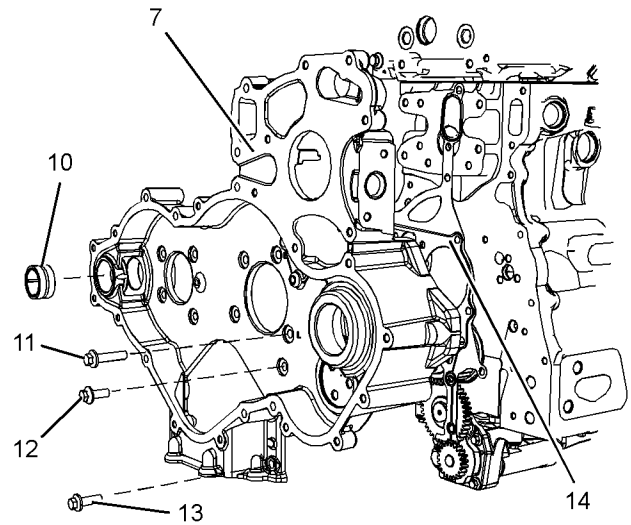


Illustration 306

g02490357

6. Remove bolts (11), bolts (12) and bolts (13) from front housing (7).

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

7. Remove front housing (7) from the cylinder block.
8. Remove gasket (14).
9. If necessary, follow Step 9a through Step 9b in order to remove bearing (10) from housing (7).
 - a. Place housing (7) onto a suitable support.
 - b. Use a suitable tool in order to press bearing (10) out of housing (7).

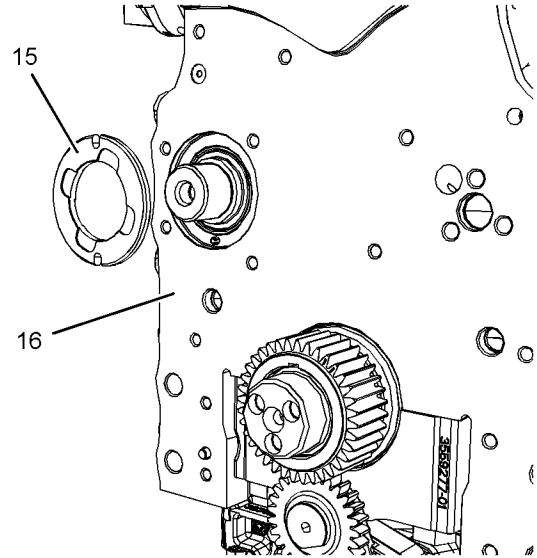


Illustration 307

g02490358

10. Remove thrust washer (15) from cylinder block (16).

i05981778

Housing (Front) - Remove

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.
- b. Remove the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Remove and Install" for the correct procedure.
- c. Remove the engine oil pan. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove" for the correct procedure.
- d. If the engine has an accessory drive, remove the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install" for the correct procedure.
- e. Remove the water pump. Refer to Disassembly and Assembly, "Water Pump - Remove" for the correct procedure.
- f. Remove the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Remove and Install" for the correct procedure.
- g. Remove the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection

Pump - Remove” for the correct procedure.**NOTICE**

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

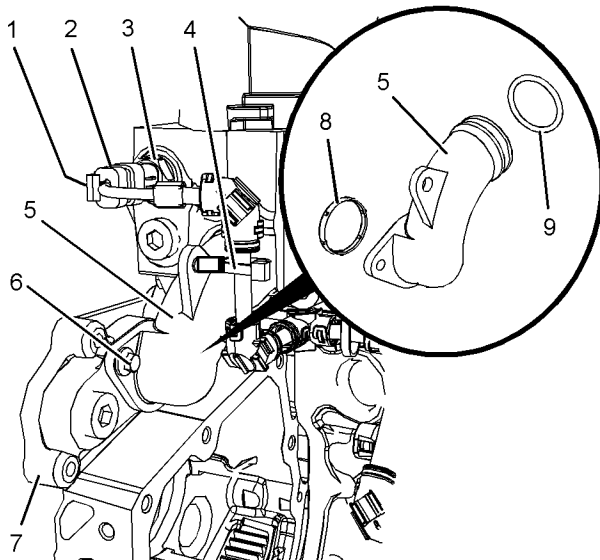


Illustration 308

g02488340

1. Slide locking tab (1) (not shown) into the unlocked position.
2. Disconnect harness assembly (2) from coolant temperature sensor (3).
3. Cut cable strap (4) and remove harness assembly (2) from bypass tube (5).
4. Remove bolts (6) that secure bypass tube (5) to front housing (7).
5. Remove bypass tube (5) from the cylinder head. Remove O-ring seal (8) and O-ring seal (9) from bypass tube (5).

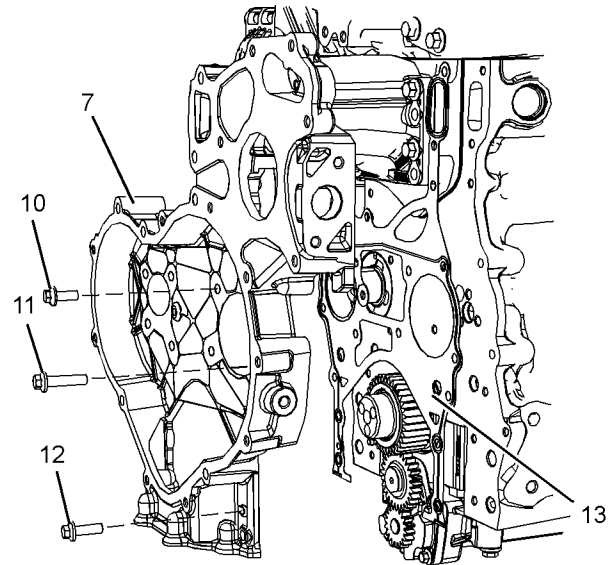


Illustration 309

g02488341

6. Remove bolts (10), bolts (11) and bolts (12) from front housing (7).

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

7. Remove front housing (7) from the cylinder block.
8. Remove gasket (13).

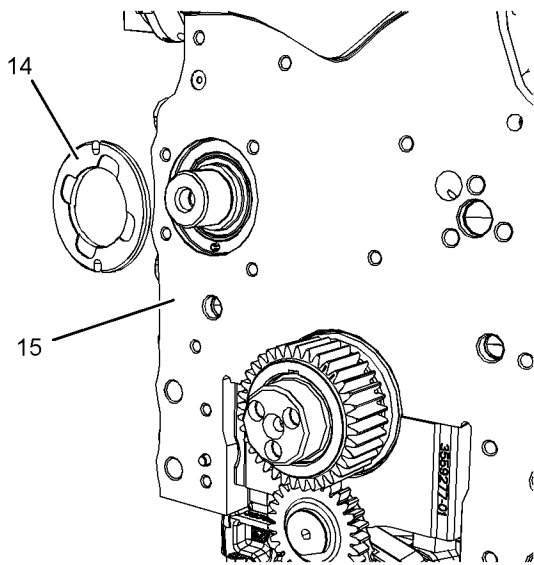


Illustration 310

g02488356

9. Remove thrust washer (14) from cylinder block (15).

i05981771

Housing (Front - Install) (Heavy Duty Housing (Front))

Installation Procedure

Table 64

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Loctite 575 Sealant	1
B	-	Guide Studs M8 by 80 mm	2
C	27610216	Alignment Tool	1
	-	Bolts M10 by 50 mm	3
D	-	Delphi Lockheed Rubber Grease	1
E	-	Loctite 609 Bearing Mount Compound	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

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

If necessary, install blanking plugs to a new front housing. Use Tooling (A) in order to seal all D-plugs.

2. Clean all the gasket surfaces of the cylinder block.

Disassembly and Assembly Section

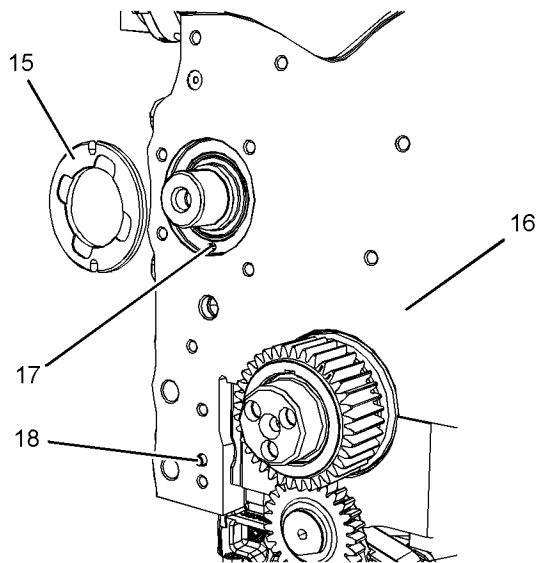


Illustration 311

g02490396

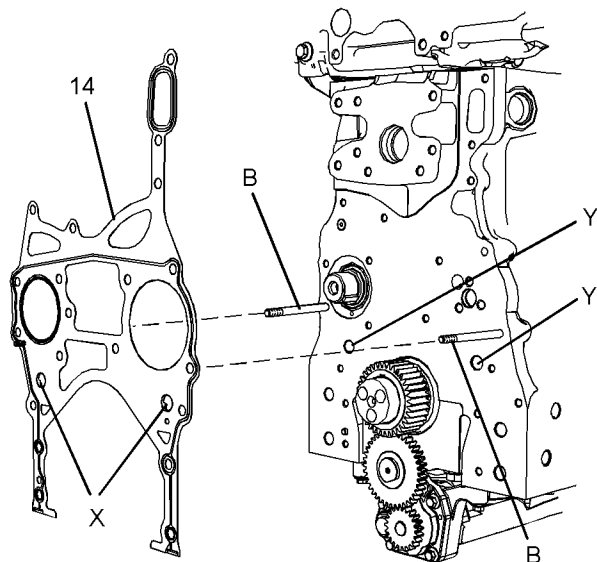


Illustration 312

g02490397

3. Inspect dowel (17) and dowel (18) for damage. If necessary, replace the dowels in the cylinder block.
4. Install thrust washer (15) into the recess in cylinder block (16). Refer to Disassembly and Assembly, "Camshaft - Install" for more information.
5. Install Tooling (B) to cylinder block (16). Refer to Illustration 312 .
6. Align a new gasket (10) with Tooling (B). Install the gasket to (16) cylinder block.

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in cylinder block (16). Ensure that dowel (18) in cylinder block (16) is engaged on the gasket.

7. Install Tooling (C) to cylinder block (16).

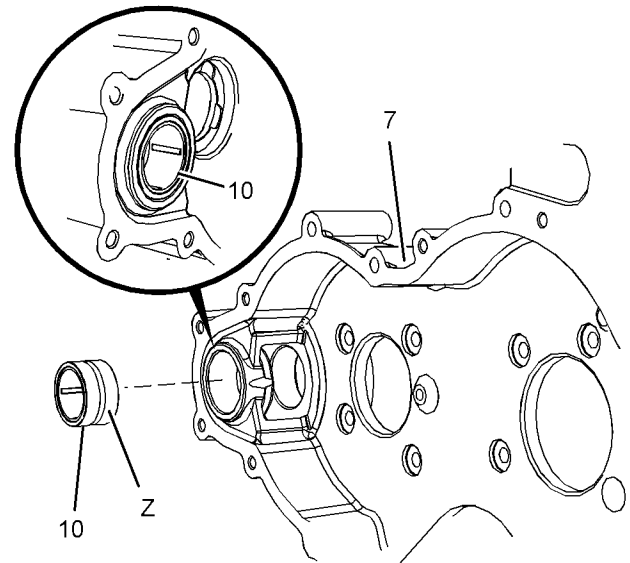


Illustration 313

g02490399

8. If necessary, follow Step 8a through Step 8c in order to install bearing (10) to housing (7).
 - a. Apply a small continuous bead of Tooling (E) to outer Surface (Z) of bearing (10).
 - b. Place housing (7) onto a suitable support.
 - c. Use a suitable tool in order to press bearing (10) into housing (7) until the bearing is in the correct position within the housing. Remove any excess bearing mount compound.
9. Install the front housing over Tooling (B) and Tooling (C) onto cylinder block (16).

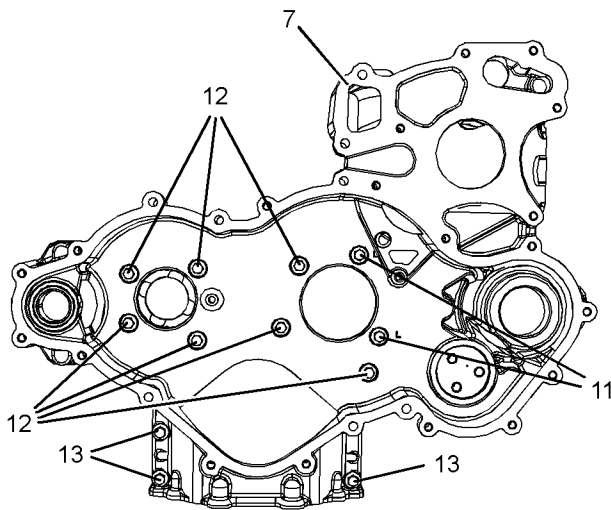


Illustration 314

g02490400

- (11) M8 by 35 mm
- (12) M8 by 20 mm
- (13) M8 by 25 mm

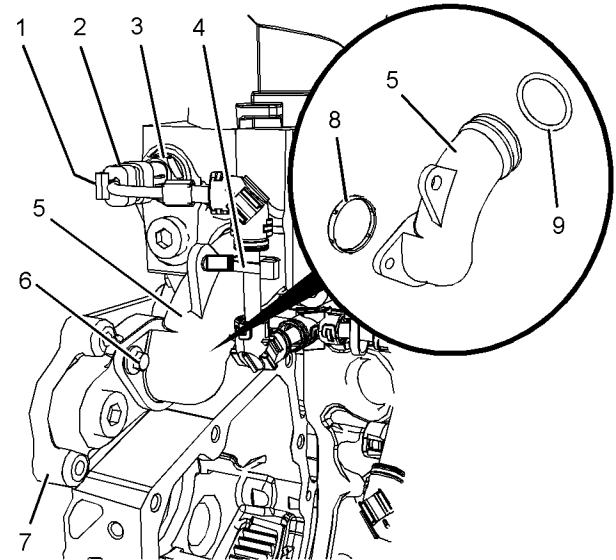


Illustration 316

g02490356

- 15.** Install a new O-ring seal (8) and a new O-ring seal (9) to bypass tube (5). Use Tooling (D) in order to lubricate the O-ring seals.
- 16.** Install bypass tube (5) to the cylinder head. Install bolts (6). Tighten the bolts to a torque of 9 N·m (80 lb in).
- 17.** Connect harness assembly (2) to coolant temperature sensor (3).
- 18.** Slide locking tab (1) (not shown) into the locked position.
- 19.** Position harness assembly (2) onto bypass tube (5). Install a new cable strap (4).

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

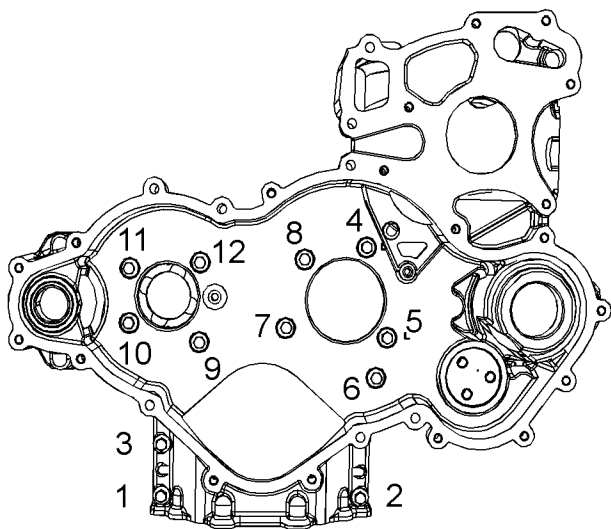


Illustration 315

g02058297

- 10.** Install bolts (13) to front housing (7) finger tight.
- 11.** Remove Tooling (B).
- 12.** Loosely install bolts (11) and bolts (12). Refer to Illustration 314 for the correct position of the bolts.
- 13.** Tighten bolts (11), bolts (12) and bolts (13) in the sequence that is shown in Illustration 315 to a torque of 28 N·m (248 lb in).
- 14.** Remove Tooling (C) from the cylinder block.

End By:

- a. Install the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install" for the correct procedure.
- b. Install the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Install" for the correct procedure.
- c. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install" for the correct procedure.
- d. Install the engine oil pan . Refer to Disassembly and Assembly, "Engine Oil Pan - Install" for the correct procedure.
- e. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Install" for the correct procedure.
- f. Install the water pump. Refer to Disassembly and Assembly, "Water Pump - Install" for the correct procedure.
- g. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.
- h. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Fill" for the correct procedure.

i05981772

Housing (Front) - Install

Installation Procedure

Table 65

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Loctite 575 Sealant	1
B	-	Guide Studs M8 by 80 mm	2
C	27610216	Alignment Tool	1
	-	Bolts M10 by 50 mm	3
D	-	Delphi Lockheed Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

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

If necessary, install blanking plugs to a new front housing. Use Tooling (A) in order to seal all D-plugs.

2. Clean all the gasket surfaces of the cylinder block.

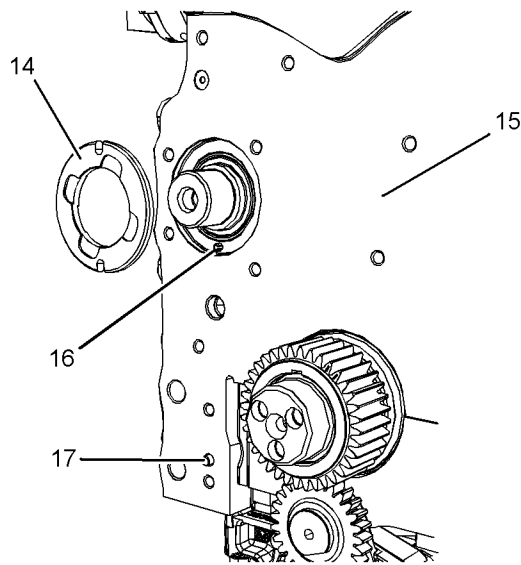


Illustration 317

g02490296

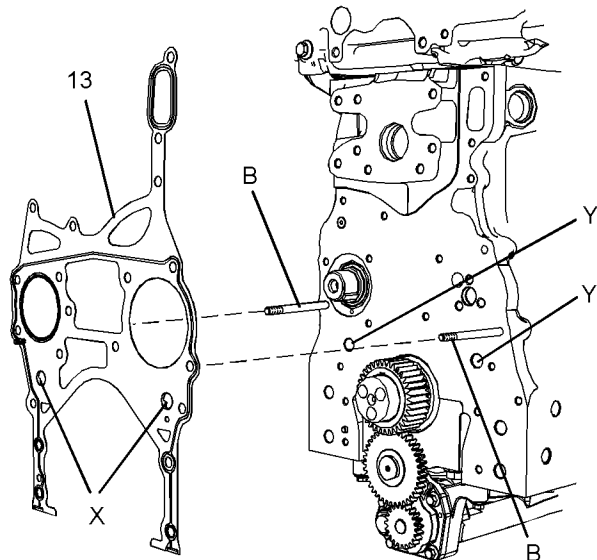


Illustration 318

g02490297

3. Inspect dowel (16) and dowel (17) for damage. If necessary, replace the dowels in cylinder block (15).
4. Install thrust washer (14) into the recess in cylinder block (15). Refer to Disassembly and Assembly, "Camshaft - Install" for more information.
5. Install Tooling (B) to cylinder block (15). Refer to Illustration 318 .
6. Align a new gasket (13) with Tooling (B). Install the gasket to cylinder block (15).

Note: Ensure that two circular Tabs (X) on the gasket are engaged in two Holes (Y) in cylinder block (15). Ensure that dowel (17) in cylinder block (15) is engaged on the gasket.

7. Install Tooling (C) to cylinder block (15).

8. Install the front housing over Tooling (B) and Tooling (C) onto cylinder block (15).

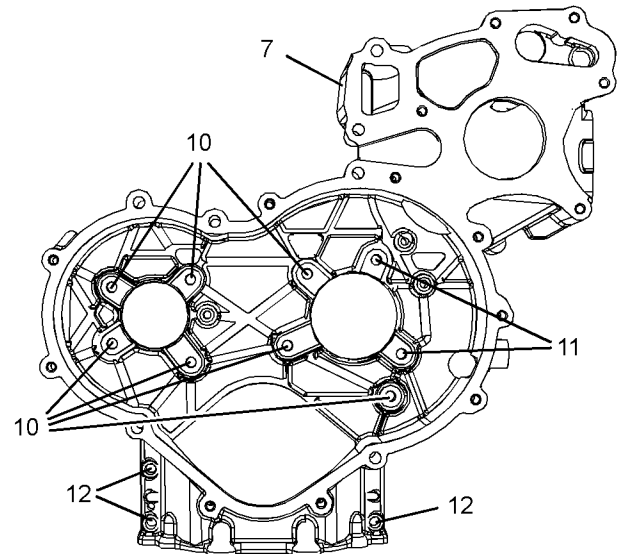


Illustration 319

g02490298

- (10) M8 by 20 mm
- (11) M8 by 35 mm
- (12) M8 by 25 mm

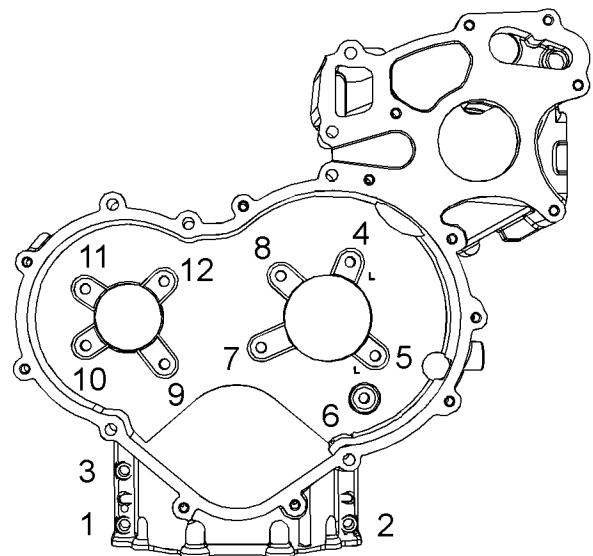


Illustration 320

g01998054

9. Install bolts (12) to front housing (7) finger tight.

10. Remove Tooling (B).
11. Loosely install bolts (10) and bolts (11). Refer to Illustration 319 for the correct position of the bolts.
12. Tighten bolts (10), bolts (11) and bolts (12) in the sequence that is shown in Illustration 320 to a torque of 28 N·m (248 lb in).
13. Remove Tooling (C) from the cylinder block.

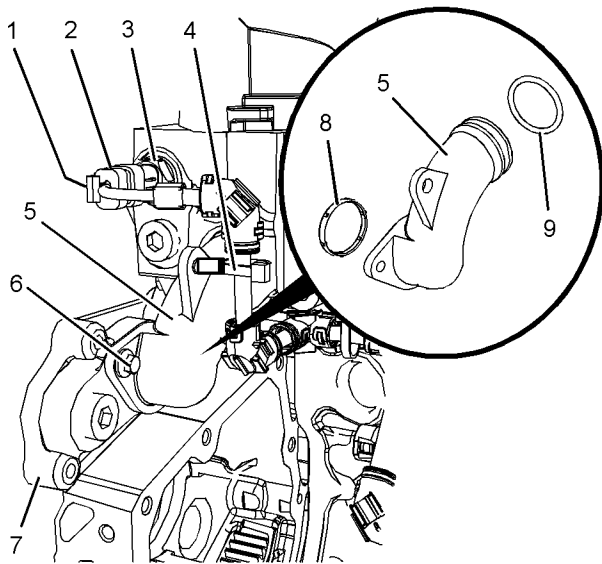


Illustration 321

g02488340

14. Install a new O-ring seal (8) and a new O-ring seal (9) to bypass tube (5). Use Tooling (D) in order to lubricate the O-ring seals.
15. Install bypass tube (5) to the cylinder head. Install bolts (6). Tighten the bolts to a torque of 9 N·m (80 lb in).
16. Connect harness assembly (2) to coolant temperature sensor (3).
17. Slide locking tab (1) (not shown) into the locked position.
18. Position harness assembly (2) onto bypass tube (5). Install a new cable strap (4).

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

End By:

- a. Install the fuel injection pump. Refer to Disassembly and Assembly, "Fuel Injection Pump - Install" for the correct procedure.
- b. Install the timing gears. Refer to Disassembly and Assembly, "Gear Group (Front) - Install" for the correct procedure.
- c. If the engine has an accessory drive, install the accessory drive. Refer to Disassembly and Assembly, "Accessory Drive - Remove and Install" for the correct procedure.
- d. Install the engine oil pan plate. Refer to Disassembly and Assembly, "Engine Oil Pan Plate - Remove" for the correct procedure.
- e. Install the crankshaft pulley. Refer to Disassembly and Assembly, "Crankshaft Pulley - Install" for the correct procedure.
- f. Install the water pump. Refer to Disassembly and Assembly, "Water Pump - Install" for the correct procedure.
- g. Install the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.
- h. Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Fill" for the correct procedure.

i05980404

Accessory Drive - Remove and Install (Accessory Drive SAE "A")

Removal Procedure

Table 66

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

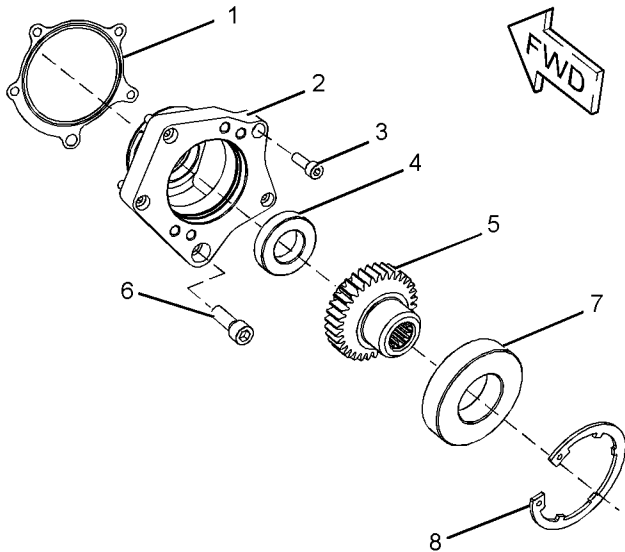


Illustration 322

g02086073

Typical example

1. Remove allen head screw (3) from accessory drive housing (2). Remove allen head screws (6) from accessory drive housing (2).
2. Remove accessory drive housing (2) from the front housing.
3. If necessary, follow Step 3a through Step 3c in order to disassemble the accessory drive.
 - a. Remove circlip (8) from accessory drive housing (2).
 - b. Place accessory drive housing (2) onto a suitable support. Press the assembly of gear (5) and bearing (7) and bearing (4) out of accessory drive housing (2). Use Tooling (A) in order to remove bearing (7) and bearing (4) from gear (5).
 - c. Remove gasket (1) from accessory drive housing (2).

Installation Procedure

Table 67

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Loctite 603 Retaining Compound	-
C	-	Loctite 242 Thread Lock Compound	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

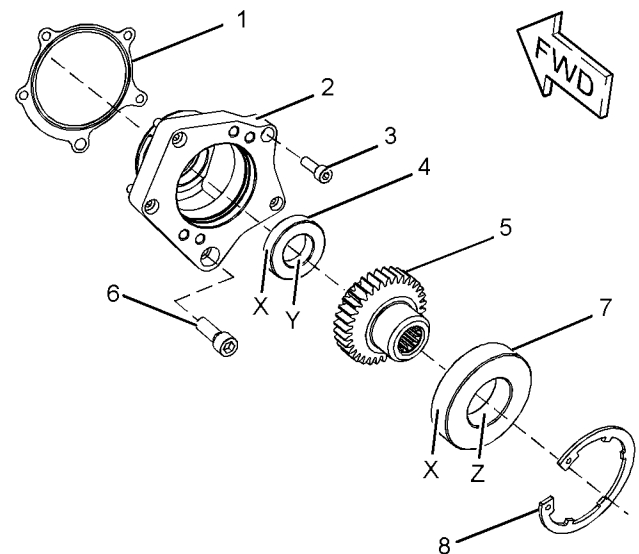


Illustration 323

g02086222

Typical example

1. If necessary, follow Step 1a through Step 1e in order to assemble the accessory drive.
 - a. Inspect the condition of the teeth and the splines of gear (5) for wear and damage. Inspect bearing (7), bearing (4), and circlip (8). Inspect the front housing for wear and damage. Replace any components that are worn or damaged.
 - b. Apply a small continuous bead of Tooling (B) to inner Surface (Y) of bearing (4). Place the gear shaft on a suitable support. Press on the inner race of bearing (4) until bearing (4) is against the shoulder of gear (5). Remove any excess compound.

- c. Apply a small continuous bead of Tooling (B) to inner Surface (Z) of bearing (7). Place the inner race of bearing (7) onto a suitable support. Press the shaft of gear (5) into bearing (7) until the shoulder of the gear is against the bearing. Remove any excess compound.
 - d. Apply a small continuous bead of Tooling (B) to the outer Surface (X) of bearing (7) and bearing (4). Place accessory drive housing (2) on a suitable support. Press the assembly of the gear into the accessory drive housing. Ensure that bearing (4) is against the front face of the recess in accessory drive housing (2). Remove any excess compound.
 - e. Install circlip (8) into the groove in accessory drive housing (2). Ensure that circlip (8) is correctly positioned in the groove.
2. Install gasket (1) to accessory drive housing (2).
 3. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install" for the correct procedure.
 4. Lightly lubricate bearing (7), bearing (4), and gear (5) with clean engine lubricating oil. Install the assembly of the accessory drive to the front housing. Ensure that the flange on the accessory drive housing is flush with the front housing.
 5. Install new M8 allen head screws (3) to accessory drive housing (2). Tighten the allen head screws to a torque of 22 N·m (195 lb in).
 6. Install a new M12 allen head screw (6) to accessory drive housing (2). Tighten the allen head screw (6) to a torque of 78 N·m (58 lb ft).

7. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.

i05980405

Accessory Drive - Remove and Install (Accessory Drive SAE "B")

Removal Procedure

Table 68

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Puller	1
	-	Crossblock	1
	-	Puller Leg	2

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. If necessary, remove the OEM driven equipment from the auxiliary drive.

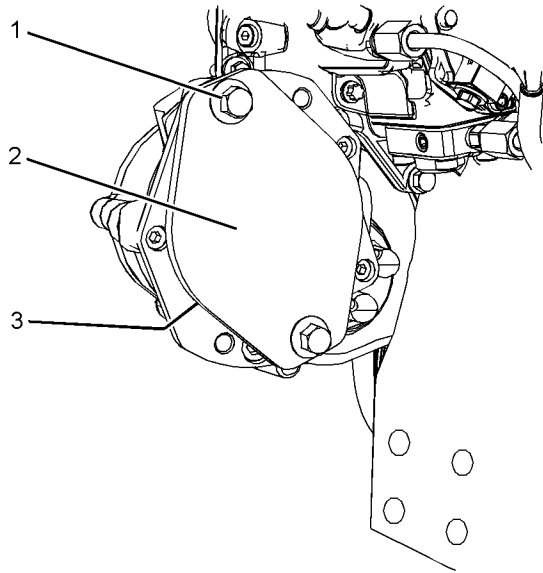


Illustration 324

g02418256

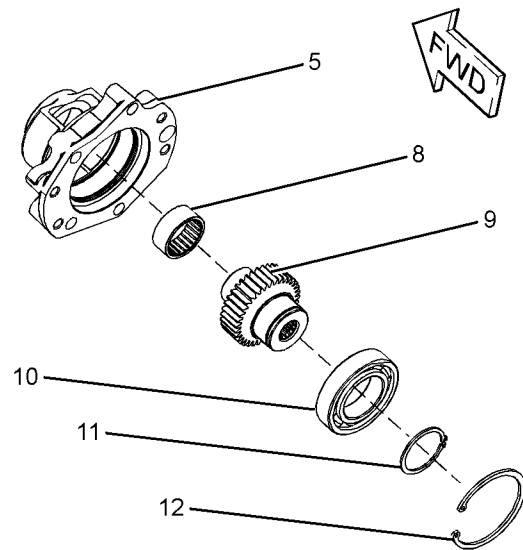


Illustration 326

g02646290

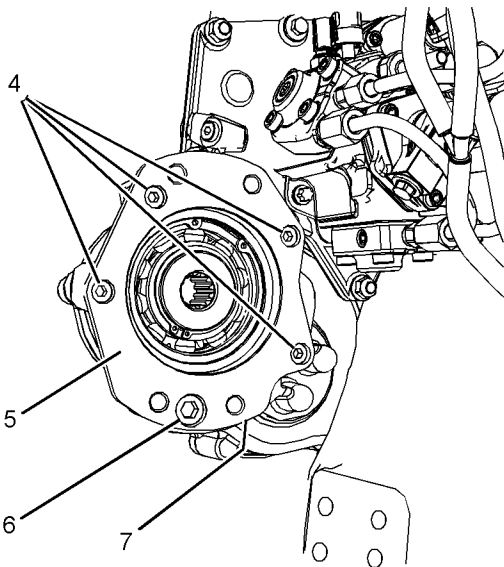


Illustration 325

g02418257

2. If OEM driven equipment has not been installed to the auxiliary drive, remove bolts (1). Remove cover plate (2) and remove gasket (3) (not shown).
3. Remove allen head screws (4) from accessory drive housing (5). Remove allen head screw (6) from accessory drive housing (5).
4. Remove accessory drive housing (5) from the front housing.
5. Remove gasket (7) from accessory drive housing (5).

6. If necessary, follow Step 6a through Step 6c in order to disassemble the accessory drive.
 - a. Remove circlip (11) and circlip (12) from accessory drive housing (5).
 - b. Place accessory drive housing (5) onto a suitable support. Press the assembly of gear (9) and bearing (10) out of accessory drive housing (5). Use Tooling (A) in order to remove bearing (10) from gear (9).
 - c. Press bearing (8) out of accessory drive housing (5).

Note: Note the position of the bearing in the accessory drive housing before removal.

Installation Procedure

Table 69

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Loctite 603 Retaining Compound	-
C	-	Loctite 242 Thread Lock Compound	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

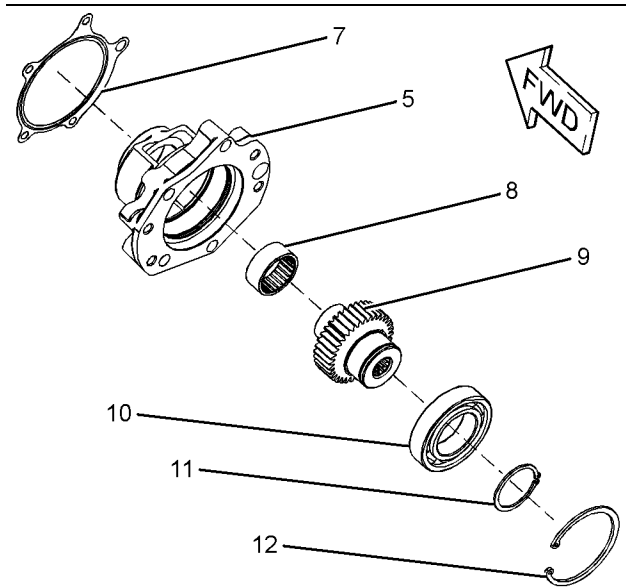


Illustration 327

g02050614

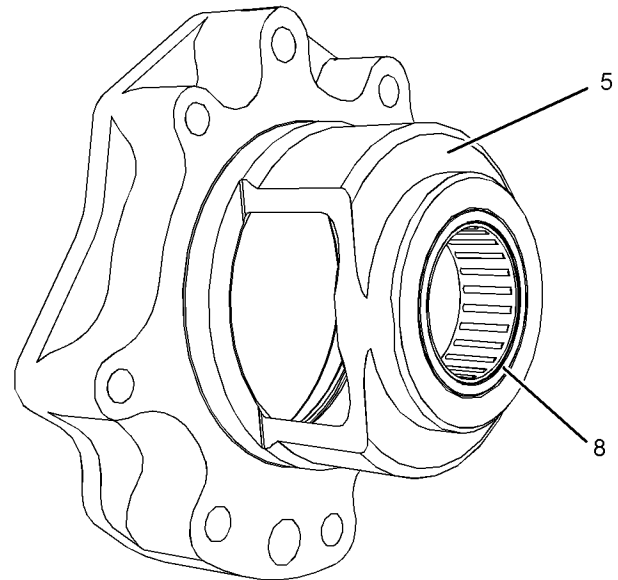


Illustration 329

g02052273

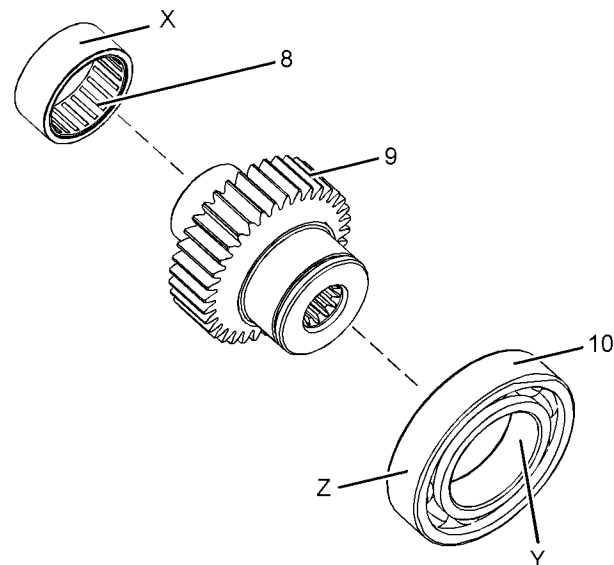


Illustration 328

g02052174

1. If necessary, follow Step 1a through Step 1f in order to assemble the accessory drive.

- a. Inspect the condition of the teeth and the splines of gear (9) for wear and damage. Inspect bearing (8), bearing (10), circlip (11) and circlip (12). Inspect the front housing for wear and damage. Replace any components that are worn or damaged.
- b. Apply a small continuous bead of Tooling (B) to outer Surface (X) of bearing (8). Place the accessory drive housing on a suitable support. Press on the outer race of bearing (8) until the bearing is in the correct position within the accessory drive housing (5). Remove any excess bearing mount compound.
- c. Apply a small continuous bead of Tooling (B) to inner Surface (Y) of bearing (10). Place the inner race of bearing (10) onto a suitable support. Press the shaft of gear (9) into bearing (10) until the shoulder of the gear is against the bearing. Remove any excess bearing mount compound.
- d. Install circlip (11) into the groove in gear (9).
- e. Apply a small continuous bead of Tooling (B) to the outer Surface (Z) of bearing (10). Place accessory drive housing (5) on a suitable support. Ensure that the shaft of gear (9) is correctly aligned with bearing (8). Press the assembly of the gear into the accessory drive housing. Remove any excess bearing mount compound.

- f. Install circlip (12) into the groove in accessory drive housing (5). Ensure that circlip (12) is correctly positioned in the groove.
2. Inspect the bore in the front housing for damage. If necessary, replace the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" and Disassembly and Assembly, "Housing (Front) - Install" for the correct procedure.
3. Lightly lubricate bearing (8), bearing (10), and gear (9) with clean engine lubricating oil.
4. Install new gasket (7) to accessory drive assembly (5). Install the assembly of the accessory drive to the front housing.

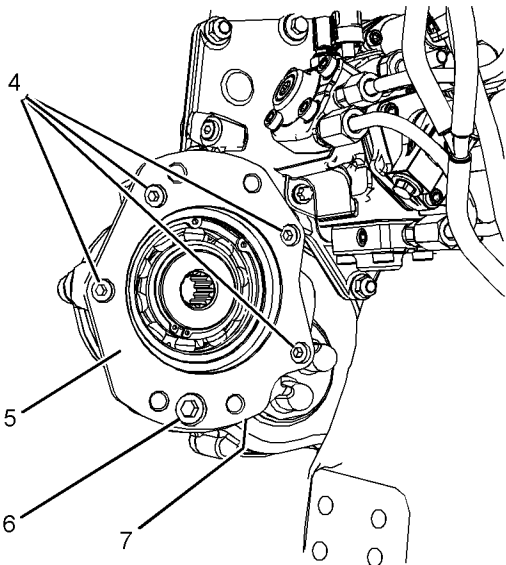


Illustration 330

g02418257

5. Apply Tooling (C) to allen head screws (4) and allen head screw (6). Install allen head screws (4) and allen head screw (6) to accessory drive housing (5).
6. Tighten allen head screws (4) to a torque of 22 N·m (195 lb in).
7. Tighten allen head screw (6) to a torque of 78 N·m (58 lb ft).
8. Ensure that there is tactile backlash between the idler gear and the accessory drive gear.
9. If necessary, install the OEM driven equipment to the auxiliary drive.

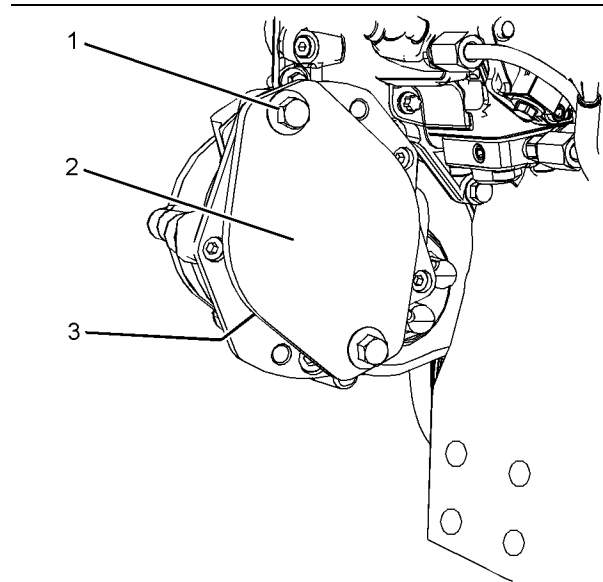


Illustration 331

g02418256

10. If OEM driven equipment is not being installed to the auxiliary drive. Install a new gasket (3) (not shown) and cover plate (2). Install bolts (1) and tighten the bolts to a torque of 44 N·m (33 lb ft).

i05980459

Crankcase Breather - Remove

Removal Procedure

NOTICE

When disconnecting and connecting the plastic tube assemblies for the crankcase breather system, the plastic tube assemblies should not be twisted. Twisting of the plastic tube assemblies will result in the seals being damaged. Damaged to seals will result in leakage.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

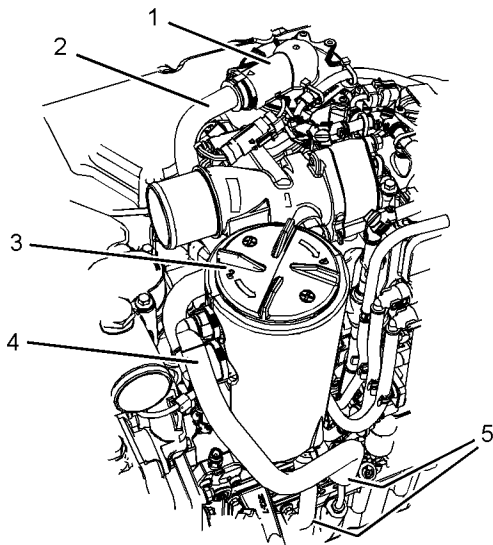


Illustration 332

g02439736

1. Disconnect plastic tube assembly (2) from breather canister (3) and breather connection (1) on the valve mechanism cover.
2. Disconnect plastic tube assembly (4) from breather canister (3).
3. Cut cable straps from clips (5) (not shown). Remove plastic tube assembly (4).

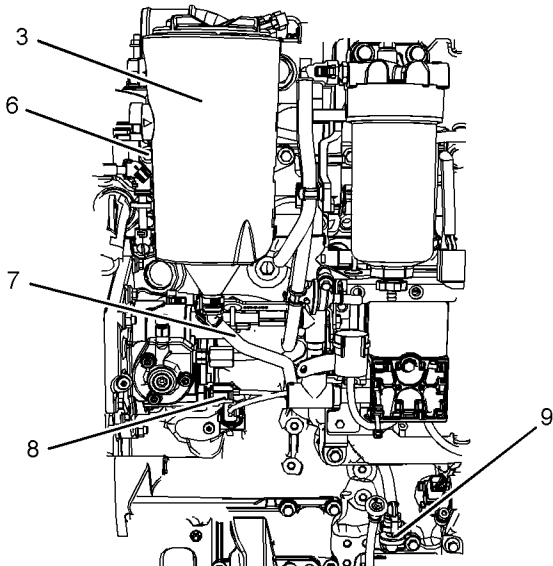


Illustration 333

g02439737

4. Disconnect harness assembly (8) from the fuel temperature sensor.
5. Remove plastic tube assembly (7) from breather canister (3) and valve (9) in the cylinder block.

6. Remove bolts (6) and remove breather canister (3) from the cylinder head.

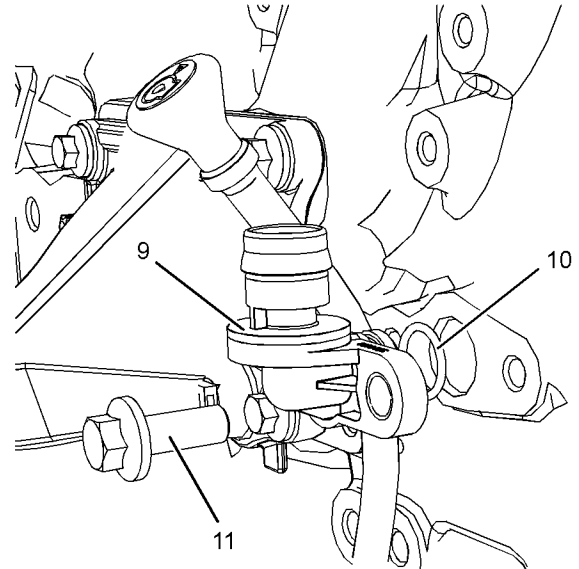


Illustration 334

g02439738

7. If necessary, follow Step 7a through Step 7b in order to remove valve (9) from the cylinder block.
 - a. Remove bolt (11) from valve (9).
 - b. Remove valve (9) from the cylinder block.
 - c. Remove O-ring seal (10) from valve (9).

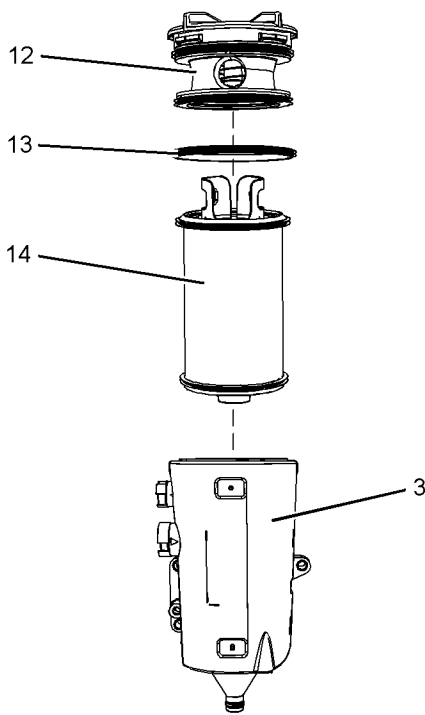


Illustration 335

g02439739

- 8.** If necessary, follow Step 8a through Step 8c in order to disassemble the breather canister.
- Remove cap (12) from breather canister (3).
 - Remove seal (13) from cap (12).
 - Remove filter element (14) from breather canister (3). Refer to Operation and Maintenance Manual, "Engine Crankcase Breather Element - Replace" for the correct procedure.

i05980456

Crankcase Breather - Install

Installation Procedure

NOTICE

When disconnecting and connecting the plastic tube assemblies for the crankcase breather system, the plastic tube assemblies should not be twisted. Twisting of the plastic tube assemblies will result in the seals being damaged. Damaged seals will result in leakage.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

- Ensure that all components of the crankcase breather are clean and free from damage. Replace any components that are damaged.

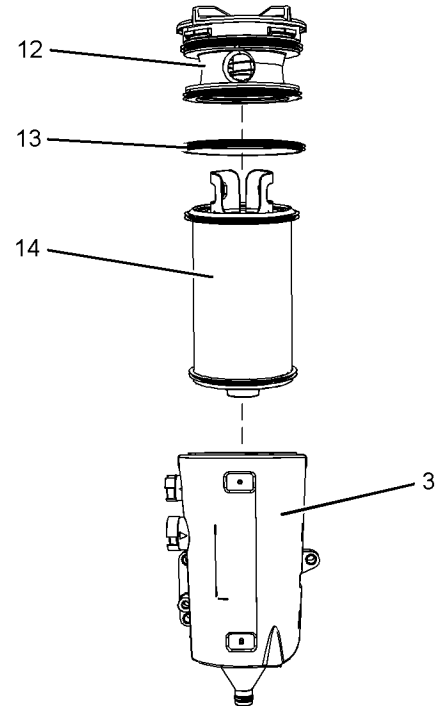


Illustration 336

g02439739

- If necessary, follow Step 2a through Step 2c in order to assemble the breather canister.
 - Install a new seal (13) to top cap (12).
 - Install a new filter element (14) to breather canister (3). Refer to Operation and Maintenance Manual, "Engine Crankcase Breather Element - Replace" for the correct procedure.
 - Install top cap (12) onto breather canister (3).

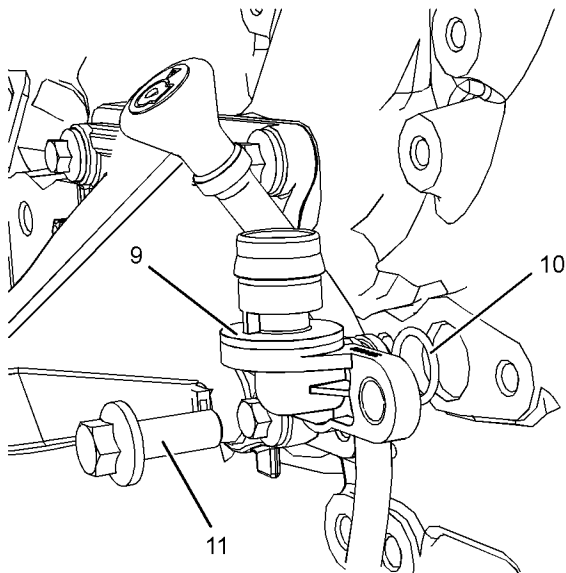


Illustration 337

g02439738

3. If necessary, follow Step 3a through Step 3c in order to install valve (9) to the cylinder block.

- a. Install a new O-ring seal (10) to valve (9).

Note: Do not lubricate the O-ring seal.

- b. Install valve (9) into the cylinder block. Install bolt (11).

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

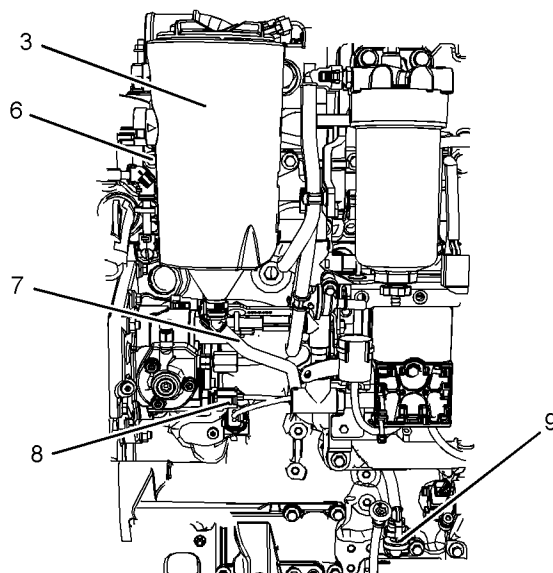


Illustration 338

g02439737

4. Position breather canister (3) onto the cylinder head and install bolts (6). Tighten the bolts to a torque of 22 N·m (195 lb in).

5. Connect plastic tube assembly (7) to breather canister (3) and valve (9) in the cylinder block.

6. Connect harness assembly (8) to the fuel temperature sensor.

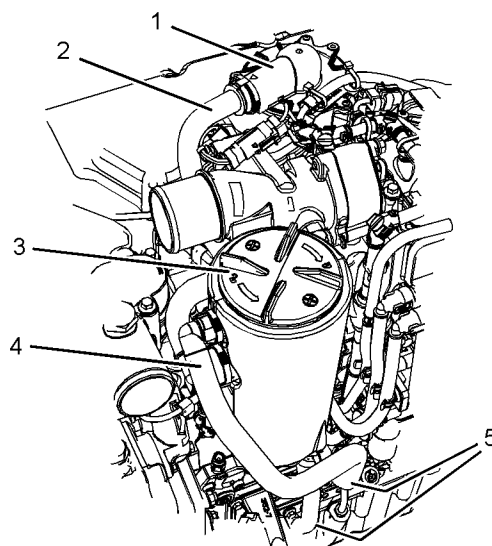


Illustration 339

g02439736

7. Connect plastic tube assembly (2) from breather canister (3) and breather connection (1) on the valve mechanism cover.

8. Connect plastic tube assembly (4) to breather canister (3).
9. Install new cable straps to clips (5) (not shown). Position plastic tube assembly (4) onto clips (5) (not shown). Install cable straps to the plastic tube assembly.

i06991676

Valve Mechanism Cover - Remove and Install

Removal Procedure

Start By:

- a. If the Clean Emission Module (CEM) is mounted on the valve mechanism cover. Removal of the CEM will be necessary to access the valve mechanism cover. Refer to Disassembly and Assembly, "Support and Mounting (CEM) - Remove and Install" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

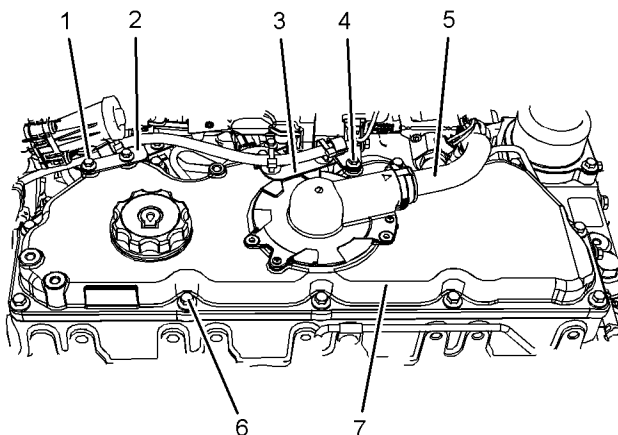


Illustration 340

g02522396

1. Remove bolts (1) and bolts (4) from bracket (2) and bracket (3). Position brackets and harness assembly away from valve mechanism cover (7).

2. Disconnect the plastic tube assembly (5) from the valve mechanism cover for the crankcase breather. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.
3. Remove bolts (6) from valve mechanism cover (7).
4. Remove valve mechanism cover (7) from the cylinder head.

Note: Remove the valve mechanism cover vertically to avoid damage to the electronic unit injectors.

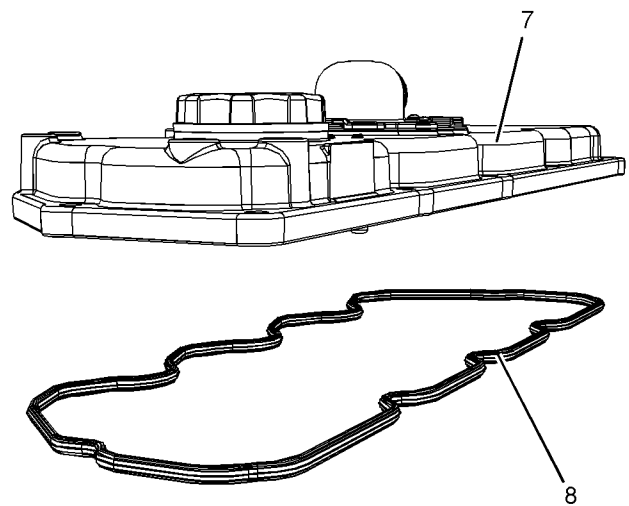


Illustration 341

g02522397

5. Remove seal (8) from valve mechanism cover (7).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

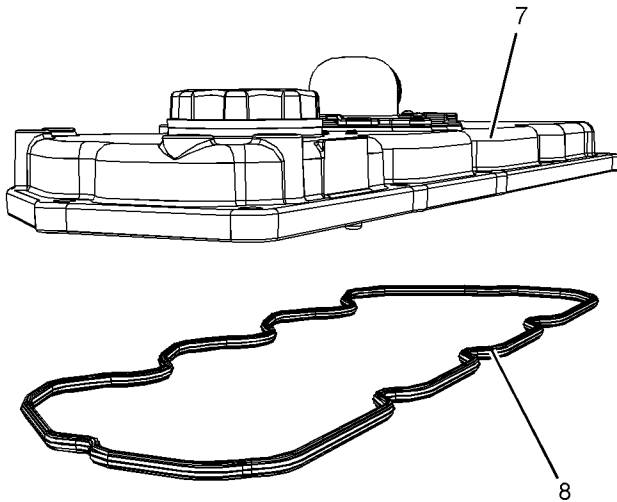


Illustration 342

g02522397

1. Thoroughly clean the seal recess in valve mechanism cover (7). Clean the sealing surfaces of the cylinder head.
2. Install new seal (8) to valve mechanism cover (7).

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

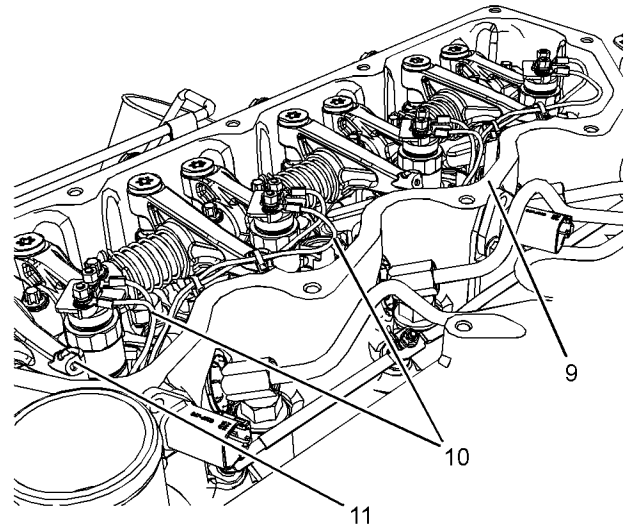


Illustration 343

g02522398

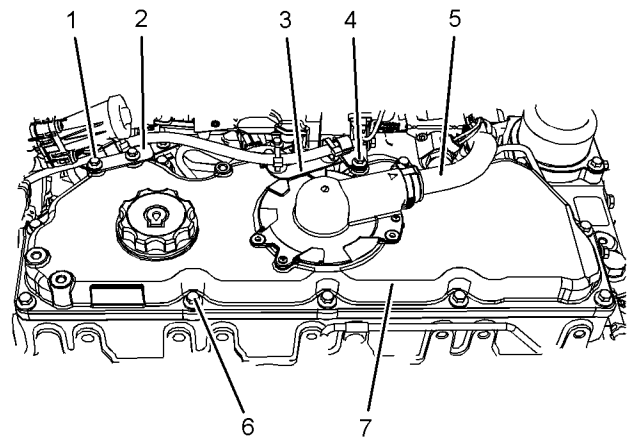


Illustration 344

g02522396

3. Ensure that harness assemblies (10) are not in contact with rocker arms (11) or cylinder head (9).

Note: Install the valve mechanism cover vertically to avoid damage to the electronic unit injectors.

4. Position valve mechanism cover (7) onto cylinder head (9). Ensure that harness assemblies (10) are not trapped during the assembly procedure.
5. Install bolts (6).

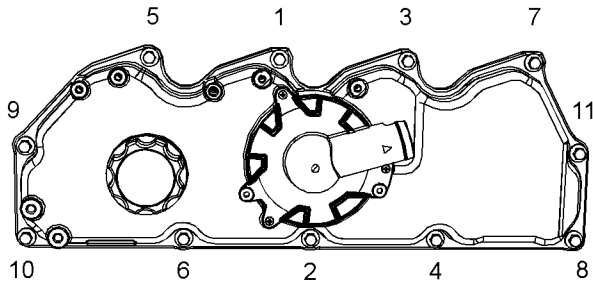


Illustration 345

g02522516

6. Tighten the bolts in the numerical sequence that is shown in Illustration 345 . Tighten the bolts to a torque of 22 N·m (195 lb in).

Repeat Step 6 to ensure correct torque.

7. Position brackets and harness assembly onto the valve mechanism cover. Install bolts (1) and bolts (4) to bracket (2) and bracket (3).

8. Tighten bolts (1) and bolts (4) 9 N·m (79 lb in).

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

End By:

a. If necessary, mount the CEM on the valve mechanism cover. Refer to Disassembly and Assembly, “Support and Mounting (CEM) - Remove and Install” for the correct procedure.

i05981813

Rocker Shaft and Pushrod - Remove

Removal Procedure

Table 70

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

(continued)

(Table 70, contd)

B	-	T40 Torx Socket	1
C	-	E10 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

a. Remove the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft the safe position. Refer to System Operation, Testing and Adjusting, “Position the Valve Mechanism Before Maintenance Procedures” for the correct procedure.

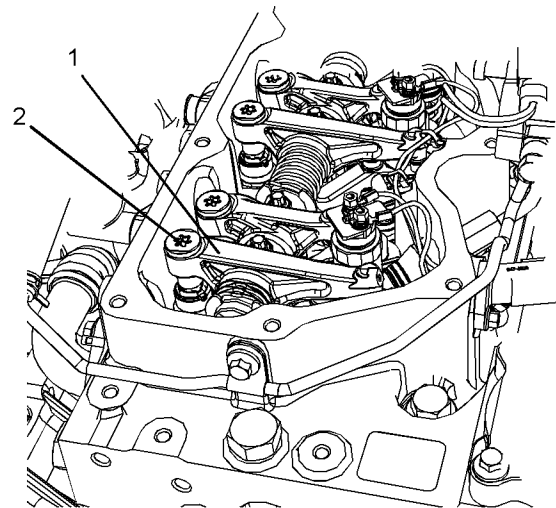


Illustration 346

g03703568

2. Use Tooling (B) in order to loosen threaded inserts (2) on all rocker arms (1). Unscrew threaded inserts (2) on all rocker arms (1) until all valves are fully closed.

Note: Ensure that ALL threaded inserts are fully unscrewed.

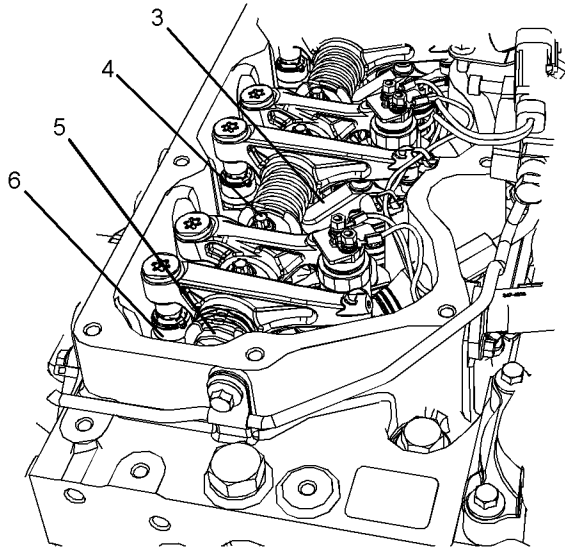


Illustration 347

g03703569

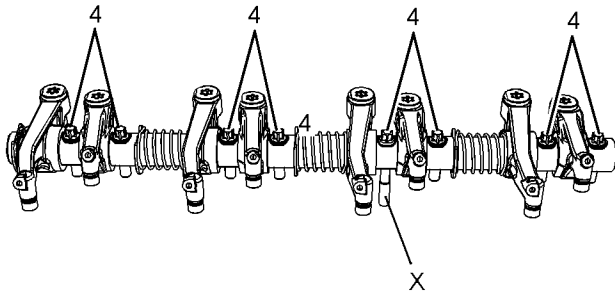


Illustration 348

g03703570

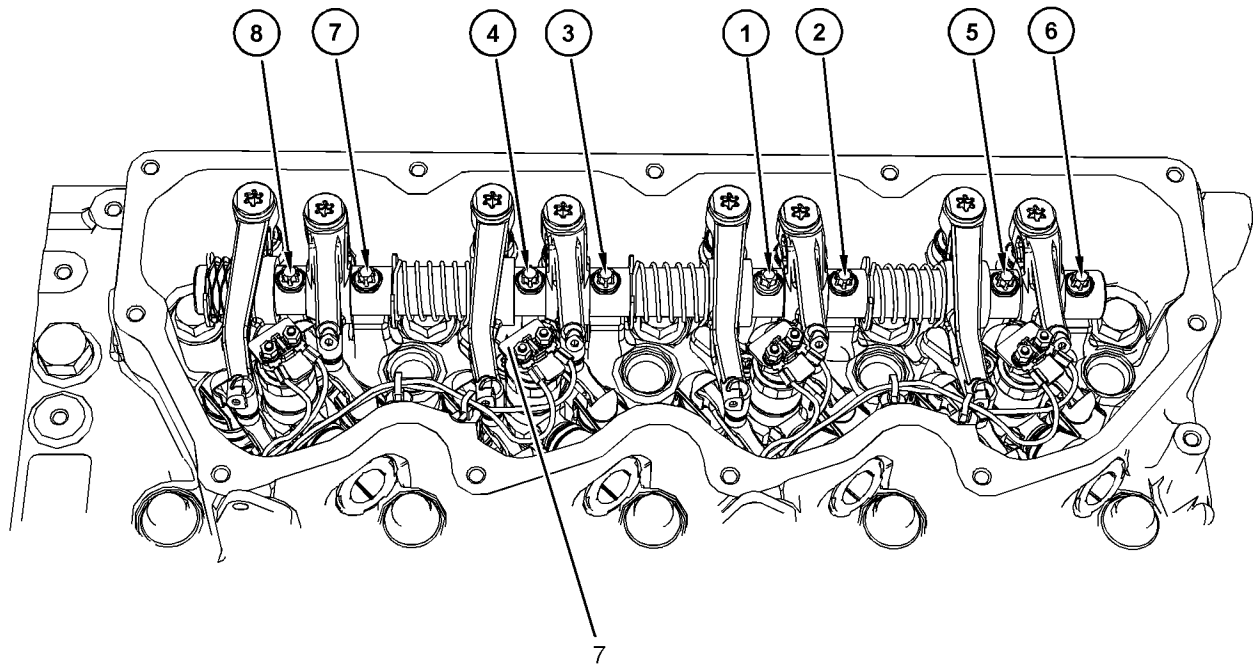


Illustration 349

g03703575

Sequence for tightening the bolts for the rocker shaft assembly

3. Use Tooling (C) to loosen Torx screws (5) in the reverse numerical order to the tightening sequence. Refer to the Illustration 349 .
4. Loosen Torx screws (4) from sufficiently in order to allow removal of rocker shaft assembly (6).

Note: Note Position (X) of different length Torx screws (4).

5. Remove rocker shaft assembly (5) from the cylinder head. Ensure that rocker shaft assembly (5) does not come into contact with the electronic unit injector identification tag (7).

6. Place an identification mark on pushrods (6) in order to show the location. Remove the pushrods from the cylinder head.

Note: Identification will ensure that the pushrods can be reinstalled in the original positions. Do not interchange the positions of used pushrods.

7. Make a temporary mark on valve bridges (3) in order to show the location and the orientation. Remove the valve bridges from the cylinder head.

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

i05981809

Rocker Shaft - Disassemble

Disassembly Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.



WARNING

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

Make sure to wear all necessary protective equipment.

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

1. Make an identification mark on each rocker arm assembly in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

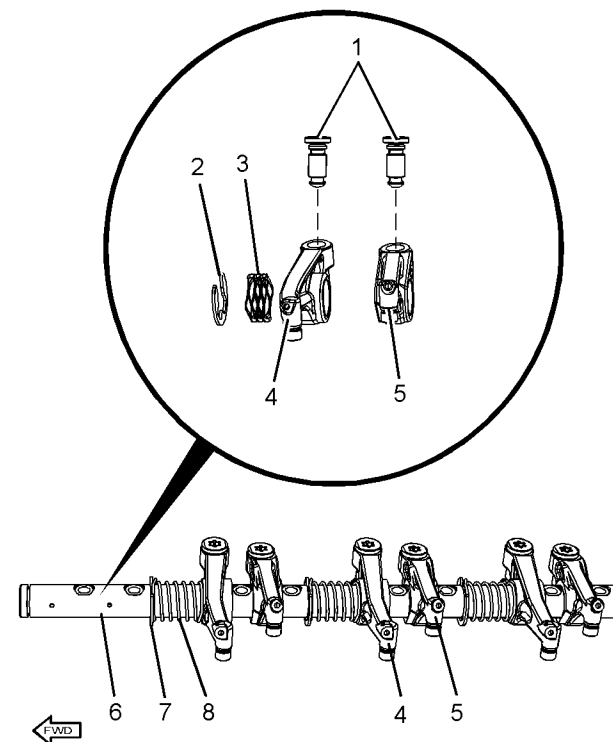


Illustration 350

g03706861

2. Remove the Torx screws from the rocker shaft assembly. Note position of different length Torx screws for assembly purposes.
 3. Remove retaining clip (2) from rocker shaft (6). Remove spring (3) from the rocker shaft.
 4. Remove rocker arm assembly (4) for the inlet valve from rocker shaft (6). Remove rocker arm assembly (5) for the exhaust valve from rocker shaft (6).
- Note:** The rocker arm assembly for the inlet valve is longer than the rocker arm assembly for the exhaust valve.
5. Remove retaining clip (7) from rocker shaft (6). Remove spring (8) from the rocker shaft.
 6. Remove rocker arm assembly (4) for the exhaust valve from rocker shaft (6). Remove rocker arm assembly (5) for the inlet valve from rocker shaft (6).
 7. Repeat Step 5 through Step 6 in order to remove the remaining rocker arms from rocker shaft (6).
 8. If necessary, follow Step 8a through Step 8b in order to remove threaded inserts (1) from the rocker arms.

- a. Make a temporary identification mark on each threaded inserts (1) in order to show the location.

Note: The components must be reinstalled in the original location. Do not interchange components.

- b. Remove threaded inserts (1) from the rocker arms.

i05981807

Rocker Shaft - Assemble

Assembly Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear and damage. Refer to Specifications, "Rocker Shaft" for more information. If necessary, replace any components that are worn or damaged.

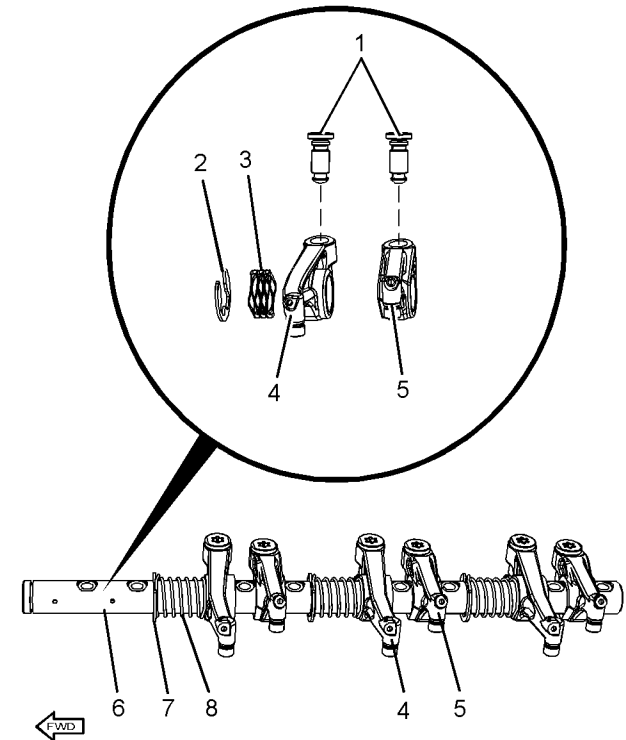


Illustration 351

g03706861

2. If necessary, loosely install threaded inserts (1) to rocker arm assembly (4) and rocker arm assembly (5).

Note: The components must be reinstalled in the original location. Do not interchange components.

3. Lubricate the bores of rocker arm assembly (4) for the inlet valve and rocker arm assembly (5) for the exhaust valve and rocker shaft (6) with clean engine oil.
4. Install retaining clip (2) and spring (3) to the front end of rocker shaft (6).
5. Install rocker arm assembly (4) for number one inlet valve to the rocker shaft. Install rocker arm assembly (5) for number one exhaust valve to rocker shaft (6).

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

⚠ WARNING

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

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

6. Install retaining clip (7) to rocker shaft (6).
7. Install spring (8) to rocker shaft (6).
8. Install rocker arm assembly (4) for number two inlet valve to the rocker shaft. Install rocker arm assembly (5) for number two exhaust valve to rocker shaft (6).

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

9. Repeat Step 6 through Step 8 in order to assemble the remaining components to rocker shaft (6).
10. Install the Torx screws to the rocker shaft assembly. Ensure that the different length Torx screws is installed into the correct position.

End By:

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

i05981811

Rocker Shaft and Pushrod - Install

Installation Procedure

Table 71

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	-	E10 Torx Socket	1
D	T400027	Rocker Arm Spacer	4

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

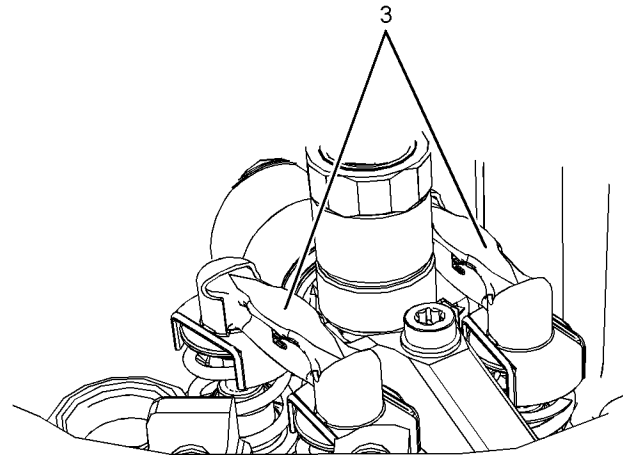


Illustration 352

g03706856

The correct location of valve bridges on valve stems is shown.

1. Clean valve bridges (3). Inspect the valve bridges for wear and damage. Replace any valve bridges that are worn or damaged.
2. Lubricate valve bridges (3) with clean engine oil.

NOTICE

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

3. Install valve bridges (3) to the valve stems.

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

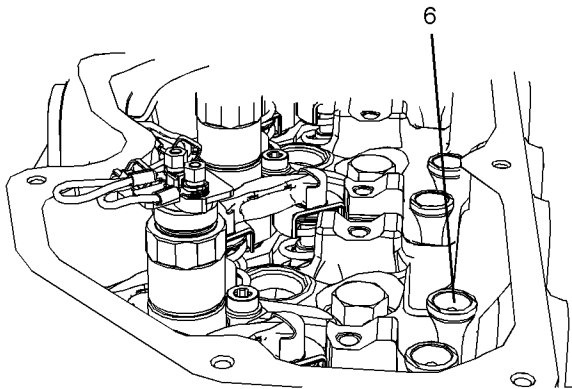


Illustration 353

g03706857

4. Clean pushrods (6). Inspect the pushrods for wear and damage. Replace any pushrods that are worn or damaged.
5. Apply clean engine oil to both ends of pushrods (6). Install the pushrods to the engine with the cup upward.

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

NOTICE

Failure to ensure that the crankshaft is set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

6. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

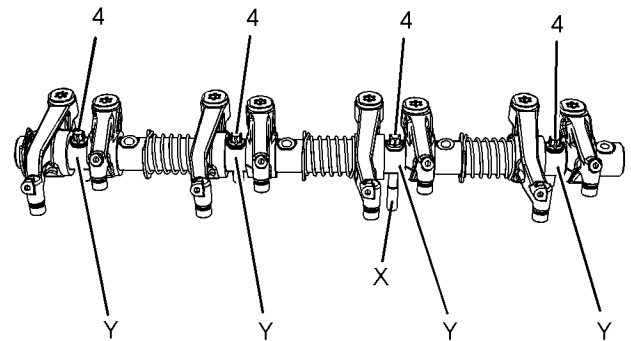


Illustration 354

g03706858

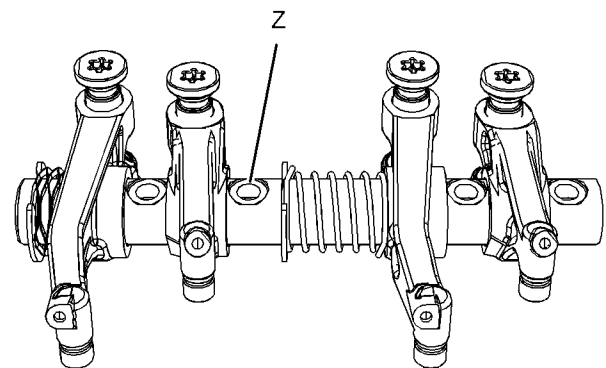


Illustration 355

g02623177

7. Ensure that the rocker shaft assembly is clean and free from wear and damage.
8. Position the rocker shaft assembly with Spotfaces (Z) for Torx screws (4) in the up ward position.
9. Install Tooling (D) to rocker shaft assembly.
10. Install Torx screws (4) in the rocker shaft in Positions (Y).

Note: Ensure that the correct Torx screw (4) is installed to Position (X).

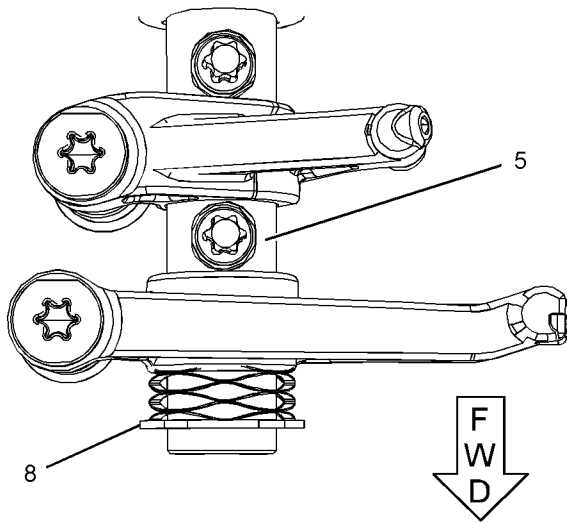


Illustration 356

g03706859

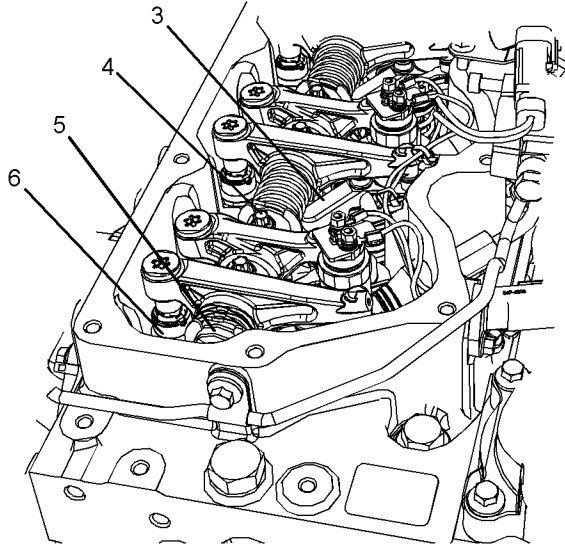


Illustration 357

g03703569

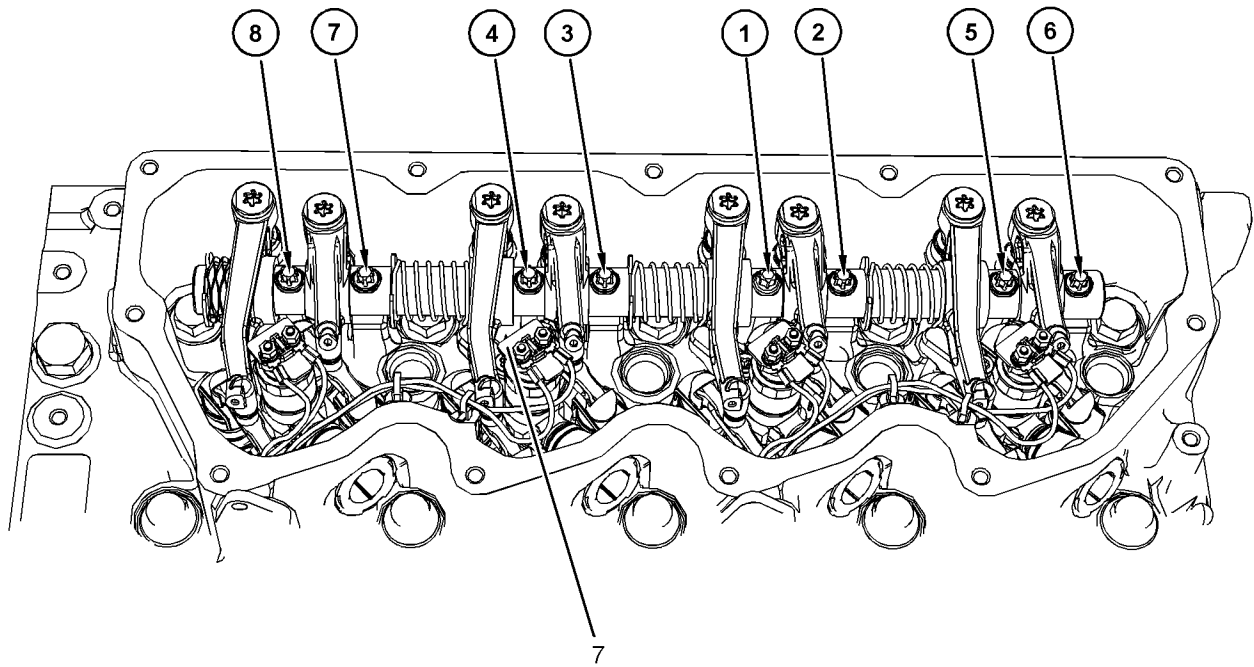


Illustration 358

g03703575

Sequence for tightening the bolts for the rocker shaft assembly

11. Ensure that ALL threaded inserts are fully unscrewed.

NOTICE

Damage to the engine will occur if all threaded inserts are not fully unscrewed.

12. Position rocker shaft assembly (5) onto the cylinder head. The retaining clip (8) should face the front of the engine. Ensure that the rocker shaft assembly (5) does not come into contact with the electronic unit injector identification tag (7).

Note: Ensure that the threaded inserts are correctly seated in ends of the pushrods.

13. Use Tooling (C) in order to tighten Torx screws (4).
14. Remove Tooling (D) from rocker shaft assembly. Install remaining Torx screws (4). Use Tooling (C) in order to tighten the remaining Torx screws (4).
15. Tighten Torx screws (4) to a torque of 35 N·m (26 lb ft) in the numerical sequence. Refer to Illustration 358 .
16. Ensure that valve bridges (4) are still located correctly on the valve stems.

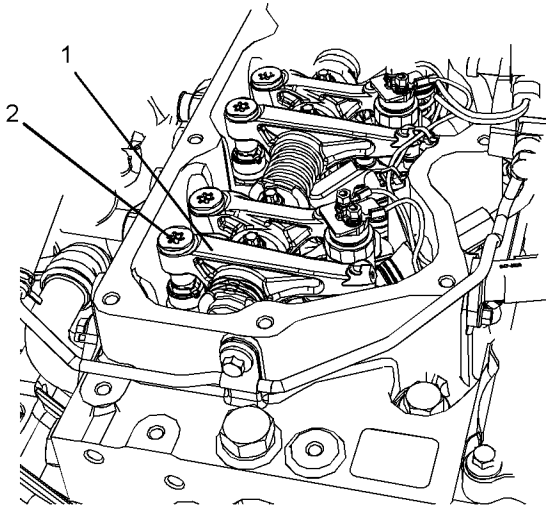


Illustration 359

g03703568

17. Use Tooling (B) in order to tighten threaded inserts (2) on all the rocker arms. Tighten the threaded inserts to a torque of 30 N·m (265 lb in).

Note: When the threaded insert is tightened, the threaded insert must be seated correctly in the cup for the pushrod.

18. The engine should not be operated for a period 45 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force of the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

- a. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i05980632

Cylinder Head - Remove

Removal Procedure

Table 72

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

Start By:

- a. If necessary, remove the secondary fuel filter and the fuel filter base. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
- b. If necessary, remove the water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Fuel Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
- c. Remove the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.
- d. Remove the fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (Rail) - Remove and Install” for the correct procedure.
- e. Remove the electronic unit injectors. Refer to Disassembly and Assembly, “Electronic Unit Injector - Remove” for the correct procedure.
- f. Remove the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

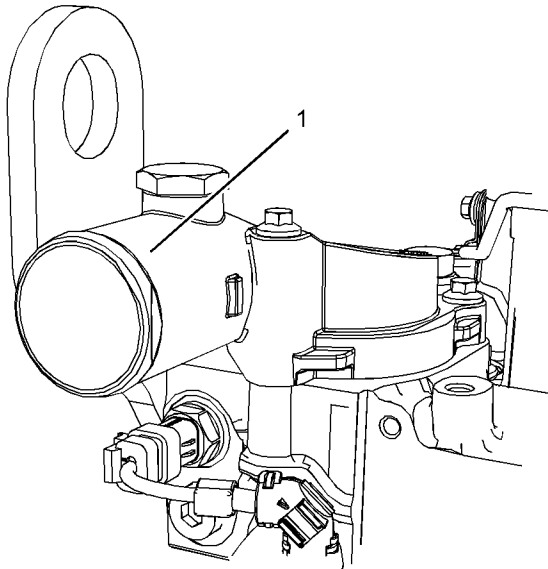


Illustration 360

g02452914

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

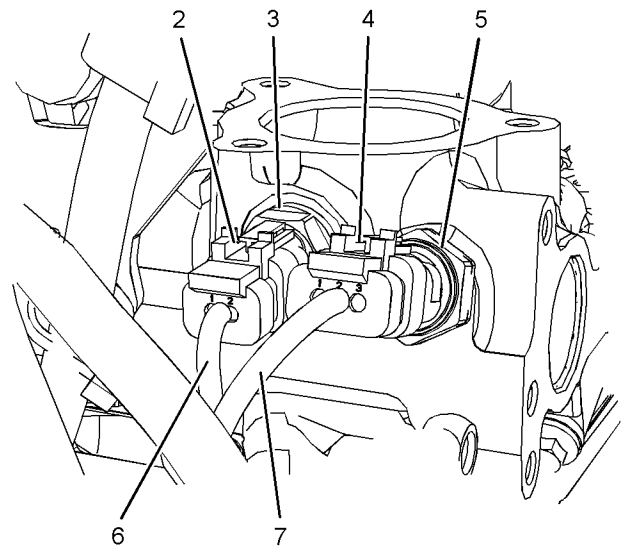


Illustration 361

g02452915

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

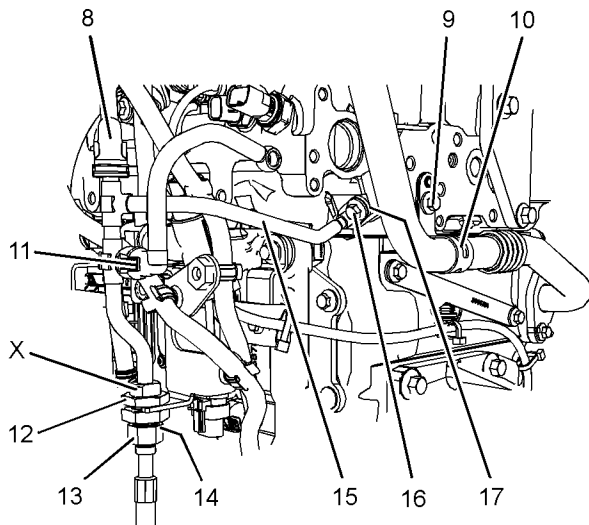


Illustration 362

g02452919

6. Disconnect plastic tube assembly (8) and plastic tube assembly (11) from tube assembly (15). Use Tooling (A) in order to plug the plastic tube assemblies and to cap the tube assembly.
7. Disconnect hose assembly (13) from connection on tube assembly (15). Remove O-ring seal (14) (not shown). Use Tooling (A) in order to plug the hose assembly and to cap the tube assembly.
8. Use a suitable tool in Position (X) in order to hold tube assembly (15) as nut (12) is loosened. Remove bolt (16) from tube assembly (15).
9. Remove tube assembly (15) from the bracket and the cylinder head. Use Tooling (A) in order to plug the cylinder head and to cap the tube assembly.
10. Remove O-ring seal (15) from tube assembly (17).

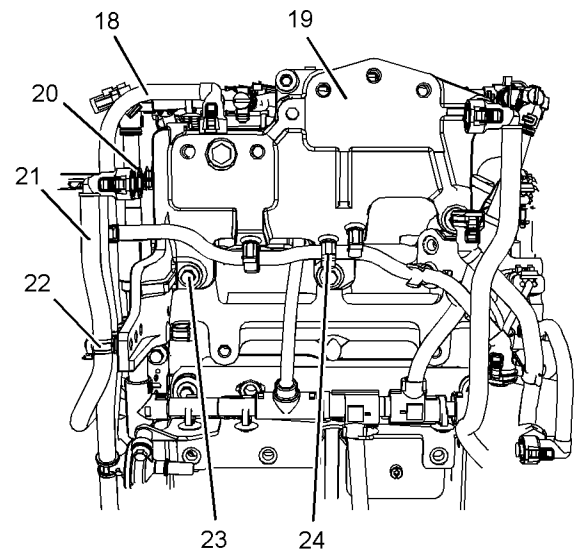


Illustration 363

g02456139

11. Disconnect plastic tube assembly (18) plastic tube assembly (20) and plastic tube assembly (21) from clips (22) and clips (24).
12. Remove bolts (23) from fuel filter bracket (19).
13. Remove fuel filter bracket (19) from the cylinder head.

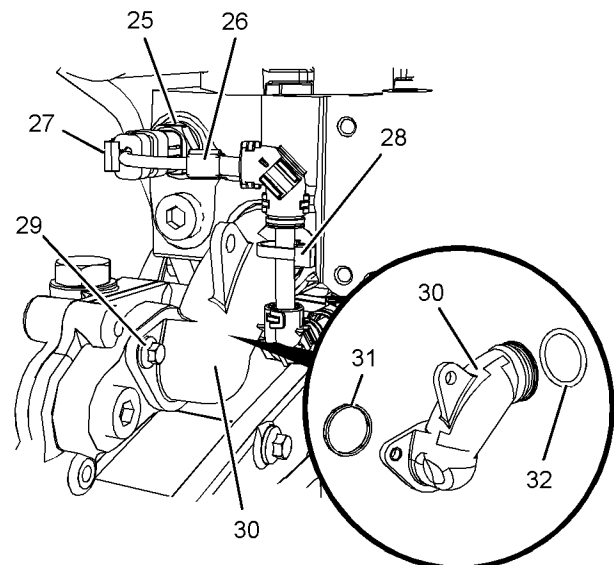


Illustration 364

g02452920

14. Follow Step 14a through Step 14c in order to disconnect harness assembly (26) from coolant temperature sensor (25).
 - a. Slide locking tab (27) into the unlocked position.

- b. Disconnect harness assembly (26) from coolant temperature sensor (25).
- c. Cut cable strap (28) and remove harness assembly (26) from bypass tube (30). The harness assembly should be positioned away from the cylinder head in order to avoid causing an obstruction during the removal of the cylinder head.
- 15.** Remove bolts (29). Remove bypass tube (30) from the cylinder head. Remove O-ring seal (31) and O-ring seal (32) from bypass tube (30).

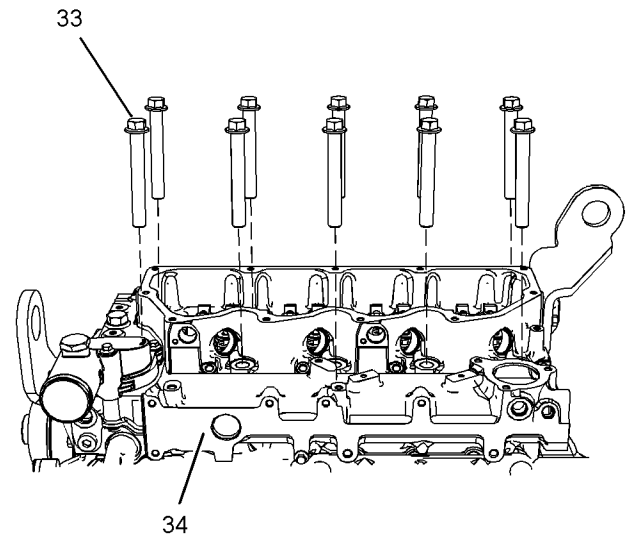


Illustration 365

g02452921

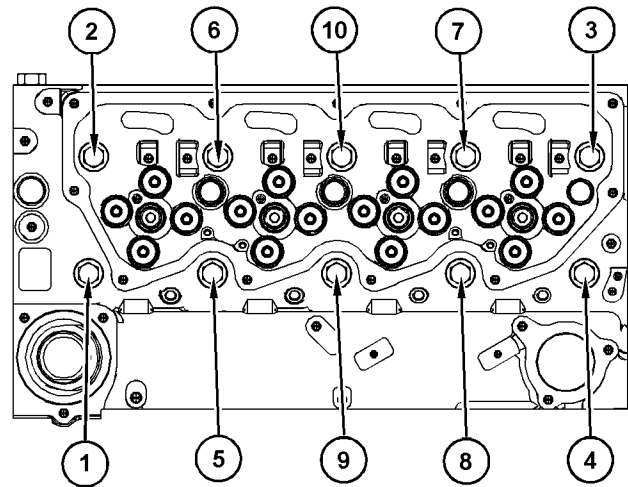


Illustration 366

g02452922

Sequence for tightening the bolts for the cylinder head

- 16.** Gradually loosen bolts (33) in the reverse numerical order to the tightening sequence. Refer to the Illustration 366 .

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

- 17.** Remove bolts (33) from cylinder head (34).

- 18.** Attach a suitable lifting device to cylinder head (34). Support the weight of the cylinder head. The weight of the cylinder head is approximately 66 kg (146 lb).

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

- 19.** Use the suitable lifting device to lift cylinder head (34) carefully off the cylinder block.

Note: Do not use a lever to separate the cylinder head from the cylinder block. Take care not to damage the machined surfaces of the cylinder head during the removal procedure.

NOTICE

Place the cylinder head on a surface that will not scratch the face of the cylinder head.

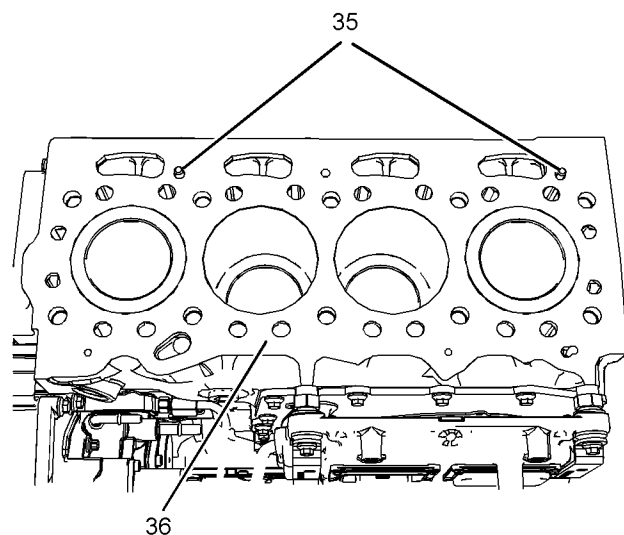


Illustration 367

g02452924

- 20.** Remove cylinder head gasket (36).
- 21.** Note the position of dowels (35) in the cylinder block.

- 22.** If necessary, remove the water temperature regulator from the cylinder head. Refer to Disassembly and Assembly, "Water Temperature Regulator - Remove and Install" for the correct procedure.

i05980636

Cylinder Head - Install

Installation Procedure

Table 73

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M16 by 115mm	2
B	21825607	Degree Wheel	1
C	-	Delphi Lockheed Rubber Grease	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

1. Thoroughly clean the gasket surfaces of the cylinder head and the cylinder block. Do not damage the gasket surfaces of the cylinder head or the cylinder block. Ensure that no debris enters the cylinder bores, the coolant passages, or the lubricant passages.
2. Inspect the gasket surface of the cylinder head for distortion. Refer to Specifications, "Cylinder Head" for more information. If the gasket surface of the cylinder head is distorted beyond maximum permitted limits, replace the cylinder head.

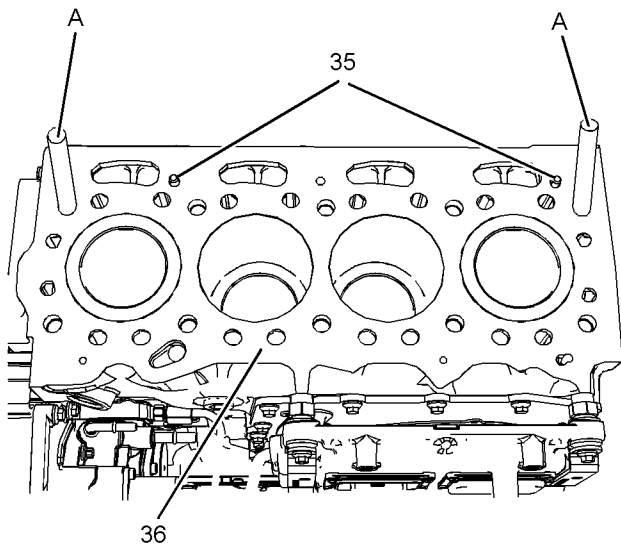


Illustration 368

g02460199

3. Inspect dowels (35) for damage. If necessary, replace the dowels in the cylinder block.
4. Install Tooling (A) to the cylinder block.
5. Align cylinder head gasket (36) with dowels (35). Install cylinder head gasket (36) onto the cylinder block.
6. Use a suitable lifting device to lift cylinder head. The weight of the cylinder head is approximately 66 kg (146 lb).

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

7. Use Tooling (A) to align the cylinder head with the cylinder block. Install the cylinder head to the cylinder block.

Note: Ensure that the cylinder head is correctly positioned on dowels (35).

8. Remove Tooling (A).

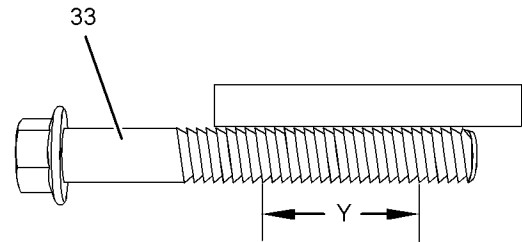


Illustration 369

g02460202

9. Clean bolts (33). Follow Step 9a for the procedure to inspect the bolts.
 - a. Use a straight edge to check the threads of the bolts. Refer to Illustration 369 . Replace any bolts that show visual reduction in the diameter of the thread over Length (Y).
10. Lubricate the threads and the shoulder of bolts (33) with clean engine oil.

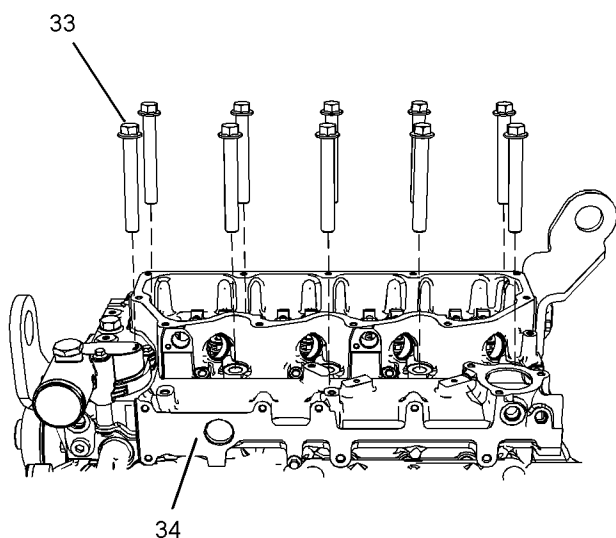


Illustration 370

g02452921

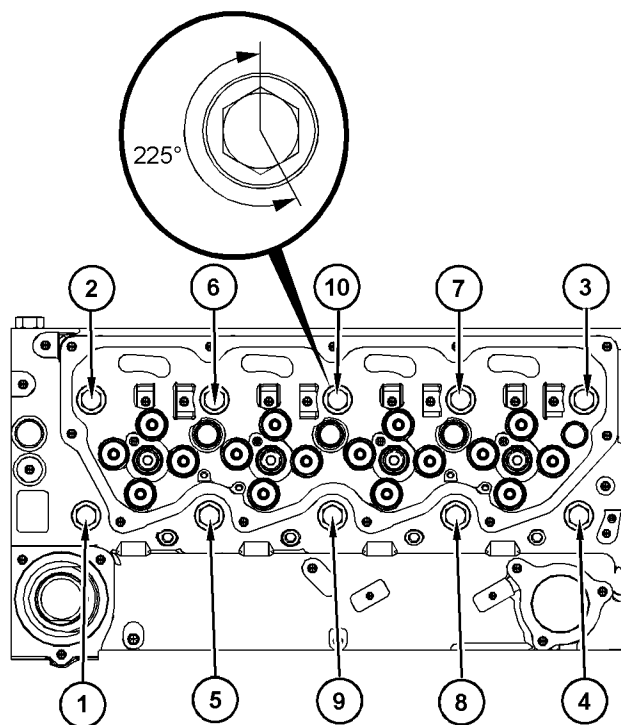


Illustration 371

g02460204

11. Install bolts (33) to cylinder head (34).

12. Tighten the bolts to a torque of 50 N·m (37 lb ft) in the numerical sequence. Refer to Illustration 371 .

13. Tighten the bolts to a torque of 100 N·m (74 lb ft) in the numerical sequence. Refer to Illustration 371 .

14. Use Tooling (B) in order to turn the bolts through an additional 225 degrees in the numerical sequence. Refer to Illustration 371 .

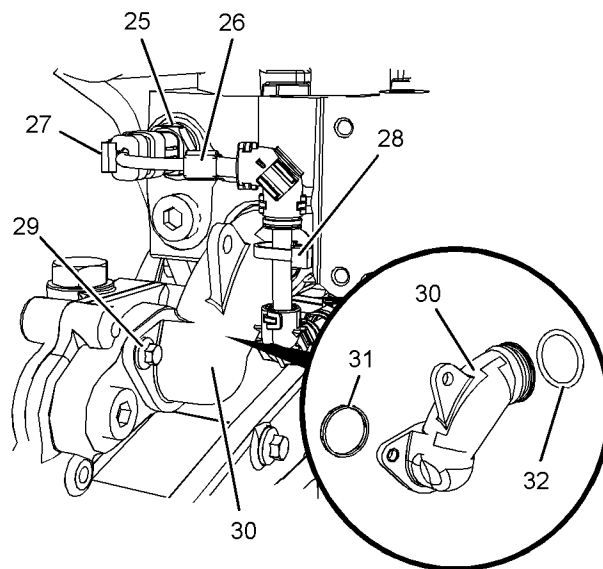


Illustration 372

g02452920

15. Use Tooling (C) in order to lubricate the O-ring seals. Install new O-ring seal (31) and O-ring seal (32) to bypass tube (30). Install the bypass tube in the cylinder head. Install bolts (29). Tighten the bolts to a torque of 22 N·m (195 lb in).

16. Follow Step 16a through Step 16d in order to connect harness assembly (26) to coolant temperature sensor (25).

- Connect harness assembly (26) to coolant temperature sensor (25).
- Slide locking tab (27) into the locked position.
- Position harness assembly (26) onto bypass tube (30).
- Install a new cable strap (28).

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

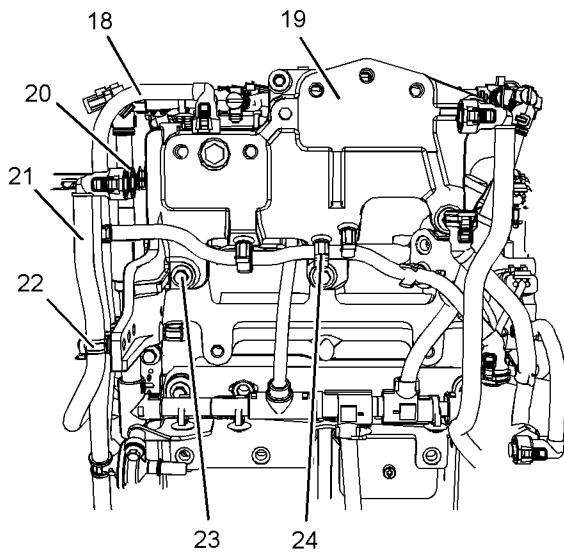


Illustration 373

g02456139

- 17.** Position fuel filter bracket (19) onto the cylinder head.
- 18.** Install bolts (23) to fuel filter bracket (19). Tighten the bolts to a torque of 22 N·m (195 lb in).
- 19.** Connect plastic tube assembly (18) plastic tube assembly (20) and plastic tube assembly (21) to clips (22) and clips (24).

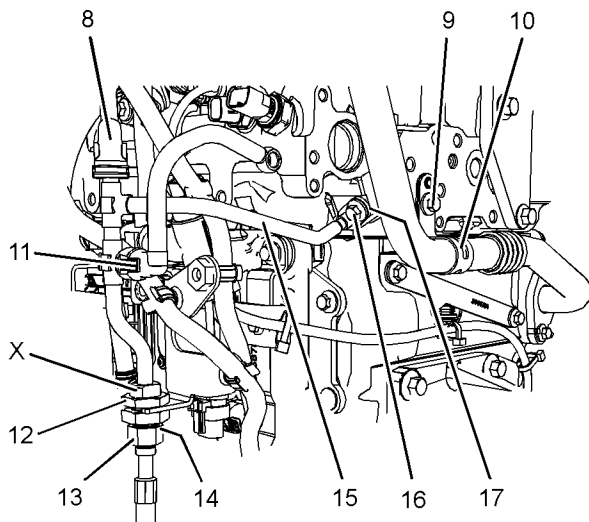


Illustration 374

g02452919

- 20.** Remove cap from tube assembly (15). Install a new O-ring seal (17) (not shown) to tube assembly (15).

- 21.** Install tube assembly (15) to the bracket and the cylinder head.
- 22.** Loosely install bolt (16) to tube assembly (15). Loosely tighten nut (12) on connection for tube assembly (15).
- 23.** Tighten bolt (16) to a torque of 22 N·m (195 lb in).
- 24.** Use a suitable tool in order to hold tube assembly (15) in Position (X). Tighten nut (12) to a torque of 28 N·m (248 lb in).
- 25.** Install a new O-ring seal (14) (not shown). Connect hose assembly (13) to connection on tube assembly (15). Tighten Hose assembly securely.
- 26.** Remove the plugs from plastic tube assembly (8) and plastic tube assembly (11). Remove caps from tube assembly (15).
- 27.** Connect plastic tube assembly (8) and plastic tube assembly (11) to tube assembly (15).

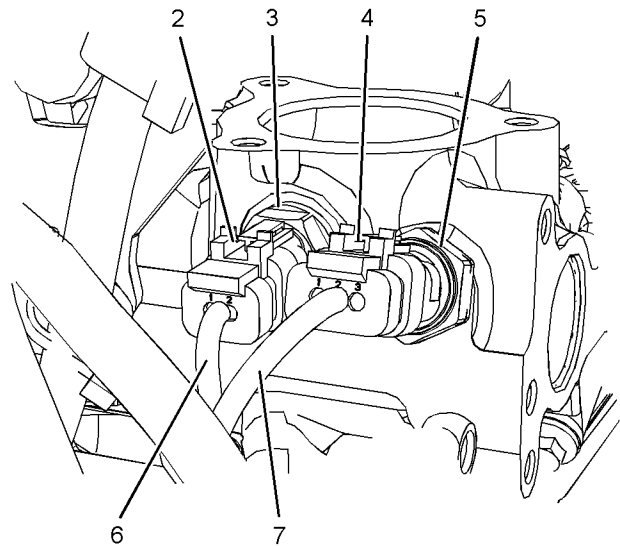


Illustration 375

g02452915

- 28.** Follow Step 28a through Step 28b in order to connect harness assembly (6) to inlet air temperature sensor (3).
 - a. Connect harness assembly (6) to inlet air temperature sensor (3).
 - b. Slide locking tab (2) into the locked position.
- 29.** Follow Step 29a through Step 29b in order to connect harness assembly (7) to boost pressure sensor (5).

- a. Connect harness assembly (7) to boost pressure sensor (5).
- b. Slide locking tab (4) into the locked position.

30. Position the harness assembly onto the cylinder head. Use new cable straps in order to secure the harness assembly to the cylinder head. Ensure that cable straps meet the OEM specification. Ensure that the harness assembly is not strained.

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

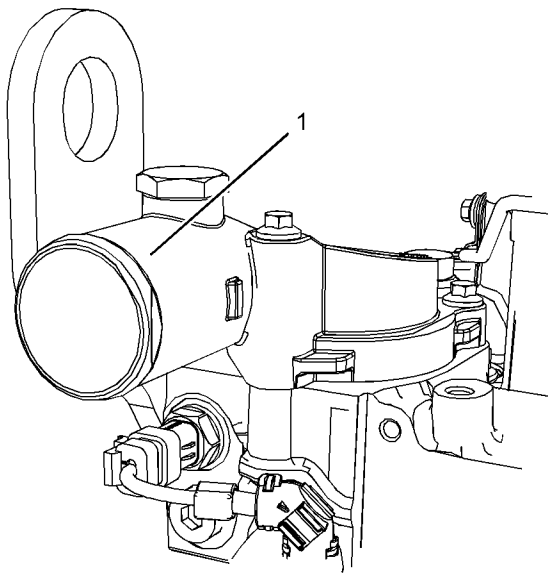


Illustration 376

g02452914

- 31.** If necessary, install water temperature regulator housing (1) to the cylinder head. Refer to Disassembly and Assembly, “Water Temperature Regulator Housing - Remove and Install” for the correct procedure.
- 32.** Connect the upper radiator hose to water temperature regulator housing (1) on the cylinder head.
- 33.** Fill the cooling system with coolant. Refer to Operation and Maintenance Manual, “Cooling System Coolant - Change” for the correct filling procedure.
- 34.** If necessary, fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, “Engine Oil Level - Check” for the correct procedure.

End By:

- a.** Install the electronic unit injectors. Refer to Disassembly and Assembly, “Electronic Unit Injector - Remove” for the correct procedure.
- b.** Install the glow plugs. Refer to Disassembly and Assembly, “Glow Plugs - Remove and Install” for the correct procedure.
- c.** Install the fuel manifold. Refer to Disassembly and Assembly, “Fuel Manifold (rail) - Remove and Install” for the correct procedure.
- d.** If necessary, install the fuel filter base and the secondary fuel filter. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
- e.** If necessary, install the water separator and fuel filter (Primary). Refer to Disassembly and Assembly, “Fuel Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
- f.** Install the exhaust manifold. Refer to Disassembly and Assembly, “Exhaust Manifold - Remove and Install” for the correct procedure.

i05981794

Lifter Group - Remove and Install

(Hydraulic Lifter Group)

Removal Procedure

Table 74

Required Tools			
Tool	Part Number	Part Description	Qty
(1)A	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

(1) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove" for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove" for the correct procedure.
- c. Remove the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install" for the correct procedure.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

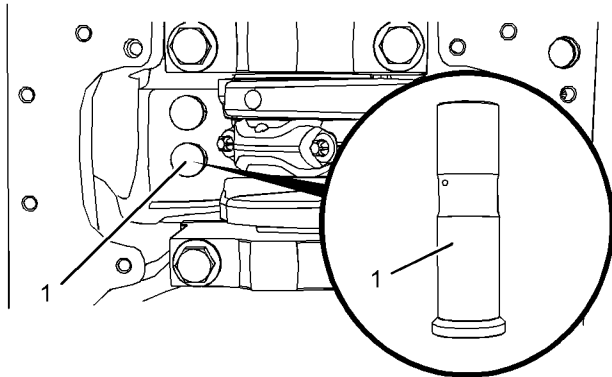


Illustration 377

g02008013

- 1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to appropriate lifters (1).
- 2. Use Tooling (B) in order to remove lifters (1).

Note: Place a temporary identification mark on each lifter in order to identify the correct location.

- 3. Repeat Step 1 through Step 2 in order to remove the remaining lifters.

Installation Procedure

Table 75

Required Tools			
Tool	Part Number	Part Description	Qty
(1)A	27610291	Housing	1
(1)A	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

(continued)

(Table 75, contd)

(1)A	27610291	Housing	1
(1)A	27610289	Engine Turning Tool	1
B	-	Telescoping Magnet	1

(1) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

- 1. Clean the lifters. Follow Step 1a through Step 1c in order to inspect the lifters. Replace any worn lifters or damaged lifters.
 - a. Inspect the seat of the pushrod in the lifter for visual wear and damage.
 - b. Inspect the shank of the lifter for wear and damage. Refer to Specifications, "Lifter Group" for more information.
 - c. Inspect the face of the lifter that runs on the camshaft for visual wear and damage.
- 2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft to access to the cylinder block in order to install appropriate lifters (1).

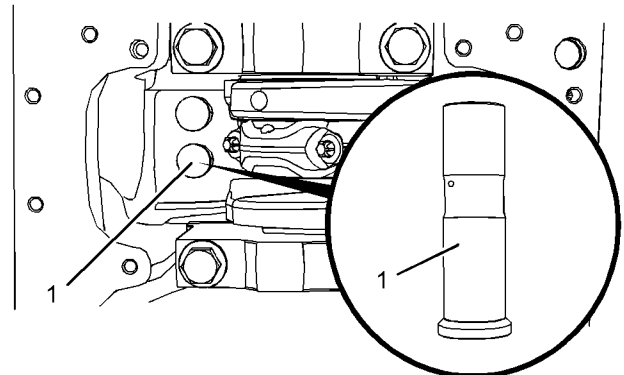


Illustration 378

g02008013

- 3. Lubricate lifters (1) with clean engine oil.
- 4. Use Tooling (B) to install lifters (1) to the cylinder block. Ensure that used lifters are installed in the correct location.

Note: The lifters should be free to rotate.

5. Repeat Step 1 through Step 4 in order to install the remaining lifters.

End By:

- a. Install the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.
- c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i05980433

Camshaft - Remove and Install

Removal Procedure

Start By:

- a. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, “Rocker shaft and Pushrod - Remove” for the correct procedure.
- b. Remove the front housing. Refer to Disassembly and Assembly, “Housing (Front) - Remove” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. The engine should be mounted on a suitable stand and placed in the inverted position.

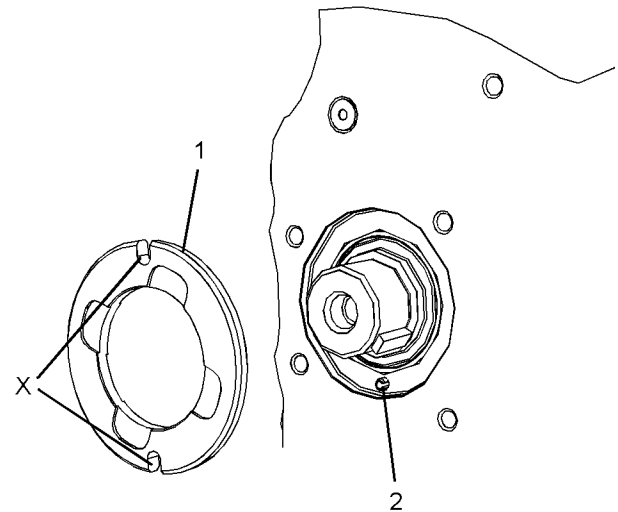


Illustration 379

g02009034

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

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

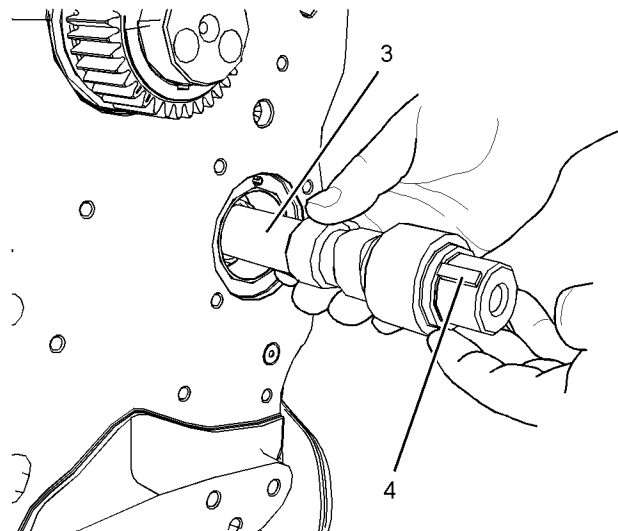


Illustration 380

g02009035

NOTICE

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

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

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

NOTICE

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

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

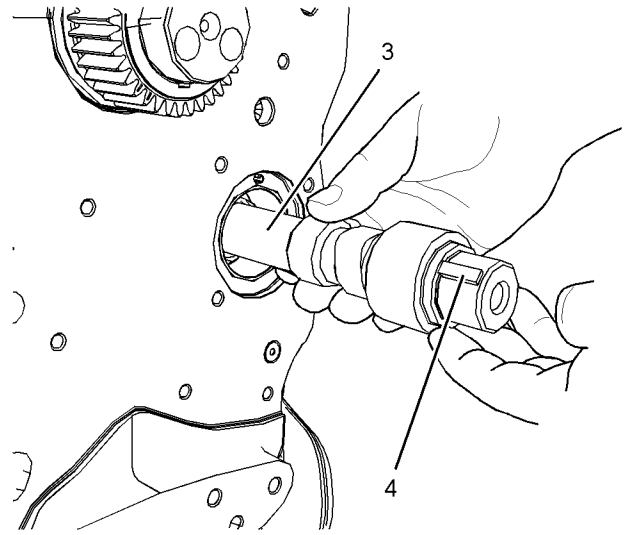


Illustration 381

g02009035

4. If necessary, install a new key (4) into camshaft (3).
5. Lubricate the bearing surfaces of camshaft (3) and lubricate the lobes of the camshaft with clean engine oil.

NOTICE

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

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

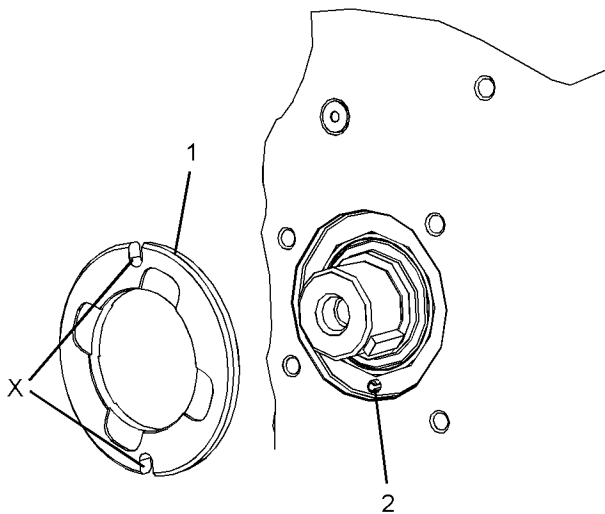


Illustration 382

g02009034

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

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

End By:

- a. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install" for the correct procedure.
- b. Install the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker shaft and Pushrod - Install" for the correct procedure.

i05980440

Camshaft Gear - Remove and Install

Removal Procedure

Table 76

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1

(continued)

(Table 76, contd)

Required Tools			
Tool	Part Number	Part Description	Qty
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T400015	Timing Pin (Fuel Injection Pump)	1
E	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

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

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

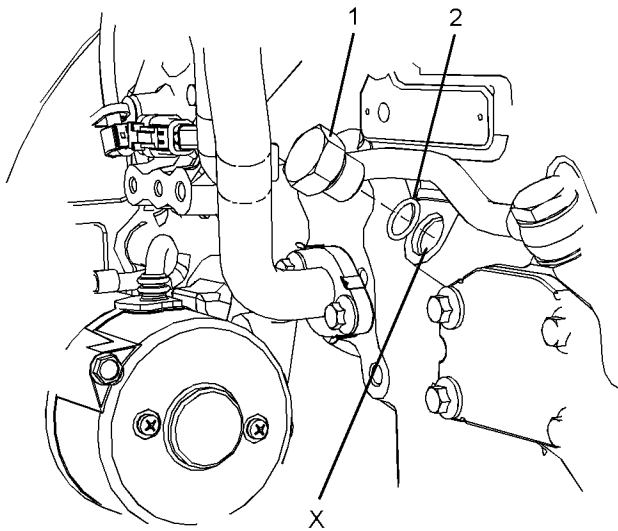


Illustration 383

g02437697

2. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
3. Install Tooling (E) into Hole (X) in the cylinder block. Use Tooling (E) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (E). Do not use Tooling (E) to hold the crankshaft during repairs.

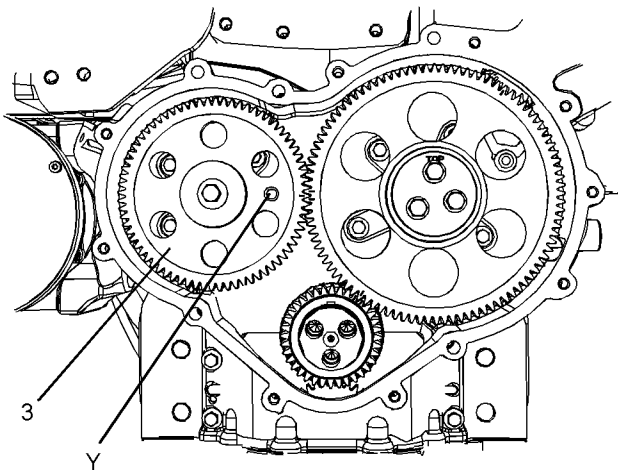


Illustration 384

g02437699

4. Install Tooling (C) through Hole (Y) in camshaft gear (3) into the front housing. Use Tooling (C) in order to lock the camshaft in the correct position.

5. Use Tooling (D) in order to lock the fuel injection pump gear in the correct position. Refer to Disassembly and Assembly, "Fuel Injection Pump - Remove" for the correct procedure.

NOTICE

Damage to the engine will occur if all threaded inserts are not fully unscrewed.

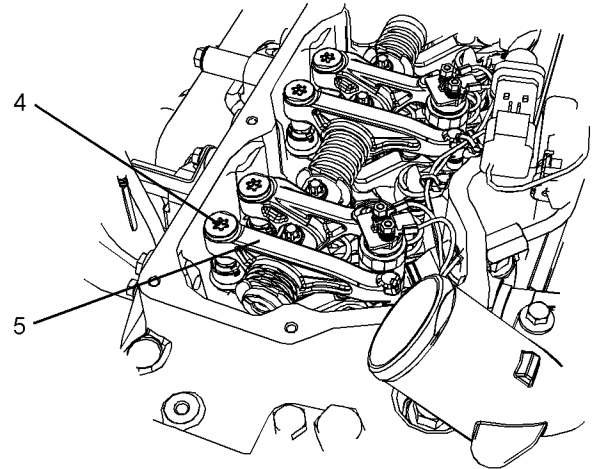


Illustration 385

g02437700

6. Use Tooling (B) in order to loosen threaded inserts (4) on all rocker arms (5). Unscrew threaded inserts (4) on all rocker arms (5) until all valves are fully closed.

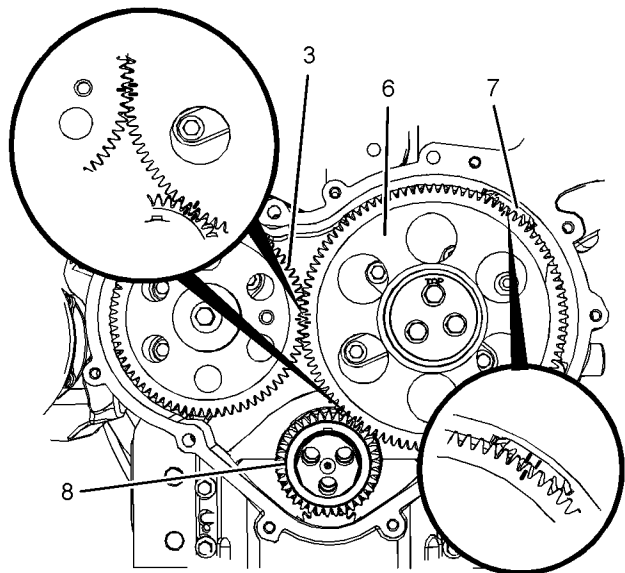


Illustration 386 g02437701

Alignment of timing marks

7. Mark gear (3), gear (6), gear (7), and gear (8) in order to show alignment. Refer to Illustration 386 .

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

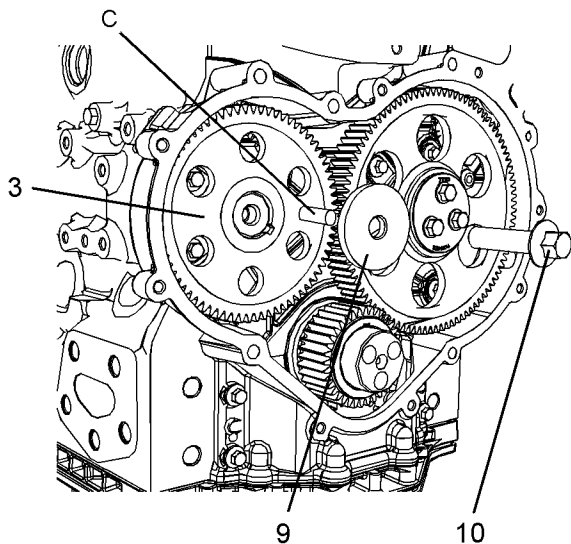


Illustration 387 g02437702

8. Remove Tooling (C). Remove bolt (10) and washer (9) from camshaft gear (3).

9. Remove camshaft gear (3) from the camshaft.

Note: If the camshaft gear is a tight fit on the nose of the camshaft, use a prybar in order to remove the camshaft gear.

10. If necessary, remove the key from the nose of the camshaft.

Installation Procedure

Table 77

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	T40 Torx Socket	1
C	27610212	Timing Pin (Camshaft)	1
D	T400015	Timing Pin (Fuel Injection Pump)	1
E	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
F	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

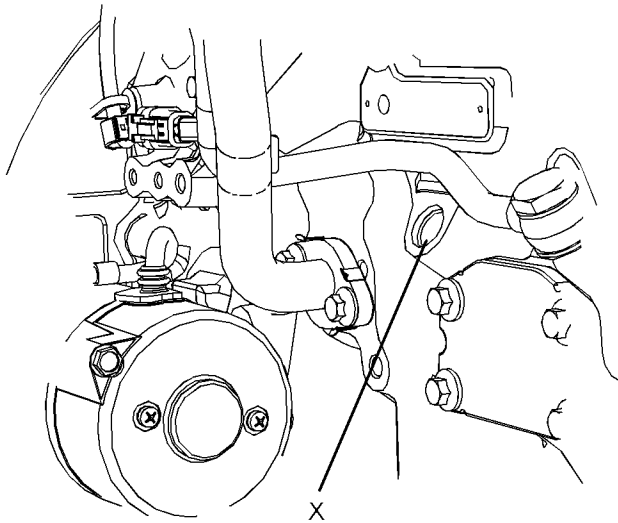


Illustration 388

g02437698

2. Ensure that Tooling (E) is installed in Hole (X) in the cylinder block. Use Tooling (E) in order to lock the crankshaft in the correct position. Refer to System Operation, Testing and Adjusting, "Finding Top Center Position for No.1 Piston" for the correct procedure.
3. Ensure that the camshaft gear and the key are clean and free from wear and damage.
4. If necessary, install the key into the nose of the camshaft.

Note: Ensure that the key is squarely seated.

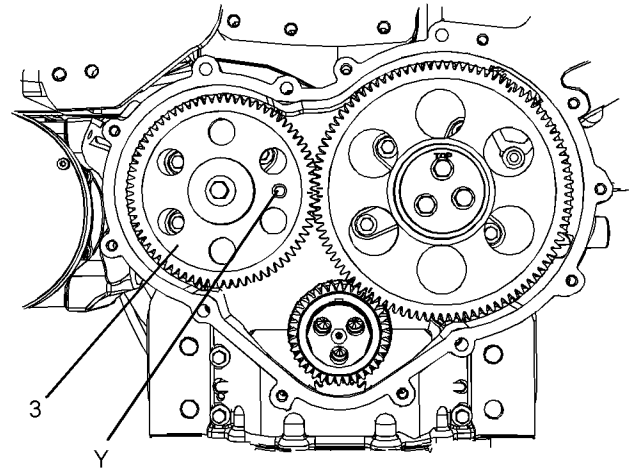


Illustration 389

g02437699

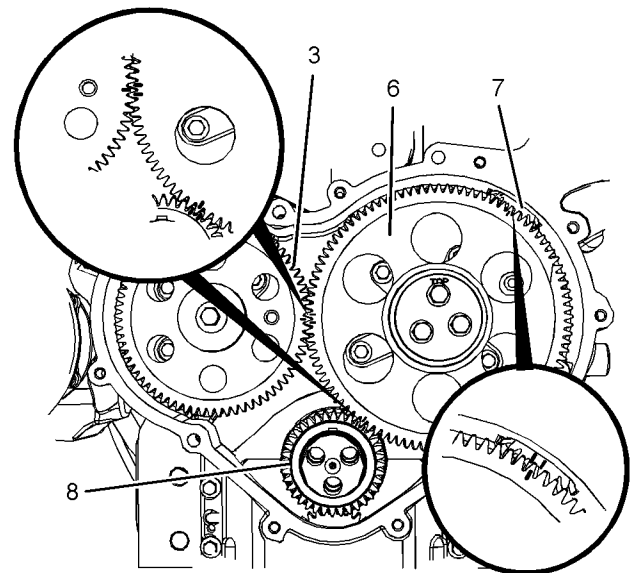


Illustration 390

g02437701

Alignment of timing marks

5. Align the keyway in camshaft gear (3) with the key in the camshaft. Install camshaft gear onto the camshaft. Ensure that the timing marks on gear (3), gear (6), gear (7) and gear (8) are in alignment and that the mesh of the gears is correct. Refer to Illustration 390 .

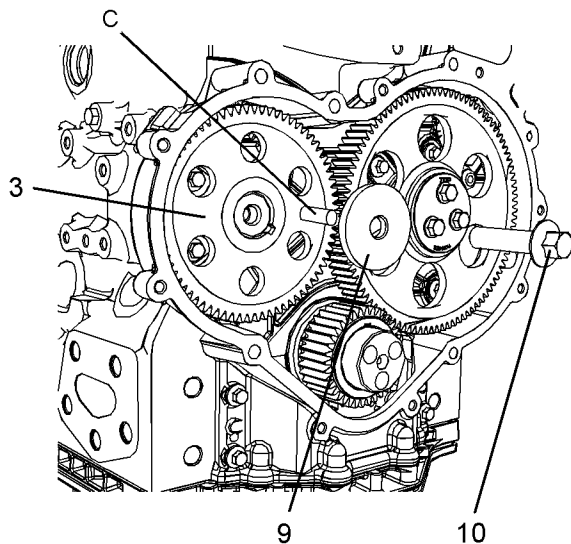


Illustration 391

g02437702

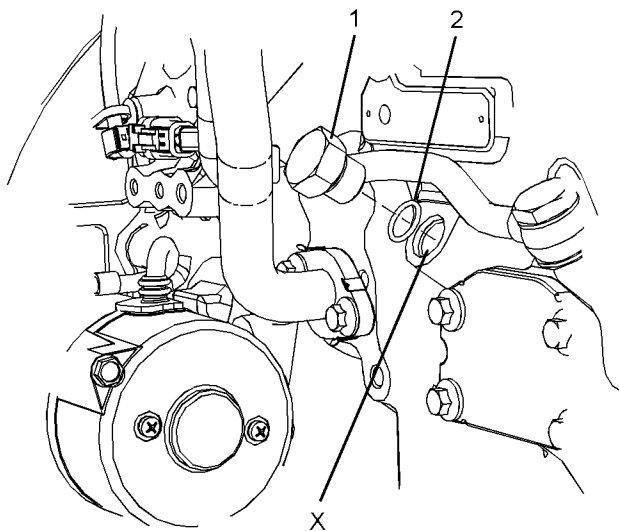


Illustration 392

g02437697

6. Install Tooling (C) through Hole (X) in the camshaft gear into the front housing. Install washer (9) and bolt (10) to camshaft gear (3).
7. Remove Tooling (E) and Tooling (C).
8. Install a new O-ring seal (2) to plug (1). Install the plug into Hole (Y) in the cylinder block. Refer to Illustration 392 . Tighten plug (1) to a torque of 21 N·m (186 lb in).
9. When bolt (10) is a 8.8 Grade. Tighten bolt (10) to a torque of 95 N·m (70 lb ft).

When bolt (10) is a 10.9 Grade. Tighten bolt (10) to a torque of 120 N·m (89 lb ft).

10. Use Tooling (F) in order to measure the backlash for gear (3), gear (6), gear (7) and gear (8). Refer to Specifications, "Gear Group (Front)" for further information.
11. Use Tooling (F) in order to measure the end play of camshaft gear (1). Refer to Specifications, "Camshaft" for further information.
12. Lubricate the teeth of the gears with clean engine oil.

NOTICE

Failure to ensure that the crankshaft is set in the safe position will result in interference between the pistons and the valves. Interference between the pistons and the valves will result in damage to the engine.

13. Use Tooling (A) in order to rotate the crankshaft in a clockwise direction and position the crankshaft at the safe position. Refer to System Operation, Testing and Adjusting, "Position the Valve Mechanism Before Maintenance Procedures" for the correct procedure.

NOTICE

Damage to the engine will occur if all threaded inserts are not fully unscrewed.

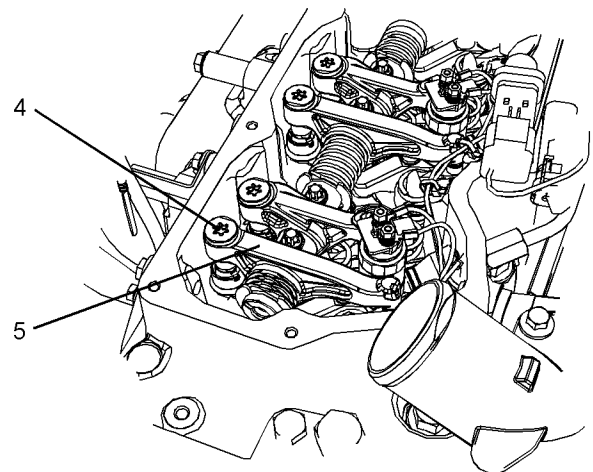


Illustration 393

g02009115

14. Ensure that the pushrods are correctly positioned on the threaded inserts (4). Use Tooling (B) in order to tighten threaded inserts (4) on all rocker arms (5). Tighten the threaded inserts to a torque of 30 N·m (266 lb in).

Note: When the threaded insert is tightened, the threaded insert must be correctly seated into the cup for the pushrod.

15. The engine should not be operated for a period 30 minutes after the threaded inserts on all the rocker arms have been tightened. This period will allow the force of the valve springs to purge off excessive engine oil from the hydraulic lifters.

End By:

- a. Install the front cover. Refer to Disassembly and Assembly, “Front Cover - Remove and Install” for the correct procedure.
- b. Install the valve mechanism cover. Refer to Disassembly and Assembly, “Valve Mechanism Cover - Remove and Install” for the correct procedure.

i05980435

Camshaft Bearings - Remove and Install

Removal Procedure

Table 78

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Camshaft Bearing Tool Group	1
	-	Ratchet Wrench	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.
- c. Remove the camshaft. Refer to Disassembly and Assembly, “Camshaft - Remove and Install” for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

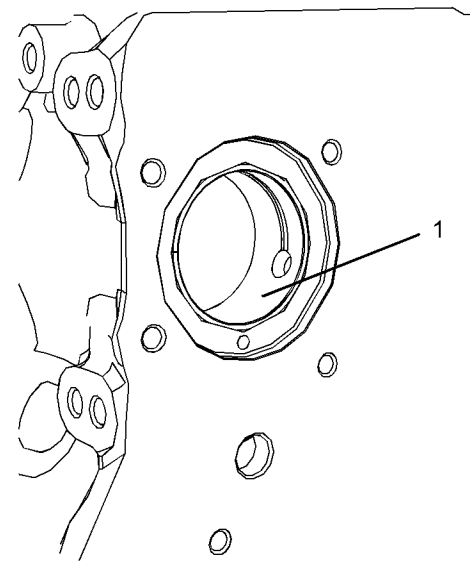


Illustration 394

g02010213

- 1. Inspect camshaft bearing (1). Refer to Specifications, “Camshaft Bearings” for more information.
- 2. If camshaft bearing (1) is worn or damaged, use Tooling (A) in order to remove the camshaft bearing from the cylinder block.

Note: Remove the camshaft bearing from the front of the cylinder block.

Installation Procedure

Table 79

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Camshaft Bearing Tool Group	1
	-	Ratchet Wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

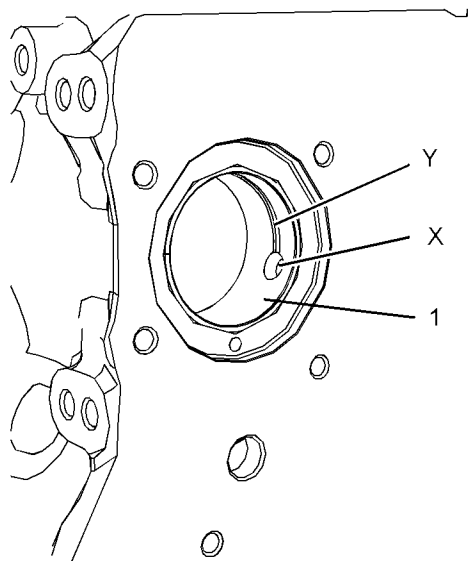


Illustration 395

g02010216

2. Lubricate the bearing housing in the cylinder block with clean engine oil.
3. Accurately align large oil Hole (X) in camshaft bearing (1) with the oil hole in the cylinder block.

Note: The Groove (Y) in the camshaft bearing must be to the top of the cylinder block.

4. Use Tooling (A) in order to install camshaft bearing (1) into the cylinder block. Install the camshaft bearing so that the front edge of the bearing is flush with the face of the recess in the cylinder block.

Note: Ensure that the oil holes are correctly aligned. If the oil is not correctly aligned, the camshaft bearing should be removed.

End By:

- a. Install the camshaft. Refer to Disassembly and Assembly, "Camshaft - Remove and Install" for the correct procedure.
- b. If the engine was equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install" for the correct procedure. If the engine was not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install" for the correct procedure.

i05981730

Engine Oil Pan - Remove and Install

(Cast Iron Oil Pan)

Removal Procedure

Table 80

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

1. In order to remove a cast iron oil pan, the engine must be removed from the machine. The engine should be mounted in a suitable stand and placed in the inverted position.

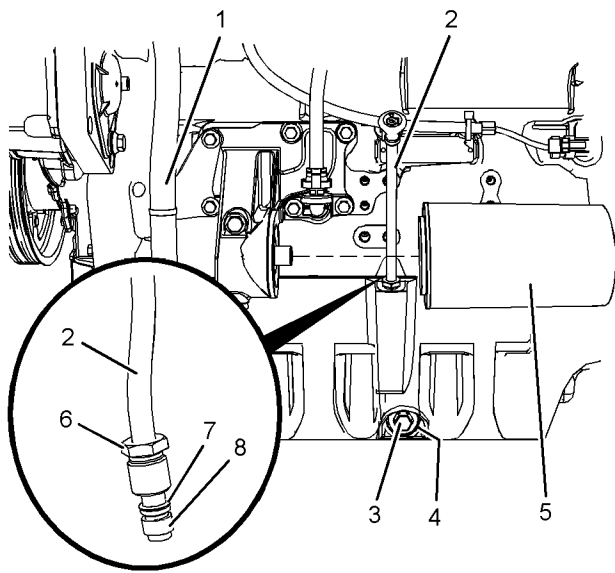


Illustration 396

g02475578

2. Use Tooling (A) in order to remove engine oil filter (5). Remove plug (3) and drain the engine lubricating oil. Remove O-ring seal (4) (not shown) from plug (3). Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for correct procedure.
3. If necessary, remove breather hose (1) from the clip. Position the breather hose away from the engine oil pan.
4. Loosen nut (6) and remove tube assembly (2). Remove O-ring seal (7) and seal (8) from the tube assembly.

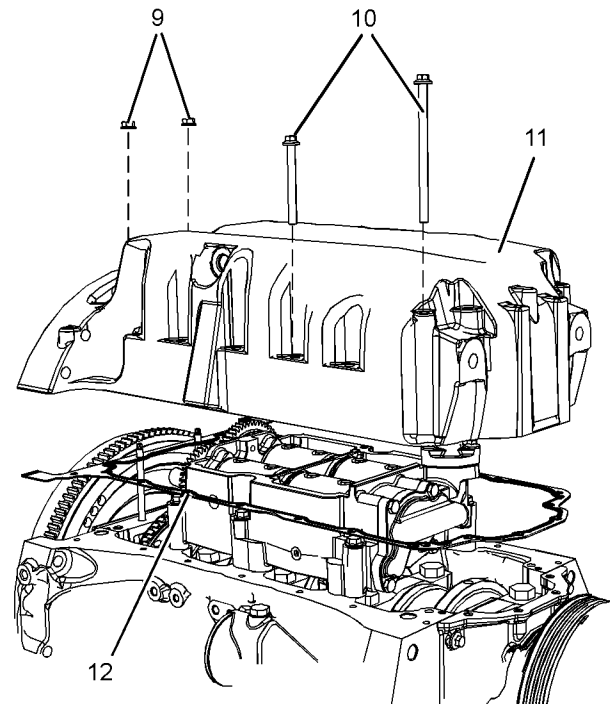


Illustration 397

g02475581

5. Remove nuts (9) and bolts (10) from engine oil pan (11).
- Note:** The bolts are different lengths. Note the position of the different bolts.
6. Attach a suitable lifting device to engine oil pan (11). Support the weight of the engine oil pan. The engine oil pan weighs approximately 41 kg (90 lb).
 7. Use the lifting device to remove engine oil pan (11) from the cylinder block.
 8. Remove gasket (12) from the cylinder block.

Installation Procedure

Table 81

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Loctite 5900	1
B	-	Loctite 243	1
C	-	Straight Edge	1

Note: In order to install a cast iron oil pan, the engine must be removed from the machine.

Disassembly and Assembly Section

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the gasket face of the cylinder block and the engine oil pan are clean and free from damage. Inspect the studs in the cylinder block for damage. If necessary, replace the studs.

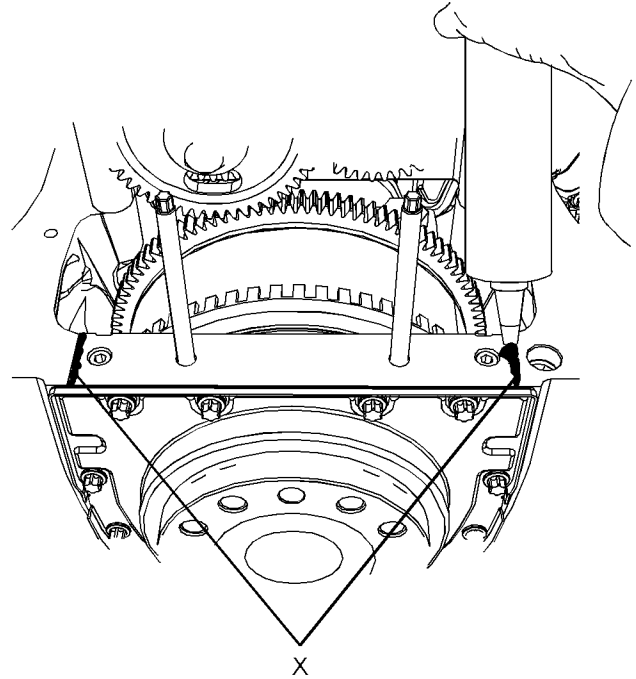


Illustration 398

g03701801

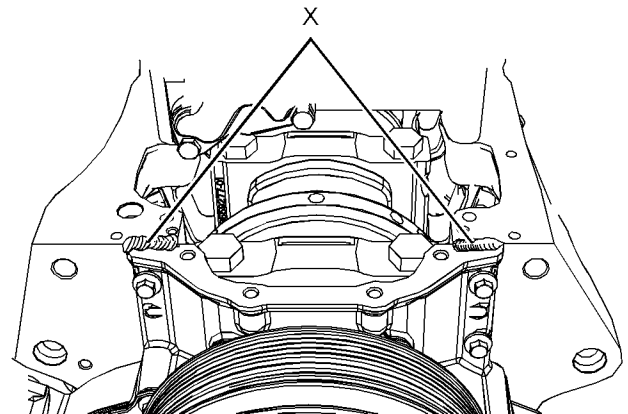


Illustration 399

g03701802

2. Apply a bead of Tooling (A) to Positions (X) on the cylinder block.

Note: If the bridge piece for the cylinder block has just been installed, the engine oil pan must be installed before Tooling (A) has cured.

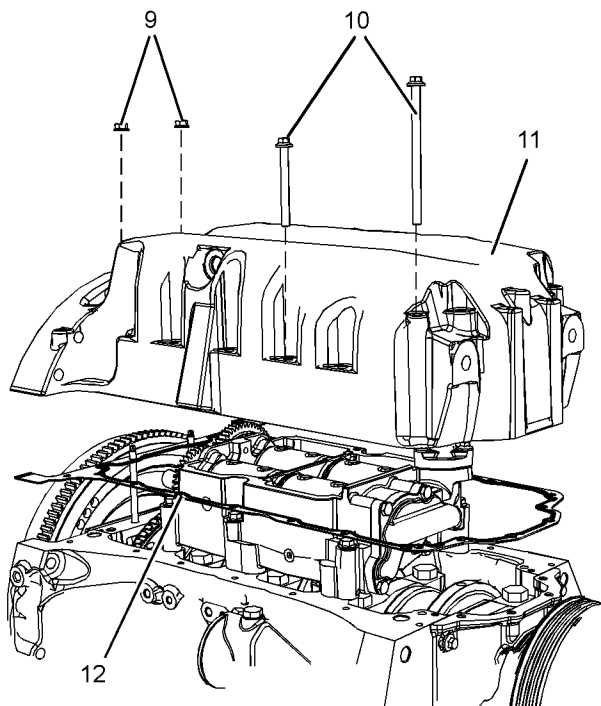


Illustration 400

g03701799

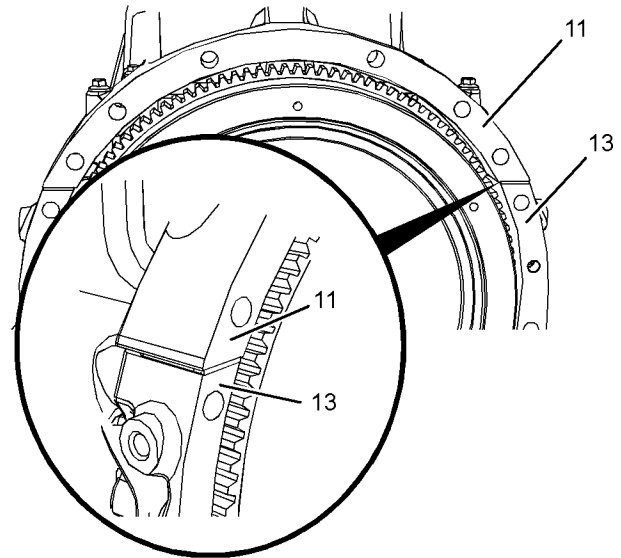


Illustration 402

g03701798

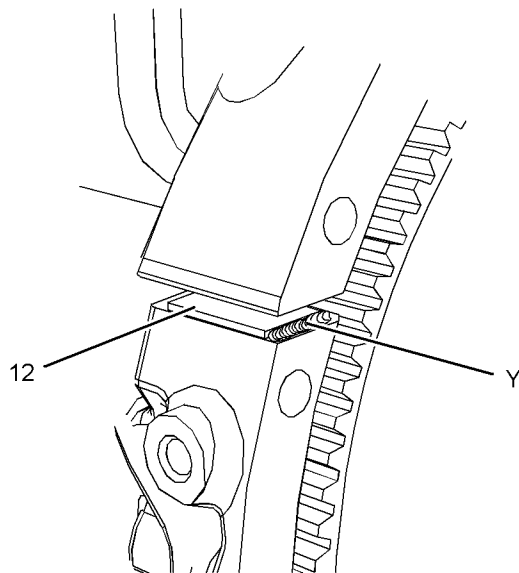


Illustration 401

g03701800

3. Align a new gasket (12) with the studs in the cylinder block. Install the gasket to the cylinder block.
4. Apply a 3 mm (0.118 inch) bead of Tooling (A) to edge of gasket (12) in Position (Y) on both sides of the gasket.
5. Attach a suitable lifting device to engine oil pan (11). The engine oil pan weighs approximately 41 kg (90 lb).
6. Use the lifting device to align engine oil pan (11) with the studs in the cylinder block. Install the engine oil pan to the cylinder block. Remove the lifting device from the engine oil pan.
7. Install nuts (9) and bolts (10) finger tight.
8. Align the rear face of engine oil pan (11) to the rear face of cylinder block (13) on both sides. Use Tooling (C) and a feeler gauge in order to check the alignment between the engine oil pan and the cylinder block. The maximum step that is allowed between the cylinder block and the sump is 0.1 mm (0.004 inch).
9. Tighten bolts (9) and nuts (10) to a torque of 22 N·m (16 lb ft). Refer to Specifications, "Engine Oil Pan" for the correct tightening sequence.

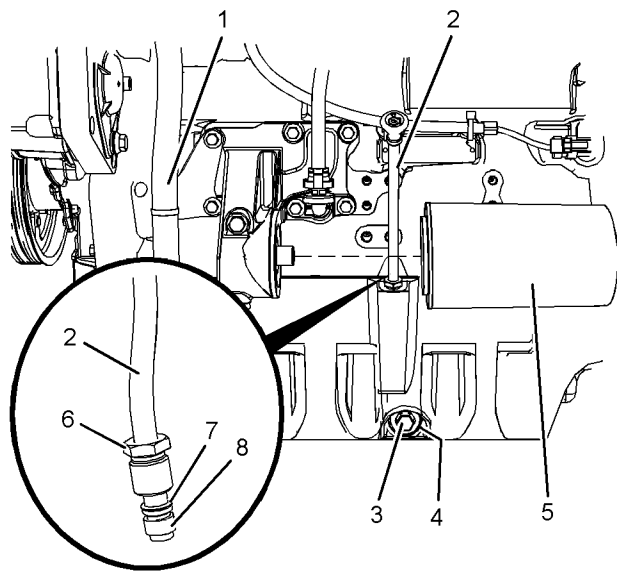


Illustration 403

g02475578

- 10.** If necessary, install a new O-ring seal (4) (not shown) to drain plug (5). Install drain plug (3) to the engine oil pan. Tighten the drain plug to a torque of 34 N·m (25 lb ft).
- 11.** Follow Step 11a through Step 11c in order to install the assembly of the dipstick tube.
- Install a new O-ring seal (7) and a new seal (8) to tube assembly (2).
 - Apply Tooling (B) to the nut of dipstick tube (2). Install the tube assembly to the engine oil pan.
- Note:** Ensure the correct orientation of the tube assembly.
- Tighten the nut to a torque of 18 N·m (13 lb ft). Install the dipstick .
- 12.** If necessary, install breather hose (1) to the clip.

- 13.** Install a new oil filter (5). After the engine has been installed, ensure that the engine oil pan is filled with lubricating oil to the correct level. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for correct procedure.

i05981731

Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

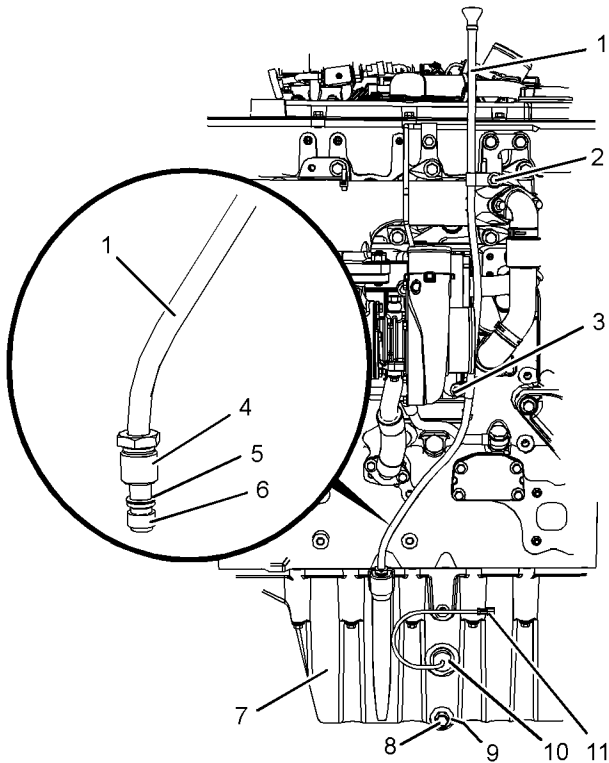


Illustration 404

g02475996

1. Place a suitable container below engine oil pan (7). Remove drain plug (8) and drain the engine lubricating oil. Refer to Operation and Maintenance Manual, "Engine Oil and Filter - Change" for correct procedure.
2. Remove O-ring seal (9) (not shown) from drain plug (8).
3. If necessary, remove the assembly of the dipstick tube. Follow Step 3a through Step 3c in order to remove dipstick tube (1) from the engine oil pan (7).
 - a. Remove bolt (2) and bolt (3).
 - b. Loosen nut (4) and remove tube assembly (1).

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

 - c. Remove O-ring seal (5) and seal (6) from tube assembly (1).
4. Disconnect the Original Equipment Manufacture (OEM) wiring harness assembly from wiring harness assembly (11) for oil level switch (10).

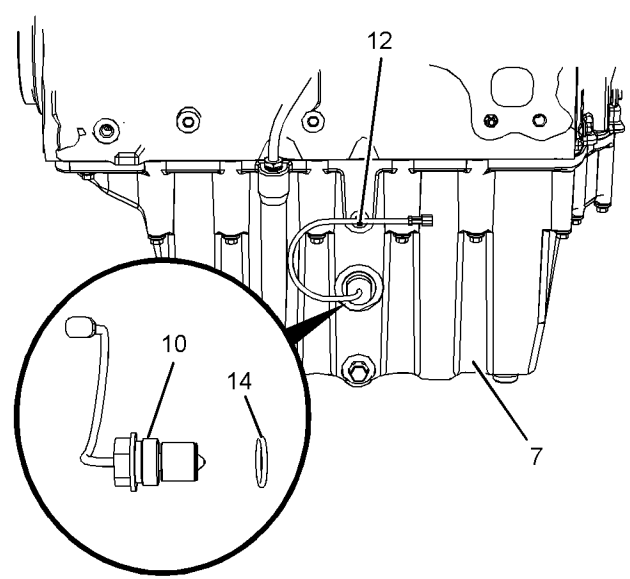


Illustration 405

g02476004

5. If necessary, remove the oil level switch. Follow Step 5a through Step 5c in order to remove oil level switch (10) from the engine oil pan (7).
 - a. Cut cable strap (12).
 - b. Remove oil level switch (10) from the engine oil pan (7).
 - c. Remove O-ring seal (14) from oil level switch (10).

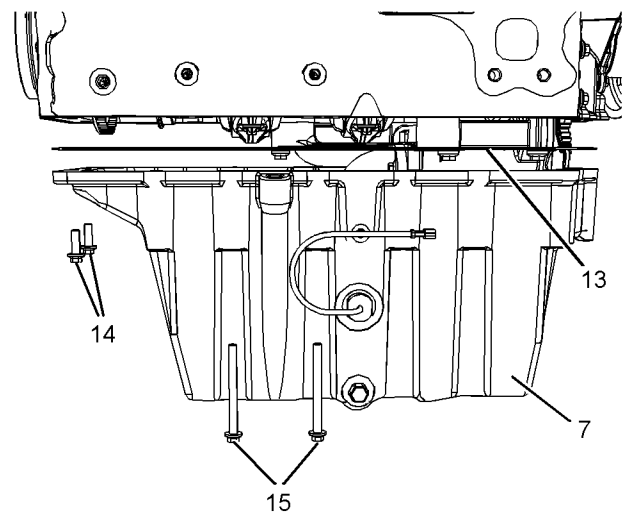


Illustration 406

g02475997

6. Support the assembly of engine oil pan (7). Remove bolts (14) and bolts (15).

7. Remove engine oil pan (7) and remove gasket (13).

Installation Procedure

Table 82

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Guide Studs M8 by 100 mm	4
B	-	Loctite 5900	1
C	-	Loctite 243	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

1. Ensure that the gasket faces of the cylinder block and the engine oil pan are clean and free from damage.

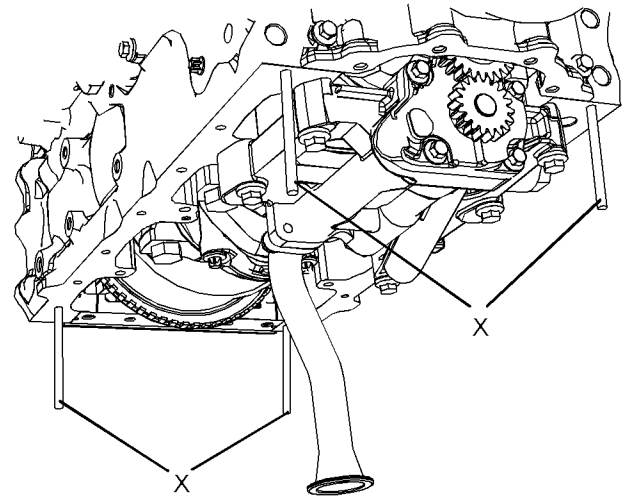


Illustration 407

g02476001

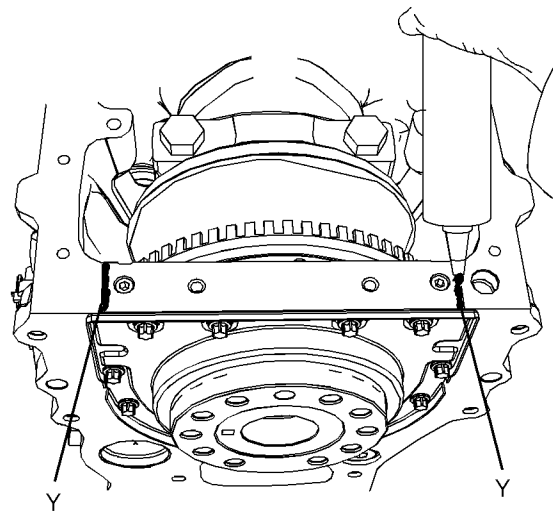


Illustration 408

g02476000

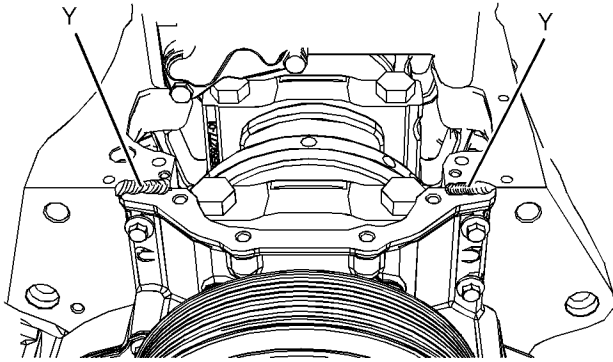


Illustration 409

g02475999

2. Install Tooling (A) to Positions (X) in the cylinder block.
3. Apply a bead of Tooling (B) to Positions (Y) on the cylinder block.

Note: If the bridge piece for the cylinder block has just been installed, the engine oil pan must be installed before Tooling (B) has cured.

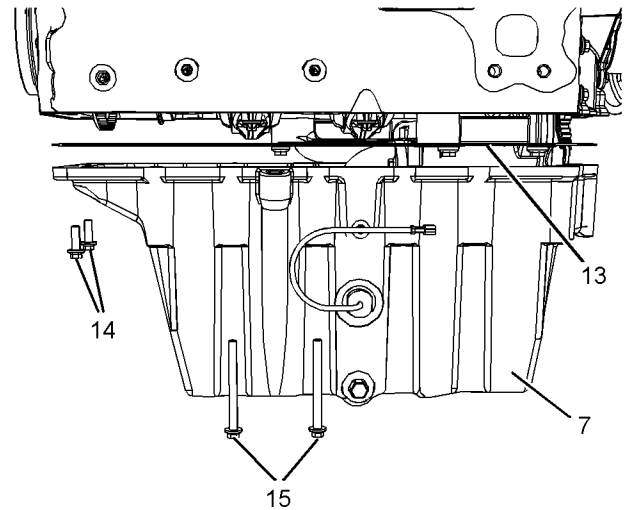


Illustration 410

g02475997

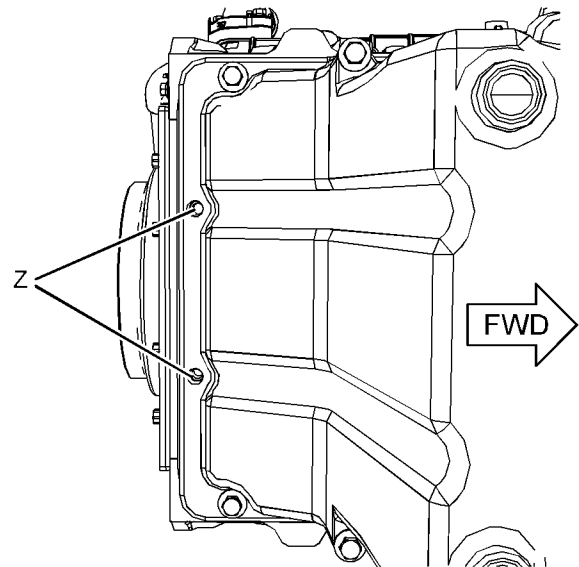


Illustration 411

g02476166

4. Position a new gasket (13) onto engine oil pan (7).
5. Align the assembly of the engine oil pan with Tooling (A). Install the assembly of engine oil pan (7) to the cylinder block.
6. Install bolts (15) finger tight.
7. Remove Tooling (A).
8. Install new bolts (14) in Position (Z) hand tight.
9. Install remaining bolts (14) and the remaining bolts (15).

- 10.** Tighten bolts (14) and bolts (15) to a torque of 22 N·m (16 lb ft). Refer to Specifications, “Engine Oil Pan” for the correct tightening sequence.

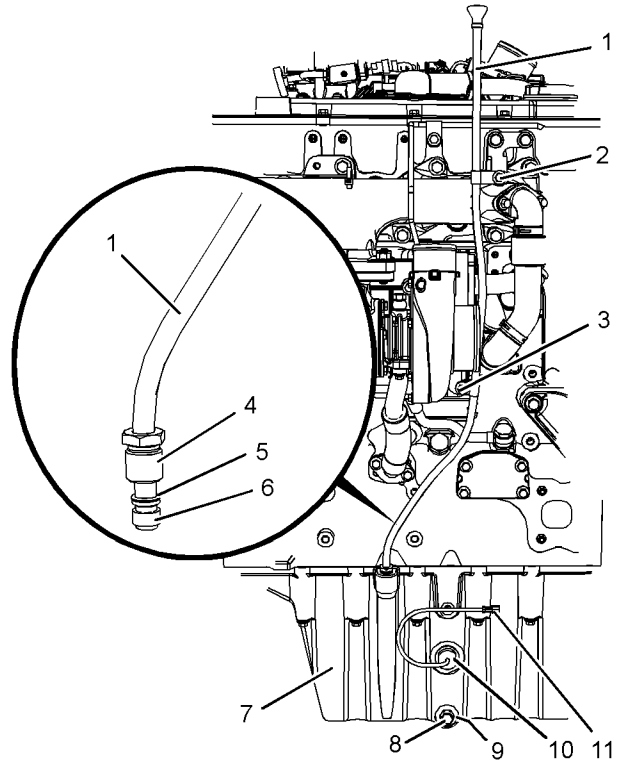


Illustration 412

g02475996

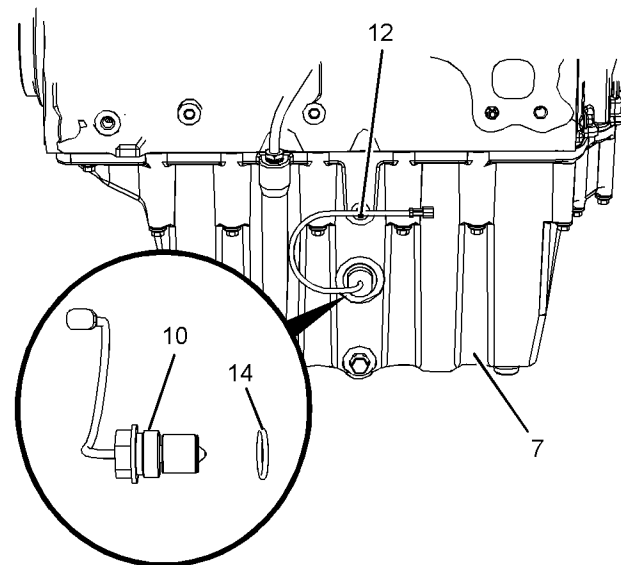


Illustration 413

g02476004

- 11.** Install a new O-ring seal (9) (not shown) to drain plug (8). Install the drain plug to engine oil pan (7). Tighten the oil drain plug to a torque of 34 N·m (25 lb ft).
- 12.** If necessary, follow Step 12a through Step 12f in order to install the assembly of the dipstick tube.

- a. Install a new O-ring seal (5) and a new seal (6) to tube assembly (1).
- b. Apply Tooling (C) to nut (4).
- c. Install the tube assembly (1) to engine oil pan (7). Loosely tight nut (4).

Note: Ensure that the orientation of the tube assembly is correct.

- d. Install bolt (2) and bolt (3) finger tight.
 - e. Tighten nut (4) to a torque of 18 N·m (13 lb ft). Install the dipstick.
 - f. Tighten bolt (2) and bolt (3) to a torque of 22 N·m (195 lb in).
- 13.** If necessary, install the oil level switch. Follow Step 13a through Step 13c in order to install oil level switch (10) to the engine oil pan (7).
- a. Install a new O-ring seal (14) oil level switch (10).
 - b. Install oil level switch (10) to engine oil pan (7). Tighten the oil level switch to a torque of 34 N·m (301 lb in).
 - c. Install a new cable strap (12).

Note: Ensure that the cable strap meets the OEM specification.

- 14.** Connect the OEM wiring harness assembly to wiring harness assembly (11) for oil level switch (10).
- 15.** Fill the engine oil pan to the correct level. Refer to Operation and Maintenance Manual, “Engine Oil and Filter - Change” for correct procedure.

i05980425

Balancer - Remove

Removal Procedure

Table 83

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1

(continued)

(Table 83, contd)

B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
C	27610225	Timing Pin (Balancer)	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.**

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

Note: In order to remove the balancer, the engine must be removed from the machine. The engine should be mounted in a suitable stand and placed in the inverted position.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

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

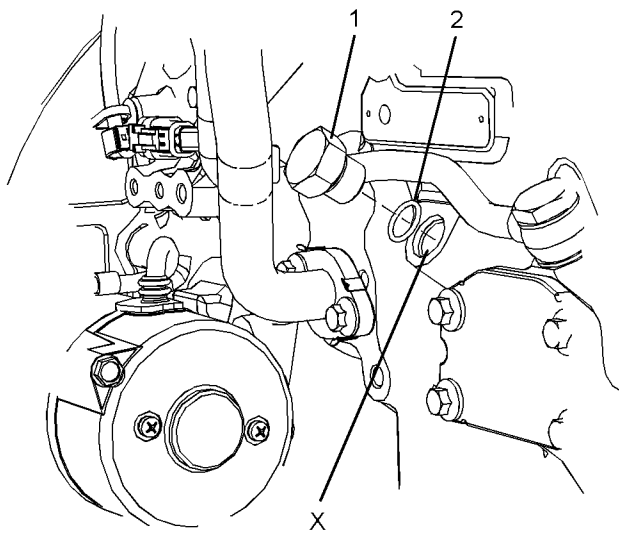


Illustration 414

g02435336

2. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
3. Install Tooling (B) through Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

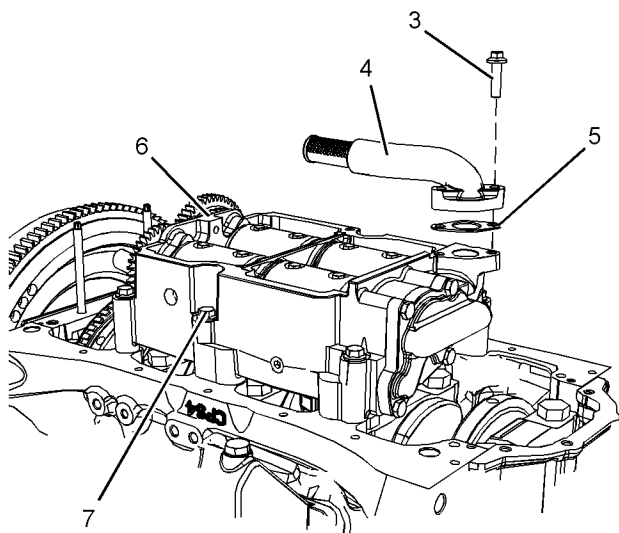


Illustration 415

g02435356

4. Remove bolts (3) from suction pipe (4).
5. Remove suction pipe (4) from balancer (6).
6. Remove gasket (5).
7. Remove bolts (7) from balancer (6).

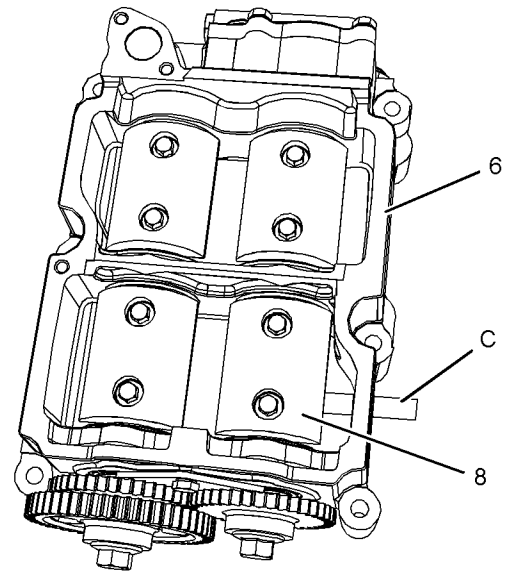


Illustration 416

g02435357

8. Install Tooling (C) into balancer (6). Ensure that Tooling (C) is engaged into the hole in drive shaft (8).
9. Attach a suitable lifting device to balancer (6). Support the weight of the balancer. The balancer weighs approximately 23 kg (51 lb).
10. Use the lifting device to remove balancer (6) from the cylinder block.

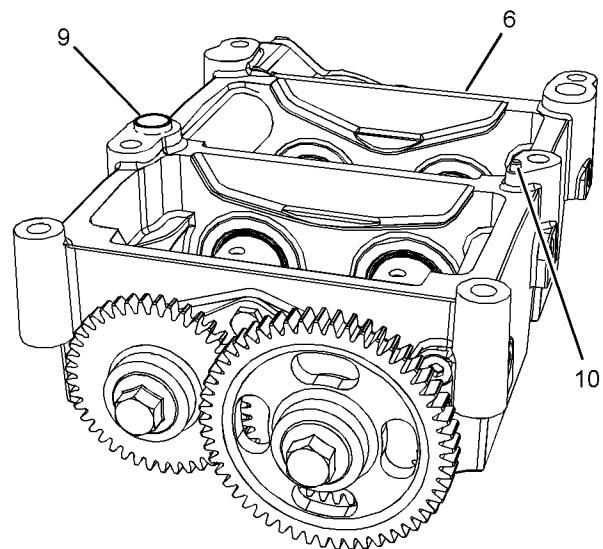


Illustration 417

g02435366

11. Do not remove dowel (9) and dowel (10) from the balancer (6) unless the dowels are damaged.

Note: The balancer unit is not a serviceable item. The engine oil pump and the engine oil relief valve are the only serviceable parts of the balancer.

i05980423

Balancer - Install

Installation Procedure

Table 84

Required Tools			
Tool	Part Number	Part Description	Qty
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
C	27610225	Timing Pin (Balancer)	1
F	21825617	Dial Indicator	1
	-	Magnetic Base and Stand	1
G	-	Guide Studs M10 by 75mm	2

2. Ensure that the surfaces of the cylinder block are clean and free from damage.

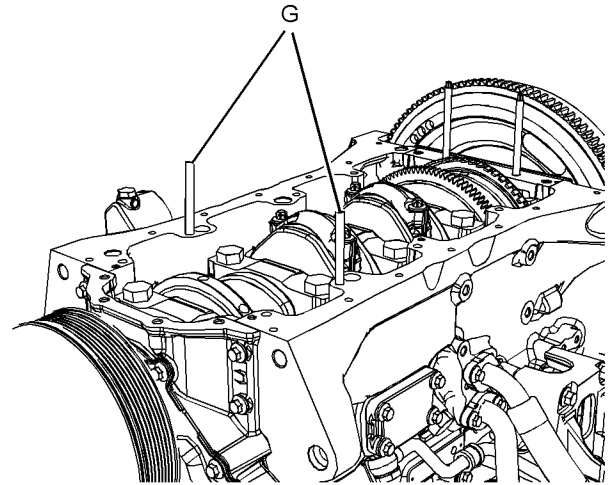


Illustration 419

g02435516

3. Install Tooling (G) to the cylinder block.

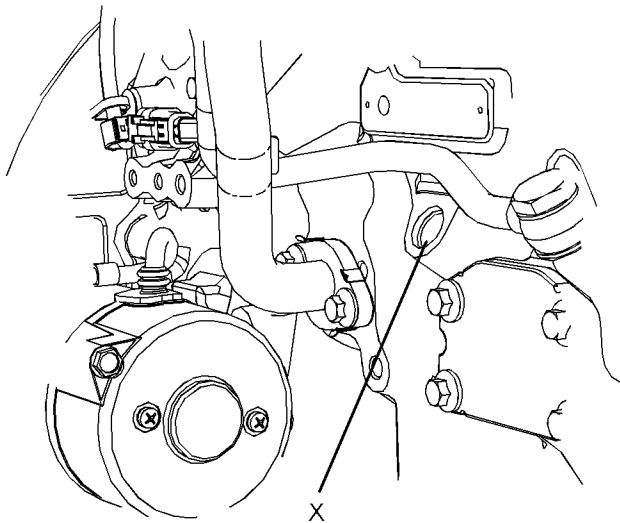


Illustration 418

g02429601

1. Ensure that Tooling (B) is installed in Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (B). Do not use Tooling (B) to hold the crankshaft during repairs.

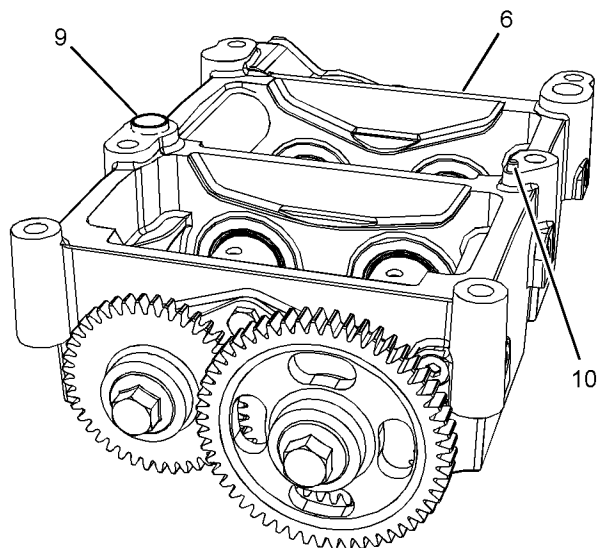


Illustration 420

g02435366

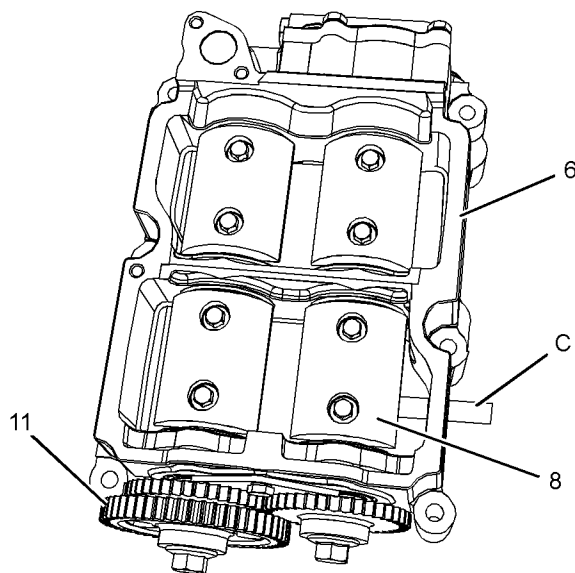


Illustration 421

g02435776

4. Ensure that dowel (9) and dowel (10) are seated in the housing of balancer (6).
5. Install Tooling (C) to balancer (6). Ensure that Tooling (C) is correctly engaged into shaft (8).
6. Attach a suitable lifting device to the balancer. The balancer weighs approximately 23 kg (51 lb).

7. Use the lifting device to align balancer (6) with Tooling (G). Install the balancer to the cylinder block. Ensure that dowel (9) and dowel (10) are aligned with the holes in the cylinder block. Ensure that gear (11) and the crankshaft gear mesh. Remove the lifting device.

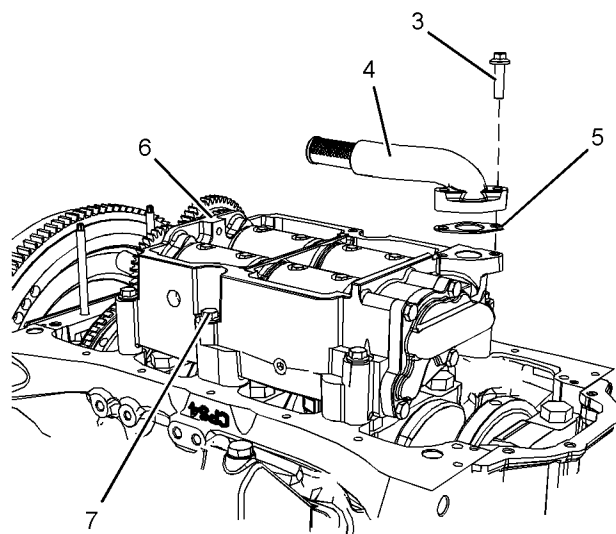


Illustration 422

g02435356

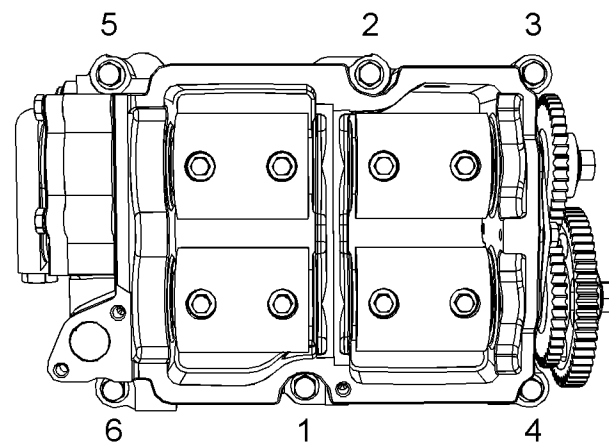


Illustration 423

g02435998

8. Install bolts (7) to balancer (6) and hand tighten the bolts.
9. Remove Tooling (G). Install remaining bolts (7) and hand tighten the bolts.
10. Remove Tooling (C) from balancer (6).

- 11. Tighten the bolts to a torque of 54 N·m (40 lb ft).
Tighten the bolts in the sequence that is shown in Illustration 423 .
 - 12. Position a new gasket (5) onto balancer (6).
 - 13. Position suction pipe (2) onto balancer (6).
- Note:** Ensure that the suction pipe is correctly orientated.
- 14. Install bolts (3) finger tight.
 - 15. Tighten bolts (3) to a torque to 22 N·m (16 lb ft).

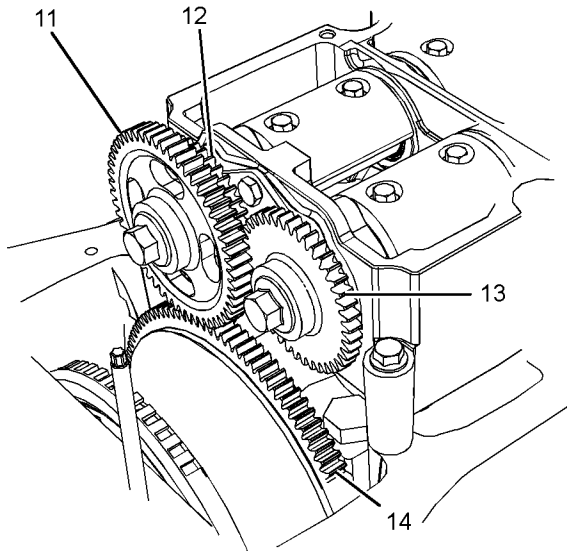


Illustration 424

g02435521

- 16. Use Tooling (F) in order to check the backlash between gear (11) and gear (14). Refer to Specifications, “Balancer Group” for correct information.
- 17. Use Tooling (F) in order to check the backlash between gear (12) and gear (13). Refer to Specifications, “Balancer Group” for correct information.

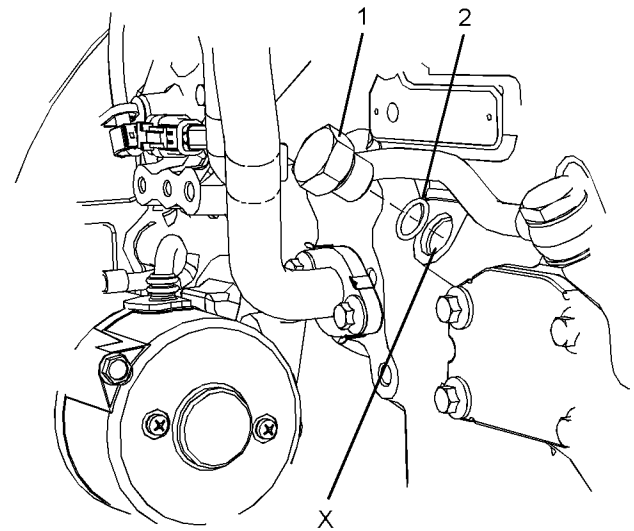


Illustration 425

g02435336

- 18. Remove Tooling (B) from Hole (X) in the cylinder block.
- 19. Install a new O-ring seal (1) to plug (2). Install the plug to the cylinder block. Tighten the plug to a torque of 21 N·m (186 lb in).

End By:

- a. Install the engine oil pan. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

i05981798

Piston Cooling Jets - Remove and Install

Removal Procedure

Table 85

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove" for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove" for the correct procedure.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to gain access to the piston cooling jet.

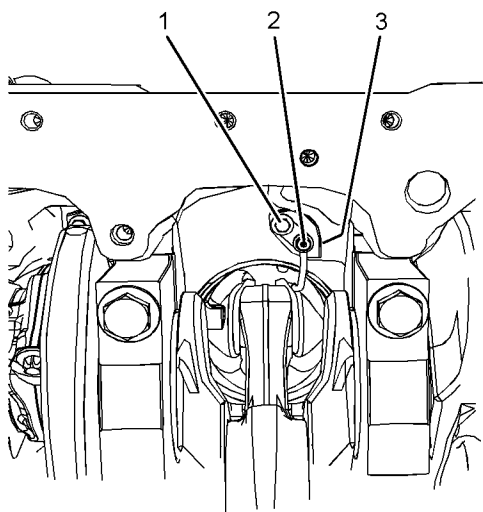


Illustration 426

g02011713

2. Remove bolt (2) and piston cooling jet (1) from the cylinder block. Remove O-ring seal (3).
3. Repeat Step 1 through Step 2 for the remaining piston cooling jets.

Installation Procedure

Table 86

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

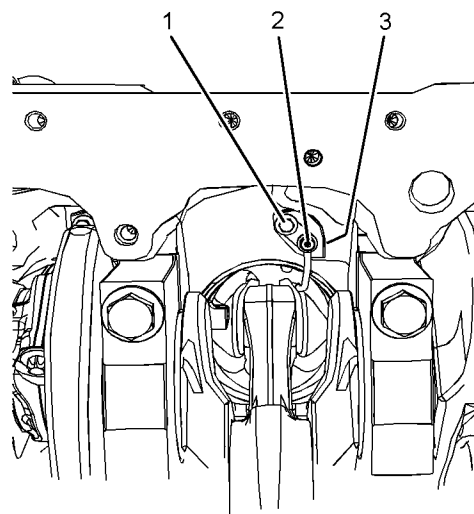


Illustration 427

g02011713

1. Clean the piston cooling jets and inspect the piston cooling jets for damage. Ensure that the valve is free to move within each piston cooling jet. Replace any damaged piston cooling jets. The procedure for checking the alignment of the piston cooling jets is described in Specifications, "Piston Cooling Jet Alignment".
2. If the crankshaft is installed, use Tooling (A) to rotate the crankshaft in order to access the mounting flange for the piston cooling jet.
3. Install a new O-ring seal (3) onto piston cooling jet (2).

4. Position piston cooling jet (2) in the cylinder block. Install bolt (1). Tighten the bolt to a torque of 9 N·m (80 lb in).
5. Repeat Step 2 through Step 4 for the remaining piston cooling jets.

End By:

- a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, “Balancer - Install” for the correct procedure.
- b. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Install” for the correct procedure.

i05981804

Pistons and Connecting Rods - Remove

Removal Procedure

Table 87

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	27610274	Ridge Reamer	1
C	-	E12 Torx Socket	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

Start By:

- a. Remove the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Remove” for the correct procedure.
- b. Remove the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install” for the correct procedure.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

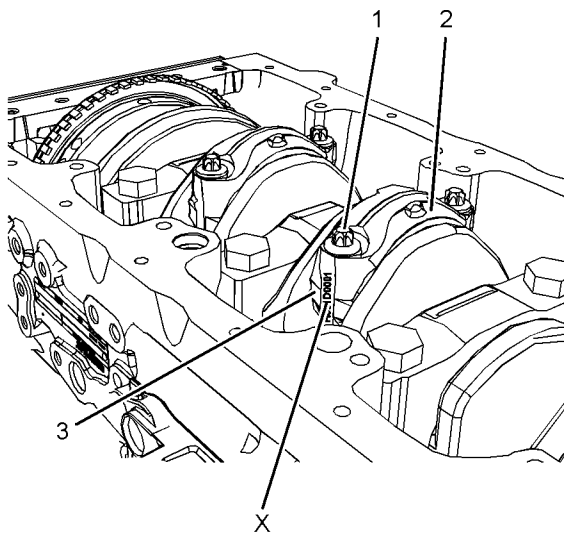


Illustration 428

g02511838

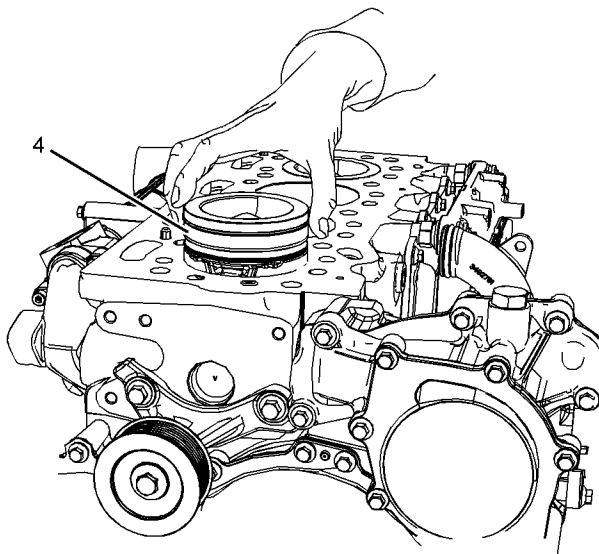


Illustration 429

g02511840

3. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. Ensure that connecting rod (3) and connecting rod cap (2) are marked for the correct location. If necessary, make a temporary mark on the connecting rod and the connecting rod cap in order to identify the cylinder number.

Note: Do not stamp the connecting rod assembly. Stamping or punching the connecting rod assembly could cause the connecting rod to fracture.

4. Use Tooling (C) to remove bolts (1). Remove connecting rod cap (2) from connecting rod (3).
5. Carefully push piston (4) and the connecting rod out of the cylinder bore. Lift piston (4) out of the top of the cylinder block.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result.

6. Repeat Step 1 through Step 5 for the remaining pistons and connecting rods.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. Temporarily install connecting rod cap (2) and bolts (1) to connecting rod (3) when the assembly is out of the engine. Ensure that the etched number on connecting rod cap matches the etched number on connecting rod. Ensure the correct orientation of the connecting rod cap. The locating tab for the upper bearing shell and the lower bearing shell should be on the same side. Tighten bolts (1) to a torque of 20 N·m (177 lb in).

i05981802

Pistons and Connecting Rods - Disassemble

Disassembly Procedure

Table 88

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

Start By:

- a. Remove the pistons and the connecting rods. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Remove" for the correct procedure.

Note: Make a temporary mark on the components of the piston and connecting rod assembly. Marking the components will ensure that the components of each piston and connecting rod assembly can be reinstalled in the original cylinder. Mark the underside of the piston on the front pin boss. Do not interchange components.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

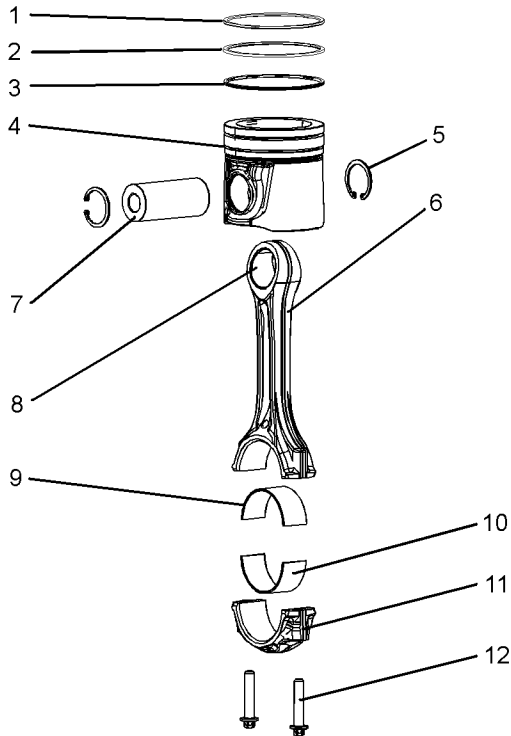


Illustration 430

g02513777

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

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the disassembly procedure for the piston and connecting rod is completed, carry out the assembly procedure and the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Assemble" and Disassembly and Assembly, "Piston and Connecting Rods - Install" for the correct procedure.

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

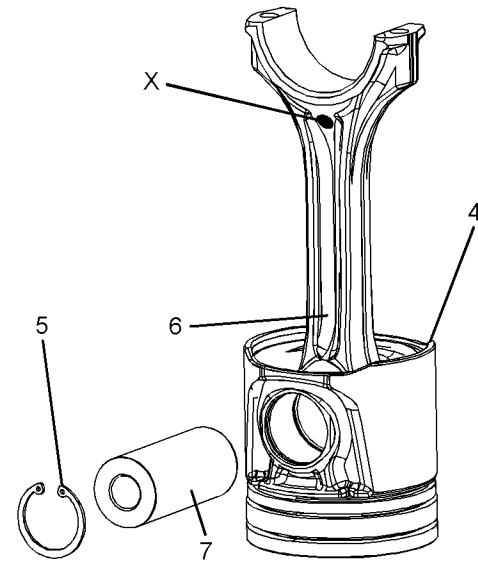


Illustration 431

g02513720

3. Place the piston and connecting rod assembly on a suitable surface with the connecting rod upward. Use Tooling (A) in order to remove circlips (5).

Note: Note the position of the forged Mark (X). The forged mark is for the purposes of correct orientation of the connecting rod assembly and piston assembly.

4. Remove piston pin (7) and connecting rod (6) from piston (4).

Note: If the piston pin cannot be removed by hand, heat the piston to a temperature of $45 \pm 5 \text{ }^\circ\text{C}$ ($113 \pm 9 \text{ }^\circ\text{F}$). Do not use a torch to heat the piston. Note the orientation of connecting rod (6) and piston (4).

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

Note: Identify the position and orientation of compression rings (1) and (2), and oil control ring (3).

NOTICE

Removal of the piston pin bushing 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.

6. Inspect the connecting rod for wear and damage. If necessary, replace connecting rod (6) or replace the bush for piston pin (8).

Note: If the connecting rod or the bush for the piston pin are replaced, refer to Specifications, "Connecting Rods" for the correct procedure.

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

i05981800

Pistons and Connecting Rods - Assemble

Assembly Procedure

Table 89

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that all components are clean and free from wear and damage. If necessary, replace any components that are worn or damaged.
2. If the original piston is assembled, follow Step 2a through Step 2e in order to install the piston rings.
 - a. Position the spring for oil control ring (3) into the oil ring groove in piston (4). The central wire must be located inside the end of the spring.

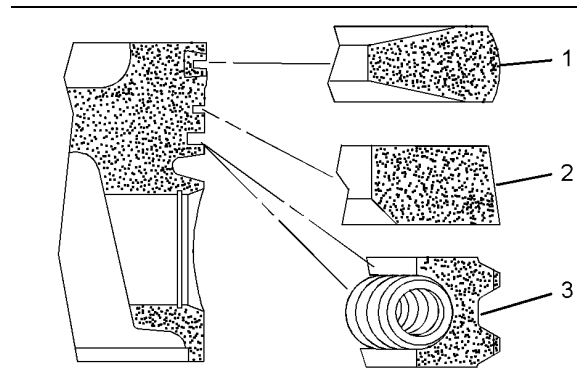


Illustration 432

g02090036

- b. Position the oil control ring with the word "TOP" in the upward position and use Tooling (B) to install oil control ring (3) over the piston and the spring.

Note: Ensure that the central wire is 180 degrees from the ring gap.

- c. Use Tooling (B) to install intermediate compression ring (2) into the second groove in piston (4). The word "TOP" must be upward. The chamfer on the inner face must be downward.
- d. Use Tooling (B) to install top compression ring (1) into the top groove in piston (4). The word "TOP" must be upward.
- e. Position the piston ring gaps at 120 degrees away from each other.

Note: A new piston assembly is supplied with new piston rings.

NOTICE

Removal of the piston pin bushing in the connecting rod must be carried out by personnel with the correct training. Also special machinery is required. For more information refer to your authorized Perkins distributor.

3. If connecting rod assembly (6), the bush for piston pin (8), connecting rod cap (11), and bolts (12) or the bush for piston pin (8) is replaced, refer to Specifications, "Connecting Rods" for further information.

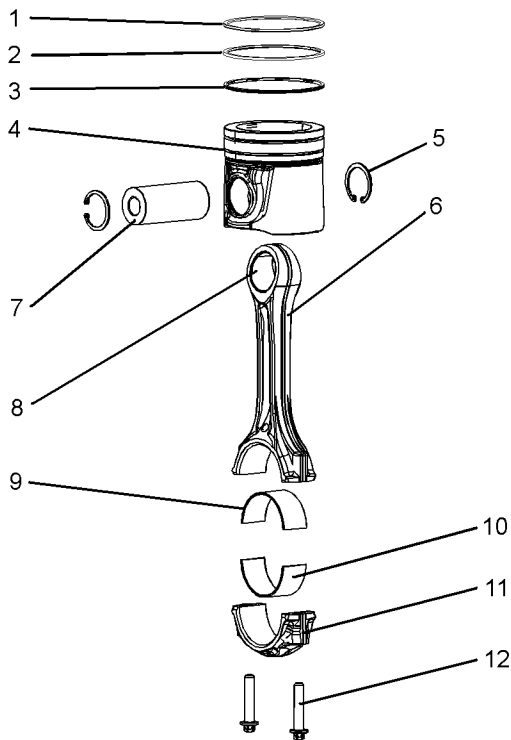


Illustration 433

g02513777

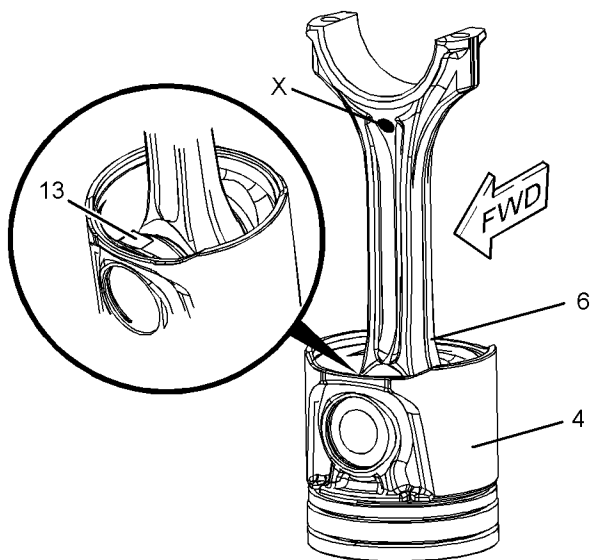


Illustration 434

g02514076

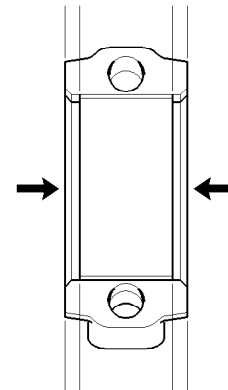


Illustration 435

g02514164

Aligning the connecting rod bearing in the center of the connecting rod

4. Lubricate the bush for piston pin (8) in connecting rod (6) with clean engine oil.
5. Lubricate the bore for the piston pin in piston (4) with clean engine oil.
6. Place piston (4) on a suitable surface with the crown downward. Position connecting rod (6) with the forged Mark (X) to the square (13) on the piston.
7. Install piston pin (7) to piston (4).

Note: If the piston pin cannot be installed by hand, heat the piston to a temperature of $45^{\circ} \pm 5^{\circ}\text{C}$ ($113^{\circ} \pm 9^{\circ}\text{F}$).

8. Use Tooling (A) in order to install circlips (5) to the piston pin bore in piston (4).

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

9. Install upper bearing shell (9) into connecting rod (6). Ensure that the bearing is centralized in the connecting rod. Refer to 435 .
10. Install lower bearing shell (10) into connecting rod cap (11). Ensure that the bearing is centralized in the connecting rod. Refer to 435 .
11. Repeat Step 2 through Step 10 for the remaining piston and connecting rod assemblies.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the assembly procedure for the piston and connecting rod is completed, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Piston and Connecting Rods - Install" for the correct procedure.

End By:

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

i05981803

Pistons and Connecting Rods - Install

Installation Procedure

Table 90

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	21825491	Piston Ring Compressor	1
C	-	E12 Torx Socket	1
D	21825607	Degree Wheel	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used Connecting Rod fasteners.

1. If the connecting rod caps were temporarily installed, remove the connecting rod caps. If necessary, thoroughly clean all of the components.
2. Apply clean engine oil to the cylinder bore, to the piston rings, to the outer surface of the piston and to the bearing shells for the connecting rod.

Note: Install the bearing shells for the connecting rods dry when clearance checks are performed. Refer to Disassembly and Assembly, "Bearing Clearance - Check" for the correct procedure. Apply clean engine oil to the bearing shells for the connecting rods during final assembly.

Note: Ensure that the piston and the connecting rod assembly are installed in the correct cylinder.

3. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom center position. Lubricate the crankshaft pin with clean engine oil.

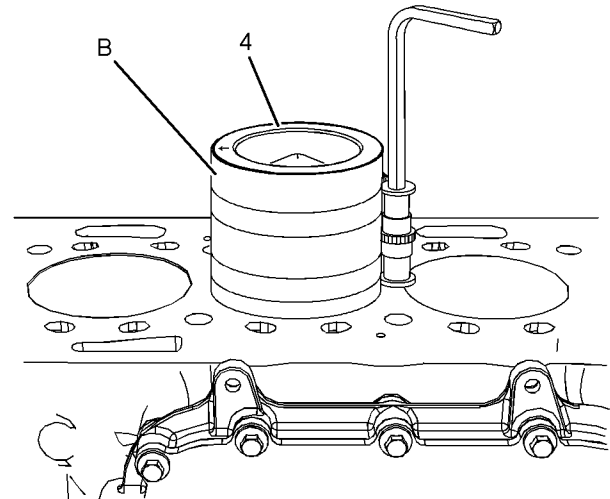


Illustration 436

g02013213

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

Note: Ensure that Tooling (B) is installed correctly and that piston (4) can easily slide from the tool.

Note: The arrow on the top of the piston must be toward the front of the engine. The locating tab for the bearing shell of the connecting rod must be on the same side of the engine as the piston cooling jet.

5. Carefully push the piston and the connecting rod assembly into the cylinder bore and onto the crankshaft pin.

Note: Do not damage the finished surface of the crankshaft pin.

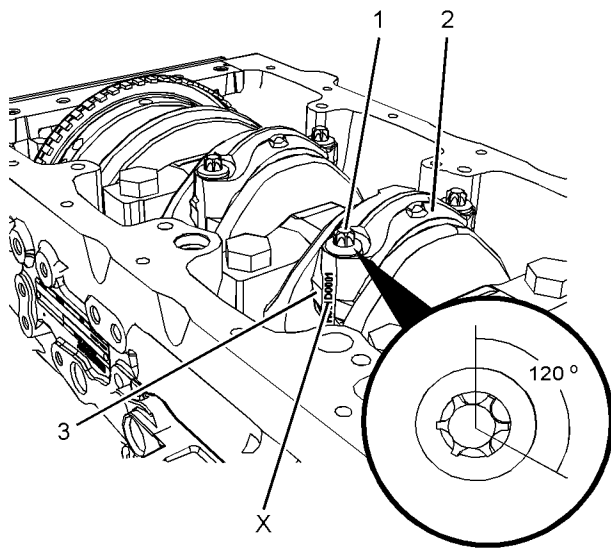


Illustration 437

g02512136

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

Note: Ensure that etched Number (X) on connecting rod cap (2) matches etched Number (X) on connecting rod (3). Ensure the correct orientation of connecting rod cap (2). The locating tab for the upper bearing shell and the lower bearing shell should be on the same side.

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

7. Install new bolts (1) to connecting rod (3). Use Tooling (C) to tighten the bolts evenly to a torque of 40 N·m (30 lb ft).
8. Turn the bolts for an additional 120 degrees in a clockwise direction. Use Tooling (C) and Use Tooling (C) to achieve the correct final torque.
9. Ensure that the installed connecting rod assembly has tactile side play. Rotate the crankshaft in order to ensure that there is no binding.
10. Repeat Step 2 through Step 9 in order to install the remaining pistons and connecting rods.

End By:

- a. Install the piston cooling jets. Refer to Disassembly and Assembly, “Piston Cooling Jets - Remove and Install” for the correct procedure.
- b. Install the cylinder head. Refer to Disassembly and Assembly, “Cylinder Head - Install” for the correct procedure.

i05980451

Connecting Rod Bearings - Remove (Connecting Rods in Position)

Removal Procedure

Table 91

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	E12 Torx Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, “Balancer - Remove” for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, “Engine Oil Pump - Remove” for the correct procedure.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used Connecting Rod fasteners.

Note: If all connecting rod bearings require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders.** Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install" for the correct procedure.

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

If necessary, remove the glow plugs. Ref to Disassembly and Assembly, "Glow Plugs - Remove and Install" for the correct procedure.

Note: Removal of glow plug aids removal of the connecting rod bearing. Removal of glow plug is not essential.

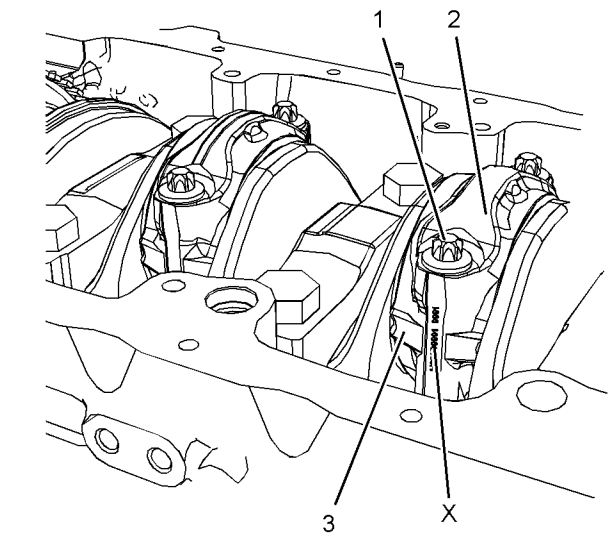


Illustration 438

g02437998

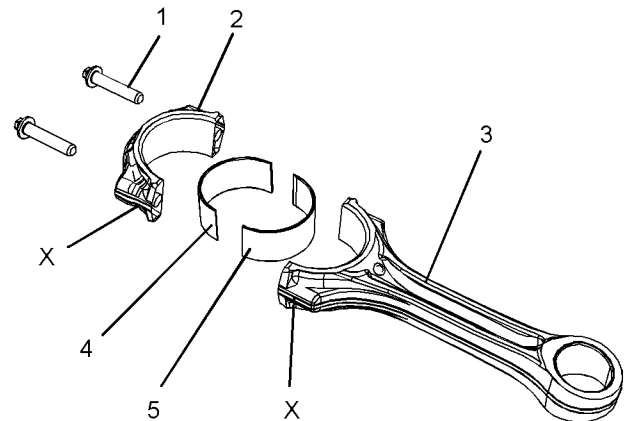


Illustration 439

g02437999

2. The connecting rod and the connecting rod cap should have an etched Number (X) on the side. The number on the connecting rod and the connecting rod cap must match. If necessary, make a temporary mark on connecting rod (3) and connecting rod cap (2) in order to identify the cylinder number.

Note: Do not punch identification marks onto fracture split connecting rods. Do not stamp identification marks onto fracture split connecting rods.

3. Use Tooling (B) to remove bolts (1). Remove connecting rod cap (2) from connecting rod (3). Discard bolts (1).
4. Remove lower bearing shell (4) from connecting rod cap (2). Keep the bearing shell and the connecting rod cap together.
5. Carefully push connecting rod (3) into the cylinder bore until connecting rod (3) is clear of the crankshaft. Remove upper bearing shell (5) from the connecting rod. Keep the bearing shells together.

Note: Do not push on the fracture split surfaces of the connecting rod as damage may result. Do not allow the connecting rod to contact the piston cooling jet.

6. Repeat Step 1 through Step 5 for the remaining bearing shells.

Note: Fracture split connecting rods should not be left without the connecting rod caps installed. After the removal procedure for the bearing shells is complete, carry out the installation procedure as soon as possible. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install" for the correct procedure.

i05980448

Connecting Rod Bearings - Install (Connecting Rods in Position)

Installation Procedure

Table 92

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	E12 Torx Socket	1
C	21825607	Degree Wheel	1

⁽¹⁾ The Crankshaft Turning Tool is used on the front pulley.

⁽²⁾ This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

Discard all used Connecting Rod fasteners.

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

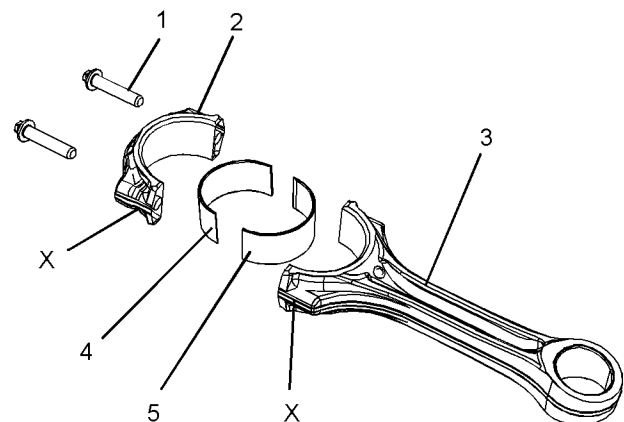


Illustration 440

g02437999

2. Install upper bearing shell (5) into connecting rod (3). Ensure that the locating tab for the upper bearing shell is correctly seated in the slot in the connecting rod.

Note: The ends of the upper bearing shell must be centered in the connecting rod. The ends of the upper bearing shell must be equally positioned in relation to the mating faces of the connecting rod.

3. Lubricate upper bearing shell (5) with clean engine oil.
4. Use Tooling (A) to rotate the crankshaft until the crankshaft pin is at the bottom dead center position.

5. Carefully pull connecting rod (3) against the crankshaft pin.

Note: Do not allow the connecting rod to contact the piston cooling jet.

6. Clean connecting rod cap (2). Install lower bearing shell (4) into connecting rod cap (2). Ensure that the locating tab for the lower bearing shell is correctly seated in the slot in the connecting rod cap.
7. Lubricate the pin of the crankshaft and lubricate lower bearing shell (4) with clean engine oil.

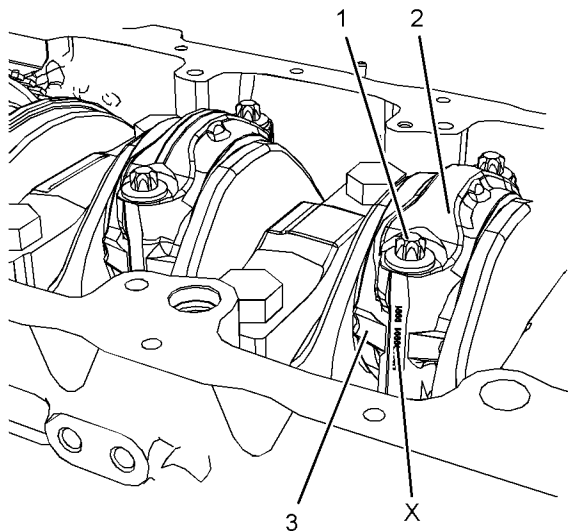


Illustration 441

g02437998

8. Install connecting rod cap (2) to connecting rod (3).

Note: Ensure that etched Number (X) on connecting rod cap (2) matches etched Number (X) on connecting rod (3). Ensure the correct orientation of the connecting rod cap. The locating tab for the upper bearing shell and the lower bearing shell should be on the same side.

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

9. Install new bolts (1) to the connecting rod. Use Tooling (B) tighten the bolts evenly to a torque of 40 N·m (30 lb ft).
10. Turn the bolts through an additional 120 degrees in a clockwise direction. Use Tooling (B) and Tooling (C) to achieve the correct final torque.
11. Ensure that the installed connecting rod assembly has tactile side play. Rotate the crankshaft in order to ensure that there is no binding.

12. Repeat Step 2 through Step 11 for the remaining connecting rod bearings.

Note: If all connecting rod bearings require replacement, the procedure can be carried out on two cylinders at the same time. The procedure can be carried out on the following pairs of cylinders. 1 with 4 and 2 with 3. **Ensure that both pairs of the connecting rod bearings are installed before changing from one pair of cylinders to another pair of cylinders.** Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install" for the correct procedure.

13. If the glow plugs were removed, install the glow plugs. Ref to Disassembly and Assembly, "Glow Plugs - Remove and Install" for the correct procedure.

End By:

- a. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install" for the correct procedure.
- b. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install" for the correct procedure.

i05980471

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

Removal Procedure

Table 93

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Housing	1
	27610289	Engine Turning Tool	1
B	-	5mm Allen Socket	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove" for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove" for the correct procedure.
- c. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" for the correct procedure.

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

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

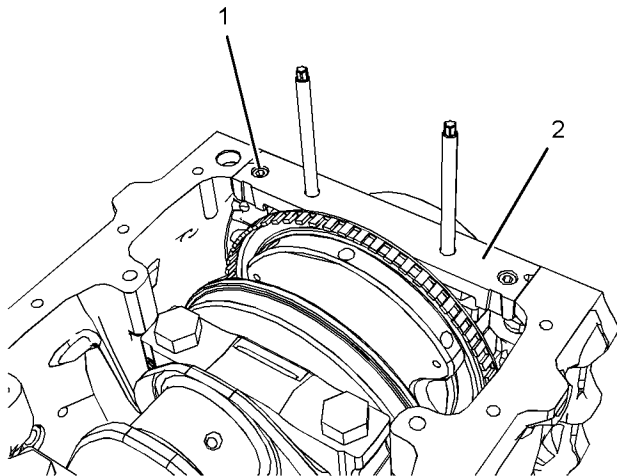


Illustration 442

g02441836

1. Use Tooling (B) in order to remove allen head screws (1). Remove bridge piece (2).

2. Ensure that the main bearing cap is marked for the correct location and orientation.

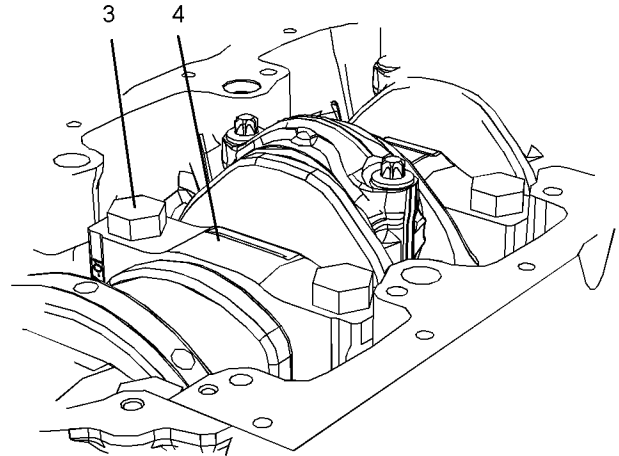


Illustration 443

g02447416

3. Remove bolts (3) and main bearing cap (4) from the cylinder block.

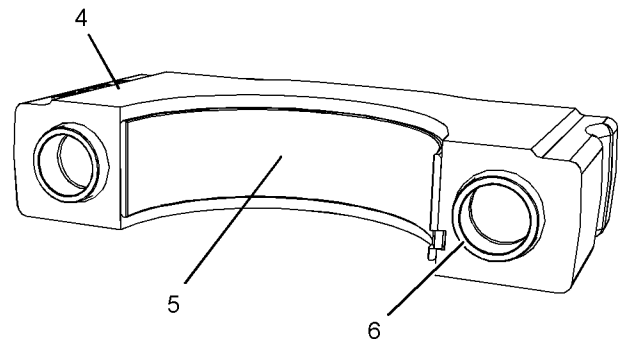


Illustration 444

g02447418

4. Remove lower main bearing shell (5) from main bearing cap (4). Keep the main bearing shell and the main bearing cap together. Take care not to displace dowels (6).

Note: The lower main bearing shell is a plain bearing that has no oil holes.

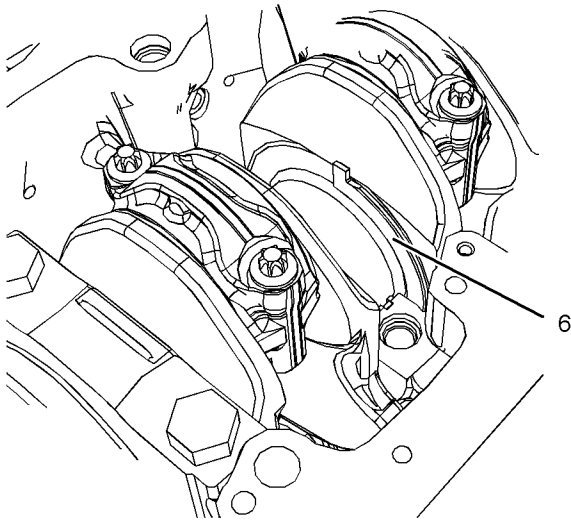


Illustration 445

g02447419

5. For number No. 3 main bearing, remove two thrust washers (7) from the cylinder block. In order to remove thrust washers (7), use Tooling (A) to rotate the crankshaft in the correct direction. If necessary, push the crankshaft toward the front of the engine or push the crankshaft toward the rear of the engine while you rotate the crankshaft, in order to aid removal.

Note: The thrust washers have a locating tab at one end.

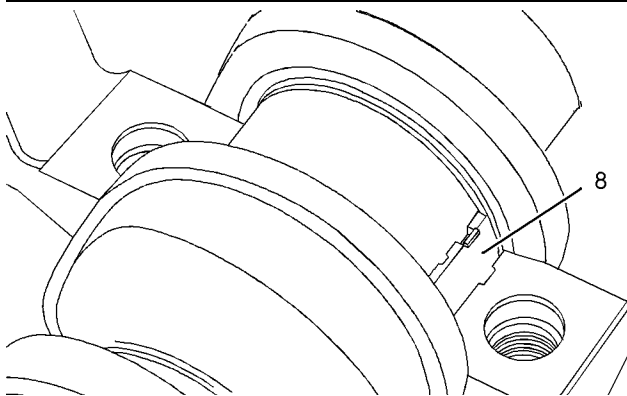


Illustration 446

g02447420

6. Push out upper main bearing shell (8) with a suitable tool from the side opposite the locating tab. Carefully rotate the crankshaft while you push on the bearing shell. Remove upper main bearing shell (8) from the cylinder block. Keep the bearing shells together.

Note: The upper main bearing shell has a groove and two oil holes.

Installation Procedure

Table 94

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	5mm Allen Socket	1
C	21825617	Dial Indicator	1
D	-	Magnetic Base and Stand	1
E	-	Straight Edge	1
F	-	Loctite 5900 Silicon Sealant	1

NOTICE

This procedure must only be used to remove and install the main bearing shells with the crankshaft in position.

The removal procedure and the installation procedure must be completed for each pair of main bearing shells before the next pair of main bearing shells are removed.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the main bearing shells are clean and free from wear and damage. If necessary, replace the main bearing shells.
2. Clean the journals of the crankshaft. Inspect the journals of the crankshaft for damage. If necessary, replace the crankshaft or recondition the crankshaft.

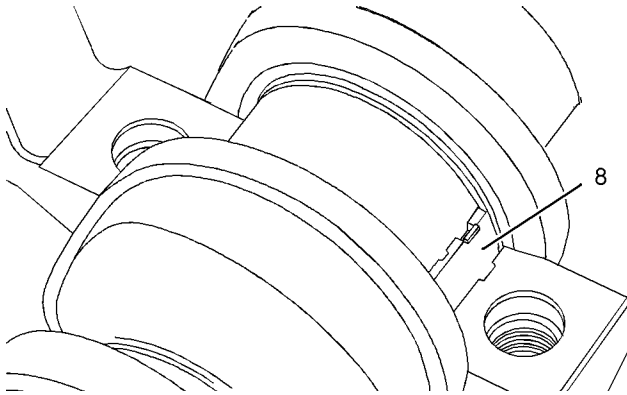


Illustration 447

g02447420

3. Lubricate the crankshaft journal and upper main bearing shell (8) with clean engine oil. Slide upper main bearing shell (8) into position between the crankshaft journal and the cylinder block. Ensure that the locating tab for the upper main bearing shell is correctly seated in the slot in the cylinder block.

Note: The upper main bearing shell has a groove and two oil holes.

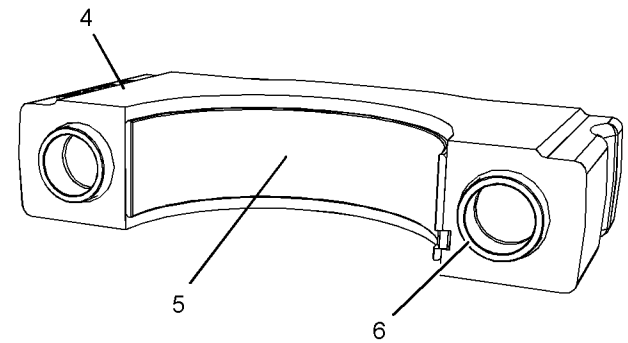


Illustration 449

g02447418

5. Install lower main bearing shell (3) into main bearing cap (2). Ensure that the locating tab for the lower main bearing shell is correctly seated into the slot in the bearing cap. Ensure that the dowel (6) is correctly located.

Note: The lower main bearing shell is a plain bearing that has no oil holes.

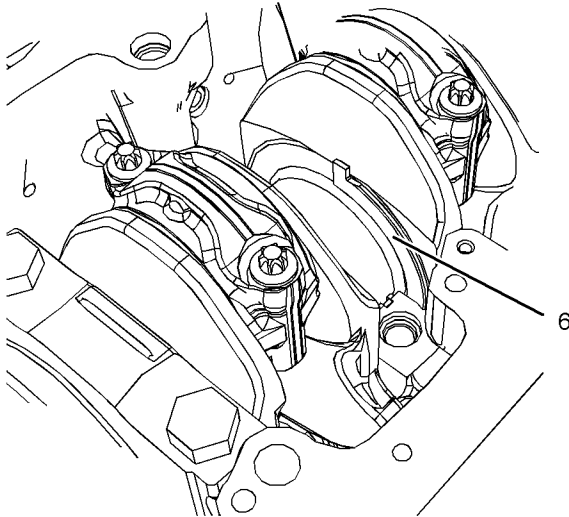


Illustration 448

g02447419

4. For number No. 3 main bearing, ensure that two thrust washers (7) are clean and free from wear and damage. If necessary, replace the thrust washers. Lubricate thrust washers (7) with clean engine oil. Slide thrust washers (4) into position between the crankshaft and the cylinder block. Ensure that the locating tab is correctly seated in the cylinder block.

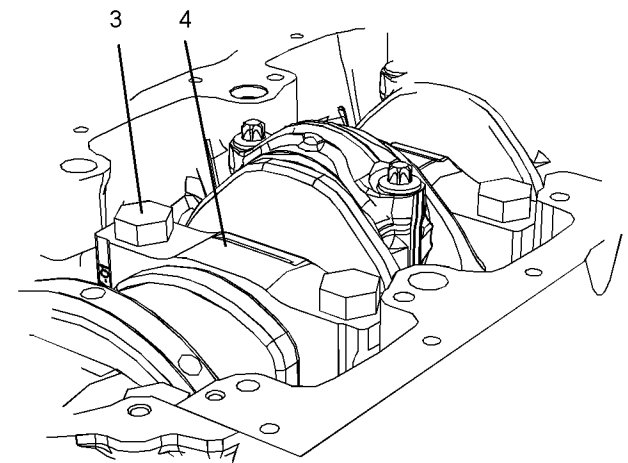


Illustration 450

g02447416

6. Lubricate the crankshaft journal and the lower main bearing shell with clean engine oil. Install lower main bearing cap (4) to the cylinder block.

Note: Ensure the correct orientation of the main bearing cap. The locating tab for the upper and the lower bearing should be on the same side of the engine.

Disassembly and Assembly Section

7. Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of bolts (3) with clean engine oil.

8. Install bolts (3) to main bearing cap (4). Evenly tighten the bolts in order to pull cap (3) into position. Ensure that the cap is correctly seated.

Note: Do not tap the main bearing cap into position as the bearing shell may be dislodged.

9. Tighten bolts (3) to a torque of 245 N·m (181 lb ft).

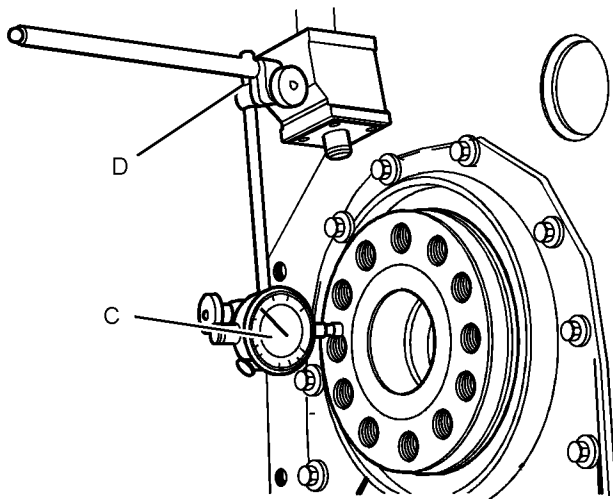


Illustration 451

g03747118

10. Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (D) and Tooling (C) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (C) to measure the crankshaft end play. The permissible crankshaft end play is 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).

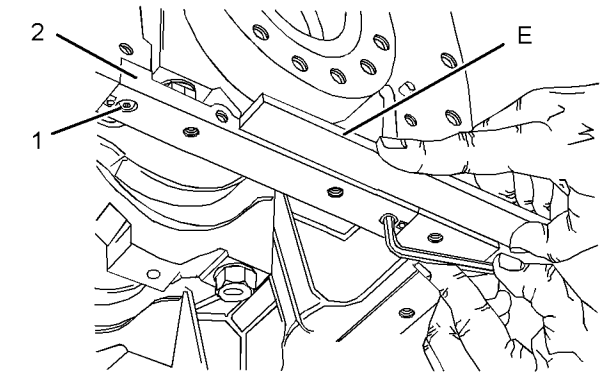


Illustration 452

g03747119

11. Follow Steps 11a through Step 11d in order to install the bridge piece.

- Ensure that the cylinder block and the bridge piece are clean, dry, and free from old sealant.
- Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.
- Use Tooling (E) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
- Use Tooling (B) in order to tighten the allen head screws to a torque of 16 N·m (142 lb in).

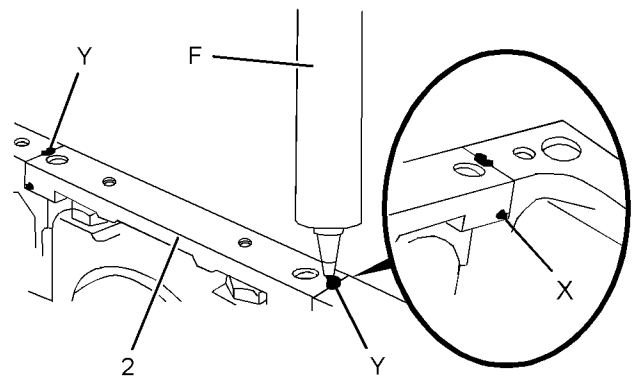


Illustration 453

g03747120

12. Apply Tooling (F) to cavities (Y) in the bridge piece (2). Continue to apply Tooling (F) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

- a. Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install" for the correct procedure.
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install" for the correct procedure.
- c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install" for the correct procedure.

i05980463

Crankshaft - Remove

Removal Procedure

Table 95

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Slings	2
B	-	5mm Allen Socket	1

Start By:

- a. If the engine is equipped with a balancer, remove the balancer. Refer to Disassembly and Assembly, "Balancer - Remove" for the correct procedure.
- b. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Remove" for the correct procedure.
- c. Remove the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Remove" for the correct procedure.
- d. Remove the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Remove" for the correct procedure.
- e. Remove the rocker shaft and pushrods. Refer to Disassembly and Assembly, "Rocker Shaft and Pushrod - Remove" for the correct procedure.
- f. If necessary, remove the cylinder head. Refer to Disassembly and Assembly, "Cylinder Head - Remove" for the correct procedure.
- g. If necessary, remove the pistons and connecting rods. Refer to Disassembly and Assembly, "Pistons and Connecting Rods - Remove" for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. The engine should be mounted on a suitable stand and placed in the inverted position.
2. If the cylinder head, the pistons and the connecting rods have not been removed already, remove the connecting rod bearings. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Remove" for the correct procedure.

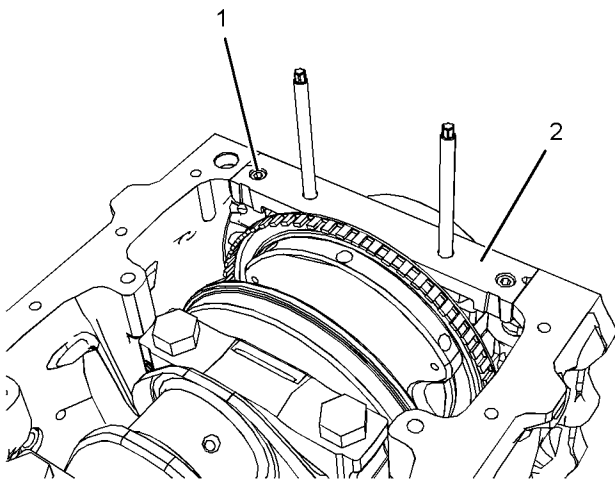


Illustration 454

g02441836

3. Use Tooling (B) in order to remove allen head screws (1). Remove bridge piece (2).
4. Ensure that the main bearing caps are marked for the location and orientation.

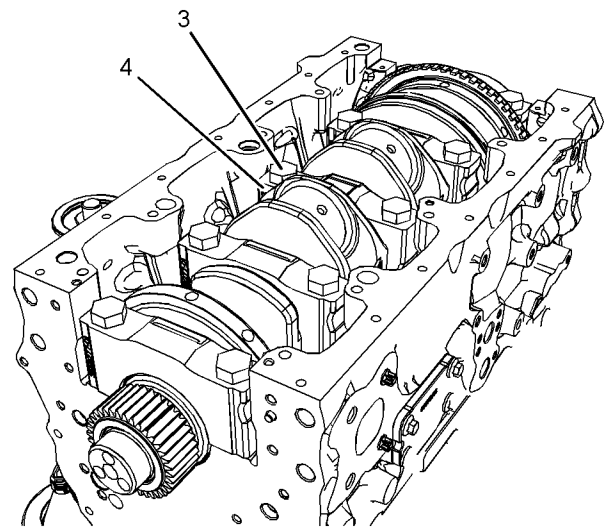


Illustration 455

g02441837

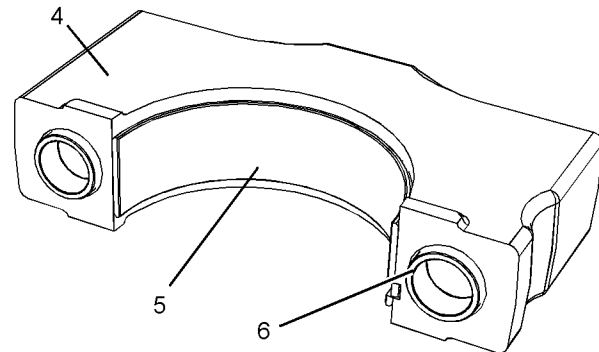


Illustration 456

g02441838

5. Remove bolts (3) from main bearing caps (2). Remove main bearing caps (2) from the cylinder block.
6. Take care not to displace dowels (6).
7. Remove lower main bearing shells (5) from main bearing caps (4). Keep the lower main bearing shells with the respective main bearing caps.

Note: The lower main bearing shells are plain bearings that have no oil holes.

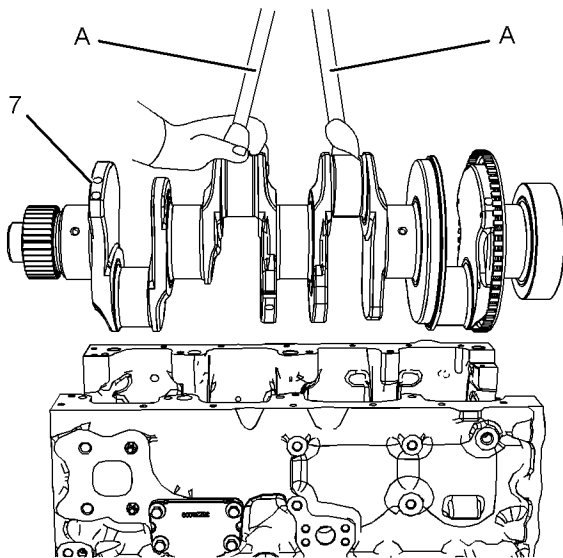


Illustration 457

g02441839

8. Attach Tooling (A) and a suitable lifting device to crankshaft (7). Lift crankshaft (7) out of the cylinder block. The weight of the crankshaft is approximately 39 kg (86 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. When the crankshaft is removed from the engine, the crankshaft must be supported on a suitable stand in order to prevent damage to the crankshaft timing ring.

Note: The upper main bearing shells have a groove and two oil holes.

10. Remove thrust washers (7).

11. If necessary, remove the crankshaft timing ring. Refer to Disassembly and Assembly, "Crankshaft Timing Ring - Remove and Install" for the correct procedure.

12. If necessary, remove the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install" for the correct procedure.

i05980460

Crankshaft - Install

Installation Procedure

Table 96

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Lifting Slings	2
B	-	5mm Allen Socket	1
C	21825617	Dial Indicator	1
D	-	Magnetic Base and Stand	1
E	-	Straight Edge	1
F	-	Loctite 5900 Silicon Sealant	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

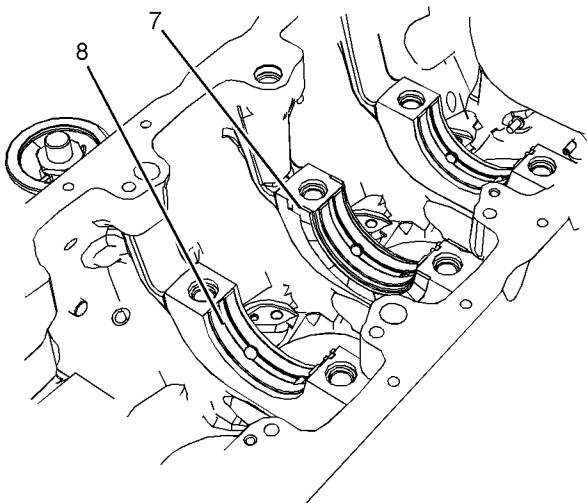


Illustration 458

g02441840

9. Remove upper main bearing shells (8) from the cylinder block. Keep the upper main bearing shells with the respective main bearing caps.

1. Clean the crankshaft and inspect the crankshaft for wear and damage. Refer to Specifications, "Crankshaft" for more information. If necessary, replace the crankshaft or recondition the crankshaft.

2. If necessary, install the crankshaft gear. Refer to Disassembly and Assembly, "Crankshaft Gear - Remove and Install" for the correct procedure.

3. If necessary, install a new crankshaft timing ring. Refer to Disassembly and Assembly, "Crankshaft Timing Ring - Remove and Install" for the correct procedure.

4. Ensure that parent bores for bearing shells in the cylinder block are clean. Ensure that the threads for the main bearing bolts in the cylinder block are clean and free from damage.

Disassembly and Assembly Section

5. Clean the main bearing shells and the thrust washers. Inspect the main bearing shells and the thrust washers for wear and damage. If necessary, replace the main bearing shells and the thrust washers.

Note: If the main bearing shells are replaced, check whether oversize main bearing shells were previously installed. If the thrust washers are replaced, check whether oversize thrust washers were previously installed.

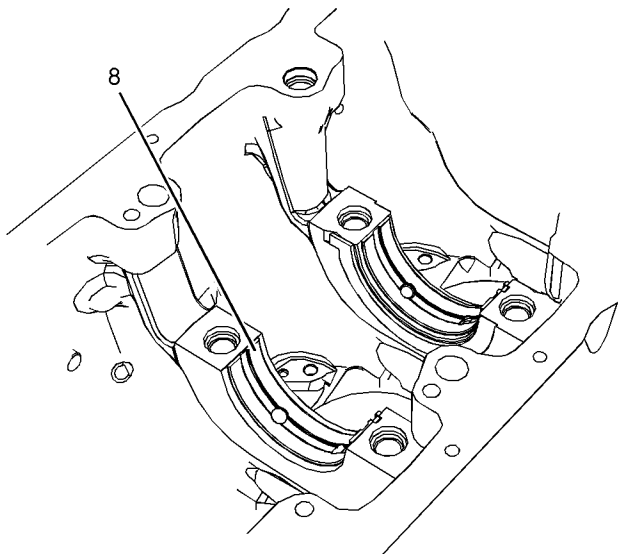


Illustration 459

g02443436

6. Install upper main bearing shells (8) to the cylinder block. Ensure that the locating tabs for the upper main bearing shells are seated in the slots in the cylinder block.

Note: The upper main bearing shells have a groove and two oil holes.

7. Lubricate upper main bearing shells (8) with clean engine oil.

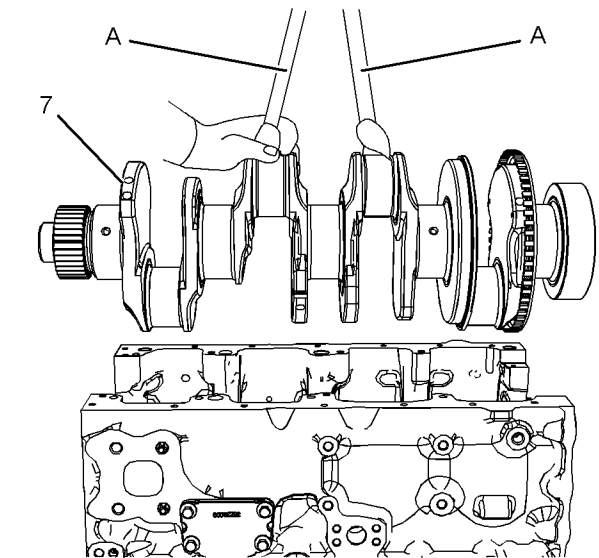


Illustration 460

g02441839

8. Attach Tooling (A) and a suitable lifting device to crankshaft (7). Lift crankshaft (7) into the cylinder block. The weight of the crankshaft is approximately 39 kg (86 lb).

Note: Do not damage any of the finished surfaces on the crankshaft. Do not damage the main bearing shells.

9. Remove Tooling (A) after installation of the crankshaft to the cylinder block.

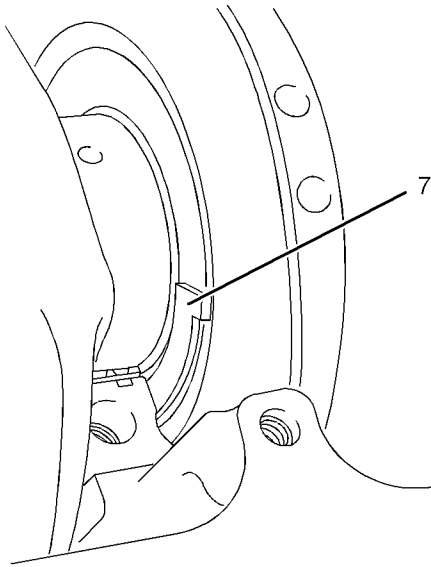


Illustration 461

g02442118

- 10.** Lubricate thrust washers (7) with clean engine oil. Install thrust washers (7) to No. 3 main bearing in the cylinder block.

Note: The grooves in the thrust washers must be located against the crankshaft. The thrust washers have a locating tab at one end. Ensure that the locating tabs are correctly seated in the cylinder block.

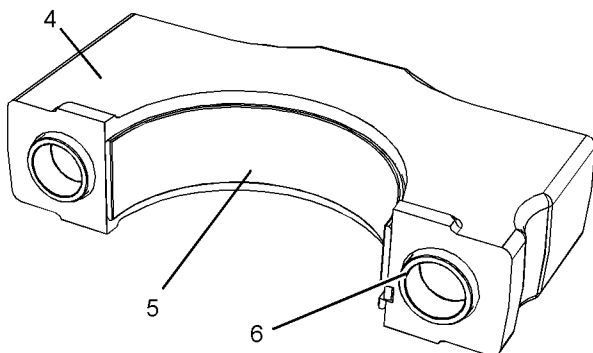


Illustration 462

g02441838

- 11.** Install lower main bearing shells (5) into main bearing caps (4). Ensure that the locating tabs for the lower main bearing shells are correctly seated into the slots in the bearing caps.

Note: The lower main bearing shells are plain bearings that do not have oil holes.

- 12.** Ensure that the dowels (6) are correctly located.

- 13.** Lubricate lower main bearing shells (5) and lubricate the journals of the crankshaft with clean engine oil. Install main bearing caps (4) to the cylinder block.

Note: Ensure the correct location and orientation of main bearing caps (4). The locating tabs for the upper and the lower main bearing shells should be on the same side of the engine.

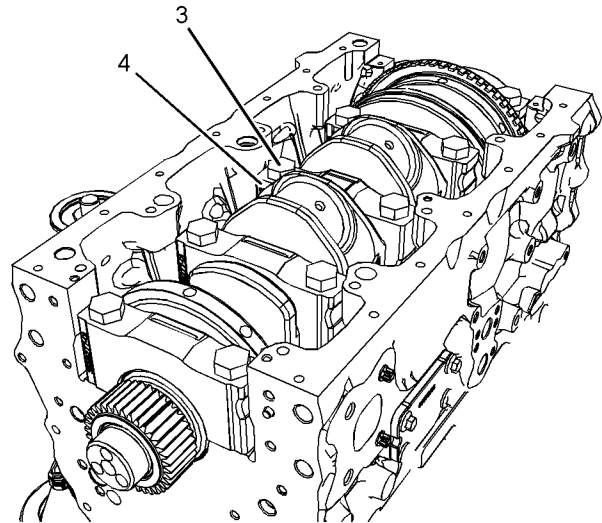


Illustration 463

g02441837

- 14.** Lubricate the threads of bolts (3) with clean engine oil. Lubricate the underside of the heads of bolts (3) with clean engine oil.

- 15.** Install bolts (3) to main bearing caps (4). Evenly tighten the bolts in order to pull the caps into position. Ensure that the caps are correctly seated.

Note: Do not tap the main bearing caps into position as the bearing shells may be dislodged.

- 16.** Tighten bolts (3) to a torque of 245 N·m (181 lb ft).

- 17.** Rotate the crankshaft in order to ensure that there is no binding.

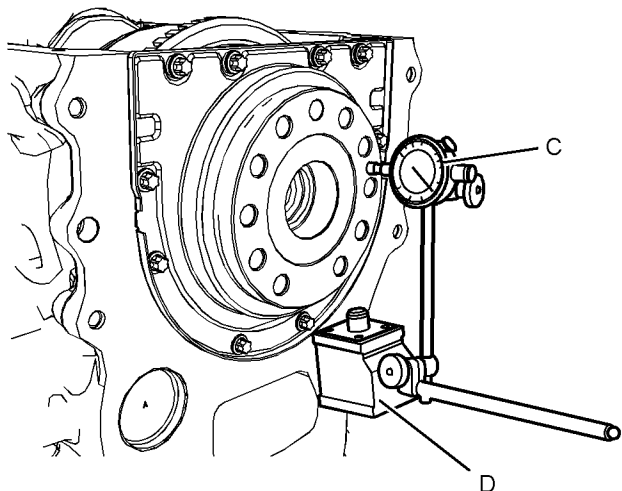


Illustration 464

g03747103

- 18.** Check the crankshaft end play. Push the crankshaft toward the front of the engine. Install Tooling (C) to the cylinder block and the rear face of the crankshaft. Push the crankshaft toward the rear of the engine. Use Tooling (C) and Tooling (D) to measure the crankshaft end play. The permissible crankshaft end play is 0.10 mm (0.004 inch) to 0.41 mm (0.016 inch).
- 19.** If the crankshaft has been replaced or the crankshaft has been reconditioned, inspect the height of the piston above the cylinder block. Refer to System Operation, Testing and Adjusting, "Piston Height - Inspect" for more information.
- 20.** If the crankshaft has not been replaced or the crankshaft has not been reconditioned, install the connecting rod bearings. Refer to Disassembly and Assembly, "Connecting Rod Bearings - Install" for the correct procedure.

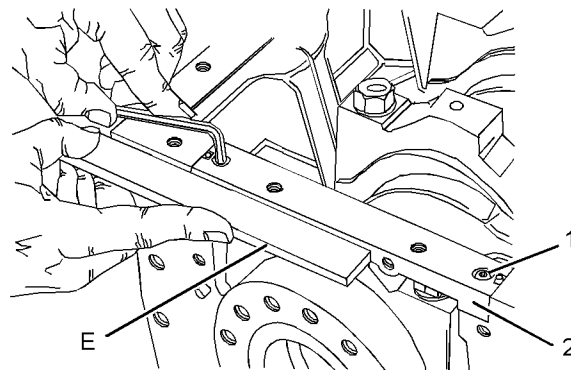


Illustration 465

g03747104

- 21.** Follow Steps 21a through Step 21d in order to install the bridge piece.
- Ensure that the cylinder block and the bridge piece are clean, dry, and free from old sealant.
 - Install bridge piece (2) and allen head screws (1). Tighten the allen head screws finger tight.
 - Use Tooling (E) in order to align the rear face of the bridge piece with the rear face of the cylinder block.
 - Use Tooling (B) in order to tighten the allen head screws to a torque of 16 N·m (142 lb in).
- 22.** Install the crankshaft rear seal. Refer to Disassembly and Assembly, "Crankshaft Rear Seal - Install" for the correct procedure.

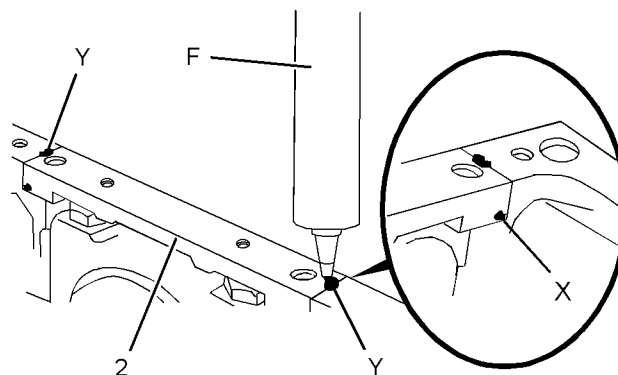


Illustration 466

g03747106

- 23.** Apply Tooling (F) to cavities (Y) in the bridge piece (2). Continue to apply Tooling (F) until sealant extrudes from cavities (X).

Note: If the oil pan will not be installed immediately, ensure that the joint face of the bridge piece and the cylinder block are left free of sealant.

End By:

- a. If necessary, install the pistons and connecting rods. Refer to **Disassembly and Assembly, "Pistons and Connecting Rods - Install"** for the correct procedure.
- b. If necessary, install the cylinder head. Refer to **Disassembly and Assembly, "Cylinder Head - Install"** for the correct procedure.
- c. Install the rockershaft and pushrods. Refer to **Disassembly and Assembly, "Rocker shaft and Push Rods - Install"** for the correct procedure.
- d. Install the crankshaft rear seal. Refer to **Disassembly and Assembly, "Crankshaft Rear Seal - Install"** for the correct procedure.
- e. Install the front housing. Refer to **Disassembly and Assembly, "Housing (Front) - Install"** for the correct procedure.
- f. If the engine is equipped with a balancer, remove the balancer. Refer to **Disassembly and Assembly, "Balancer - Remove"** for the correct procedure.
- g. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to **Disassembly and Assembly, "Engine Oil Pump - Remove"** for the correct procedure.

i05982982

Crankshaft Timing Ring - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankshaft. Refer to **Disassembly and Assembly, "Crankshaft - Remove"** for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

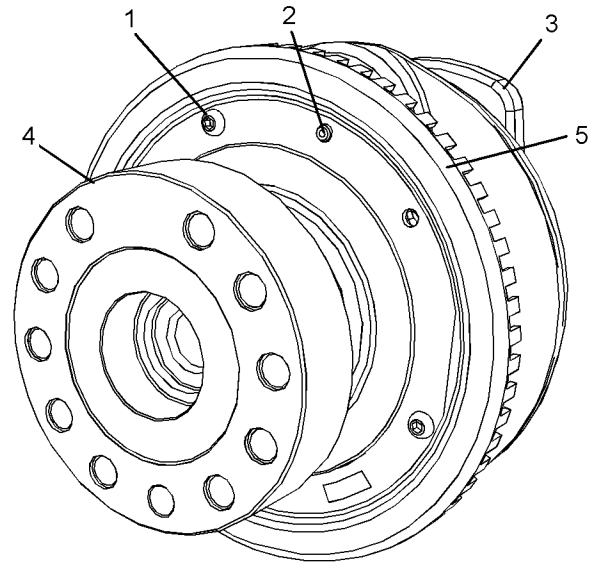


Illustration 467

g02452037

1. Support crankshaft (3) on a suitable stand.
2. Remove allen head screws (1) from crankshaft timing ring (5). Do not reuse the allen head screws.
3. Carefully remove crankshaft timing ring (5) from crankshaft (3). Do not reuse the crankshaft timing ring.

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

Note: Do not remove dowel (2) from crankshaft (3) unless the dowel is damaged.

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Ensure that the flange for the crankshaft timing ring on the crankshaft is clean and free from damage.

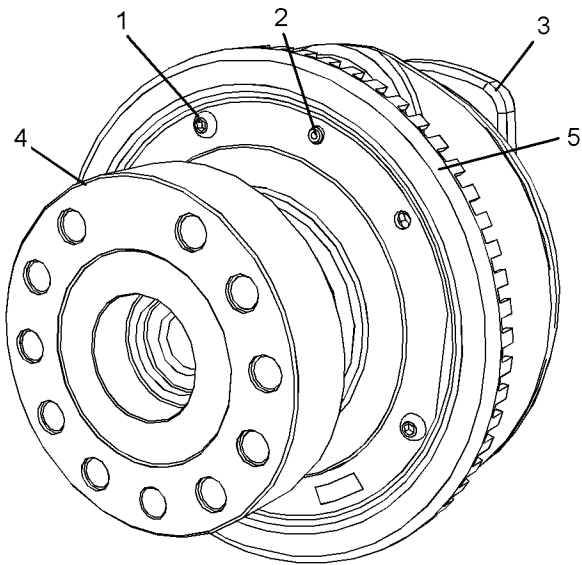


Illustration 468

g02452037

2. Support crankshaft (3) on a suitable stand.
 3. If dowel (2) was removed, install a new dowel to crankshaft (3).
 4. Position a new crankshaft timing ring (5) on the crankshaft with the teeth toward the crankshaft web. Align the hole in crankshaft timing ring (5) with dowel (2) in the crankshaft. Carefully install crankshaft timing ring (5) to crankshaft (3).
- Note:** Ensure that seal surface (4) on the crankshaft is not damaged when the crankshaft timing ring is installed.
5. Install new allen head screws (1). Tighten the allen head screws to a torque of 15 N·m (133 lb in).

End By:

- a. Install the crankshaft. Refer to **Disassembly and Assembly, "Crankshaft - Install"** for the correct procedure.

i05980470

Crankshaft Gear - Remove and Install

Removal Procedure

Table 97

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bearing Puller	1
	-	Screw	1
	-	Crossblock	1
	-	Puller Leg	2

Start By:

- a. Remove the front housing. Refer to **Disassembly and Assembly, "Housing (Front) - Remove"** for the correct procedure.
- b. If the engine is equipped with a balancer, remove the balancer. Refer to **Disassembly and Assembly, "Balancer - Remove"** for the correct procedure.
- c. If the engine is not equipped with a balancer, remove the engine oil pump. Refer to **Disassembly and Assembly, "Engine Oil Pump - Remove"** for the correct procedure.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

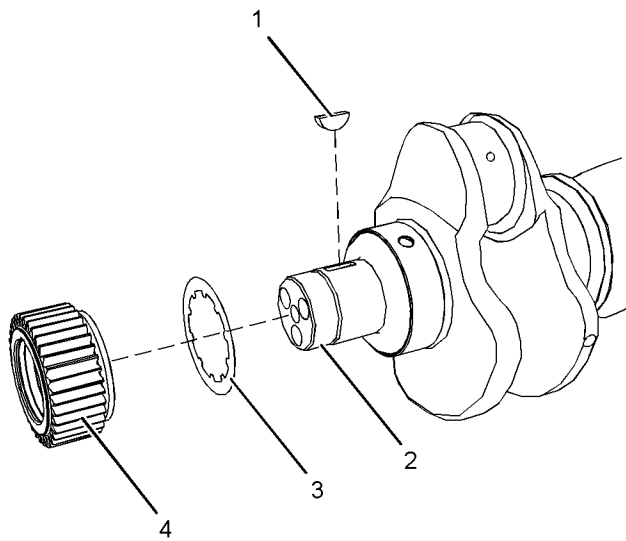


Illustration 469

g02445757

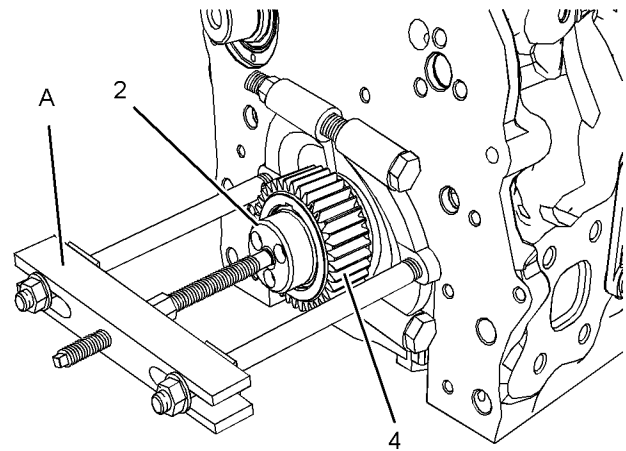


Illustration 470

g02445756

1. Use Tooling (A) in order to remove crankshaft gear (4) from crankshaft (2).
2. If necessary, remove key (1) and remove friction shim (3) from crankshaft (2).

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

Installation Procedure

Table 98

Required Tools			
Tool	Part Number	Part Description	Qty
B	-	Hot Plate	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

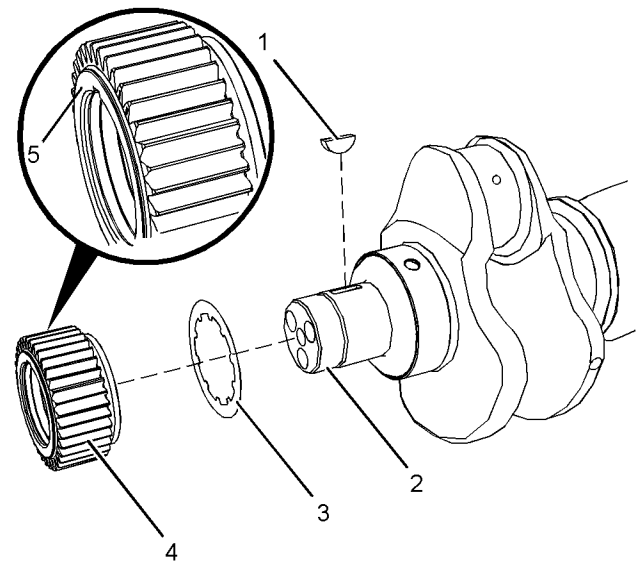


Illustration 471

g02445758

2. If necessary, install a new friction shim (3) to crankshaft (2).
3. If necessary, install a new key (1) to crankshaft (2).

Note: The crankshaft gear may be a sliding fit on the crankshaft or an interference fit on the crankshaft.

WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

4. Use Tooling (B) to heat crankshaft gear (4) in an oven to $150^{\circ} \pm 50^{\circ}\text{C}$ ($302^{\circ} \pm 90^{\circ}\text{F}$). Align the keyway on crankshaft gear (4) with key (1) in the crankshaft. Install crankshaft gear (4) to crankshaft (2).

Ensure that shoulder (5) of crankshaft gear (4) is toward the front of the engine.

End By:

- a. Install the front housing. Refer to Disassembly and Assembly, "Housing (Front) - Install" for the correct procedure.
- b. If the engine is equipped with a balancer, install the balancer. Refer to Disassembly and Assembly, "Balancer - Install" for the correct procedure.
- c. If the engine is not equipped with a balancer, install the engine oil pump. Refer to Disassembly and Assembly, "Engine Oil Pump - Install" for the correct procedure.

i05980468

Crankshaft Gear (Balancer Drive) - Remove and Install

Removal Procedure

Start By:

- a. Remove the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove" for the correct procedure.

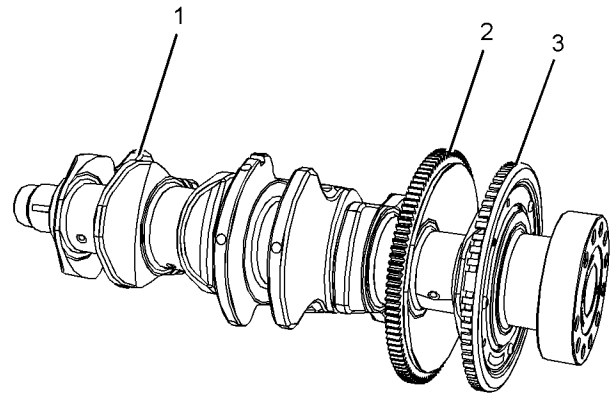


Illustration 472

g02649077

1. Place crankshaft assembly (1) on a suitable stand. Ensure that crankshaft timing ring (3) is not damaged.

2. Use a suitable tool in order to apply heat evenly around the diameter of the balancer drive gear (2). Ensure that heating is performed without causing any discoloration to either crankshaft assembly (1) or crankshaft balancer gear (2).
3. Use a suitable tool in order to remove the balancer drive gear (2) from crankshaft assembly (1).

Note: Ensure that the bearing surfaces or the crankshaft timing ring are not damaged as the balancer drive gear is removed.

Installation Procedure

Table 99

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Hot Plate	1

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

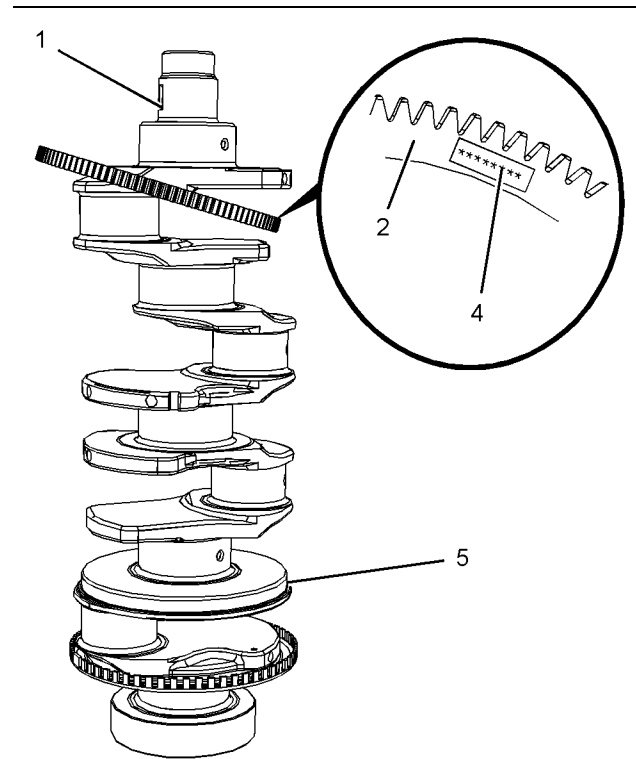


Illustration 473

g02649080

⚠ WARNING

Hot parts or hot components can cause burns or personal injury. Do not allow hot parts or components to contact your skin. Use protective clothing or protective equipment to protect your skin.

2. Position the crankshaft (1) in a suitable stand with the crankshaft in the vertical position.
3. Use Tooling (A) to heat a new balancer drive gear (2) in an oven to $150^{\circ} \pm 50^{\circ}\text{C}$ ($302^{\circ} \pm 90^{\circ}\text{F}$) for 1 hour.
4. Ensure that the balancer drive gear serial number (4) is facing upward position.
5. Position the balancer drive gear (2) onto the crankshaft (1) ensure that the balancer drive gear is correctly seated onto machined surface (5).

Note: Take care when manipulating the balancer drive gear over the crankshaft not to damage or scratch the crankshaft bearing surfaces.

End By:

- a. Install the crankshaft. Refer to Disassembly and Assembly, "Crankshaft - Remove" for the correct procedure.

i05980323

Bearing Clearance - Check

Measurement Procedure

Table 100

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 474 .

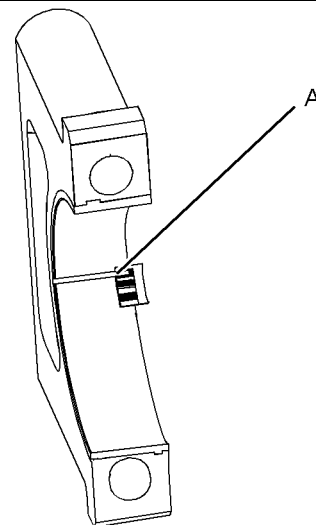


Illustration 474

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.

i05981806

Refrigerant Compressor - Remove and Install

Removal Procedure

Note: Cleanliness is an important factor. Before the disassembly procedure, the exterior of the component should be cleaned thoroughly. Thoroughly cleaning the component will help to prevent dirt from entering the internal mechanism.

WARNING

Personal injury can result from contact with refrigerant.

Contact with refrigerant can cause frost bite. Keep face and hands away to help prevent injury.

Protective goggles must always be worn when refrigerant lines are opened, even if the gauges indicate the system is empty of refrigerant.

Always use precaution when a fitting is removed. Slowly loosen the fitting. If the system is still under pressure, release it slowly in a well ventilated area.

Personal injury or death can result from inhaling refrigerant through a lit cigarette.

Inhaling air conditioner refrigerant gas through a lit cigarette or other smoking method or inhaling fumes released from a flame contacting air conditioner refrigerant gas, can cause bodily harm or death.

Do not smoke when servicing air conditioners or wherever refrigerant gas may be present.

Use a certified recovery and recycling cart to properly remove the refrigerant from the air conditioning system.

Note: Put identification marks on all lines, on all hoses, on all wires, and on all tubes for installation purposes. Plug all lines, hoses, and tubes assemblies. Plugging all lines, hoses, and tubes assemblies can prevent fluid loss and to keep contaminants from entering the system.

1. Turn the battery disconnect switch to the OFF position.
2. If the hose assemblies are to be removed from the refrigerant compressor. Removal of the refrigerant from the air conditioning system will be necessary. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

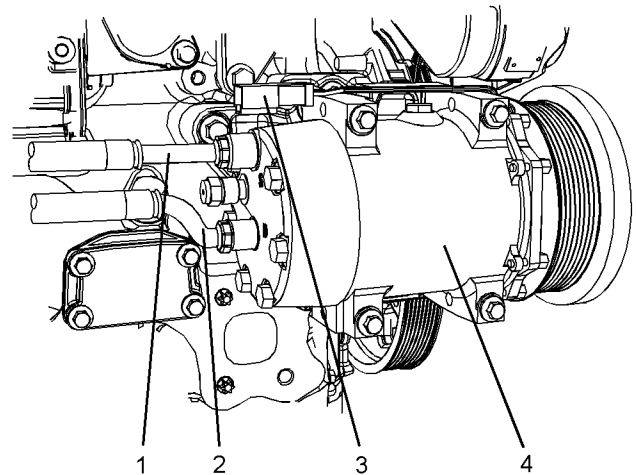


Illustration 475

g02518538

3. Disconnect hose assembly (1) and hose assembly (2) from refrigerant compressor (4). Refer to the Original Equipment Manufactures (OEM) for the correct procedure.

Note: Plug the hose assemblies with new plugs. Cap the ports in the refrigerant compressor with new caps.

4. Disconnect harness assembly (3) from refrigerant compressor (4).

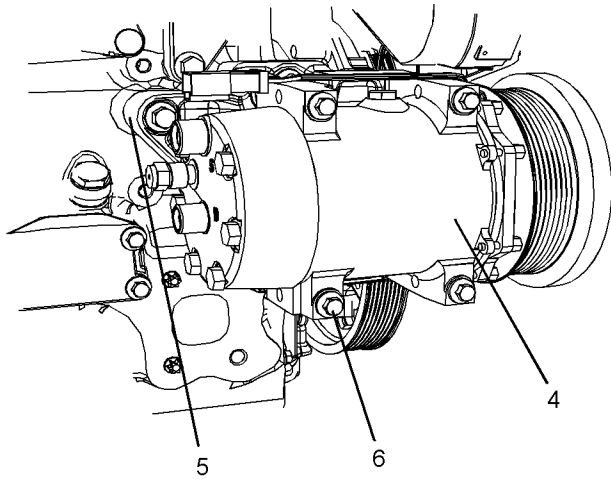


Illustration 476

g02518539

5. Remove the alternator belt. Refer to Disassembly and Assembly Manual, "Alternator Belts - Remove and Install" for the correct procedure.

6. Remove bolts (6) from refrigerant compressor (4).

Note: Support the weight of the refrigerant compressor on removal of the bolts.

7. Remove refrigerant compressor (4) from bracket (5).

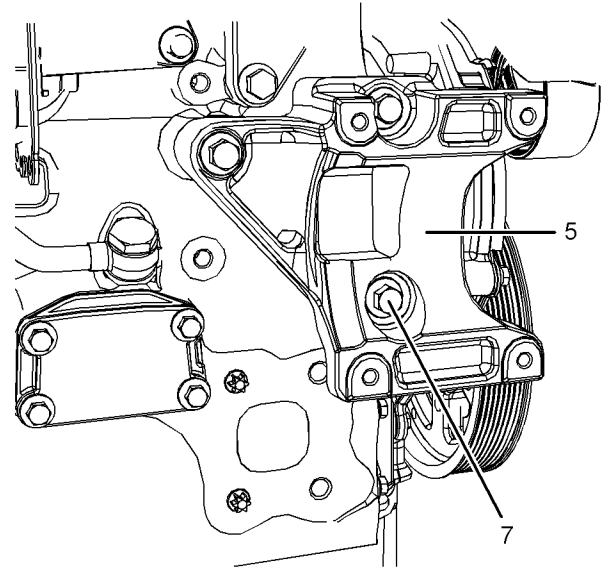


Illustration 477

g02518540

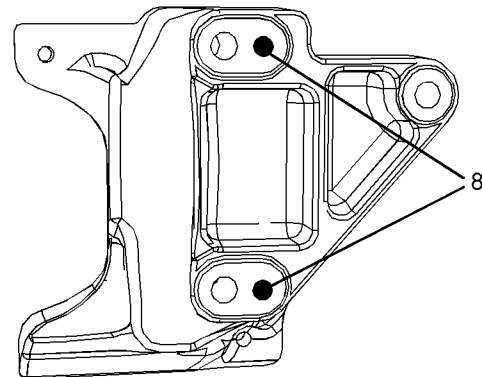


Illustration 478

g02518541

8. If necessary, follow Step 8a through Step 8c in order to remove bracket (5) for the refrigerant compressor from the cylinder block.

- a. Remove bolts (7) from bracket (5).
- b. Remove bracket (5) from the cylinder block.
- c. Note the position of dowels (8) in bracket (5).

Installation Procedure

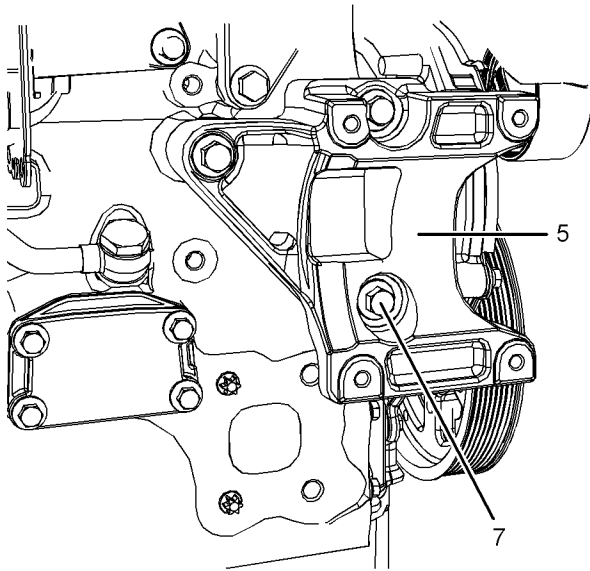


Illustration 479

g02518540

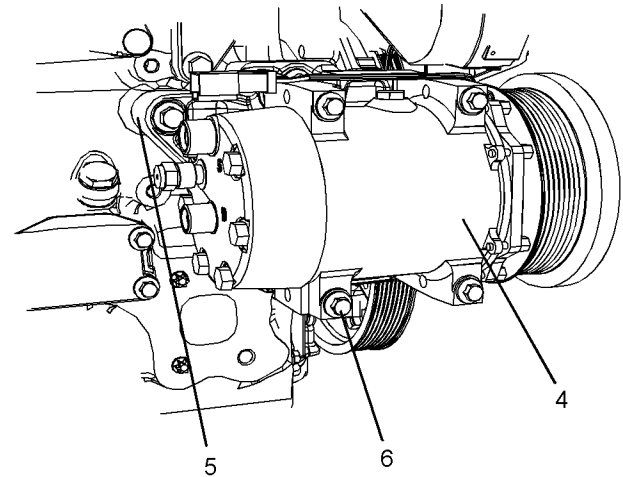


Illustration 481

g02518539

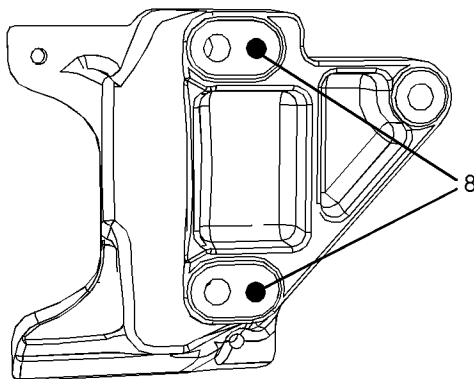


Illustration 480

g02518541

1. If necessary, follow Step 1a through Step 1d in order to install bracket (5) for the refrigerant compressor to the cylinder block.
 - a. Ensure that bracket (5) is clean and free from wear and damage. If necessary, replace the bracket.
 - b. Ensure that dowels (8) are free from wear and damage. If necessary, replace the dowels.
 - c. Position bracket (5) onto the cylinder block. Install bolts (7) and hand tighten bolts.
 - d. Tighten bolts (7) to a torque of 44 N·m (32 lb ft).

2. Position refrigerant compressor (4) onto bracket (5).

Note: Support the weight of the refrigerant compressor.

3. Install bolts (6) to the refrigerant compressor (4).
4. Tighten bolts (6) to a torque of 22 N·m (195 lb in).
5. Install the alternator belt. Refer to Disassembly and Assembly Manual, "Alternator Belts - Remove and Install" for the correct procedure.

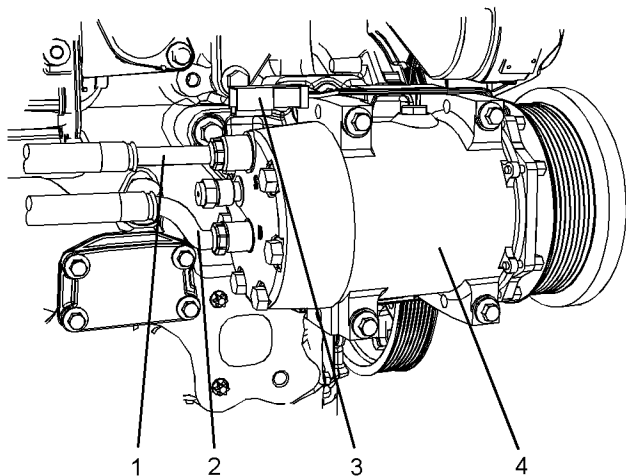


Illustration 482

g02518538

6. Connect harness assembly (3) to refrigerant compressor (4).
7. Remove the plugs from hose assemblies and remove the plugs from the ports of the refrigerant compressor. Connect hose assembly (1) and hose assembly (2) to refrigerant compressor (4). Refer to the OEM for the correct procedure.
8. If the hose assemblies were removed from the refrigerant compressor. Refer to the OEM for the correct charging procedures.
9. Turn the battery disconnect switch to the ON position.

i05981796

Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor Positioned in Original Equipment Manufacture (OEM) Exhaust Tube Assembly)

Removal Procedure

1. Ensure that the nitrogen oxide sensor is not dropped or knocked. If the nitrogen oxide sensor, has been dropped or knocked the nitrogen oxide sensor must be replaced as an assembly.

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

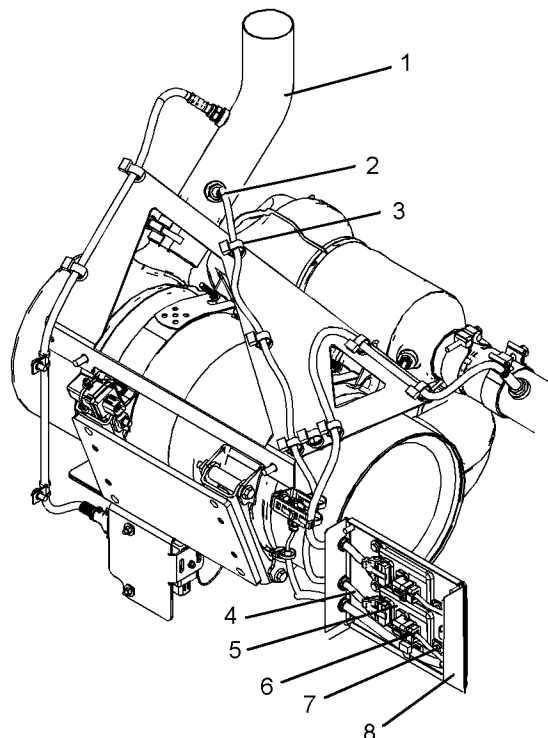


Illustration 483

g03732053

Typical example

3. Cut cable straps (3) from harness assembly (4). Note the position of all cable straps for installation purposes.

Note: Ensure that the harness assembly is not damaged as the cable straps are cut.

4. Remove nitrogen oxide sensor (2) from the Original Equipment Manufacture (OEM) exhaust tube assembly (1). Ensure that harness assembly (4) is not damaged as the nitrogen oxide sensor is removed. **Place the probe of the nitrogen oxide sensor in a plastic bag and secure the plastic bag with a cable strap.**
5. If necessary, follow Step 5a through Step 5b in order to remove nitrogen oxide sensor Electronic Control Module (ECM) (5) from bracket (8).
 - a. Disconnect OEM harness assembly (6) from the nitrogen oxide sensor ECM (5).
 - b. Remove bolts (7) nitrogen oxide sensor ECM (5). Remove the nitrogen oxide sensor ECM from bracket (8). Refer to OEM for further information.

Installation Procedure

Table 101

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1
B	-	22 mm Crows Foot	1

1. Ensure that the nitrogen oxide sensor is free from wear or damage. Replace the nitrogen oxide sensor as an assembly if worn or damaged.
2. Check the threads of the mounting point for nitrogen oxide sensor in the OEM tube assembly for wear or damage. Replace the OEM tube assembly if the mounting point is worn or damage. Refer to the OEM for the correct procedure.

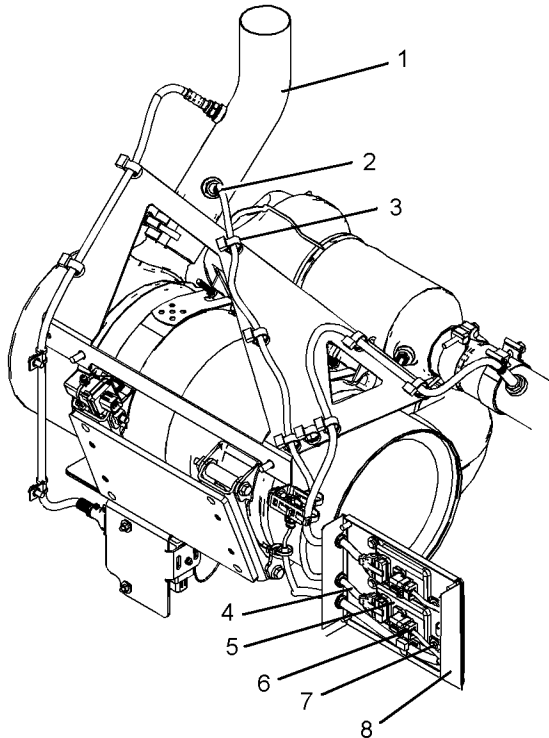


Illustration 484

g03732053

Typical example

3. If necessary, follow Step 3a through Step 3c in order to install nitrogen oxide sensor ECM (5) to bracket (8).
 - a. Position nitrogen oxide sensor ECM (5) onto bracket (8). Ensure that the nitrogen oxide sensor ECU is correctly orientated onto the bracket. Refer to OEM for further information.

- b. Install bolts (7) to the nitrogen oxide sensor ECM. Support the nitrogen oxide sensor ECM as the bolts are installed. Tighten the bolts to a torque of 10 N·m (89 lb in).

- c. Connect OEM harness assembly (6) to the nitrogen oxide sensor ECM (5).

4. New nitrogen oxide sensor (2) are pre-lubricated. When installing an existing nitrogen oxide sensor (2), lightly lubricate the thread of the nitrogen oxide sensor with Tooling (A).
5. Remove the probe of nitrogen oxide sensor (2) from the plastic bag. Install the nitrogen oxide sensor to OEM exhaust tube assembly (1). Ensure that harness assembly (4) is not damaged as the nitrogen oxide sensor is installed.

Note: Ensure that the nitrogen oxide sensor is not contaminated.

6. Use Tooling (B) to tighten nitrogen oxide sensor (2) to a torque of 50 N·m (37 lb ft).

7. Install new cable straps (3) to harness assembly (4). Ensure that the cable straps are installed into the original position.

Note: Ensure that the cable straps meet OEM specifications.

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

i05981797

Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor on Engine)

Removal Procedure

1. Ensure that the nitrogen oxide sensor is not dropped or knocked. If the nitrogen oxide sensor, has been dropped or knocked the nitrogen oxide sensor must be replaced as an assembly.
2. Turn the battery disconnect switch to the OFF position.

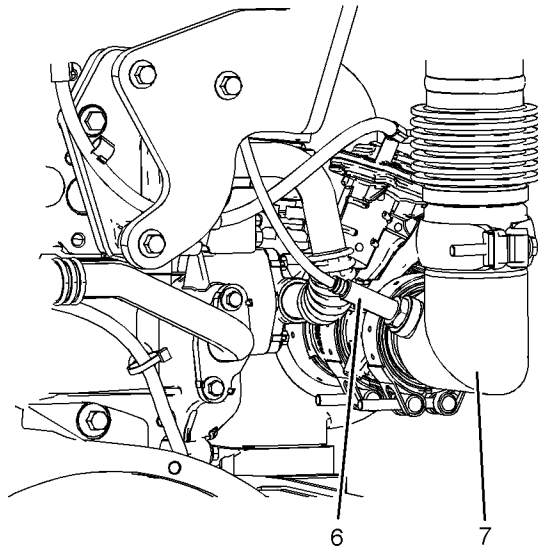


Illustration 485

g03731237

Typical example

- a. Disconnect Original Equipment Manufacture (OEM) harness assembly (3) from the nitrogen oxide sensor ECM (2).
- b. Cut cable straps (1) from the harness assembly. Note the position of all cable straps for installation purposes.

Note: Ensure that the harness assembly is not damaged as the cable straps are cut.

- c. Remove bolts (4) nitrogen oxide sensor ECM (2). Remove the nitrogen oxide sensor ECM from bracket (5).

Installation Procedure

Table 102

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1
B	-	22 mm Crows Foot	1

1. Ensure that the nitrogen oxide sensor is free from wear or damage. Replace the nitrogen oxide sensor as an assembly if worn or damaged.
2. Check the threads of the mounting point for nitrogen oxide sensor in the exhaust elbow. Replace the elbow if the mounting point is worn or damaged.

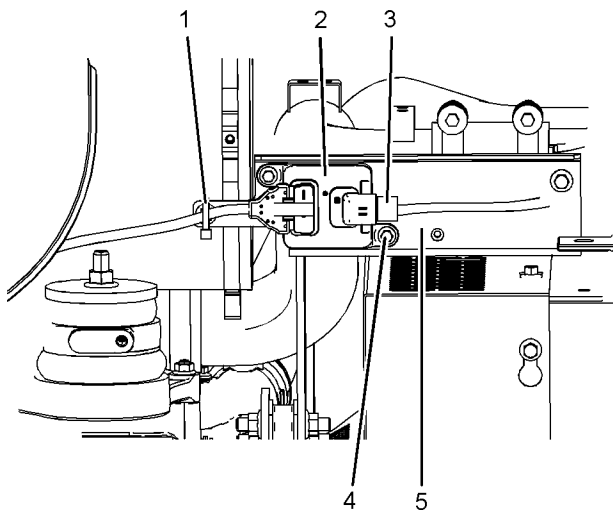


Illustration 486

g03731236

Typical example

3. Remove nitrogen oxide sensor (6) from exhaust tube assembly (7). Ensure that the harness assembly is not damaged as the nitrogen oxide sensor is removed. **Place the probe of the nitrogen oxide sensor in a plastic bag and secure the plastic bag with a cable strap.**
4. If necessary, follow Step 4a through Step 4c in order to remove nitrogen oxide sensor Electronic Control Module (ECM) (2).

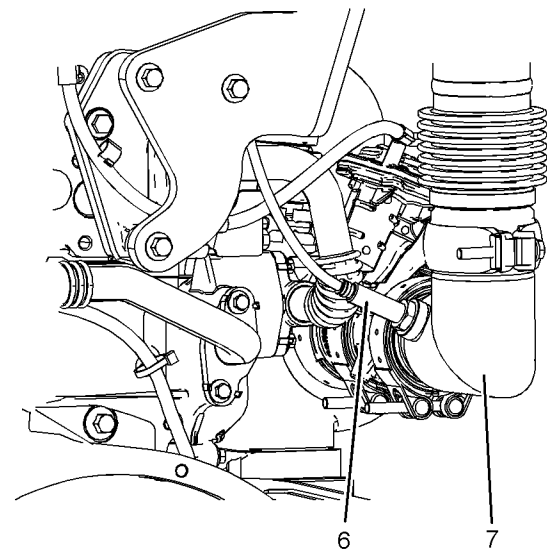


Illustration 487

g03731237

Typical example

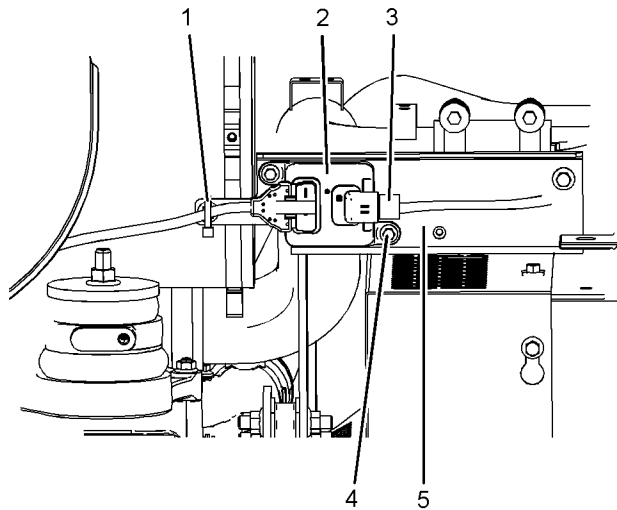


Illustration 488

g03731236

Typical example

3. If necessary, follow Step 3a through Step 3c in order to install nitrogen oxide sensor ECM (2).
 - a. Position nitrogen oxide sensor ECM (2) onto bracket (5). Ensure that the nitrogen oxide sensor ECM is correctly orientated onto the bracket.
 - b. Install bolts (4) to nitrogen oxide sensor ECM (2). Support the nitrogen oxide sensor ECM as the bolts are installed. Tighten the bolts to a torque of 10 N·m (89 lb in).
 - c. Connect OEM harness assembly (3) to nitrogen oxide sensor ECM (2).
 4. New nitrogen oxide sensor (6) are pre-lubricated. When installing an existing nitrogen oxide sensor (6), lightly lubricate the thread of the nitrogen oxide sensor with Tooling (A).
- Note:** Ensure that the nitrogen oxide sensor is not contaminated.
5. Remove the probe of nitrogen oxide sensor (6) from the plastic bag. Install the nitrogen oxide sensor to exhaust tube assembly (7). Ensure that the harness assembly is not damaged as the nitrogen oxide sensor is installed.
 6. Use Tooling (B) to tighten nitrogen oxide sensor (6) to a torque of 50 N·m (37 lb ft).
 7. Install new cable straps (1) to the harness assembly. Ensure that the cable straps are installed into the original position.

Note: Ensure that the cable straps meet OEM specifications.

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

i05980420

Atmospheric Pressure Sensor - Remove and Install

Removal Procedure

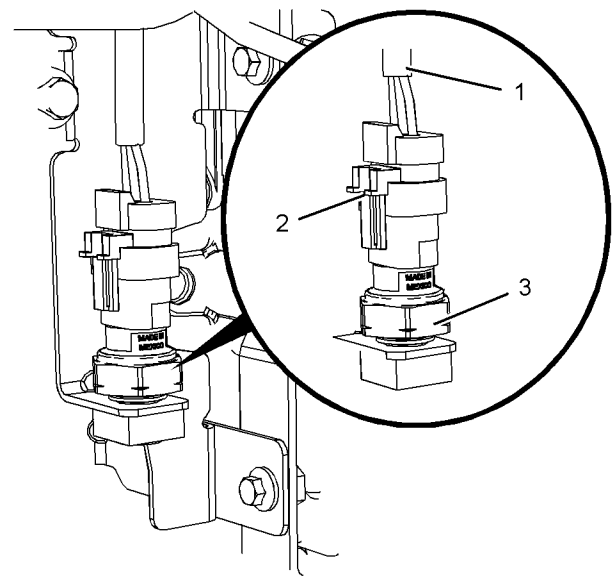


Illustration 489

g02433676

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

Installation Procedure

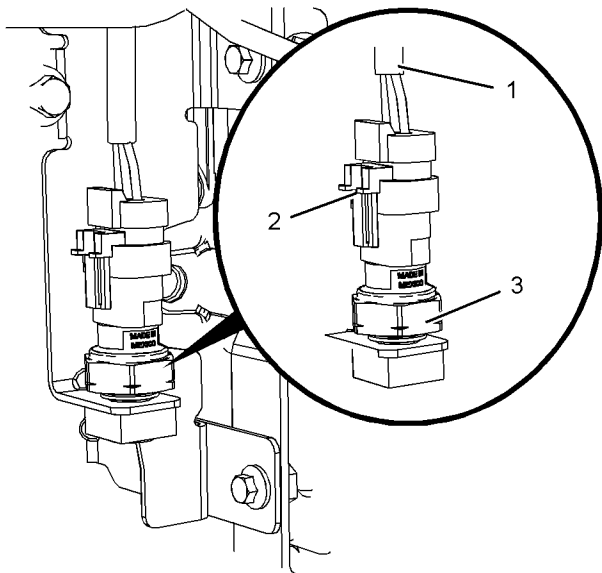


Illustration 490

g02433676

1. Install atmospheric pressure sensor (3). Tighten atmospheric pressure sensor (3) to a torque of 10 N·m (89 lb in).

Note: The atmospheric pressure sensor should not be installed with an O-ring seal.

2. Connect harness assembly (1) to atmospheric pressure sensor (3). Slide locking tab (2) into the locked position.

i05980443

Camshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

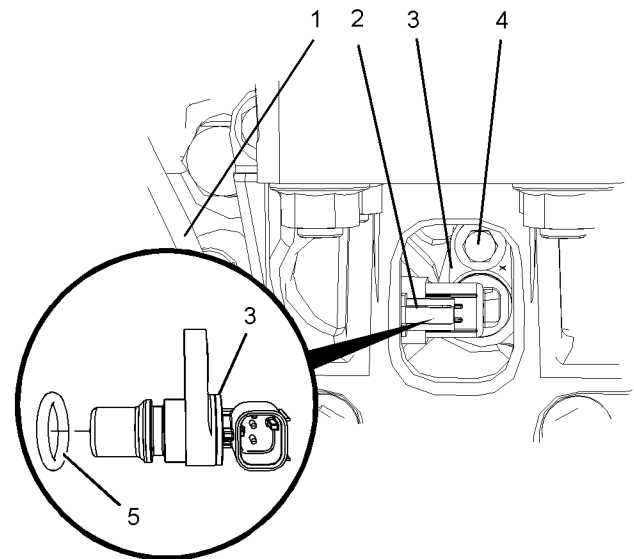


Illustration 491

g02437917

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

Note: Do not use a lever to remove the camshaft position sensor.

3. Remove O-ring seal (5) from camshaft position sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

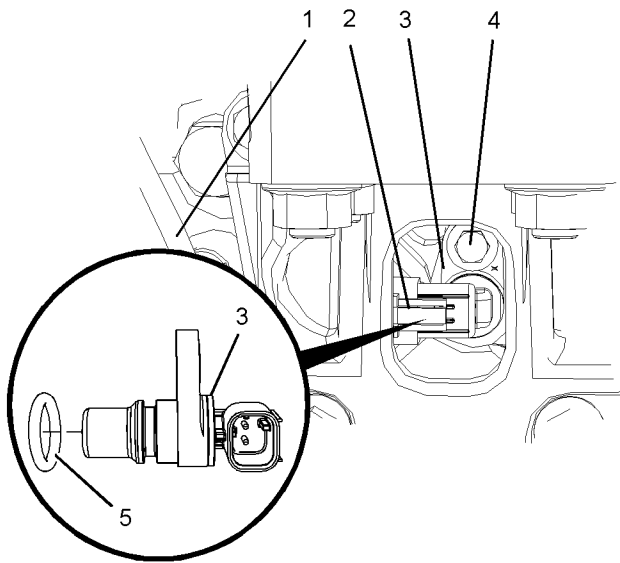


Illustration 492

g02437917

1. Install a new O-ring seal (5) to camshaft position sensor (3).

Note: Do not lubricate the O-ring seal.

2. Install camshaft position sensor (3) to the cylinder block. Install bolt (4) and tighten the bolt to a torque of 14 N·m (124 lb in).
3. Connect harness assembly (1) to camshaft position sensor (3). Slide locking tab (2) into the locked position.

i05980473

Crankshaft Position Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

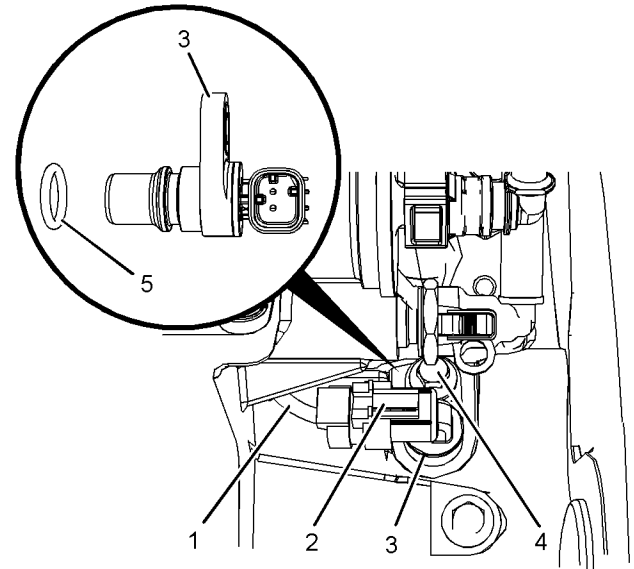


Illustration 493

g02449496

1. Slide locking tab (2) into the unlocked position. Disconnect harness assembly (1) from crankshaft position sensor (3).
 2. Remove bolt (4) from the cylinder block.
 3. Carefully remove crankshaft position sensor (3) from the cylinder block.
- Note:** Do not use a lever to remove the crankshaft position sensor from the cylinder block.
4. Remove O-ring seal (5) from crankshaft position sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

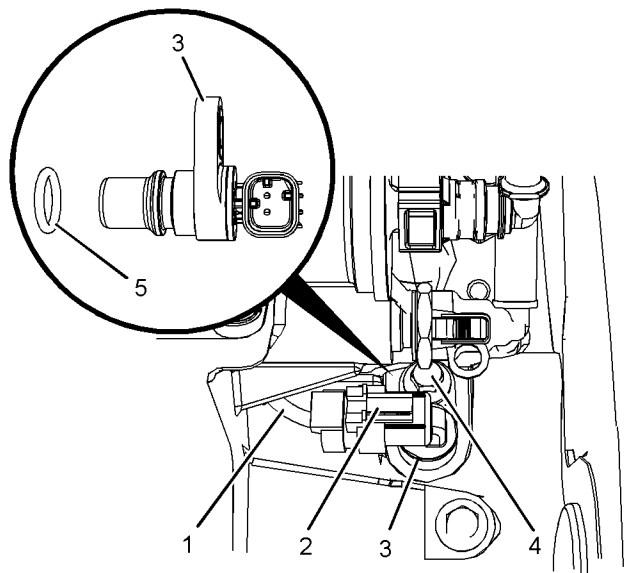


Illustration 494

g02449496

1. Install a new O-ring seal (5) to crankshaft position sensor (3).

Note: Do not lubricate the O-ring seal.

2. Install crankshaft position sensor (3) to the cylinder block. Install bolt (4) and tighten the bolt to a torque of 14 N·m (124 lb in).
3. Connect harness assembly (1) to crankshaft position sensor (3). Slide locking tab (2) into the locked position.

i05980454

Coolant Temperature Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

Dispose of all fluids according to local regulations and mandates.

1. Drain the coolant from the cooling system to a level below the coolant temperature sensor. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.

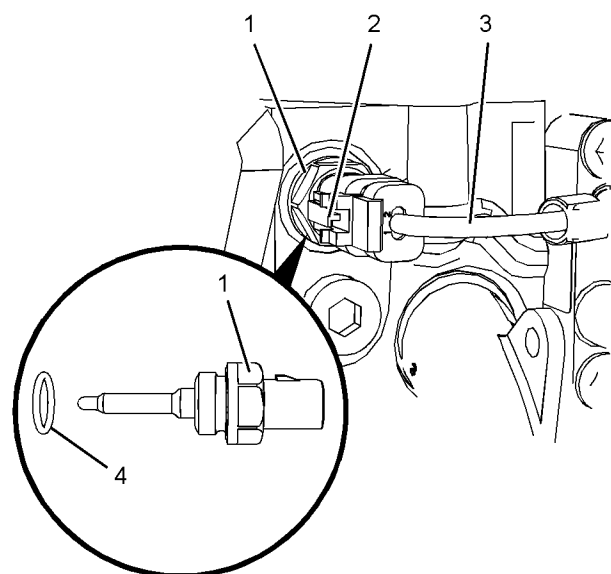


Illustration 495

g02439656

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

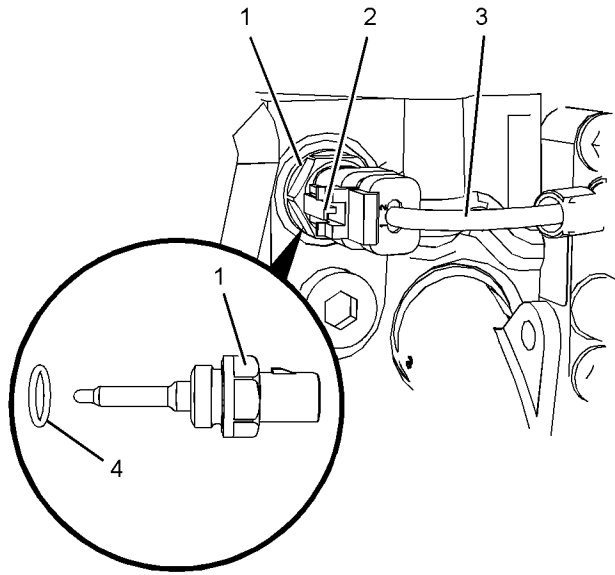


Illustration 496

g02439656

1. Install a new O-ring seal (4) onto coolant temperature sensor (1).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket in order to install coolant temperature sensor (1) to the cylinder head. Tighten the coolant temperature sensor to a torque of 20 N·m (177 lb in).
3. Connect harness assembly (3) to coolant temperature sensor (1). Slide locking tab (2) into the locked position.
4. Fill the cooling system to the correct level. Refer to Operation and Maintenance Manual, "Cooling System Coolant Level - Check" and refer to Operation and Maintenance Manual, "Cooling System Coolant - Test/Add" for the correct filling procedure.

i05981732

Engine Oil Pressure Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

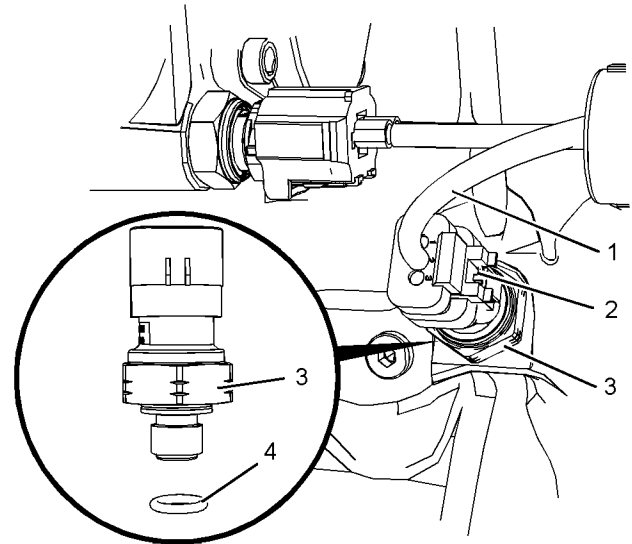


Illustration 497

g02476247

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

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

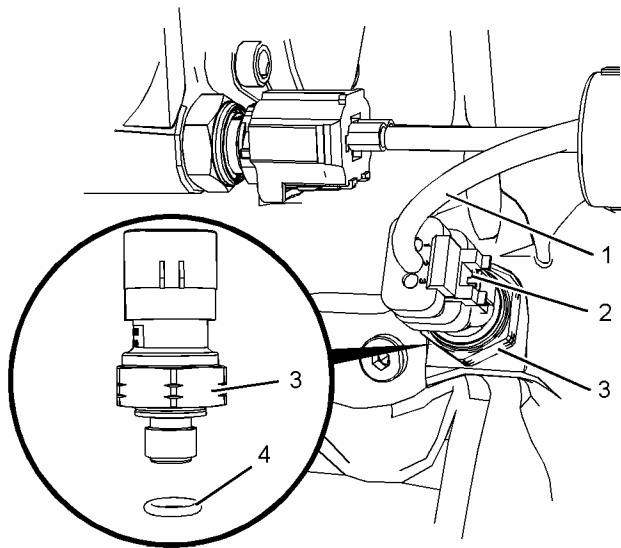


Illustration 498

g02476247

1. Install a new O-ring seal (4) onto engine oil pressure sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install engine oil pressure sensor (3) to the cylinder block. Tighten the engine oil pressure sensor to a torque of 10 N·m (89 lb in).
3. Connect harness assembly (1) to engine oil pressure sensor (3).
4. Slide locking tab (2) into the locked position.
5. If necessary, fill the engine oil pan to the correct level that is indicated on the engine oil level gauge. Refer to Operation and Maintenance Manual, "Engine Oil Level - Check" for the correct procedure.

i08443057

Fuel Pressure Sensor - Remove and Install

Removal Procedure

Table 103

Required Tools			
Tool	Part Number	Part Description	Qty
A	T410437	Capping Kit	1
B	-	27mm Deep Socket	1

Start By:

- a. Remove the fuel manifold (Rail). Refer to Disassembly and Assembly, "Fuel Manifold (Rail) - Remove and Install" for the correct procedure.

⚠ WARNING

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

NOTICE

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

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

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

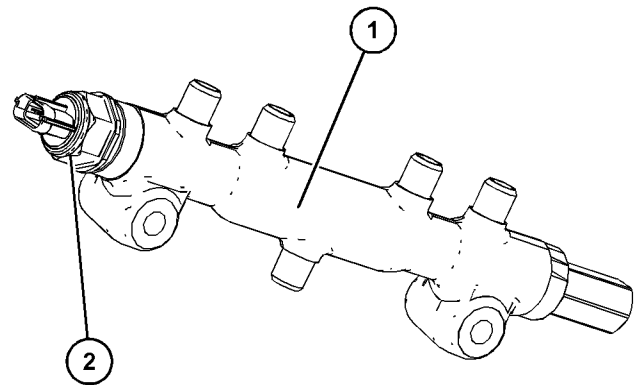


Illustration 499

g06666904

Typical Example

1. Using Tooling (A), ensure that all open ports of fuel manifold (1) are capped.
2. Thoroughly clean the fuel manifold (1) and pressure sensor (2) before starting disassembly.
3. Place fuel manifold (1) in a suitable support, such as a soft jawed vice.
4. Using Tooling (B), remove pressure sensor (2) from fuel manifold (1).

Note: Once the pressure sensor is removed, discard the pressure sensor.

- Once pressure sensor (2) is removed, use Tooling (A) to cap fuel manifold.

Installation Procedure

Table 104

Required Tools			
Tool	Part Number	Part Description	Qty
A	T410437	Capping Kit	1
B	-	27mm Deep Socket	1
C	21825607	Degree Wheel	1

NOTICE

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

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

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

NOTICE

DO NOT handle the connector section of the pressure sensor during installation, as pressure sensor damage may occur.

- Ensure that all ports on the fuel manifold are capped using Tooling (A). Ensure that the fuel manifold is externally clean and free from damage.

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

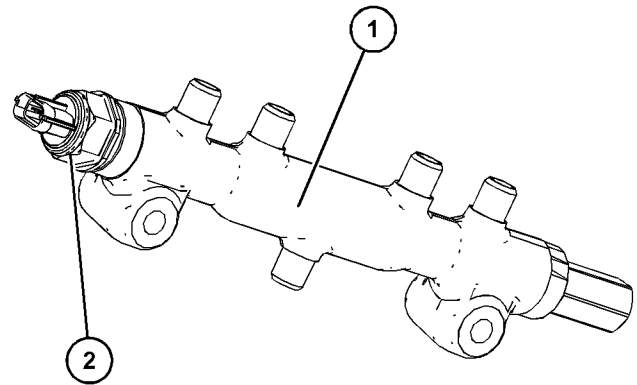


Illustration 500

g06666904

Typical Example

- Place fuel manifold (1) in a suitable support, such as a soft jawed vice.
- Install new pressure sensor (2) to fuel manifold (1) hand tight. Ensure that the pressure sensor is installed until it reaches the bottom seat of the fuel manifold.

Note: If the pressure sensor does not reach the bottom seat of the fuel manifold **Do Not** overtighten, replace the pressure sensor

- Using Tooling (B), tighten pressure sensor (2) to a snug torque of 20 N·m (177 lb in).
- Using Tooling (B) and Tooling (C), turn pressure sensor (2) for an additional 15 degrees.

End By:

- Install the fuel manifold (Rail). Refer to Disassembly and Assembly, "Fuel Manifold (Rail) - Remove and Install" for the correct procedure.
- Use the electronic service tool to perform the "Fuel Rail Pressure Test" to check for fuel leaks. Refer to Troubleshooting, "Service Tool Features" for more information.

i05981765

Fuel Temperature Sensor - Remove and Install

Removal Procedure

Table 105

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

WARNING

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

NOTICE

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

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

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

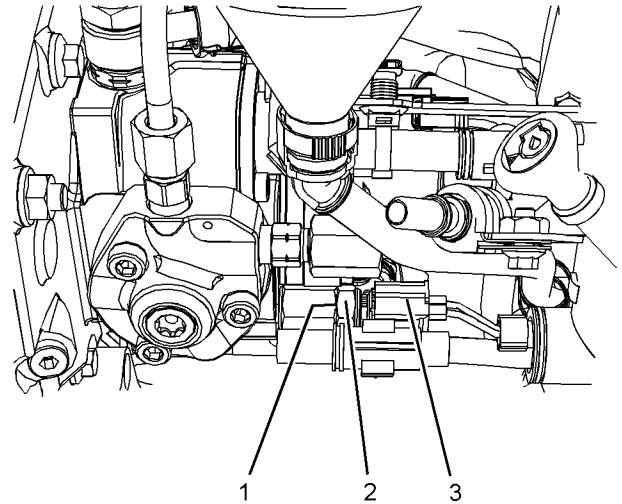


Illustration 501

g02596796

3. Disconnect harness assembly (3) from fuel temperature sensor (2).
4. Use a deep socket in order to remove fuel temperature sensor (2) from the fuel injection pump.
5. Use Tooling (A) to plug the open port of the fuel injection pump.
6. Remove O-ring seal (1) (not shown) from fuel temperature sensor (2).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

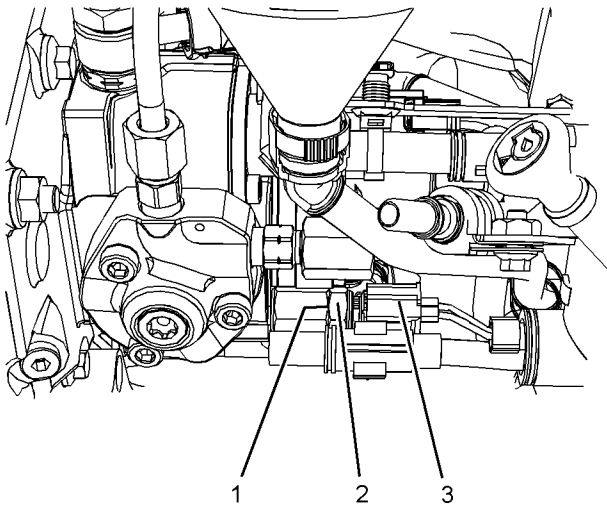


Illustration 502

g02596796

2. Install a new O-ring seal (1) (not shown) on the fuel temperature sensor (2).
3. Remove the plug from the fuel injection pump.
4. Install fuel temperature sensor (2) to the fuel injection pump. Use a deep socket to tighten the fuel temperature sensor to a torque of 22 N·m (195 lb in).
5. Connect harness assembly (3) to fuel temperature sensor (2).
6. Turn the fuel supply to the ON position.
7. Turn the battery disconnect switch to the ON position.

i05980419

Ammonia Sensor - Remove and Install (Ammonia Sensor if Equipped)

Removal Procedure

1. **Ensure that the ammonia sensor is not dropped or knocked. If the ammonia sensor, has been dropped or knocked the ammonia sensor must be replaced as an assembly.**
2. Turn the battery disconnect switch to the OFF position.

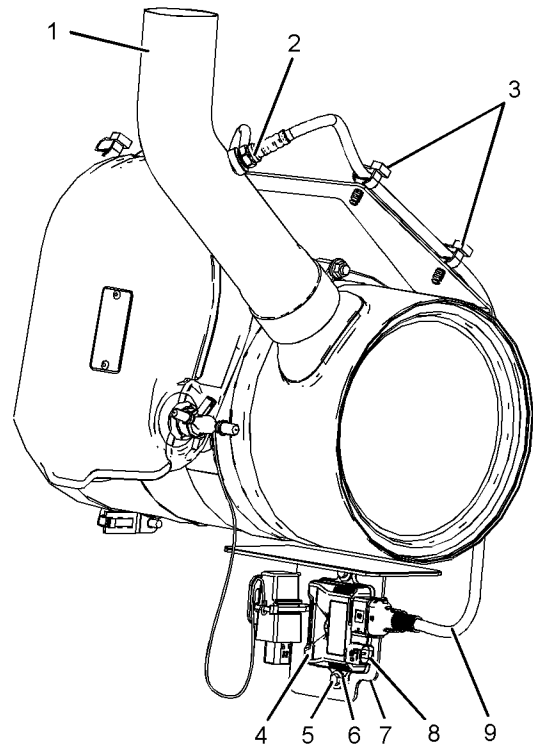


Illustration 503

g03730069

3. Cut cable straps (3) from harness assembly (9). Ensure that all the cable straps are removed from the harness assembly. Refer to the Original Equipment Manufacture (OEM) for the correct location and the correct removal procedure.
- Note:** Ensure that the harness assembly is not damaged as the cable straps are cut.
4. Disconnect harness assembly (9) from control module (4).
 5. Remove ammonia sensor (2) from OEM tube assembly (1). Ensure that harness assembly (9) is not damaged as the ammonia sensor is removed. **Place the probe of the ammonia sensor in a plastic bag and secure the plastic bag with a cable strap. Ensure that the ammonia sensor sensing element is not contaminated.**
 6. If necessary, follow Step 6a through Step 6c to remove the ammonia sensor control module (4) from bracket (7).
 - a. Disconnect the OEM harness assembly from connection (8).
 - b. Remove bolts (5) and washers (6) from control module (4). Support the control module as the bolts are removed.

- c. Remove control module (4) and harness assembly (9) from bracket (7).

Installation Procedure

Table 106

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1
B	-	22 mm Crows Foot	1

1. Ensure that the ammonia sensor is free from wear or damage. Replace the ammonia sensor as an assembly if worn or damaged.
2. Check the threads of the mounting point for ammonia sensor in the OEM tube assembly for wear or damage. Replace the OEM tube assembly if the mounting point is worn or damaged. Refer to the OEM for the correct procedure.

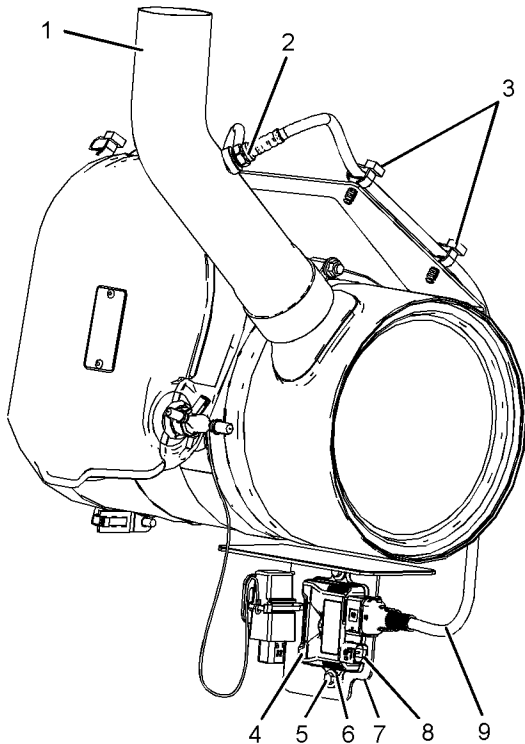


Illustration 504

g03730069

3. If necessary, follow Step 3a through Step 3d to install the ammonia sensor control module (4) from bracket (7).
 - a. Position control module (4) onto bracket (7). Ensure that the control module is correctly oriented onto the bracket.

- b. Install washers (6) and bolts (5) to control module (4). Support the control module as the bolts are installed.

- c. Tighten bolts (5) to a torque of 12 N·m (106 lb in).

- d. Connect the OEM harness assembly to connection (8).

4. Lightly lubricate the thread of ammonia sensor (2) with Tooling (A).
5. Remove the probe of ammonia sensor (2) from the plastic bag. Install the ammonia sensor to OEM tube assembly (1). Ensure that harness assembly (9) is not damaged as the ammonia sensor is installed.

Note: Ensure that the ammonia sensor sensing element is not contaminated.

6. Use Tooling (B) to tighten ammonia sensor (2) to a torque of 50 N·m (37 lb ft).

7. Install new cable straps (3) to harness assembly (9). Ensure that all the cable straps are installed onto the harness assembly. Refer to the OEM for the correct location and the correct installation procedure.

Note: Ensure that the cable straps meet OEM specifications.

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

i05981817

Soot Antenna - Remove and Install

Removal Procedure

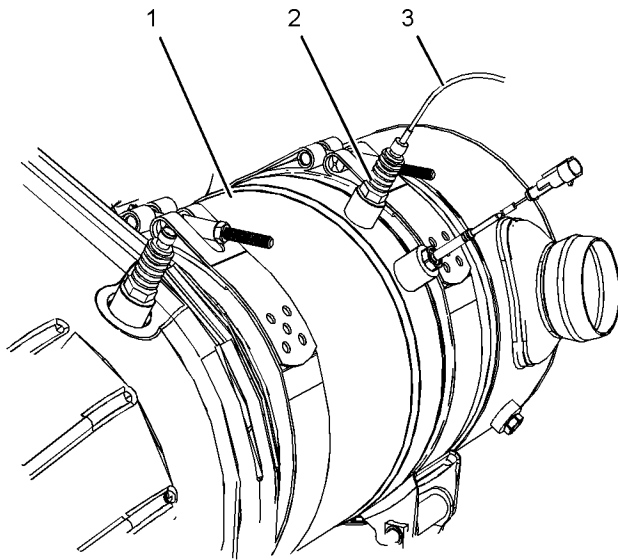


Illustration 505

g03728597

1. Use a suitable tool to disconnect harness assembly (3) from soot antenna (2).
2. Repeat Step 1 in order to disconnect the remaining harness assembly from the remaining soot antenna.
3. Remove soot antenna (2) from the assembly of the Clean Emissions Module (CEM) (1).
4. Repeat Step 3 In order to remove the remaining soot antenna.

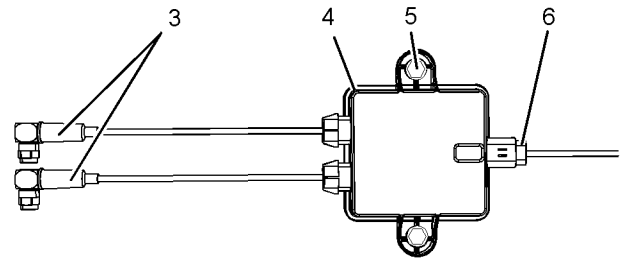


Illustration 506

g03738277

5. If necessary, follow Step 5a through Step 5c in order to remove soot antenna monitor (4). Refer to the Original Equipment Manufacture (OEM) for the correct location of soot antenna monitor.
 - a. If necessary, use a suitable tool to disconnect harness assemblies (3) from the soot antennas.
 - b. Disconnect the OEM harness assembly (6) from soot antenna monitor (4).
 - c. Remove bolts (5) from soot antenna monitor (4). Remove the soot antenna monitor from the bracket.

Installation Procedure

Table 107

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1
B	-	19 mm Crows Foot	1

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

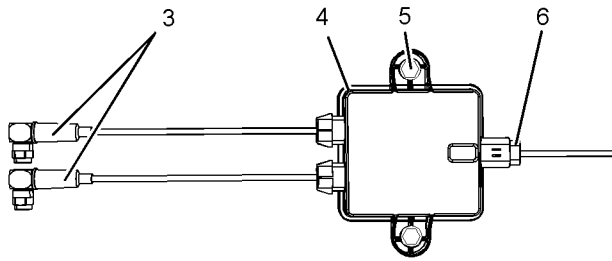


Illustration 507

g03738277

2. If necessary, follow Step 2a through Step 2c in order to install soot antenna monitor (4). Refer to the OEM for the correct location of soot antenna monitor.
 - a. Install soot antenna monitor (4) onto the bracket. Install bolts (5) to the soot antenna monitor. Tighten the bolts to a torque of 12 N·m (106 lb in).
 - b. Connect the OEM harness assembly (6) to soot antenna monitor (4).
 - c. If necessary, connect harness assemblies (3) to the soot antennas. Tighten the connection for the harness assemblies to a torque of 1.2 N·m (11 lb in).

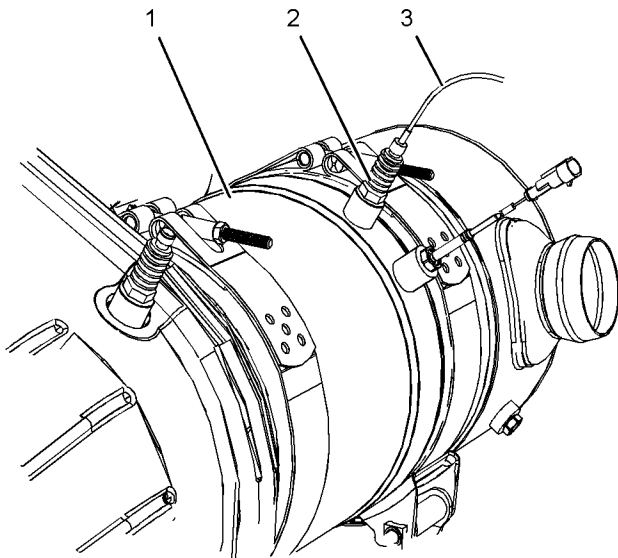


Illustration 508

g03728597

3. If new soot antennas are to be install, the protective cover on the new soot antenna will need to be removed prior to installation.

4. Lightly lubricate the thread of soot antenna (2) with Tooling (A). Install soot antenna (2) to CEM (1).
5. Use Tooling (B) to tighten soot antenna (2) to a torque of 45 N·m (33 lb ft).
6. Repeat Step 3 in order to install the remaining soot antenna.
7. Connect harness assembly (3) to soot antenna (2). Use a suitable tool to tighten the harness assembly to a torque of 1.2 N·m (11 lb in).
8. Repeat Step 7 in order to connect the remaining harness assembly.

i05981821

Temperature Sensor (Exhaust - Remove and Install (Selective Catalytic Reduction (SCR) Temperature Sensor)

Removal Procedure

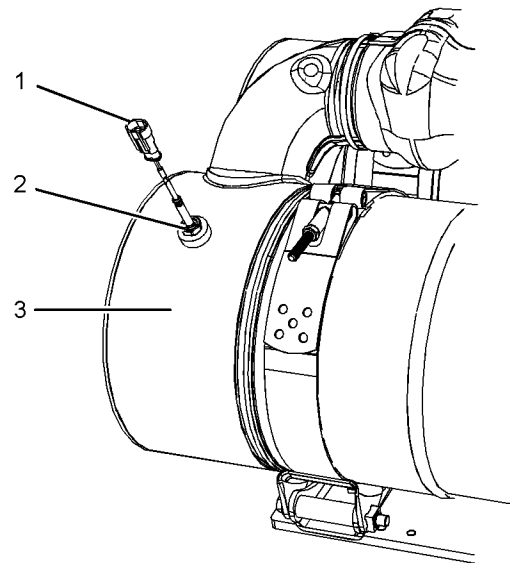


Illustration 509

g03730056

1. Disconnect the harness assembly from harness assembly (1) for Selective Catalytic Reduction (SCR) temperature sensor (2).
2. Remove the SCR temperature sensor (2) from Clean Emissions Module (CEM) (1).

Installation Procedure

Table 108

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1

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

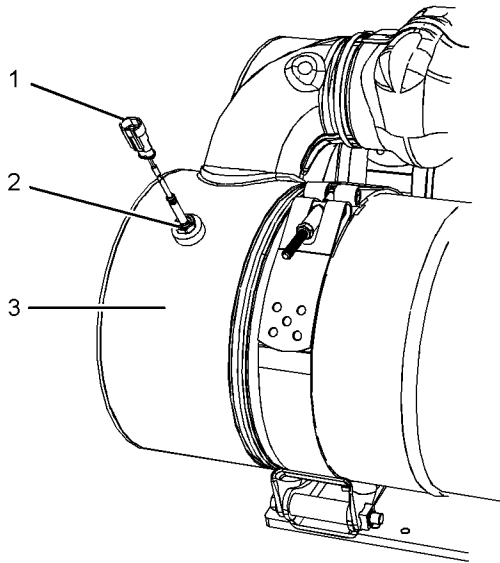


Illustration 510

g03730056

2. Lightly lubricate the thread of SCR temperature sensor (2) with Tooling (A). Install the SCR temperature sensor to CEM (1).
3. Torque SCR temperature sensor (2) to a torque of 45 N·m (33 lb ft).

4. Connect the harness assembly to harness assembly (1) for SCR temperature sensor (2).

i05981820

Temperature Sensor (DPF - Remove and Install

Removal Procedure

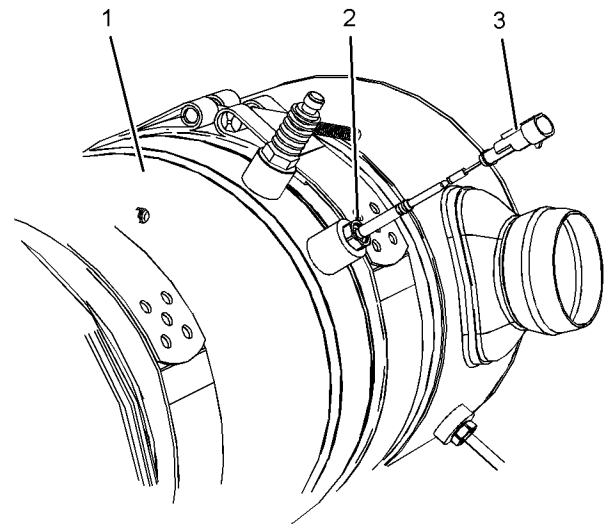


Illustration 511

g03729016

1. Disconnect the harness assembly from harness assembly (3) for temperature sensor (2).
2. Remove the Diesel Particulate Filter (DPF) temperature sensor (2) from DPF (1).

Installation Procedure

Table 109

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1

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

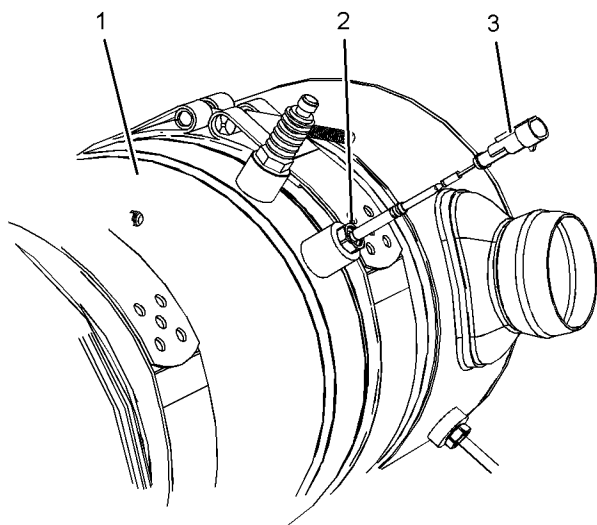


Illustration 512

g03729016

2. Lightly lubricate the thread of DPF temperature sensor (2) with Tooling (A). Install the DPF temperature sensor to DPF (1).
3. Torque DPF temperature sensors (2) to a torque of 45 N·m (33 lb ft).

4. Connect the harness assembly to harness assembly (3) for DPF temperature sensor (2).

i05981819

Temperature Sensor (Catalyst Inlet) - Remove and Install

Removal Procedure

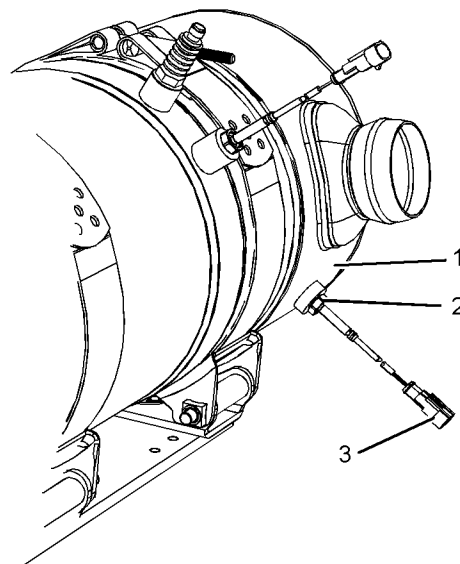


Illustration 513

g03729002

1. Disconnect the harness assembly from harness assembly (3) from temperature sensor (2).
2. Remove temperature sensor (2) from the assembly of the Clean Emissions Module (CEM) (1).

Installation Procedure

Table 110

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1

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

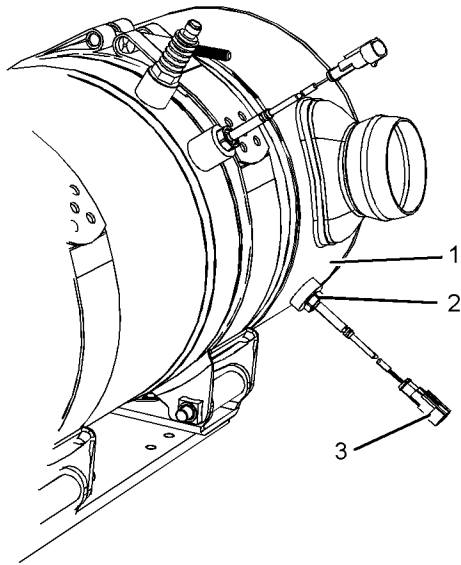


Illustration 514

g03729002

2. Lightly lubricate the thread of temperature sensor (2) with Tooling (A). Install the temperature sensor to CEM (1). Tighten the soot antenna to a torque of 45 N·m (33 lb ft).

3. Connect the harness assembly to harness assembly (3) from temperature sensor (2).

i05981823

Temperature Sensor (Cooled Exhaust Gas - Remove and Install

Removal Procedure

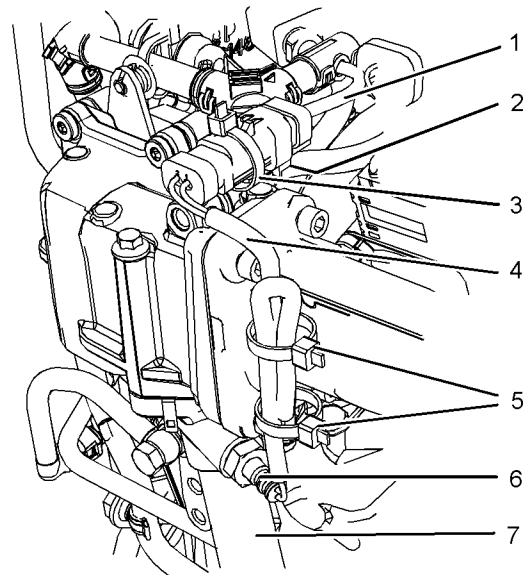


Illustration 515

g02520941

1. Slide locking tab (2) (not shown) into the unlocked position. Disconnect harness assembly (1) from harness assembly (4) for the temperature sensor.
2. Cut cable straps (5) and cable strap (3).
3. Remove temperature sensor (6) from tube assembly (7) for the NRS Induction mixer.

Installation Procedure

Table 111

Required Tools			
Tool	Part Number	Part Description	Qty
A	-	Bostik Pure Nickel Anti-Seize Compound	1

NOTICE

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

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

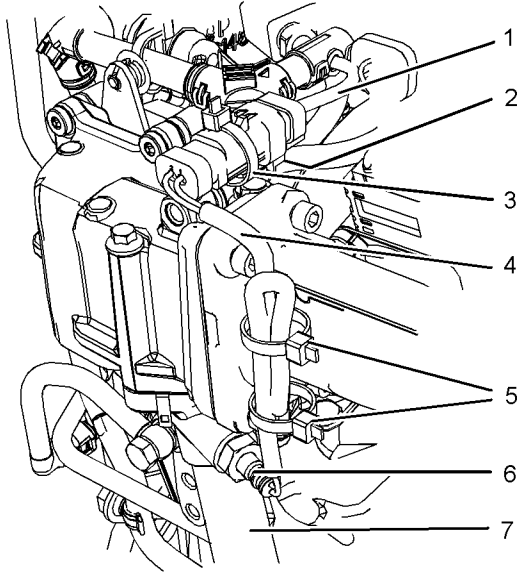


Illustration 516

g02520941

2. Lightly lubricate the thread of temperature sensor (6) with Tooling (A). Install temperature sensor (6) to tube assembly (7) for the NRS Induction mixer.
3. Torque temperature sensors (6) to a torque of 24 N·m (212 lb in).
4. Connect harness assembly (1) to harness assembly (4) for the temperature sensor. Slide locking tab (2) (not shown) into the locked position.
5. Install new cable straps (5) and a new cable strap (3) to harness assembly (4).

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

i05981805

Pressure Sensor (Cooled Exhaust Gas - Remove and Install (Differential Pressure Sensor and Inlet Pressure Sensor)

Removal Procedure

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

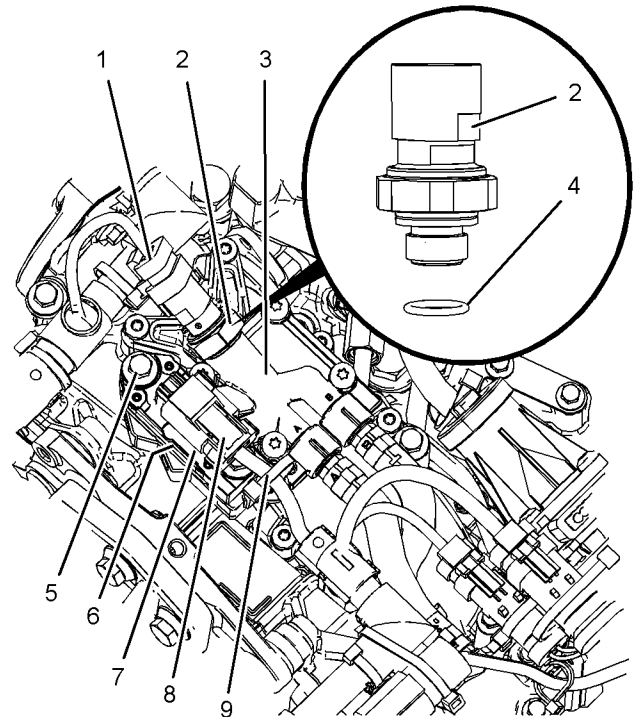


Illustration 517

g03728150

2. Disconnect harness assembly (1) from inlet pressure sensor (2).
3. Use a deep socket in order to remove inlet pressure sensor (2) from manifold (3).
4. Remove O-ring seal (4) from inlet pressure sensor (2).
5. Cut cable strap (9) from harness assembly (8).

6. Disconnect harness assembly (8) from differential pressure sensor (7).
7. Remove bolts (5) from differential pressure sensor (7). Remove the differential pressure sensor from manifold (3). Remove O-ring seals (6) (not shown).

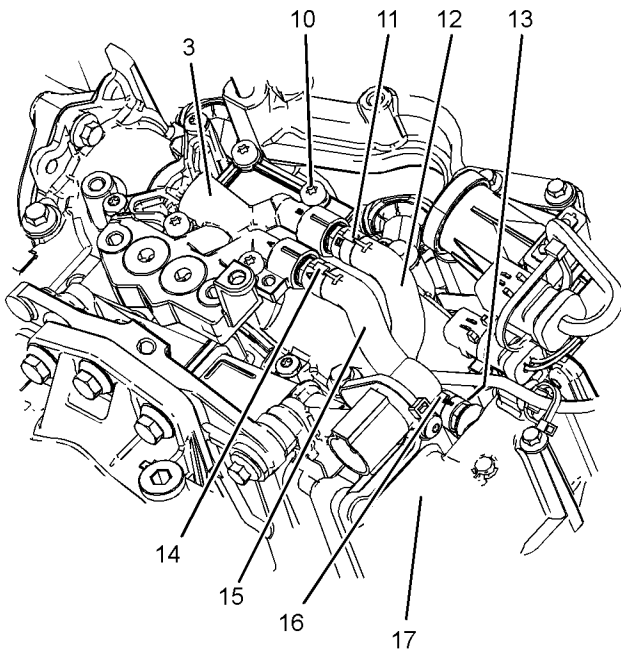


Illustration 518

g03728151

8. If necessary, follow Step 8a through Step 8c in order to remove the manifold (3) and the hose assemblies from NRS Induction mixer.
 - a. Use a suitable tool to remove clamp (11) and clamp (14) from hose assembly (12) and hose assembly (15). Disconnect the hose assemblies from manifold (3).
 - b. Remove Torx screws (10) from manifold (3). Remove the manifold from NRS Induction mixer (17).
 - c. Use a suitable tool to remove clamp (13) (not shown) and clamp (16) from hose assembly (12) and hose assembly (15). Remove the hose assemblies from NRS Induction mixer (17).

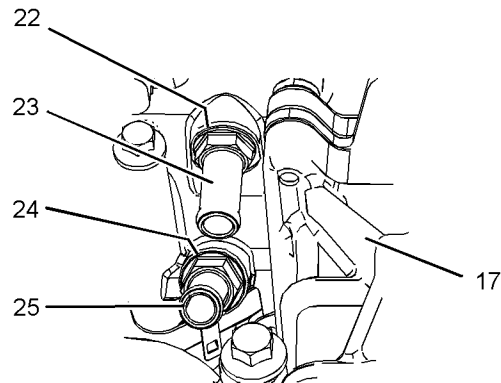
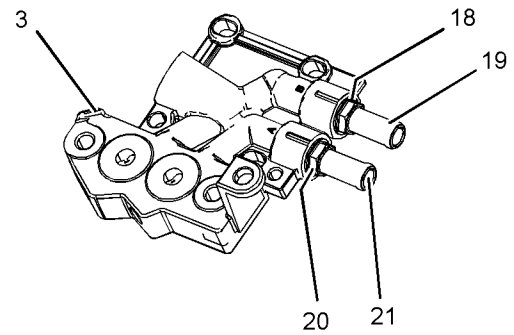


Illustration 519

g03728459

9. If necessary, follow Step 2a through Step 2c in order to remove the connections from manifold (3) and NRS Induction mixer (17).
 - a. Remove connection (19) and connection (21) from manifold (3).
 - b. Remove O-ring seal (18) (not shown) and O-ring seal (20) (not shown) from connection (19) and connection (21).
 - c. Make temporary marks on connection (23) and connection (25) for installation purposes. Remove the connections from NRS Induction mixer (17).
 - d. Remove O-ring seal (22) (not shown) and O-ring seal (24) (not shown) from connection (23) and connection (25).

Installation Procedure

NOTICE

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

Disassembly and Assembly Section

1. Ensure that all components are clean and free from wear damage and restriction. If necessary, replace any components that are worn, damaged, or not free from restriction.

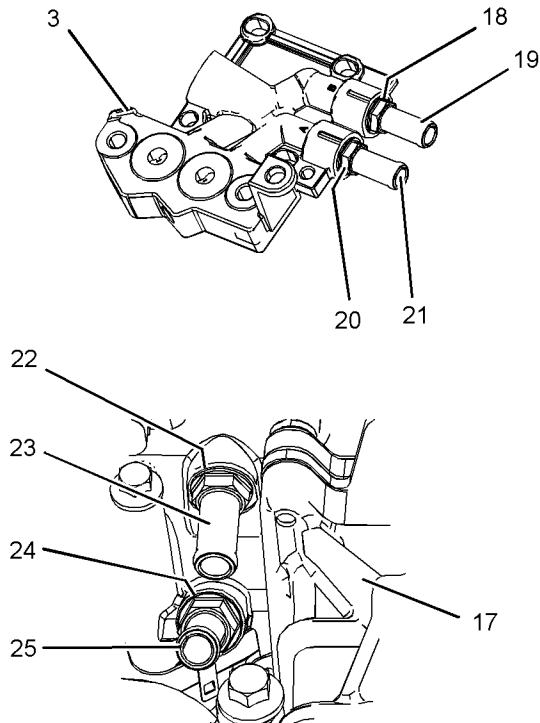


Illustration 520

g03728459

2. If necessary, follow Step 2a through Step 2e in order to install connections to manifold (3) and NRS Induction mixer (17).
 - a. Install a new O-ring seal (22) (not shown) and a new O-ring seal (24) (not shown) to connection (23) and connection (25).
 - b. Install connection (19) and connection (21) to NRS Induction mixer (17). Ensure that the connections are installed into the correct position on the NRS Induction mixer.
 - c. Tighten connection (19) and connection (21) to a torque of 17 N·m (150 lb in).
 - d. Install a new O-ring seal (18) (not shown) and a new O-ring seal (20) (not shown) to connection (19) and connection (21).
 - e. Install connection (19) and connection (21) to manifold (3). Tighten the connections to a torque of 17 N·m (150 lb in).

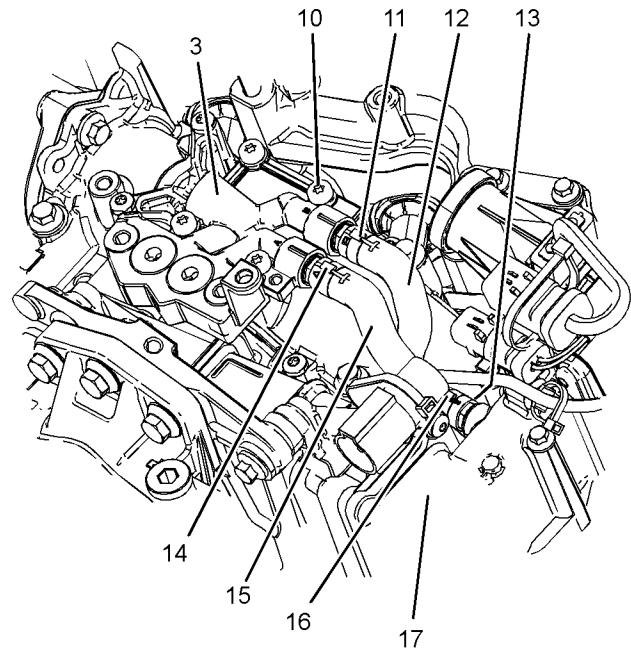


Illustration 521

g03728151

3. If necessary, follow Step 3a through Step 3e in order to install the manifold (3) and the hose assemblies from NRS Induction mixer.
 - a. Install a new hose clamp (13) (not shown) and a new hose clamp (16) onto hose assembly (12) and hose assembly (15). Ensure that the clamps are correctly orientated.
 - b. Install hose assembly (12) and hose assembly (15) onto NRS Induction mixer (17). Ensure that the hose assemblies are install in the correct position on the connections on the NRS Induction mixer.
 - c. Install a new hose clamp (11) and a new hose clamp (14) onto hose assembly (12) and hose assembly (15). Ensure that the hose clamps are correctly orientated.
 - d. Position manifold (3) onto from NRS Induction mixer (17). Install hose assembly (12) and hose assembly (15) onto the manifold. Ensure that the hose assemblies are install in the correct position on the connections on the manifold.
 - e. Install Torx screws (10) to manifold (3). Tighten the Torx screws to a torque of 10 N·m (89 lb in).
 - f. Use a suitable tool to tighten clamp (11), clamp (14), clamp (13) (not shown) and clamp (16) to

a torque of 3.5 N·m (31 lb in). Ensure that hose assembly (12) and hose assembly (15) are correctly orientated.

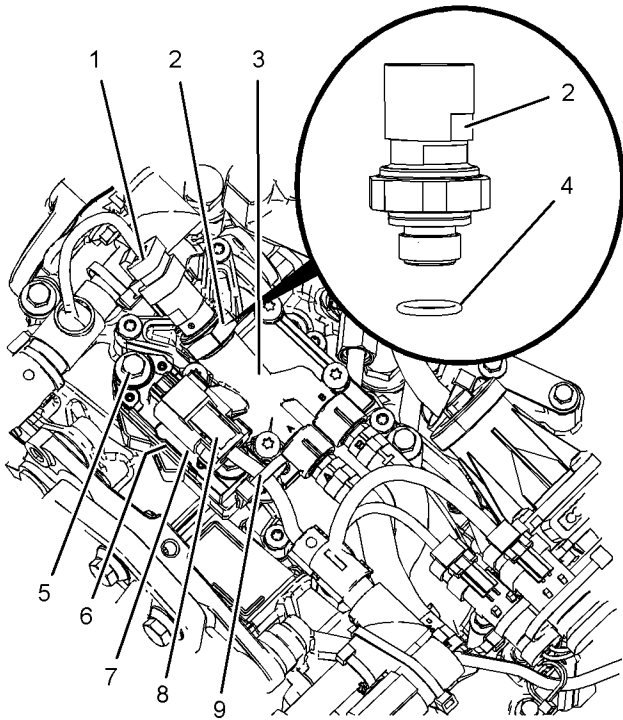


Illustration 522

g03728150

4. Install new O-ring seals (6) (not shown) to differential pressure sensor (7). Ensure that the O-rings are correctly installed into the recesses of the differential pressure sensor.
5. Install differential pressure sensor (7) onto manifold (3). Ensure that the differential pressure sensor is installed in the correct orientation on the manifold.
6. Install bolts (5) to differential pressure sensor. Tighten the bolts to a torque 22 N·m (195 lb in).
7. Connect harness assembly (8) to differential pressure sensor (7).
8. Install a new O-ring seal (4) to inlet pressure sensor (2).
9. Use a deep socket in order to install inlet pressure sensor (2) to manifold (3). Tighten the pressure sensor to a torque of 10 N·m (89 lb in).
10. Connect harness assembly (1) to inlet pressure sensor (2).
11. Install a new cable strap (9) to harness assembly (8).

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

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

i05980428

Boost Pressure Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

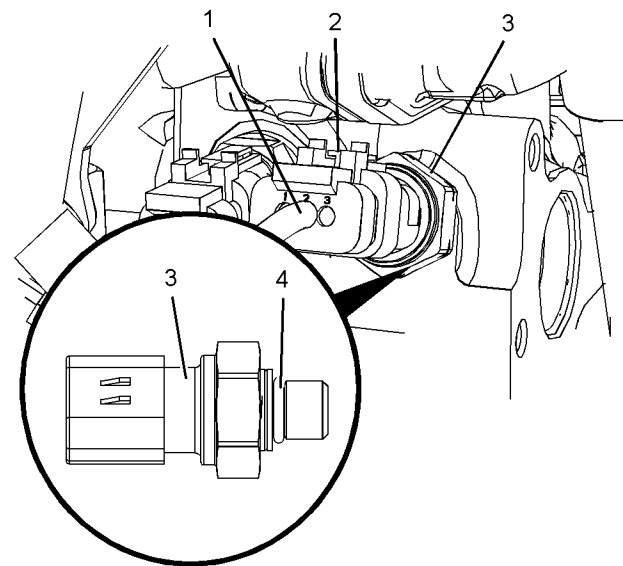


Illustration 523

g02437637

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

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

3. Use a deep socket to remove boost pressure sensor (3) from the cylinder head.
4. Remove O-ring seal (4) from the boost pressure sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

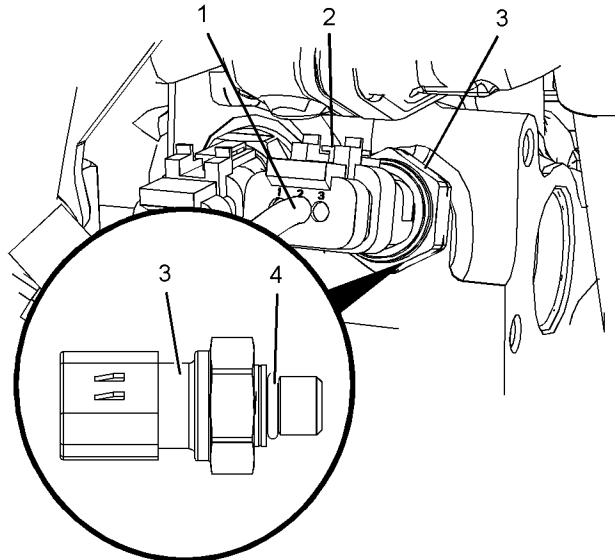


Illustration 524

g02437637

1. Install the new O-ring seal (4) onto boost pressure sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install boost pressure sensor (3) to the cylinder head. Tighten the boost pressure sensor to a torque of 10 N·m (89 lb in).
3. Connect harness assembly (1) to boost pressure sensor (3).
4. Slide locking tab (2) into the locked position.

i05981793

Inlet Manifold Temperature Sensor - Remove and Install

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

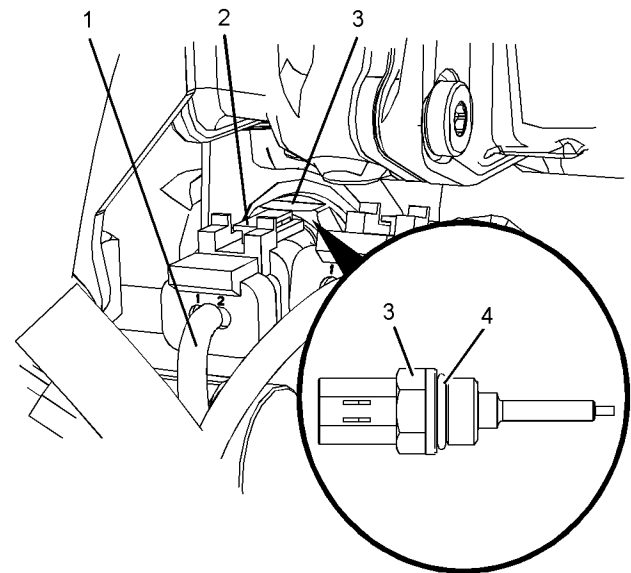


Illustration 525

g02437677

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

Note: The inlet manifold temperature sensor has a two-wire plug.

3. Use a deep socket to remove inlet manifold temperature sensor (3) from the cylinder head.
4. Remove O-ring seal (4) from the inlet manifold temperature sensor (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

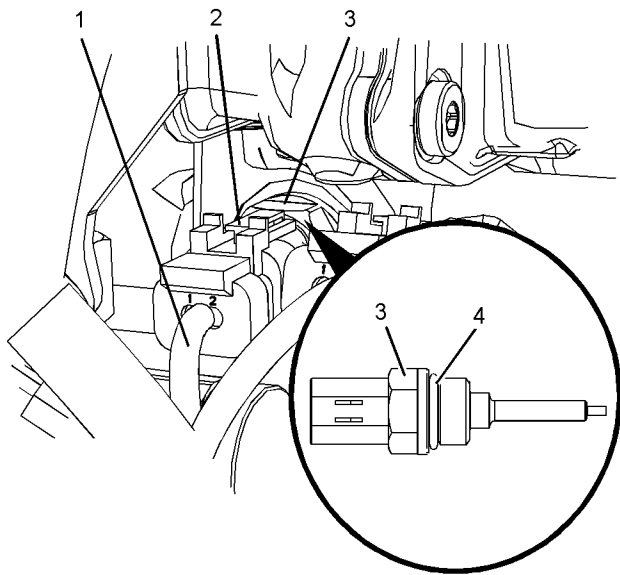


Illustration 526

g02437677

1. Install the new O-ring seal (4) to inlet manifold temperature sensor (3).

Note: Do not lubricate the O-ring seal.

2. Use a deep socket to install inlet manifold temperature sensor (3) to the cylinder head. Tighten the inlet manifold temperature sensor to a torque of 20 N·m (177 lb in).
3. Connect harness assembly (1) to inlet manifold temperature sensor (3).
4. Slide locking tab (2) into the locked position.

i05981770

Glow Plugs - Remove and Install

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

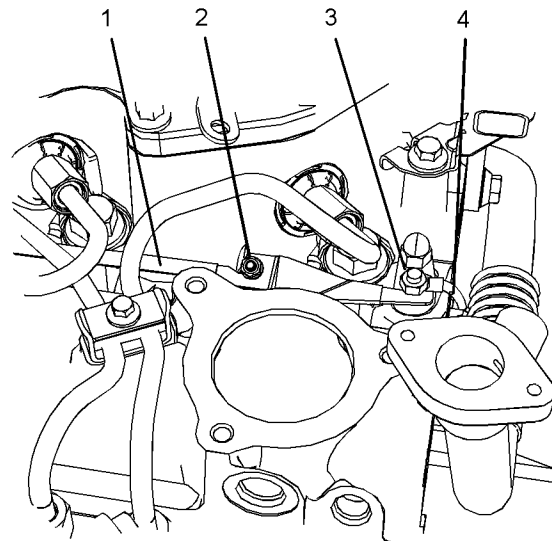


Illustration 527

g02488236

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

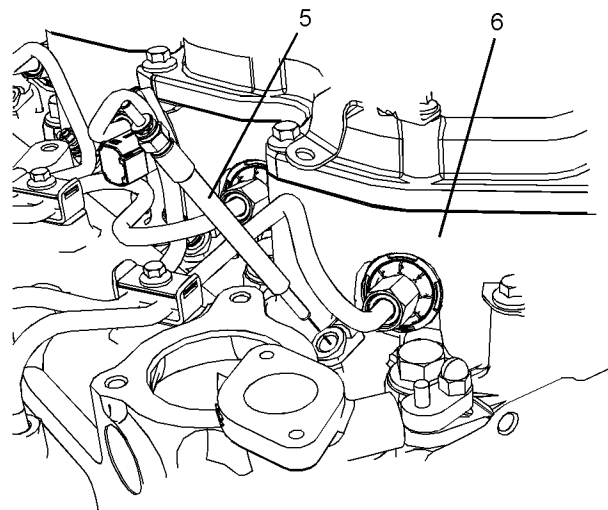


Illustration 528

g02488237

6. Remove glow plugs (5) from cylinder head (6).

Installation Procedure

Table 112

Required Tools			
Tool	Part Number	Part Description	Qty
A	27610296	Torque Wrench	1

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

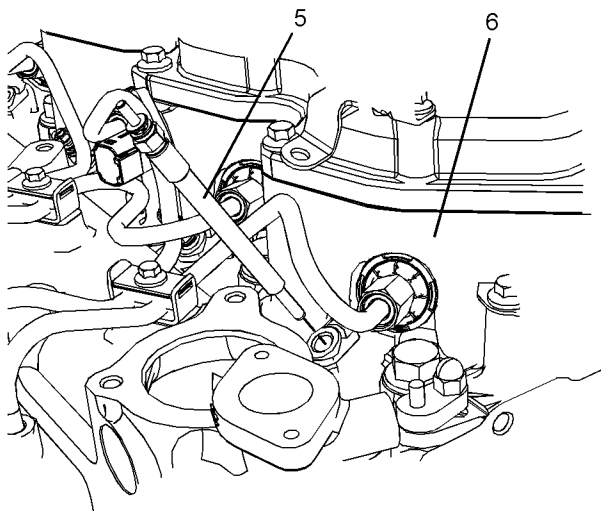


Illustration 529

g02488237

1. Ensure that the threads of the glow plugs are clean and free from damage. Replace any damaged glow plugs.
2. Install glow plugs (5) into cylinder head (6). Tighten the glow plugs to a torque of 15 N·m (132 lb in).

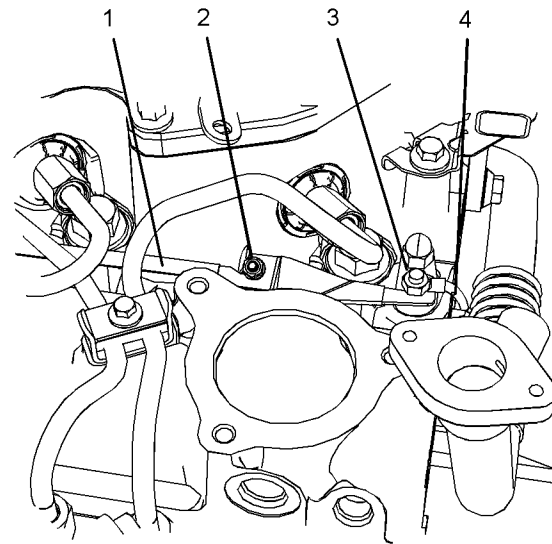


Illustration 530

g02488236

3. Position bus bar (1) onto the glow plugs. Install nuts (2) onto the glow plugs.
4. Use Tooling (A) to tighten nuts (2) to a torque of 2 N·m (17 lb in).
5. Connect wire (4) to the stud on the terminal insulator.
6. Install nut (3) to the stud on the terminal insulator. Tighten the nut to a torque of 6 N·m (53 lb in).
7. Turn the battery disconnect switch to the ON position.

End By:

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

i05980416

Alternator Belt - Remove and Install

Removal Procedure

Table 113

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

1. If the engine has guards, remove the guards. Refer to the OEM for the correct procedure.

Note: Mark the direction of rotation of the alternator belt, if the belt will be reused.

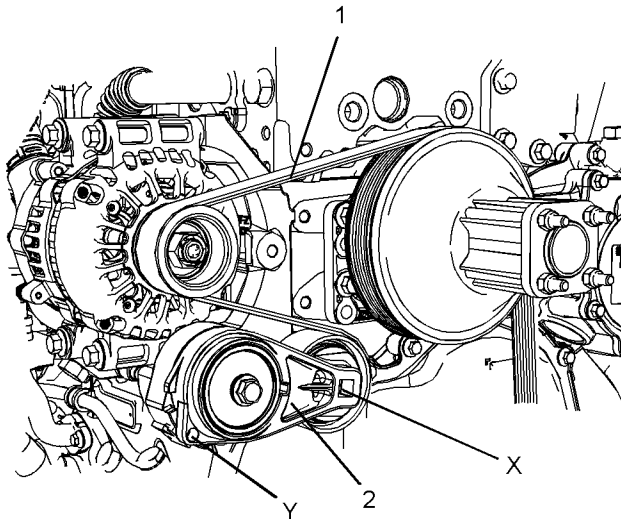


Illustration 531 g02433716

Typical example

2. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction.
3. Insert Tooling (A) into Hole (Y).
4. Remove alternator belt (1).
5. If necessary, Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction and remove Tooling (A) from Hole (Y).
6. Release the pressure on the 1/2" square drive tool and remove the 1/2" square drive tool from Hole (X).

Installation Procedure

Table 114

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

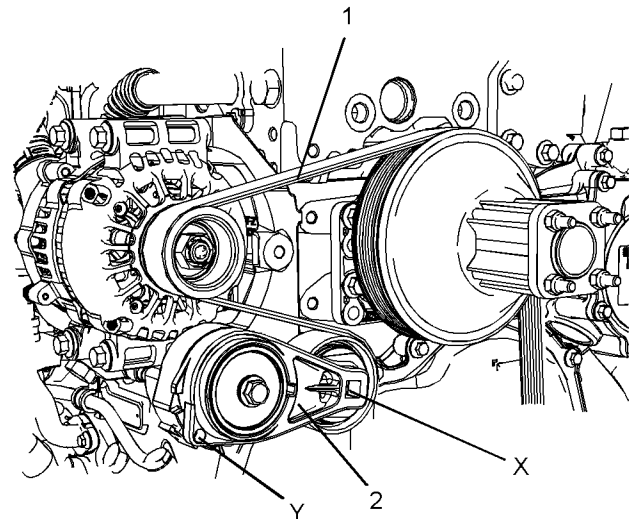


Illustration 532 g02433716

Typical example

1. If necessary, follow Step 1a through Step 1c in order to position the tensioner correctly.
 - a. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction.
 - b. Insert Tooling (A) into Hole (Y).
 - c. Release the pressure on the 1/2" square drive tool and remove the 1/2" square drive tool from Hole (X).
 2. Clean all pulleys and guide rollers. Ensure that the pulleys and all guide rollers are clean. Ensure that the pulleys and guide rollers are free from dirt and build up from the old belt.
- Note:** The grooves on the alternator belt must be located into the grooves of all pulleys.
3. Position alternator belt (1). Ensure that the alternator belt is centered on all pulleys. A used alternator belt should be installed in the original direction of rotation.
 4. Install a 1/2" square drive tool into Hole (X) in tensioner (2). From the front of the engine, turn the tool in a clockwise direction. Remove Tooling (A) from Hole (Y).
 5. Release the pressure on the 1/2" square drive tool until the alternator belt is tensioned. Remove the 1/2" square drive tool from Hole (X).

Note: The tensioner should be at the nominal position.

6. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i05981782

Idler Pulley - Remove and Install (Flat Idler Pulley)

Removal Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

1. Remove the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install" for the correct procedure.

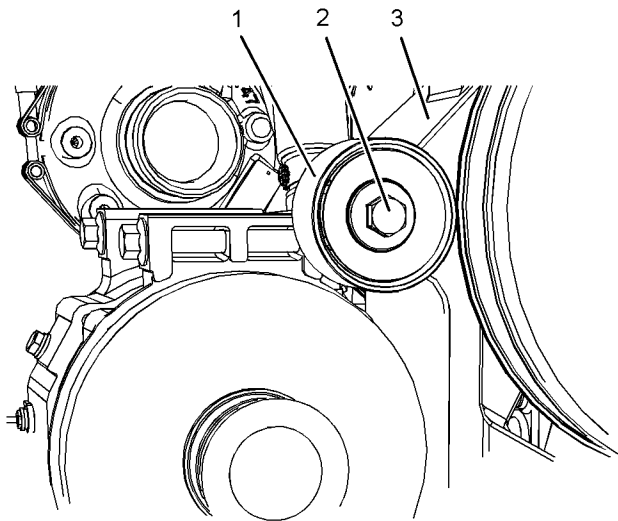


Illustration 533

g02501036

Typical example

2. Remove bolt (2).
3. Remove flat idler pulley (1) from bracket (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

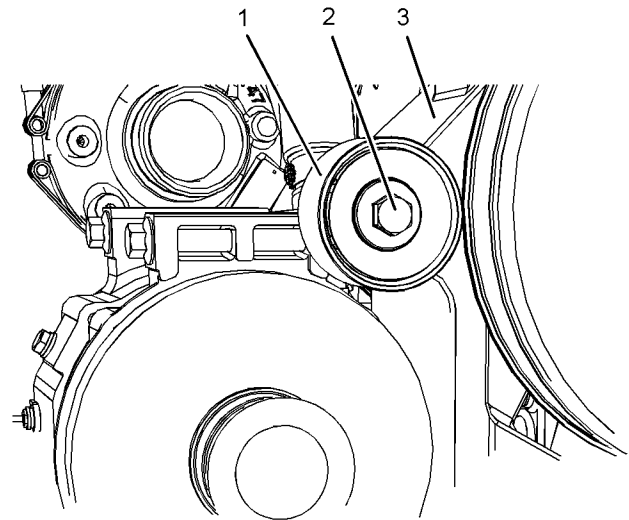


Illustration 534

g02501036

Typical example

1. Position flat idler pulley (1) on bracket (3). Loosely tighten bolt (2).
2. Install bolt (2). Tighten the bolt to a torque of 44 N·m (32 lb ft).
3. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install" for the correct procedure.

i05981788

Idler Pulley - Remove and Install (Grooved Idler Pulley)

Removal Procedure

Start By:

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

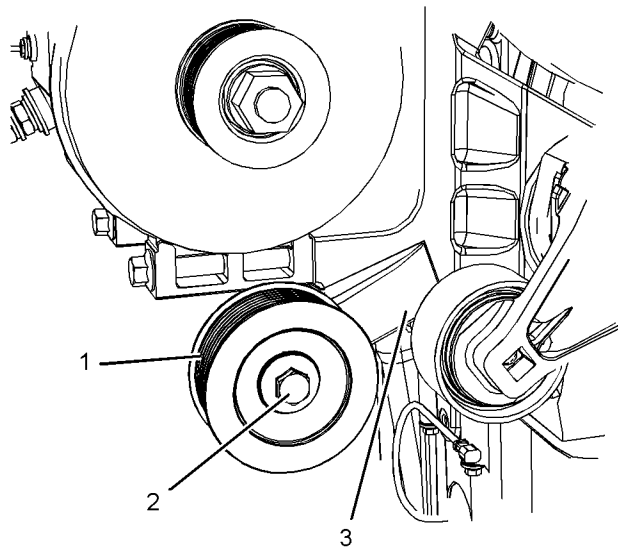


Illustration 535

g02501039

Typical example

1. Remove bolt (2).
2. Remove grooved idler pulley (4) from bracket (3).

Installation Procedure

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

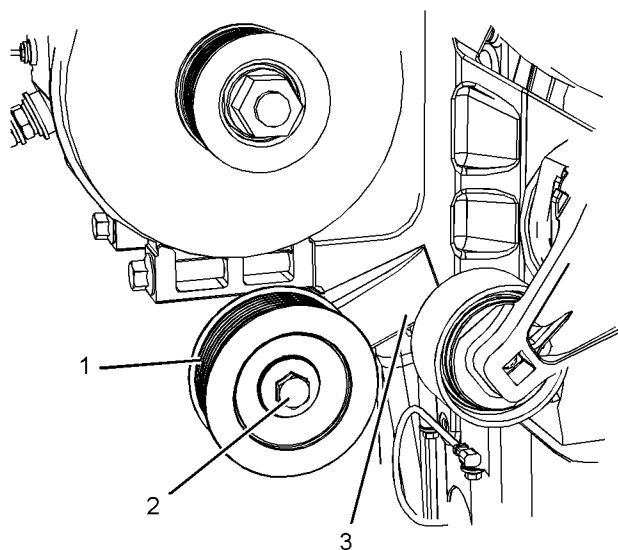


Illustration 536

g02501039

Typical example

1. Position grooved idler pulley (1) onto bracket (3). Loosely tighten bolt (2).
2. Tighten bolt (2) to a torque of 44 N·m (32 lb ft).

End By:

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

i05980426

Belt Tensioner - Remove and Install

Removal Procedure

1. If the engine has guards, remove the guards. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.
2. Remove the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install." for the correct procedure.

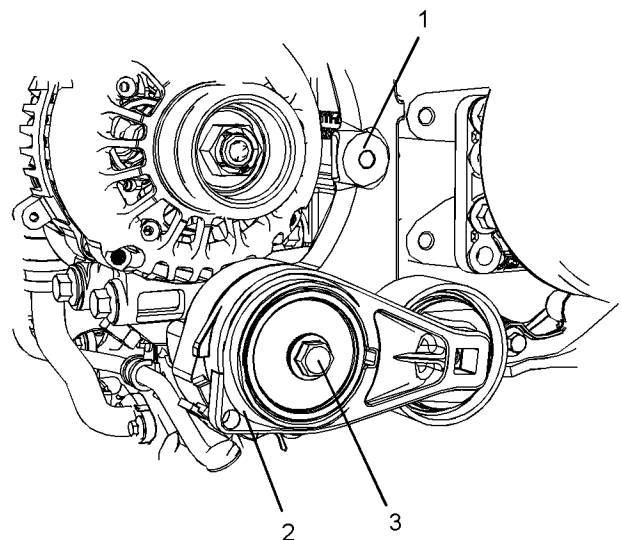


Illustration 537

g02437576

3. Loosen bolt (3) sufficiently in order to remove tensioner (2) from mounting bracket (1).
4. Remove tensioner (2) from mounting bracket (1).

Installation Procedure

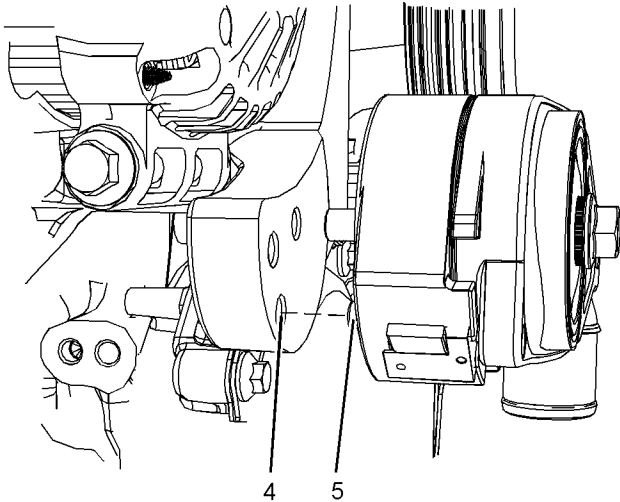


Illustration 538

g02437596

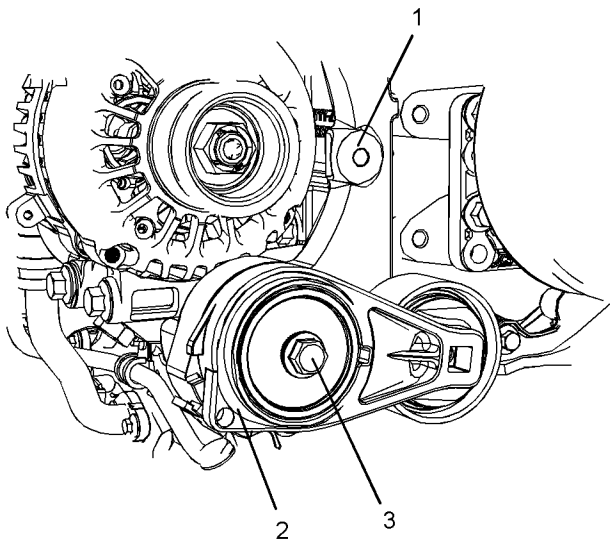


Illustration 539

g02437576

1. Position belt tensioner (3) with locating pin (5) in locating hole (4) on the mounting bracket. Tighten bolt (3) finger tight.
2. Tighten bolt (3) to a torque of 45 N·m (33 lb ft).
3. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install." for the correct procedure.

4. If the engine has guards, install the guards. Refer to the OEM for the correct procedure.

i05981744

Fan - Remove and Install

Removal Procedure

Start By:

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

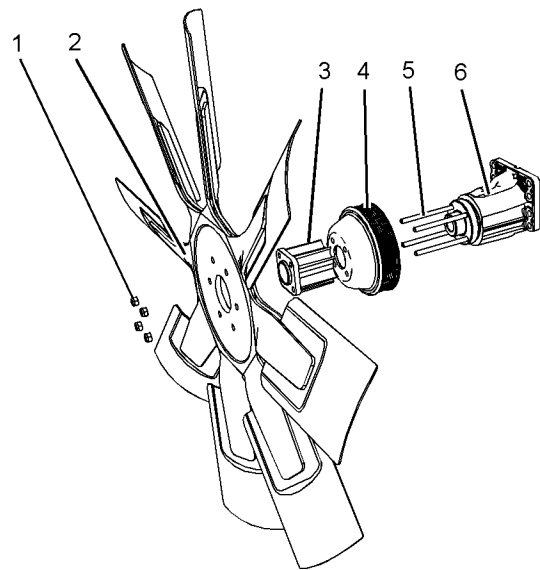


Illustration 540

g02101373

Typical example

1. Remove locking nuts (1).
 2. Remove fan (2).
- Note:** Note the orientation of the fan.
3. Remove fan adapter (3).
 4. Remove fan pulley (4).
 5. If necessary, remove studs (5) from fan drive (6).

Installation Procedure

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

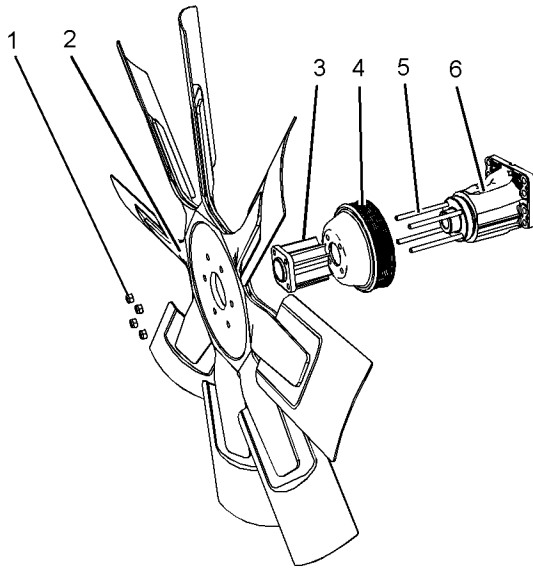


Illustration 541

g02101373

Typical example

2. If necessary, install studs (5) to fan drive (6). Tighten studs (5) to a torque of 11 N·m (97 lb in).
 3. If studs (5) have not been previously installed to fan drive (6). Checking the installation of the studs will be necessary, to check for the correct installation of the studs to the fan drive. Tighten studs (5) to a torque of 11 N·m (97 lb in).
 4. Install fan pulley (4).
 5. Install fan adapter (3).
 6. Install fan (2).
- Note:** Ensure that the fan is correctly oriented.
7. Inspect the condition of locking nuts (1). If necessary, replace the locking nuts. Install locking nuts (1). Tighten locking nuts (1) to a torque of 22 N·m (195 lb in).

End By:

- a. Install the Alternator Belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install" for the correct procedure.

i05981745

Fan Drive - Remove and Install

Removal Procedure

Start By:

- a. Remove the fan. Refer to Disassembly and Assembly, "Fan - Remove and Install" for the correct procedure.

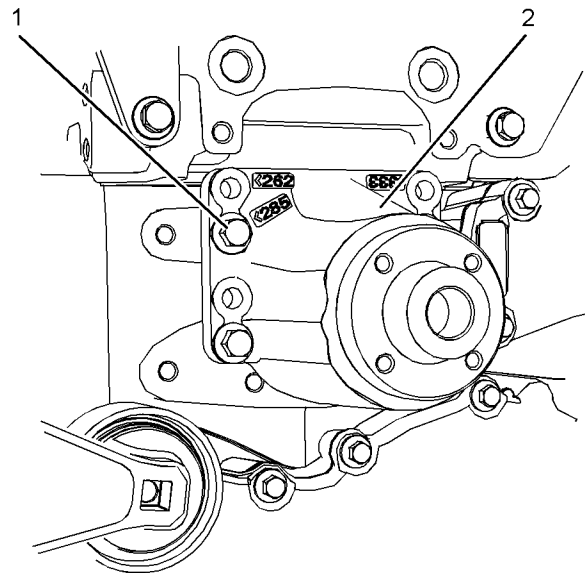


Illustration 542

g02014594

Typical example

1. Make a temporary mark on fan drive assembly (2) in order to identify the orientation and the position.
2. Remove bolts (1) from fan drive assembly (2).
3. Remove fan drive assembly (2).

Installation Procedure

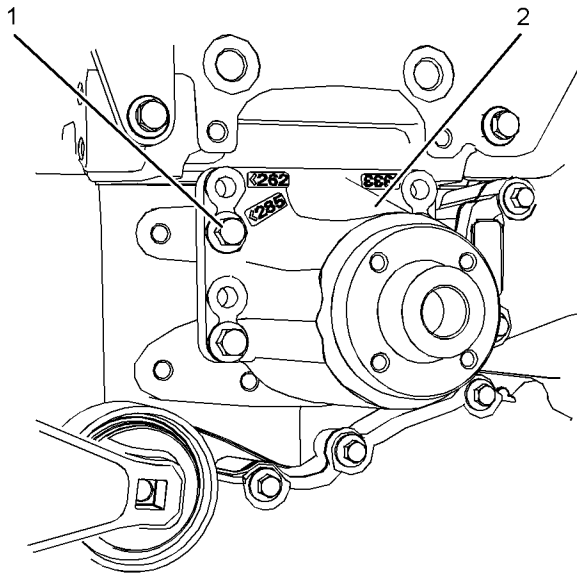


Illustration 543

g02014594

Typical example

1. Check the fan drive for wear and damage. If the fan drive is worn or damaged, replace the fan drive.

2. Install fan drive assembly (2).

Note: Ensure that the fan drive is correctly oriented.

3. Install bolts (1) finger tight to fan drive assembly (2). Tighten the bolts to a torque of 44 N·m (32 lb ft).

End By:

a. Install the fan. Refer to Disassembly and Assembly, “Fan - Remove and Install” for the correct procedure.

i05980716

Electronic Control Module - Remove

Removal Procedure

Table 115

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

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

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

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

1. The Electronic Control Module (ECM) can be a fuel cooled ECM or air cooled ECM. The removal procedure is similar for a fuel cooled ECM or air cooled ECM.
2. Turn the battery disconnect switch to the OFF position.
3. Turn the fuel supply to the OFF position.
4. If necessary, remove the secondary filter assembly. Refer to Disassembly and Assembly, “Fuel Filter Base - Remove and Install” for the correct procedure.
5. If necessary, remove the primary fuel filter assembly. Refer to Disassembly and Assembly, “Water Separator and Fuel Filter (Primary) - Remove and Install” for the correct procedure.
6. If necessary, remove the dipstick tube assembly. Refer to Disassembly and Assembly, “Engine Oil Pan - Remove and Install” for the correct procedure.

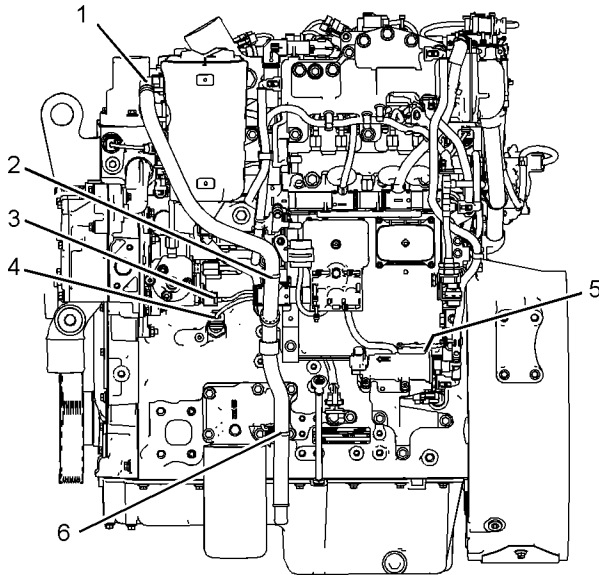


Illustration 544

g03738323

Typical example

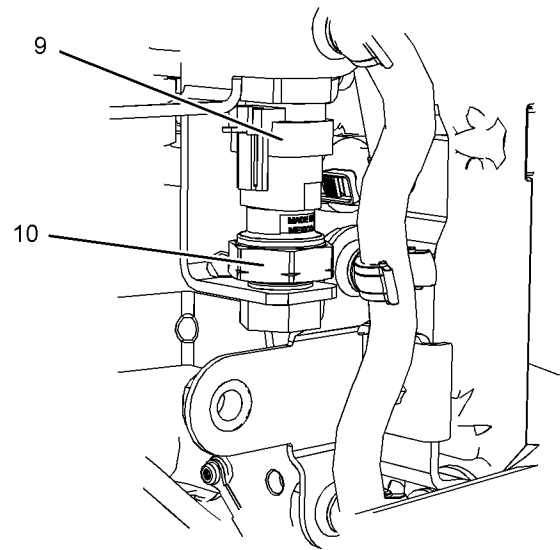


Illustration 546

g03738326

Typical example

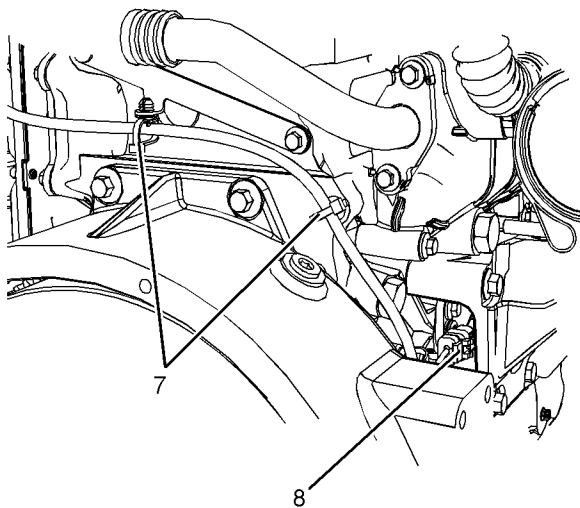


Illustration 545

g03738325

Typical example

7. Cut cable strap (2) and cable strap (6) from plastic tube assembly (1).
8. Remove plastic tube assembly (1) from the crankcase breather canister. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.
9. Disconnect harness assembly (3) from the fuel temperature sensor. Refer to Disassembly and Assembly, "Fuel Temperature Sensor - Remove and Install" for the correct procedure.
10. Disconnect harness assembly (4) from the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install" for the correct procedure.
11. Disconnect the harness assembly from crankshaft position sensor (5) (not shown). Refer to Disassembly and Assembly, "Crankshaft Position Sensor - Remove and Install" for the correct procedure.
12. Cut cable straps (7) from harness assembly for camshaft position sensor (8) (not shown). Disconnect the harness assembly from camshaft position sensor (9) (not shown). Refer to Disassembly and Assembly, "Camshaft Position Sensor - Remove and Install" for the correct procedure.

- 13.** Disconnect harness assembly (9) from atmospheric pressure sensor (10). Refer to Disassembly and Assembly, "Atmospheric Pressure Sensor - Remove and Install" for the correct procedure.

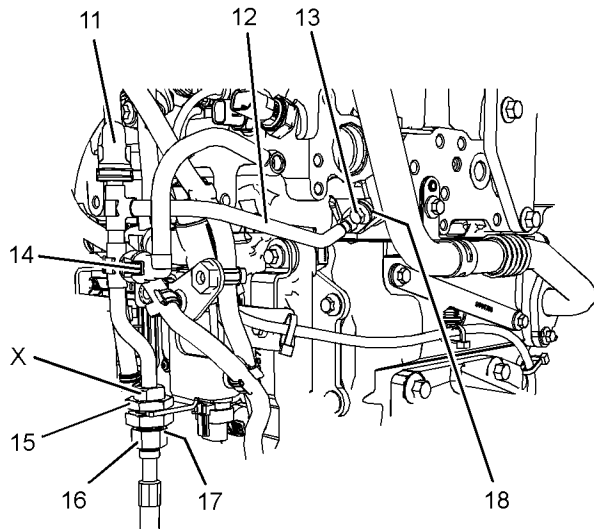


Illustration 547

g03738863

Typical example

- 14.** Disconnect plastic tube assembly (11) and plastic tube assembly (14) from tube assembly (12). Use Tooling (A) in order to plug the plastic tube assemblies and to cap the tube assembly.
- 15.** Use a suitable tool in Position (X) in order to hold and disconnect hose assembly (16) from connection on tube assembly (13). Remove O-ring seal (17) (not shown). Use Tooling (A) in order to plug the hose assembly and to cap the tube assembly.
- 16.** Use a suitable tool in Position (X) in order to hold tube assembly (12) as nut (15) is loosened. Remove bolt (13) from tube assembly (12).
- 17.** Remove tube assembly (12) from the bracket and the cylinder head.
- 18.** Remove O-ring seal (18) (not shown) from tube assembly (12).
- 19.** Use Tooling (A) in order to plug the cylinder head and to cap the tube assembly.

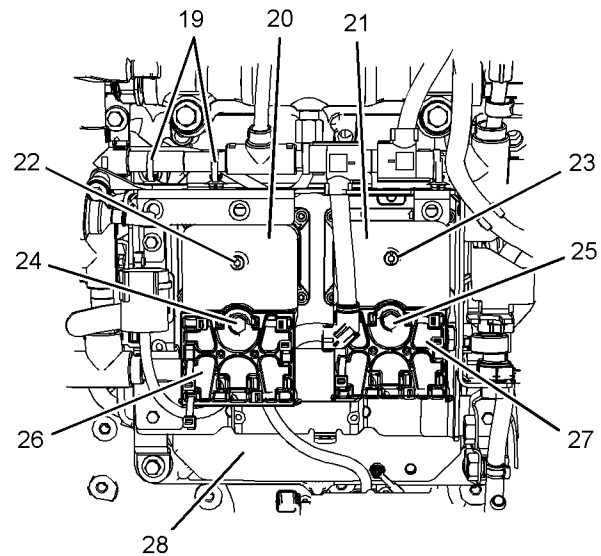


Illustration 548

g03738899

Typical example

- 20.** Cut cable straps (19) from engine harness assembly. Ensure that all the cable straps are removed.
- 21.** Remove bolt (24) from ECM plug (20).
- 22.** Loosen the allen head bolt (22) that secures ECM plug (20) for engine harness assembly (26) to ECM (28).
- 23.** Position engine harness assembly (26) away from the ECM.
- 24.** Remove bolt (25) from Original Equipment Manufacture (OEM) plug (21).
- 25.** Loosen the allen head bolt (23) that secures OEM plug (21) for the OEM harness assembly (27) to ECM (28).
- 26.** Position OEM harness assembly (27) away from the ECM.

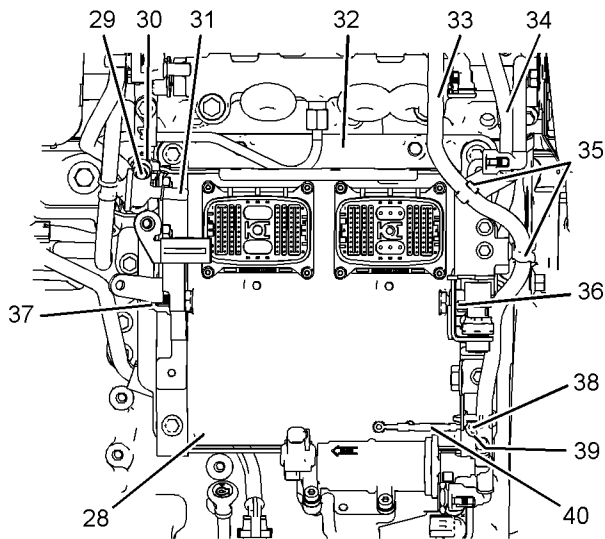


Illustration 549

g03738900

Typical example

27. Make temporary identification marks on the plastic tube assembly (37) and plastic tube assembly (36) for installation purposes.
 28. Place a suitable container below the ECM (28) in order to catch any fuel that might be spilled.
 29. Disconnect plastic tube assembly (37) and plastic tube assembly (36). Drain the fuel from ECM (28).
 30. Use Tooling (A) in order to plug plastic tube assembly (37) and plastic tube assembly (36).
 31. Use Tooling (A) in order to cap connections on the ECM for plastic tube assemblies.
 32. Remove plastic tube assembly (33) and plastic tube assembly (34) from clips (35).
 33. Disconnect the plastic tube assembly from valve (31). Use Tooling (A) in order to cap connection on valve (31) and the plastic tube assembly.
 34. Remove bolt (29) spacer (30) for valve (31).
 35. Remove bolts (38) and washer (39) (not shown) from bracket (32) and from ECM (28). Ensure that earth strap (40) is not damaged as the bolts are removed. Support the weight of the ECM as the bolts are removed.
- Note:** Note the orientation and position of the brackets
36. Remove bracket (32) and ECM (28) from the engine.

Note: When removing the bolts from the ECM, ensure that the fuel injection line from the fuel injection pump to the fuel manifold is not damaged.

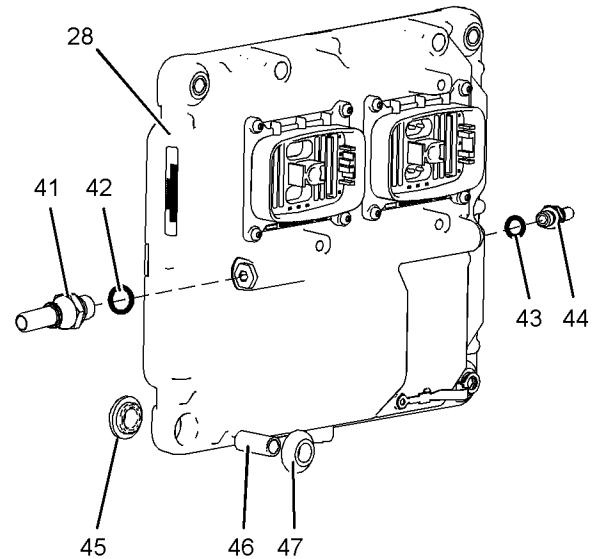


Illustration 550

g03738901

Fuel cooled ECM

37. If necessary, follow Step 37a through Step 37d in order to disassemble ECM (28).
 - a. Remove isolation mount (45), isolation mount (47), and limit sleeves (46).
 - b. If necessary, remove connection (41) and connection (44) from ECM (28).
 - c. If necessary, remove O-ring seal (42) and O-ring seal (43) from the connections.
 - d. Use Tooling (A) in order to plug ECM (28). Use Tooling (A) in order to cap the connection (41) and connection (44).

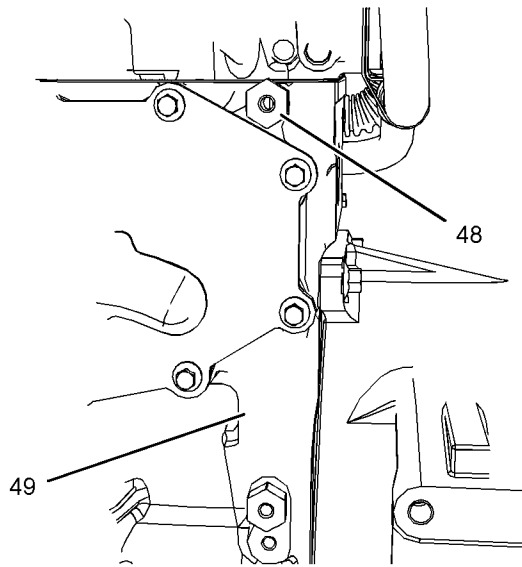


Illustration 551

g03738902

Typical example

- 38.** If necessary, remove spacers (48) from cylinder block (49).

i05980701

Electronic Control Module - Install

Installation Procedure

NOTICE

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

1. The Electronic Control Module (ECM) can be a fuel cooled ECM or air cooled ECM. The installation procedure is similar for a fuel cooled ECM or air cooled ECM.
2. If a replacement ECM is installed, the replacement ECM must be programmed with the correct information. Refer to Troubleshooting Guide, "Replacing the ECM" and refer to Troubleshooting Guide, "Flash Programming" for the correct procedure.
3. Ensure that the electronic control module is clean and free from damage. If necessary, replace the electronic control module.

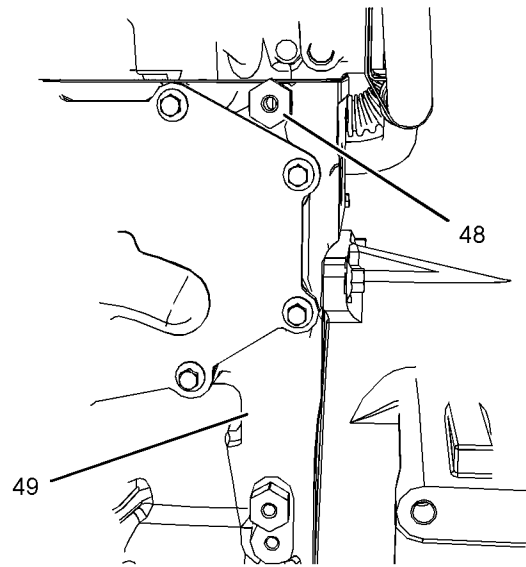


Illustration 552

g03738902

Typical example

- 4.** If necessary, install spacers (48) to cylinder block (49). Tighten the spacers to a torque of 44 N·m (32 lb ft).

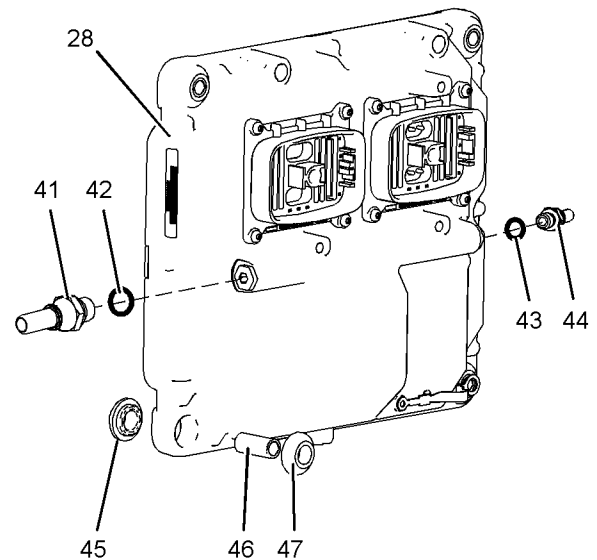


Illustration 553

g03738901

Fuel cooled ECM

- 5.** If necessary, follow Step 5a through Step 5d in order to assemble ECM (28).
- a. Remove caps from connection (41). Install new O-ring seal (42) to the connection.
 - b. Remove caps from connection (44). Install a new O-ring seal (43) to the connection.

- c. Remove plugs from ECM (28). Install connection (41) and connection (44) to the ECM. Tighten the connections to a torque of 18 N·m (159 lb in).
- d. Install isolation mount (45), isolation mount (47), and limit sleeves (46) to ECM (28).

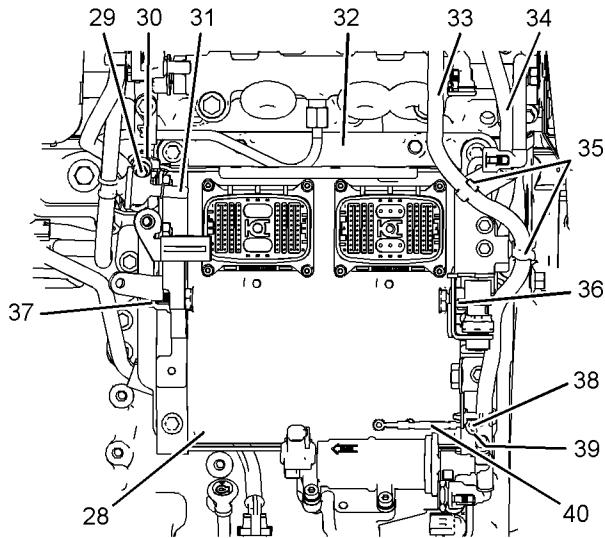


Illustration 554

g03738900

Typical example

6. Position bracket (32) onto ECM (28). Ensure that the bracket is correctly orientated.
 7. Position bracket (32) and ECM (28) onto the cylinder block. Support the weight of the ECM as the bolts are installed.
- Note:** Ensure that the fuel injection line is not damaged during the installation of the bracket.
8. Install bolts (38) and washer (39) (not shown) to bracket (32) and to ECM (28). Ensure that earth strap (40) is correctly positioned between the bolts and the washers. Hand tighten the bolts.
 9. Tighten bolts (38) to a torque of 22 N·m (195 lb in).
 10. Install spacer (30) and bolt (29) to valve (31). Tighten the bolt to a torque of 9 N·m (80 lb in).
 11. Remove caps connection on valve (31) and the plastic tube assembly. Connect the plastic tube assembly to valve (31)
 12. Install plastic tube assembly (33) and plastic tube assembly (34) to clips (35).

13. Remove caps connections on the ECM for plastic tube assemblies. Remove plugs from plastic tube assembly (37) and plastic tube assembly (36).
14. Connect plastic tube assembly (37) and plastic tube assembly (36) to connections on ECM (28).

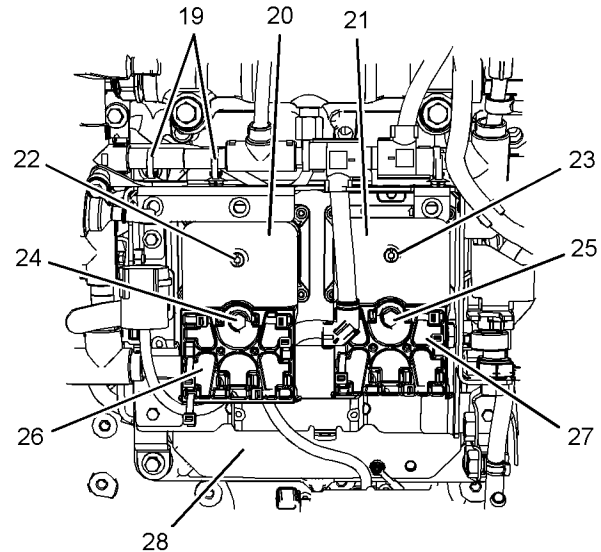


Illustration 555

g03738899

15. Position the OEM harness assembly (27) onto ECM (28).
 16. Tighten the allen head bolt (23) that secures OEM plug (21) for the OEM harness assembly (27) to ECM (28). Ensure that the OEM wiring harness is correctly routed.
- Note:** Care must be taken in order to avoid damage to the connector pins during installation of the harness assembly.
17. Install bolt (25) to OEM plug (21). Hand tighten the bolt.
 18. Tighten allen head bolt (23) to a torque of 6 N·m (53 lb in).
Tighten bolt (25) to a torque of 6.5 N·m (59 lb in).
 19. Position engine harness assembly (26) onto ECM (28). Ensure that the engine wiring harness is correctly routed.
 20. Tighten the allen head bolt (22) that secures ECM plug (20) for engine harness assembly (26) to ECM (28).

Note: Care must be taken in order to avoid damage to the connector pins during installation of the harness assembly.

Disassembly and Assembly Section

21. Install bolt (24) to ECM plug (20). Hand tighten the bolt.
22. Tighten allen head bolt (22) to a torque of 6 N·m (53 lb in).
Tighten bolt (24) to a torque of 6.5 N·m (59 lb in).
23. Install new cable straps (19) to engine harness assembly.

Note: Ensure that the cable straps meet OEM specifications.

30. Remove the plug from hose assembly (16) and remove the cap from tube assembly (12).
31. Install a new O-ring seal (17) (not shown). Ensure that the O-ring seal is correctly seated into the recess of the tube assembly.
32. Connect hose assembly (16) from connection on tube assembly (13) hand tight.
33. Use the suitable tool to hold tube assembly (12) in Position (X). Tighten the nut for hose assembly to a torque of 43 N·m (32 lb ft).

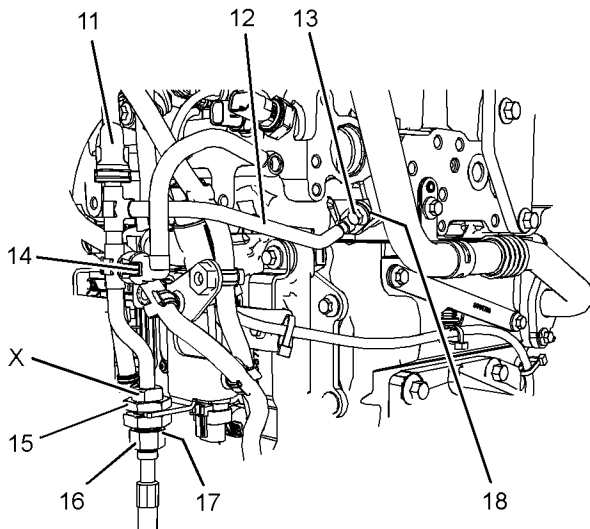


Illustration 556

g03738863

Typical example

24. Remove the plug from cylinder head and to the cap from tube assembly (12). Install a new O-ring seal (18) (not shown) to the tube assembly.
25. Install tube assembly (12) to the bracket and the cylinder head. Install bolt (13) to the tube assembly hand tight.
26. Use a suitable tool in Position (X) in order to hold tube assembly (12) as nut (15) is tightened hand tight.
27. Tighten bolt (13) to a torque of 22 N·m (195 lb in).
28. Use the suitable tool to hold tube assembly (12) in Position (X). Tighten nut (15) to a torque of 28 N·m (248 lb in). Ensure that the tube assembly is not strained as the nut is tightened.
29. Remove the plug from plastic tube assemblies and the cap from tube assembly (12). Connect plastic tube assembly (11) and plastic tube assembly (14) to the tube assembly

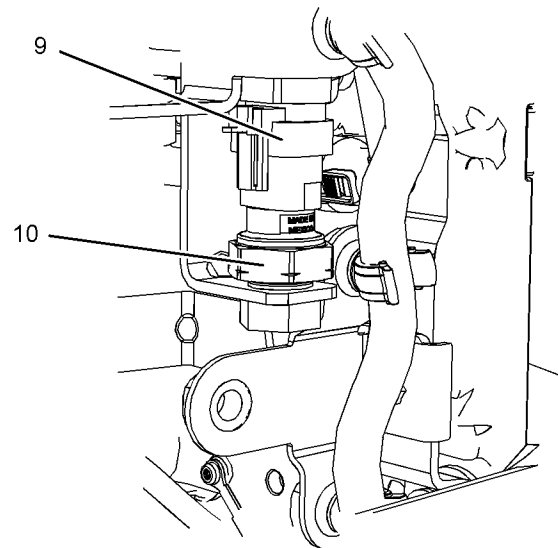


Illustration 557

g03738326

Typical example

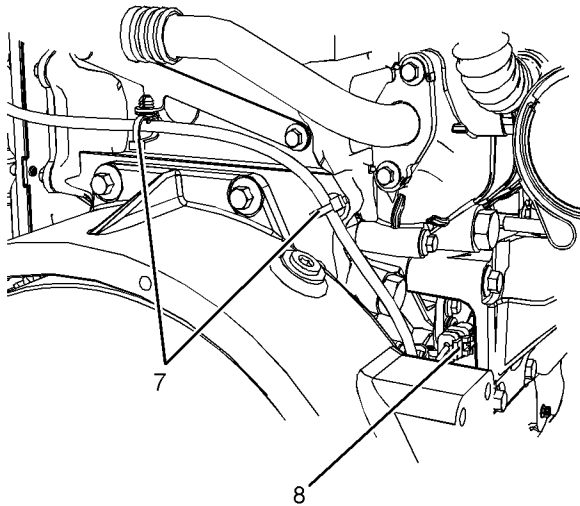


Illustration 558

g03738325

Typical example

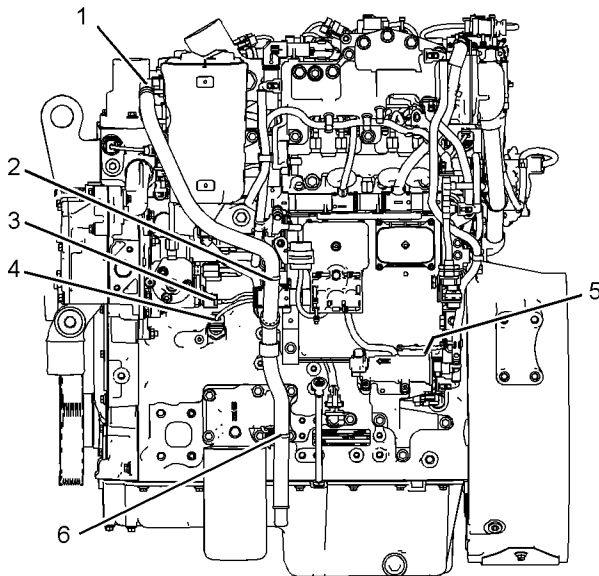


Illustration 559

g03738323

Typical example

34. Connect harness assembly (9) to atmospheric pressure sensor (10). Refer to Disassembly and Assembly, "Atmospheric Pressure Sensor - Remove and Install" for the correct procedure.
35. Connect the harness assembly to camshaft position sensor (8). Refer to Disassembly and Assembly, "Camshaft Position Sensor - Remove and Install" for the correct procedure.
36. Install new cable straps (7) to harness assembly for camshaft position sensor (8).

Note: Ensure that cable straps meet the OEM specification.

37. Connect the harness assembly from crankshaft position sensor (5) (not shown). Refer to Disassembly and Assembly, "Crankshaft Position Sensor - Remove and Install" for the correct procedure.
38. Connected harness assembly (4) to the engine oil pressure sensor. Refer to Disassembly and Assembly, "Engine Oil Pressure Sensor - Remove and Install" for the correct procedure.
39. Connected harness assembly (3) to the fuel temperature sensor. Refer to Disassembly and Assembly, "Fuel Temperature Sensor- Remove and Install" for the correct procedure.
40. Install plastic tube assembly (1) to the crankcase breather canister. Refer to Disassembly and Assembly, "Crankcase Breather - Remove" for the correct procedure.
41. Install new cable strap (2) and cable strap (6) to plastic tube assembly (1).

Note: Ensure that cable straps meet the OEM specification.

42. If necessary, install the dipstick tube assembly. Refer to Disassembly and Assembly, "Engine Oil Pan - Remove and Install" for the correct procedure.
43. If necessary, install the primary fuel filter assembly. Refer to Disassembly and Assembly, "Water Separator and Fuel Filter (Primary) - Remove and Install" for the correct procedure.
44. If necessary, install the secondary filter assembly. Refer to Disassembly and Assembly, "Fuel Filter Base - Remove and Install" for the correct procedure.
45. Turn the fuel supply to the ON position.
46. Turn the battery disconnect switch to the ON position.

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

i05980410

Alternator - Remove

Removal Procedure

Table 116

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	-	1/2 Inch Drive T50 Torx Bit	1
	-	1/2 Inch Drive x 8 mm Hex Drive	1

(1) Either tool may be necessary in order to remove the alternator pulley.

Start By:

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

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

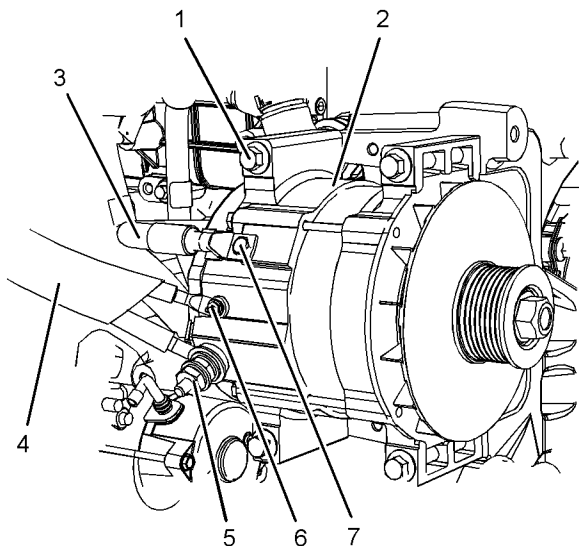


Illustration 560

g02422737

Heavy Duty Alternator

2. Place identification marks on all of the wiring harness connections (4). Remove nut (5) and nut (6).
3. Disconnect harness assembly (4) from alternator (2).

4. Remove bolt (7) from alternator (2). Disconnect grounding strap (3) from alternator (2).
5. Support the weight of the alternator and remove bolts (1). Remove alternator (2) from the alternator bracket.

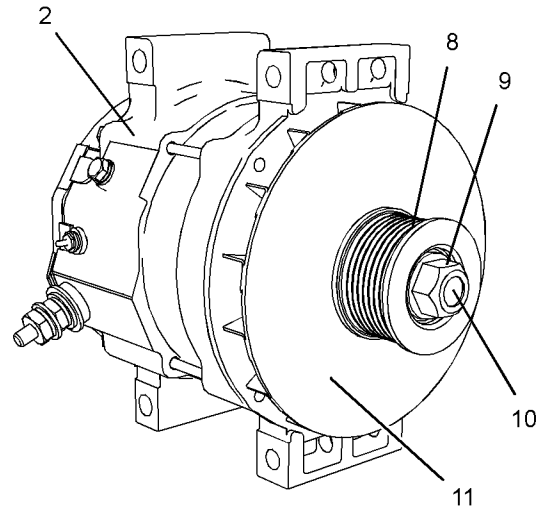


Illustration 561

g02422738

Heavy Duty Alternator

6. If necessary, follow Step 6a through Step 6d in order to remove pulley (8) from alternator (2).

Note: Either of Tooling (A) may be required in order to carry out the removal of the alternator pulley.

- a. Hold shaft (10) of alternator (2) with Tooling (A). Use a cranked ring spanner to loosen nut (9).
- b. Make a temporary mark on pulley (8) in order to show correct orientation.
- c. Remove nut (9) and pulley (8) from alternator (2).
- d. Remove fan (11) from alternator (2).

Note: Note on some alternator the fan is an internal part of the alternator.

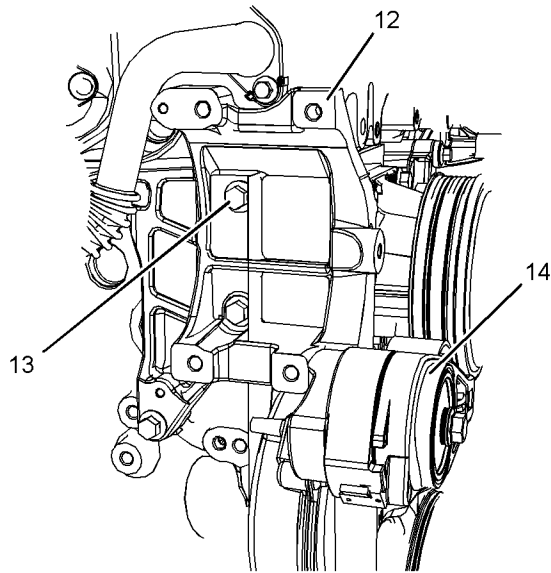


Illustration 562

g02422739

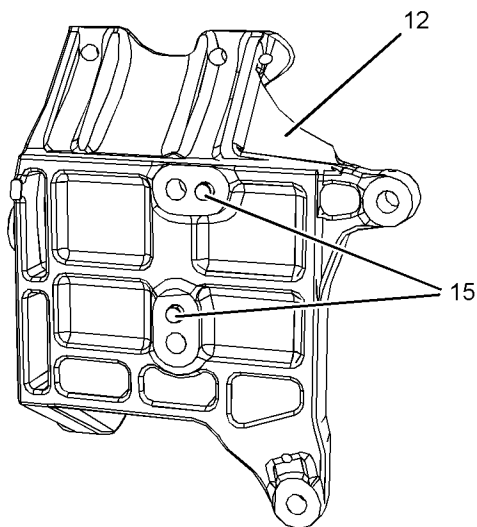


Illustration 563

g02422740

7. If necessary, follow Step 7a through Step 7d in order to remove alternator bracket (12) from the cylinder block.
 - a. If necessary, remove belt tensioner (14) from alternator bracket (12). Refer to Disassembly and Assembly, "Belt Tensioner - Remove and Install" for the correct procedure.
 - b. Remove bolts (13) from alternator bracket (12).
 - c. Remove alternator bracket (12) from the cylinder block.

- d. Note the position of dowels (15) in alternator bracket (12).

Removal Procedure for Heavy Duty Alternator Bracket

Start By:

- a. Remove fan drive. Refer to Disassembly and Assembly, "Fan Drive - Remove and Install" for the correct procedure.

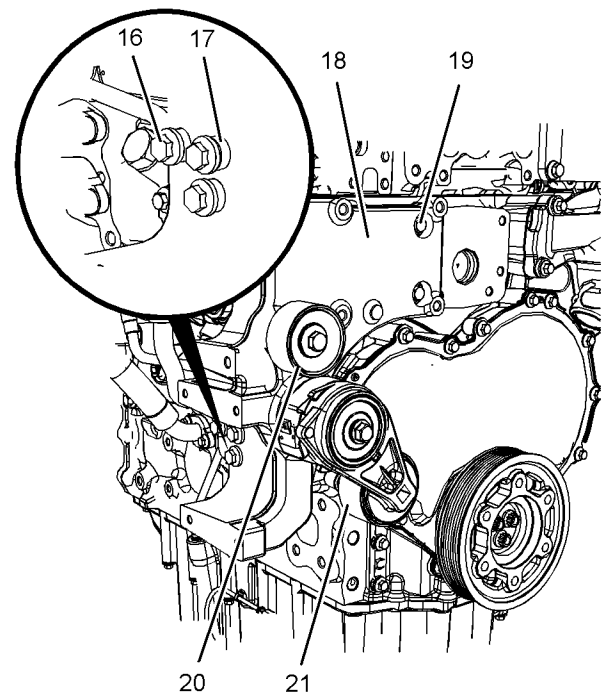


Illustration 564

g03740878

1. If necessary, follow Step 1a through Step 1e in order to remove heavy-duty alternator bracket (18) from the cylinder block.
 - a. If necessary, remove belt tensioner (21) from heavy-duty alternator bracket (18). Refer to Disassembly and Assembly, "Belt Tensioner - Remove and Install" for the correct procedure.
 - b. If necessary, remove idler pulley (20) from heavy-duty alternator bracket (18). Refer to Disassembly and Assembly, "Idler Pulley (Flat) - Remove and Install" for the correct procedure.
 - c. Remove bolts (18). Note the position of spacers (19) in the heavy-duty alternator bracket (18).
 - d. Remove bolts (19) from heavy-duty alternator bracket (18). Support the heavy-duty alternator bracket as the bolts are removed.

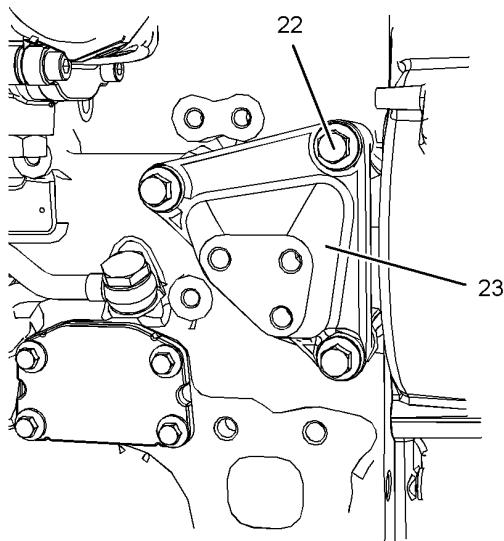


Illustration 565

g02422757

- e. Remove bolts (22) and remove bracket (23) from the cylinder block.

i05980409

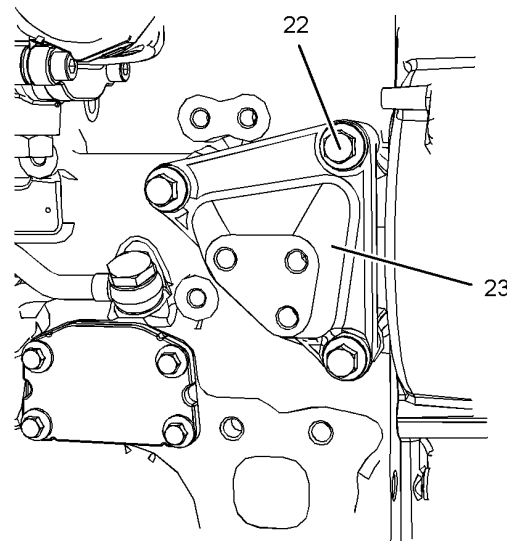


Illustration 566

g02422757

- b. Position bracket (23) onto the cylinder block. Ensure that the bracket is correctly oriented.
- c. Install bolts (22) and tighten the bolts to a torque of 44 N·m (32 lb ft).

Alternator - Install

Installation Procedure for the Heavy-Duty Alternator Bracket

Table 117

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	-	1/2 Inch Drive T50 Torx Bit	1
	-	1/2 Inch Drive x 8 mm Hex Drive	1

⁽¹⁾ Either tool may be necessary in order to install the alternator pulley.

1. If necessary, follow Step 1a through Step 1j in order to install the alternator bracket to the cylinder block of the hydraulic excavator.
 - a. Ensure that all of the components of the alternator bracket are clean and free from wear and damage. If necessary, replace any components that are worn or damaged.

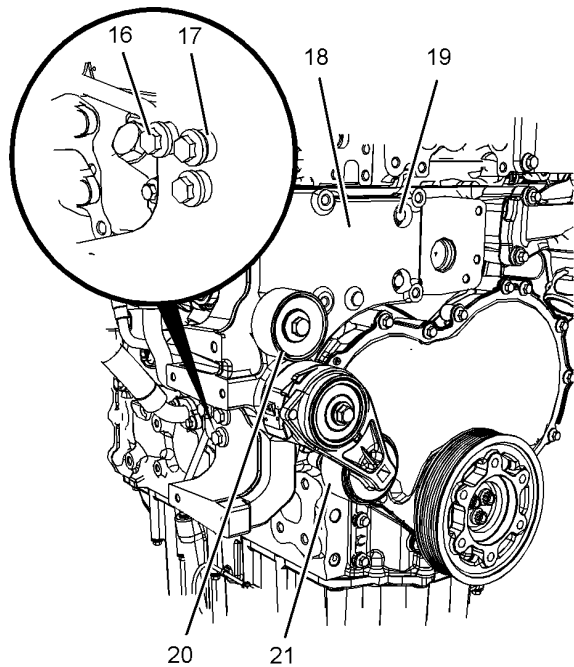


Illustration 567

g03740878

the bolts.

Note: Support the heavy-duty alternator bracket as the bolts are installed.

- e. Ensure that the spacers (17) are correctly installed to heavy-duty alternator bracket (18).
- f. Install bolts (16) to heavy-duty alternator bracket (18). Hand tighten the bolts.
- g. Tighten bolts (19) to a torque of 44 N·m (32 lb ft).

Note: Ensure that Position (X) on heavy-duty alternator bracket (18) does not move in either direction as the bolts are tightened.

- h. Tighten bolts (16) to a torque of 44 N·m (32 lb ft).
- i. If necessary, install belt tensioner (20) to heavy-duty alternator bracket (18). Refer to Disassembly and Assembly, "Belt Tensioner - Remove and Install" for the correct procedure.
- j. If necessary, install idler pulley (21) to heavy-duty alternator bracket (18). Refer to Disassembly and Assembly, "Idler Pulley (flat) - Remove and Install" for the correct procedure.

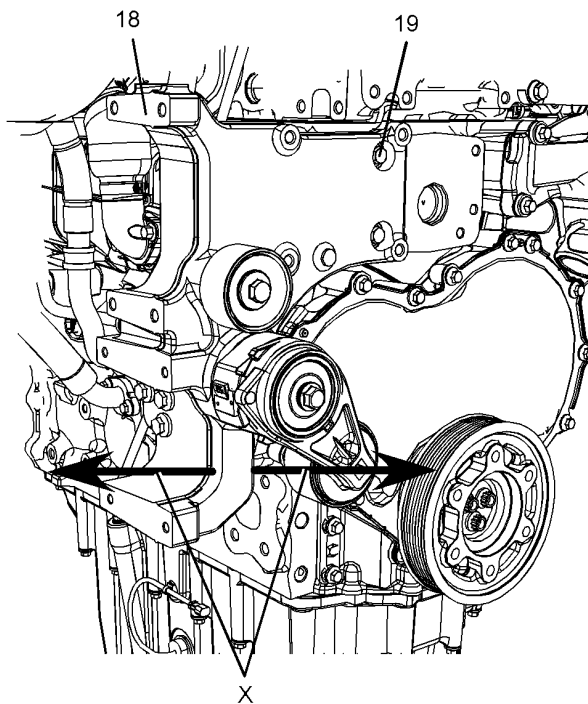


Illustration 568

g03740879

- d. Position heavy-duty alternator bracket (18) onto the cylinder block. Install bolts (19) to the heavy-duty alternator bracket and hand tighten

Installation Procedure

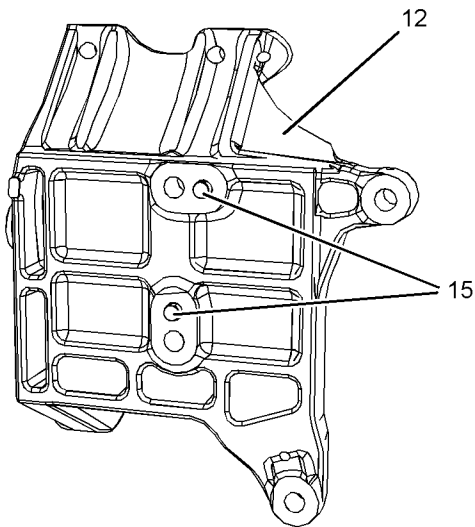


Illustration 569

g02422740

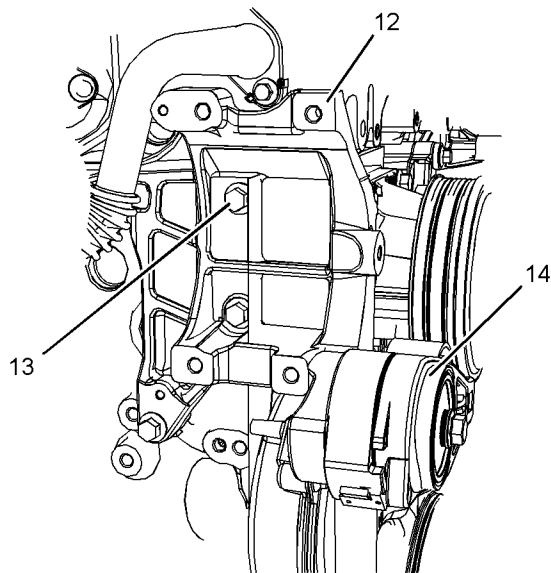


Illustration 570

g02422739

1. If necessary, follow Step 1a through Step 1f in order to install alternator bracket (12) onto the cylinder block.
 - a. Ensure that bracket (12) is clean and free from wear and damage. If necessary, replace the bracket.
 - b. Ensure that dowels (15) are free from wear and damage. If necessary, replace the dowels.
 - c. Position bracket (12) onto the cylinder block. Ensure that the dowels (15) are correctly

located into the cylinder block.

- d. Install bolts (13) hand tight.
- e. Tighten bolts (13) to a torque of 44 N·m (32 lb ft).
- f. If necessary, install the belt tensioner (14) onto alternator bracket (12). Refer to Disassembly and Assembly, "Belt Tensioner - Install" for the correct procedure.

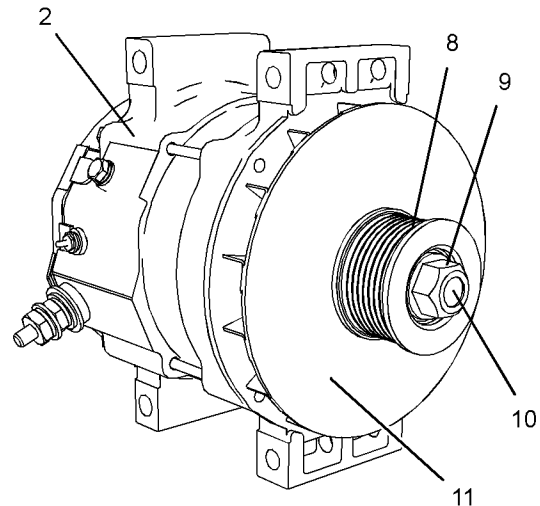


Illustration 571

g02422738

Heavy Duty Alternator

2. If necessary, follow Step 2a through Step 2d in order to install pulley (8) to alternator (2).

Note: Either of Tooling (A) may be required in order to carry out the installation of the alternator pulley.

- a. Install fan (11) from alternator (2). Ensure that the fan is correct oriented.

Note: Note on some alternator the fan is an internal part of the alternator.

- b. Ensure that the pulley (8) is correctly oriented.
- c. Install pulley (8) and nut (9) to alternator (2).
- d. Position a cranked ring spanner onto nut (9) and use a suitable tool in order to prevent the cranked ring spanner from turning. Use Tooling (A) in order to turn the shaft of the alternator in a counterclockwise direction. Tighten the nut to the correct torque. Refer to Specifications, "Alternator" for the correct torque.

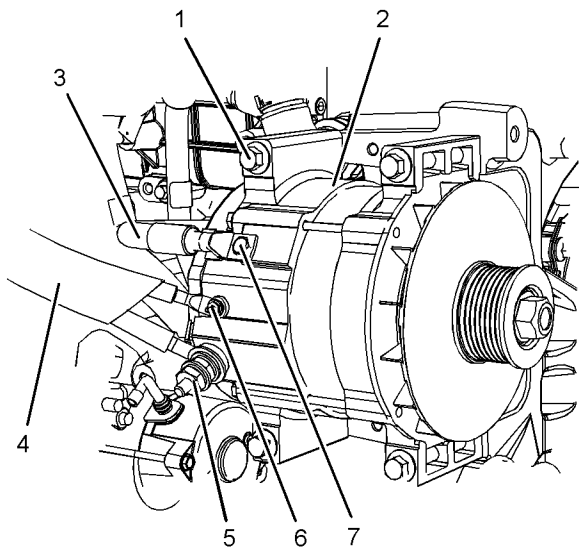


Illustration 572

g02422737

Heavy Duty Alternator

6. Connect wiring harness assembly (4) to alternator (2). Install nut (5) and nut (6). Tighten the nuts to the correct torque. Refer to Specifications, "Alternator" for the correct torque.
7. Connect grounding strap (3) to alternator (2). Install bolt (7). Tighten the bolt to the correct torque. Refer to Specifications, "Alternator" for the correct torque.
8. Install the alternator belt. Refer to Disassembly and Assembly, "Alternator Belt - Remove and Install" for the correct procedure.
9. Turn the battery disconnect switch to the ON position.

i05980683

Electric Starting Motor - Remove and Install

Removal Procedure

⚠ WARNING

Accidental engine starting can cause injury or death to personnel working on the equipment.

To avoid accidental engine starting, disconnect the battery cable from the negative (-) battery terminal. Completely tape all metal surfaces of the disconnected battery cable end in order to prevent contact with other metal surfaces which could activate the engine electrical system.

Place a Do Not Operate tag at the Start/Stop switch location to inform personnel that the equipment is being worked on.

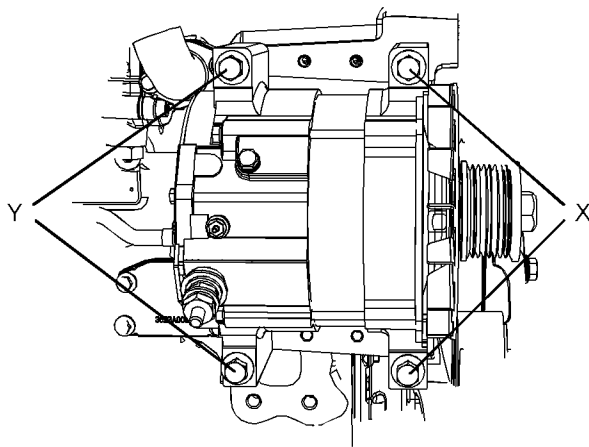


Illustration 573

g02426956

Heavy Duty Alternator

3. Position alternator (2) onto the alternator mounting bracket. Install bolts (1). Tighten the bolts hand tight.
4. Tighten the bolts in Position (X) to a torque of 50 N·m (37 lb ft).
5. Tighten the bolts in Position (Y) to a torque of 50 N·m (37 lb ft).

1. Turn the battery disconnect switch to the OFF position.
2. Place identification marks on the harness assembly that is connected to the electric starting motor and the solenoid.

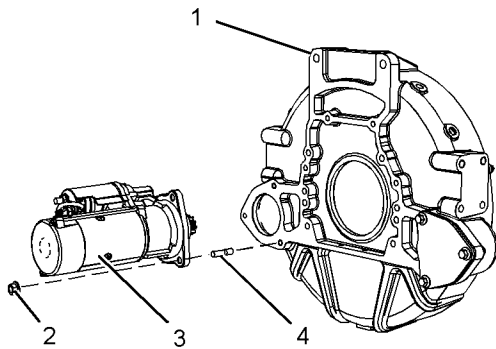


Illustration 574

g02646292

Typical example

3. Disconnect the harness assembly from the electric starting motor and the solenoid.
4. Support electric starting motor (3). Remove nuts (2).
5. Remove electric starting motor (3) from flywheel housing (1).
6. If necessary, remove studs (5) from flywheel housing (1).

Installation Procedure

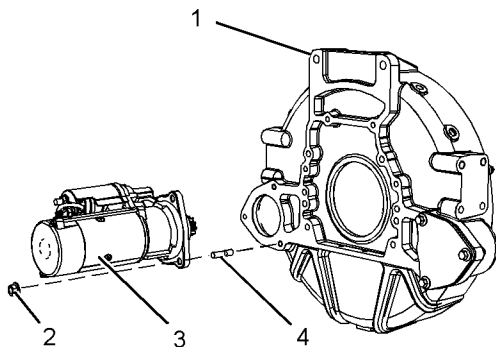


Illustration 575

g02646292

Typical example

1. If necessary, install studs (5) into flywheel housing (1).
Tighten M10 studs to a torque of 18 N·m (159 lb in).
2. Position electric starting motor (3) onto the studs in flywheel housing (1).
3. Install nuts (2).
Tighten M10 nuts to a torque of 44 N·m (33 lb ft).

4. Connect the harness assembly to the electric starting motor and the solenoid.
5. Turn the battery disconnect switch to the ON position.

i05980406

Air Compressor - Remove and Install (Single Cylinder Air Compressor)

Removal Procedure

Table 118

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
C	-	Combination Puller	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

⚠ WARNING

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.
2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.
3. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump. Refer to the OEM for the correct procedure.
4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

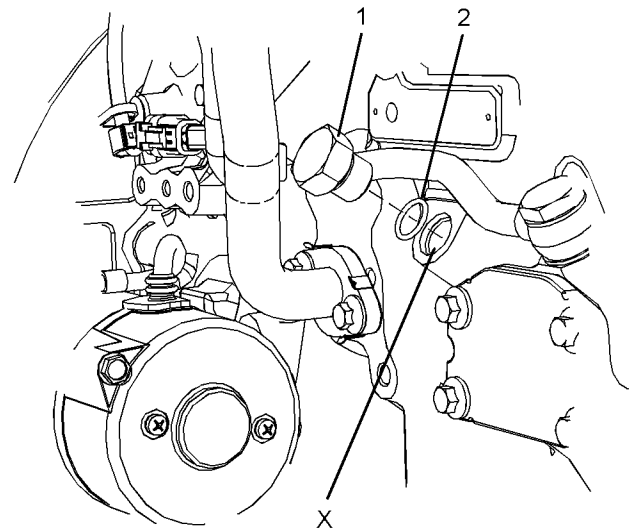


Illustration 576

g02429600

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
6. Install Tooling (B) into Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (B). Do not use Tooling (B) to hold the crankshaft during repairs.

Disassembly and Assembly Section

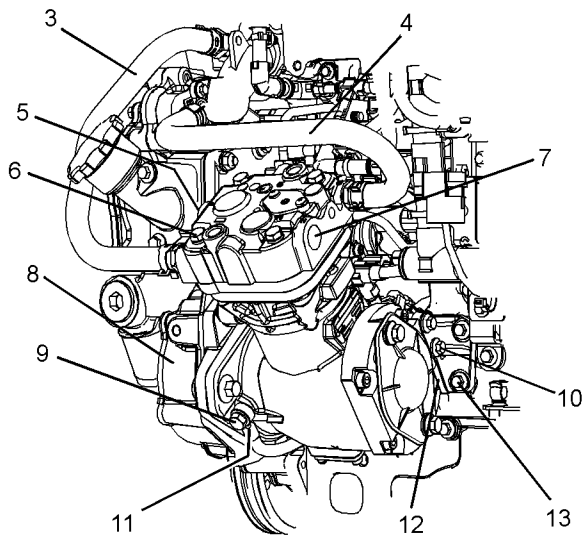


Illustration 577

g02429596

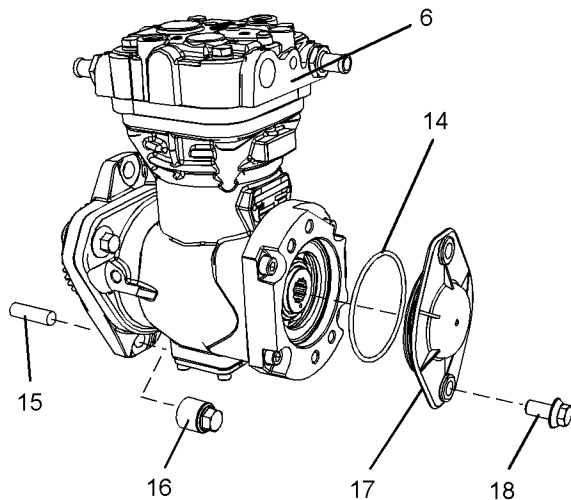


Illustration 578

g02429597

7. Slide hose clamps for coolant hose (3) and coolant hose (4) along the hose assemblies.
8. Disconnect coolant hose (3) and coolant hose (4) from the connections on air compressor (6).
9. Disconnect the air lines from port (5) (not shown) and air lines from port (7). Refer to the OEM for the correct procedure.
10. Remove banjo bolt (9) and remove sealing washers (11) (not shown) from air compressor (6).
11. Remove bolts (10) and bolts (13) from support bracket (12) and remove the support bracket.

12. Support air compressor (6). Remove nuts (16) and remove the air compressor from front housing (8).
13. If necessary, remove studs (15) from front housing (8).
14. If necessary, remove bolts (18) and remove plate (17). Remove O-ring seal (14) from plate (17).

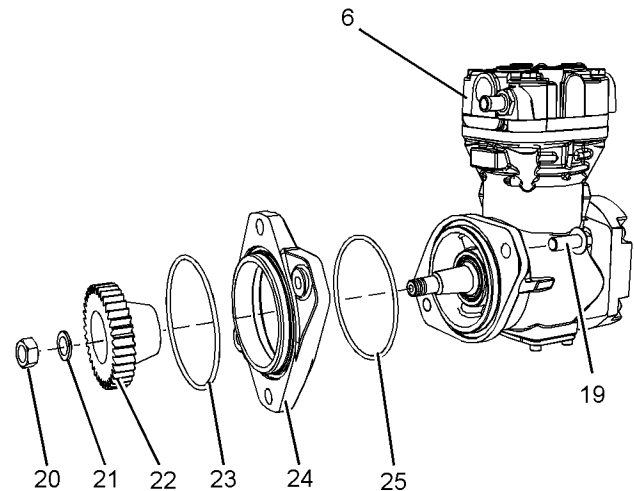


Illustration 579

g02429598

15. Remove O-ring seal (23) from adapter (24).
16. If necessary, follow Step 16a through Step 16b in order to remove gear (22) from the crankshaft of the air compressor.
 - a. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Remove nut (20) and remove spring washer (21).
 - b. Use Tooling (C) in order to remove gear (22) from the crankshaft of air compressor (6).
17. If necessary, follow Step 17 through Step 17c in order to remove adapter (24) from air compressor (6).
 - a. Remove bolts (19) from adapter (24).
 - b. Remove adapter (24) from air compressor (6).
 - c. Remove O-ring seal (25).

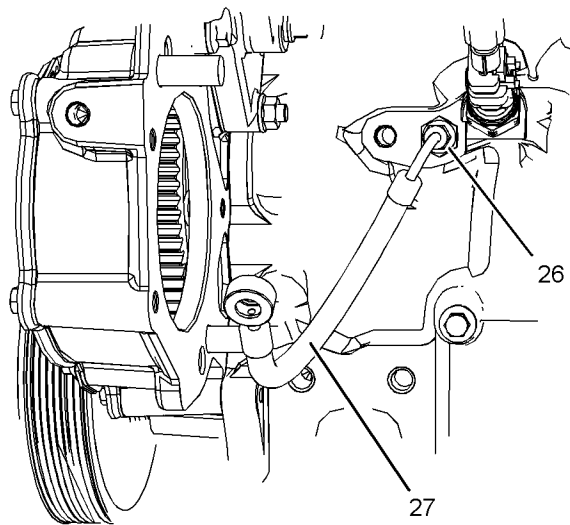


Illustration 580

g02429599

18. If necessary, follow Step 18a through Step 18b in order to remove the hose assembly.

- a. Make a temporary mark in order to identify the position of hose assembly (27).
- b. Disconnect nut (26) and remove hose assembly (27).

Installation Procedure

Table 119

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
D	-	Loctite 638 High Strength Retaining	1
E	-	Delphi Lockheed Rubber Grease	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

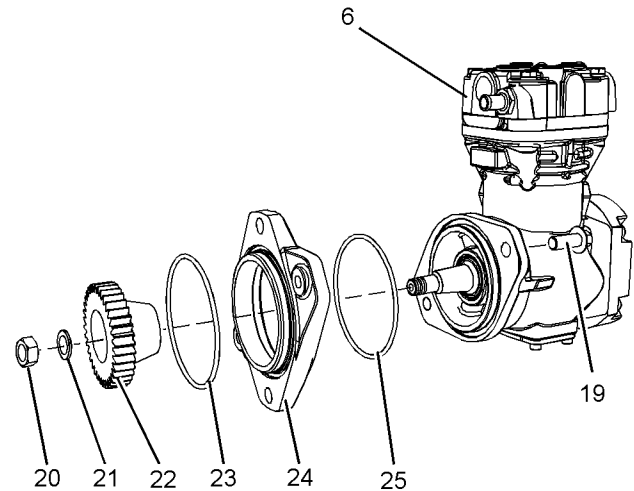


Illustration 581

g02429598

1. If necessary, follow Step 1a through Step 1d in order to install adapter (24) to air compressor (6).

- a. Use Tooling (E) in order to lubricate a new O-ring seal (25). Install the O-ring seal to air compressor (6).
- b. Position adapter (24) onto air compressor (6).
- c. Install bolts (19) to air compressor (6).
- d. Tighten bolts (19) to a torque of 78 N·m (58 lb ft).

2. If necessary, follow Step 2a through Step 2e in order to install gear (22) to the crankshaft of the air compressor.

- a. Ensure that the crankshaft of air compressor (6) is clean and dry. Ensure that gear (22) is clean and free from damage.

Disassembly and Assembly Section

- b. Install gear (22) and a new spring washer (21) to the crankshaft of the air compressor.
 - c. Apply Tooling (D) to the threads of the crankshaft. Install nut (20) to the crankshaft of air compressor (6).
 - d. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Tighten nut (20) to a torque of 120 N·m (89 lb ft).
 - e. Use Tooling (E) in order to lubricate O-ring seal (23). Install the O-ring seal to air compressor (6).
3. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

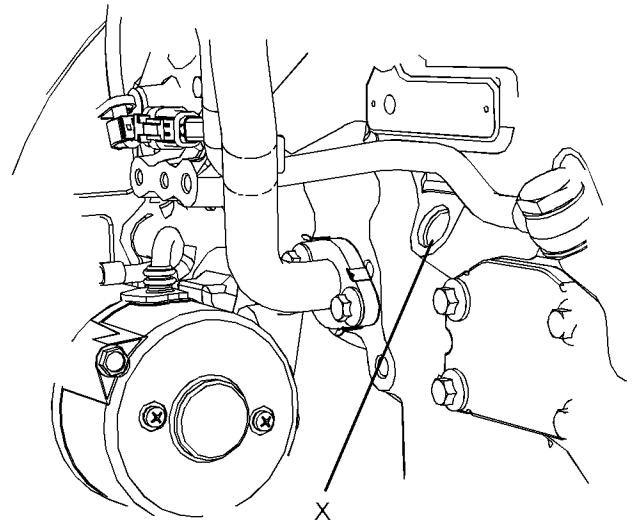


Illustration 582

g02429601

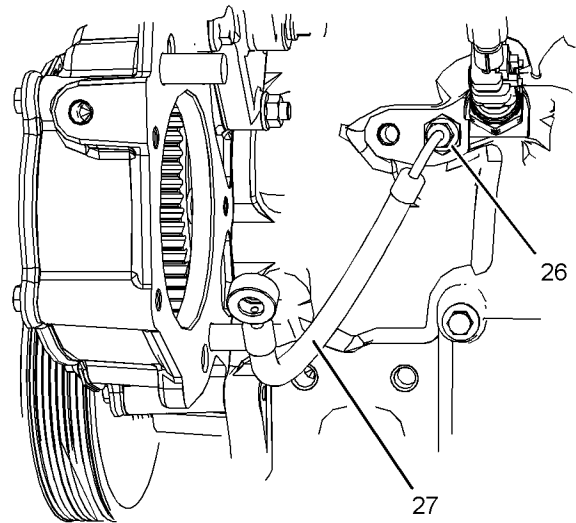


Illustration 583

g02429599

4. Ensure that Tooling (B) is installed in Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (B). Do not use Tooling (B) to hold the crankshaft during repairs.

5. If necessary, install hose assembly (27) to the connection on the cylinder block. Align hose assembly with the temporary marks. Tighten nut (26) to a torque of 9 N·m (80 lb in).

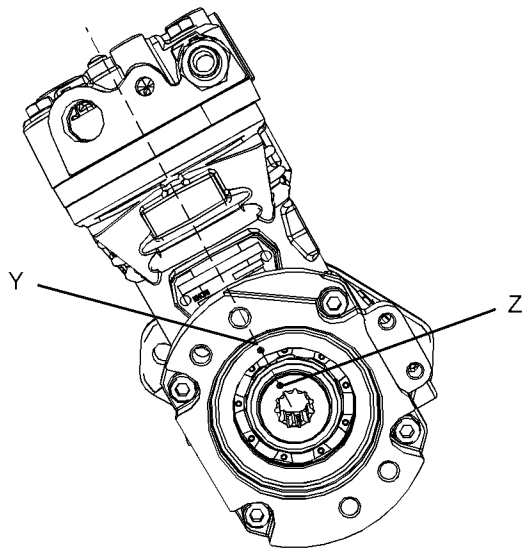


Illustration 584

g02430197

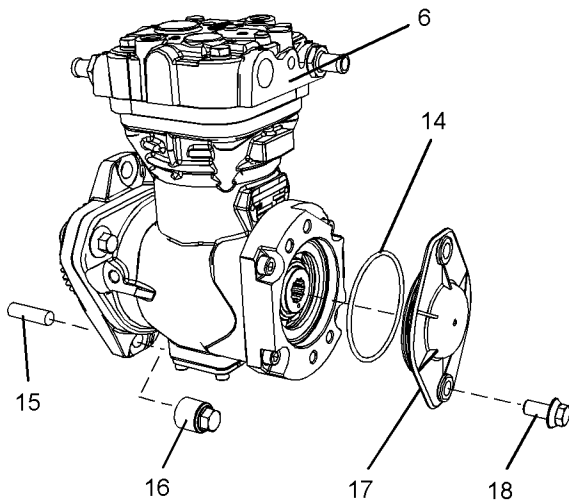


Illustration 585

g02429597

6. Rotate the crankshaft of the air compressor until timing Mark (Z) is aligned with center Line (Y) of the cylinder of the air compressor.
7. If necessary, install studs (15) from the front housing. Tighten the studs to a torque of 25 N·m (221 lb in).
8. Align air compressor (6) with studs (15). Install the air compressor to the front housing. If necessary, rotate the crankshaft of the air compressor in order to allow the gears to align.

9. Install nuts (16). Tighten the nuts to a torque of 78 N·m (58 lb ft).
10. If necessary, follow Step 10a through Step 10c in order to install cover (16).
 - a. Use Tooling (E) in order to lubricate a new O-ring seal (14). Install the O-ring seal to cover (17).
 - b. Install cover (17) to the air compressor.
 - c. Install bolts (18). Tighten the bolts to a torque of 16 N·m (142 lb in).

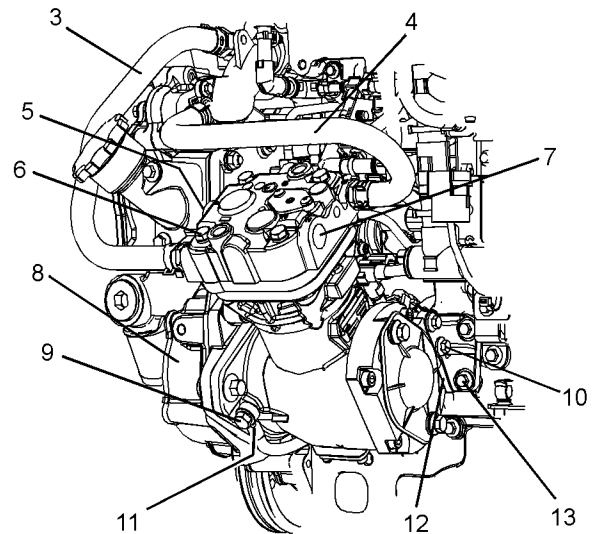


Illustration 586

g02429596

11. Position support bracket (12) onto air compressor (6) and the cylinder block.
12. Install bolts (13) and bolts (10) finger tight.
13. Tighten bolts (13) to a torque of 22 N·m (195 lb in).
14. Tighten bolts (10) to a torque 22 N·m (195 lb in).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

15. Connect coolant hose (3) and coolant hose (4) onto the connections on the air compressor.
16. Slide hose clamps along coolant hose (3) and coolant hose (4). Ensure that the hose clamps are correctly positioned over coolant hoses.

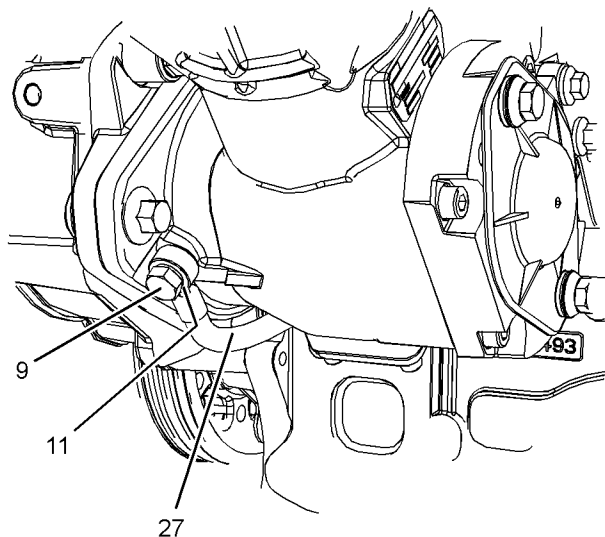


Illustration 587

g02430379

- 17.** Install new sealing washer (11) (not shown) onto banjo bolt (9). Install the banjo bolt onto tube assembly (27) and install remaining sealing washer (11) (not shown).
- 18.** Connect hose assembly (27) onto the air compressor. Tighten the banjo bolt to a torque of 17 N·m (150 lb in).
- Note:** Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.
- 19.** Connect the air line to port (5) (not shown) and the air line to port (7) in the air compressor. Refer to the OEM for the correct procedure.

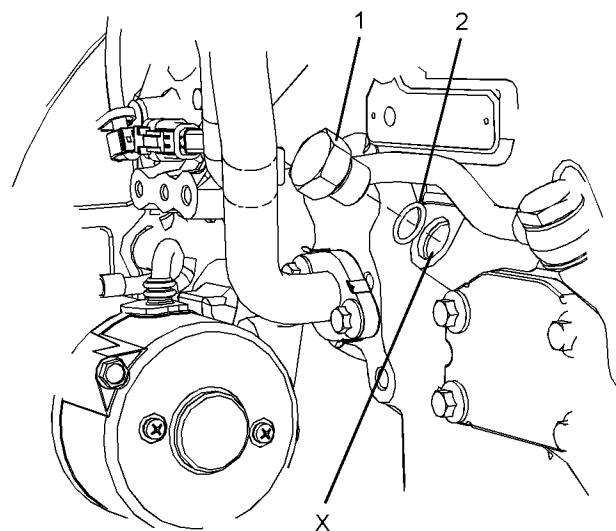


Illustration 588

g02429600

- 20.** Remove Tooling (B) from Hole (X) in the cylinder block.
- 21.** Install a new O-ring seal (1) to plug (2). Install the plug to the cylinder block. Refer to Illustration 588. Tighten the plug to a torque of 21 N·m (186 lb in).
- 22.** If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump. Refer to the OEM for the correct procedure.
- 23.** Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, "Refill Capacities" and Operation and Maintenance Manual, "Cooling System Coolant Level - Check" for the correct procedures.

i05980408

Air Compressor - Remove and Install (Twin Cylinder Air Compressor)

Removal Procedure

Table 120

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1

(continued)

(Table 120, contd)

A ⁽²⁾	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1
B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
C	-	Combination Puller	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

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

 **WARNING**

Do not disconnect the air lines until the air pressure in the system is at zero. If hose is disconnected under pressure it can cause personal injury.

1. Release the pressure from the air system. Refer to the Original Equipment Manufactures (OEM) for the correct procedure.
2. Drain the coolant from the cooling system into a suitable container for storage or for disposal. Refer to Operation and Maintenance Manual, "Cooling System Coolant - Change" for the correct draining procedure.

3. If the engine is equipped with a hydraulic pump on the rear of the air compressor, remove the hydraulic pump. Refer to the OEM for the correct procedure.
4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

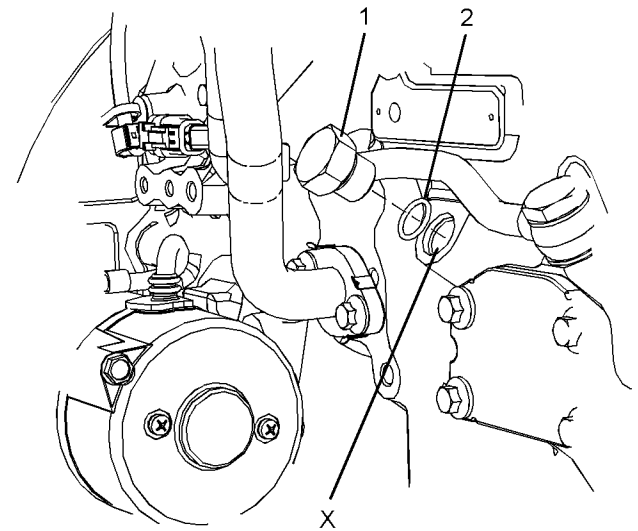


Illustration 589

g02418379

5. Remove plug (1) from the cylinder block. Remove O-ring seal (2) from the plug.
6. Install Tooling (B) into Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (B). Do not use Tooling (B) to hold the crankshaft during repairs.

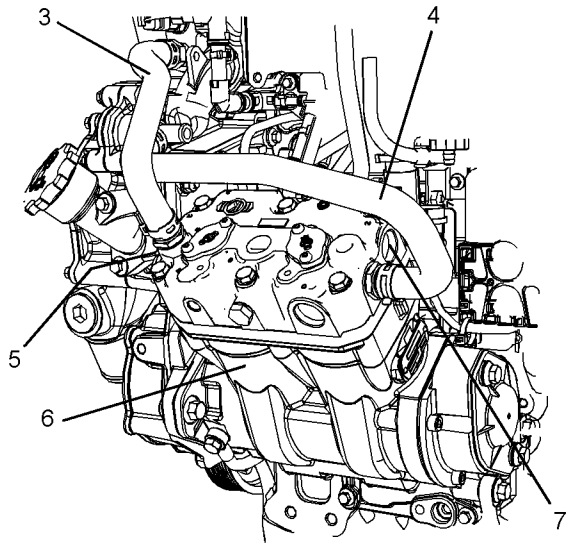


Illustration 590

g02418397

7. Slide hose clamps for coolant hose (3) and coolant hose (4) along the hose assemblies.
8. Disconnect coolant hose (3) and coolant hose (4) from the connections on air compressor (6).
9. Disconnect the air line from port (5) (not shown) and air line from port (7). Refer to the OEM for the correct procedure.

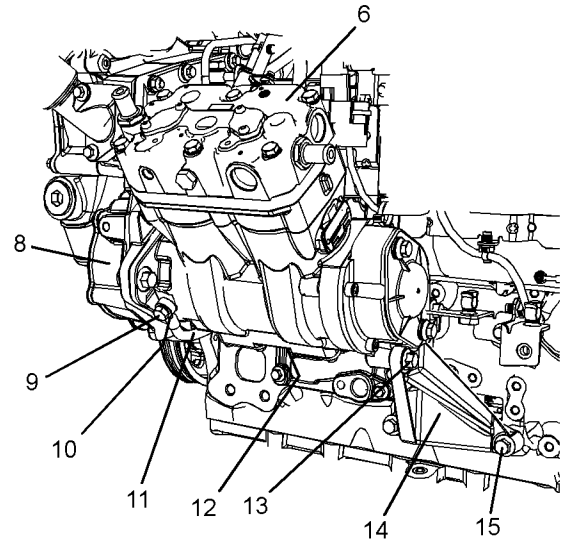


Illustration 591

g02418398

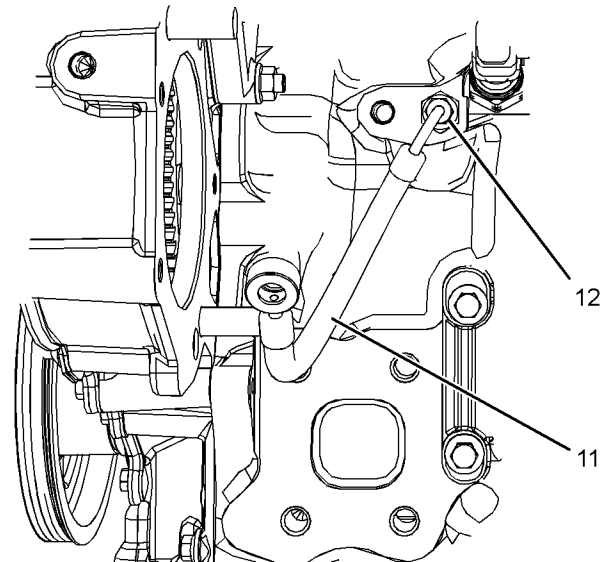


Illustration 592

g02420556

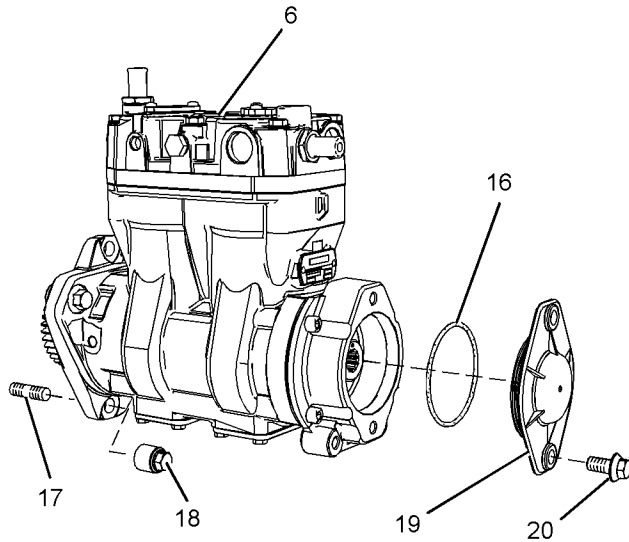


Illustration 593

g02418399

- 10. Remove banjo bolt (9) and remove sealing washers (10) (not shown).
- 11. Remove bolt (13) and bolt (15) from support bracket (14). Remove support bracket (14) from compressor (6) and the cylinder block.
- 12. Support air compressor (6). Remove nuts (18) and remove the air compressor from front housing (8).
- 13. If necessary, follow Step 13a through Step 13b in order to remove the hose assembly.
 - a. Make a temporary mark in order to identify the position of hose assembly (11).
 - b. Disconnect nut (12) and remove hose assembly (11).
- 14. If necessary, remove studs (17) from front housing (8).
- 15. If necessary, remove bolts (20) and remove plate (19). Remove O-ring seal (16) from plate (19). Refer to Illustration 593 .

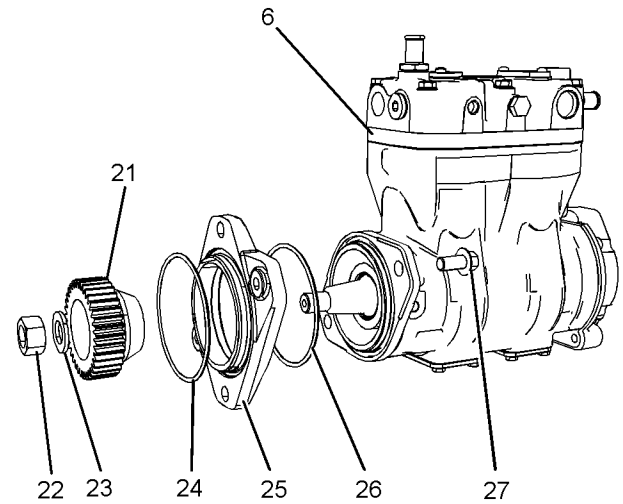


Illustration 594

g02418401

- 16. Remove O-ring seal (24) from the adapter on air compressor (6).
- 17. If necessary, follow Step 17a through Step 17b in order to remove gear (21) from the crankshaft of the air compressor.
 - a. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Remove nut (22) and remove spring washer (23) (not shown).
 - b. Use Tooling (C) in order to remove gear (21) from the crankshaft of the air compressor.
- 18. If necessary, follow Step 18 through Step 18c in order to remove adapter (25) from air compressor (6).
 - a. Remove bolts (27) from adapter (25).
 - b. Remove adapter (25) from air compressor (6).
 - c. Remove O-ring seal (26).

Installation Procedure

Table 121

Required Tools			
Tool	Part Number	Part Description	Qty
A ⁽¹⁾	T400011	Crankshaft Turning Tool	1
A ⁽²⁾	27610291	Shaft Housing	1
	27610289	Engine Turning Tool	1

(continued)

Disassembly and Assembly Section

(Table 121, contd)

B	27610286	Timing Pin (Crankshaft)	1
	27610287	Adapter	1
D	-	Loctite 638 High Strength Retaining	1
E	-	Delphi Lockheed Rubber Grease	1

(1) The Crankshaft Turning Tool is used on the front pulley.

(2) This Tool is used in the aperture for the electric starting motor.

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

NOTICE

Keep all parts clean from contaminants.

Contaminants may cause rapid wear and shortened component life.

NOTICE

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

Dispose of all fluids according to local regulations and mandates.

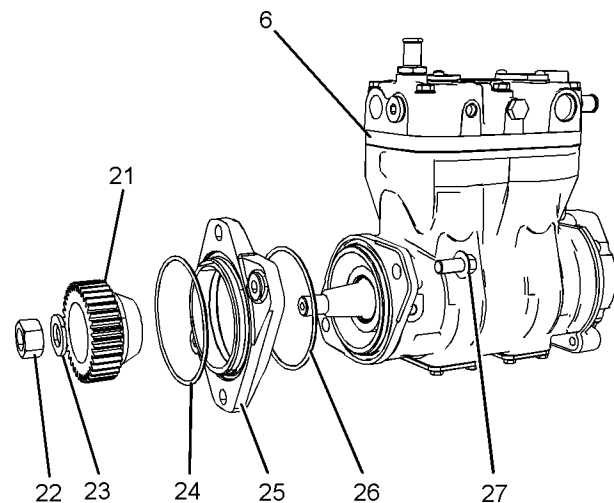


Illustration 595

g02418401

a. Use Tooling (E) in order to lubricate a new O-ring seal (26). Install the O-ring seal to air compressor (6).

b. Position adapter (25) onto air compressor (6).

c. Install bolts (27) to air compressor (6).

d. Tighten bolts (27) to a torque of 78 N·m (58 lb ft).

2. If necessary, follow Step 2a through Step 2d in order to install gear (21) to the crankshaft of the air compressor.

a. Ensure that the crankshaft of air compressor (6) is clean and dry. Ensure that gear (21) is clean and free from damage.

b. Install gear (21) and a new spring washer (23) (not shown) to the crankshaft of the air compressor.

c. Apply Tooling (D) to the threads of the crankshaft. Install nut (22) to the crankshaft of air compressor (6).

d. Use a suitable tool in order to prevent the crankshaft of the compressor from rotating. Tighten nut (22) to a torque of 190 N·m (140 lb ft).

3. Use Tooling (E) in order to lubricate O-ring seal (24). Install the O-ring seal to air compressor (6).

4. Use Tooling (A) in order to rotate the crankshaft so that number one piston is at the top center position on the compression stroke. Refer to Systems Operation, Testing and Adjusting, "Fuel Injection Timing - Check" for the correct procedure.

Note: The air compressor must be timed with the engine in order to minimize engine vibration.

1. If necessary, follow Step 18 through Step 18c in order to install adapter (25) to air compressor (6).

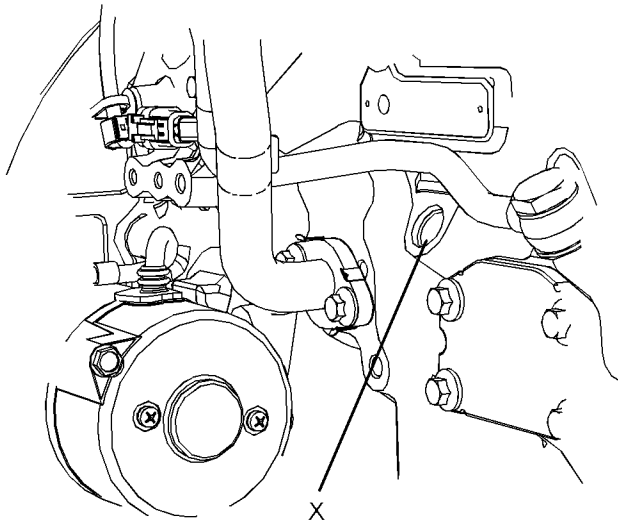


Illustration 596

g02420499

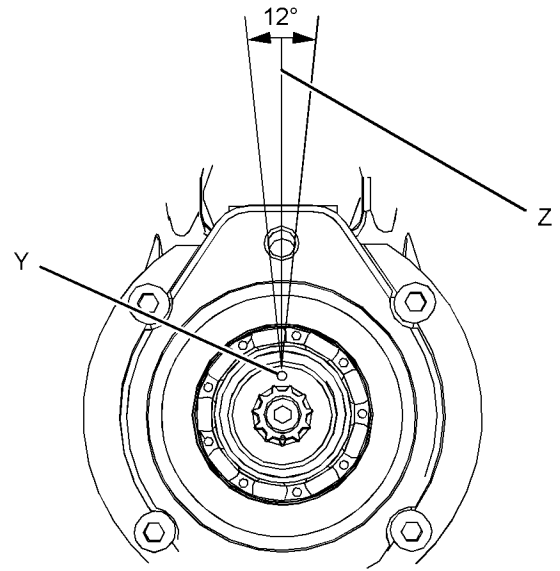


Illustration 598

g01970516

7. Rotate the crankshaft of the air compressor until timing Mark (Y) is within (+/-) 6 degrees of Position (Z).

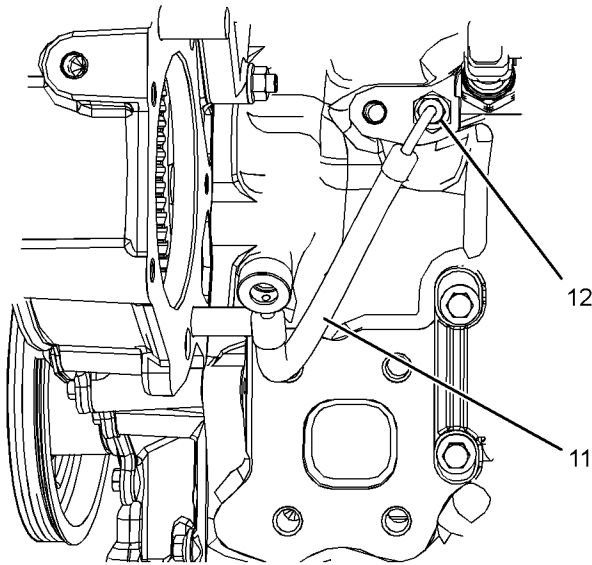


Illustration 597

g02420556

5. Ensure that Tooling (B) is installed in Hole (X) in the cylinder block. Use Tooling (B) in order to lock the crankshaft in the correct position.

Note: Do not use excessive force to install Tooling (B). Do not use Tooling (B) to hold the crankshaft during repairs.

6. If necessary, install hose assembly (11) to the connection on the cylinder block. Align hose assembly with the temporary marks. Tighten nut (12) to a torque of 9 N·m (80 lb in).

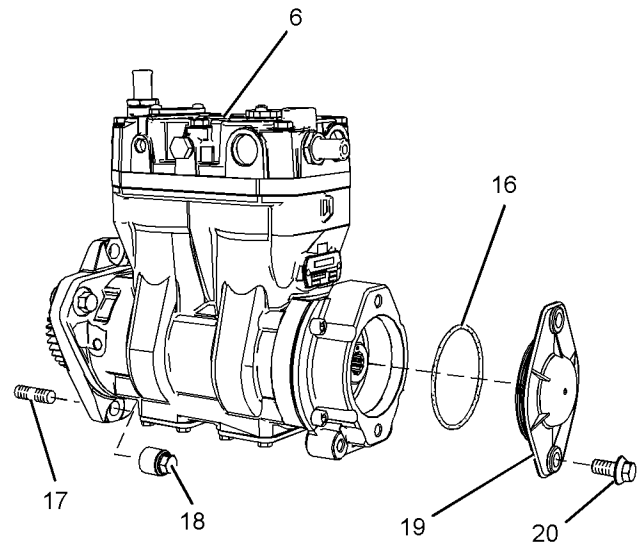


Illustration 599

g02418399

8. If necessary, install studs (17) from the front housing. Tighten the studs to a torque 25 N·m (221 lb in).
9. Align air compressor (6) with studs (17). Install the air compressor to the front housing. If necessary, rotate the crankshaft of the air compressor in order to allow the gears to align.

Note: Ensure that timing Mark (Y) is aligned with timing Marks (Z). Refer to Illustration 598 for the correct position of timing marks.

10. Install nuts (18). Tighten the nuts to a torque of 78 N·m (58 lb ft).
11. If necessary, follow Step 11a through Step 11c in order to install cover (19).
 - a. Use Tooling (E) in order to lubricate a new O-ring seal (16). Install the O-ring seal to cover (19).
 - b. Install cover (19) to air compressor (6).
 - c. Install bolts (20). Tighten the bolts to a torque of 16 N·m (142 lb in).

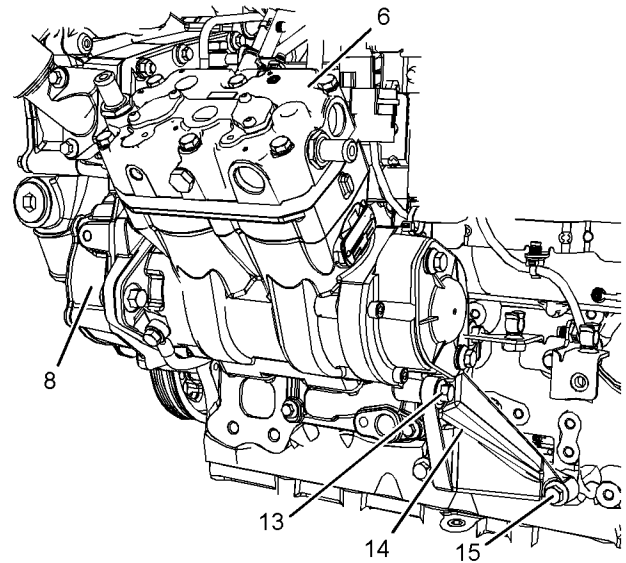


Illustration 600

g02432317

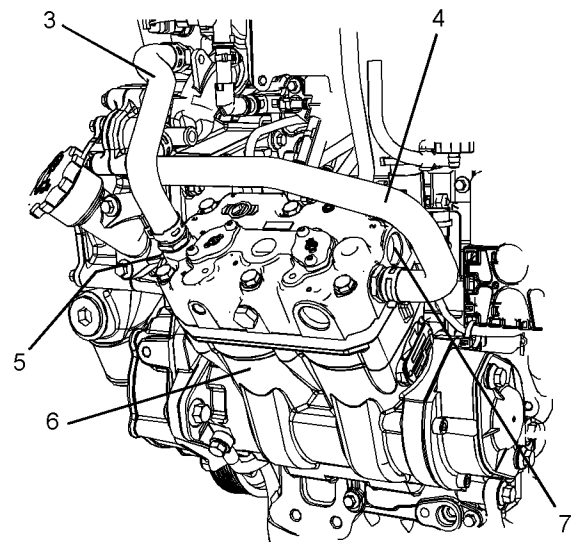


Illustration 601

g02418397

12. Position support bracket (14) onto air compressor (6) and the cylinder block.
13. Install bolts (13) and bolts (15) finger tight.
14. Tighten bolts (13) to a torque of 44 N·m (32 lb ft).
15. Tighten bolts (15) to a torque of 44 N·m (32 lb ft).

Note: Ensure that the air compressor is not stressed as the bolts are tightened.

16. Connect the air line to port (5) (not shown) and the air line to port (7) in the air compressor. Refer to the OEM for the correct procedure.

17. Connect coolant hose (3) and coolant hose (4) onto the connections on the air compressor.
18. Slide hose clamps along coolant hose (3) and coolant hose (4). Ensure that the hose clamps are correctly positioned over coolant hoses.

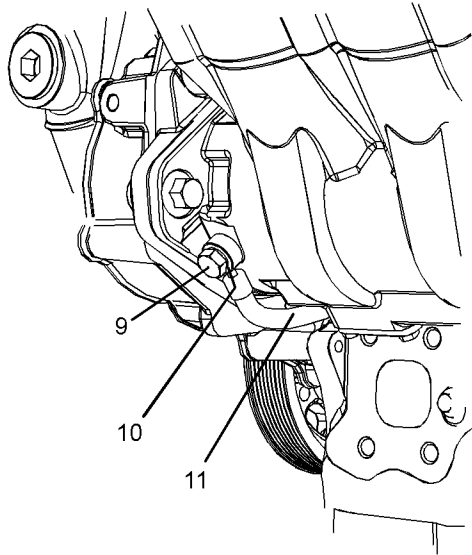


Illustration 602

g02420683

19. Install new sealing washer (10) (not shown) onto banjo bolt (10). Position the banjo bolt onto tube assembly (11) and install remaining sealing washer (10).
20. Connect hose assembly (27) onto the air compressor. Tighten the banjo bolt to a torque of 17 N·m (150 lb in).

Note: Ensure that the hose assembly is not stressed during the tightening procedure of the banjo bolt.

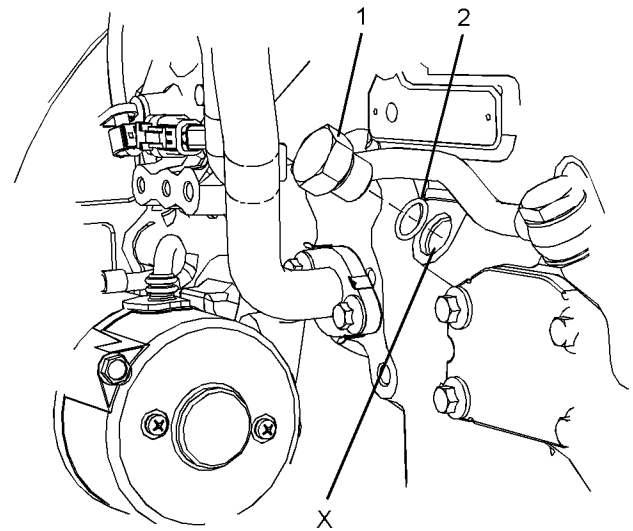


Illustration 603

g02418379

21. Remove Tooling (B) from Hole (X) in the cylinder block.
22. Install a new O-ring seal (2) to plug (1). Install the plug to the cylinder block. Tighten the plug to a torque of 21 N·m (186 lb in).
23. If the engine is equipped with a hydraulic pump on the rear of the air compressor, install the hydraulic pump. Refer to the OEM for the correct procedure.
24. Fill the cooling system with coolant to the correct level. Refer to Operation and Maintenance Manual, "Refill Capacities" and Operation and Maintenance Manual, "Cooling System Coolant Level - Check" for the correct procedure.

Index

A

Accessory Drive - Remove and Install (Accessory Drive SAE "A")	184
Installation Procedure	185
Removal Procedure	184
Accessory Drive - Remove and Install (Accessory Drive SAE "B")	186
Installation Procedure	187
Removal Procedure	186
Air Compressor - Remove and Install (Single Cylinder Air Compressor)	310
Installation Procedure	313
Removal Procedure	310
Air Compressor - Remove and Install (Twin Cylinder Air Compressor)	316
Installation Procedure	319
Removal Procedure	316
Alternator - Install	306
Installation Procedure	308
Installation Procedure for the Heavy-Duty Alternator Bracket	306
Alternator - Remove	304
Removal Procedure	304
Removal Procedure for Heavy Duty Alternator Bracket	305
Alternator Belt - Remove and Install	290
Installation Procedure	291
Removal Procedure	290
Ammonia Sensor - Remove and Install (Ammonia Sensor if Equipped)	277
Installation Procedure	278
Removal Procedure	277
Atmospheric Pressure Sensor - Remove and Install	269
Installation Procedure	270
Removal Procedure	269

B

Balancer - Install	233
Installation Procedure	233
Balancer - Remove	231
Removal Procedure	231
Bearing Clearance - Check	262
Measurement Procedure	262
Belt Tensioner - Remove and Install	293
Installation Procedure	294
Removal Procedure	293
Boost Pressure Sensor - Remove and Install	287
Installation Procedure	288
Removal Procedure	287

C

Camshaft - Remove and Install	214
Installation Procedure	215
Removal Procedure	214
Camshaft Bearings - Remove and Install	221
Installation Procedure	221
Removal Procedure	221
Camshaft Gear - Remove and Install	216
Installation Procedure	218
Removal Procedure	216

Camshaft Position Sensor - Remove and Install ..	270
Installation Procedure	270
Removal Procedure	270
Clean Emissions Module - Remove and Install	85
Installation Procedure	86
Removal Procedure	85
Connecting Rod Bearings - Install (Connecting Rods in Position)	245
Installation Procedure	245
Connecting Rod Bearings - Remove (Connecting Rods in Position)	243
Removal Procedure	243
Coolant Temperature Sensor - Remove and Install	272
Installation Procedure	272
Removal Procedure	272
Crankcase Breather - Install	191
Installation Procedure	191
Crankcase Breather - Remove	189
Removal Procedure	189
Crankshaft - Install	253
Installation Procedure	253
Crankshaft - Remove	251
Removal Procedure	251
Crankshaft Front Seal - Remove and Install	151
Installation Procedure	151
Removal Procedure	151
Crankshaft Front Seal - Remove and Install (Crankshaft Front Seal for Heavy Duty Front Cover)	150
Installation Procedure	150
Removal Procedure	150
Crankshaft Gear - Remove and Install	258
Installation Procedure	259
Removal Procedure	258
Crankshaft Gear (Balancer Drive) - Remove and Install	260
Installation Procedure	261
Removal Procedure	260
Crankshaft Main Bearings - Remove and Install (Crankshaft in Position)	246
Installation Procedure	248
Removal Procedure	246
Crankshaft Position Sensor - Remove and Install	271
Installation Procedure	271
Removal Procedure	271
Crankshaft Pulley - Remove and Install	149
Installation Procedure	149
Removal Procedure	149
Crankshaft Rear Seal - Install	142
Installation Procedure	142
Crankshaft Rear Seal - Remove	141
Removal Procedure	141
Crankshaft Timing Ring - Remove and Install	257
Installation Procedure	257
Removal Procedure	257
Cylinder Head - Install	208
Installation Procedure	208
Cylinder Head - Remove	204
Removal Procedure	204

D

DEF Injector and Mounting - Remove and Install ...	92
Installation Procedure	93
Removal Procedure	92
Diesel Exhaust Fluid Lines - Remove and Install ...	87
Installation Procedure	89
Removal Procedure	87
Diesel Exhaust Fluid Pump - Remove and Install ...	90
Installation Procedure	91
Removal Procedure	90
Diesel Exhaust Fluid Tank - Remove and Install ...	95
Installation Procedure	96
Removal Procedure	95
Disassembly and Assembly Section	5

E

Electric Starting Motor - Remove and Install	309
Installation Procedure	310
Removal Procedure	309
Electronic Control Module - Install	300
Installation Procedure	300
Electronic Control Module - Remove	296
Removal Procedure	296
Electronic Unit Injector - Install	51
Installation Procedure	51
Electronic Unit Injector - Remove	48
Removal Procedure	48
Engine Oil Cooler - Install	131
Installation Procedure	131
Engine Oil Cooler - Remove	130
Removal Procedure	130
Engine Oil Filter Base - Remove and Install	129
Installation Procedure	129
Removal Procedure	129
Engine Oil Pan - Remove and Install (Aluminum and Pressed Steel Oil Pans)	226
Installation Procedure	228
Removal Procedure	226
Engine Oil Pan - Remove and Install (Cast Iron Oil Pan)	222
Installation Procedure	223
Removal Procedure	222
Engine Oil Pressure Sensor - Remove and Install	273
Installation Procedure	273
Removal Procedure	273
Engine Oil Pump - Install	133
Installation Procedure	133
Engine Oil Pump - Remove	132
Removal Procedure	132
Exhaust Back Pressure Valve - Remove and Install	73
Installation Procedure	74
Removal Procedure	73
Exhaust Cooler (NRS) - Remove and Install (Side Mounted Turbocharger)	31
Installation Procedure	32
Removal Procedure	31
Exhaust Cooler (NRS) - Remove and Install (Top Mounted Turbocharger)	34
Installation Procedure	36
Removal Procedure	34
Exhaust Cooler (NRS) - Remove and Install (Twin Turbochargers)	27
Installation Procedure	29
Removal Procedure	27

Exhaust Elbow - Remove and Install	119
Installation Procedure	120
Removal Procedure	119
Exhaust Elbow - Remove and Install (Top Mounted and Side Mounted Turbocharger Exhaust Elbow)	118
Installation Procedure	119
Removal Procedure	118
Exhaust Gas Valve (NRS) - Remove and Install ...	75
Installation Procedure	80
Method 2	76
Removal Procedure	75
Exhaust Manifold - Remove and Install (Single Turbocharger Exhaust Manifold)	110
Installation Procedure	112
Removal Procedure	110
Exhaust Manifold - Remove and Install (Twin Turbochargers Exhaust manifold)	115
Installation Procedure	116
Removal Procedure	115

F

Fan - Remove and Install	294
Installation Procedure	294
Removal Procedure	294
Fan Drive - Remove and Install	295
Installation Procedure	296
Removal Procedure	295
Flexible Exhaust Pipe - Remove and Install	106
Assembly Procedure for the Flexible Exhaust Pipe Assembly	108
Disassembly Procedure for the Flexible Exhaust Pipe Assembly	107
Installation Procedure for the Flexible Exhaust Pipe as an Assembly	109
Removal Procedure for the Flexible Exhaust Pipe as an Assembly	106
Flow Control Valve - Remove and Install	6
Installation Procedure	7
Removal Procedure	6
Flywheel - Install	140
Installation Procedure	140
Flywheel - Remove	139
Removal Procedure	139
Flywheel Housing - Remove and Install (Standard Housing)	143
Installation Procedure (Standard Housing)	144
Removal Procedure	143
Flywheel Housing - Remove and Install (Wet Back End Housing)	146
Installation Procedure (Wet Back End Housing)	147
Removal Procedure	146
Front Cover - Remove and Install	154
Installation Procedure	154
Removal Procedure	154
Front Cover - Remove and Install (Heavy Duty Front Cover)	152
Installation Procedure	153
Removal Procedure	152
Fuel Filter Base - Remove and Install (Single Secondary Fuel Filter)	9
Installation Procedure	11
Removal Procedure	9
Fuel Filter Base - Remove and Install (Twin Secondary Fuel Filter)	13

Index Section

Installation Procedure	14	Installation Procedure	293
Removal Procedure	13	Removal Procedure	292
Fuel Injection Lines - Install	25	Important Safety Information	2
Installation Procedure	25	Inlet Air Control - Install (NRS Induction Mixer)	40
Fuel Injection Lines - Remove	23	Installation Procedure	40
Removal Procedure	23	Inlet Air Control - Remove (NRS Induction Mixer)	38
Fuel Injection Pump - Install	45	Removal Procedure	38
Installation Procedure	45	Inlet and Exhaust Valve Springs - Remove and Install	122
Fuel Injection Pump - Remove	43	Installation Procedure	124
Removal Procedure	43	Removal Procedure	122
Fuel Injection Pump Gear - Install	47	Inlet and Exhaust Valves - Remove and Install	126
Installation Procedure	47	Installation Procedure	127
Fuel Injection Pump Gear - Remove	47	Removal Procedure	126
Removal Procedure	47	Inlet Manifold Temperature Sensor - Remove and Install	288
Fuel Manifold (Rail) - Remove and Install	19	Installation Procedure	288
Installation Procedure	20	Removal Procedure	288
Removal Procedure	19		
Fuel Pressure Sensor - Remove and Install	274		
Installation Procedure	275		
Removal Procedure	274		
Fuel Priming Pump - Remove and Install (Electric Fuel Lift Pump (EFLP))	5		
Installation Procedure	6		
Removal Procedure	5		
Fuel Temperature Sensor - Remove and Install	275		
Installation Procedure	276		
Removal Procedure	275		
G		L	
Gear Group (Front) - Remove and Install	164	Lifter Group - Remove and Install (Hydraulic Lifter Group)	212
Installation Procedure	166	Installation Procedure	213
Removal Procedure	164	Removal Procedure	212
Gear Group (Front) - Remove and Install (Heavy Duty Gear Group (Front))	155		
Installation Procedure	158		
Removal Procedure	155		
Glow Plugs - Remove and Install	289		
Installation Procedure	290		
Removal Procedure	289		
H		M	
Housing (Front) - Install	182	Manifold (DEF Heater) - Remove and Install	97
Installation Procedure	182	Installation Procedure	99
Housing (Front) - Install (Heavy Duty Housing (Front))	179	Removal Procedure	97
Installation Procedure	179	Manifold (DEF Heater) Sensor - Assemble (Temperature, Level, Quality DEF Manifold Sensor)	102
Housing (Front) - Remove	177	Assembly Procedure	102
Removal Procedure	177	Manifold (DEF Heater) Sensor - Disassemble (Temperature, Level, Quality DEF Manifold Sensor)	101
Housing (Front) - Remove (Heavy Duty Housing (Front))	175	Disassemble Procedure	101
Removal Procedure	175		
I		N	
Idle Gear - Install	172	Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor on Engine)	267
Installation Procedure	172	Installation Procedure	268
Idle Gear - Remove	169	Removal Procedure	267
Removal Procedure	169	Nitrogen Oxide Sensor - Remove and Install (Nitrogen Oxide Sensor Positioned in Original Equipment Manufacture (OEM) Exhaust Tube Assembly)	266
Idle Pulley - Remove and Install (Flat Idler Pulley)	292	Installation Procedure	267
Installation Procedure	292	Removal Procedure	266
Removal Procedure	292		
Idle Pulley - Remove and Install (Grooved Idler Pulley)	292		
		P	
		Piston Cooling Jets - Remove and Install	235
		Installation Procedure	236
		Removal Procedure	235
		Pistons and Connecting Rods - Assemble	240
		Assembly Procedure	240
		Pistons and Connecting Rods - Disassemble	238
		Disassembly Procedure	238
		Pistons and Connecting Rods - Install	242
		Installation Procedure	242
		Pistons and Connecting Rods - Remove	237
		Removal Procedure	237

Pressure Sensor (Cooled Exhaust Gas) - Remove and Install (Differential Pressure Sensor and Inlet Pressure Sensor)	284
Installation Procedure	285
Removal Procedure	284

R

Refrigerant Compressor - Remove and Install	263
Installation Procedure	265
Removal Procedure	263
Relief Valve (Fuel) - Remove and Install	21
Installation Procedure	21
Removal Procedure	21
Rocker Shaft - Assemble	199
Assembly Procedure	199
Rocker Shaft - Disassemble	198
Disassembly Procedure	198
Rocker Shaft and Pushrod - Install	200
Installation Procedure	200
Rocker Shaft and Pushrod - Remove	195
Removal Procedure	195

S

Solenoid Valve (DEF Heater Coolant) - Remove and Install	105
Installation Procedure	105
Removal Procedure	105
Soot Antenna - Remove and Install	279
Installation Procedure	279
Removal Procedure	279
Support and Mounting (CEM) - Remove and Install	120
Installation Procedure	121
Removal Procedure	120

T

Table of Contents	3
Temperature Sensor (Catalyst Inlet) - Remove and Install	282
Installation Procedure	282
Removal Procedure	282
Temperature Sensor (Cooled Exhaust Gas) - Remove and Install	283
Installation Procedure	283
Removal Procedure	283
Temperature Sensor (DPF) - Remove and Install	281
Installation Procedure	281
Removal Procedure	281
Temperature Sensor (Exhaust) - Remove and Install (Selective Catalytic Reduction (SCR) Temperature Sensor)	280
Installation Procedure	281
Removal Procedure	280
Turbocharger - Install (First Stage Turbocharger)	61
Installation Procedure	61
Turbocharger - Install (Second Stage Turbocharger)	66
Installation Procedure	66
Turbocharger - Install (Side Mounted Turbochargers)	69
Installation Procedure	69

Turbocharger - Install (Top Mounted Turbocharger)	64
Installation Procedure	64
Turbocharger - Remove (First Stage Turbocharger)	54
Removal Procedure	54
Turbocharger - Remove (Second Stage Turbocharger)	56
Removal Procedure	56
Turbocharger - Remove (Side Mounted Turbochargers)	58
Removal Procedure	58
Turbocharger - Remove (Top Mounted Turbocharger)	59
Removal Procedure	59

V

Valve Mechanism Cover - Remove and Install	193
Installation Procedure	193
Removal Procedure	193

W

Wastegate Solenoid - Remove and Install	71
Installation Procedure	71
Removal Procedure	71
Water Pump - Install	136
Installation Procedure	136
Water Pump - Remove	135
Removal Procedure	135
Water Separator and Fuel Filter (Primary) - Remove and Install	16
Installation Procedure	18
Removal Procedure	16
Water Temperature Regulator - Remove and Install	138
Installation Procedure	138
Removal Procedure	138

UENR4491
©2021 Perkins Engines Company Limited
All Rights Reserved