

Specifications

402D-403D-404D Industrial Engine

GG (Engine)
GH (Engine)
GJ (Engine)
GK (Engine)
GL (Engine)
GM (Engine)
GN (Engine)
GP (Engine)
GQ (Engine)
GS (Engine)

Important Safety Information

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

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

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

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

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



The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

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

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



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

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

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Specifications Section

Engine Design

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402D-05 Engine

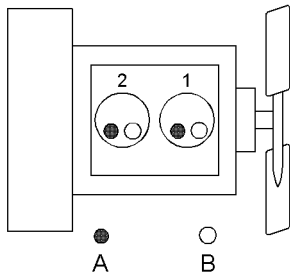


Illustration 1 g01111232

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 (31 in ³)
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.

403D-07 Engine

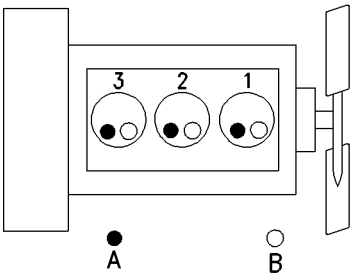


Illustration 2 g00852304

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 in ³)
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.

403D-11 Engine

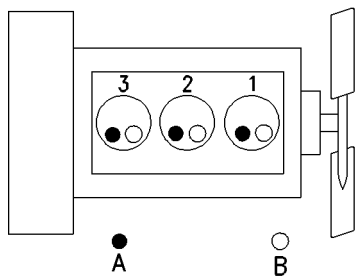


Illustration 3
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

Bore	77 mm (3.03 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	22.75:1
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.

403D-15 Engine

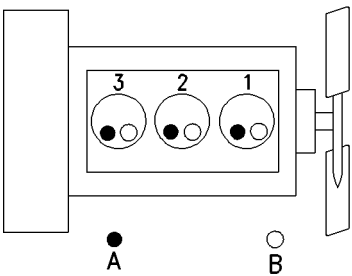


Illustration 4
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

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	22.2:1
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.

403D-15T

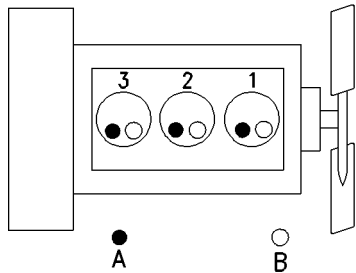


Illustration 5
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

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.

403D-17 Engine

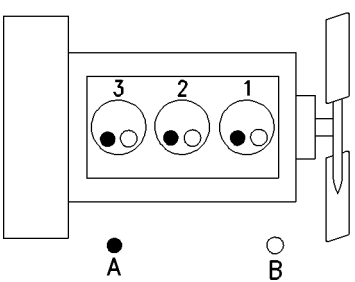


Illustration 6
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

Bore	84 mm (3.3 inch)
Stroke	100 mm (3.94 inch)
Displacement	1.662 L (101.4 in ³)
Cylinder arrangement	In-line
Type of combustion	Indirect injection
Compression ratio	23.1:1
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

The crankshaft is viewed from the front of the engine. Direction of rotation Clockwise

The camshaft is viewed from the front of the engine. Direction of rotation 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.

404D-15 Engine

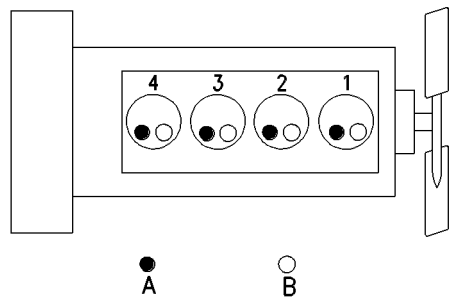


Illustration 7
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

Bore	77 mm (3.03 inch)
Stroke	81 mm (3.19 inch)
Displacement	1.508 L (92 in ³)
Cylinder arrangement	In-line
Type of combustion	Indirect injection
Compression ratio	23:1
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.

404D-22 Engine

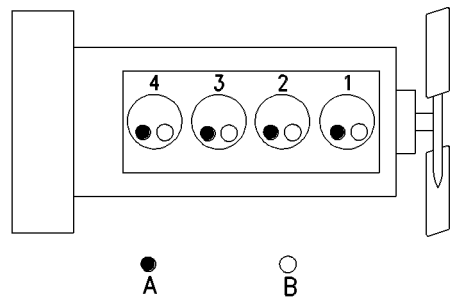


Illustration 8
Cylinder and valve location
(A) Exhaust valve
(B) Inlet valve

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	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.

404D-22T Engine

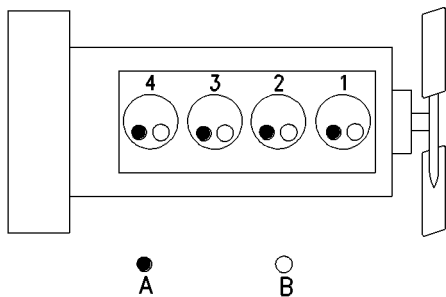


Illustration 9

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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 23.5:1
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.

404D-22TA Engine

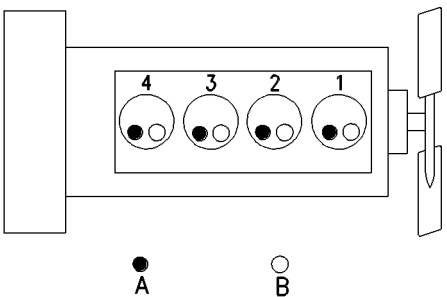


Illustration 10

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 23.5:1
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.

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Fuel Injection Lines

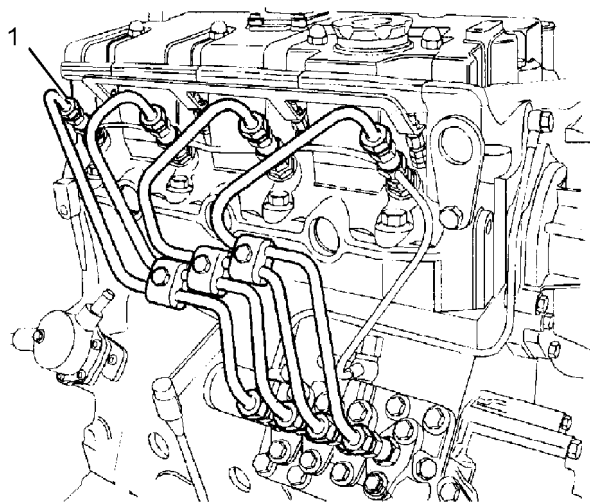


Illustration 11

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- (1) Torque for the union nuts for the fuel injectors
All models 20 N·m (15 lb ft)

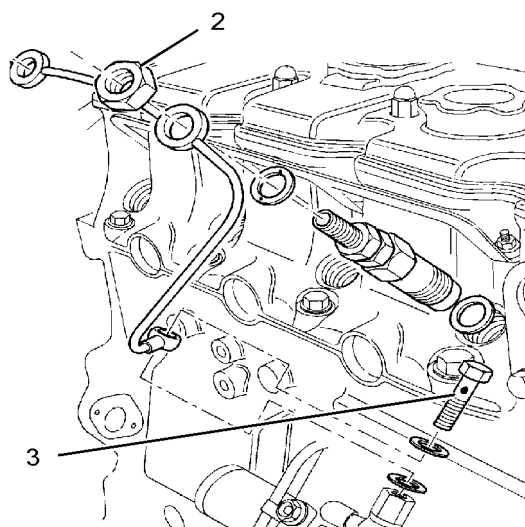


Illustration 12

g01442096

- (2) Torque for the nut 27 N·m (20 lb ft)
(3) Torque for the banjo bolt 2.5 N·m (22 lb in)

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

Fuel Injection Pump

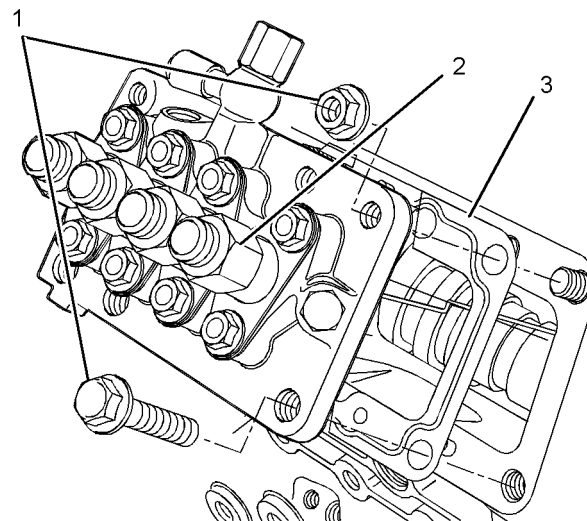


Illustration 13

g01329882

Typical example

Type of fuel injection pump In-line cassette

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

- (1) Torque for the mounting nuts and setscrews
402D-05, 403D-07, 403D-11 and
404D-15 10 N·m (89 lb in)
403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 15 N·m (11 lb ft)
- (2) Torque for the delivery valve holders 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, new shims, which have the same thickness as the original shims, must be installed.

If any of the following new components are installed, new shims which have the same thickness as the original shims must be used.

- Camshaft

- Cylinder block

The following thicknesses of shims are available:

- 0.20 mm (0.008 inch)
- 0.25 mm (0.010 inch)
- 0.35 mm (0.014 inch)
- 0.50 mm (0.020 inch)

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Fuel Injector

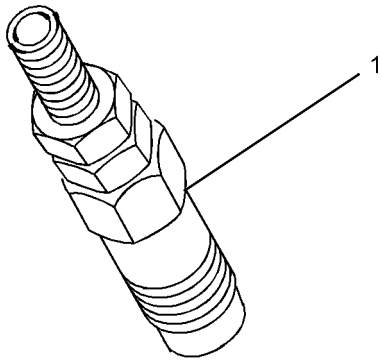


Illustration 14

g01335248

(1) Torque for the fuel injectors

All models 64 N·m (47 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.

Table 1

Injector Opening Pressures	
Engine Model	Opening pressure
402D-05	11960 kPa (1734 psi)
403D-07	11960 kPa (1734 psi)
403D-11	13930 kPa (2020 psi)
404D-15	14700 kPa (2132 psi)
403D-15	14700 kPa (2132 psi)
403D-15T	14700 kPa (2132 psi)
403D-17	14700 kPa (2132 psi)
404D-22	14700 kPa (2132 psi)
404D-22T	14700 kPa (2132 psi)
404D-22TA	14700 kPa (2132 psi)

Leakage in 10 seconds 0 drops

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Fuel Transfer Pump

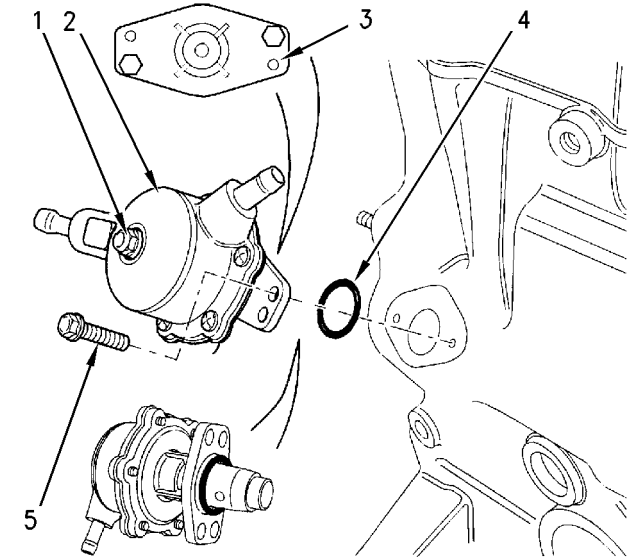


Illustration 15

g00819278

Typical example

- (1) Torque for the adjustment screw for the fuel priming pump 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)

i02959996

Lifter Group

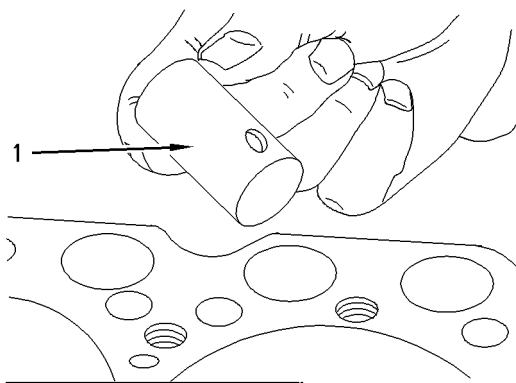


Illustration 16

g00692979

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

Standard maximum clearance

403D-11, 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 0.058 mm (0.0023 inch)

402D-05, 403D-07 and 404D-15 0.053 mm (0.0021 inch)

Repair limit for all engines 0.080 mm (0.0031 inch)

Rocker Shaft

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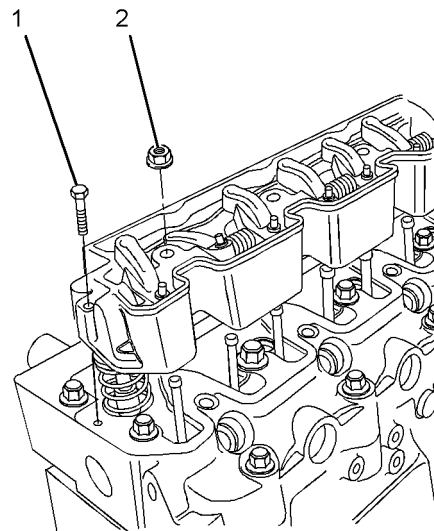


Illustration 17

g01440959

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

- (1) Torque for the setscrews

All models 10 N·m (89 lb in)

- (2) Torque for the nuts

402D-05 and 403D-07 10 N·m (89 lb in)

403D-11 and 404D-15 23 N·m (17 lb ft)

403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 33 N·m (24 lb ft)

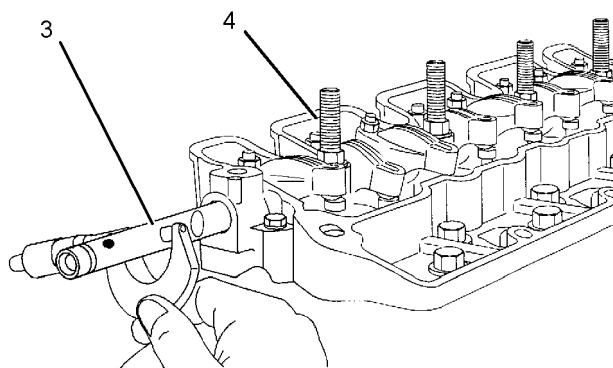


Illustration 18

g01440976

(3) Rocker shaft

Diameter of the rocker shaft for the 402D-05 Engine and 403D-07 Engine .. 9.95 to 9.968 mm (0.3917 to 0.3924 inch)

Service limit 9.87 mm (0.3886 inch)

Diameter of the rocker shaft for the 403D-11 Engine and 404D-15 Engine .. 11.65 to 11.67 mm (0.4587 to 0.4595 inch)

Service limit 11.57 mm (0.4555 inch)

Diameter of the rocker shaft for the 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA Engines 14.95 to 14.97 mm (0.5886 to 0.5894 inch)

Service limit 14.87 mm (0.5854 inch)

(4) Torque for the studs

402D-05 and 403D-07 10 N·m (89 lb in)

403D-11 and 404D-15 26 N·m (19 lb ft)

403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 56 N·m (41 lb ft)

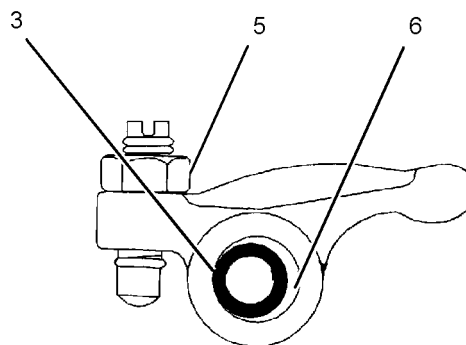


Illustration 19

g01440948

(5) Torque for the locknut 14 N·m (10 lb ft)

(6) Rocker arm clearance on the rocker shaft

Minimum permissible clearance for the 402D-05 Engine and 403D-07 Engine .. 0.032 to 0.065 mm (0.00126 to 0.00260 inch)

Minimum permissible clearance for the 403D-11 Engine and 404D-15 Engine .. 0.032 to 0.068 mm (0.00126 to 0.00268 inch)

Minimum permissible clearance for the 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA Engines 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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Valve Mechanism Cover

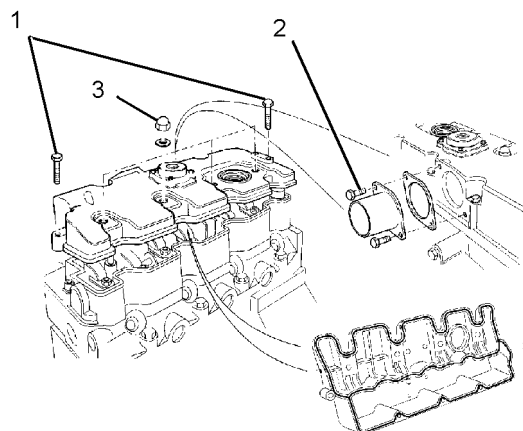


Illustration 20

g01441024

- (1) Torque for the setscrews for the valve mechanism cover

All models 10 N·m (89 lb in)

- (2) Torque for the setscrews for the connector on the inlet manifold

All models 14 N·m (10 lb ft)

- (3) Torque for the cap nuts for the valve mechanism cover

402D-05, 403D-07, 403D-11 and
404D-15 10 N·m (89 lb in)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 14 N·m (10 lb ft)

Cylinder Head Valves

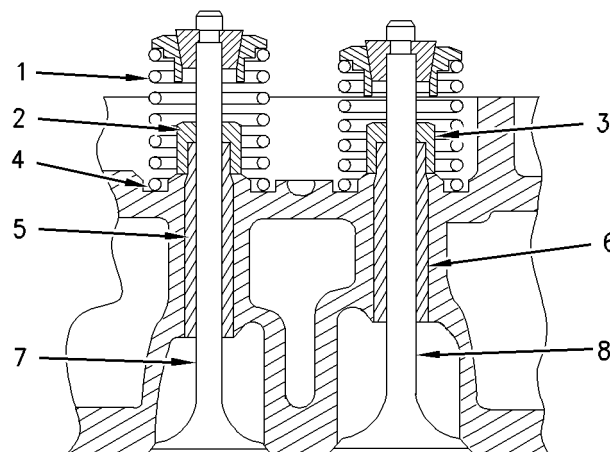


Illustration 21

g00903737

- (1) Valve spring

Standard free length for 403D-11, 403D-15,
403D-15T, 403D-17, 404D-15, 404D-22,
404D-22T and 404D-22TA 35.0 mm
(1.378 inch)

Standard free length for 402D-05 and
403D-07 33 mm (1.2992 inch)

Service limit for the standard free length for
403D-11, 403D-15, 403D-15T, 403D-17, 404D-15,
404D-22, 404D-22T and 404D-22TA 33.5 mm
(1.319 inch)

Service limit for the standard free length for
402D-05 and 403D-07 31.5 mm (1.2402 inch)

Standard test force for 403D-11, 403D-15,
403D-15T, 403D-17, 404D-15, 404D-22,
404D-22T and 404D-22TA 79 N (17.8 lb)

Standard test force for 402D-05 and
403D-07 68 N (15.3 lb)

Service limit for the standard test force for
403D-11, 403D-15, 403D-15T, 403D-17, 404D-15,
404D-22, 404D-22T and 404D-22TA 68.6 N
(15.4 lb)

Service limit for the standard test force for
402D-05 and 403D-07 59 N (13.3 lb)

Length under test force for 403D-11, 403D-15,
403D-15T, 403D-17, 404D-15, 404D-22,
404D-22T and 404D-22TA 30.4 mm
(1.197 inch)

Length under test force for 402D-05 and
403D-07 28.3 mm (1.1142 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

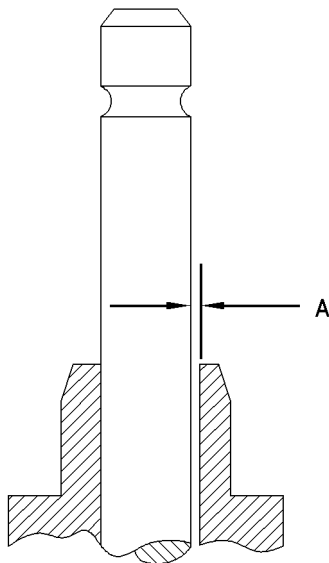


Illustration 22

g00903744

(5) Exhaust valve guide

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

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA ... 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

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 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 for 402D-05
and 403D-07 5.940 to 5.955 mm
(0.2339 to 0.2344 inch)

Service limit 5.90 mm (0.232 inch)

Diameter of the exhaust valve stem for
403D-11, 403D-15, 403D-15T, 403D-17,
404D-15, 404D-22, 404D-22T and
404D-22TA 6.940 to 6.955 mm
(0.2732 to 0.2738 inch)

Service limit 6.84 mm (0.269 inch)

(8) Inlet valve stem

Diameter of the inlet valve stem for 402D-05 and
403D-07 5.960 to 5.975 mm
(0.2346 to 0.2352 inch)

Service limit 5.90 mm (0.232 inch)

Diameter of the inlet valve stem for
403D-11, 403D-15, 403D-15T, 403D-17,
404D-15, 404D-22, 404D-22T and
404D-22TA 6.955 to 6.970 mm
(0.27382 to 0.27441 inch)

Service limit 6.89 mm (0.271 inch)

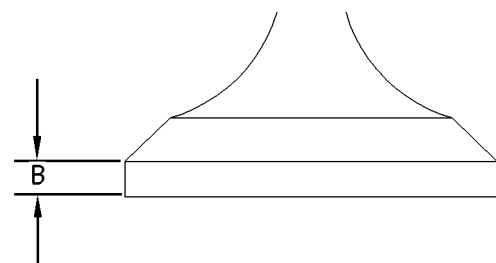


Illustration 23

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)

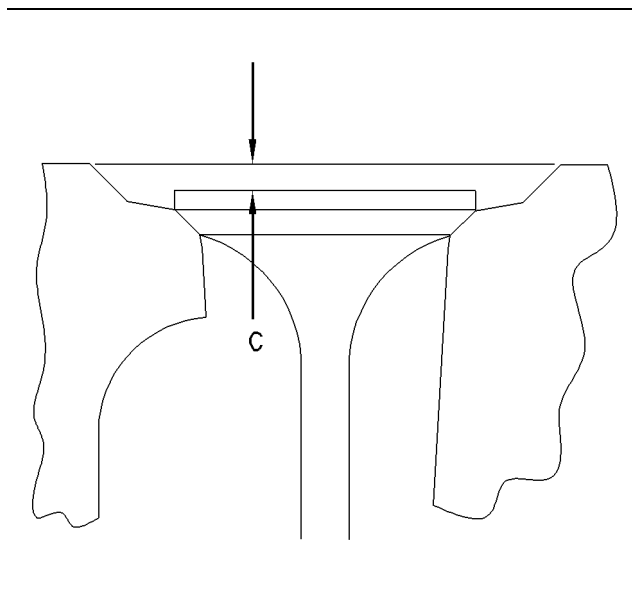


Illustration 24

g00903773

(C) Valve depth below the cylinder head face

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

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

Inlet and exhaust valves for 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 0.65 to 0.95 mm
(0.0256 to 0.0374 inch)

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

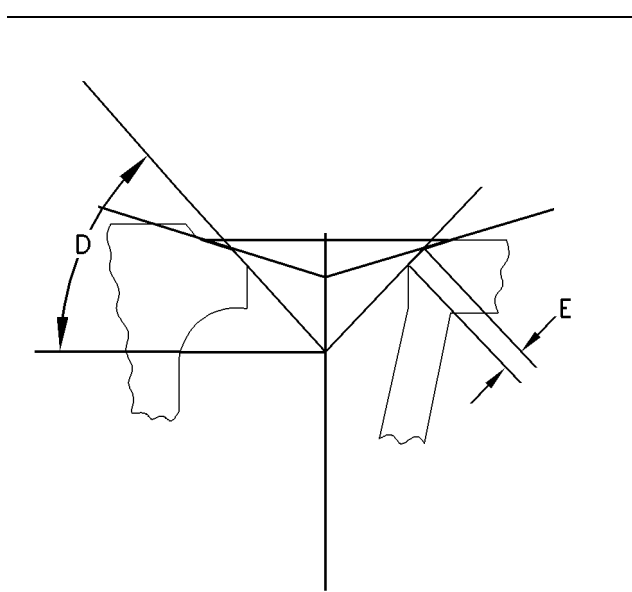


Illustration 25

g00903760

(D) Valve seat angle 45 degrees**(E) Contact face****Exhaust valve**

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

403D-15, 403D-15T and 403D-17 1.66 to 1.73 mm
(0.0653 to 0.0681 inch)

404D-22, 404D-22T and 404D-22TA 1.94 to 2.16 mm
(0.0764 to 0.0850 inch)

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

Inlet valve

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

403D-15, 403D-15T and 403D-17 1.66 to 1.87 mm
(0.0653 to 0.0736 inch)

404D-22, 404D-22T and 404D-22TA 1.50 to 2.00 mm
(0.0591 to 0.0790 inch)

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

i02961016

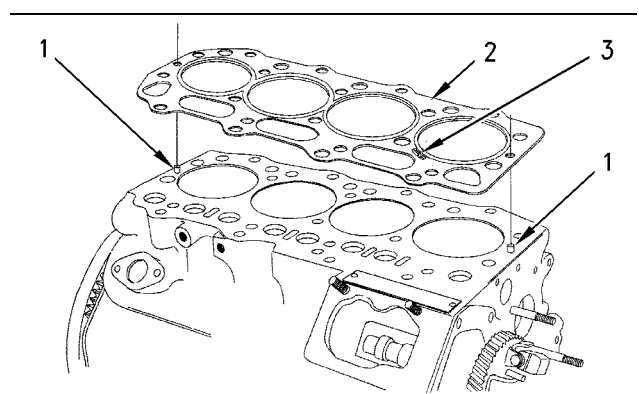
Cylinder Head

Illustration 26

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 2

Selection of Head Gasket for the 402D-05, 403D-07, 403D-11 and 404D-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 3

Selection of Head Gasket for the 403D-15 and 403D-15T Engines	
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 4

Selection of Head Gasket for the 403D-17 Engine	
Piston Height Above Top Face of Cylinder Block	Gasket Thickness
0.45 to 0.55 mm (0.0177 to 0.0217 inch)	1.3 mm (0.051 inch)
0.56 to 0.70 mm (0.0220 to 0.0276 inch)	1.4 mm (0.055 inch)

Table 5

Selection of Head Gasket for the 404D-22, 404D-22T and 404D-22TAE Engines	
Piston Height below Top Face of Cylinder Block	Gasket Thickness
+0.35 to +0.5 mm (+0.0138 to +0.020 inch)	1.2 mm (0.047 inch)
+0.5 to + 0.6 mm (+0.020 to + 0.024 inch)	+1.3 mm (+0.051 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

402D-05 Engine

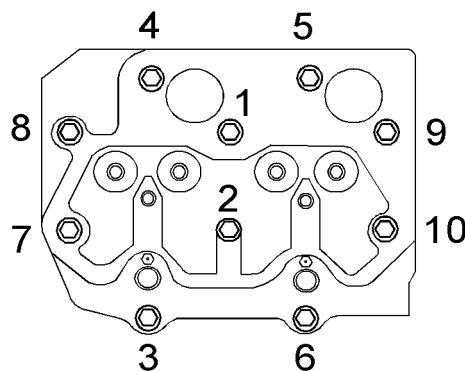


Illustration 27

g01317344

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 27.

Torque for bolts

402D-05 37 N·m (27 lb ft)

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

403D-07, 403D-11, 403D-15, 403D-15T and 403D-17 Engines

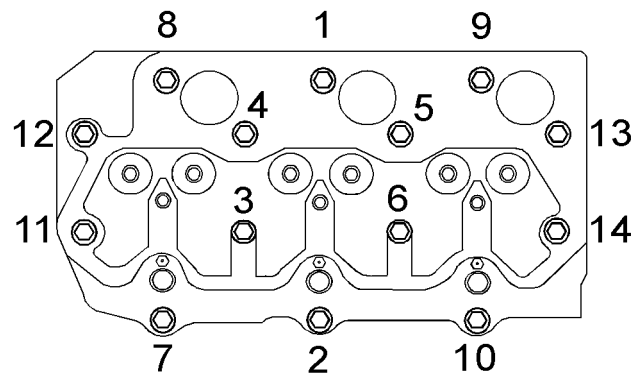


Illustration 28

g01317351

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 28.

Torque for bolts

403D-07	37 N·m (27 lb ft)
403D-11	51 N·m (37 lb ft)
403D-15, 403D-15T and 403D-17	101 N·m (75 lb ft)

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

404D-15, 404D-22, 404D-22T and 404D-22TA Engines

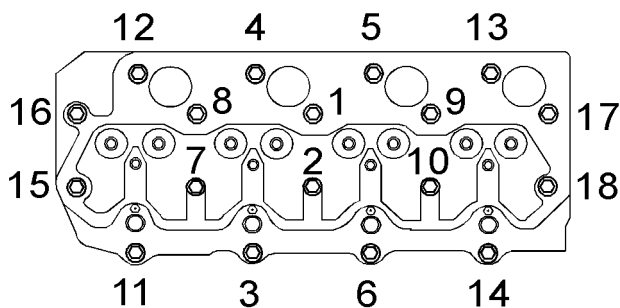


Illustration 29

g01309552

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 29.

Torque for bolts

404D-15	51 N·m (37 lb ft)
404D-22, 404D-22T and 404D-22TA	101 N·m (75 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

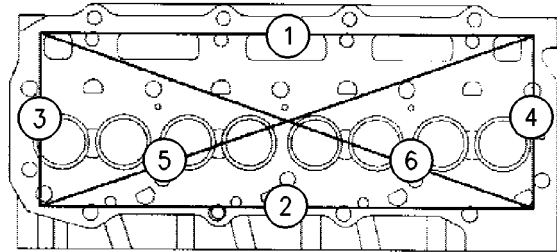


Illustration 30

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 regrounding 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 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.

i02961020

Turbocharger

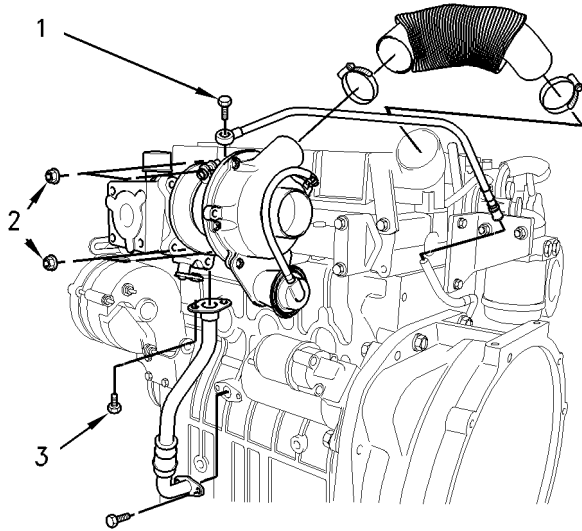


Illustration 31

g00921767

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

i02961021

Exhaust Manifold

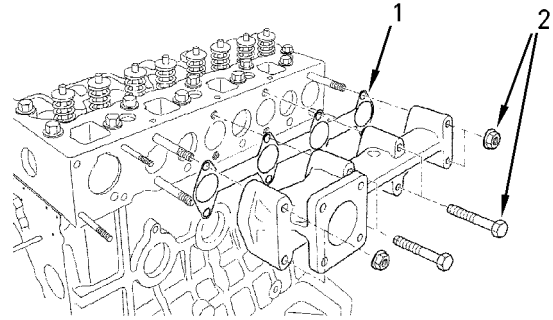


Illustration 32

g00899933

- (1) Gasket
- (2) Torque for the nuts and the setscrews for the exhaust manifold

402D-05, 403D-07, 403D-11 and 404D-15	9.8 N·m (7.2 lb ft)
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	25 N·m (18.4 lb ft)

i02961025

Camshaft

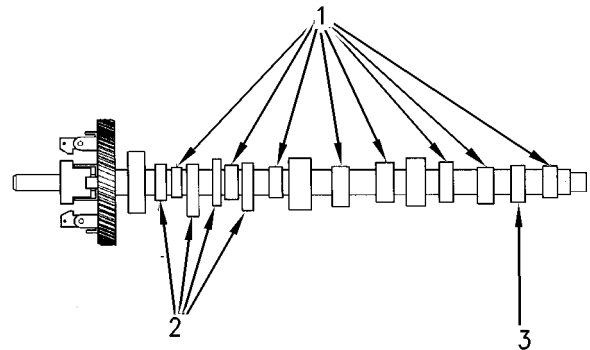


Illustration 33

g00819857

Typical example

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

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

403D-15, 403D-15T and
403D-17 34.453 to 34.507 mm
(1.3564 to 1.3585 inch)

404D-22, 404D-22T and
404D-22TA 34.453 to 34.507 mm
(1.3564 to 1.3585 inch)

Service limit

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 33.7 mm
(1.3270 inch)

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

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

404D-15 40.900 to 41.100 mm
(1.6102 to 1.6181 inch)

403D-15, 403D-15T and
403D-17 41.940 to 42.060 mm
(1.6512 to 1.6559 inch)

404D-22, 404D-22T and
404D-22TA 41.940 to 42.060 mm
(1.6512 to 1.6559 inch)

Service limit

402D-05, 403D-07, 403D-11 and
404D-15 39.8 mm (1.5669 inch)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 41.8 mm
(1.6450 inch)

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

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

403D-15, 403D-15T and
403D-17 31.900 to 32.000 mm
(1.2559 to 1.2598 inch)

404D-22, 404D-22T and
404D-22TA 31.900 to 32.000 mm
(1.2559 to 1.2598 inch)

Service limit

402D-05, 403D-07, 403D-11 and
404D-15 27.0 mm (1.0630 inch)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 30.0 mm
(1.1810 inch)

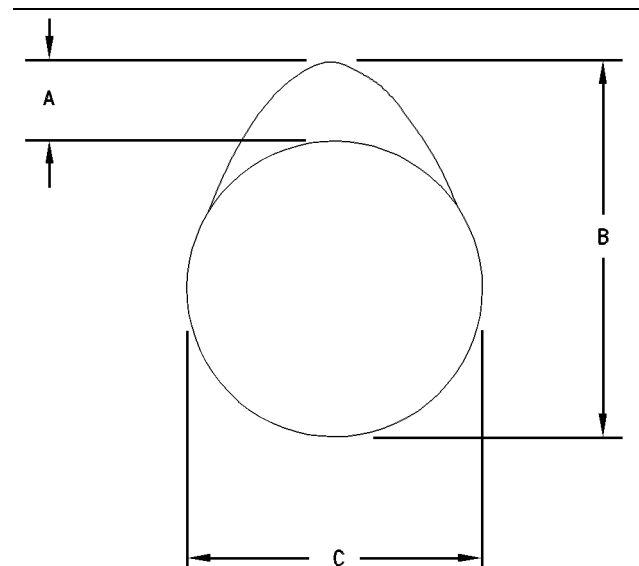


Illustration 34

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.

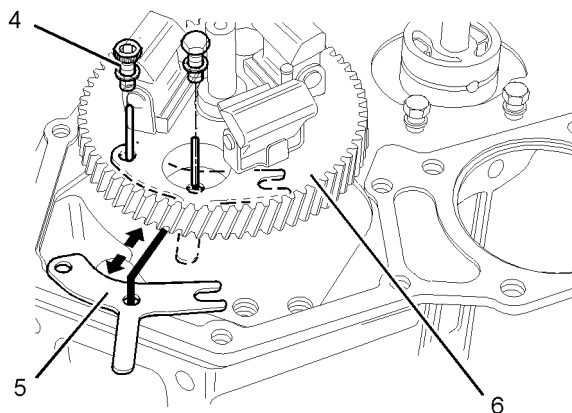


Illustration 35

g01297670

Typical example

(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

i02961066

Engine Oil Lines

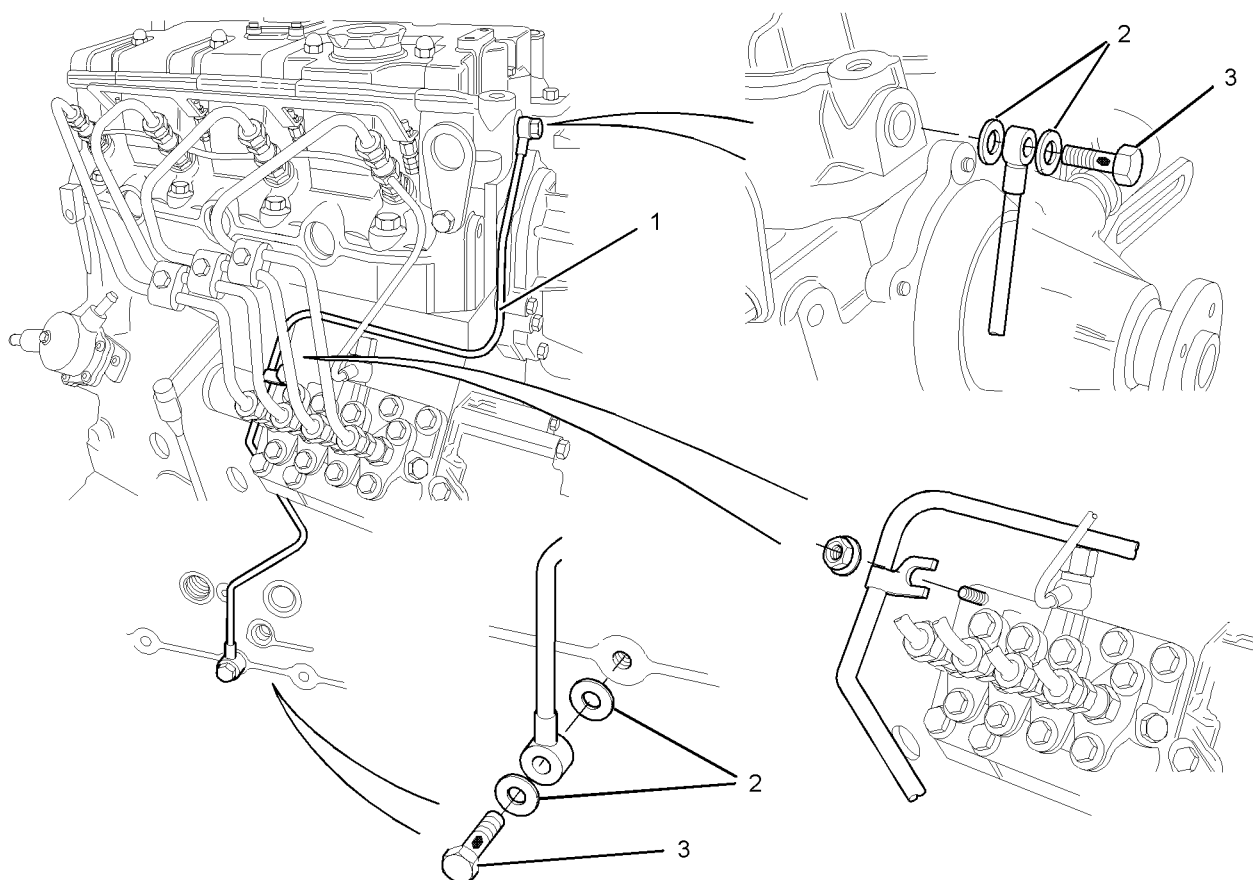


Illustration 36
Typical example

g01093847

(1) Engine oil line

(2) Washers

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

(3) Torque for the banjo bolts 12 N·m (9 lb ft)

i02961095

Engine Oil Relief Valve

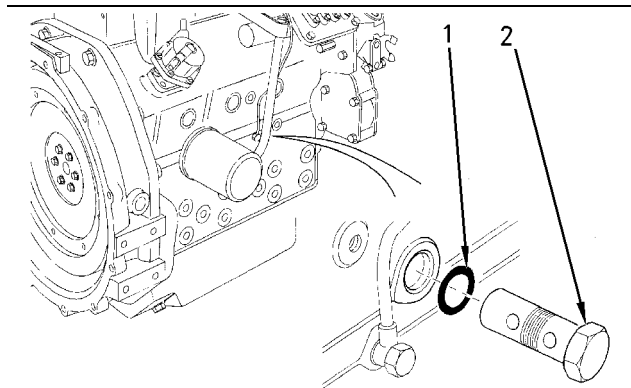


Illustration 37

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.

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

403D-15, 403D-15T and
403D-17 262 to 359 kPa (38 to 52 psi)

402D-05, 403D-07, 404D-22, 404D-22T and
404D-22TA 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.

i02589699

Engine Oil Pump

NOTICE

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

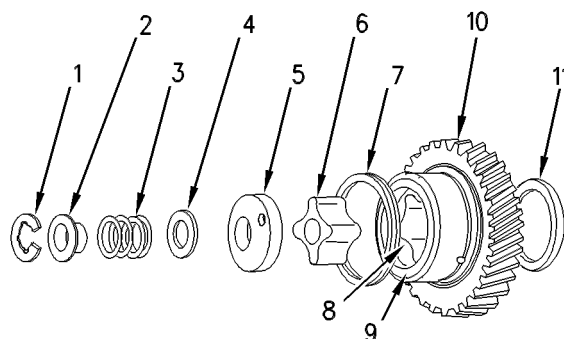


Illustration 38

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

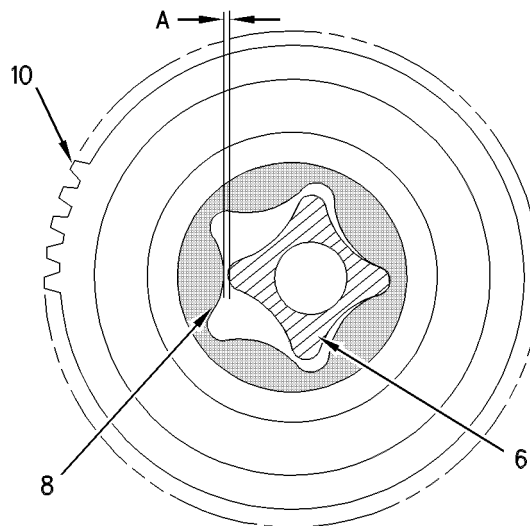


Illustration 39

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

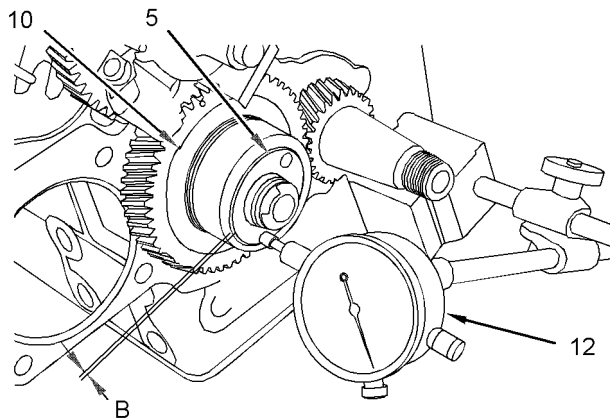


Illustration 40

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 Pan

i02586871

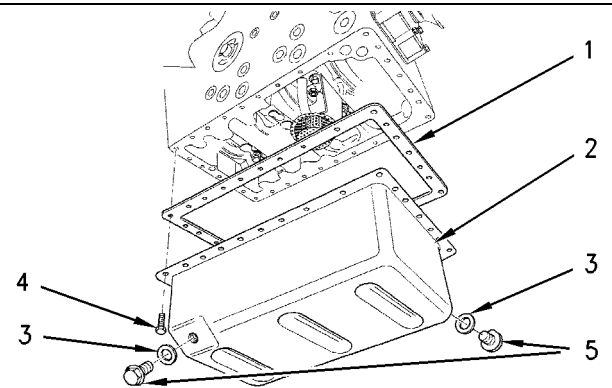


Illustration 41

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

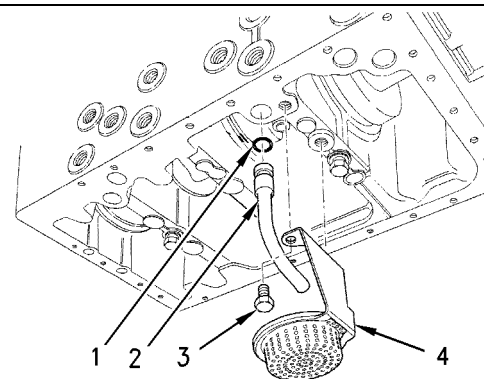


Illustration 42

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.

i02961110

Water Temperature Regulator

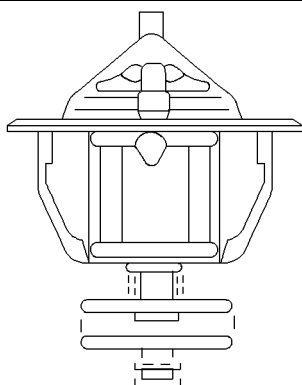


Illustration 43

g00877006

Opening temperature of the water temperature regulator

402D-05, 403D-07, 403D-11 and 404D-15	75 °C (167 °F)
403D-15, 403D-15T and 403D-17	80° to 84°C (176° to 183°F)
404D-22	80° to 84 °C (176° to 183 °F)
404D-22T and 404D-22TA	82 °C (180 °F)

Fully open temperature of the water temperature regulator

402D-05, 403D-07, 403D-11 and 404D-15	87 °C (189 °F)
403D-15, 403D-15T and 403D-17	95 °C (203 °F)
404D-22	95 °C (203 °F)
404C-22T and 404D-22TA	95 °C (203 °F)

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

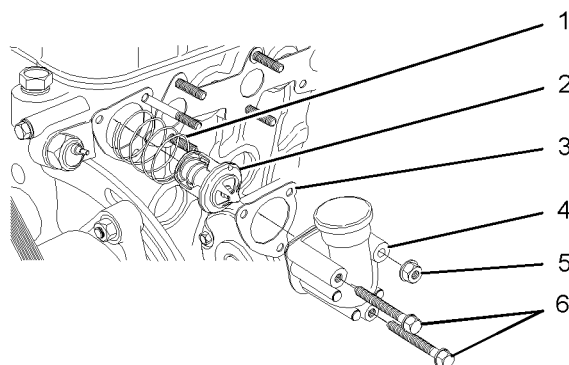


Illustration 44

g01112497

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

Water Temperature Regulator Housing for 403D-11, 403D-15, 403D-15T, 403D-17, 404D-15, 404D-22, 404D-22T and 404D-22TA Engines

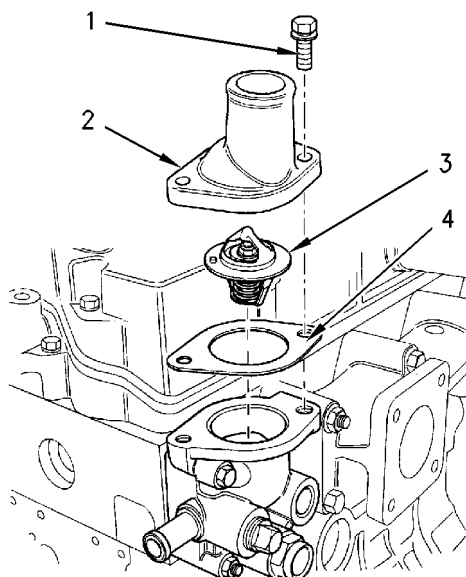


Illustration 45

g00820265

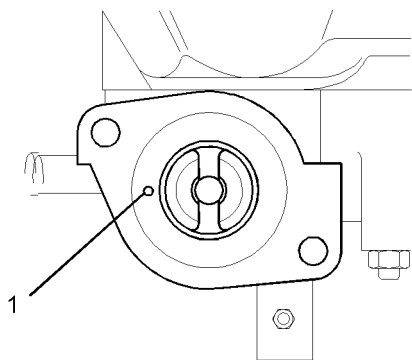


Illustration 46

g01114379

Water temperature regulator for naturally aspirated engines

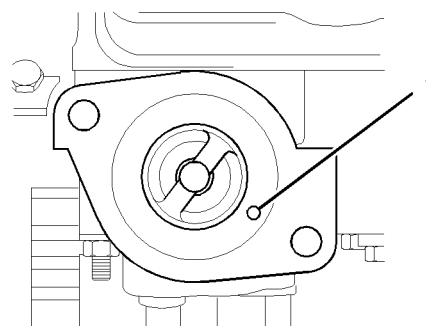


Illustration 47

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 46 and 47.

- (1) Torque for the two setscrews for the water temperature regulator housing
403D-11 and 404D-15 engine 6 N·m (53 lb in)
- (1) Torque for the two setscrews for the water temperature regulator housing
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA engines 14 N·m (10 lb ft)
- (2) Cover
- (3) Water temperature regulator
- (4) Gasket

i02961162

Cylinder Block

Service limit

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

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 84.200 mm
(3.3150 inch)

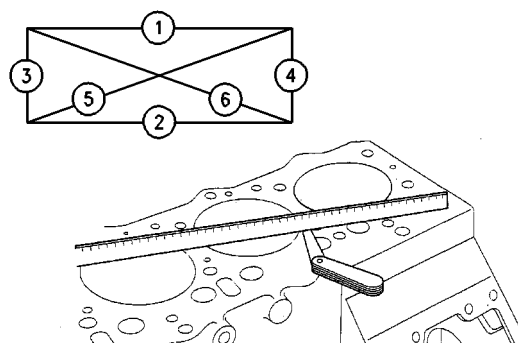


Illustration 49

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.

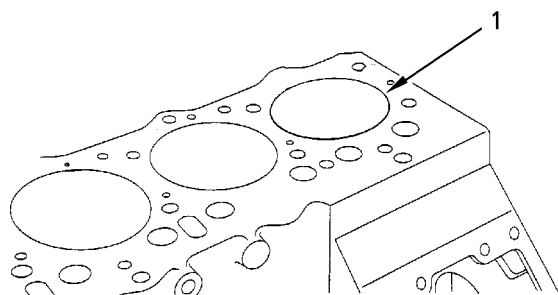


Illustration 48

g00904878

(1) Diameter of the bore in the cylinder block

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

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

403D-15, 403D-15T, 403D-17, 404D-22, 404D-
22T and 404D-22TA 84.000 to 84.019 mm
(3.3071 to 3.3078 inch)

i02961165

Crankshaft

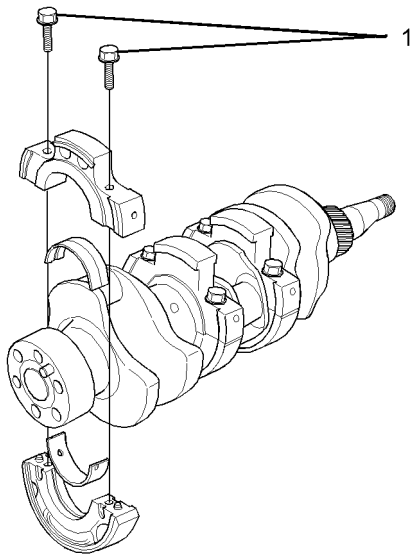


Illustration 50

g01113243

Typical crankshaft for a 3 cylinder engine

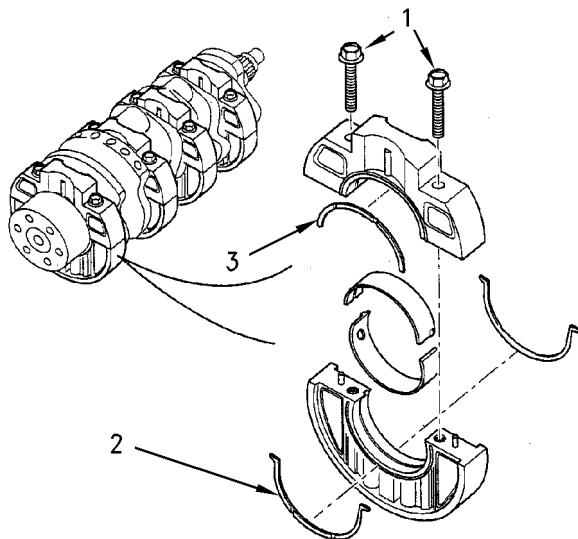


Illustration 51

g00904902

Typical crankshaft for a 4 cylinder engine

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

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 52 N·m (38.3 lb ft)

(2) Thrust washers

402D-05 and 403D-07

Standard thickness 21.85 to 21.95 mm
(0.8602 to 0.8642 inch)

Service limit 21.60 mm (0.8504 inch)

403D-11 and 404D-15

Standard thickness 21.85 to 21.95 mm
(0.8602 to 0.8642 inch)

Service limit 21.60 mm (0.8504 inch)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA

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 402D-05, 403D-07, 403D-11 and 404D-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 404D-22, 404D-22T and 404D-22TA engine.

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

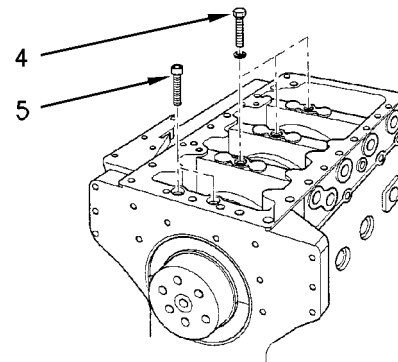


Illustration 52

g00904925

- (4) Tighten the retaining bolts for the crankshaft to the following torque.

402D-05, 403D-07, 403D-11 and
404D-15 27 N·m (19.9 lb ft)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 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 (All models) 0.10 to 0.30 mm
(0.0040 to 0.0118 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.

i02961169

Connecting Rod Bearing Journal

Table 6

Diameter of the 402D-05 and 403D-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 403D-11 and 404D-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 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 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

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

403D-11 (Journals 1 and 2) .. 0.035 to 0.083 mm
(0.0014 to 0.0033 inch)

403D-15, 403D-15T and
403D-17 0.035 to 0.085 mm
(0.00138 to 0.00335 inch)

404D-15 0.035 to 0.083 mm
(0.0014 to 0.0033 inch)

404D-22, 404D-22T and
404D-22TA 0.035 to 0.085 mm
(0.00138 to 0.00335 inch)

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

i02961840

Main Bearing Journal

Table 9

Diameter of 402D-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)

Table 10

Diameter of 403D-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)

Table 11

Diameter of 403D-11 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1 and 2	47.964 to 47.975 mm (1.8883 to 1.8888 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)

Table 12

Diameter of 404D-15 Main Bearing Journals			
Size	Journal	Diameter	Service limit
Standard	1, 2 and 3	47.964 to 47.975 mm (1.8883 to 1.8888 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)

Table 13

Diameter of 403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA 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

402D-05 and 403D-07 0.035 to 0.088 mm
(0.0014 to 0.0035 inch)

403D-11 and 404D-15 0.039 to 0.092 mm
(0.0015 to 0.0036 inch)

403D-15, 403D-15T and
403D-17 0.044 mm to 0.102 mm
(0.0017 inch to 0.0040 inch)

404D-22, 404D-22T and
404D-22TA 0.044 to 0.102 mm
(0.0017 to 0.0040 inch)

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

i02961860

Connecting Rod

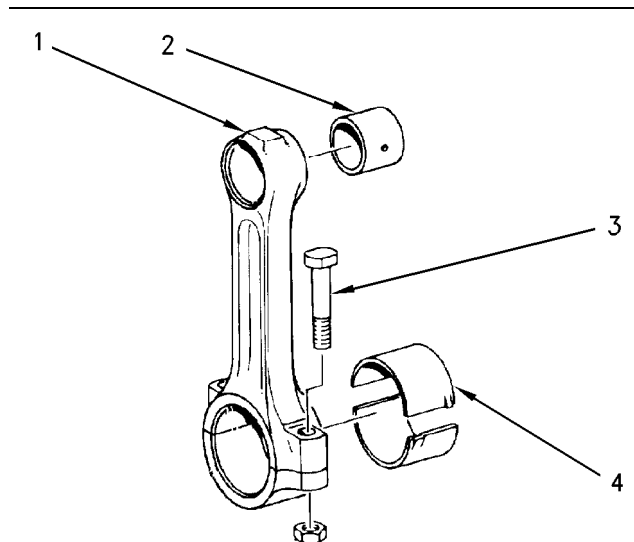


Illustration 53

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

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

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

403D-15, 403D-15T and 403D-17 0.10 mm (0.004 inch)

404D-22, 404D-22T and 404D-22TA 0.10 mm (0.004 inch)

(3) Torque for the nut and the bolt

402D-05 and 403D-07 23 N·m (17 lb ft)

403D-11 and 404D-15 32 N·m (23.6 lb ft)

403D-15, 403D-15T and 403D-17 52 N·m (38 lb ft)

404D-22, 404D-22T and 404D-22TA 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

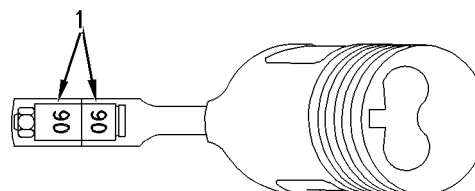


Illustration 54

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.

i02961863

Piston and Rings

Markings on the Piston

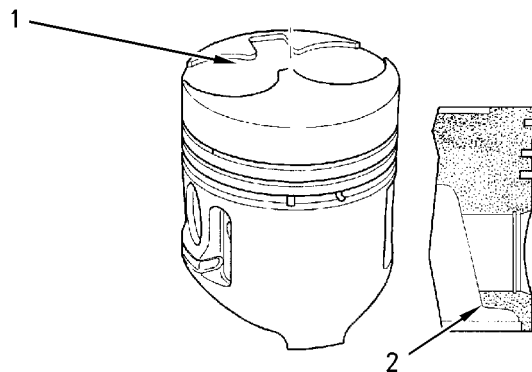


Illustration 55

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

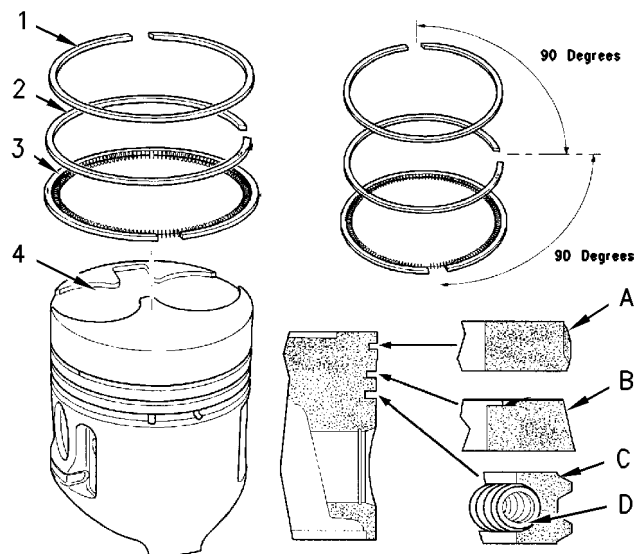


Illustration 56

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 Half keystone

402D-05 and 403D-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 0.28 mm
(0.0051 to 0.0110 inch)

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

403D-11 and 404D-15

Clearance between piston ring groove and top piston ring 0.08 to 0.12 mm
(0.0031 to 0.0047 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)

403D-15, 403D-15T, 403D-17 and 404D-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 403D-15T, 404D-22T and 404D-22TA turbocharged engines. When either the intermediate ring or the oil control ring is outside the service limit, renew all of the rings.

Note: Install the letters "T" or "RN" 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 404D-22T and 404D-22TA 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

402D-05 and 403D-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 0.25 mm
(0.0039 to 0.0098 inch)

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

403D-11 and 404D-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 0.20 to 0.35 mm
(0.0079 to 0.0138 inch)

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA

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)

403D-15, 403D-15T, 403D-17 and 404D-22
gap of the intermediate ring 0.2 to 0.4 mm
(0.0079 to 0.0157 inch)

404D-22T and 404D-22TA
gap of the intermediate ring 0.5 to 0.7 mm
(0.020 to 0.023 inch)

Service limit for gap of intermediate ring .. 1.2 mm
(0.047 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

402D-05 and 403D-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)

403D-11 and 404D-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 0.15 to 0.35 mm
(0.0059 to 0.0138 inch)

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA

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 0.25 to 0.50 mm
(0.0098 to 0.0197 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

402D-05 and 403D-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 .. 18.996 to 19.002 mm
(0.7479 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 to +0.008 mm
(0 to +0.0003 inch)

Service limit 0.02 mm (0.0008 inch)

403D-11 and 404D-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 to +0.008 mm
(0 to +0.0003 inch)

Service limit 0.02 mm (0.0008 inch)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA

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 .. 27.994 to 28.000 mm
(1.1021 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 +0.011 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 gasket thickness.

i02613910

Housing (Front)

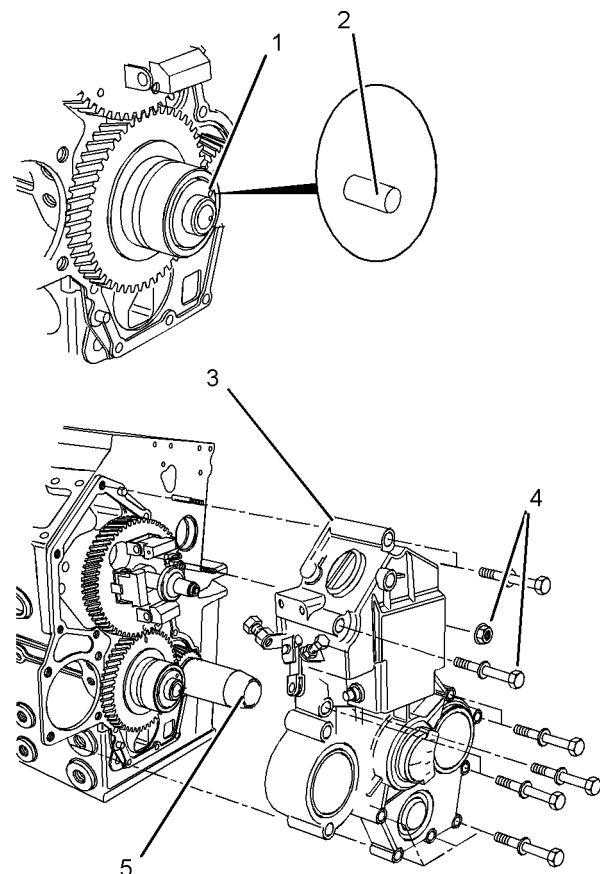


Illustration 57
Typical example

g01308682

- (1) Locator hole
- (2) Locator pin
- (3) Front housing
- (4) 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.

- (5) Seal protector

i02961882

Gear Group (Front)

Table 14

Injection timing		
Engine	Maximum rated engine speed	Injection timing (BTDC) ⁽¹⁾
402D-05 Industrial engine	2800	18° ± 1°
402D-05 Industrial engine	3000	20° ± 1°
402D-05 Industrial engine	3600	21° ± 1°
403D-07 Industrial engine	2800	18° ± 1°
403D-07 Industrial engine	3000	20° ± 1°
403D-07 Industrial engine	3600	21° ± 1°
403D-11 Industrial engine	2200	23° ± 1°
403D-11 Industrial engine	2600	24° ± 1°
403D-11 Industrial engine	2800	24° ± 1°
403D-11 Industrial engine	3000	24° ± 1°
403D-11 Industrial engine	3400	23° ± 1°
403D-11 Industrial engine	3600	23° ± 1°
403D-15 Industrial engine	2200	22° ± 1°

(continued)

(Table 14, contd)

403D-15 Industrial engine	2400	22° ± 1°
403D-15 Industrial engine	2600	22° ± 1°
403D-15 Industrial engine	2800	22° ± 1°
403D-15 Industrial engine	3000	22° ± 1°
403D-15T Industrial engine	2200	17° ± 1°
403D-15T Industrial engine	2400	17° ± 1°
403D-15T Industrial engine	2600	17° ± 1°
403D-15T Industrial engine	2800	17° ± 1°
403D-15T Industrial engine	3000	17° ± 1°
403D-17 Industrial engine	2400	20° ± 1°
403D-17 Industrial engine	2600	20° ± 1°
404D-15 Industrial engine	2800	22° ± 1°
404D-15 Industrial engine	3000	22° ± 1°
404D-22 Industrial engine	2200	19° ± 1°
404D-22 Industrial engine	2400	19° ± 1°
404D-22 Industrial engine	2600	20° ± 1°
404D-22 Industrial engine	2800	20° ± 1°
404D-22 Industrial engine	3000	20° ± 1°
404D-22 Industrial engine	2800 DERATE	20° ± 1°
404D-22 Industrial engine	3000 DERATE	20° ± 1°
404D-22 with balancer	2800	20° ± 1°
404D-22T Industrial engine	2600	19° ± 1°
404D-22T Industrial engine	2800	20° ± 1°
404D-22T Industrial engine	3000	20° ± 1°

(continued)

(Table 14, contd)

404D-22T with Balancer	2600	$19^{\circ} \pm 1^{\circ}$
404D-22TA Industrial engine	2800	$23^{\circ} \pm 1^{\circ}$

(1) Before Top Dead Center

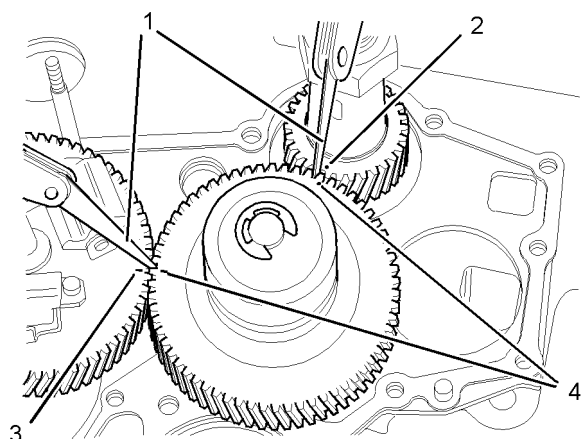


Illustration 58

g01298853

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).

Flywheel

i02590383

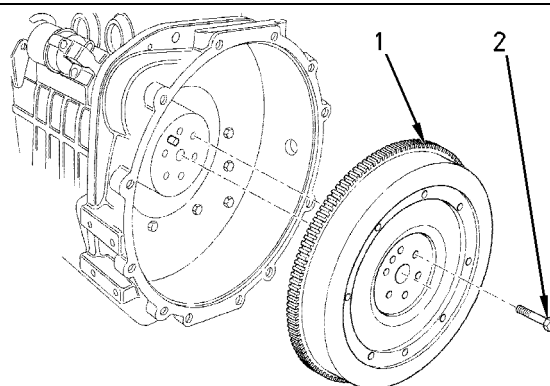


Illustration 59

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)

i02961960

Flywheel Housing

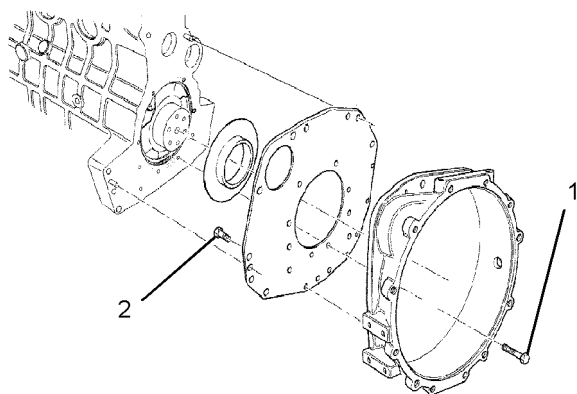


Illustration 60

g01442020

(1) Torque for the setscrews for the back plate

402D-05 and 403D-07	15 N·m (11 lb ft)
403D-11 and 404D-15	50 N·m (36.9 lb ft)
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	25 N·m (18.8 lb ft)

(2) Torque for the setscrews for the flywheel housing

402D-05 and 403D-07	15 N·m (11 lb ft)
403D-11 and 404D-15	50 N·m (36.9 lb ft)
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	25 N·m (18.8 lb ft)

i02961964

Crankshaft Pulley

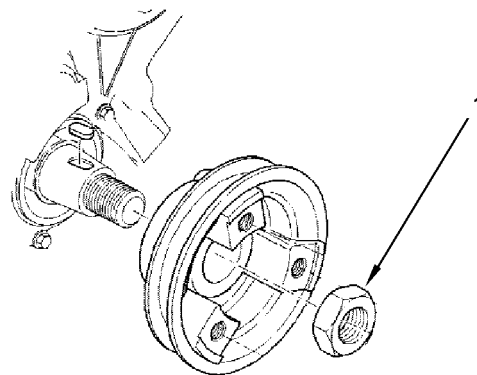


Illustration 61

g00904688

(1) Torque for the crankshaft pulley nut

402D-05 and 403D-07	93 N·m (68.6 lb ft)
403D-11 and 404D-15	123 N·m (90.7 lb ft)
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	304 N·m (224.2 lb ft)

i02585985

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.

i02590411

Fan Drive

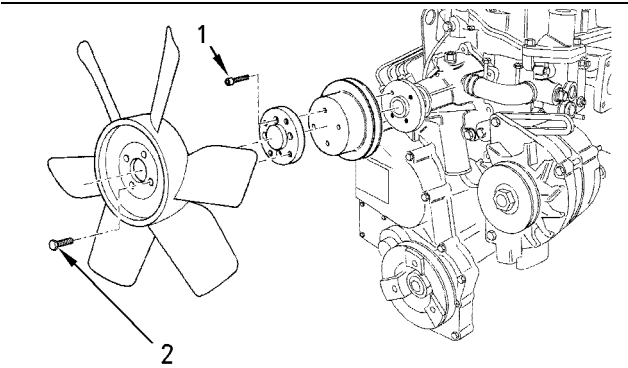


Illustration 62 g00904732

- (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)

i02590622

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)

i02961981

Alternator and Regulator

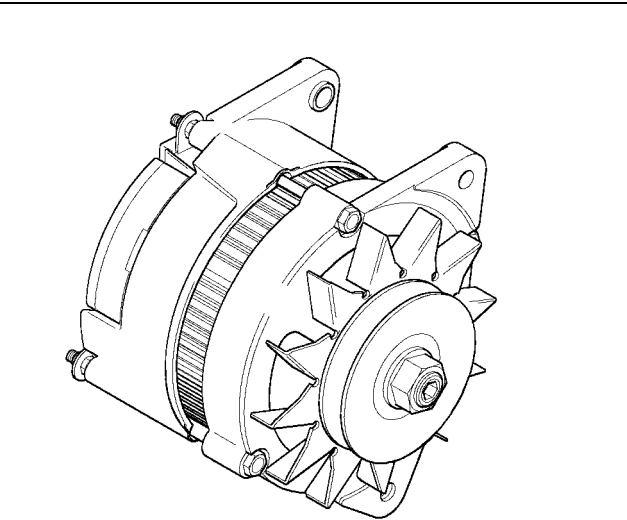


Illustration 63 g00909016
Typical Example

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

402D-05 and 403D-07	14 amperes
403D-11	15 or 40 amperes
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	55, 65 or 85 amperes
404D-15	40 amperes

i02962000

Electric Starting Motor

Starting Motor

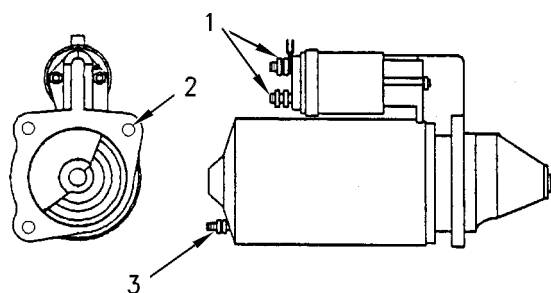


Illustration 64

g00379835

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

402D-05 and 403D-07	
Standard	0.8 kilowatts
Option	1.2 kilowatts
403D-11	
Standard	1.4 kilowatts
Option	1.1 kilowatts
404D-15	1.4 kilowatts
403D-15, 403D-15T, 403D-17, 404D-22, 404D-22T and 404D-22TA	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

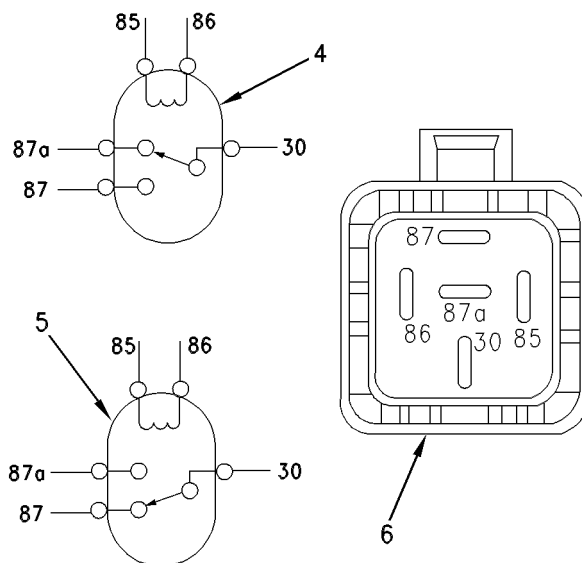


Illustration 65

g00381753

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

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Coolant Temperature Switch

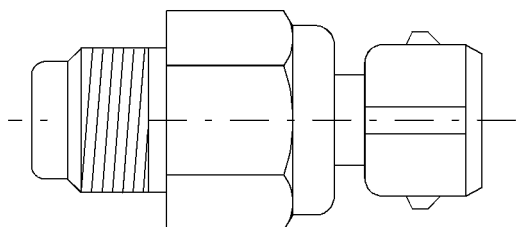


Illustration 66

g01094334

Typical coolant temperature switch

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

Engine Oil Pressure Switch

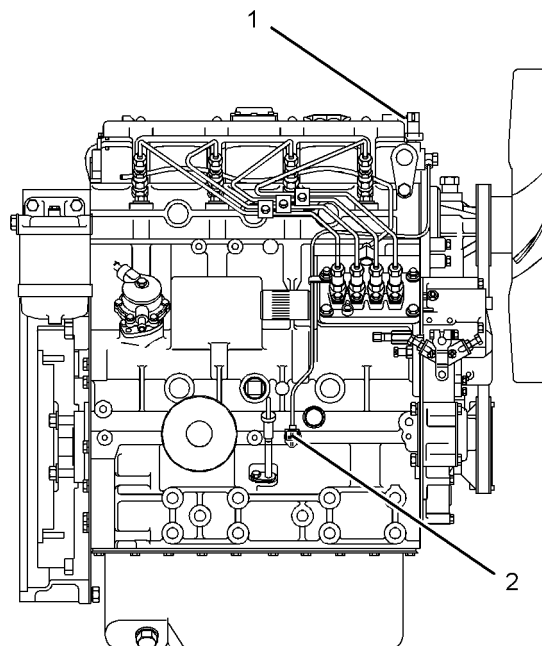


Illustration 67

g01335504

Typical example

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

Torque for the engine oil pressure switch .. 11 N·m
(97 lb in)

403D-11

..... (Deutsch) Green sticker with a white dot

402D-05, 403D-07, 403D-15, 403D-15T,
403D-17, 404D-15, 404D-22, 404D-22T and
404D-22TA (Amp) Brown connector

Pressure rating

403D-11 49.0 kPa (7.11 psi)

402D-05, 403D-07, 403D-15, 403D-15T,
403D-17, 404D-15, 404D-22, 404D-22T and
404D-22TA 29.4 kPa (4.26 psi)

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

Torque for the engine oil pressure switch .. 23 N·m
(17 lb ft)

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

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

403D-15, 403D-15T, 403D-17, 404D-22, 404D-
22T and 404D-22TA (Amp) Black connector

Pressure rating

403D-11 49.0 kPa (7.11 psi)

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

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA ... 68.9 kPa (10.0 psi)

i02962420

Glow Plugs

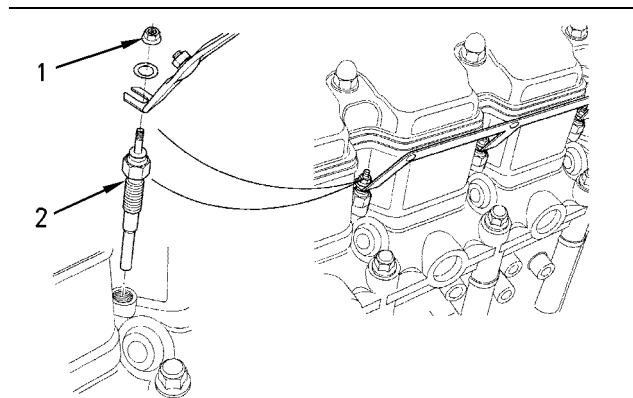


Illustration 68

g00904843

(1) Torque for the nut on the bus bar
(All models) 1.2 N·m (11 lb in)

(2) Torque for the glow plug

402D-05, 403D-07, 403D-11 and
404D-15 12 N·m (106 lb in)

403D-15, 403D-15T, 403D-17, 404D-22,
404D-22T and 404D-22TA 18 N·m (13 lb ft)

Fuel Shutoff Solenoid

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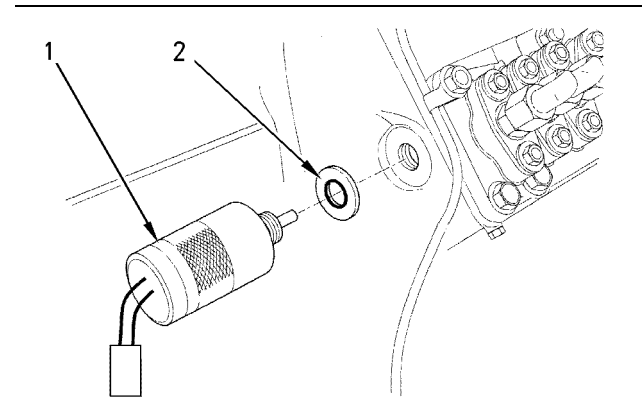


Illustration 69

g00820306

(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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