M0108283-02 (en-us)
October 2022

Perkins®

THE HEART OF EVERY GREAT MACHINE

Specifications

403J-E17T, 404J-E22T and 404J-E22TA Industrial Engines

Important Safety Information

Most accidents that involve product operation, maintenance and repair are caused by failure to observe basic safety rules or precautions. An accident can often be avoided by recognizing potentially hazardous situations before an accident occurs. A person must be alert to potential hazards. This person should also have the necessary training, skills and tools to perform these functions correctly.

Incorrect operation, lubrication, maintenance or repair of this product can be dangerous and could result in injury or death.

Do not operate or perform any lubrication, maintenance or repair on this product, until you have read and understood the operation, lubrication, maintenance and repair information.

Safety precautions and warnings are provided in this manual and on the product. If these hazard warnings are not heeded, bodily injury or death could occur to you or to other persons.

The hazards are identified by the “Safety Alert Symbol” and followed by a “Signal Word” such as “DANGER”, “WARNING” or “CAUTION”. The Safety Alert “WARNING” label is shown below.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

The message that appears under the warning explains the hazard and can be either written or pictorially presented.

Operations that may cause product damage are identified by “NOTICE” labels on the product and in this publication.

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. You must not use this product in any manner different from that considered by this manual without first satisfying yourself that you have considered all safety rules and precautions applicable to the operation of the product in the location of use, including site-specific rules and precautions applicable to the worksite. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that you are authorized to perform this work, and that the product will not be damaged or become unsafe by the operation, lubrication, maintenance or repair procedures that you intend to use.

The information, specifications, and illustrations in this publication are on the basis of information that was available at the time that the publication was written. The specifications, torques, pressures, measurements, adjustments, illustrations, and other items can change at any time. These changes can affect the service that is given to the product. Obtain the complete and most current information before you start any job. Perkins dealers or Perkins distributors have the most current information available.

⚠ WARNING

When replacement parts are required for this product Perkins recommends using Perkins replacement parts.

Failure to heed this warning can lead to premature failures, product damage, personal injury or death.

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

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i07915354

Engine Design

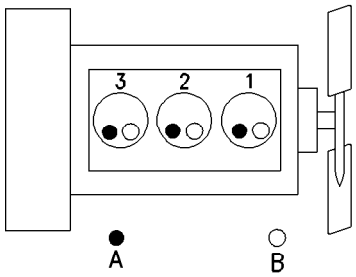

Illustration 1 g00852304

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore . . . . . 84 mm ((3.3 inch))

Stroke . . . . . 100 mm ((3.9 inch))

Displacement . . . . . 1.66 L ((101.3 inch ^{3}))

Cylinder arrangement . . . . . In-line

Type of combustion . . . . . Direct injection

Compression ratio 17.3:1

Number of cylinders 3

Valves per cylinder 2

Valve lash

Inlet valve . . . . . 0.2 mm ((0.0078 inch))
Exhaust valve . . . . . 0.2 mm ((0.0078 inch))

Firing order 1, 2, 3

When the crankshaft is viewed from the front of the engine, the crankshaft rotates in the following direction. . . . . Clockwise

When the camshaft is viewed from the front of the engine, the camshaft rotates in the following direction. . . . . Clockwise

The front of the engine is opposite the flywheel end of the engine. The left side and the right side of the engine are determined from the flywheel end. Number 1 cylinder is the front cylinder of the engine.

i07915355

Engine Design

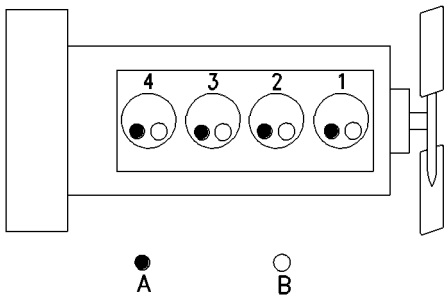

Illustration 2 g00296424

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore . . . . . 84 mm ((3.3 inch))

Stroke . . . . . 100 mm ((3.9 inch))

Displacement . . . . . .2.216 L ((135 in^3))

Cylinder arrangement . . . . . In-line

Type of combustion . . . . . Direct injection

Compression ratio

Turbocharged engines 17.3:1
Turbocharged aftercooled engines 17.3:1

Number of cylinders 4

Valves per cylinder 2

Valve lash

Inlet valve . . . . . 0.2 mm ((0.0078 inch))
Exhaust valve . . . . . 0.2 mm ((0.0078 inch))

Firing order 1, 3, 4, 2

When the crankshaft is viewed from the front of the engine, the crankshaft rotates in the following direction. . . . . Clockwise

When the camshaft is viewed from the front of the engine, the camshaft rotates in the following direction. . . . . Clockwise

The front of the engine is opposite the flywheel end of the engine. The left side and the right side of the engine are determined from the flywheel end. Number 1 cylinder is the front cylinder of the engine.

i07940054

Fuel Injection Lines

⚠ 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.

Refer to Operation and Maintenance Manual, “General Hazard Information and High-Pressure Fuel Lines” before adjustments and repairs are performed.

NOTICE

Refer to Systems 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.

Ensure that all adjustments and repairs are performed by authorized personnel that have had the correct training.

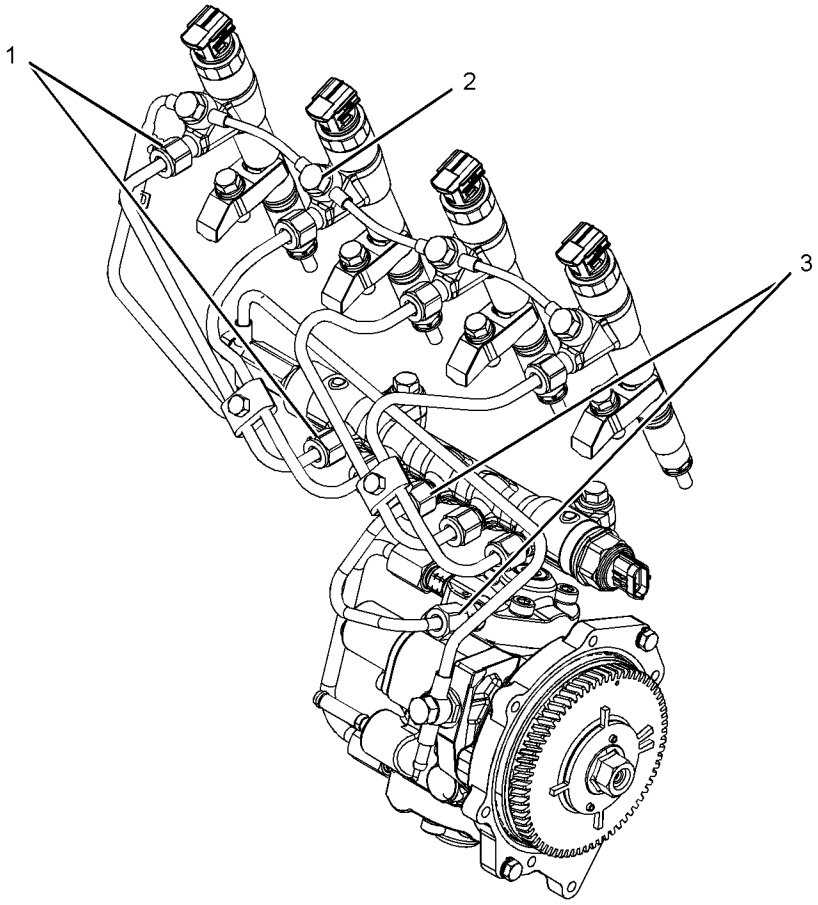

Illustration 3 g03788573
Typical example

(1) (3) Tighten the nuts on the high-pressure fuel lines to the following torque. . . .22.5 N·m ((16.6 lb ft))

(2) Tighten the bolts to the following torque. . 20 N·m ((177 lb in))

i07816511

NOTICE
Refer to Systems 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.

Fuel Injection Pump

Note: The timing of the fuel injection pump will need to be checked by trained personnel. To check the timing of the fuel injection pump, refer to Systems Operation, Testing, and Adjusting, “Fuel Injection Pump Timing - Check”.

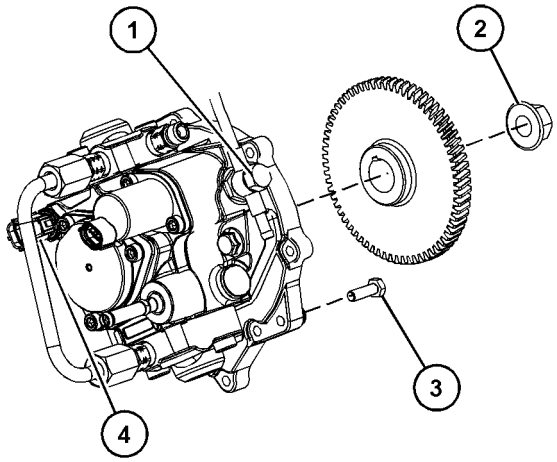

Illustration 4 g06443472
Typical example

(1) Tighten the bolt to the following torque. . . . 20 N·m ((177 lb in))

(2) Tighten the nut to the following torque. . . . . 60 N·m ((44 lb ft))

(3) Tighten the setscrews to the following torque. . . . . 30 N·m ((22 lb ft))

(4) Tighten the sensor to the following torque. . . . . 22 N·m ((195 lb in))

i06547378

Fuel Injectors

Refer to Operation and Maintenance Manual, “General Hazard Information and High-Pressure Fuel Lines” before adjustments and repairs are performed.

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

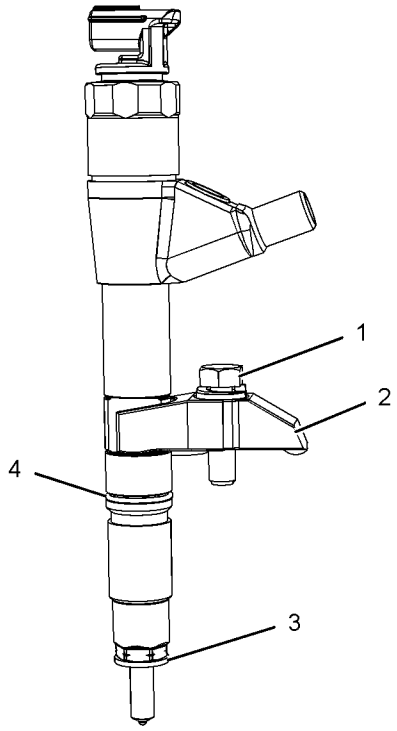

Illustration 5 g03788565
Typical example

(2) Clamp
(3) Washer
(4) O ring seal

(1) Torque for the bolt in the clamp for the fuel injection nozzle. . . . . 25.5 N·m ((18.8 lb ft))

i06547391

Fuel Filter Base
(Secondary Fuel Filter Base)

NOTICE
Refer to Systems 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.

If necessary, install a new fuel filter to canister (5). Refer to Operation and Maintenance Manual, “Fuel System Secondary Filter - Replace” for the correct procedure.

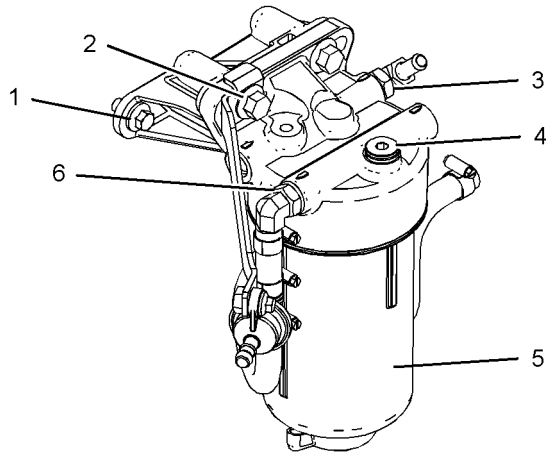

Illustration 6 g06005288
Typical example

(1) Tighten the bolts to the following torque. . 26 N·m ((19 lb ft))

(2) Tighten the bolts to the following torque. . 50 N·m ((37 lb ft))

(3) Tighten the elbow to the following torque. . . . . 24 N·m ((18 lb ft))

(4) Tighten the vent screw to the following torque. . . . . 24 N·m ((18 lb ft))

(6) Tighten the elbow to the following torque. . . . . 24 N·m ((18 lb ft))

i07816507

Fuel Manifold (Rail)

Refer to Operation and Maintenance Manual, “General Hazard Information and High-Pressure Fuel Lines” before adjustments and repairs are performed.

NOTICE
Refer to Systems 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.

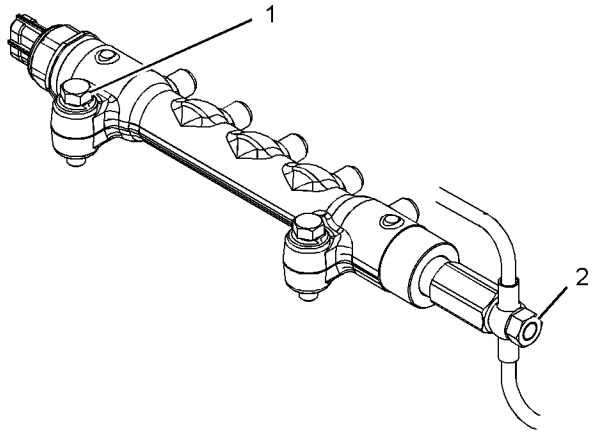

Illustration 7 g03788579
Typical example

(1) Tighten the bolts to the following torque. . 26 N·m ((19 lb ft))

(2) Tighten the bolt to the following torque. . . 20 N·m ((177 lb in))

i05097794

Lifter Group

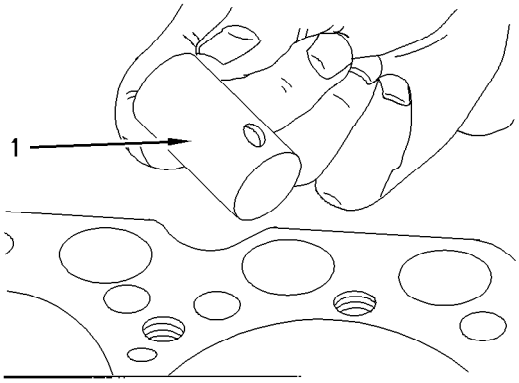

Illustration 8 g00692979
Typical example

Clearance between the lifter (1) and the bore in the engine for the lifter

Standard maximum clearance . . . . . 0.058 mm ((0.0023 inch))
Repair limit . . . . . 0.080 mm ((0.0031 inch))

i06042349

Rocker Shaft

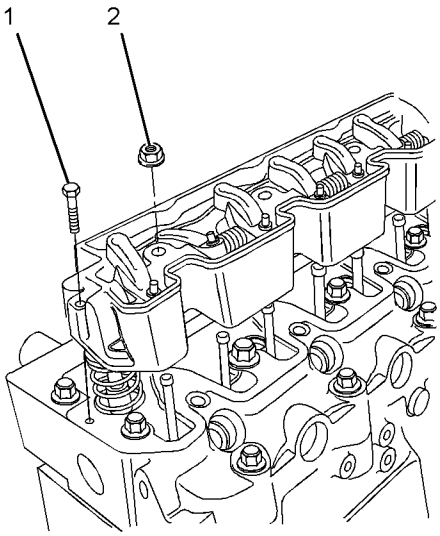

Illustration 9 g01440959
Typical example

Note: Before assembly, lubricate the components with clean engine oil.

(1) Tighten the setscrews to the following torque. . . . . 10 N·m ((89 lb in))

(2) Tighten the nuts to the following torque. . 33 N·m ((24 lb ft))

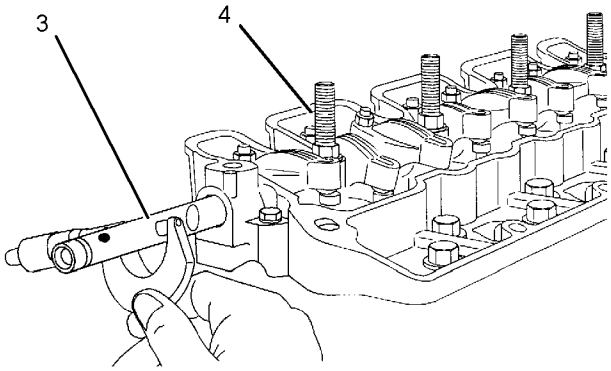

Illustration 10 g01440976
Typical example

(3) Rocker shaft

Diameter of the rocker shaft
. . . . 14.95 to 14.97 mm ((0.5886 to 0.5894 inch))

Service limit . . . . . 14.87 mm ((0.5854 inch))

(4) Tighten the studs to the following torque.
. . . . . 56 N·m ((41 lb ft))

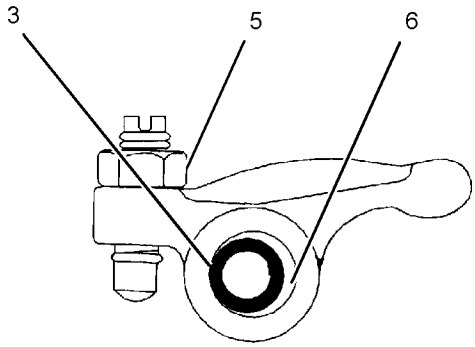

Illustration 11 g01440948
Typical example

(5) Tighten the locknut to the following torque.
. . . . . 14 N·m ((10 lb ft))

(6) Rocker arm clearance on the rocker shaft

Minimum permissible clearance
. . 0.032 to 0.068 mm ((0.00126 to 0.00268 inch))

Maximum permissible clearance . . . . . 0.2 mm ((0.008 inch))

i07815310

Valve Mechanism Cover

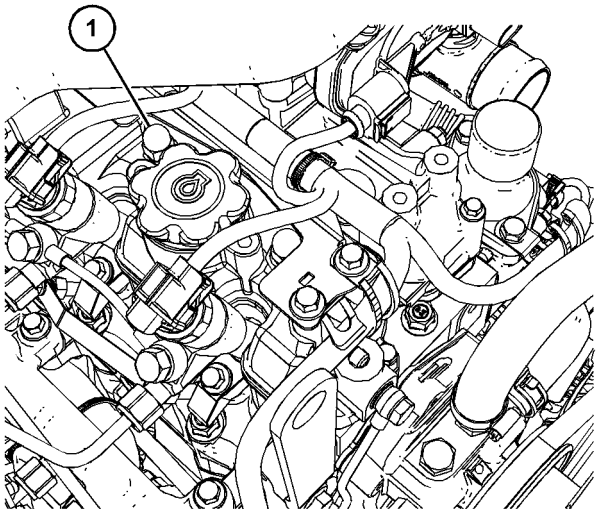

Illustration 12 g06442767
Typical example

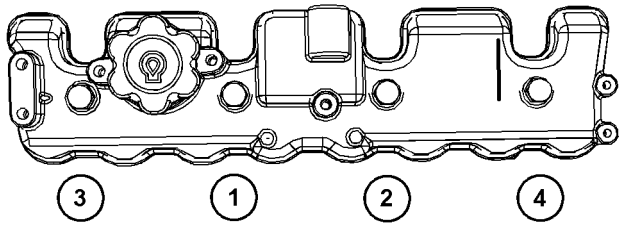

Illustration 13 g06442804
Typical example

(1) Tighten the cap nuts for the valve mechanism cover in the sequence that is shown in illustration 13 to the following torque.. . . . . 14 N·m ((124 lb in))

i07815369

Valve Mechanism Cover

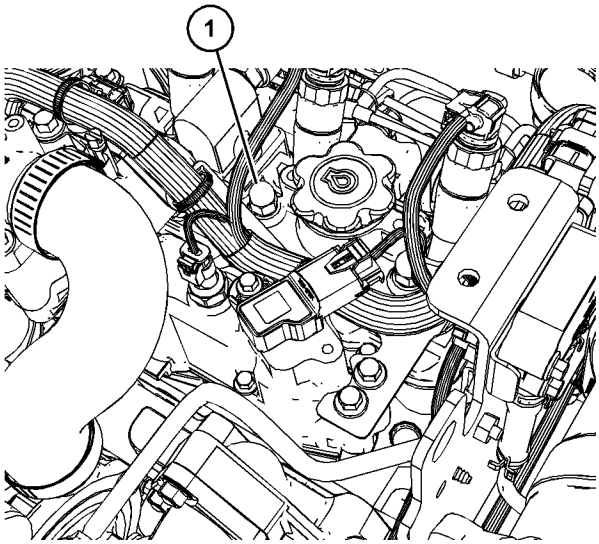

Illustration 14 g06443176
Typical example

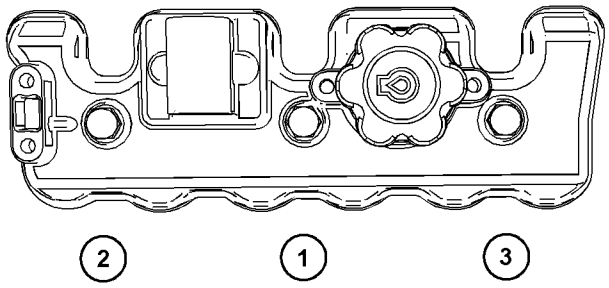

Illustration 15 g06443186
Typical example

(1) Tighten the cap nuts for the valve mechanism cover in the sequence that is shown in illustration 15 to the following torque.. . . . . 14 N·m ((124 lb in))

i06039673

Cylinder Head Valves

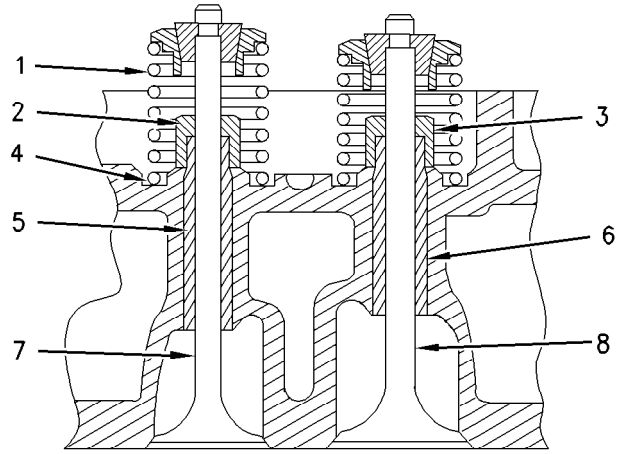

Illustration 16 g00903737
Typical example

(1) Valve spring

Standard free length . . . . 35.0 mm ((1.378 inch))

Service limit for the standard free length . . . . . 33.5 mm ((1.319 inch))

Standard test force . . . . . 79.4 N ((17.8 lb))

Service limit for the standard test force . . . 68.6 N ((15.4 lb))

Length under test force . 30.4 mm ((1.197 inch))

(2) Valve guide seal for the exhaust valve

Identification . . . . . Black garter spring
Label on the black garter spring . . . . . “EX”

(3) Valve guide seal for the inlet valve

Identification . . . . . Silver garter spring

(4) Valve spring recess for the valve spring

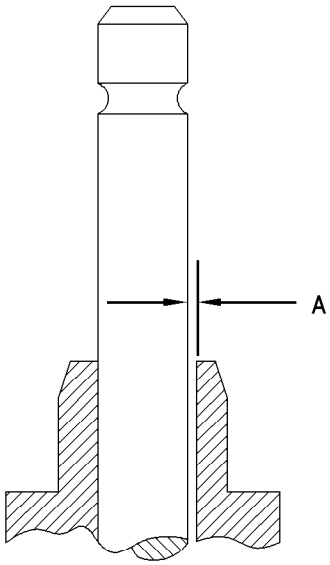

Illustration 17 g00903744
Typical example

(5) Exhaust valve guide

(A) Clearance between the exhaust valve and the valve guide . . . . . 0.03 to 0.06 mm ((0.00118 to 0.00236 inch))

Service limit . . . . . .0.2 mm ((0.008 inch))

(6) Inlet valve guide

(A) Clearance between the inlet valve and the valve guide . . 0.03 to 0.06 mm ((0.00118 to 0.00236 inch))

Service limit . . . . . .0.2 mm ((0.008 inch))

(7) Exhaust valve stem

Diameter of the exhaust valve stem . . 6.955 to 6.970 mm ((0.27382 to 0.27441 inch))

Service limit . . . . . 6.89 mm ((0.27126 inch))

(8) Inlet valve stem

Diameter of the inlet valve stem . . 6.955 to 6.970 mm ((0.27382 to 0.27441 inch))

Service limit . . . . . 6.89 mm ((0.271 inch))

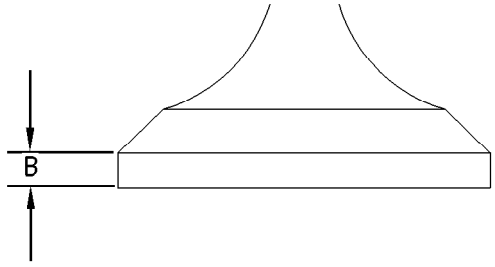

Illustration 18 g00845823
Typical example

(B) Thickness of the valve head . . . . . 0.9 to 1.1 mm ((0.0354 to 0.0433 inch))

Service limit . . . . . .0.5 mm ((0.020 inch))

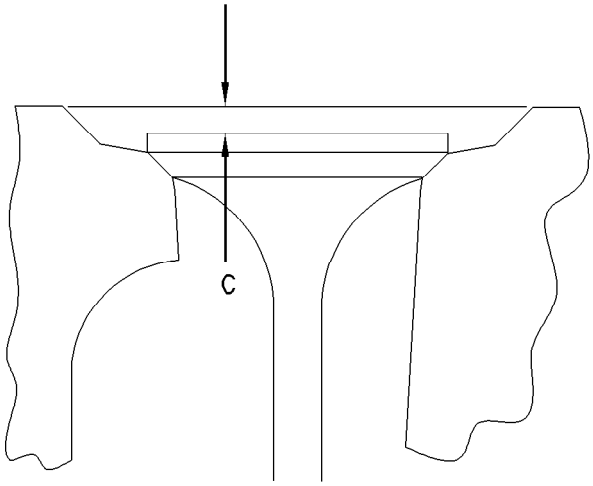

Illustration 19 g00903773
Typical example

(C) Valve depth below the cylinder head face

Inlet and exhaust valves . . . . . 0.75 to 0.85 mm ((0.0295 to 0.0335 inch))

Service limit . . . . . .1.6 mm ((0.063 inch))

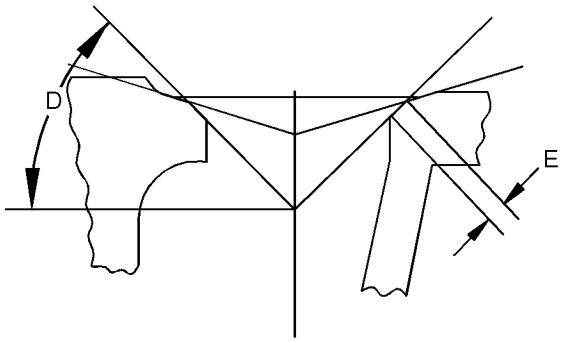

Illustration 20 g03811083
Typical example

(D) Valve seat angle . . . . . 45 degrees

(E) Contact face

Exhaust valve . . . . . 1.50 to 1.86 mm ((0.059 to 0.073 inch))
Service limit . . . . . .2.5 mm ((0.098 inch))

Inlet valve . . . . . 2.16 to 2.38 mm ((0.085 to 0.093 inch))
Service limit . . . . . .2.7 mm ((0.106 inch))

i07915356

Cylinder Head

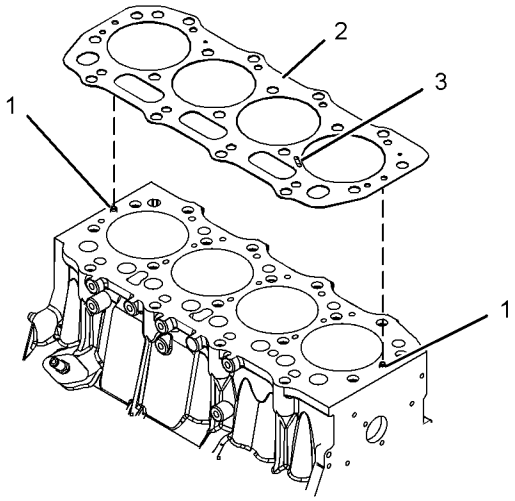

Illustration 21 g03811103

Typical example

(1) Dowel pins

The dowel pins in the cylinder block hold the cylinder head gasket in the correct position when the cylinder head is installed.

(2) Cylinder head gasket

Table 1

Selection of Head Gasket for the three cylinder engine	
Piston Height Above Top Face of Cylinder Block	**Gasket Thickness**
0.45 to 0.67 mm (0.01772 to 0.02638 inch)	1.3 mm (0.051 inch)
0.67 to 0.80 mm (0.02638 to 0.03150 inch)	1.4 mm (0.055 inch)

Table 2

Selection of Head Gasket for the four cylinder engine	
Piston Height Above Top Face of Cylinder Block	**Gasket Thickness**
+0.3 mm to 0.4 mm (+0.0118 inch to 0.016 inch)	1.1 mm (0.043 inch)
+0.4 mm to 0.5 mm (+0.016 inch to 0.020 inch)	1.2 mm (0.047 inch)
+0.5 mm to 0.6 mm (+0.020 inch to 0.024 inch)	1.3 mm (+0.051 inch)

(3) The stamped marking on the cylinder head gasket must face upward. The stamped marking ensures that the cylinder head gasket is installed correctly.

Tightening Procedure for the Cylinder Head

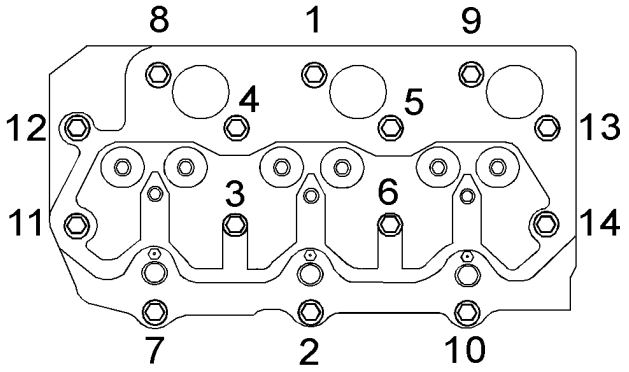

Illustration 22 g01317351

Tightening sequence for the three cylinder engine

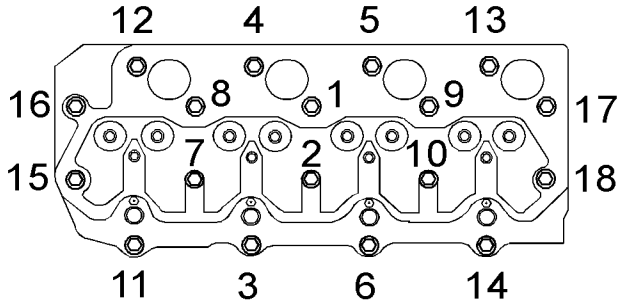

Illustration 23 g01309552

Tightening sequence for the four cylinder engine

Use the following procedure to tighten the bolts for the cylinder head.

1. Put clean engine oil on the threads of the bolts. The bolts are tightened in the numerical sequence that is shown in illustration 22 or illustration 23 .

Torque for the bolts . . . . . 50 N·m ((37 lb ft))

Tighten the bolts to the additional amount.. . . . . 150 degrees

Measuring the Distortion of the Cylinder Head

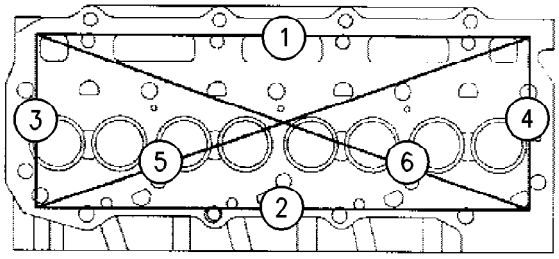

Illustration 24 g00900977
Typical example

Distortion of the cylinder head . . 0.00 mm to 0.05 mm ((0.000 inch to 0.002 inch))

Maximum service limit . . . . . 0.12 mm ((0.005 inch))

Maximum limit for regrinding . . . . . 0.15 mm ((0.006 inch))

Note: Use a straight edge and a feeler gauge to check the six positions for distortion.

Refer to Systems Operation, Testing and Adjusting, “Cylinder Head - Inspect” for the procedures for measuring the cylinder head.

Note: If the cylinder head has been machined, check the valve depth below the cylinder head face. Refer to Specifications, “Cylinder Head Valves” for valve depth.

i07816439

Turbocharger

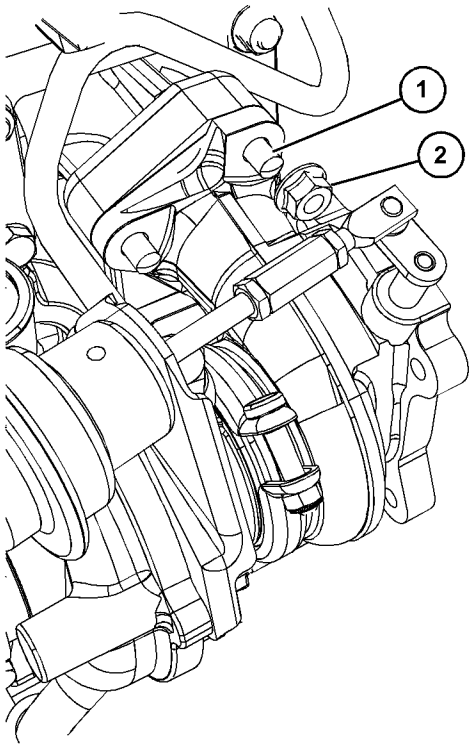

Illustration 25 g06443406
Typical example

(1) Tighten the studs to the following torque. . . . . 11 N·m ((97 lb in))

(2) Tighten the nuts to the following torque. . . 25 N·m ((221 lb in))

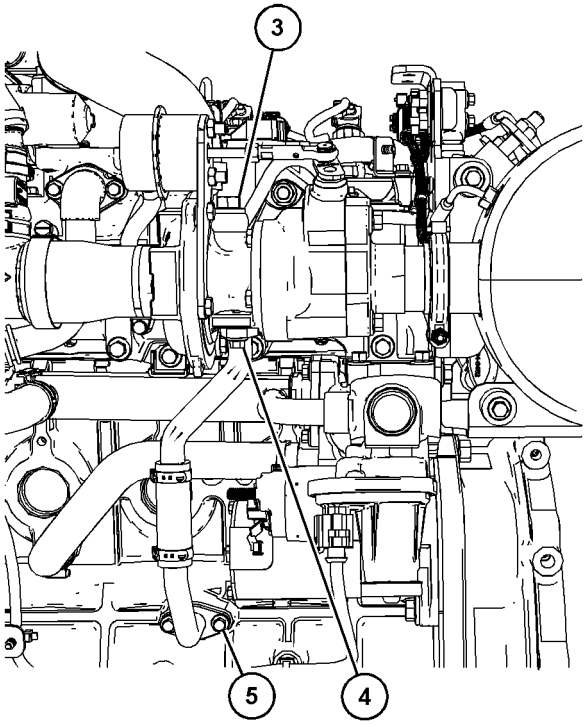

Illustration 26 g06443427
Typical example

(3) Tighten the bolt to the following torque. . . . 15 N·m ((133 lb in))

(4) (5) Tighten the bolts to the following torque. . . . . 10 N·m ((89 lb in))

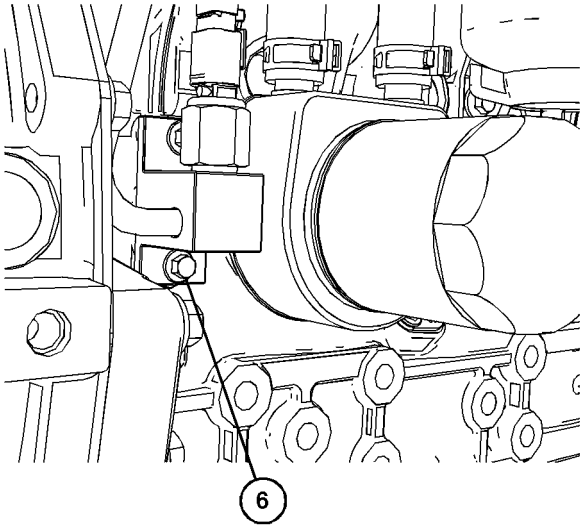

Illustration 27 g06443444
Typical example

(6) Tighten the bolts (if equipped) to the following torque. . . . . 10 N·m ((89 lb in))

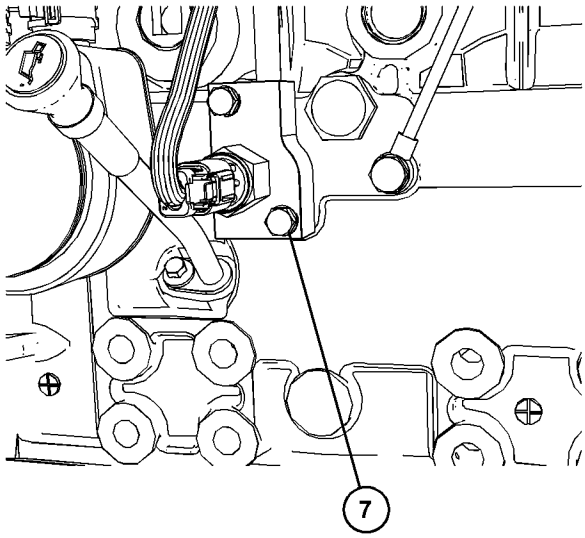

Illustration 28 g06443452
Typical example

(7) Tighten the bolts (if equipped) to the following torque. . . . . 12 N·m ((106 lb in))

The movement for the actuator rod. . . . . 2 mm ((0.0787 inch))

Table 3

Turbocharger Part Number	Wastegate Pressure
T433974	155.0 kPa (22.48 psi)
T434107	155.0 kPa (22.48 psi)
T432501	148.4 kPa (21.52 psi)
T433717	158.1 kPa (22.93 psi)

i07815095

Exhaust Gas Valve (NRS)
(Throttle Valve)

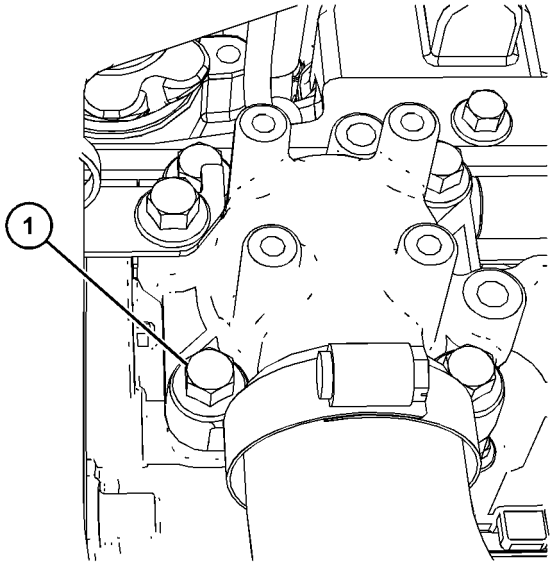

Illustration 29 g06442618
Typical example

(1) Tighten the bolts to the following torque. . 25 N·m ((221 lb in))

i07815148

Exhaust Gas Valve (NRS)

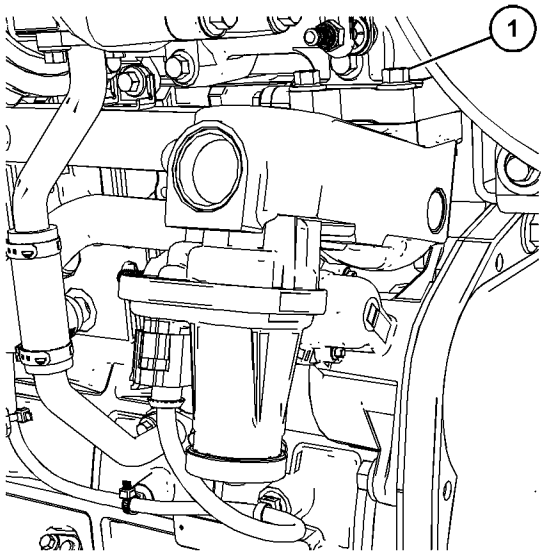

Illustration 30 g06442675
Typical example

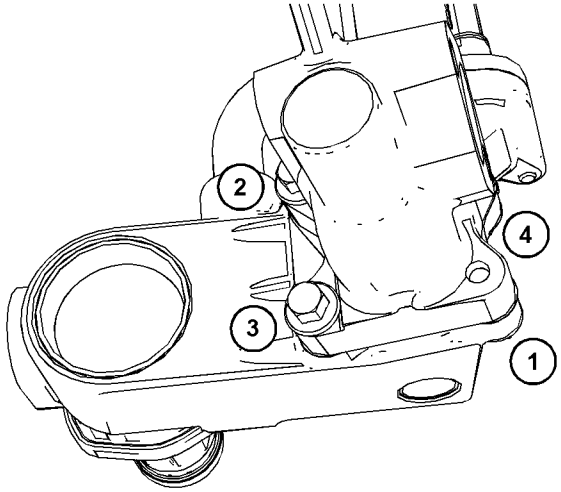

Illustration 31 g06442681
Typical example

(1) Tighten the bolts in the sequence shown in illustration 31 to the following torque. . . . . 25 N·m ((221 lb in))

i07815098

Exhaust Cooler (NRS)

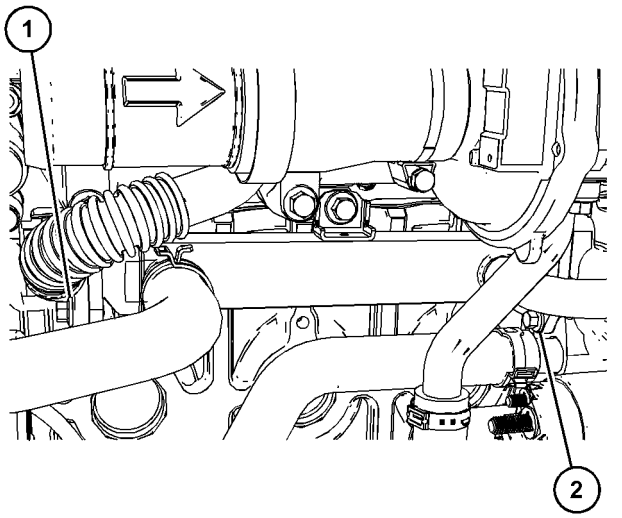

Illustration 32 g06442628
Typical example

(1) Tighten the bolts to the following torque. . 25 N·m ((221 lb in))

(2) Tighten the bolts to the following torque. . 25 N·m ((221 lb in))

i07816269

Inlet Manifold

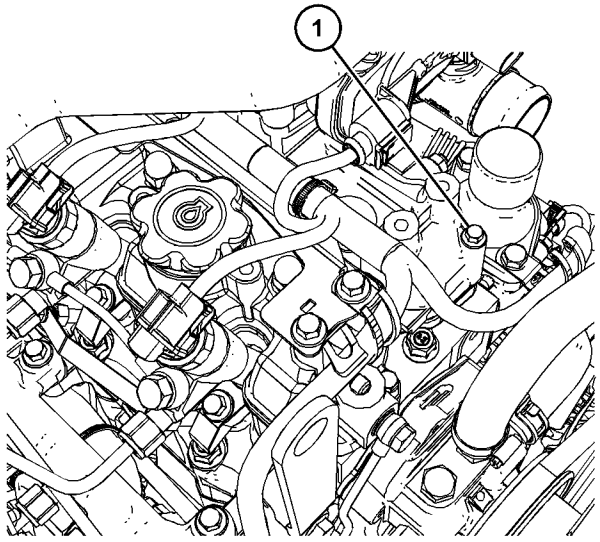

Illustration 33 g06443197
Typical example

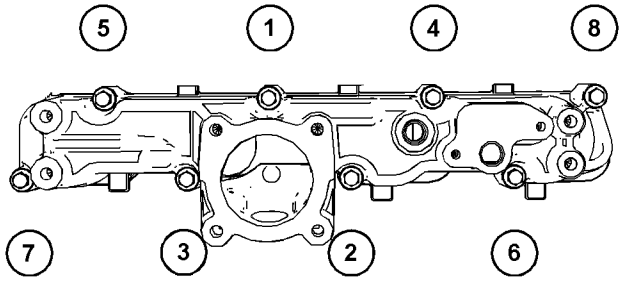

Illustration 34 g06443221
Typical example

(1) Tighten the bolts in the sequence that is shown in illustration 34 to the following torque. . . . . 10 N·m ((89 lb in))

i07816376

Inlet Manifold

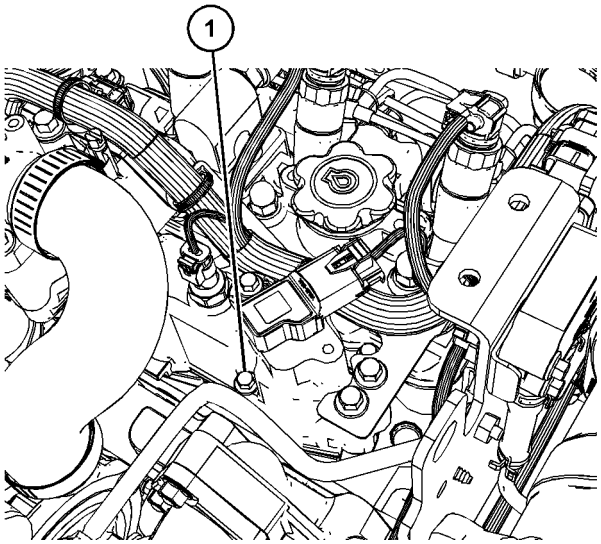

Illustration 35 g06443277
Typical example

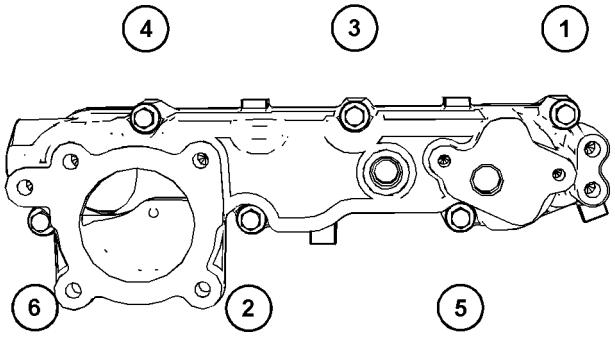

Illustration 36 g06443294
Typical example

(1) Tighten the bolts in the sequence that is shown in illustration 36 to the following torque. . . . . 10 N·m ((89 lb in))

i09647618

Exhaust Manifold

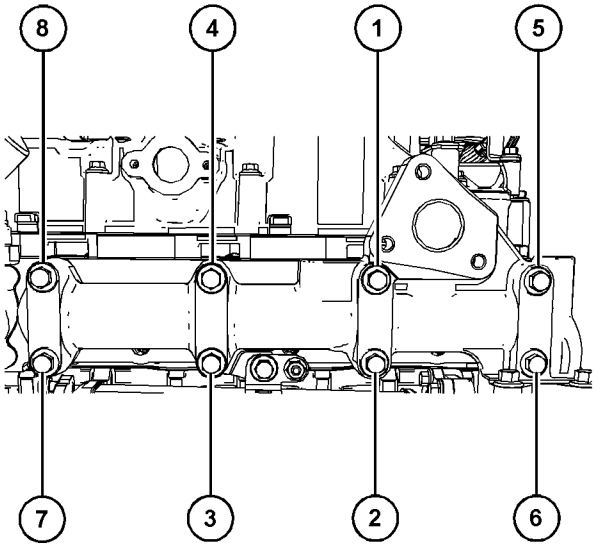

Illustration 37 g06477757
Typical example

Tighten the bolts for the exhaust manifold in the sequence shown in illustration 37 to an initial torque. . . . . 28 N·m ((248 lb in))

Tighten the bolts for the exhaust manifold in the sequence shown in illustration 37 to a final torque. . . . . 36 N·m ((27 lb ft))

i09647620

Exhaust Manifold

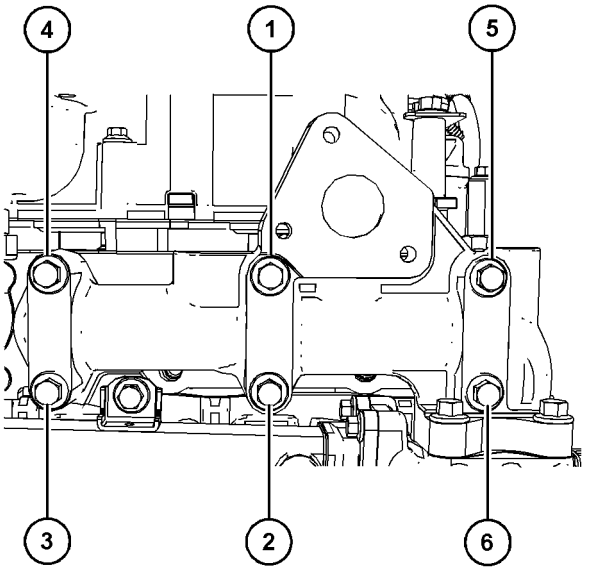

Illustration 38 g06477780
Typical example

Tighten the nuts and bolts for the exhaust manifold in the sequence shown in illustration 38 to an initial torque.. . . . . 28 N·m ((248 lb in))

Tighten the nuts and bolts for the exhaust manifold in the sequence shown in illustration 38 to a final torque.. . . . . .36 N·m ((27 lb ft))

i06038206

Camshaft

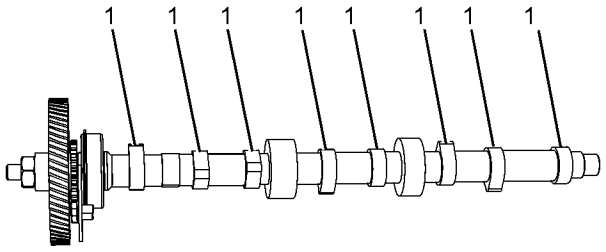

Illustration 39 g03785127
Typical example

(1) Height of the camshaft lobe for the inlet and exhaust valves . . . . . .34.438 to 34.538 mm ((1.35582 to 1.35976 inch))

Service limit . . . . . 34.1 mm ((1.34252 inch))

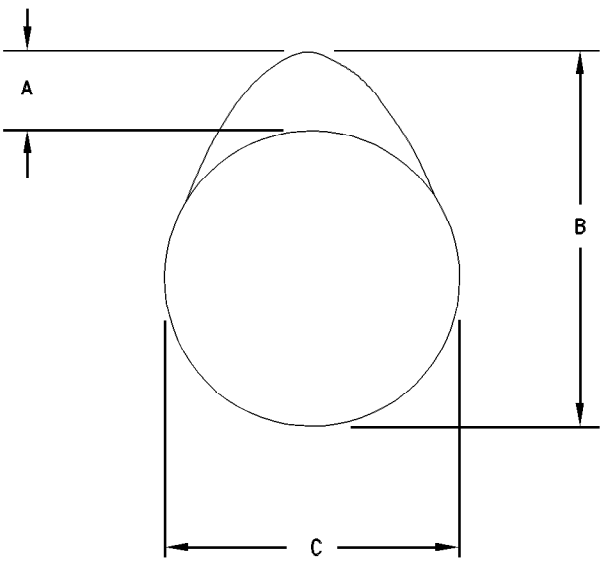

Illustration 40 g00295323
Typical example

(A) Actual camshaft lobe lift

(B) Height of the camshaft lobe

(C) Base circle

To determine the lobe lift, use the procedure that follows:

1. Measure the height of the camshaft lobe (B).

2. Measure the base circle (C).

3. Subtract the base circle that is found in Step 2 from the height of the camshaft lobe that is found in Step 1. The difference is the actual camshaft lobe lift.

Maximum camshaft run out . . . . . 0.03 mm ((0.00118 inch))

Service limit . . . . . 0.1 mm ((0.00394 inch))

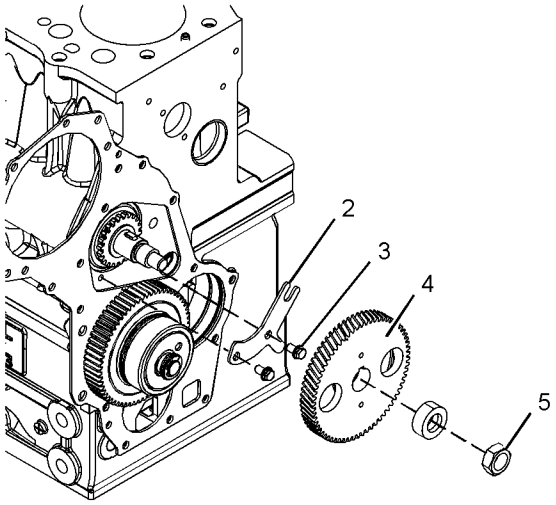

Illustration 41 g03785128

Typical example

(2) Retainer plate for the camshaft

(3) Tighten the setscrews for the retainer plate for the camshaft to the following torque. . . . . 11 N·m ((97 lb in))

(4) Camshaft gear

(5) Tighten the nut for the camshaft gear to the following torque. . . . . 70 N·m ((52 lb ft))

i06039726

Engine Oil Lines

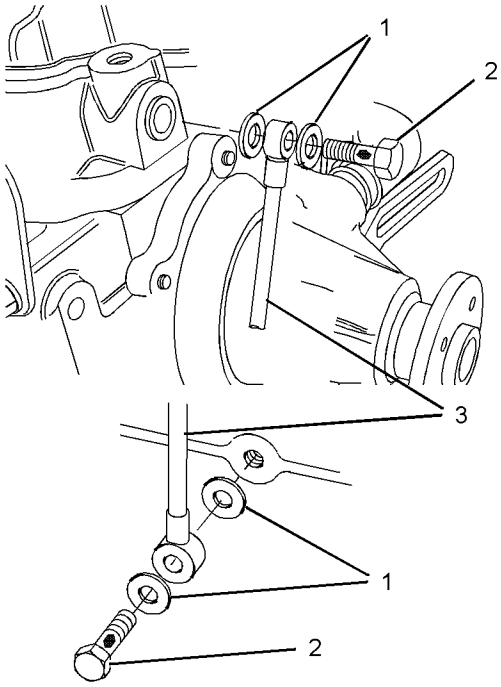

Illustration 42 g03791823

Typical example

(1) Washers

(3) Engine oil line

Note: The washers must be replaced with new washers when the engine oil line is removed.

(2) Torque for the bolts . . . . . 12 N·m ((9 lb ft))

i07814036

Engine Oil Relief Valve

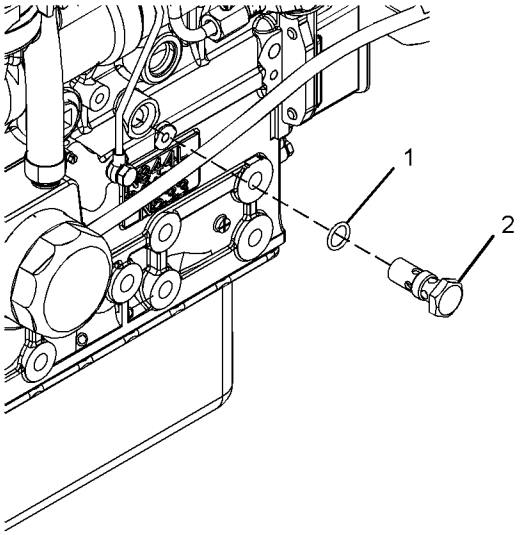

Illustration 43 g03785177

Typical example

Note: When the engine oil relief valve is installed, ensure that all components are clean. Lightly lubricate all components with clean engine oil.

(1) O-ring

A new O-ring should be used when the engine oil relief valve is installed.

(2) Tighten the engine oil relief valve to the following torque. . . . . 50 N·m ((37 lb ft))

The engine oil pressure at the engine oil relief valve is the following value. . . . . 402 kPa ((58 psi))

Note: Always remove the engine oil relief valve before removing or installing the crankshaft. Damage to the engine oil relief valve or damage to the crankshaft may occur.

i08617626

Engine Oil Pump

NOTICE
If the front housing is not installed, do not turn the crankshaft. Damage to the engine may occur.

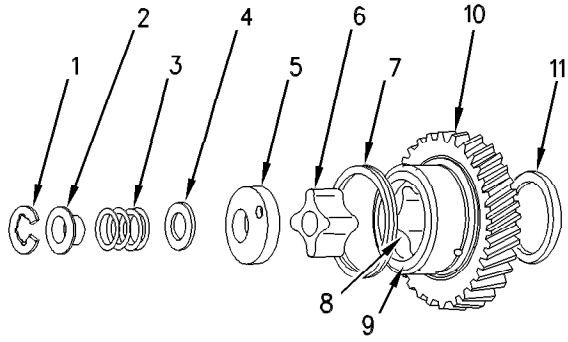

Illustration 44 g00458938

Idler gear and components of the engine oil pump

Type . . . . . Gerotor pump

(1) C-clip

(2) Collar

(3) Spring

(4) Shim

(5) Oil pump cover

(6) Inner rotor

Number of lobes 4

(7) Spring

(8) Outer rotor

Number of lobes 5

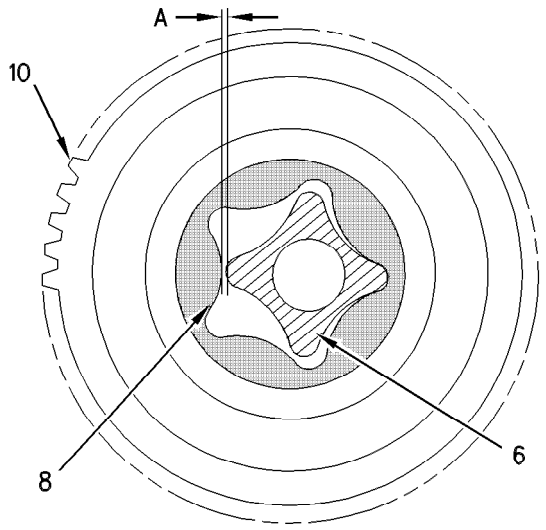

Illustration 45 g00459701

(A) Clearance between the inner rotor and the outer rotor is the following value. . . . . 0.04 to 0.15 mm ((0.002 to 0.006 inch))

Service Limit. . . . . 0.25 mm ((0.010 inch))

(9) Bushing

(10) Idler gear

(11) Thrust washer

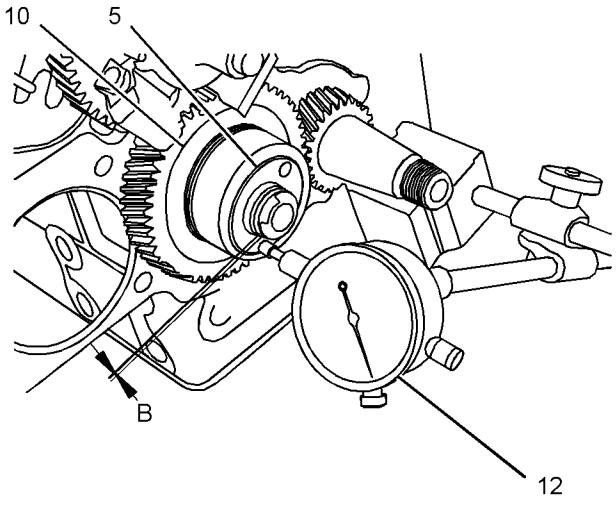

Illustration 46 g03131156

Typical example

(12) Dial indicator

(B) When the components of the oil pump are installed on the front housing, measurement (B) between C-clip (1) and collar (2) should not exceed the following distance. . . . . 0.10 to 0.15 mm ((0.004 to 0.006 inch))

Service limit . . . . . 0.20 mm ((0.008 inch))

The distance between the faces is adjusted with shims (4). The following sizes of shims are available:

- 0.10 mm
- 0.15 mm
- 0.20 mm
- 0.50 mm

i08093172

Engine Oil Pan
(Engines With a Balancer)

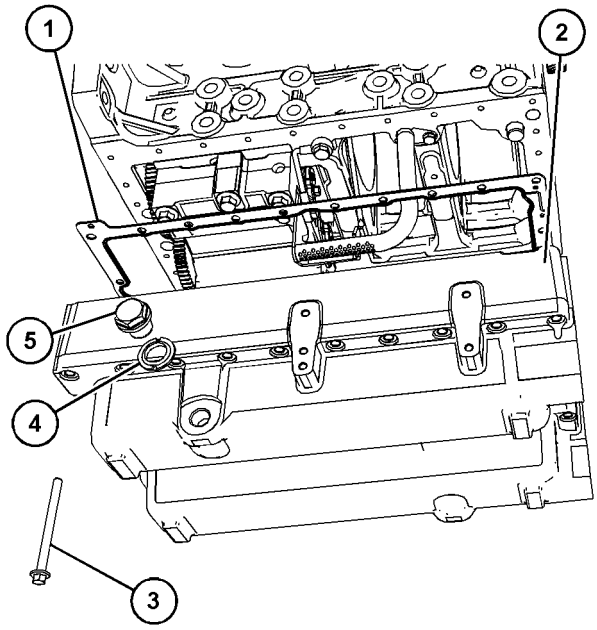

Illustration 47 g06540703
Typical example

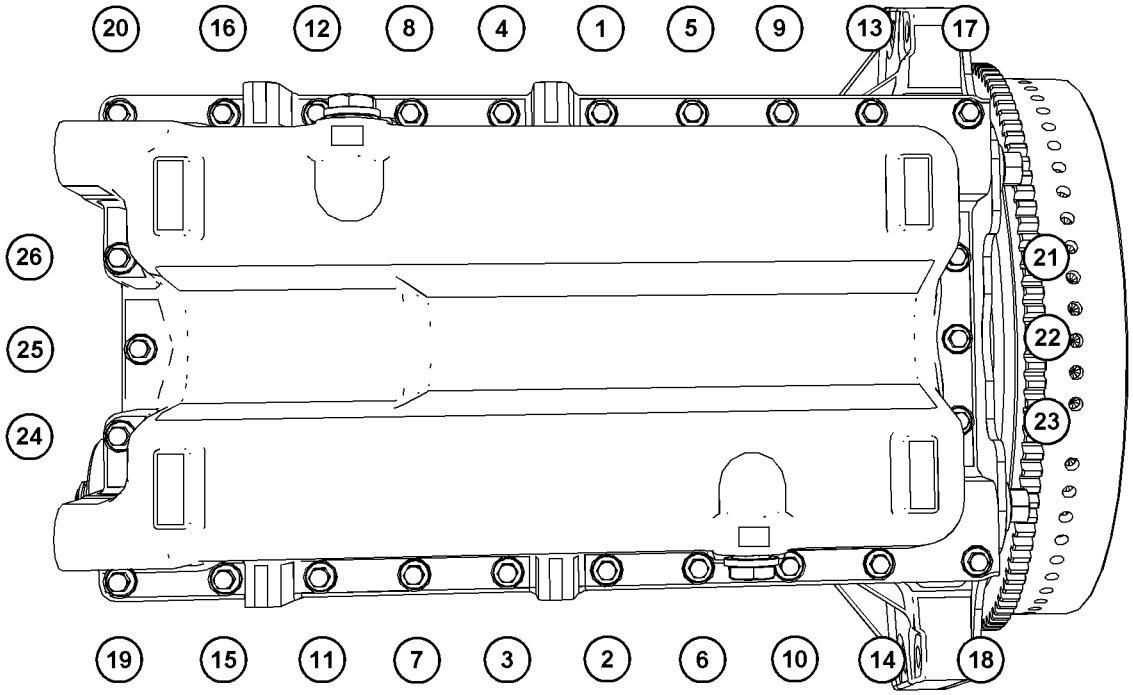

Illustration 48 g06540735

Tightening sequence

(1) Gasket

(2) Engine oil pan

(3) Tighten the setscrews for the engine oil pan in the sequence that is shown in illustration 48 to the following torque. . . . . 13 N·m ((115 lb in))

(4) Washer

(5) Tighten the drain plugs of the engine oil pan to the following torque. . . . . 35 N·m ((310 lb in))

Oil Suction Tube and Oil Strainer

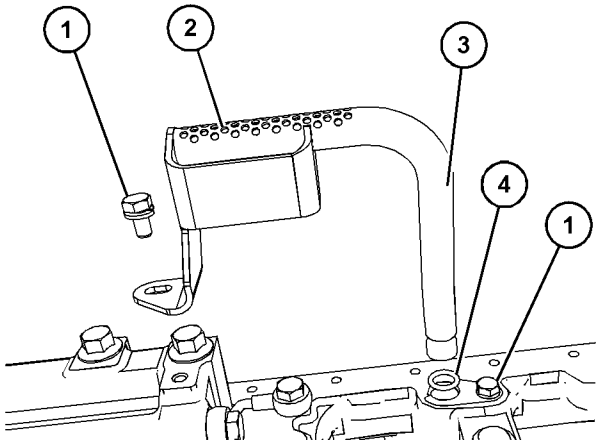

Illustration 49 g06540686

Typical example

(1) Tighten the bolts to the following torque. . 11 N·m ((97 lb in))

(2) Strainer

(3) Oil suction tube

Note: Install a new O-ring (4) in the hole of the cylinder block when the oil suction tube is removed or replaced.

i09646451

Engine Oil Pan

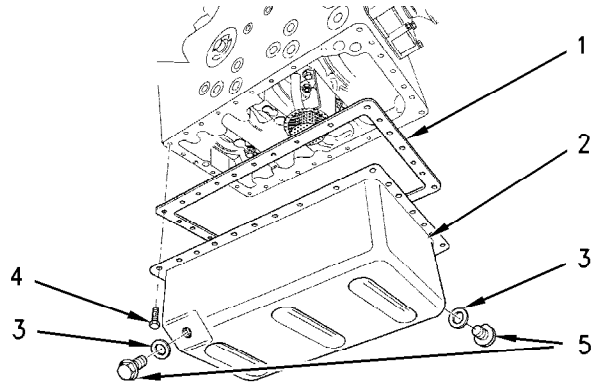

Illustration 50 g00820013

Typical example

(1) Gasket

(2) Engine oil pan

(3) Washer

(4) Bolts

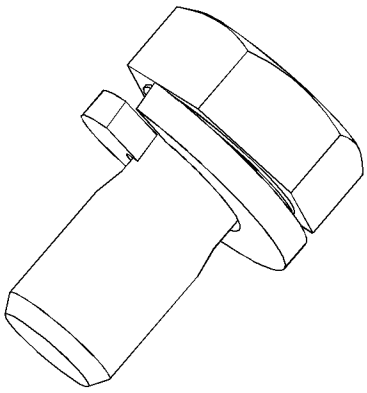

Illustration 51 g06693251

Type 1 Bolt

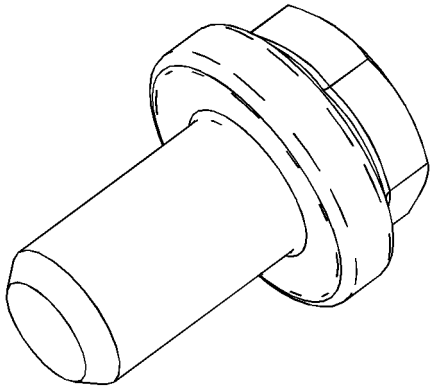

Illustration 52 g06693253

Type 2 Bolt

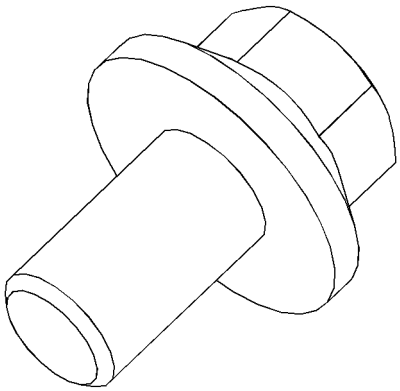

Illustration 53 g06693255

Type 3 Bolt

Tighten type 1 bolts to the following torque. . . 10 N·m ((89 lb in))

Tighten type 2 bolts and type 3 bolts to the following torque.. . . . . 12.5 N·m ((111 lb in))

(5) Oil drain plugs

Tighten the M12 drain plugs of the engine oil pan to the following torque. . . . .22.5 N·m ((199 lb in))
Tighten the M16 drain plugs of the engine oil pan to the following torque. . . . . 35 N·m ((310 lb in))

Oil Suction Tube and Oil Strainer

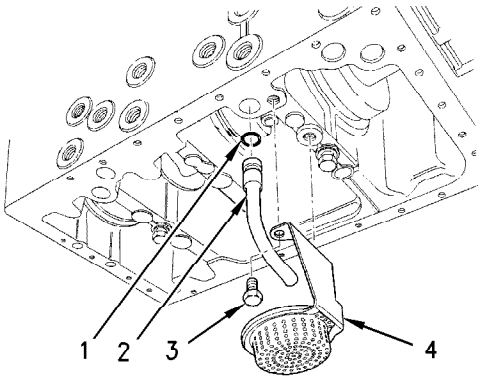

Illustration 54 g00820021

Typical example

(1) O-ring

(2) Oil suction tube

(3) Tighten the bolts for the oil strainer to the following torque. . . . . 11 N·m ((97 lb in))

(4) Strainer

Note: Install a new O-ring (1) when the oil suction tube is removed or replaced.

i06046829

Crankcase Breather

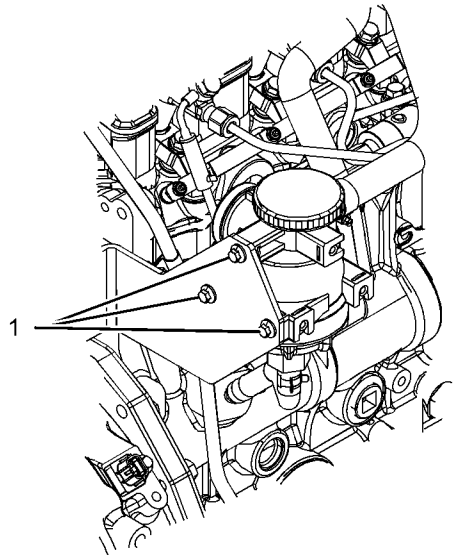

Illustration 55 g03788625

Typical example

(1) Tighten the setscrews to the following torque. . . . . 7.5 N·m ((66 lb in))

i09631084

Crankcase Breather

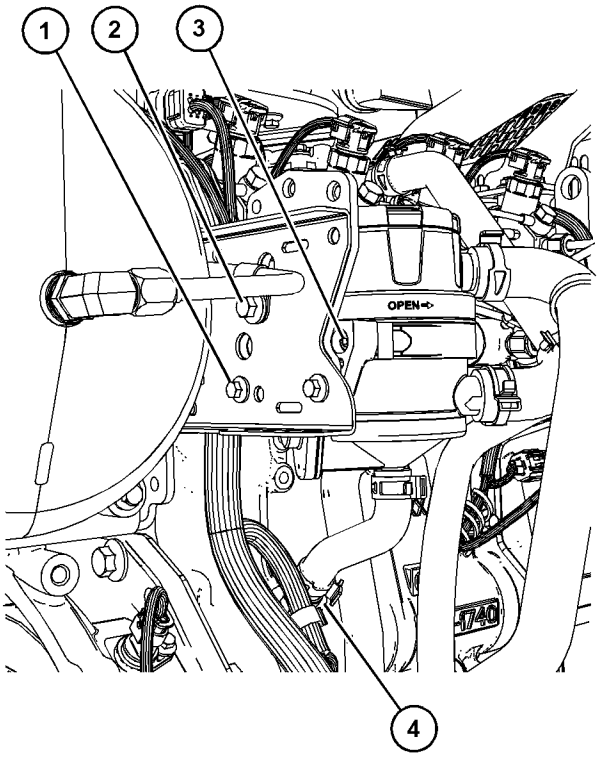

Illustration 56 g07521073

Typical example

(1) Tighten the bolts to the following torque. . 10 N·m ((89 lb in))

(2) Tighten the bolt to the following torque. . . 25 N·m ((221 lb in))

(3) Tighten the bolts to the following torque. . 10 N·m ((89 lb in))

(4) Tighten the one-way valve to the following torque. . . . . 14 N·m ((124 lb in))

i06539501

Water Temperature Regulator

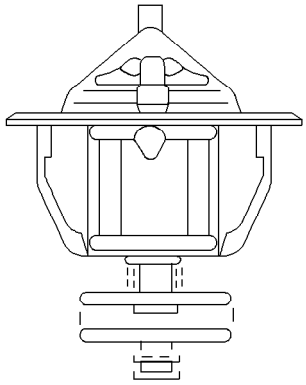

Illustration 57 g00877006
Typical example

Water temperature regulator

Opening temperature . . . . . 82° C ((180° F))
Maximum open length of 8 mm (0.31496 inch) is achieved at the following temperature. . . . . 95° C ((203° F))

Water Temperature Regulator Housing

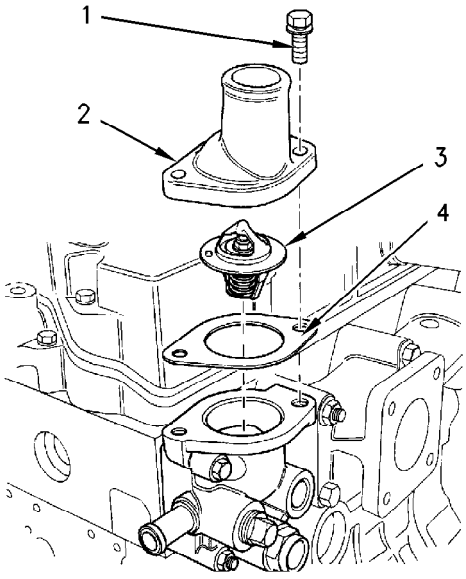

Illustration 58 g00820265
Typical example

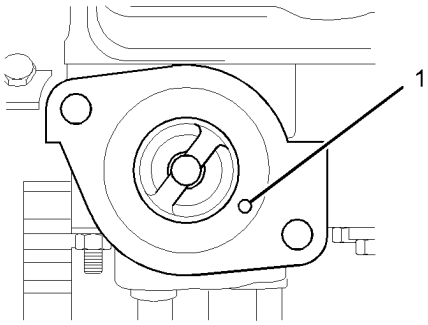

Illustration 59 g01114381
Typical example

Note: Ensure that the water temperature regulator is seated correctly in the housing.

Note: Ensure that the jiggle pin (1) on the water temperature regulator is correctly positioned. Refer to illustration 59 .

(1) Tighten the two setscrews for the water temperature regulator housing to the following torque. . . . . 14 N·m ((10 lb ft))

(2) Cover

(3) Water temperature regulator

(4) Gasket

i06104356

Cylinder Block

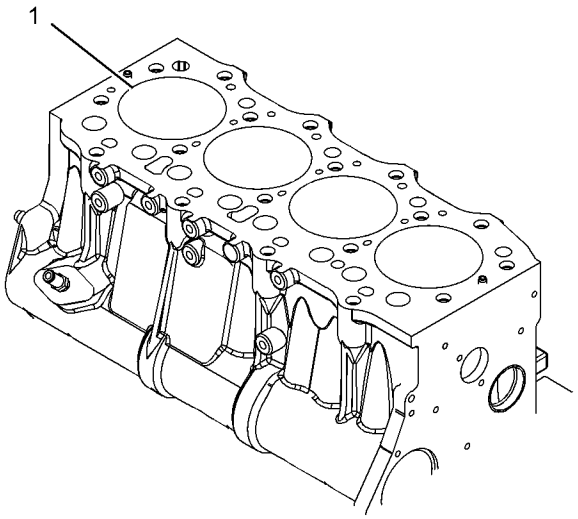

Illustration 60 g03811194
Typical example

(1) Diameter of the bore in the cylinder block
. . . . .84.000 to 84.019 mm ((3.3071 to 3.3078 inch))

Service limit . . . . . 84.200 mm ((3.3150 inch))

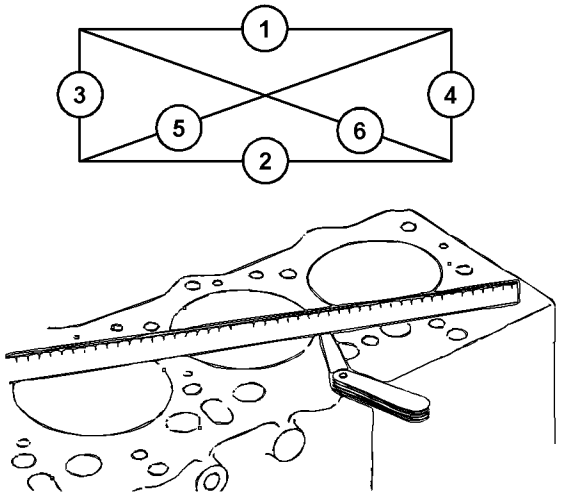

Illustration 61 g03811195
Typical example

Flatness of the top of the cylinder block . . . Less than 0.05 mm (0.002 inch)

Service limit . . . . . 0.12 mm ((0.005 inch))

Note: Use a straight edge and a feeler gauge to check the six positions for flatness.

Note: The front crankshaft bearing must be installed with the chamfer toward the cylinder block. Ensure that the oil hole in the front crankshaft bearing is aligned with the oil hole in the cylinder block.

i07915360

Crankshaft

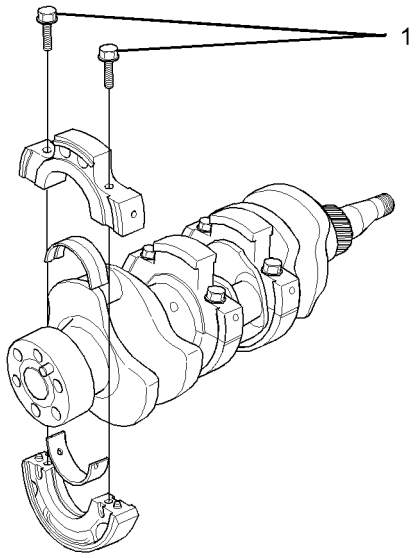

Illustration 62 g01113243
Typical example for a three cylinder engine

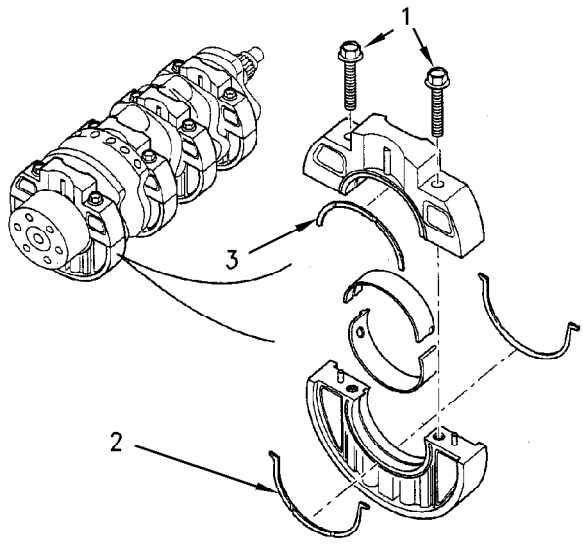

Illustration 63 g00904902
Typical example for a four cylinder engine

(1) Tighten the bolts of the holder for the main bearing to the following torque. . . . . 57 N·m ((42 lb ft))

(2) Thrust washers

Standard thickness . . . . . 2.95 mm to 3.00 mm ((0.1161 inch to 0.1181 inch))

Service limit . . . . . .2.80 mm ((0.1102 inch))

(3) Top thrust washer

Ensure that the oil grooves of all the thrust washers are toward the crankshaft.

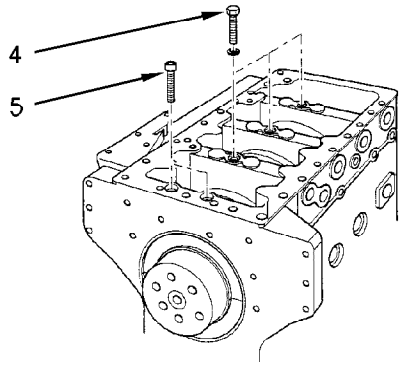

Illustration 64 g00904925
Typical example

(4) Tighten the retaining bolts for the crankshaft to the following torque. . . . . 57 N·m ((42 lb ft))

(5) Tighten the allen head screws to the following torque. . . . . 29 N·m ((257 lb in))

Crankshaft end play . . . . . 0.10 mm to 0.30 mm ((0.0040 inch to 0.0118 inch))

Service limit . . . . . 0.50 mm ((0.0197 inch))

Note: If the crankshaft end play exceeds the service limit, check the thrust washers for wear.

Maximum crankshaft run out . . . . . 0.03 mm ((0.00118 inch))

Service limit . . . . . 0.06 mm ((0.00236 inch))

Refer to Specifications, “Connecting Rod Bearing Journal” for information on the connecting rod bearing journals of the crankshaft.

Refer to Specifications, “Main Bearing Journal” for information on the main bearing journals of the crankshaft.

i06038109

Connecting Rod Bearing Journal

Table 4

Diameter of the Connecting Rod Bearing Journals		
Journals	**Diameter**	**Service limit**
Standard	51.964 to 51.975 mm (2.04582 to 2.04626 inch)	51.90 mm (2.0433 inch)
Undersize 0.25 mm (0.010 inch)	51.714 to 51.725 mm (2.03598 to 2.03641 inch)	51.65 mm (2.0335 inch)
Undersize 0.50 mm (0.020 inch)	51.464 to 51.475 mm (2.02614 to 2.02660 inch)	51.40 mm (2.0236 inch)(1)

(1) If the diameter of the connecting rod bearing journal is less than the maximum undersize service limit, the crankshaft must be replaced.

Clearance between the connecting rod bearing and the connecting rod bearing journal

Standard clearance . . . . . 0.035 to 0.085 mm ((0.00138 to 0.00335 inch))

Service limit . . . . . 0.20 mm ((0.0079 inch))

i06038111

Main Bearing Journal

Table 5

Diameter of Main Bearing Journals		
Journals	**Diameter**	**Service limit**
Standard	67.957 to 67.970 mm (2.67550 to 2.67597 inch)	67.90 mm (2.6732 inch)

Clearance between the main bearing and the main bearing journal

Standard clearance . . . . . 0.044 to 0.102 mm ((0.0017 to 0.0040 inch))

Service limit . . . . . 0.20 mm ((0.0079 inch))

i06038031

Connecting Rod

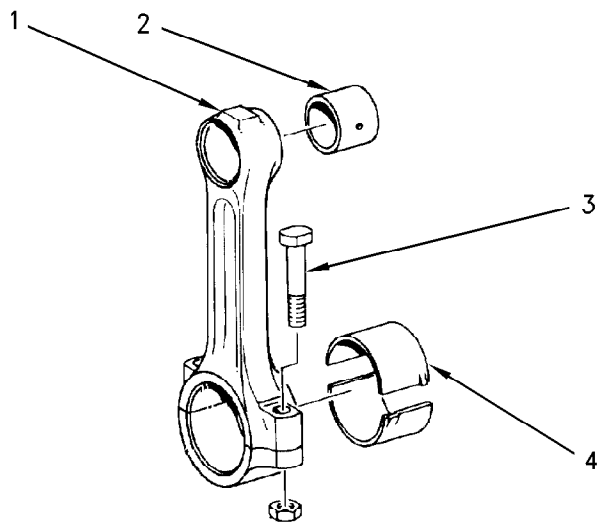

Illustration 65 g00693257

Typical example

(1) Connecting rod

(2) Piston pin bearing

Clearance between the piston pin and the piston pin bearing . . . . . 0.010 to 0.027 mm ((0.0004 to 0.0011 inch))

Service limit . . . . . 0.08 mm ((0.00315 inch))

(3) Tighten the nut and bolt to the following torque. . . . . 52 N·m ((38 lb ft))

(4) Connecting rod bearing

Clearance between the connecting rod bore and the connecting rod bearing . . . . 0.10 to 0.30 mm ((0.004 to 0.012 inch))

Service limit . . . . . 0.70 mm ((0.0276 inch))

Markings on the Connecting Rod

i07815287

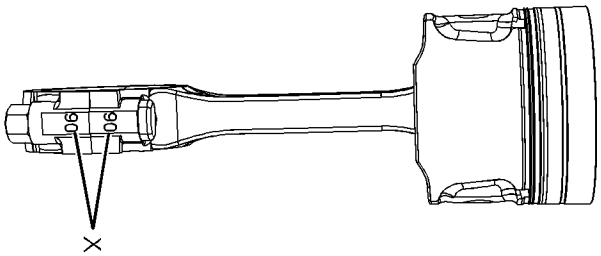

Illustration 66 g03811199
Typical example

The pistons and connecting rods are matched to each cylinder. Note the position of each connecting rod and piston for correct assembly.

Identification marks (X) on the connecting rod and on the connecting rod cap must be matched and aligned. When the connecting rod is installed correctly, the marks should face the right side of the engine.

Refer to Systems Operation, Testing and Adjusting, “Connecting Rod - Inspect” for the procedure to measure distortion and parallelism of the connecting rod.

Piston and Rings

Markings on the Piston

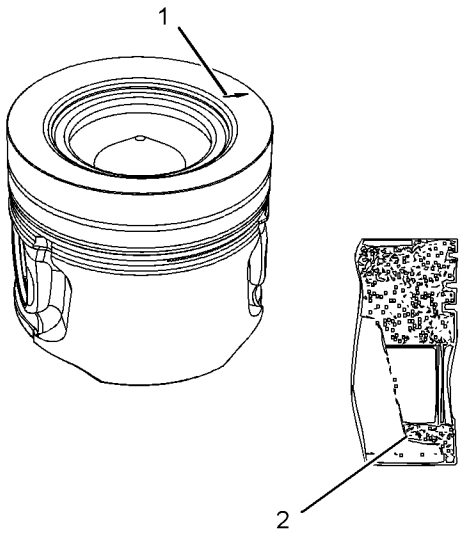

Illustration 67 g03811576
Typical example

(1) The arrow that is on the top of the piston must face the front of the engine.

(2) An identification mark is located inside the piston.

Piston and Piston Rings

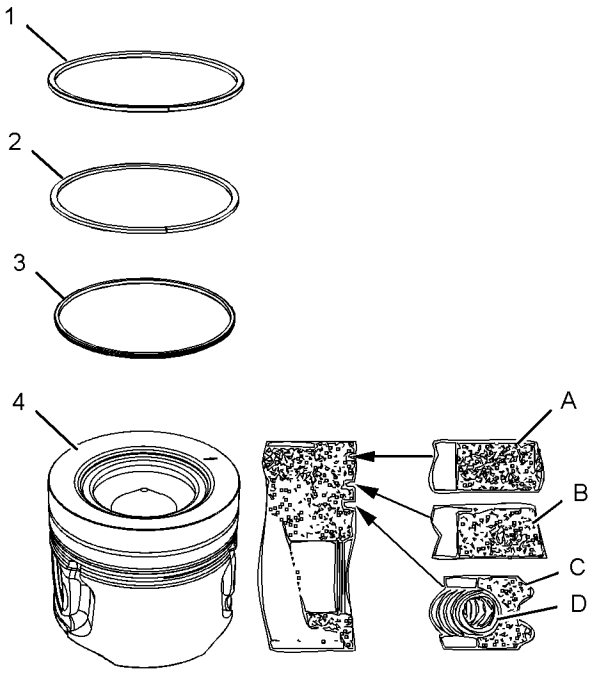

Illustration 68 g03811577
Typical example

Use a feeler gauge to measure the clearance between the piston ring groove and the piston ring. If the clearance is greater than the service limit, use a new piston ring and check the clearance.

If the clearance is within the service limit, renew the piston rings. If the clearance is outside of the service limit, renew the piston.

(1) Top piston ring

Shape of top ring (A) . . . . . Half keystone
Gap of top piston ring . . . . . 0.25 to 0.40 mm ((0.00984 to 0.01575 inch))
Service limit for gap of top piston ring . . . 1.0 mm ((0.039 inch))

Note: It is difficult to measure the wear of the top piston ring. When either the intermediate ring or the oil control ring is outside the service limit, renew all the rings.

Note: Install the letters “T” or “RN” toward the top of the piston. New top piston rings have a red identification mark. The identification mark must be on the left of the ring gap when the top piston ring is installed on an upright piston.

Note: New top piston rings have a yellow identification mark. The identification mark must be on the left of the ring gap when the top piston ring is installed on an upright piston.

Note: The top surface of the piston ring should be equally distant from the top face of the cylinder block at all points before the piston ring end gap is measured with a feeler gauge.

(2) Intermediate ring

Shape of intermediate ring (B) . . . . . Taper

Clearance between piston ring groove and intermediate ring . . . . . 0.04 to 0.08 mm ((0.0016 to 0.0032 inch))

Service limit for clearance of intermediate ring . . . . . 0.25 mm ((0.0098 inch))

Gap of the intermediate ring . . . . . 0.5 to 0.7 mm ((0.020 to 0.023 inch))

Service limit for gap of intermediate ring . . . . . .1.0 mm ((0.039 inch))

Note: Install the word “Top” toward the top of the piston. New intermediate rings have a green identification mark. The identification mark must be on the left of the ring gap when the intermediate ring is installed on an upright piston.

Note: The top surface of the piston ring should be equally distant from the top face of the cylinder block at all points before the piston ring end gap is measured with a feeler gauge.

(3) Oil control ring

Clearance between piston ring groove and oil control ring . . . . . 0.02 to 0.06 mm ((0.0008 to 0.0024 inch))

Service limit for clearance of oil control ring . . . . . 0.25 mm ((0.0098 inch))

Gap of oil control ring . . . . . 0.1 to 0.4 mm ((0.00394 to 0.01575 inch))

Service limit for gap of oil control ring . . . 1.2 mm ((0.047 inch))

The oil control ring has two components. The two components of the oil control ring are installed in the following order.

1. Spring (D).

2. Oil control ring (C).

Note: A latch pin is used to hold both ends of the spring of the oil control ring in position. The ends of the spring of the oil control ring must be 180 degrees opposite the end gap of the oil control ring.

Note: The top surface of the piston ring should be equally distant from the top face of the cylinder block at all points before the piston ring end gap is measured with a feeler gauge.

(4) Piston

Diameter of the piston skirt
. . 83.943 to 83.958 mm ((3.3048 to 3.3054 inch))

Service limit . . . . . 83.7 mm ((3.295 inch))

Clearance of the piston skirt to the cylinder wall
. . . . . 0.0425 to 0.0615 mm ((0.00167 to 0.00242 inch))

Service limit . . . . . 0.25 mm ((0.010 inch))

Diameter of the piston pin
. . 27.994 to 28.000 mm ((1.1021 to 1.1024 inch))

Service limit . . . . . 27.97 mm ((1.10118 inch))

Clearance between the hole for the piston pin and the piston pin . . . . . −0.001 to +0.011 mm ((−0.0004 to +0.0004 inch))

Service limit . . . . . 0.02 mm ((0.0008 inch))

Refer to Specifications, “Cylinder Head” for the piston height for a given cylinder head gasket thickness.

i08093115

Balancer

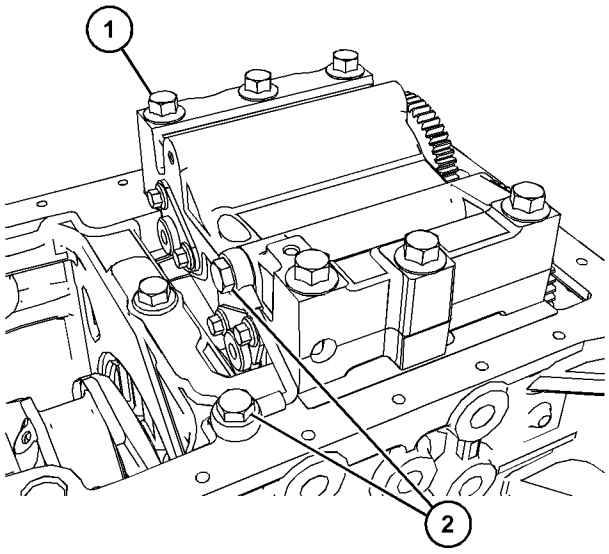

Illustration 69 g06540662
Typical example

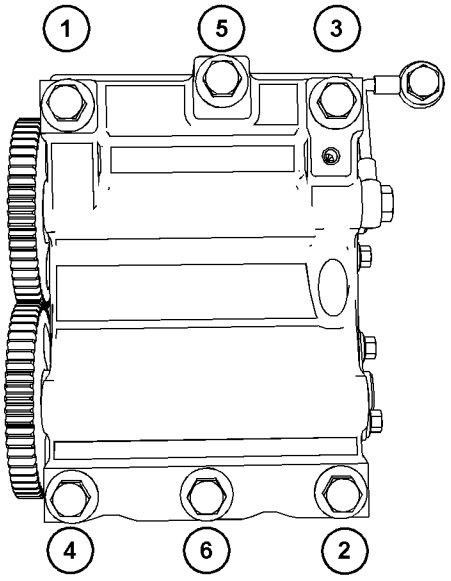

Illustration 70 g06540670
Tightening sequence

(1) Tighten the setscrews that retain the balancer to the cylinder block in the sequence shown in illustration 70 to the following torque. . . . . 52 N·m ((38 lb ft))

(2) Tighten the banjo bolts to the following torque. . . . . 14 N·m ((124 lb in))

The backlash between the crankshaft gear and the balancer gear . . . . . 0.254 to 0.369 mm ((0.01000 to 0.01453 inch))

Note: The balancer has shims to reduce the backlash on the balancer gear.

i06050884

Housing (Front)

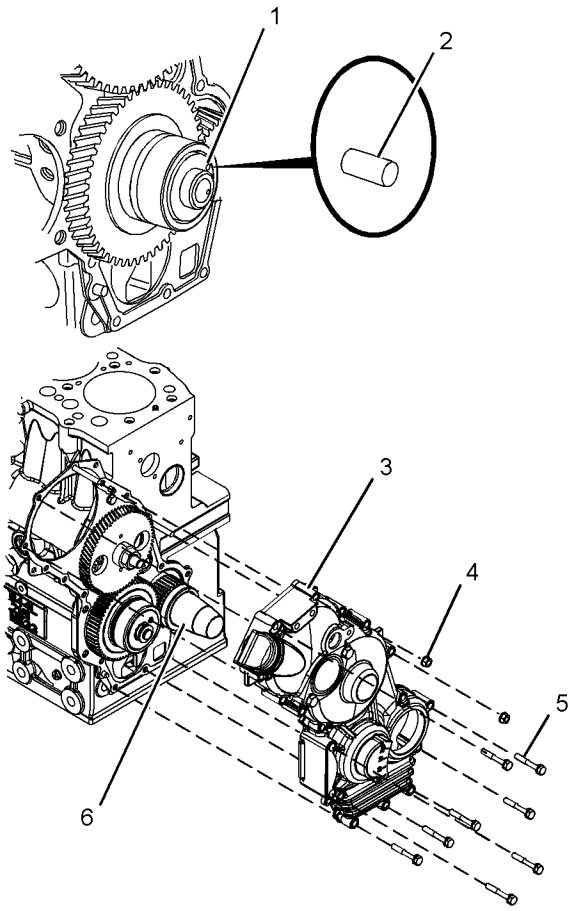

Illustration 71 g03791080

Typical example

(1) Locator hole

(2) Locator pin

(3) Front housing

(4) (5) Tighten the nuts and setscrews to the following torque. . . . . 10 N·m ((7 lb ft))

Note: Note the positions of the setscrews when the bolts are removed. The setscrews have different lengths.

(6) Seal protector

i06050885

Gear Group (Front)

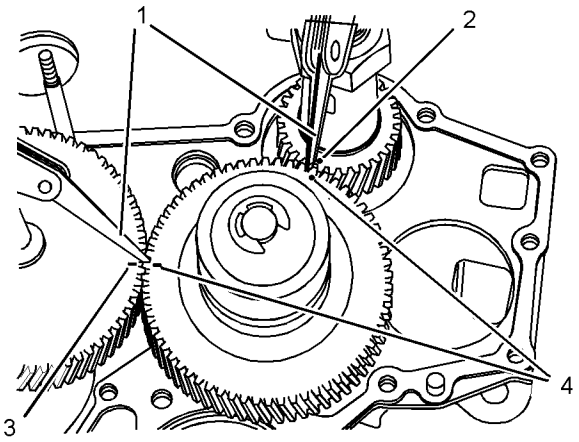

Illustration 72 g03791821

Typical example

(1) Feeler gauge

(2) Timing mark on the crankshaft gear

(3) Timing mark on the camshaft gear

(4) Timing mark on the idler gear

Minimum backlash for all gears . . . . . 0.08 mm ((0.003 inch))

Maximum backlash for all gears . . . . . 0.25 mm ((0.010 inch))

Note: If the backlash is greater than the maximum backlash, replace the camshaft gear, the idler gear, and the crankshaft gear.

When the idler gear is installed on the shaft of the oil pump, align a timing mark on idler gear (4) with the timing mark on crankshaft gear (2). Also, align the other timing mark on idler gear (4) with the timing mark on camshaft gear (3).

i06105060

Flywheel

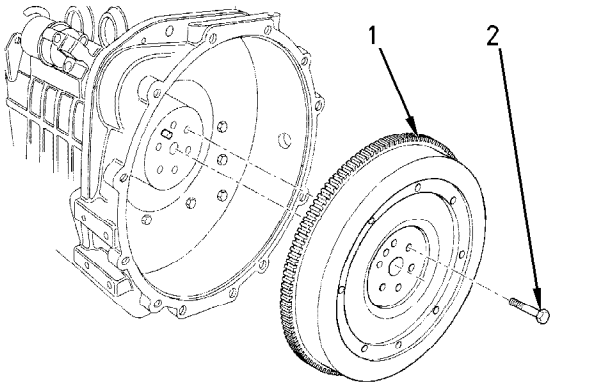

Illustration 73 g00820355

Typical example

(1) Heat the flywheel ring gear to the following temperature. . . . 120 ° to 150 ° C ((248 ° to 302 ° F))

Note: If excessive wear is not present, remove the ring gear and install the ring gear at 90 degrees from the original position. Heat the ring gear evenly.

(2) Tighten the flywheel bolts to the following torque. . . . . 76 N·m ((56 lb ft))

Maximum flywheel runout . . . 0.20 mm ((0.008 inch))

i05164369

Flywheel Housing

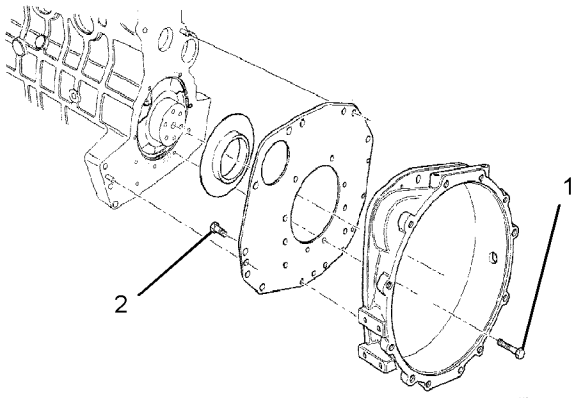

Illustration 74 g01442020

Typical example

(1) Tighten the setscrews for the back plate to the following torque. . . . . 25 N·m ((19 lb ft))

(2) Tighten the setscrews for the flywheel housing to the following torque. . . . . 25 N·m ((19 lb ft))

i08477367

Belt Tension Chart

i09646416

Crankshaft Pulley

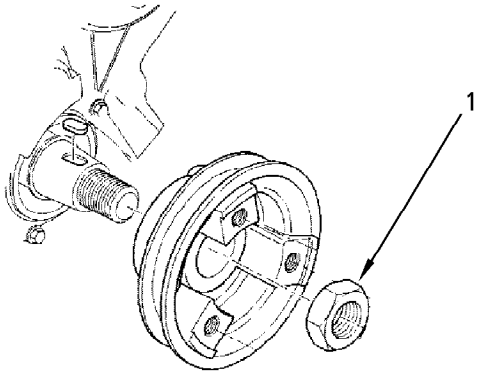

Illustration 75 g00904688

Typical example

(1) Torque for the crankshaft pulley nut

403J-E17T engine . . . . . 50 N·m ((37 lb ft))
Tighten the nut an extra amount. . . . 120 degrees

404J-E22T, and 404J-E22TA engines . . . 50 N·m ((37 lb ft))
Tighten the nut an extra amount. . . . 130 degrees

Table 6

Alternator Belt Tension and Frequency					
Engine Model	**Approximate Span (mm)**	**New belt**		**Used Belt**	
		Frequency (Hz)	**Tension (Nm) and (lb)**	**Frequency (Hz)**	**Tension (Nm) and (lb)**
402-05	188 mm	190-200 Hz	350 to 405 N (79 to 91 lb)	160-170 Hz	267 to 356 N (60 to 80 lb)
403-07	169 mm - 188 mm	190-200 Hz	350 to 405 N (79 to 91 lb)	160-170 Hz	267 to 356 N (60 to 80 lb)
403-11	167 mm - 205 mm	190-200 Hz	400 N (90 lb)	160-170 Hz	300 N (67 lb)
403-11 Turbocharged	167 mm - 205 mm	222-229 Hz	425 to 456 N (96 to 103 lb)	205-214 Hz	364 to 395 N (82 to 89 lb)

(continued)

(Table 6, contd)

Alternator Belt Tension and Frequency					
Engine Model	**Approximate Span (mm)**	**New belt**		**Used Belt**	
		Frequency (Hz)	**Tension (Nm) and (lb)**	**Frequency (Hz)**	**Tension (Nm) and (lb)**
403-15	220 mm - 232 mm	150-170 Hz	400 to 489 N (90 to 110 lb)	130-145 Hz	267 to 356 N (60 to 80 lb)
403-17	215 mm - 225 mm	150-170 Hz	400 to 489 N (90 to 110 lb)	130-145 Hz	267 to 356 N (60 to 80 lb)
404-15	236 mm - 247 mm	190-200 Hz	400 to 489 N (90 to 110 lb)	160-170 Hz	267 to 356 N (60 to 80 lb)
404-22	236 mm - 247 mm	130-150 Hz	400 to 489 N (90 to 110 lb)	110 -130 Hz	267 to 356 N (60 to 80 lb)

Note: The Used Belt Tension refers to a belt that has been in operation for 30 minutes or more at the rated speed.

i02590411

Fan Drive

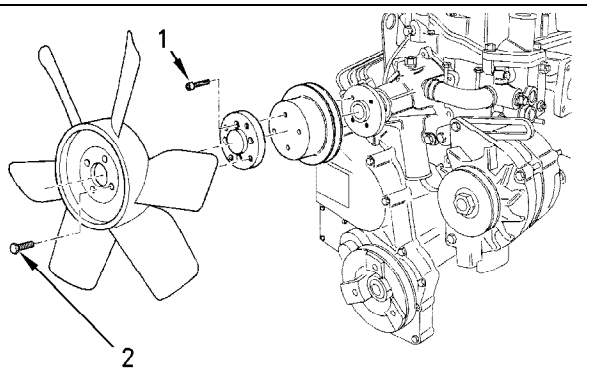

Illustration 76 g00904732

(1) Tighten the allen head screws for the adapter to the following torque. . . . . 11 N·m ((8 lb ft))

(2) Tighten the setscrews for the fan to the following torque. . . . . 11 N·m ((8 lb ft))

i06539513

Engine Lifting Bracket

All engines are equipped with two engine lifting brackets.

Tighten the bolt on each engine lifting bracket to the following torque. . . . . 50 N·m ((37 lb ft))

Note: Ensure that Loctite 243 is applied to the threads of the bolts.

i09631043

Engine Support (Front)

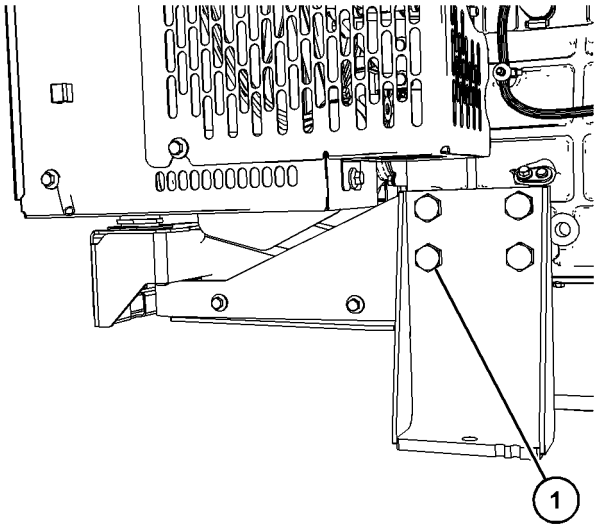

Illustration 77 g07521000

Typical example

(1) Tighten the bolts to the following torque.
. . . . . 118 N·m ((87 lb ft))

i09631064

Engine Support (Rear)
(Four Cylinder Engines)

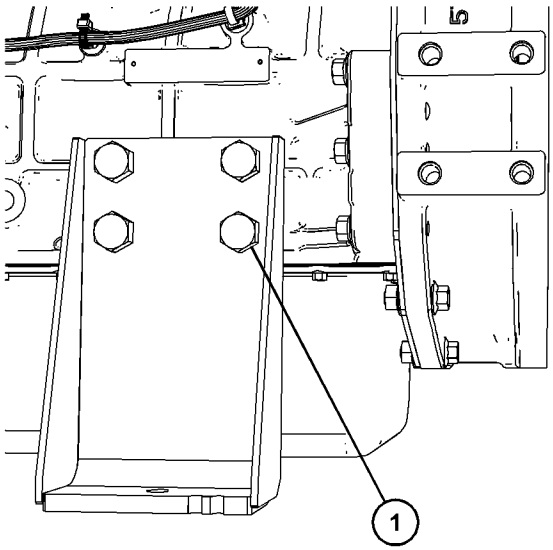

Illustration 78 g07521017

Typical example

(1) Tighten the bolts to the following torque.
. . . . . 118 N·m ((87 lb ft))

i09631073

Engine Support (Rear)
(Three Cylinder Engines)

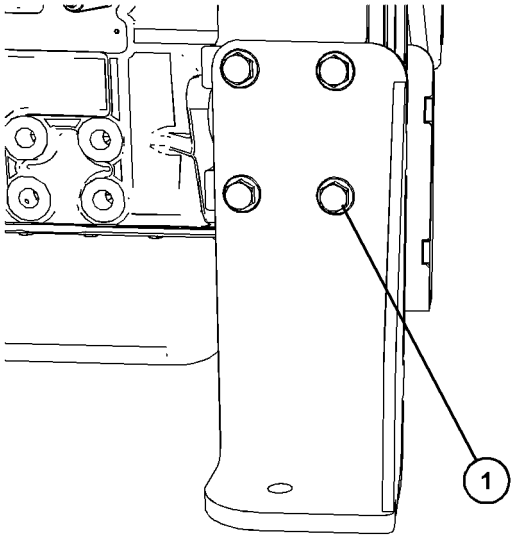

Illustration 79 g07521027

Typical example

(1) Tighten the bolts to the following torque. . 47 N·m ((35 lb ft))

i09647622

Alternator and Regulator

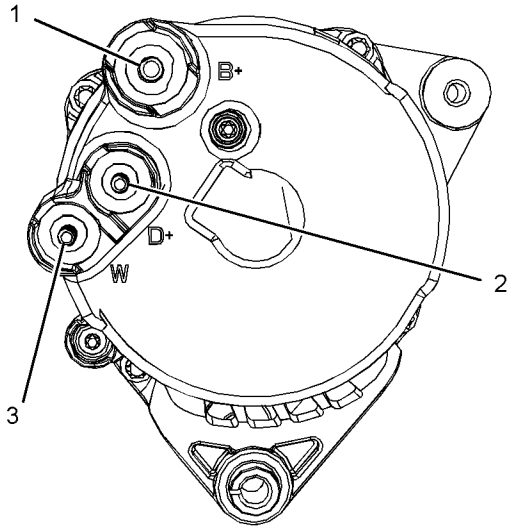

Illustration 80 g03799869

Typical example

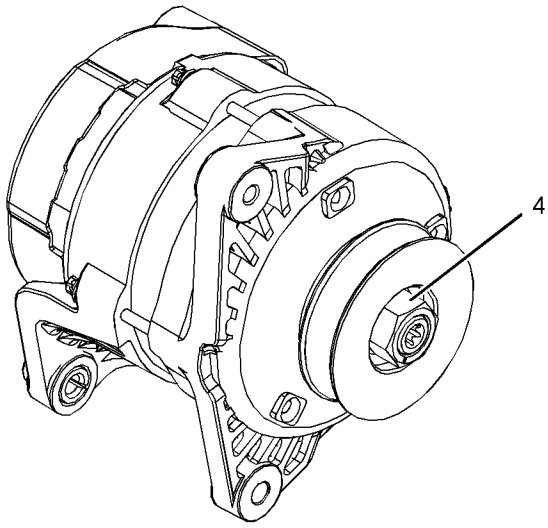

Illustration 81 g03799870

Typical example

(1) Tighten terminal nut “B+” to the following torque. . . . . 9 N·m ((80 lb in))

(2) Tighten terminal nut “D+” to the following torque. . . . . 3.7 N·m ((33 lb in))

(3) Tighten terminal nut “W” to the following torque. . . . . 3.7 N·m ((33 lb in))

(4) Tighten the pulley nut to the following torque. . . . . 95 N·m ((70 lb ft))

The rotation of the alternator is clockwise when the alternator is viewed from the pulley.

The regulator of the alternator is sealed. The regulator is a nonserviceable part.

Polarity . . . . . Negative ground to the case

Rotation . . . . . Either direction

Output voltage . . . . . 14 V

Rated voltage . . . . . 12 V

Rated current output . . . . . 60 or 85 A

i09647627

Electric Starting Motor

Starting Motor

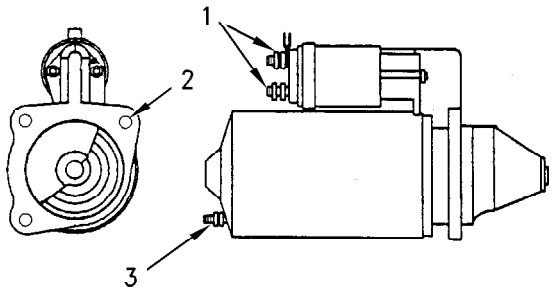

Illustration 82 g00379835

A typical example of a starting motor and starting motor solenoid

No load conditions at 25°C (77°F)

- Rpm with no load . . . . . 3500 rpm
- Maximum current . . . . . 450 A
- Current draw with no load . . . . . 130 A
- Voltage . . . . . 11.5 V
- Rated voltage . . . . . 12 V

Power rating . . . . . 2 kW

Minimum average cranking rpm 130

Starting motor solenoid

- Pull-in current . . . . . 37 A
- Hold-in current . . . . . 9 A

(1) Tighten the battery terminal nut to the following torque.. . . . . 13.5 N·m ((119 lb in))

(2) Tighten the two mounting bolts to the following torque.. . . . . 50 N·m ((37 lb ft))

(3) Tighten the nut for the switch terminal to the following maximum torque. . . . . 6 N·m ((53 lb in))

Maximum resistance of the starter cable at 20°C (68°F) and at 12 V . . . . . 0.0017 ohms

i07812712

Coolant Temperature Sensor

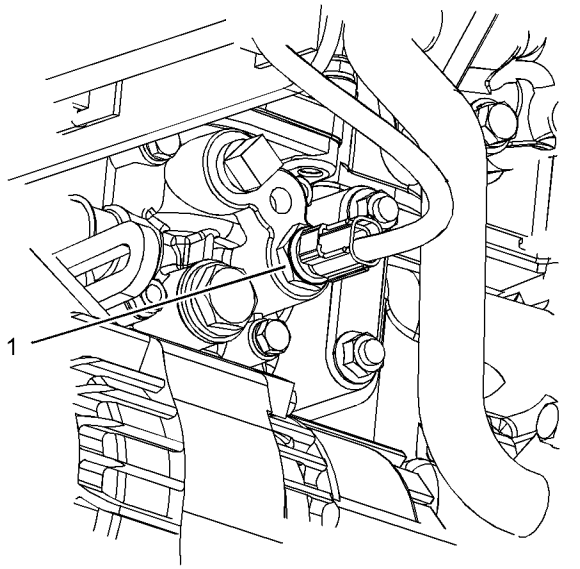

Illustration 83 g03325662

Typical example

(1) Tighten the coolant temperature sensor to the following torque. . . . . 20 N·m ((177 lb in))

i07812759

Engine Oil Pressure Switch

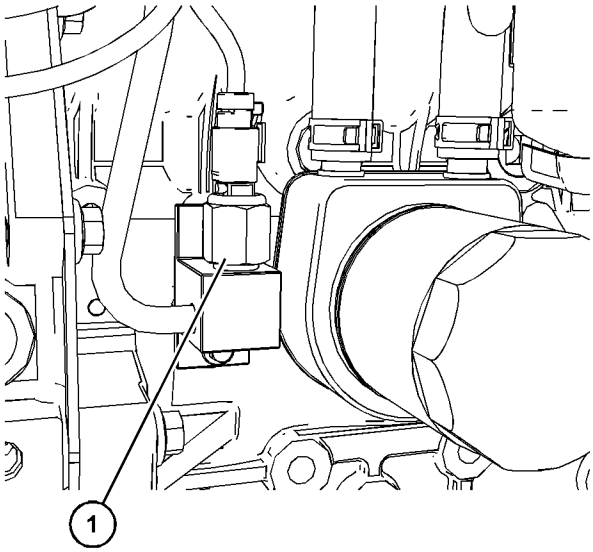

Illustration 84 g06441820

Typical example

(1) Engine oil pressure switch

Tighten the engine oil pressure switch to the following torque. . . . . 20 N·m ((177 lb in))
Pressure rating . . . . . 72.4 kPa ((10.5 psi))

i02576790

Inlet Air Temperature Sensor

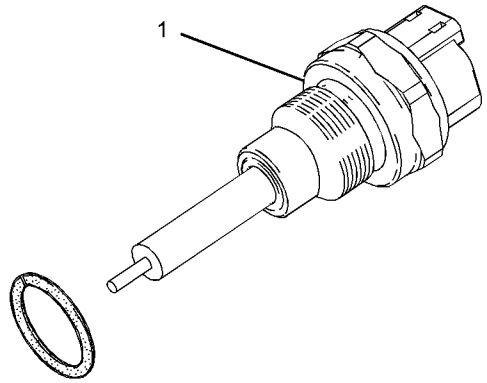

Illustration 85 g01291117

Typical example

(1) Sensor assembly

Torque for sensor . . . . . 20 N·m ((15 lb ft))

i07814158

Inlet Manifold Temperature Sensor

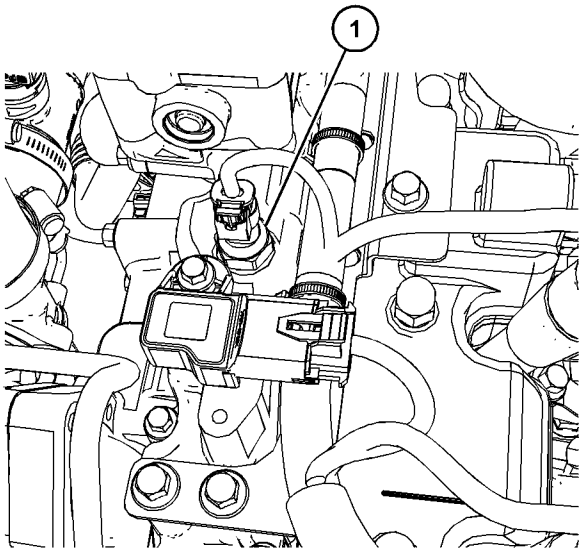

Illustration 86 g06442240

Typical example

(1) Tighten the sensor to the following torque. . . . . 17 N·m ((150 lb in))

i07814136

Inlet Manifold Temperature and Pressure Sensor

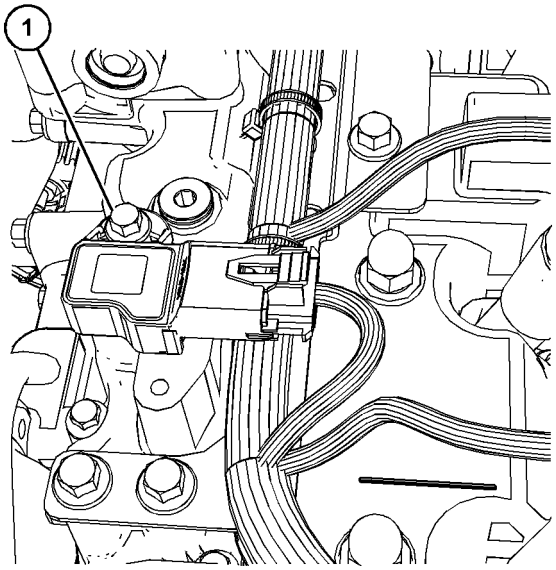

Illustration 87 g06442228
Typical example

(1) Tighten the bolt for the inlet manifold air pressure and temperature sensor to the following torque. . . . . 8 N·m ((71 lb in))

i07812814

Temperature Sensor (DPF Inlet)

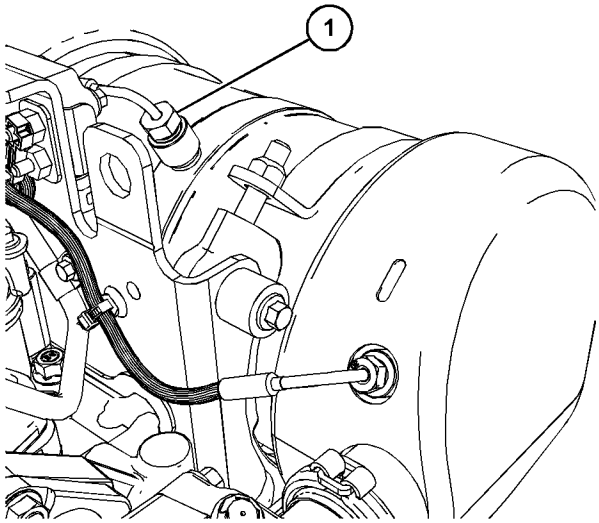

Illustration 88 g06441901
Typical example

(1) Tighten the temperature sensor to the following torque.. . . . . 45 N·m ((33 lb ft))

i08360575

Temperature Sensor (DOC Inlet)

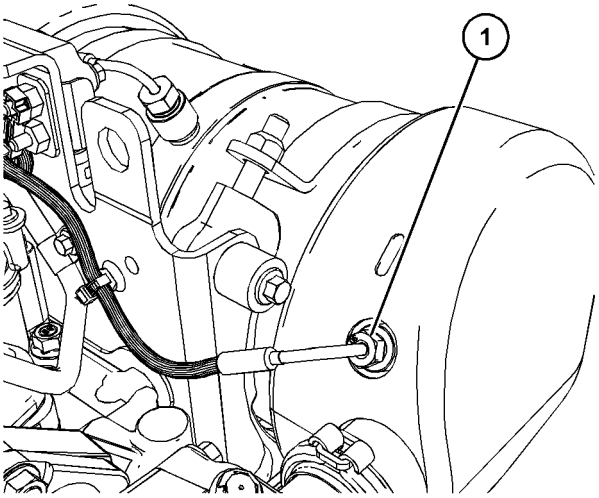

Illustration 89 g06441891

Typical example

(1) Tighten the temperature sensor to the following torque.. . . . . 33 N·m ((292 lb in))

i07812695

Speed/Timing Sensor

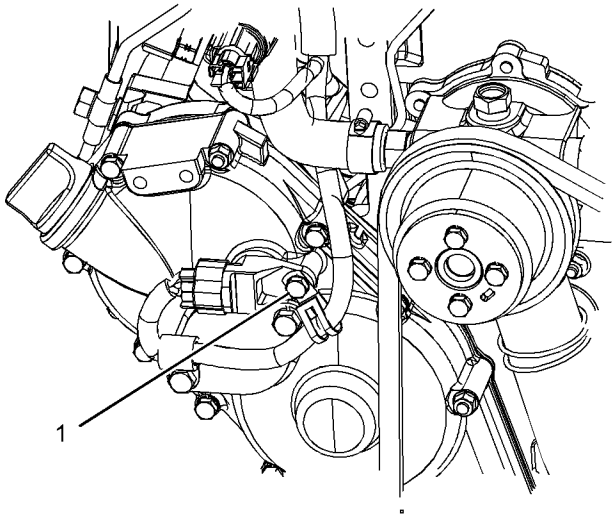

Illustration 90 g03788559

Typical example

(1) Tighten the bolt for the sensor to the following torque.. . . . . 14 N·m ((124 lb in))

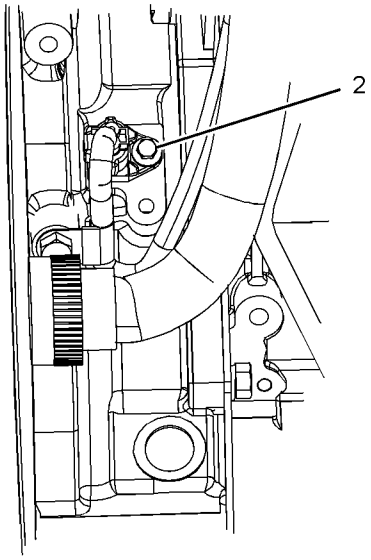

Illustration 91 g03788560

Typical example

(2) Tighten the bolt for the sensor to the following torque.. . . . . 12 N·m ((106 lb in))

i06792654

Glow Plugs

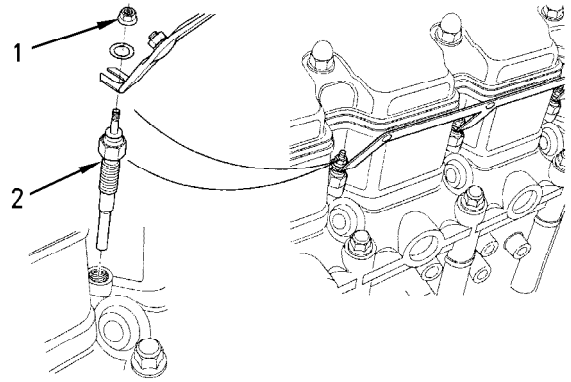

Illustration 92 g00904843
Typical example

(1) Tighten the nut on the bus bar to the following torque.. . . . . 1.2 N·m ((11 lb in))

(2) Tighten the glow plugs to the following torque. . . . . 23 N·m ((204 lb in))

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