

Specifications

400 Engine

HB11-Up (Machine)
HD11-Up (Machine)
HH11-Up (Machine)
HL11-Up (Machine)
HN11-Up (Machine)
HP11-Up (Machine)
HR11-Up (Machine)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. If a tool, procedure, work method or operating technique that is not specifically recommended by Perkins is used, you must satisfy yourself that it is safe for you and for others. You should also ensure that the product will not be damaged or be made unsafe by the operation, lubrication, maintenance or repair procedures that you choose.

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



When replacement parts are required for this product Perkins recommends using Perkins replacement parts or parts with equivalent specifications including, but not limited to, physical dimensions, type, strength and material.

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

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Specifications Section

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Engine Design

402C-05 Engine

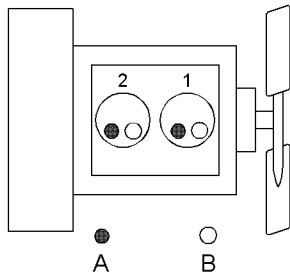


Illustration 1 g01111232

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore 67 mm (2.64 inch)
Stroke 72 mm (2.83 inch)
Displacement 0.507 L (30.94 in³)
Cylinder arrangement In-line
Type of combustion Indirect injection
Compression ratio 23.5:1
Number of cylinders 2
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

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.

403C-07 Engine

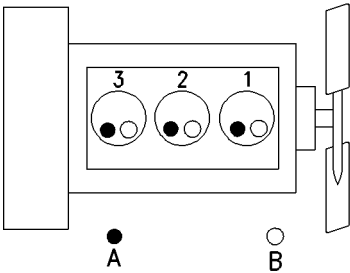


Illustration 2 g00852304

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore 67 mm (2.64 inch)
Stroke 72 mm (2.83 inch)
Displacement 0.762 L (46.5 in³)
Cylinder arrangement In-line
Type of combustion Indirect injection
Compression ratio 23.5:1
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.

403C-11 Engine

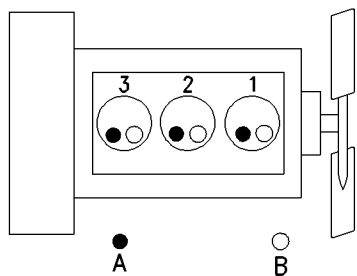


Illustration 3
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

Bore	77 mm (3.0 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.131 L (69 in ³)
Cylinder arrangement	In-line
Type of combustion	Indirect injection
Compression ratio	23:1
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.

403C-15 Engine

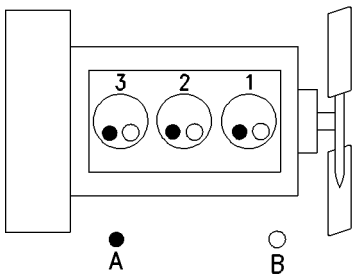


Illustration 4
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

Bore	84 mm (3.3 inch)
Stroke	90 mm (3.5 inch)
Displacement	1.496 L (91 in ³)
Cylinder arrangement	In-line
Type of combustion	Indirect injection
Compression ratio	22.5:1
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.

404C-15 Engine

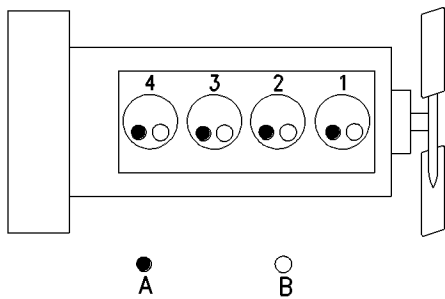


Illustration 5 g00296424

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore 77 mm (3.03 inch)
Stroke 81 mm (3.19 inch)
Displacement 1.508 L (92 in³)
Cylinder arrangement In-line
Type of combustion Indirect injection
Compression ratio 23.5:1
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.

404C-22/404C-22T Engine

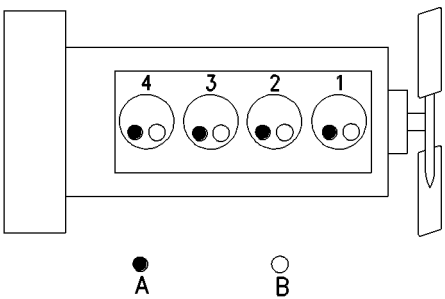


Illustration 6 g00296424

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 in³)
Cylinder arrangement In-line
Type of combustion Indirect injection
Compression ratio 23.3:1
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.

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Fuel Injection Lines

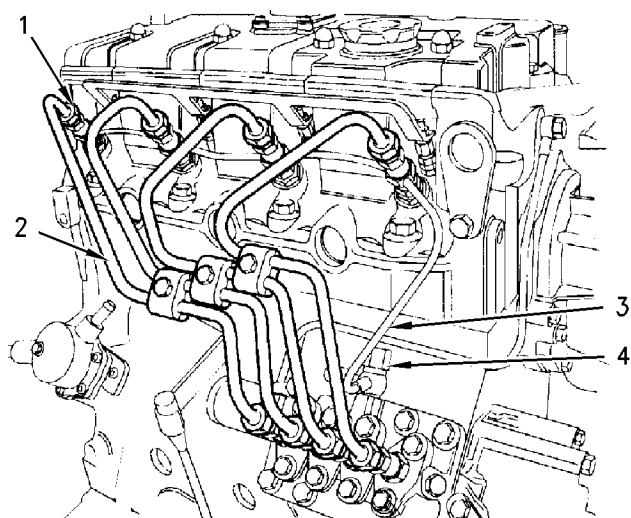


Illustration 7

g00818680

- (1) Tighten the union nuts for the fuel injector to the following torque.
 402C-05, 403C-07 and 404C-15 20 N·m
 (14.75 lb ft)
 403C-11, 403C-15, 404C-22 and
 404C-22T 23 N·m (17 lb ft)
- (2) High pressure fuel supply line
- (3) Low pressure fuel return line
- (4) Tighten the banjo bolt to the following torque. 2.5 N·m (22 lb in)

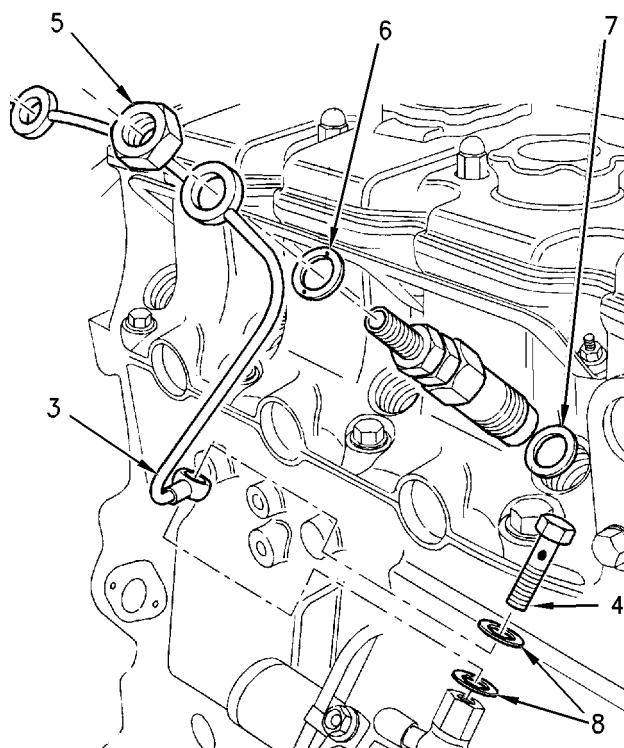


Illustration 8

g00818888

- (5) Tighten the nut to the following torque. 27 N·m
 (20 lb ft)
- (6) Washers for the fuel return line
- (7) Washer for the fuel injector
- (8) Washers for the banjo bolt

Note: All washers must be replaced when the fuel lines are removed.

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Fuel Injection Pump

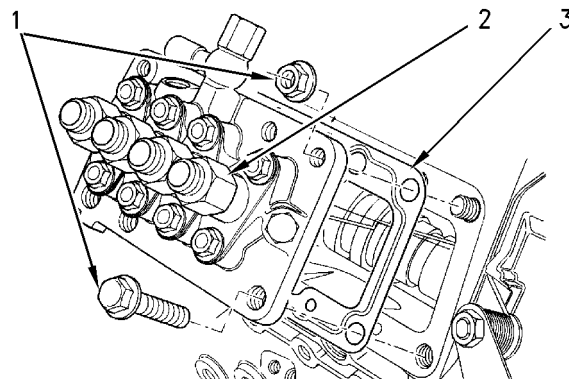


Illustration 9

g00899711

Type of fuel injection pump In-line cassette

i02144747

Direction of rotation of the camshaft for the fuel injection pump Clockwise from the drive end

- (1) Tighten the mounting nuts and setscrews to the following torque.
402C-05, 403C-07, 403C-11 and 404C-15 6 N·m (4.4 lb ft)
403C-15, 404C-22 and 404C-22T 15 N·m (11 lb ft)
- (2) Tighten the delivery valve holders to the following torque. 42 N·m (31 lb ft)
- (3) Shim

The shim adjusts the timing of the fuel injection pump. A thicker shim retards the timing. A thinner shim advances the timing. The timing changes one degree for each 0.10 mm (0.004 inch) difference in the thickness of the shim. More than one shim can be used. If the fuel injection pump is reinstalled, a new shim, which is the same thickness as the original shim, must be installed.

If any of the following new components are installed, a new shim which has a thickness of 0.5 mm (0.020 inch) must be used until the timing of the fuel injection is correctly adjusted.

- Camshaft
- Cylinder block

The following thicknesses of shims are available:

- 0.10 mm (0.004 inch)
- 0.20 mm (0.008 inch)
- 0.30 mm (0.012 inch)
- 0.40 mm (0.016 inch)
- 0.50 mm (0.020 inch)

Fuel Injectors

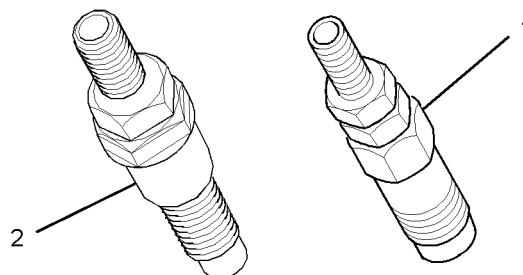


Illustration 10

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- (1) Tighten the fuel injectors to the following torque.
403C-11, 403C-15, 404C-22 and 404C-22T 64 N·m (47.2 lb ft)
- (2) Tighten the fuel injectors to the following torque.
402C-05, 403C-07 and 404C-15 64 N·m (47.2 lb ft)

Note: Remove the original seat washer from the hole for the fuel injector. Do not reuse the original seat washer.

Note: Apply a 2 mm (0.0787 inch) bead of 1861117 POWERPART Sealant to the first 6 mm (0.2362 inch) of the thread to the fuel injector.

The fuel injector (1) will open at the following pressure. 14707 kPa (2133 psi)

The fuel injector (2) will open at the following pressure. 11769 kPa (1707 psi)

Leakage in 10 seconds 0 drops

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i02145684

Fuel Priming Pump

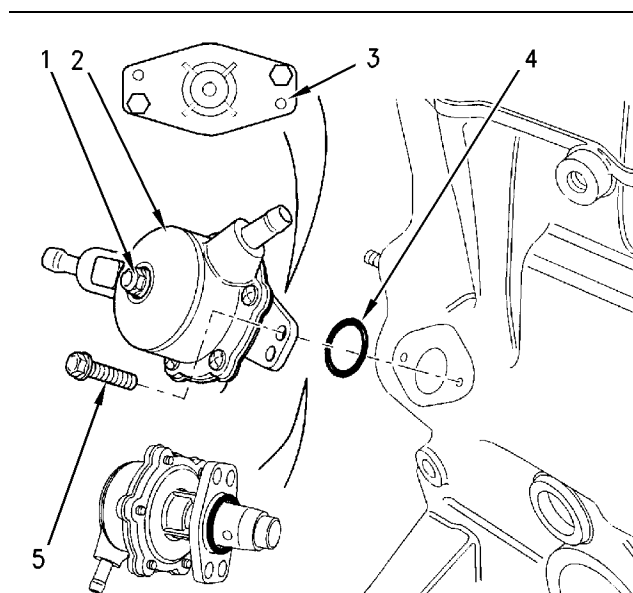


Illustration 11

g00819278

(1) Tighten the adjustment screw for the fuel priming pump to the following torque. ... 2.5 N·m (22 lb in)

(2) Fuel priming pump

(3) Flange for the fuel priming pump

Note: The fuel inlet for the fuel priming can be rotated 360 degrees. The fuel inlet is adjustable in 15 degree increments.

Note: The flange of the fuel priming pump has two sets of locating holes. This allows the fuel priming pump to be mounted in four positions for the outlet connection.

(4) O-ring

(5) Tighten the mounting bolts to the following torque. 6 N·m (53 lb in)

Lifter Group

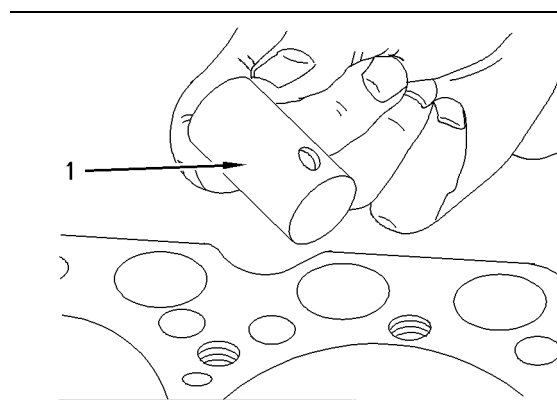


Illustration 12

g00692979

Clearance between the lifter and the bore in the engine for the lifter

Standard maximum clearance

404C-22 and 403C-15 ... 0.058 mm (0.0023 inch)

402C-05, 403C-07 and 403C-11 0.053 mm
(0.0021 inch)

Repair limit for all engines 0.080 mm
(0.0031 inch)

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Rocker Shaft

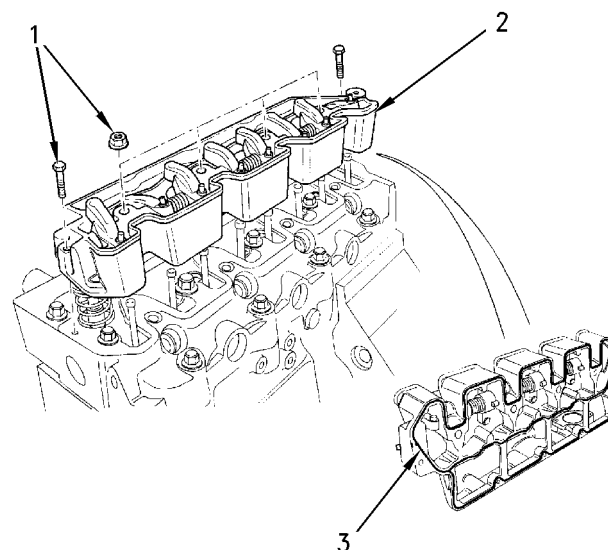


Illustration 13

g00819372

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

- (1) Tighten the nuts and setscrews for the housing of the rocker shaft to the following torque.

402C-05 and 403C-07	9.5 N·m (7.0 lb ft)
403C-11 and 404C-15	23 N·m (17 lb ft)
403C-15, 404C-22, and 404C-22T	33 N·m (24 lb ft)

- (2) Housing for the rocker shaft assembly

- (3) Seal

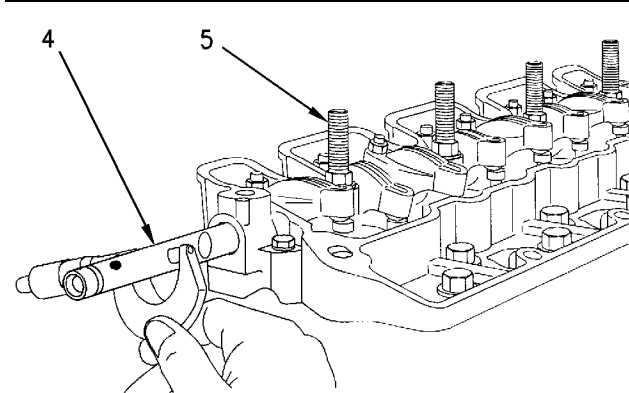


Illustration 14

g00819413

- (4) Rocker shaft

402C-05 and 403C-07	
Diameter of the rocker shaft ...	9.95 to 9.968 mm (0.3917 to 0.3924 inch)
Service limit	9.87 mm (0.3886 inch)
403C-11, 403C-15 and 404C-15	
Diameter of the rocker shaft ..	11.65 to 11.67 mm (0.4587 to 0.4595 inch)
Service limit	11.57 mm (0.4555 inch)
404C-22 and 404C-22T	
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)

- (5) Stud

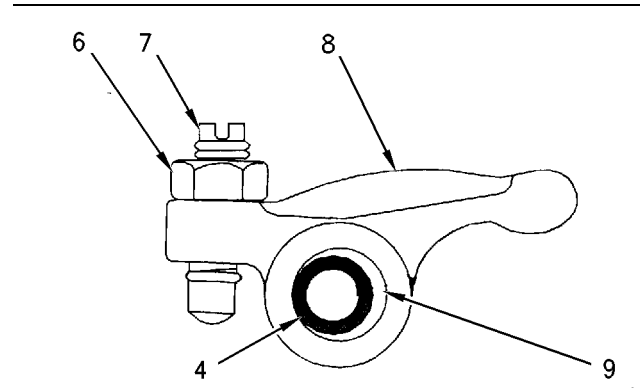


Illustration 15

g00819419

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

- (7) Adjustment screw for the rocker arm

- (8) Rocker arm

- (9) Rocker arm clearance on the rocker shaft

402C-05 and 403C-07

Minimum permissible
clearance 0.032 to 0.065 mm
(0.00126 to 0.00260 inch)

403C-11, 403C-15 and 404C-15

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

404C-22 and 404C-22T

Minimum permissible
clearance 0.030 to 0.093 mm
(0.00120 to 0.00366 inch)

Maximum permissible clearance (All
models) 0.2 mm (0.008 inch)

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i02138491

Valve Mechanism Cover

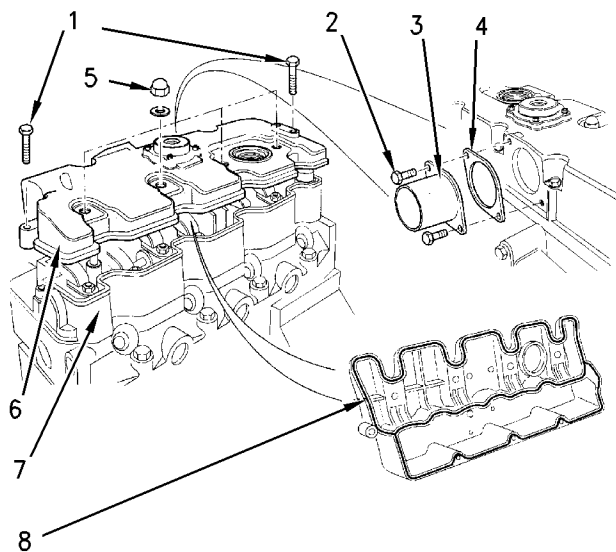


Illustration 16

g00819350

- (1) Tighten the setscrews for the valve mechanism cover to the following torque.

402C-05, 403C-07, 403C-11 and 404C-15	11 N·m (8 lb ft)
403C-15, 404C-22 and 404C-22T	14 N·m (10 lb ft)
- (2) Tighten the setscrews for the connector for the inlet manifold to the following torque.

402C-05, 403C-07, 403C-11 and 404C-15	11 N·m (8 lb ft)
403C-15, 404C-22 and 404C-22T	14 N·m (10 lb ft)
- (3) Connector for the inlet manifold
- (4) Gasket
- (5) Tighten the cap nuts for the valve mechanism cover to the following torque.

402C-05 and 403C-07	10 N·m (7.3 lb ft)
403C-11 and 404C-15	11 N·m (8 lb ft)
403C-15, 404C-22 and 404C-22T	14 N·m (10 lb ft)
- (6) Valve mechanism cover
- (7) Housing for the rocker shaft assembly
- (8) Seal

Cylinder Head Valves

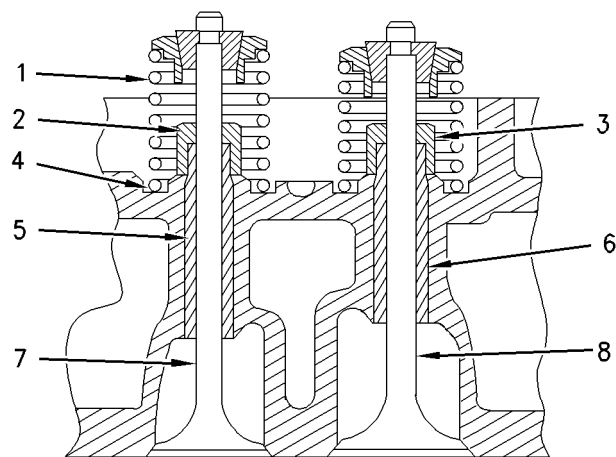


Illustration 17

g00903737

- (1) Valve spring

Standard free length	35.0 mm (1.378 inch)
Service limit	33.5 mm (1.319 inch)
Standard test force	79 N (17.8 lb)
Service limit	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
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- (4) Valve spring recess for the valve spring

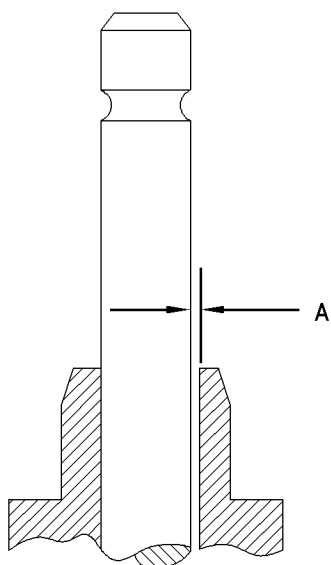


Illustration 18

g00903744

(5) Exhaust valve guide

(A) Clearance between the exhaust valve and the valve guide

402C-05, 403C-07, 403C-11 and
404C-15 0.045 to 0.072 mm
(0.0020 to 0.0030 inch)

403C-15, 404C-22 and 404C-
22T .. 0.050 to 0.075 mm (0.0020 to 0.0030 inch)

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

(6) Inlet valve guide

(A) Clearance between the inlet valve and the valve guide

402C-05, 403C-07, 403C-11 and
404C-15 0.025 to 0.052 mm
(0.0010 to 0.0020 inch)

403C-15, 404C-22 and 404C-
22T .. 0.030 to 0.060 mm (0.0012 to 0.0024 inch)

Service limit (All models) 0.2 mm (0.008 inch)

(7) Exhaust valve stem

Diameter of the exhaust valve
stem 6.940 to 6.950 mm
(0.27323 to 0.27362 inch)

Service limit 6.84 mm (0.269 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)

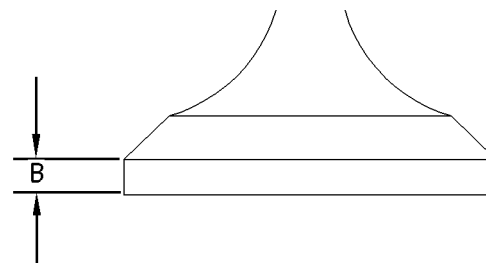


Illustration 19

g00845823

(B) Thickness of the valve head .. 0.925 to 1.075 mm
(0.03642 to 0.04232 inch)

Service limit 0.5 mm (0.020 inch)

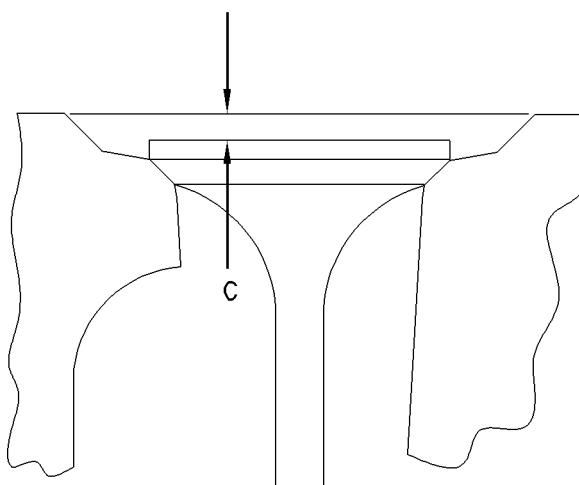


Illustration 20

g00903773

(C) Valve depth below the cylinder head face

Exhaust valve for 402C-05, 403C-07, 403C-11
and 404C-15 0.85 to 1.15 mm
(0.0335 to 0.0453 inch)

Inlet valve for 402C-05, 403C-07, 403C-11 and
404C-15 0.65 to 0.95 mm
(0.0256 to 0.0374 inch)

Inlet and exhaust valves for 403C-
15 0.85 to 1.15 mm (0.0335 to 0.0453 inch)

Inlet and exhaust valves for 404C-22 and 404C-22T 0.65 to 0.95 mm
(0.0256 to 0.0374 inch)

Service limit (All models) 1.8 mm (0.071 inch)

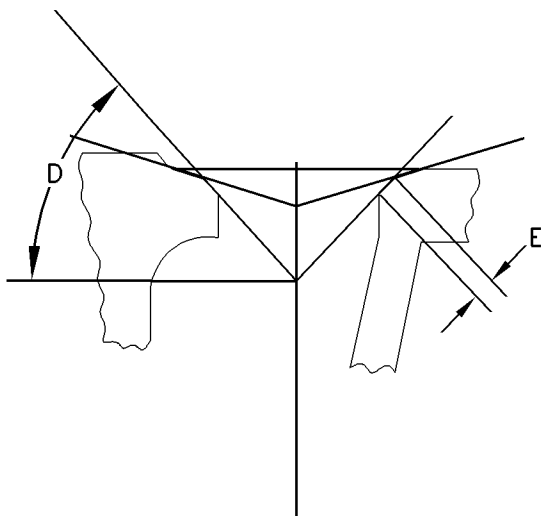


Illustration 21

g00903760

(D) Valve seat angle 45 degrees

(E) Contact face

Exhaust valve

402C-05, 403C-07, 403C-11 and 404C-15 1.70 to 2.10 mm
(0.0670 to 0.0830 inch)

403C-15 1.66 to 1.73 mm
(0.0653 to 0.0681 inch)

404C-22 and 404C-22T 1.94 to 2.16 mm
(0.0764 to 0.0850 inch)

Service limit (All models) 2.5 mm (0.098 inch)

Inlet valve

402C-05, 403C-07, 403C-11 and 404C-15 1.70 to 2.10 mm
(0.0670 to 0.0830 inch)

403C-15 1.66 to 1.87 mm
(0.0653 to 0.0736 inch)

404C-22 and 404C-22T 1.50 to 2.00 mm
(0.0591 to 0.0790 inch)

Service limit (All models) 2.5 mm (0.098 inch)

Cylinder Head

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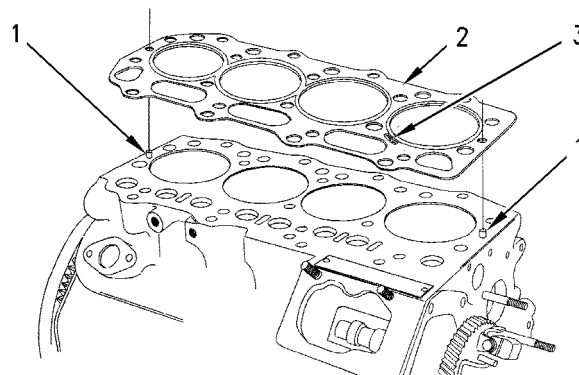


Illustration 22

g00819698

(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 402C-05, 403C-07, 403C-11 and 404C-15 Engines	
Piston Height above Top Face of Cylinder Block	Gasket Thickness
0.55 to 0.64 mm (0.0217 to 0.0252 inch)	1.2 mm (0.047 inch)
0.65 to 0.75 mm (0.0256 to 0.0295 inch)	1.3 mm (0.051 inch)

Table 2

Selection of Head Gasket for the 403C-15 Engine	
Piston Height above Top Face of Cylinder Block	Gasket Thickness
0.60 to 0.69 mm (0.0236 to 0.0272 inch)	1.3 mm (0.051 inch)
0.70 to 0.79 mm (0.0276 to 0.0311 inch)	1.4 mm (0.055 inch)

Table 3

Selection of Head Gasket for the 404C-22 Engine	
Piston Height below Top Face of Cylinder Block	Gasket Thickness
-0.45 to -0.30 mm (-0.0177 to -0.0118 inch)	0.4 mm (0.016 inch)
-0.29 to -0.20 mm (-0.0114 to -0.0079 inch)	0.5 mm (0.020 inch)

Table 4

Selection of Head Gasket for the 404C-22T Engine	
Piston Height below Top Face of Cylinder Block	Gasket Thickness
-0.29 to -0.20 mm (-0.0114 to -0.0079 inch)	0.5 mm (0.020 inch)

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

Tightening Procedure for the Cylinder Head

402C-05 Engine

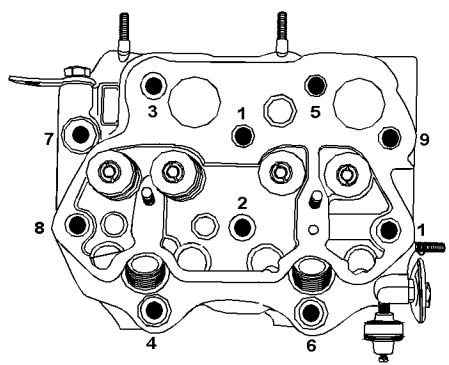


Illustration 23 g01112400

Use the following procedure in order 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 23.

Torque for bolts

402C-05 36.5 N·m (26.9 lb ft)

2. Repeat the procedure in Step 1 to ensure that all of the bolts are tightened to the correct torque.

403C-07, 403C-11 and 403C-15 Engines

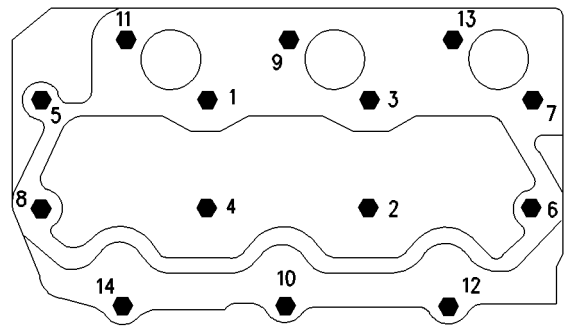


Illustration 24 g00900073

Use the following procedure in order 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 24.

Torque for bolts

403C-11 51 N·m (37.6 lb ft)

403C-15 101 N·m (74.5 lb ft)

2. Repeat the procedure in Step 1 to ensure that all of the bolts are tightened to the correct torque.

404C-22 and 404C-22T Engine

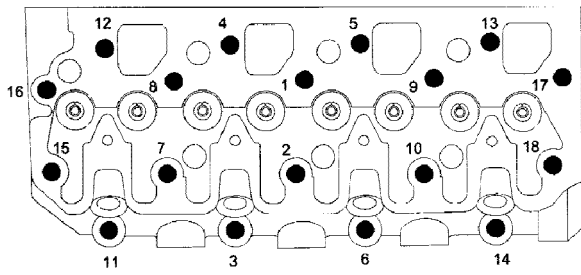


Illustration 25 g00900074

Use the following procedure in order 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 25.

Torque for bolts 101 N·m (74.5 lb ft)

2. Repeat the procedure in Step 1 to ensure that all of the bolts are tightened to the correct torque.

Measuring the Distortion of the Cylinder Head

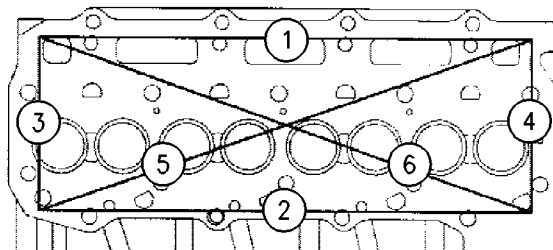


Illustration 26

g00900977

Typical example

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

Maximum service limit 0.12 mm (0.005 inch)

Maximum limit for regrinding the cylinder
head 0.15 mm (0.006 inch)

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

Refer to 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.

Turbocharger

i02138984

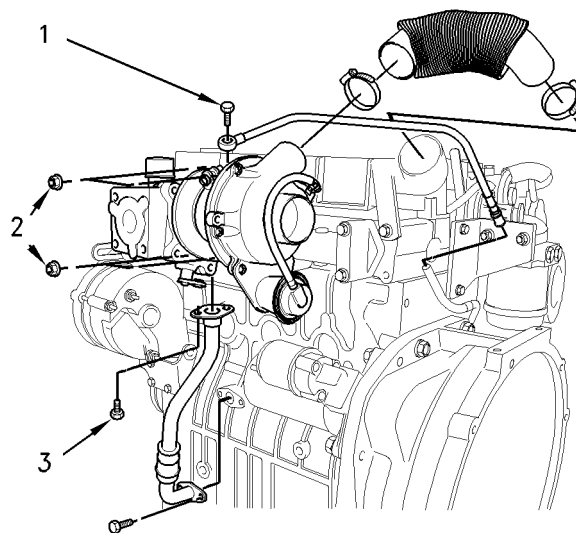


Illustration 27

g00921767

- (1) Tighten the banjo bolt for the oil supply line to the following torque. 18 N·m (13.3 lb ft)
- (2) Tighten the nuts that secure the turbocharger to the exhaust manifold to the following torque. 25 N·m (18 lb ft)
- (3) Tighten the setscrews for the oil drain tube to the following torque. 10 N·m (7 lb ft)

i02139001

Exhaust Manifold

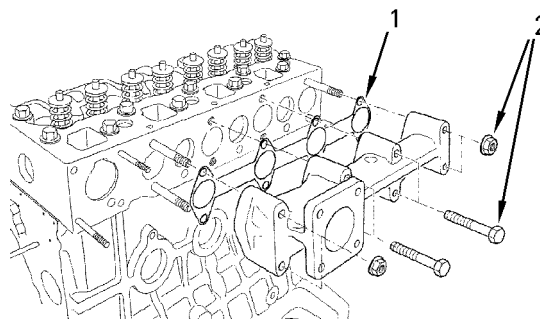


Illustration 28

g00899933

- (1) Gasket

- (2) Tighten the nuts and setscrews for the exhaust manifold to the following torque.

402C-05, 403C-07, 403C-11 and 404C-15	9.8 N·m (7.2 lb ft)
403C-15, 404C-22 and 404C-22T	25 N·m (18.4 lb ft)
404C-22T exhaust elbow	32.4 N·m (23.9 lb ft)

404C-22 and 404C-22T 41.940 to 42.060 mm
(1.6512 to 1.6559 inch)

Service limit

402C-05, 403C-07, 403C-11 and 404C-15	39.8 mm (1.5669 inch)
403C-15, 404C-22 and 404C-22T	41.8 mm (1.6450 inch)

- (3) Height of the camshaft lobe for the fuel priming pump

402C-05, 403C-07, 403C-11 and
404C-15 27.900 to 28.000 mm
(1.0984 to 1.1024 inch)

403C-15 31.900 to 32.000 mm
(1.2559 to 1.2598 inch)

404C-22 and 404C-22T 31.900 to 32.000 mm
(1.2559 to 1.2598 inch)

Service limit

402C-05, 403C-07, 403C-11 and 404C-15	27.0 mm (1.0630 inch)
403C-15, 404C-22 and 404C-22T	30.0 mm (1.1810 inch)

Camshaft

i02139017

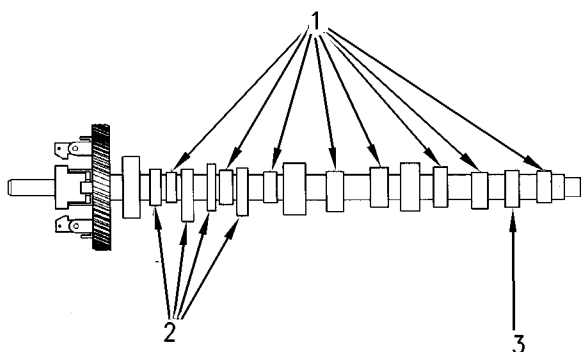


Illustration 29

g00819857

- (1) Height of the camshaft lobe for the inlet and exhaust valves

402C-05, 403C-07, 403C-11 and
404C-15 26.955 to 27.010 mm
(1.0612 to 1.0634 inch)

403C-15 34.453 to 34.507 mm
(1.3564 to 1.3585 inch)

404C-22 and 404C-22T 34.453 to 34.507 mm
(1.3564 to 1.3585 inch)

Service limit

402C-05, 403C-07, 403C-11 and
404C-15 26.5 mm (1.0430 inch)

403C-15, 404C-22 and 404C-22T 33.7 mm
(1.3270 inch)

- (2) Height of the camshaft lobe for the fuel injection pump

402C-05, 403C-07, 403C-11 and
404C-15 39.900 to 40.100 mm
(1.5709 to 1.5787 inch)

403C-15 41.940 to 42.060 mm
(1.6512 to 1.6559 inch)

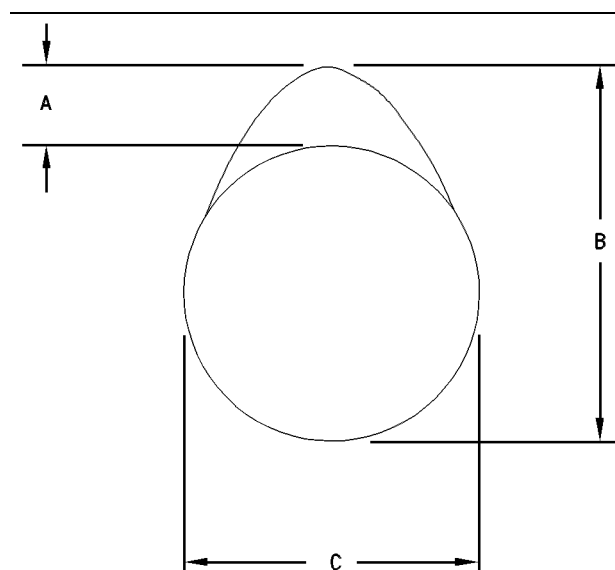


Illustration 30

g00295323

(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.

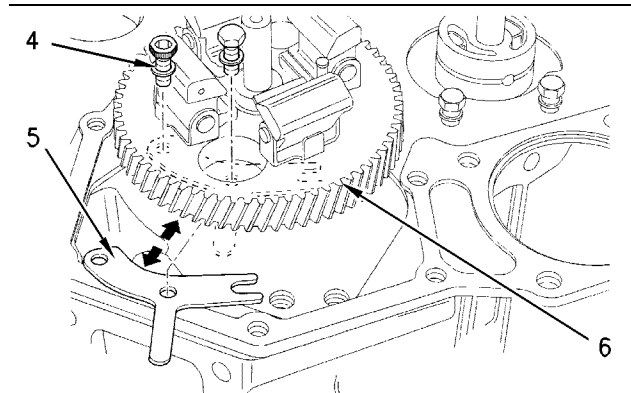


Illustration 31

g00819901

- (4) Tighten the setscrews for the retainer plate for the camshaft to the following torque. 11 N·m
(8.0 lb ft)
- (5) Retainer plate for the camshaft
- (6) Camshaft gear

i02139045

Engine Oil Lines

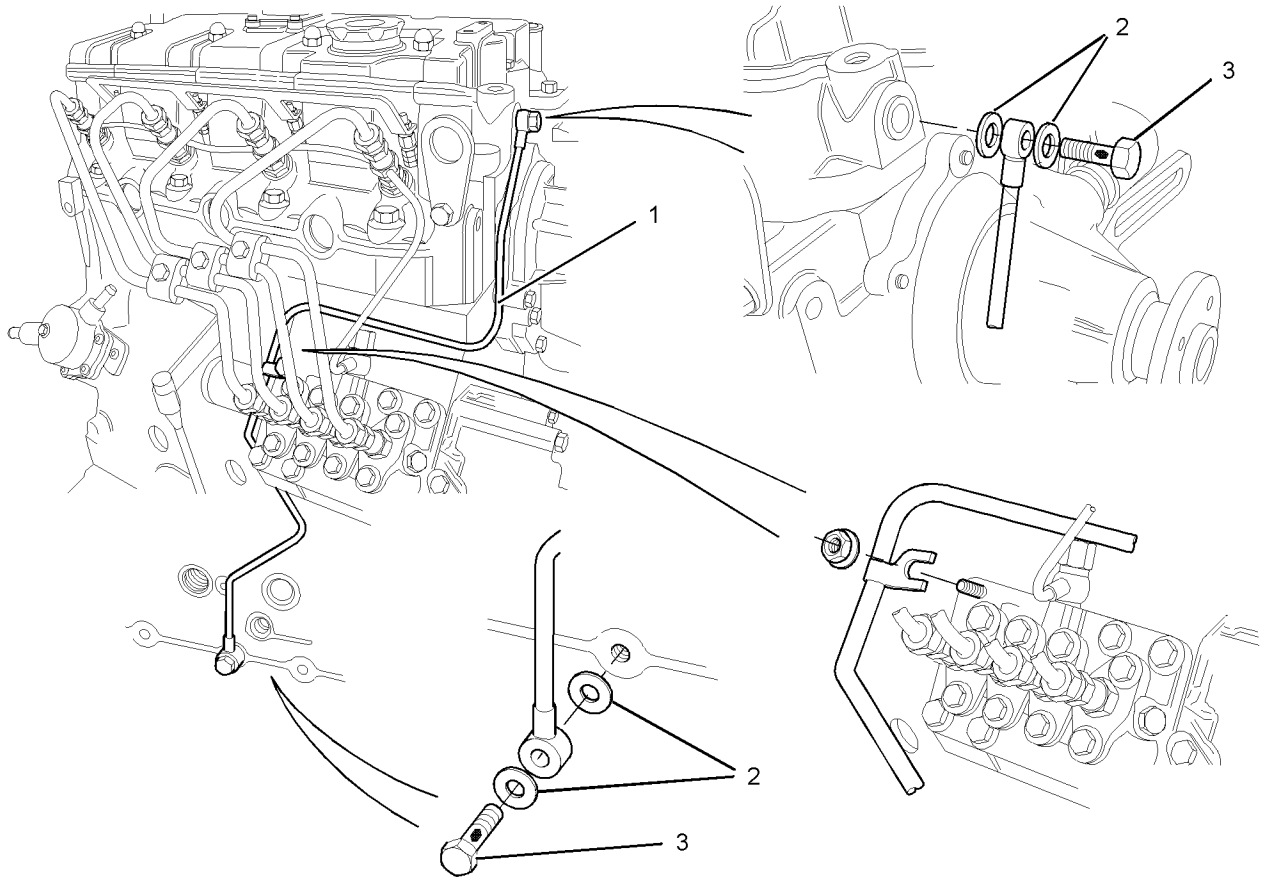


Illustration 32

g01093847

(1) Engine oil line

(2) Washers

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

(3) Tighten the banjo bolts to the following torque. 12 N·m (9 lb ft)

i02139768

Engine Oil Relief Valve

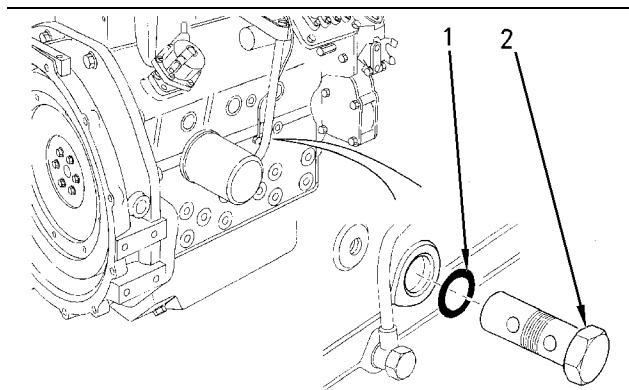


Illustration 33

g00820218

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

- (1) 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. 64 N·m (47 lb ft)

The engine oil pressure at the engine oil relief valve is the following value.

403C-11 and 404C-15 304 to 500 kPa
(44 to 73 psi)

403C-15 262 to 359 kPa (38 to 52 psi)

402C-05, 403C-07, 404C-22 and
404C-22T 352 to 448 kPa (51 to 65 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.

i02139769

Engine Oil Pump

NOTICE

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

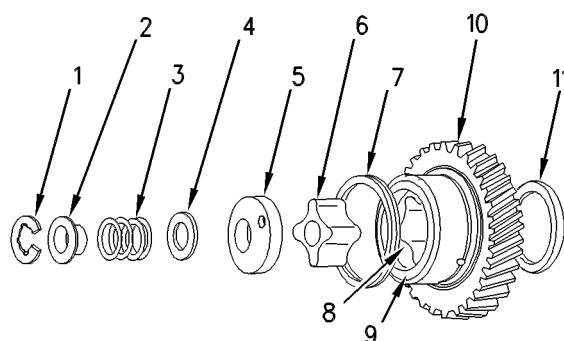


Illustration 34

g00458938

Idle gear and components of the engine oil pump

Type Gerotor pump

(1) Circlip

(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

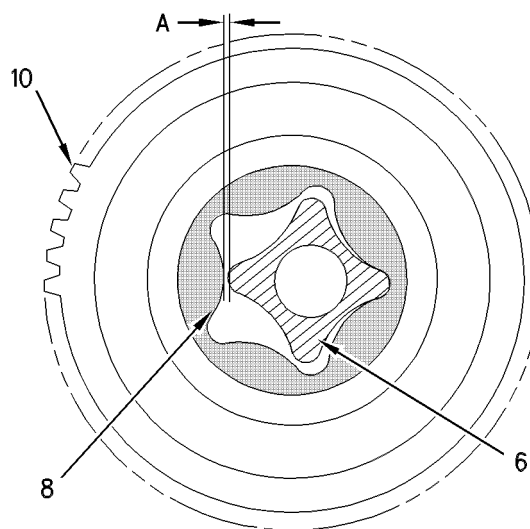


Illustration 35

g00459701

- (A) Clearance between the inner rotor and the outer rotor is the following value. 0.01 to 0.15 mm (0.0004 to 0.006 inch)

Service Limit 0.25 mm (0.0098 inch)

(9) Bushing

(10) Idler gear

(11) Thrust washer

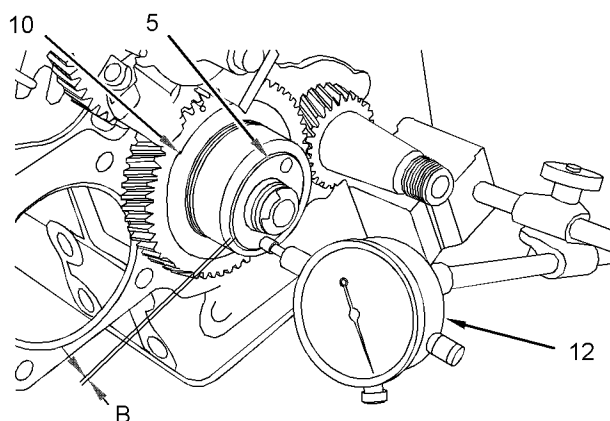


Illustration 36

g01088627

(12) Dial indicator

- (B) When the components of the oil pump are installed on the front housing, measurement (B) between the face of oil pump cover (5) and the face of the idler gear (10) must 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

Engine Oil Pressure

i02145682

Table 5

Oil Pressure ⁽¹⁾	
Oil Pressure at high idle	196 to 441 kPa (28.4 to 64 psi)
Oil pressure at low idle	49 kPa (7 psi) or more

⁽¹⁾ The oil temperature must be 80° to 110°C (176° to 230°F).

i02141054

Engine Oil Pan

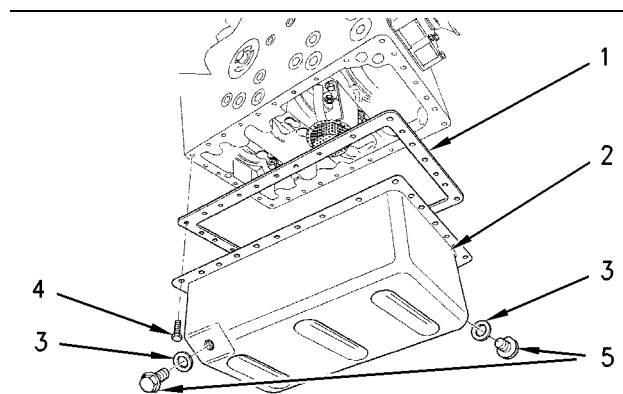


Illustration 37

g00820013

- (1) Gasket
- (2) Engine oil pan
- (3) Washer
- (4) Tighten the bolts for the engine oil pan to the following torque. 11 N·m (8 lb ft)
- (5) Tighten the drain plugs of the engine oil pan to the following torque. 35 N·m (26 lb ft)

Note: Install a new gasket (1) when the engine oil pan is removed or replaced.

Oil Suction Tube and Oil Strainer

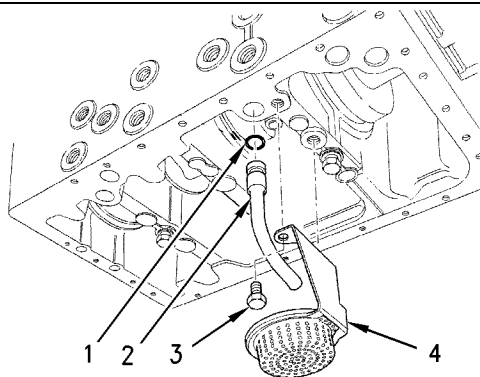


Illustration 38

g00820021

- (1) O-ring
- (2) Oil suction tube
- (3) Tighten the bolts for the oil strainer to the following torque. 11 N·m (8 lb ft)
- (4) Strainer

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

i02141055

Water Temperature Regulator

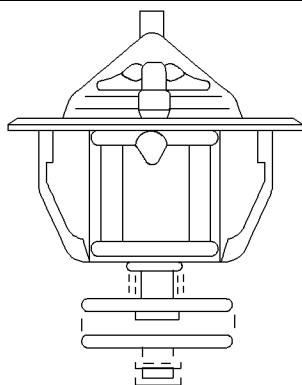


Illustration 39

g00877006

Opening temperature of the water temperature regulator

402C-05, 403C-07, 403C-11 and 404C-15	75 °C (167 °F)
403C-15	80° to 84°C (176° to 183°F)
404C-22	80° to 84 °C (176° to 183 °F)
404C-22T	71 °C (160 °F)

Fully open temperature of the water temperature regulator

402C-05, 403C-07, 403C-11 and 404C-15	87 °C (189 °F)
403C-15	95 °C (203 °F)
404C-22	95 °C (203 °F)
404C-22T	82 °C (180 °F)

Water Temperature Regulator Housing for 402C-05 and 403C-07 Engines

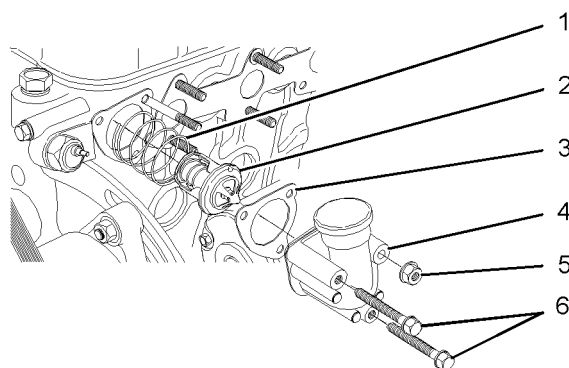


Illustration 40

g01112497

- (1) Spring
- (2) Water temperature regulator
- (3) Gasket
- (4) Cover
- (5) Tighten the nut for the water temperature regulator housing to the following torque. ... 6 N·m (4.4 lb ft)
- (6) Tighten the two setscrews for the water temperature regulator housing to the following torque. 6 N·m (4.4 lb ft)

Water Temperature Regulator Housing for 403C-11, 403C-15, 404C-15, 404C-22 and 404C-22T Engines

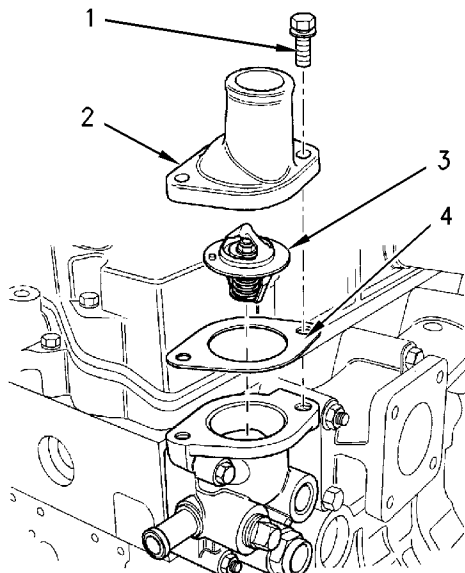


Illustration 41

g00820265

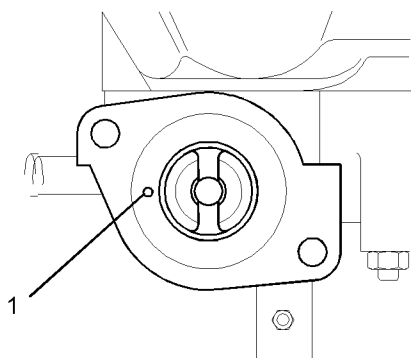


Illustration 42

g01114379

Water temperature regulator for naturally aspirated engines

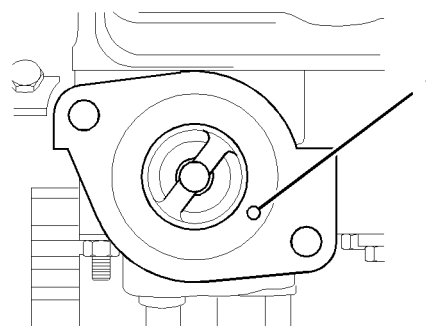


Illustration 43

g01114381

Water temperature regulator for turbocharged engines

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 illustrations 42 and 43.

- (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

i02141056

Cylinder Block

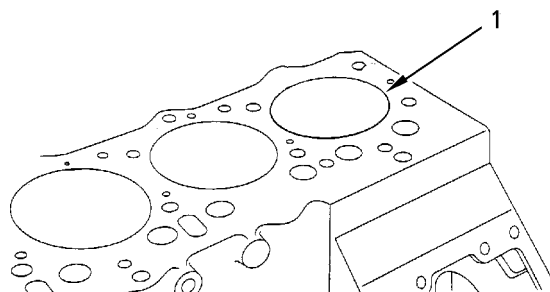


Illustration 44

g00904878

- (1) Diameter of the bore in the cylinder block

402C-05 and 403C-07 67.000 to 67.019 mm
(2.6378 to 2.6385 inch)

403C-11 and 404C-15 77.000 to 77.019 mm
(3.0310 to 3.0320 inch)

403C-15, 404C-22 and 404C-22T 84.000 to 84.019 mm
(3.3071 to 3.3078 inch)

Service limit

402C-05 and 403C-07 67.200 mm
(2.6457 inch)

403C-11 and 404C-15 77.200 mm
(3.0390 inch)

403C-15, 404C-22 and 404C-22T 84.200 mm
(3.3150 inch)

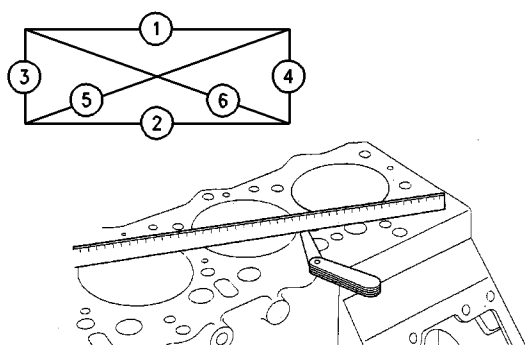


Illustration 45

g00901145

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 bush for the crankshaft must be installed with the chamfer toward the cylinder block. Ensure that the oil hole in the front bush for the crankshaft is aligned with the oil hole in the cylinder block.

Crankshaft

i02141058

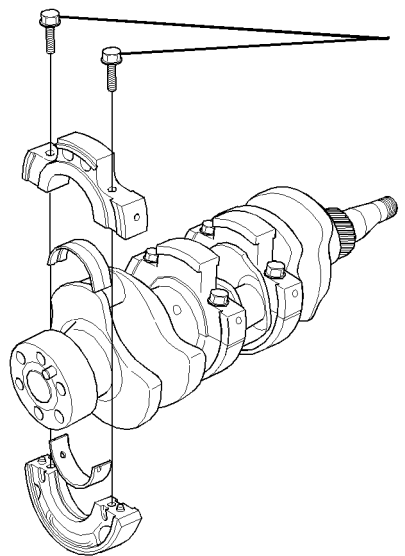


Illustration 46

g01113243

Typical crankshaft for a 3 cylinder engine

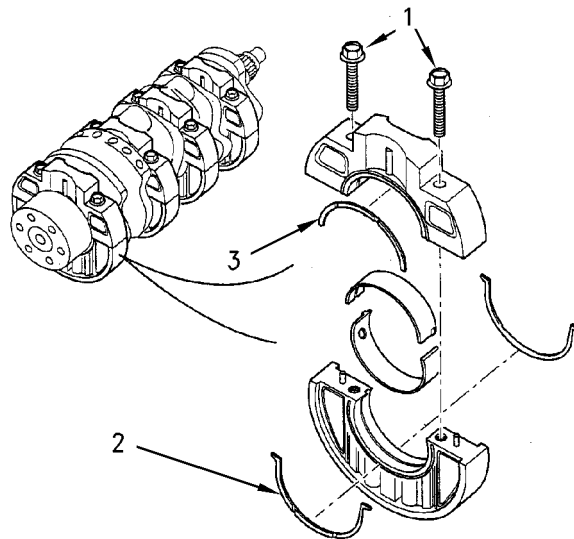


Illustration 47

g00904902

Typical crankshaft for a 4 cylinder engine

- (1) Tighten the bolts of the holder for the main bearing to the following torque.

402C-05, 403C-07, 403C-11 and 404C-15 23 N·m (16.9 lb ft)

403C-15, 404C-22 and 404C-22T 52 N·m (38.3 lb ft)

- (2) Thrust washers

402C-05 and 403C-07	
Standard thickness	21.85 to 21.95 mm (0.8602 to 0.8642 inch)
Service limit	21.60 mm (0.8504 inch)
403C-11 and 404C-15	
Standard thickness	21.85 to 21.95 mm (0.8602 to 0.8642 inch)
Service limit	21.60 mm (0.8504 inch)
403C-15, 404C-22 and 404C-22T	
Standard thickness	2.95 to 3.00 mm (0.1161 to 0.1181 inch)
Service limit	2.80 mm (0.1102 inch)

Note: The thrust washer for the 402C-05, 403C-07, 403C-11 and 404C-15 engines is machined into the holder for the main bearing.

(3) Top thrust washer

Note: The top thrust washer (3) is used only on the 404C-22 and 404C-22T engine.

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

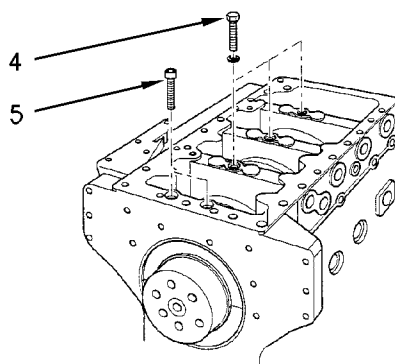


Illustration 48

g00904925

- (4) Tighten the retaining bolts for the crankshaft to the following torque.
- | | |
|---|---------------------|
| 402C-05, 403C-07, 403C-11 and 404C-15 | 27 N·m (19.9 lb ft) |
| 403C-15, 404-22 and 404C-22T | 52 N·m (38.3 lb ft) |
- (5) Tighten the allen head screws to the following torque. 27 N·m (19.9 lb ft)

Crankshaft end play

402C-05, 403C-07, 403C-11 and 404C-15	0.10 to 0.30 mm (0.0040 to 0.0118 inch)
---	---

403C-15, 404C-22 and 404C-22T	0.10 to 0.40 mm (0.0040 to 0.0160 inch)
Service limit (All models)	0.50 mm (0.0197 inch)

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

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.

i02141059

Connecting Rod Bearing Journal

Table 6

Diameter of the 402C-05 and 403C-07 Connecting Rod Bearing Journals		
Journals	Diameter	Service limit
Standard	34.964 to 34.975 mm (1.3765 to 1.3770 inch)	34.9 mm (1.3740 inch)
Undersize 0.25 mm (0.010 inch)	34.714 to 34.725 mm (1.3667 to 1.3671 inch)	34.65 mm (1.3642 inch)
Undersize 0.50 mm (0.020 inch)	34.464 to 34.475 mm (1.3568 to 1.3573 inch)	34.4 mm (1.3543 inch) ⁽¹⁾

Table 7

Diameter of the 403C-11 and 404C-15 Connecting Rod Bearing Journals		
Journals	Diameter	Service limit
Standard	40.964 to 40.975 mm (1.61280 to 1.61320 inch)	40.90 mm (1.6102 inch)
Undersize 0.25 mm (0.010 inch)	40.714 to 40.725 mm (1.60290 to 1.60330 inch)	40.65 mm (1.6003 inch)
Undersize 0.50 mm (0.020 inch)	40.464 to 40.475 mm (1.59310 to 1.59350 inch)	40.40 mm (1.5905 inch) ⁽¹⁾

Table 8

Diameter of the 403C-15, 404C-22 and 404C-22T 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

402C-05 and 403C-07 0.031 to 0.079 mm
(0.00122 to 0.00311 inch)

403C-11 (Journals 1 and 2) .. 0.039 to 0.092 mm
(0.00150 to 0.00360 inch)

403C-11 (Journal 3) 0.029 to 0.082 mm
(0.00110 to 0.00320 inch)

403C-15 0.035 to 0.085 mm
(0.00138 to 0.00335 inch)

404C-15 0.039 to 0.092 mm
(0.00150 to 0.00360 inch)

404C-22 and 404C-22T 0.035 to 0.085 mm
(0.00138 to 0.00335 inch)

Service limit (All models) 0.20 mm
(0.0079 inch)

Main Bearing Journal

Table 9

Diameter of 402C-05 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1	42.964 to 42.975 mm (1.69150 to 1.69193 inch)	42.90 mm (1.6890 inch)
	2	45.948 to 45.959 mm (1.80897 to 1.80941 inch)	45.90 mm (1.8071 inch)
Undersize 0.25 mm (0.010 inch)	1	42.714 to 42.725 mm (1.68165 to 1.68210 inch)	42.65 mm (1.6791 inch)
	2	45.698 to 45.709 mm (1.79913 to 1.79960 inch)	45.65 mm (1.7972 inch)
Undersize 0.50 mm (0.020 inch)	1	42.464 to 42.475 mm (1.67181 to 1.67224 inch)	42.40 mm (1.6693 inch) ⁽¹⁾
	2	45.448 to 45.459 mm (1.78930 to 1.78972 inch)	45.40 mm (1.7874 inch) ⁽¹⁾

i02141129

Table 10

Diameter of 403C-07 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1 and 2	42.964 to 42.975 mm (1.69150 to 1.69193 inch)	42.90 mm (1.6890 inch)
	3	45.948 to 45.959 mm (1.80897 to 1.80941 inch)	45.90 mm (1.8071 inch)
Undersize 0.25 mm (0.010 inch)	1 and 2	42.714 to 42.725 mm (1.68165 to 1.68210 inch)	42.65 mm (1.6791 inch)
	3	45.698 to 45.709 mm (1.79913 to 1.79960 inch)	45.65 mm (1.7972 inch)
Undersize 0.50 mm (0.020 inch)	1 and 2	42.464 to 42.475 mm (1.67181 to 1.67224 inch)	42.40 mm (1.6693 inch) ⁽¹⁾
	3	45.448 to 45.459 mm (1.78930 to 1.78972 inch)	45.40 mm (1.7874 inch) ⁽¹⁾

Table 11

Diameter of 403C-11 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1 and 2	47.965 to 47.975 mm (1.88830 to 1.88880 inch)	47.90 mm (1.8858 inch)
	3	47.954 to 47.965 mm (1.88800 to 1.88830 inch)	47.90 mm (1.8858 inch)
Undersize 0.25 mm (0.010 inch)	1 and 2	47.714 to 47.725 mm (1.87850 to 1.87890 inch)	47.65 mm (1.8750 inch)
	3	47.704 to 47.715 mm (1.87810 to 1.87850 inch)	47.65 mm (1.8750 inch)
Undersize 0.50 mm (0.020 inch)	1 and 2	47.464 to 47.475 mm (1.86870 to 1.86910 inch)	47.40 mm (1.8660 inch) ⁽¹⁾
	3	47.454 to 47.465 mm (1.86250 to 1.86870 inch)	47.40 mm (1.8660 inch) ⁽¹⁾

Table 12

Diameter of 404C-15 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1, 2 and 3	47.965 to 47.975 mm (1.88830 to 1.88880 inch)	47.90 mm (1.8858 inch)
	4	47.954 to 47.965 mm (1.88800 to 1.88830 inch)	47.90 mm (1.8858 inch)
Undersize 0.25 mm (0.010 inch)	1, 2 and 3	47.714 to 47.725 mm (1.87850 to 1.87890 inch)	47.65 mm (1.8750 inch)
	4	47.704 to 47.715 mm (1.87810 to 1.87850 inch)	47.65 mm (1.8750 inch)
Undersize 0.50 mm (0.020 inch)	1, 2 and 3	47.464 to 47.475 mm (1.86870 to 1.86910 inch)	47.40 mm (1.8660 inch) ⁽¹⁾
	4	47.454 to 47.465 mm (1.86250 to 1.86870 inch)	47.40 mm (1.8660 inch) ⁽¹⁾

Table 13

Diameter of 403C-15, 404C-22 and 404C-22T 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)
Undersize 0.25 mm (0.010 inch)	67.707 to 67.720 mm (2.66563 to 2.66614 inch)	67.65 mm (2.6634 inch)
Undersize 0.50 mm (0.020 inch)	67.457 to 67.470 mm (2.65579 to 2.65630 inch)	67.40 mm (2.6535 inch) ⁽¹⁾

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

Clearance between the main bearing and the main bearing journal

Standard clearance

402C-05 Journal 1	0.035 to 0.088 mm (0.0014 to 0.0035 inch)
402C-05 Journal 2	0.039 to 0.092 mm (0.0015 to 0.0036 inch)
403C-07 Journals 1 and 2	0.039 to 0.106 mm (0.0015 to 0.0042 inch)

403C-07 Journal 3 0.039 to 0.092 mm
(0.0015 to 0.0036 inch)

403C-11 and 404C-15 0.039 to 0.106 mm
(0.0015 to 0.0042 inch)

403C-15 0.044 mm to 0.102 mm
(0.0017 inch to 0.0040 inch)

404C-22 and 404C-22T 0.044 to 0.102 mm
(0.0017 to 0.0040 inch)

Service limit (All models) 0.20 mm (0.0079 inch)

i02141200

Connecting Rod

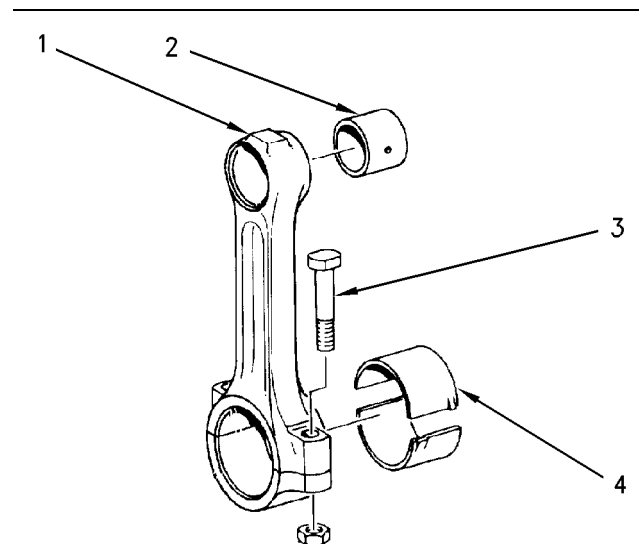


Illustration 49

g00693257

(1) Connecting rod

(2) Piston pin bearing

Clearance between the piston pin and the piston pin bearing (All models) 0.010 to 0.025 mm
(0.00040 to 0.00099 inch)

Service limit

402C-05 and 403C-07 0.10 mm (0.004 inch)

403C-11 and 404C-15 0.08 mm (0.0031 inch)

403C-15 0.10 mm (0.004 inch)

404C-22 and 404C-22T 0.10 mm (0.004 inch)

(3) Tighten the nut and bolt to the following torque.

402C-05 and 403C-07 23 N·m (17 lb ft)

403C-11 32 N·m (23.6 lb ft)

403C-15 52 N·m (38.3 lb ft)

404C-22 and 404C-22T 52 N·m (38.3 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

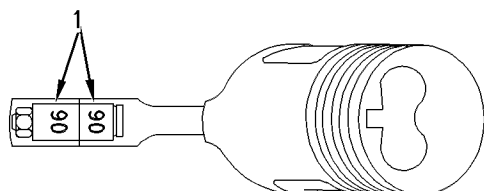


Illustration 50

g00555416

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 (1) 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 Testing and Adjusting, "Connecting Rod - Inspect" for the procedure to measure distortion and parallelism of the connecting rod.

Piston and Rings

i02141224

Markings on the Piston

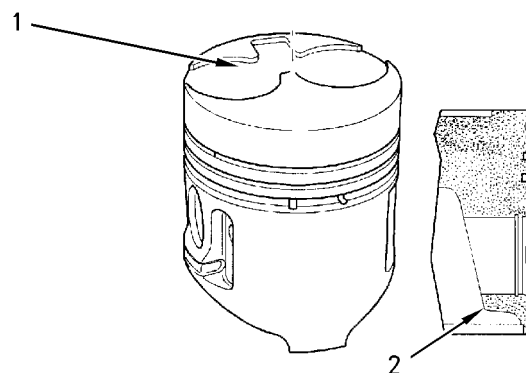


Illustration 51

g00845975

- (1) The chamber that is on the top of the piston must face the right side of the engine.
- (2) The Shibaura name that is on the inside of the piston must align with the stamped number on the connecting rod.

Piston and Piston Rings

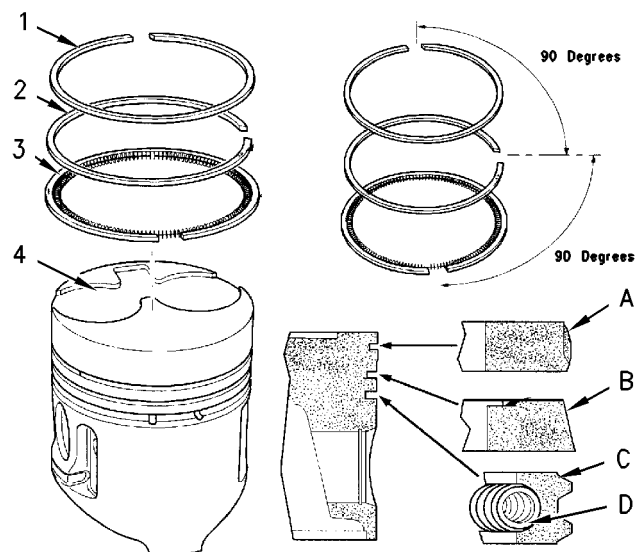


Illustration 52

g00845969

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)

Naturally aspirated Barrel face

Turbocharged Keystone

402C-05 and 403C-07

Clearance between piston ring groove and top piston ring 0.06 to 0.10 mm
(0.0024 to 0.0039 inch)

Service limit for clearance of top piston ring 0.25 mm (0.0098 inch)

Gap of top piston ring 0.13 to 0.25 mm
(0.0051 to 0.0098 inch)

Service limit for gap of top piston ring 1.0 mm
(0.039 inch)

403C-11 and 404C-15

Clearance between piston ring groove and top piston ring 0.06 to 0.10 mm
(0.0024 to 0.0039 inch)

Service limit for clearance of top piston ring 0.25 mm (0.0098 inch)

Gap of top piston ring 0.15 to 0.27 mm
(0.0059 to 0.0106 inch)

Service limit for gap of top piston ring 1.0 mm
(0.039 inch)

403C-15 and 404C-22

Clearance between piston ring groove and top piston ring 0.07 to 0.11 mm
(0.0028 to 0.0043 inch)

Service limit for clearance of top piston ring 0.25 mm (0.0098 inch)

Gap of top piston ring 0.20 to 0.35 mm
(0.0079 to 0.0138 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 on the 404C-22T turbocharged engine. When either the intermediate ring or the oil control ring is outside the service limit, renew all of the rings.

Note: Install the word "Top" toward the top of the piston. New top piston rings have a red identification mark which 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 for the 404C-22T have a yellow identification mark which 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

402C-05 and 403C-07

Clearance between piston ring groove and intermediate ring 0.05 to 0.09 mm
(0.0020 to 0.0035 inch)

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

Gap of intermediate ring 0.10 to 0.22 mm
(0.0039 to 0.0087 inch)

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

403C-11 and 404C-15

Clearance between piston ring groove and intermediate ring 0.05 to 0.09 mm
(0.0020 to 0.0035 inch)

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

Gap of intermediate ring 0.12 to 0.24 mm
(0.0047 to 0.0094 inch)

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

403C-15, 404C-22 and 404C-22T

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 intermediate ring 0.20 to 0.40 mm
(0.0079 to 0.0158 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 which 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

402C-05 and 403C-07

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 0.15 mm (0.0059 inch)

Gap of oil control ring 0.10 to 0.30 mm
(0.0039 to 0.0118 inch)

Service limit for gap of oil control ring 1.0 mm
(0.039 inch)

403C-11 and 404C-15

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 0.15 mm (0.0059 inch)

Gap of oil control ring 0.20 to 0.35 mm
(0.0079 to 0.0138 inch)

Service limit for gap of oil control ring 1.0 mm
(0.039 inch)

403C-15, 404C-22 and 404C-22T

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 0.15 mm (0.0059 inch)

Gap of oil control ring 0.20 to 0.40 mm
(0.0079 to 0.0158 inch)

Service limit for gap of oil control ring 1.0 mm
(0.039 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 in order 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

402C-05 and 403C-07

Diameter of the piston skirt 66.9375 to 66.9525 mm
(2.6353 to 2.6359 inch)

Service limit 66.7 mm (2.6260 inch)

Clearance of the piston skirt to the cylinder wall .. 0.048 to 0.082 mm (0.0019 to 0.0032 inch)

Service limit 0.25 mm (0.010 inch)

Diameter of the piston pin .. 18.998 to 19.002 mm
(0.7480 to 0.7481 inch)

Service limit 18.98 mm (0.7472 inch)

Clearance between the hole for the piston pin and the piston pin -0.004 to +0.004 mm
(-0.00016 to +0.00016 inch)

Service limit 0.02 mm (0.0008 inch)

403C-11 and 404C-15

Diameter of the piston skirt 76.932 to 76.947 mm
(3.0288 to 3.0294 inch)

Service limit 76.7 mm (3.020 inch)

Clearance of the piston skirt to the cylinder wall 0.0525 to 0.0865 mm
(0.00210 to 0.00340 inch)

Service limit 0.25 mm (0.010 inch)

Diameter of the piston pin .. 20.996 to 21.002 mm
(0.8266 to 0.8269 inch)

Service limit 20.98 mm (0.826 inch)

Clearance between the hole for the piston pin and the piston pin -0.004 to +0.004 mm
(-0.00016 to +0.00016 inch)

Service limit 0.02 mm (0.0008 inch)

403C-15, 404C-22 and 404C-22T

Diameter of the piston skirt 83.948 to 83.963 mm
(3.3050 to 3.3056 inch)

Service limit 83.7 mm (3.295 inch)

Clearance of the piston skirt to the cylinder wall 0.0380 to 0.0720 mm
(0.00150 to 0.00283 inch)

Service limit 0.25 mm (0.010 inch)

Diameter of the piston pin .. 27.996 to 28.000 mm
(1.1022 to 1.1024 inch)

Service limit 27.98 mm (1.1016 inch)

Clearance between the hole for the piston pin
and the piston pin -0.001 to +0.007 mm
(-0.0004 to +0.0003 inch)

Service limit 0.02 mm (0.0008 inch)

Refer to Specifications, "Cylinder Head" for the piston height for a given gasket thickness.

i02141282

Housing (Front)

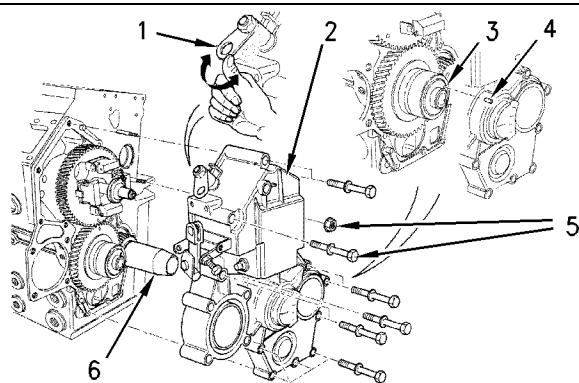


Illustration 53

g00827564

- (1) Mechanical stop lever
- (2) Front housing
- (3) Locator hole
- (4) Locator pin
- (5) Tighten the setscrews and nuts 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

Gear Group (Front)

i02141412

Table 14

Injection timing		
Engine	Maximum rated engine speed	Injection timing (BTDC) ⁽¹⁾
402C-05 Genset	1800	12° ± 1°
402C-05 Genset	3000	20° ± 1°
402C-05 Genset	3600	21° ± 1°
402C-05 Industrial engine	2800	18° ± 1°
402C-05 Industrial engine	3000	20° ± 1°
402C-05 Industrial engine	3200	20° ± 1°
402C-05 Industrial engine	3600	21° ± 1°
403C-07 Genset	1800	12° ± 1°
403C-07 Genset	3000	20° ± 1°
403C-07 Genset	3600	21° ± 1°
403C-07 Industrial engine	2800	18° ± 1°
403C-07 Industrial engine	3000	20° ± 1°
403C-07 Industrial engine	3200	20° ± 1°
403C-07 Industrial engine	3400	21° ± 1°
403C-07 Industrial engine	3600	21° ± 1°
403C-11 Genset	1500	18° ± 1°
403C-11 Genset	1800	18° ± 1°
403C-11 Genset	3000	23° ± 1°
403C-11 Genset	3600	22° ± 1°
403C-11 Industrial engine	2200	23° ± 1°
403C-11 Industrial engine	2400	23° ± 1°
403C-11 Industrial engine	2600	23° ± 1°
403C-11 Industrial engine	2800	23° ± 1°
403C-11 Industrial engine	3000	23° ± 1°
403C-15 Genset	1500	14° ± 1°

(continued)

(Table 14, contd)

403C-15 Genset	1800	$14^{\circ} \pm 1^{\circ}$
403C-15 Genset	3000	$20^{\circ} \pm 1^{\circ}$
403C-15 Industrial engine	2200	$22^{\circ} \pm 1^{\circ}$
403C-15 Industrial engine	2400	$22^{\circ} \pm 1^{\circ}$
403C-15 Industrial engine	2600	$22^{\circ} \pm 1^{\circ}$
403C-15 Industrial engine	2800	$20^{\circ} \pm 1^{\circ}$
403C-15 Industrial engine	3000	$20^{\circ} \pm 1^{\circ}$
404C-15 Genset	1500	$18^{\circ} \pm 1^{\circ}$
404C-15 Genset	1800	$18^{\circ} \pm 1^{\circ}$
404C-15 Genset	3000	$23^{\circ} \pm 1^{\circ}$
404C-15 Genset	3600	$22^{\circ} \pm 1^{\circ}$
404C-15 Industrial engine	2200	$23^{\circ} \pm 1^{\circ}$
404C-15 Industrial engine	2400	$23^{\circ} \pm 1^{\circ}$
404C-15 Industrial engine	2600	$23^{\circ} \pm 1^{\circ}$
404C-15 Industrial engine	2800	$23^{\circ} \pm 1^{\circ}$
404C-15 Industrial engine	3000	$23^{\circ} \pm 1^{\circ}$
404C-22 Genset	1500	$15^{\circ} \pm 1^{\circ}$
404C-22 Genset	1800	$12^{\circ} \pm 1^{\circ}$
404C-22 Genset	3000	$18^{\circ} \pm 1^{\circ}$
404C-22 Industrial engine	2200	$18^{\circ} \pm 1^{\circ}$
404C-22 Industrial engine	2400	$18^{\circ} \pm 1^{\circ}$
404C-22 Industrial engine	2600	$20^{\circ} \pm 1^{\circ}$
404C-22 Industrial engine	2800	$20^{\circ} \pm 1^{\circ}$
404C-22 Industrial engine	3000	$20^{\circ} \pm 1^{\circ}$
404C-22T Industrial engine	2800	$18^{\circ} \pm 1^{\circ}$
404C-22T Industrial engine	3000	$18^{\circ} \pm 1^{\circ}$

(1) Before Top Dead Center

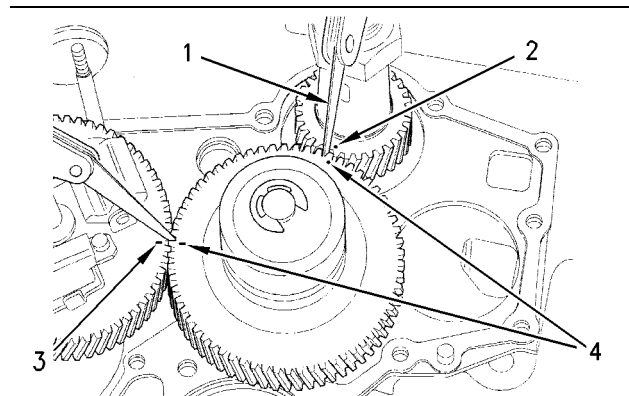


Illustration 54

g00821197

- (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).

i02142620

Flywheel

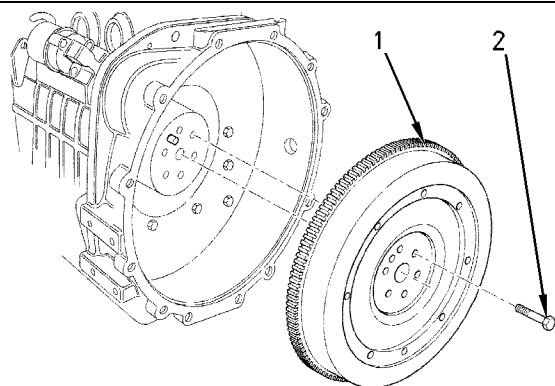


Illustration 55

g00820355

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

Note: If the ring gear is excessively worn, renew the ring gear. 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 setscrews on the flywheel to the following torque. 74 N·m (55 lb ft)

Maximum flywheel runout 0.20 mm (0.008 inch)

i02142625

Flywheel Housing

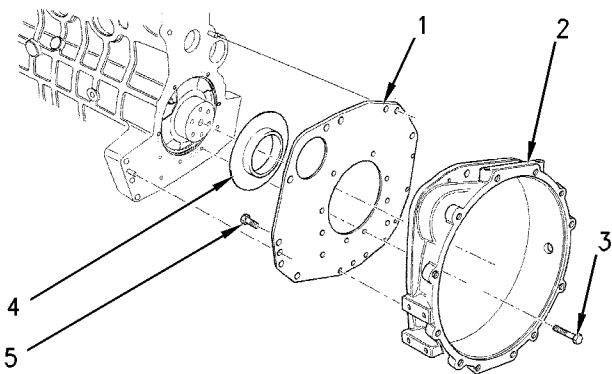


Illustration 56

g00820369

- (1) Back plate
(2) Flywheel housing
(3) Tighten the setscrews for the back plate to the following torque.

402C-05 and 403C-07	15 N·m (11 lb ft)
403C-11 and 404C-15	50 N·m (36.9 lb ft)
403C-15, 404C-22 and 404C-22T	25 N·m (18.8 lb ft)

- (4) Crankshaft rear seal

- (5) Tighten the setscrews for the flywheel housing to the following torque.

402C-05 and 403C-07	15 N·m (11 lb ft)
403C-11 and 404C-15	50 N·m (36.9 lb ft)
403C-15, 404C-22 and 404C-22T	25 N·m (18.8 lb ft)

i02142629

Crankshaft Pulley

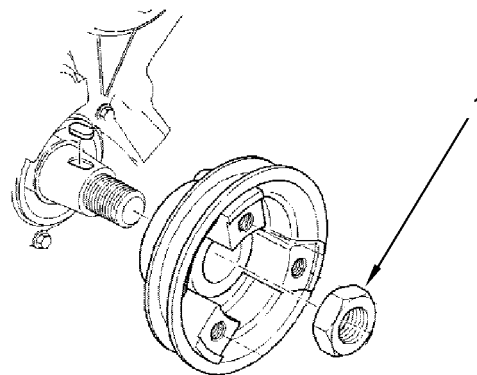


Illustration 57

g00904688

- (1) Tighten the crankshaft pulley nut to the following torque.

402C-05 and 403C-07	93 N·m (68.6 lb ft)
403C-11 and 404C-15	123 N·m (90.7 lb ft)
403C-15, 404C-22 and 404C-22T	304 N·m (224.2 lb ft)

i02142647

Belt Tension Chart

Table 15

Belt Tension Chart	
Gauge Reading	
Initial Belt Tension ⁽¹⁾	Used Belt Tension ⁽²⁾
400 to 489 N (90 to 110 lb)	267 to 356 N (60 to 80 lb)

- (1) Initial Belt Tension refers to a new belt.
(2) Used Belt Tension refers to a belt that has been in operation for 30 minutes or more at the rated speed.

i02142675

Fan Drive

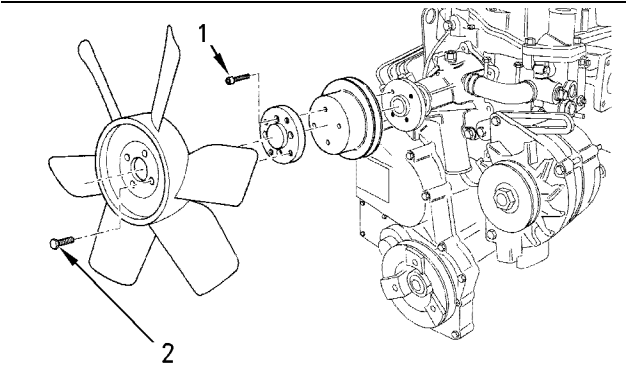


Illustration 58 g00904732

- (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)

i02142717

Engine Lifting Bracket

All engines are equipped with two engine lifting brackets.

Tighten the setscrew on each engine lifting bracket to the following torque. .. 26 N·m (20 lb ft)

i02142764

Alternator and Regulator

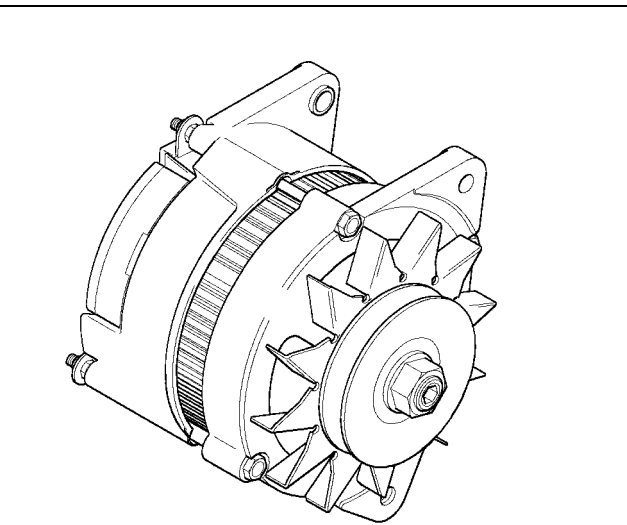


Illustration 59 g00909016
Typical Example

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 14.0 ± 0.5 volts

Rated voltage 12 volts

Rated current output

402C-05 and 403C-07	14 amperes
403C-11	15 or 40 amperes
403C-15	55 or 65 amperes
404C-15	40 amperes
404C-22 and 404C-22T	55 or 65 amperes

i02142799

Electric Starting Motor

Starting Motor

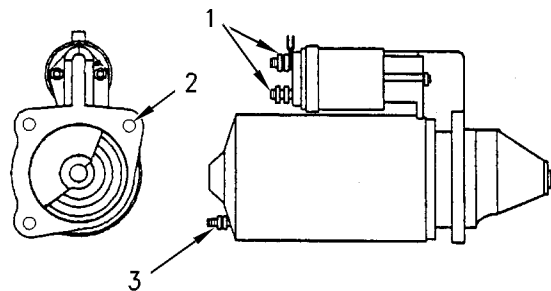


Illustration 60
Starting motor and starting motor solenoid

No load conditions at 25°C (77°F)	
Rpm with no load	4000 to 6000 rpm
Maximum current	540 amperes
Current draw with no load	130 amperes
Voltage	11.5 volts
Rated voltage	12 volts
Power rating	2.0 kilowatts
Power rating	
402C-05, 403C-07, 403C-11 and 404C-15	
Standard	1.1 kilowatts
Option	1.4 kilowatts
403C-15, 404C-22 and 404C-22	
2.0 kilowatts	
Minimum average cranking rpm	130
Starting motor solenoid	
Pull-in current	54.5 amperes
Hold-in current	10.5 amperes

- (1) Tighten the battery terminal nut to the following torque. 15 N·m (11 lb ft)

- (2) Tighten the two mounting bolts to the following torque. 50 ± 6 N·m (37 ± 4 lb ft)
- (3) Tighten the nut for the switch terminal to the following torque. 1.0 to 1.3 N·m (9 to 12 lb in)

Maximum resistance of the starter cable at 20°C (68°F) and at 12 volts 0.04 ohms

Start Relays

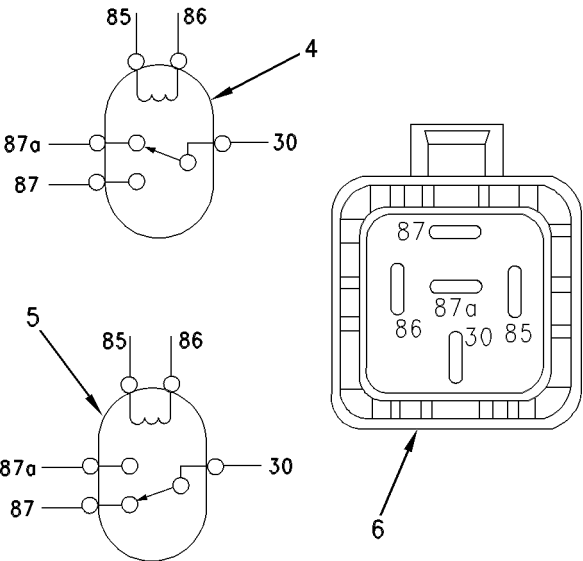


Illustration 61
Schematic of the relays

- (4) When the ignition switch is in the OFF position or the RUN position, the relay switch is closed across the contact “30” and the contact “87a”.
- (5) When the ignition switch is in the START position, the relay switch is closed across the contact “30” and the contact “87”. Then, the starting motor is engaged.

Maximum voltage drop in closed position 0.150 to 0.250 volts

- (6) Connector pins on the start relay
- Resistance between contact “85” and contact “86” 7.2 ± 0.7 ohms

i02142810

Coolant Temperature Switch

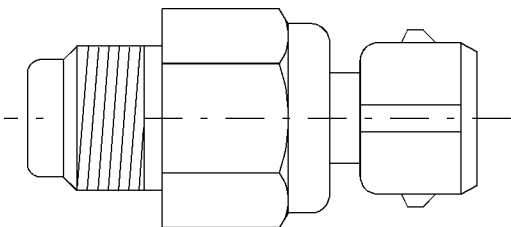


Illustration 62

g01094334

Typical coolant temperature switch

Tighten the coolant temperature switch to the following torque. 27 N·m (20 lb ft)

i02142815

Engine Oil Pressure Switch

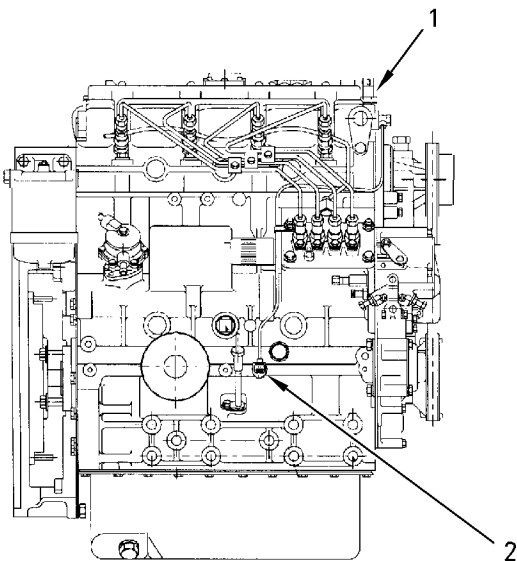


Illustration 63

g00904803

Tighten the engine oil pressure switch to the following torque.

402C-05 and 403C-07 18 N·m (13.3 lb ft)

403C-11, 403C-15, 404C-15, 404C-22 and
404C-22T 10 N·m (7 lb ft)

Note: The engine oil pressure switch can be found in two positions.

- (1) Engine oil pressure switch that is located on the valve mechanism cover

403C-11 (Deutsch) Green sticker with a white dot

402C-05, 403C-07, 403C-15, 404C-15, 404C-22 and 404C-22T (Amp) Brown connector

Pressure rating

403C-11 49.0 kPa (7.11 psi)

402C-05, 403C-07, 403C-15, 404C-15, 404C-22 and 404C-22T 29.4 kPa (4.26 psi)

- (2) Engine oil pressure switch that is located on the cylinder block

403C-11 (Deutsch) Green sticker with a white dot

402C-05, 403C-07 and 404C-15 (Deutsch) Green sticker with a red dot

403C-15, 404C-22 and 404C-22T before engine Serial number 519585L ... (Amp) Blue connector

403C-15, 404C-22 and 404C-22T after engine Serial number - 519585L (Amp) Black connector

Pressure rating

403C-11 49.0 kPa (7.11 psi)

402C-05, 403C-07 and 404C-15 68.9 kPa (10.0 psi)

403C-15, 404C-22 and 404C-22T before engine Serial number - 519585L 98 kPa (14.21 psi)

403C-15, 404C-22 and 404C-22T after engine Serial number - 519585L 68.9 kPa (10.0 psi)

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Glow Plugs

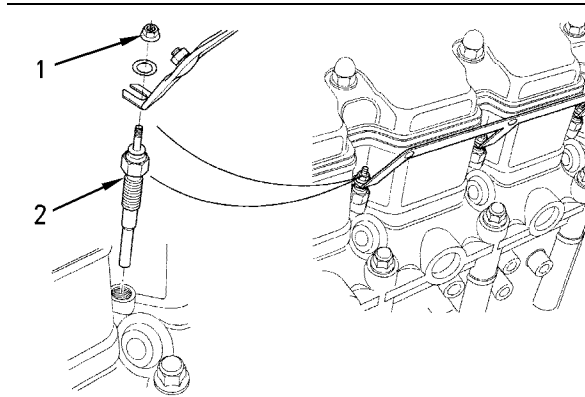


Illustration 64

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- (1) Tighten the nut on the bus bar to the following torque (All models). 1.2 N·m (11 lb in)
- (2) Tighten the glow plug to the following torque.
402C-05, 403C-07, 403C-11 and
404C-15 11.5 N·m (8.9 lb ft)
403C-15, 404C-22 and 404C-22T 17.5 N·m
(12.9 lb ft)

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Fuel Shutoff Solenoid

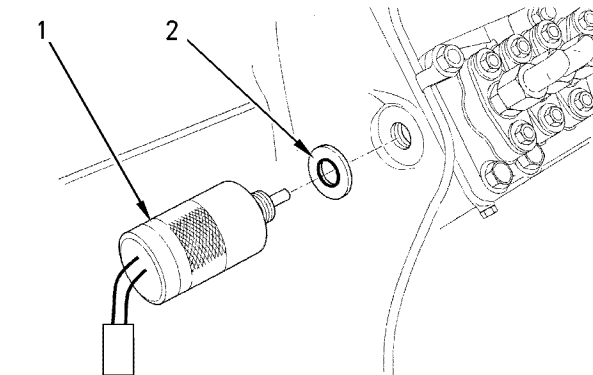


Illustration 65

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- (1) Tighten the fuel shutoff solenoid to the following torque. 17 N·m (13 lb ft)
- (2) Washer

Ensure that the washer is replaced with a new washer during the installation of the fuel shutoff solenoid (1).

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