SENR9979-01
September 2007

Specifications

1106D Industrial Engine

PJ (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.

⚠ WARNING

The meaning of this safety alert symbol is as follows:

Attention! Become Alert! Your Safety is Involved.

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

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

Perkins cannot anticipate every possible circumstance that might involve a potential hazard. The warnings in this publication and on the product are, therefore, not all inclusive. 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.

⚠ WARNING

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

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

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Engine Design

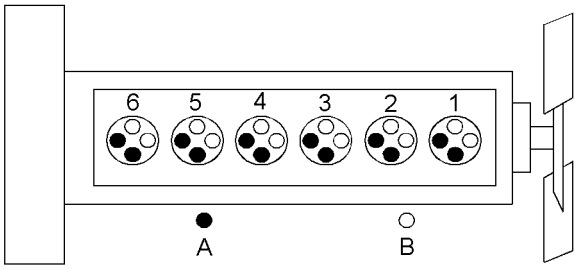

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Illustration 1

Cylinder and valve location

(A) Exhaust valve
(B) Inlet valve

Bore ..... 105 mm (4.133 inch)

Stroke ..... 127 mm (5.000 inch)

Displacement ..... 6.6 L (403 cu in)

Cylinder arrangement ..... In-line

Type of combustion ..... Direct injection

Compression ratio

Turbocharged aftercooled 16.2:1

Number of cylinders 6

Valves per cylinder 4

Valve lash

Inlet valve ..... 0.35 mm (0.0138 inch)
Exhaust valve ..... 0.35 mm (0.0138 inch)

Firing order 1, 5, 3, 6, 2, 4

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. The left side and the right side of the engine are viewed from the flywheel end. The No. 1 cylinder is the front cylinder.

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Fuel Injection Lines

⚠ WARNING

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

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

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

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

Manifold to Injector

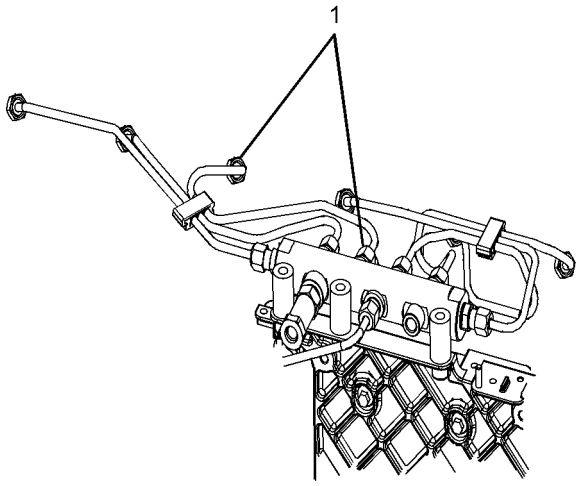

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Illustration 2

Typical example

(1) Tighten the nuts for the high pressure fuel lines to the following torque. ... 30 ± 2.4 N·m (22 ± 2 lb ft)

Pump to Manifold

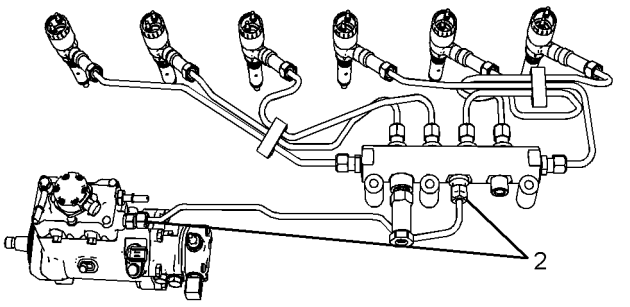

Illustration 3 g01344392
Typical example

(2) Tighten the nuts for the high pressure fuel line to the following torque. ... 30 ± 2.4 N·m (22 ± 2 lb ft)

i02711163

Fuel Injection Pump

Note: Before the pump is removed from the engine the fuel injection pump shaft must be locked. Position the engine to TC compression stroke of number one cylinder before tightening the locking screw. The locking screw will prevent the shaft from rotating. If the fuel injection pump was removed prior to correctly timing the engine and locking the shaft, the fuel injection pump will need to be timed by trained personnel. In order to time the fuel injection pump, refer to Disassembly and Assembly, “Fuel Injection Pump - Install”.

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

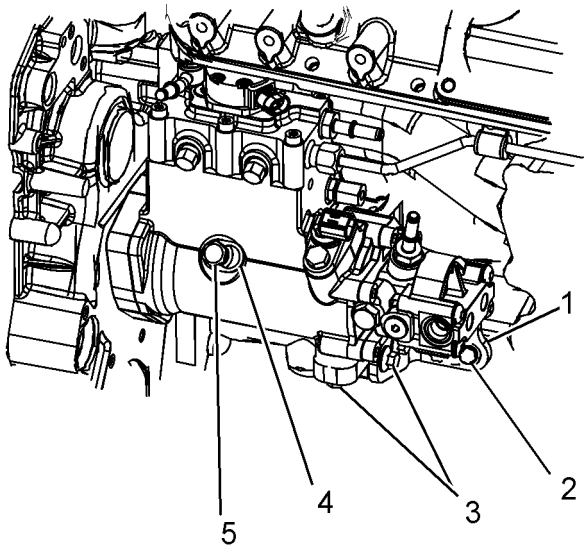

Illustration 4 g01360951
Typical example

(1) Support bracket

(2) Setscrew

(3) Setscrews

(4) Washer

(5) Locking screw

Locking the shaft

Loosen locking screw (5) and move the washer (4) to the locked position. Tighten the locking screw to the following torque. .... 9 N·m (79 lb in)

Unlocking the shaft

Loosen locking screw (5) and move the washer (4) to the unlocked position. Tighten the locking screw to the following torque. ..... 9 N·m (79 lb in)

(2) Tighten the mounting setscrews to the following torque. ..... 44 N·m (32 lb ft)

(3) Tighten the mounting setscrews and the nut to the following torque. ..... 22 N·m (16 lb ft)

Note: The support bracket must be installed after the coolant pump is installed. In order to stop the distortion of the timing case, finger tighten the setscrew (2) and then tighten the setscrews (3).

Tighten the bolts that hold the fuel pump to the front housing to the following torque. ..... 25 N·m (18 lb ft)

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Fuel Injectors

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

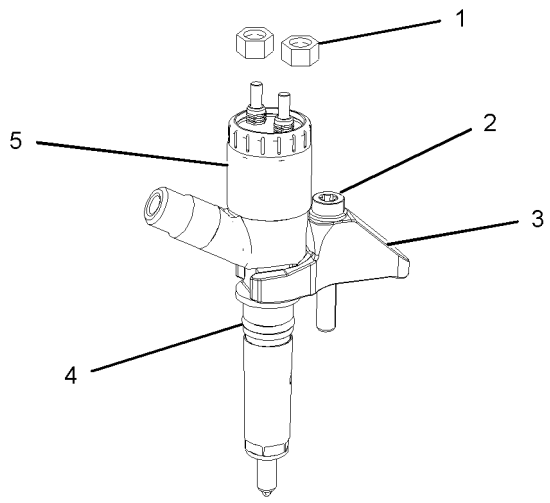

Illustration 5 g01179017

(1) Tighten the nuts to the following torque 2.4 N·m (21 lb in).

(2) Tighten the bolt in the clamp for the fuel injection nozzle to the following torque. .. 27 N·m (19 lb ft)

(3) Clamp

(4) O ring seal

(5) trim code

Note: Refer to the Troubleshooting guide, “Injector Trim File” for more information.

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Fuel Transfer Pump

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

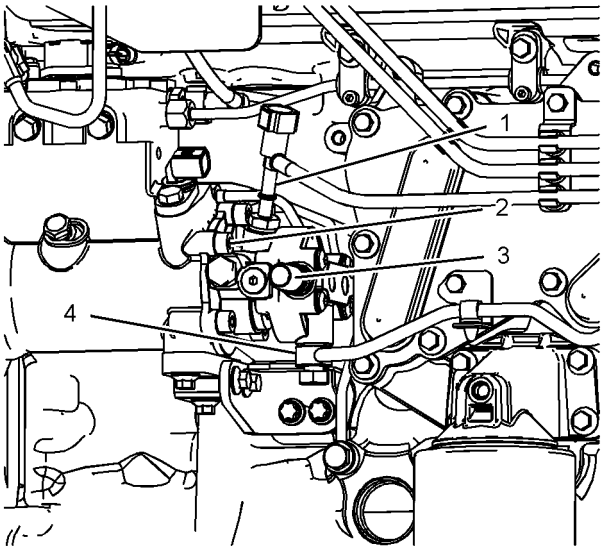

Illustration 6 g01360953

(1) Fuel outlet
(2) Retaining setscrew
(3) Fuel supply
(4) Fuel return from cylinder head

(2) Retaining setscrew ..... 30 N·m (22 lb ft)

The outlet pressure for the fuel ..... 400 to 500 kPa (58.0160 to 72.5200 psi)

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Fuel Filter Base

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

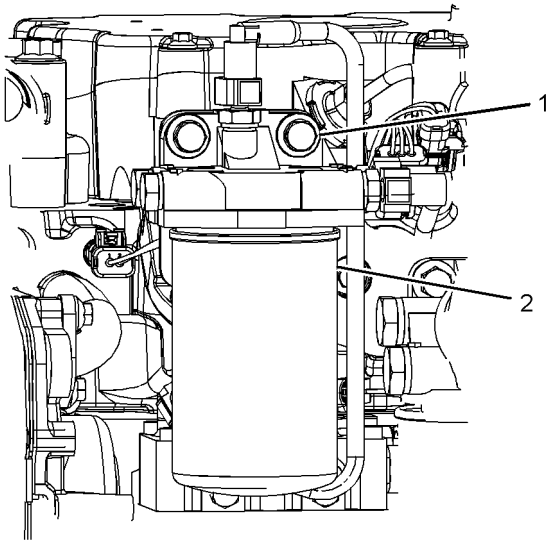

Illustration 7 g01344713
Typical example

(1) Retaining setscrew ..... 44 N·m (32 lb ft)

(2) The canister for the fuel filter

i02711169

Fuel Priming Pump

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

Hand Fuel Priming Pump

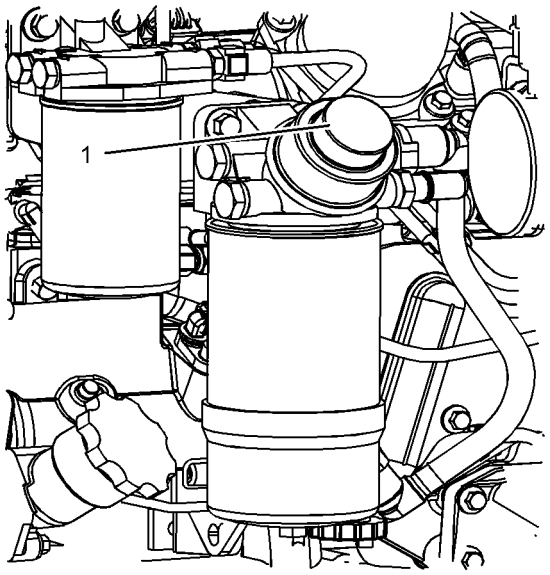

Illustration 8 g01360958
Typical example

(1) The plunger that is hand operated.

Electric fuel Priming Pump

The electric fuel priming pump operates on 12 volts or 24 volts.

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Lifter Group

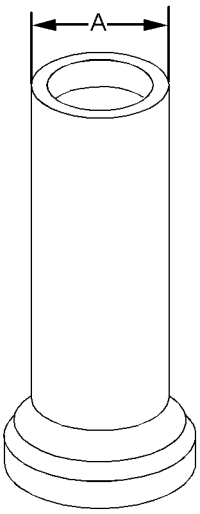

Illustration 9 g01344742

(A) Diameter of the lifter body .. 18.987 to 19.012 mm (0.7475 to 0.7485 inch)

Bore diameter in the cylinder block ..... 19.05 to 19.082 mm (0.7500 to 0.7513 inch)

Clearance

Clearance of the lifter ..... 0.038 to 0.095 mm (0.0015 to 0.0037 inch)

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Rocker Shaft

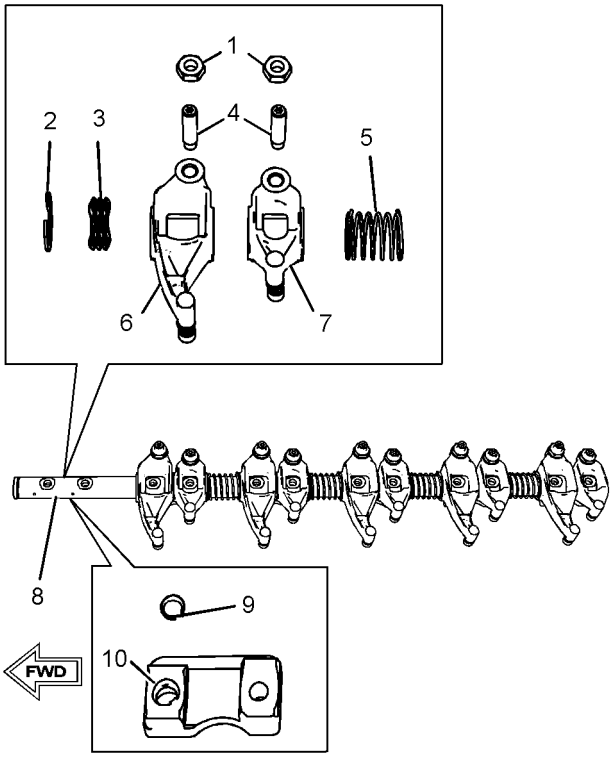

Illustration 10 g01333829

Typical example

(1) Locknut

Torque for the locknut ..... 27 N·m (20 lb ft)

(2) Snap ring

(3) Spring

(4) Adjuster

(5) Spring

(6) Inlet rocker arm

Diameter of the rocker arm bore .... 25.013 to 25.051 mm (0.9848 to 0.9863 inch)

(7) Exhaust rocker arm

Diameter of the rocker arm bore .... 25.013 to 25.051 mm (0.9848 to 0.9863 inch)

Clearance

Maximum clearance of both the rocker arm bores. ..... 0.089 mm (0.0035 inch)
The service limit for both rocker arm bores ..... 0.17 mm (0.0067 inch)

(8) Rocker shaft

Diameter of the rocker shaft ..... 24.962 to 24.987 mm (0.9828 to 0.9837 inch)

(9) Locator

(10) Pedestal

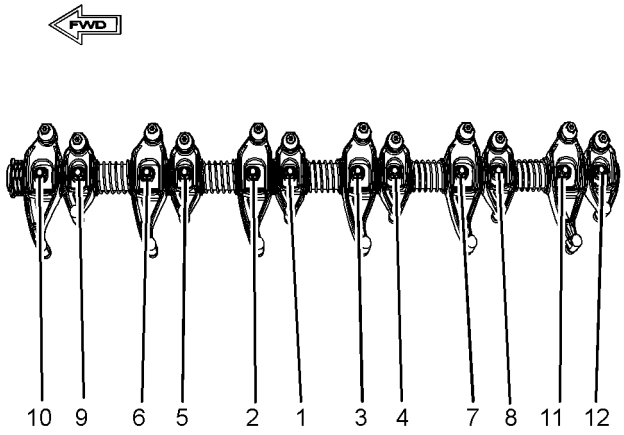

Illustration 11 g01333830

Tightening sequence

Tighten the fasteners in the sequence that is in illustration 11. Tighten the fasteners to the following torque. ..... 35 N·m (25 lb ft)

i02634785

Valve Mechanism Cover

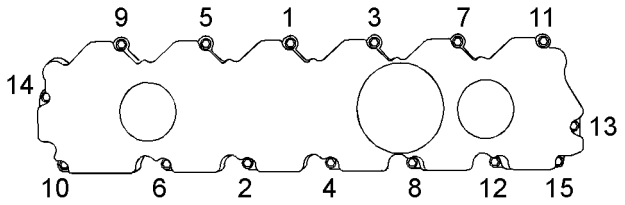

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Illustration 12

Typical example

Tighten the bolts for the valve mechanism cover in the sequence that is shown in illustration 12 to the following torque. ..... 6 N·m (53 lb in)

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Cylinder Head Valves

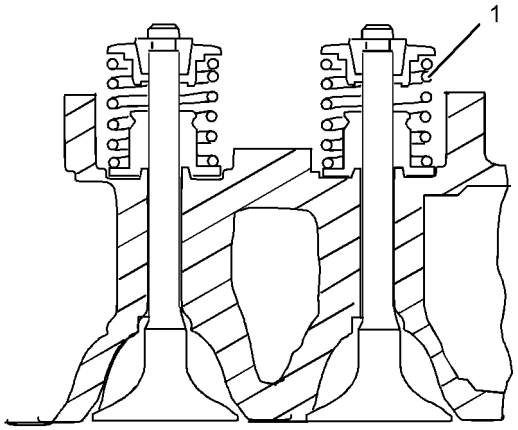

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Illustration 13

Typical example

The same valve spring (1) is used on both valves.

When the valve springs are replaced the valve springs must be replaced in pairs.

Refer to table 1 for information on the length of the valve spring and the load of the valve spring.

Table 1

The load for the valve spring	The length of the valve spring
147.3 to 162.8 N (33.1145 to 36.5991 lb)	31.5 mm (1.2402 inch)
296.4 to 327.6 N (66.6337 to 73.6478 lb)	22.2 mm (0.8740 inch)

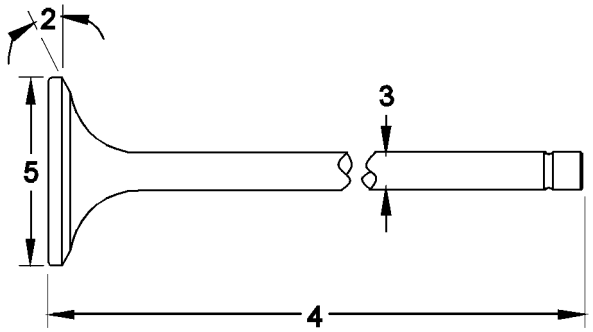

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Illustration 14

(2) Valve face angle

Inlet ..... 30 degrees
Exhaust ..... 45 degrees

(3) Valve stem diameter

Inlet .. 5.942 to 5.957 mm (0.2339 to 0.2345 inch)
Exhaust ..... 5.927 to 5.942 mm (0.2333 to 0.2339 inch)

Clearance

Maximum clearance of the inlet valve stem ..... 0.05 mm (0.0020 inch)
The service limit for the inlet valve stem ..... 0.08 mm (0.0031 inch)

Clearance

Maximum clearance of the exhaust valve stem ..... 0.065 mm (0.0026 inch)
The service limit for the inlet valve stem ..... 0.09 mm (0.0035 inch)

(4) Length of valve

Inlet valve ..... 107.925 to 108.375 mm (4.2490 to 4.2667 inch)
Exhaust valve ..... 107.703 to 108.153 mm (4.2403 to 4.2580 inch)

(5) Valve head

Diameter of inlet valve head ..... 35 mm (1.3780 inch)
Diameter of exhaust valve head ..... 33 mm (1.2992 inch)

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Cylinder Head

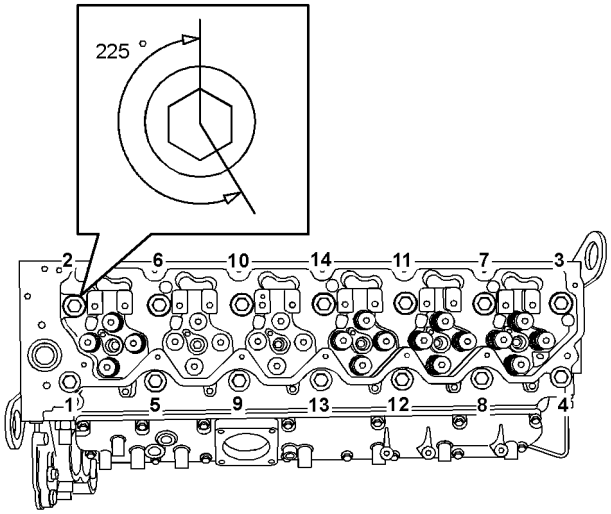

Illustration 15 g01345226
Typical example

Lubricate the threads and the underside of the head bolts with clean engine oil.

Tighten the bolts in the sequence that is shown in Illustration 15 to the following torque. ..... 50 N·m (37 lb ft)
Tighten the bolts again to the following torque. ..... 100 N·m (74 lb ft)
Tighten the head bolts to the additional amount. ..... 225 degrees

Minimum thickness of cylinder head ..... 94.80 mm (3.7323 inch)

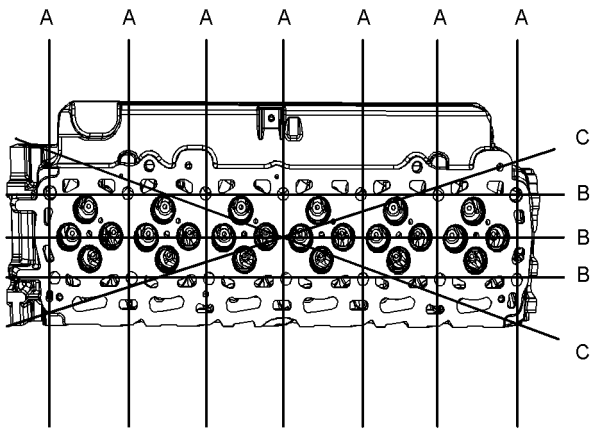

Illustration 16 g01345227
Typical example

Note: The maximum distortion of the cylinder head is given in table 2.

Table 2

Dimension	Maximum Permissible Distortion
Width (A)	0.03 mm (0.0012 inch)
Length (B)	0.05 mm (0.0020 inch)
Diagonal Line (C)	0.05 mm (0.020 inch)

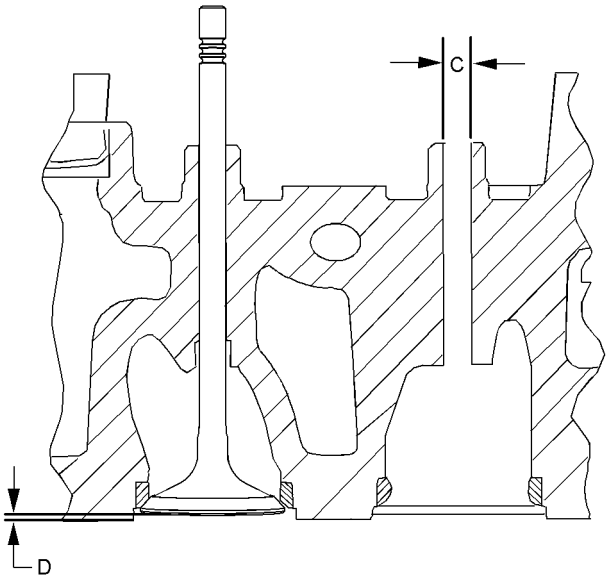

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Illustration 17

Typical example

(C) Valve guide bores

Inlet and exhaust ..... 5.979 to 5.992 mm (0.2354 to 0.2359 inch)

(D) Valve depths

Inlet .. 0.905 to 1.163 mm (0.0356 to 0.0458 inch)
The service limit for the depth of the inlet valve ..... 1.41 mm (0.0555 inch)
Exhaust ..... 0.876 to 1.131 mm (0.0345 to 0.0445 inch)
The service limit for the exhaust valve depth ..... 1.38 mm (0.0543 inch)

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Turbocharger

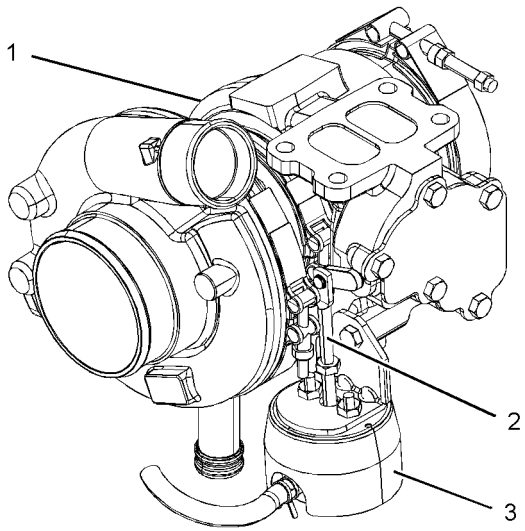

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Illustration 18

Typical example

(1) Turbocharger

(2) Actuator rod

(3) Actuator

The maximum test pressure for the wastegate ..... 80 kPa (11.6032 psi)

The movement for the rod actuator ..... 1 mm (0.0394 inch)

Table 3

The part number for the turbocharger	The pressure for the wastegate
2674A256	60 kPa (8.7024 psi)
2674A604	60 kPa (8.7024 psi)
2674A238	60 kPa (8.7024 psi)
2674A609	60 kPa (8.7024 psi)
2674A236	80 kPa (11.6032 psi)
2674A237	80 kPa (11.6032 psi)
2674A271	80 kPa (11.6032 psi)
2674A607	80 kPa (11.6032 psi)
2674A608	80 kPa (11.6032 psi)

Table 4

Engine kW	The pressure for the wastegate
90 to 130 kW (120.6900 to 174.3300 hp)	60 kPa (8.7024 psi)
131 to 168 kW (175.6710 to 225.2880 hp)	80 kPa (11.6032 psi)

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Inlet Manifold

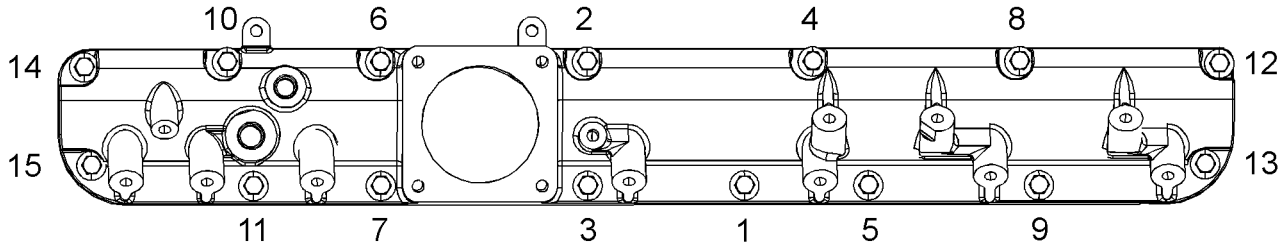

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Illustration 19

Typical example

Tighten the setscrew in the sequence in illustration 19 to the following torque. ..... 22 N·m (16 lb ft)

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Exhaust Manifold

Exhaust manifold for Top Mounted Turbocharger

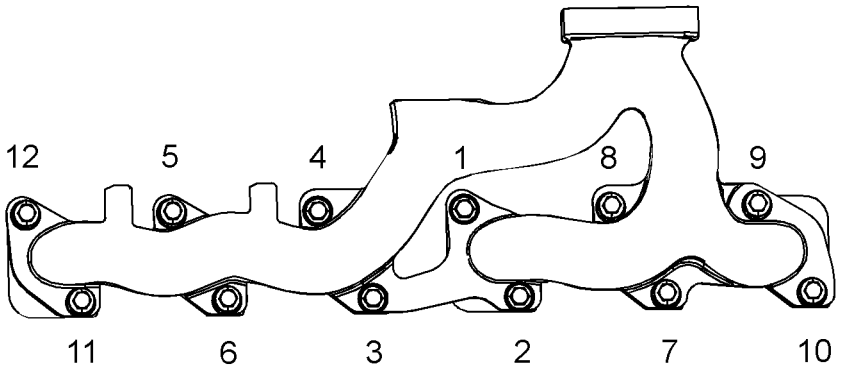

Illustration 20 g01332117

Typical example

Tighten the exhaust manifold bolts in the sequence that is shown in illustration 20 to the following torque. ..... 44 N·m (32 lb ft)

Exhaust manifold for Side Mounted Turbocharger

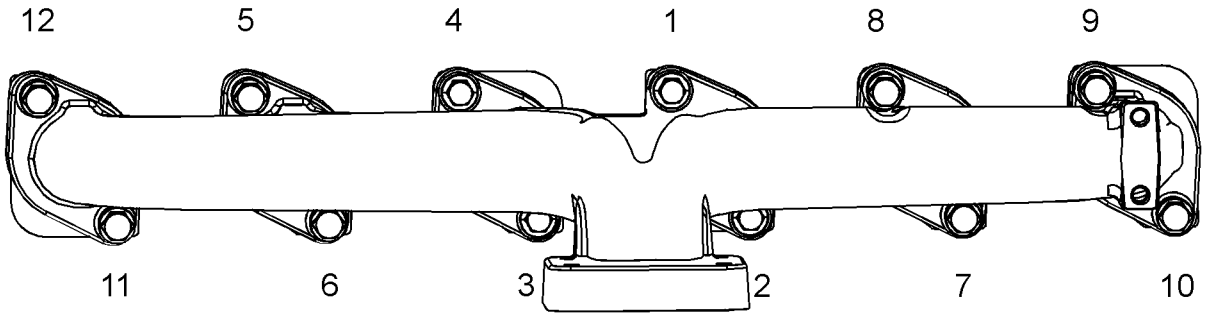

Illustration 21 g01332119

Typical example

Tighten the exhaust manifold bolts in the sequence that is shown in illustration 21 to the following torque. ..... 44 N·m (32 lb ft)

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Camshaft

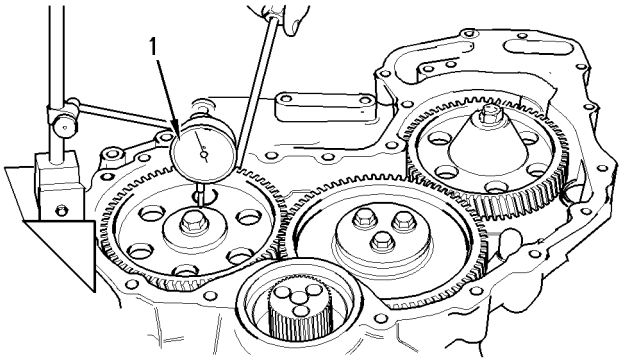

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Illustration 22

Checking the end play of the camshaft

(1) End play of a camshaft ..... 0.126 to 0.558 mm (0.0050 to 0.0220 inch)

Maximum permissible end play of a worn camshaft ..... 0.62 mm (0.0244 inch)

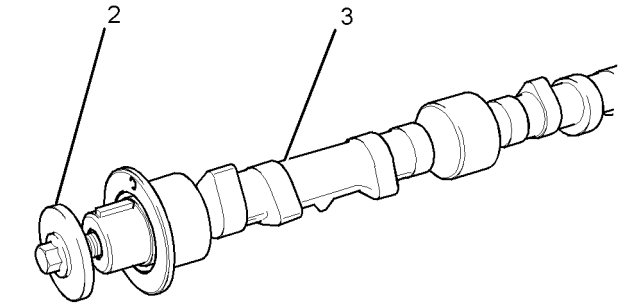

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Illustration 23

Typical example

(2) Bolt

Tighten the bolt to the following torque. ... 95 N·m (70 lb ft)

(3) The diameters of the camshaft journals are given in the following tables.

Table 5

Camshaft Journals	Standard Diameter
1	50.711 to 50.737 mm (1.9965 to 1.9975 inch)
2	50.457 to 50.483 mm (1.9865 to 1.9875 inch)
3	50.203 to 50.229 mm (1.9765 to 1.9775 inch)
4	49.949 to 49.975 mm (1.9665 to 1.9675 inch)

Maximum wear on the camshaft journals ... 0.05 mm (0.0021 inch)

Check the camshaft lobes for visible damage. If a new camshaft is installed you must install new lifters.

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Camshaft Bearings

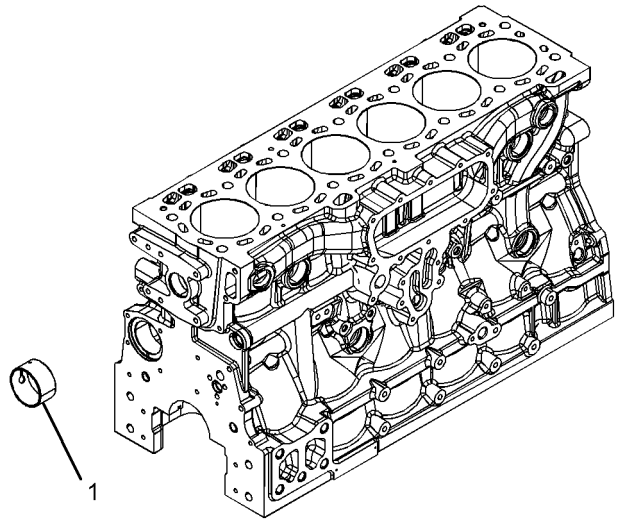

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Illustration 24

Typical example

(1) The diameter of the installed camshaft bearing ..... 50.787 to 50.848 mm (1.9995 to 2.0019 inch)

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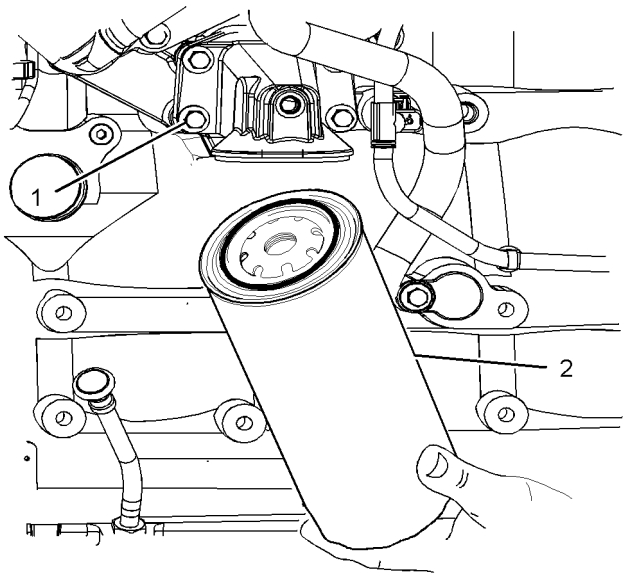
Engine Oil Filter Base



g01332125

Illustration 25

Typical example

(1) Setscrew

Tighten the setscrews to the following torque. ..... 22 N·m (16 ft)

(2) Engine oil filter

Tighten the engine oil filter to the following torque. ..... 12 N·m (8 lb ft)

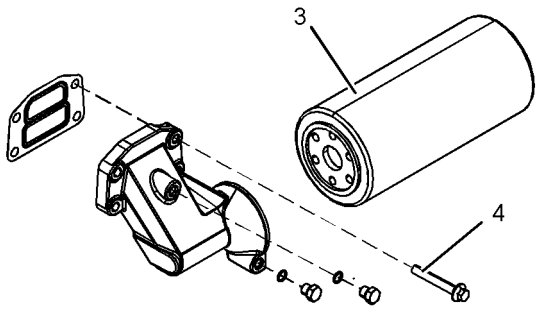


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Illustration 26

Typical example

(3) Engine oil filter

Tighten the engine oil filter to the following torque. ..... 12 N·m (8 lb ft)

(4) Setscrew

Tighten the setscrews to the following torque. ..... 22 N·m (16 ft)

i02636972

Engine Oil Cooler

Engine Oil Cooler with a Low Mounted Filter Base

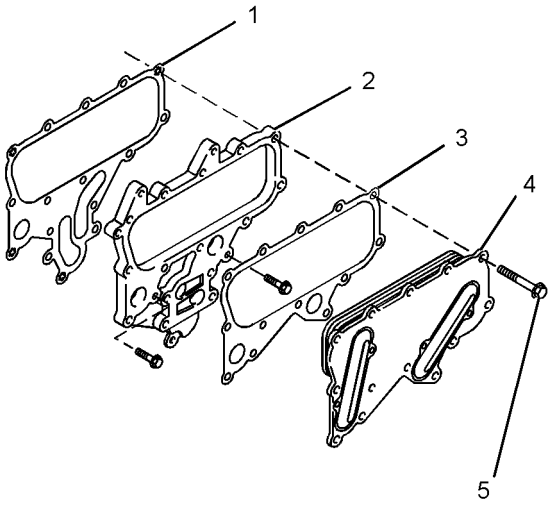

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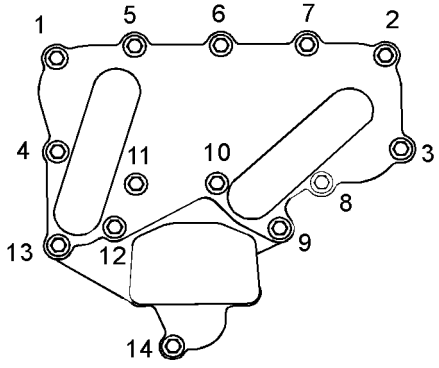
Illustration 27

(1) Joint
(2) Housing
(3) Joint
(4) Oil cooler
(5) Setscrew



g01332172

Illustration 28

Setscrews

Tighten the setscrews (5) in the sequence that is in illustration 28 to the following torque. .. 22 N·m (16 lb ft)

Engine Oil Cooler with a High Mounted Filter Base

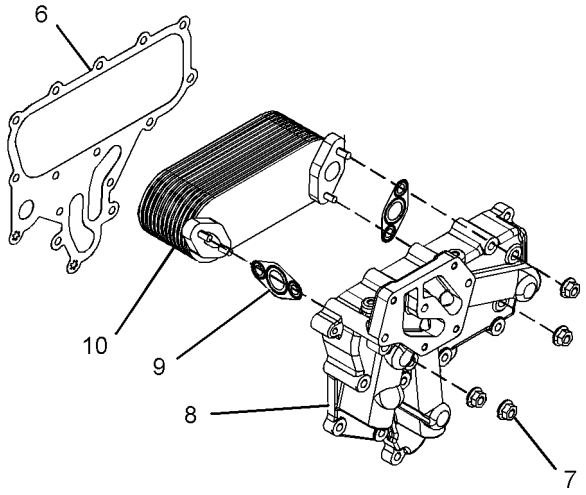


Illustration 29 g01322246

(6) Joint
(7) Nuts
(8) Housing
(9) Joint
(10) Oil cooler

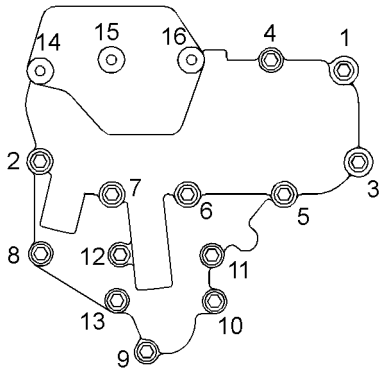


Illustration 30 g01332195

Setscrews

Tighten the setscrews in the sequence that is in illustration 30 to the following torque. ..... 22 N·m (16 lb ft)

i02369776

Engine Oil Pump

Type ..... Gear-driven differential rotor

Number of lobes

Inner rotor 4
Outer rotor 5

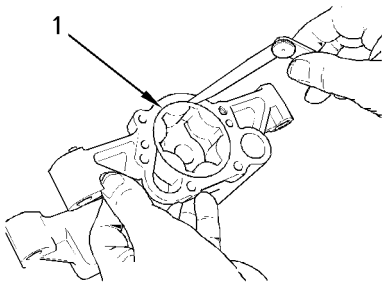


Illustration 31 g00938064

(1) Clearance of the outer rotor to the body ..... 0.050 to 0.330 mm (0.0020 to 0.0130 inch)

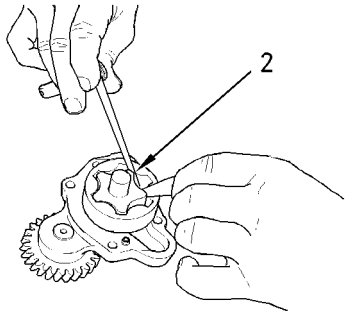


Illustration 32 g00938061

Checking the clearance

(2) Service limit of inner rotor to outer rotor ..... 0.080 to 0.250 mm (0.0031 to 0.0098 inch)

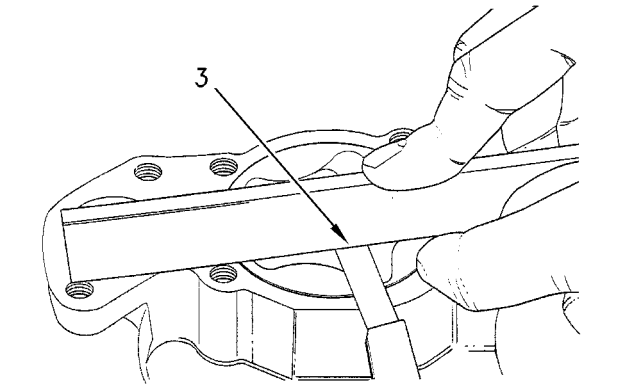


Illustration 33 g00938799
Checking the end play

(3) End play of rotor assembly

Inner rotor ..... 0.050 to 0.180 mm (0.0020 to 0.0071 inch)
Outer rotor ..... 0.050 to 0.180 mm (0.0020 to 0.0071 inch)

Tighten the bolts that hold the front cover of the oil pump assembly to the following torque. ..... 22 N·m (16 lb ft)

i02379117

Engine Oil Pressure

The minimum oil pressure at the maximum engine speed and at normal operating temperature is the following value. ..... 315 kPa (45 psi)

i02797469

Engine Oil Pan

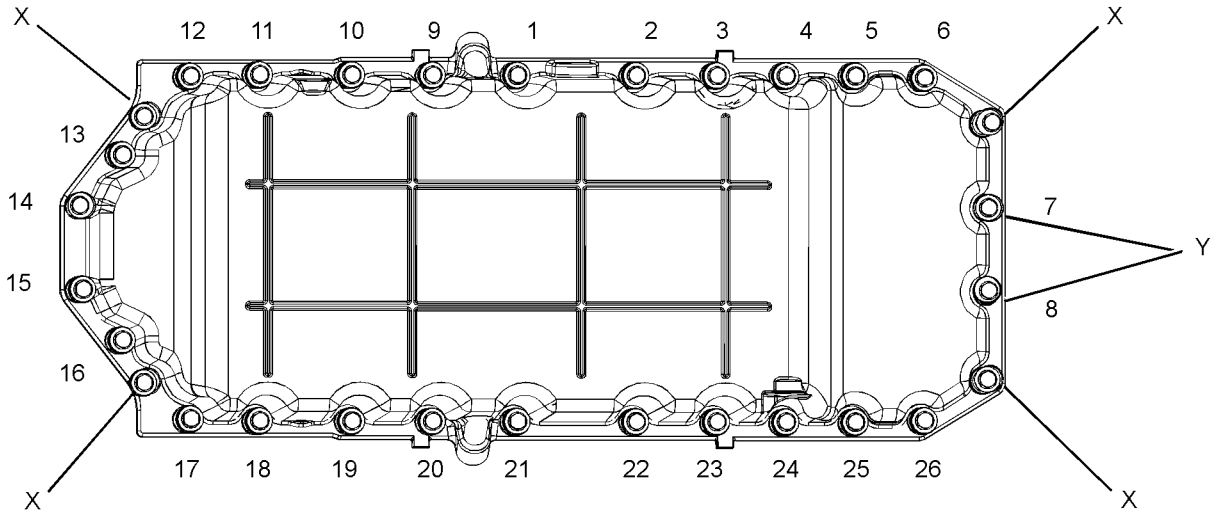


Illustration 34 g01184169

(x) Guide studs (y) Short fastener

Tighten the fasteners in the sequence that is shown in illustration 34 to the following torque. ..... 22 N·m (16 lb ft)

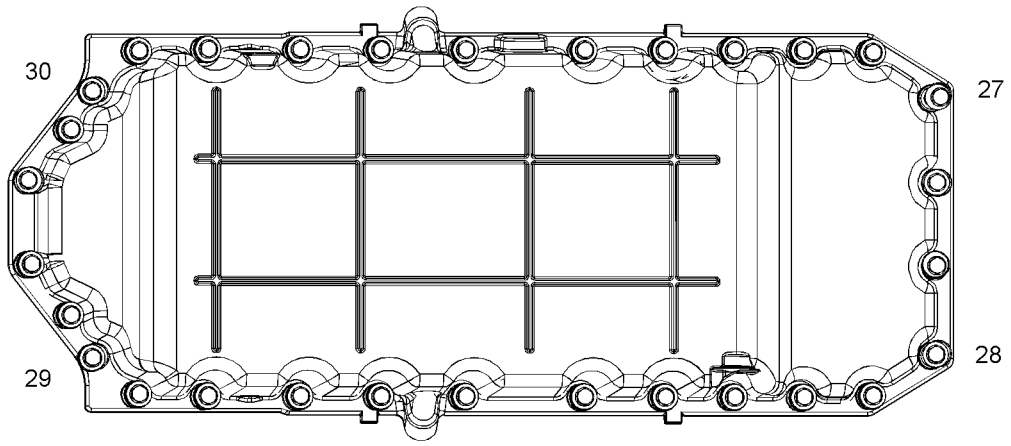


Illustration 35 g01184167

Install the fastener (27 and 28). Install all the remaining fasteners .

Tighten the fastener in the sequence that is shown in illustration 35 to the following torque. ..... 22 N·m (16 lb ft)

Refer to the Disassembly and Assembly, “Engine Oil Pan” for tooling information.

The Cast Iron Oil Pan

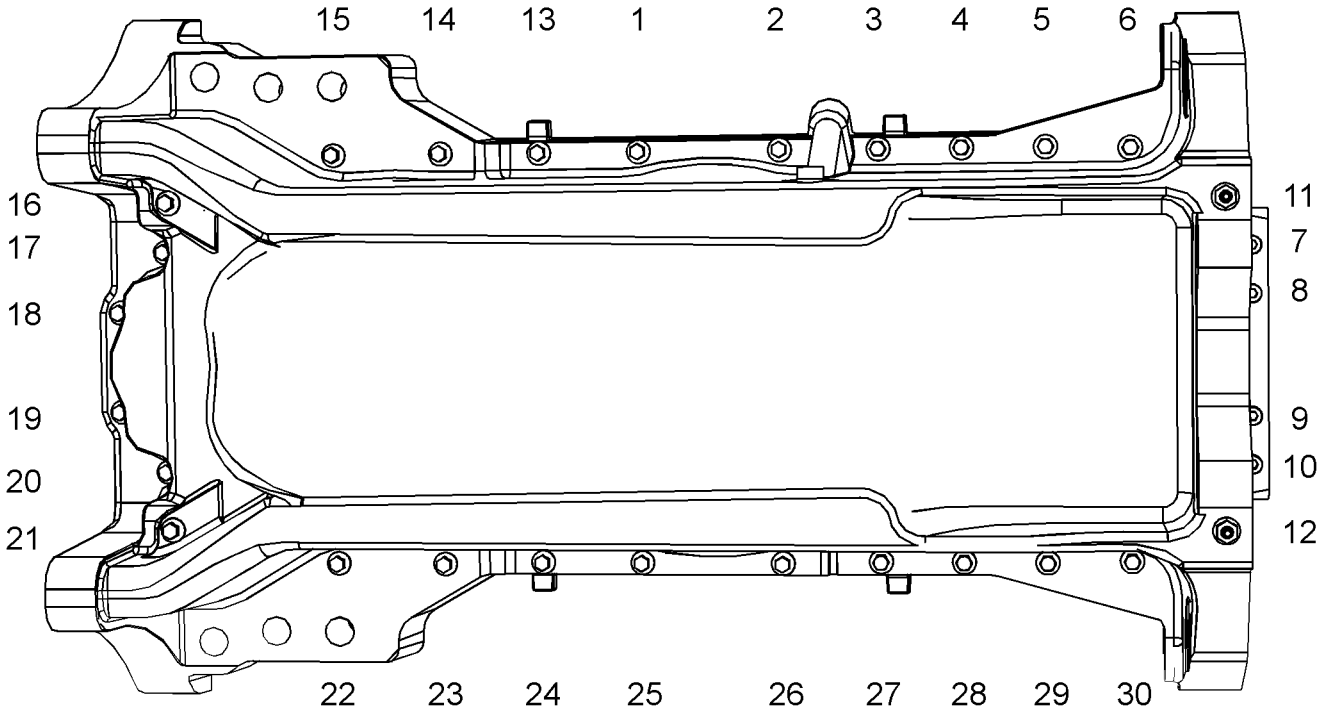


Illustration 36 g01397669

Tightening sequence

Tighten the fasteners in the sequence that is shown in illustration 36 to the following torque. ..... 22 N·m (16 lb ft)

i02636973

Crankcase Breather

Unfiltered Breather

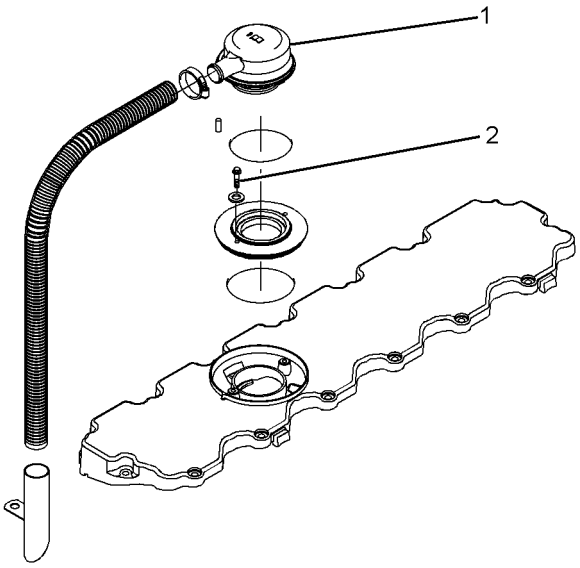


Illustration 37 g01322247
Typical example

(1) Breather

Tighten the breather to the following torque. ..... 8 N·m (70 lb in)

(2) Setscrews

Tighten the setscrews to the following torque. ..... 4.4 N·m (39 lb in)

Align the outlet of the breather to the flexible pipe.

Filtered Breather

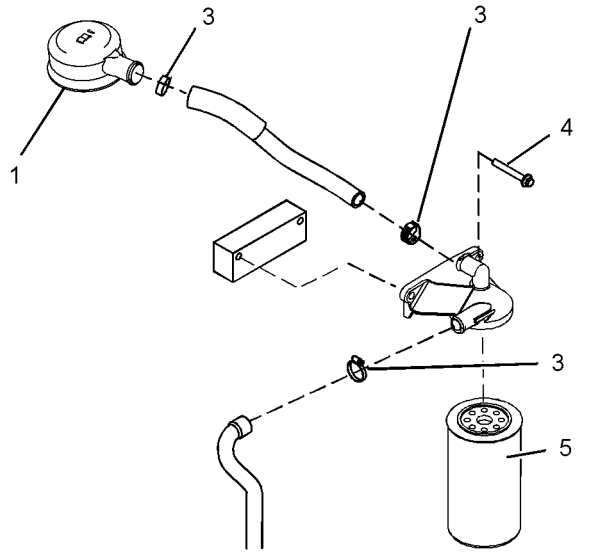


Illustration 38 g01322248
Typical example

(3) Clamps

Tighten the clamps to the following torque. ..... 5 N·m (44 lb in)

(4) Setscrews

Tighten the setscrews to the following torque. ..... 22 N·m (16 lb ft)

(4) Canister

Tighten the canister to the following torque. ..... 12 N·m (106 lb in)

i02374160

Water Temperature Regulator Housing

Tighten the bolts (1) that fasten the housing to the following torque. ..... 44 N·m (32 lb ft)

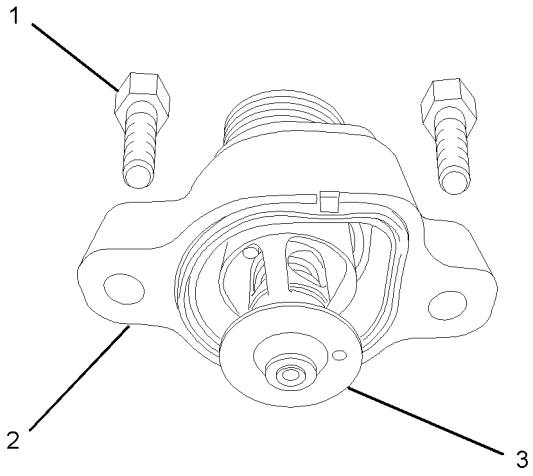


Illustration 39 g01180140

Typical example

(2) The water temperature regulator housing

(3) The water temperature regulator

Opening temperature ..... 82° to 87°C (179.6000° to 156.6000°F)

Full opening temperature ..... 95 °C (203.0000 °F)

Minimum stroke at full temperature ..... 9 mm (0.3543 inch)

i02363605

Water Pump

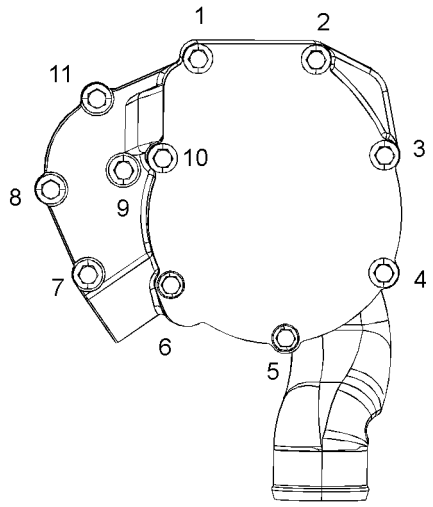


Illustration 40 g01183807

Tightening sequence

Tighten the setscrews in the numerical sequence that is shown in illustration 40 to the following torque. ..... 22 N·m (16 lb ft)

i02655588

Cylinder Block

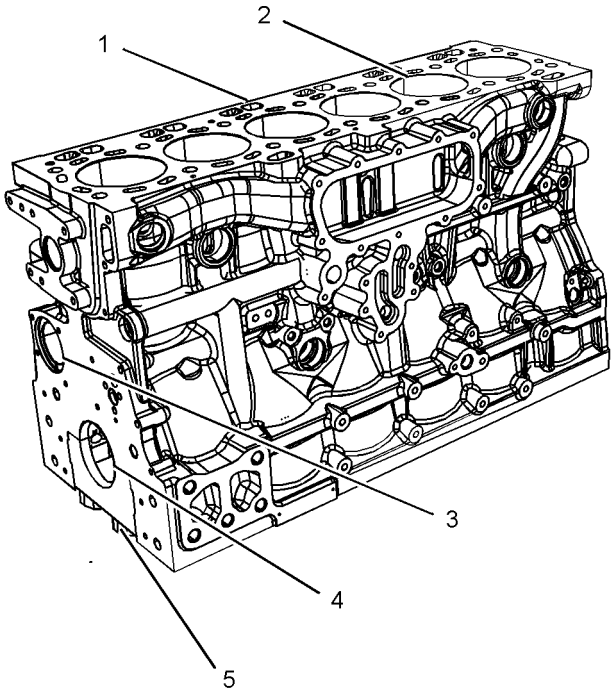


Illustration 41 g01333870
Cylinder block

(1) Cylinder block

(2) Cylinder bore ..... 105.000 to 105.025 mm (4.1338 to 4.1348 inch)

The first oversize bore diameter ..... 105.5 to 105.525 mm (4.1535 to 4.1545 inch)

The second oversize bore diameter ..... 106.000 to 106.025 mm (4.1732 to 4.1742 inch)

The maximum permissible wear for the cylinder bore ..... 0.15 mm (0.0059 inch)

(3) Camshaft bearings

Diameter of the bushing in the cylinder block for the number 1 camshaft bearing ..... 55.563 to 55.593 mm (2.1875 to 2.1887 inch)

Diameter of the bore in the cylinder block for the number 2 camshaft journal ..... 50.546 to 50.597 mm (1.9900 to 1.9920 inch)

Diameter of the bore in the cylinder block for the number 3 camshaft journal ..... 50.292 to 50.343 mm (1.9800 to 1.9820 inch)

Diameter of the bore in the cylinder block for the number 4 camshaft journal ..... 50.038 to 50.089 mm (1.9700 to 1.9720 inch)

(4) Main bearings

Bore in the cylinder block for the main bearings ..... 88.246 to 88.272 mm (3.4742 to 3.4753 inch)

(5) Main bearing cap bolts

Use the following procedure in order to install the main bearing cap bolts:

1. Apply clean engine oil to the threads of the main bearing cap bolts.

2. Put the main bearing caps in the correct position that is indicated by a number on the top of the main bearing cap. Install the main bearing caps with the locating tabs in correct alignment with the recess in the cylinder block.

3. Evenly tighten the main bearing cap bolts.

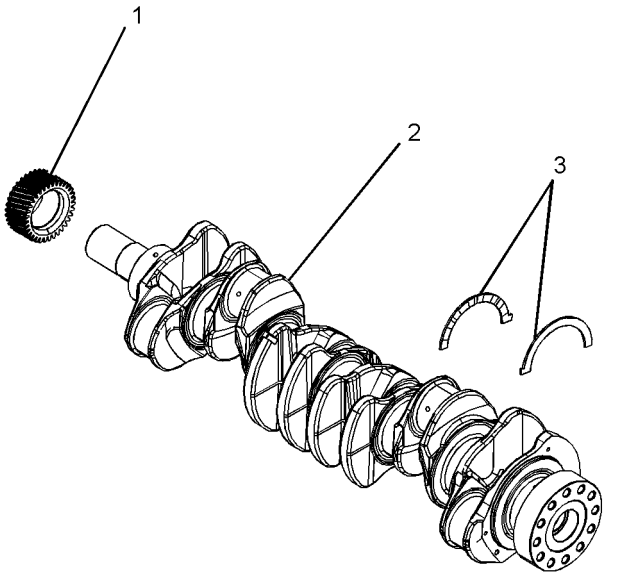
Torque for the main bearing cap bolts. ..... 80 N·m (59 lb ft)

4. Tighten the bolts for the main bearing cap for an additional 90 degrees.

Note: Ensure that the crankshaft can rotate freely.

i02687040

Crankshaft



g01349782

Illustration 42

Typical example

(1) Crankshaft gear
(2) Crankshaft
(3) Crankshaft thrust washers

Maximum permissible temperature of the gear for installation on the crankshaft ..... 180 °C (356 °F)

The end play of a new crankshaft ... 0.17 to 0.41 mm (0.0067 to 0.0161 inch)

Standard thickness of thrust washer ..... 2.69 to 2.75 mm (0.1059 to 0.1083 inch)

Oversize thickness of thrust washer ..... 2.89 to 2.95 mm (0.1138 to 0.1161 inch)

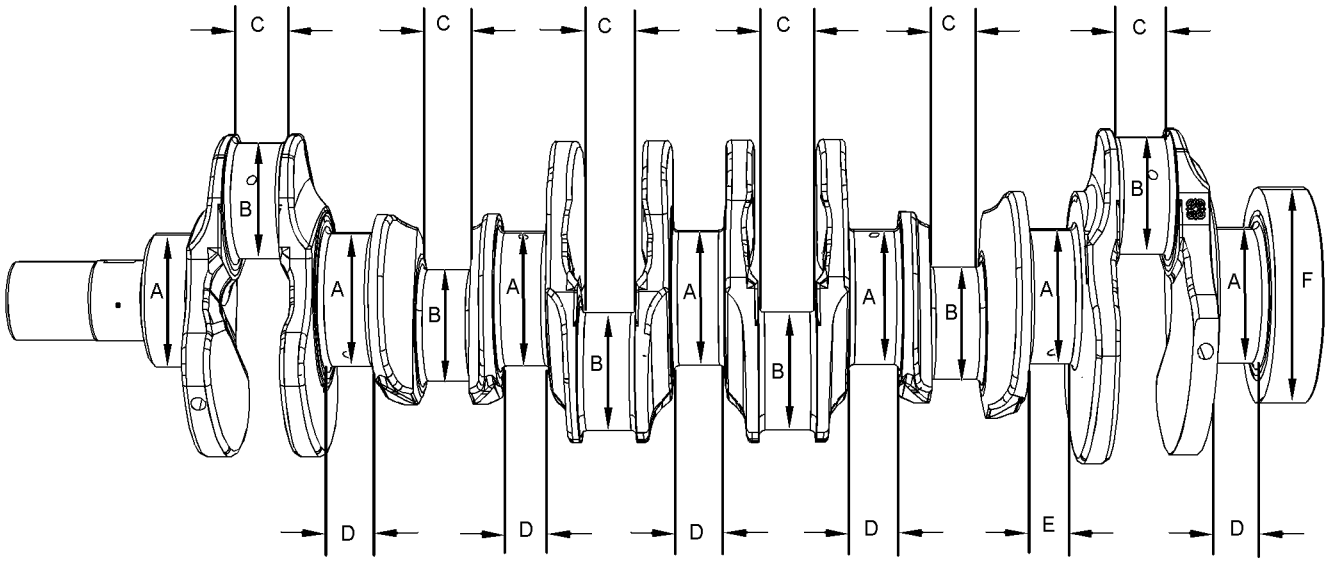


Illustration 43
g01349784

Typical example

Table 6

The Undersize Diameter of the Crankshaft Journals			
Dimension	**0.25 mm (0.010 inch)**	**0.51 mm (0.020 inch)**	**0.76 mm (0.030 inch)**
A	83.756 to 83.736 mm (3.2975 to 3.2967 inch)	83.502 to 83.482 mm (3.2875 to 3.2867 inch)	83.248 to 83.228 mm (3.2775 to 3.2767 inch)
B	71.746 to 71.726 mm (2.8246 to 2.8239 inch)	71.492 to 71.472 mm (2.8146 to 2.8139 inch)	71.238 to 71.218 mm (2.8046 to 2.8039 inch)
C	38.165 mm (1.5026 inch)	38.165 mm (1.5026 inch)	38.165 mm (1.5026 inch)
D	35.38 mm (1.3929 inch)maximum	35.38 mm (1.3929 inch)maximum	35.38 mm (1.3929 inch)maximum
E	35.5 to 35.7 mm (1.3976 to 1.4055 inch)	35.5 to 35.7 mm (1.3976 to 1.4055 inch)	35.5 to 35.7 mm (1.3976 to 1.4055 inch)
F	Do not machine this diameter.	Do not machine this diameter.	Do not machine this diameter.

Dimension (F) in Table 6 can be repaired with a crankshaft wear sleeve. Refer to Disassembly and Assembly, “Crankshaft Wear Sleeve (Rear) Remove and Install” for more information.

Table 7

Minimum Width of machined Area of Crankshaft Web				
Web	1	2 to 9	10 and 11	12
	25.11 mm (0.9886 inch)	22.86 mm (0.9000 inch)	23.15 mm (0.9114 inch)	26.86 mm (1.0575 inch)

If necessary, machine the thrust face in order to remove damage. Refer to Table 7 for information.

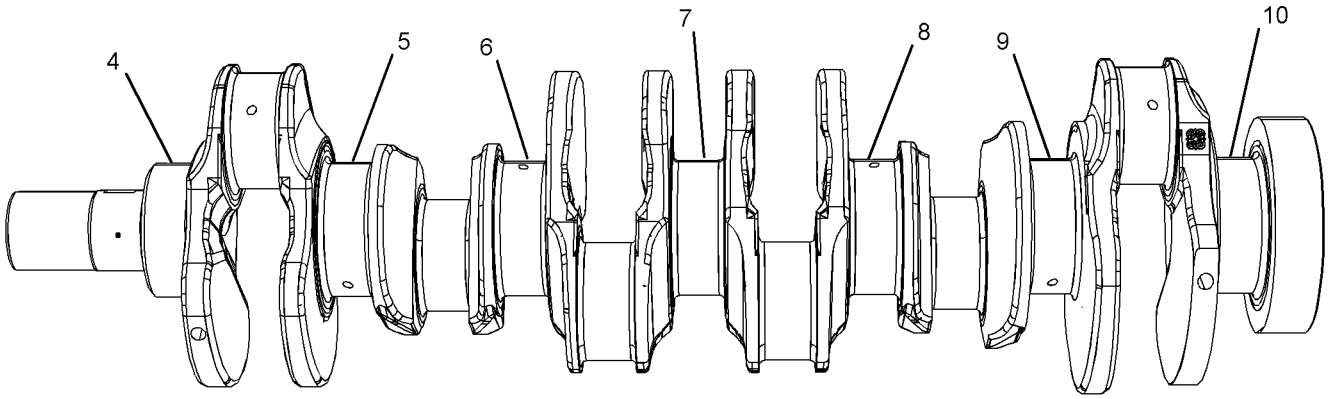


Illustration 44 g01283112

(4) Journal #1
(5) Journal #2
(6) Journal #3
(7) Journal #4
(8) Journal #5
(9) Journal #6
(10) Journal # 7

Refer to Table 8 for the run out of the crankshaft journals.

Table 8

Journal	Run Out of the Journals
(1)	Mounting
(2)	0.05 mm (0.0020 inch)
(3)	0.1 mm (0.0039 inch)
(4)	0.15 mm (0.0059 inch)
(5)	0.1 mm (0.0039 inch)
(6)	0.05 mm (0.0020 inch)
(7)	Mounting

The radii of all the crankshaft journals must be machined. This machining must return the crankshaft to the original standard. The radii must give a smooth transition from the journal to the side machined face.

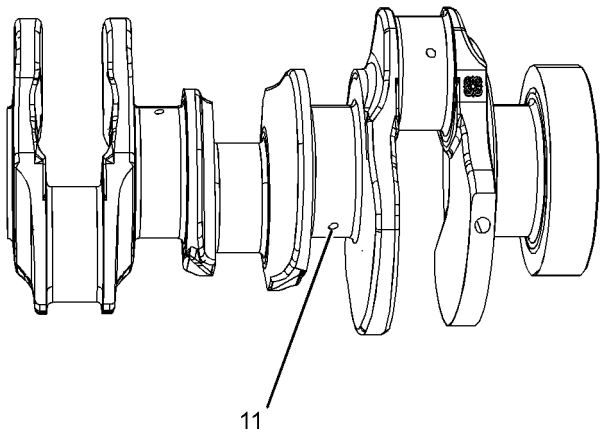


Illustration 45 g01283119

Typical example

The edge of the oil holes (11) must be machined to the original standard after machining of the crankshaft.

Oil hole

The maximum radius of the edge of the oil hole ..... 0.5 mm (0.0197 inch)

Surface finish of all journals ..... Ra 0.2 microns

Surface finish of all radii ..... Ra 0.4 microns

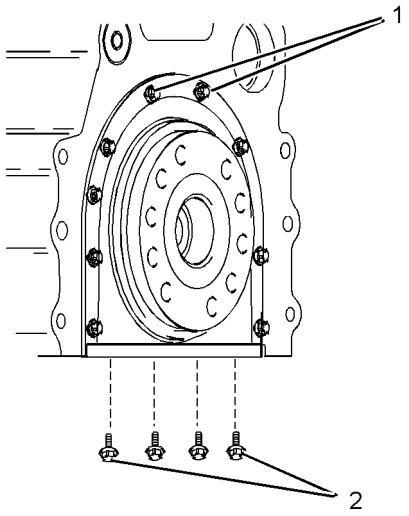
Inspect the crankshaft for structural cracking after machining.

Refer to the Specifications Module, “Connecting Rod Bearing Journal” topic for more information on the connecting rod bearing journals and connecting rod bearings.

Refer to the Specifications Module, “Main Bearing Journal” topic for information on the main bearing journals and for information on the main bearings.

i02652052

Crankshaft Seals



g01332235

Illustration 46

Typical example

You do not need to remove the engine oil pan in order to install the oil seal.

Note: Some engines also have an oil seal that is installed in the flywheel housing. Refer to Specifications, “Flywheel Housing” for more information.

The sequence for installation of the rear oil seal

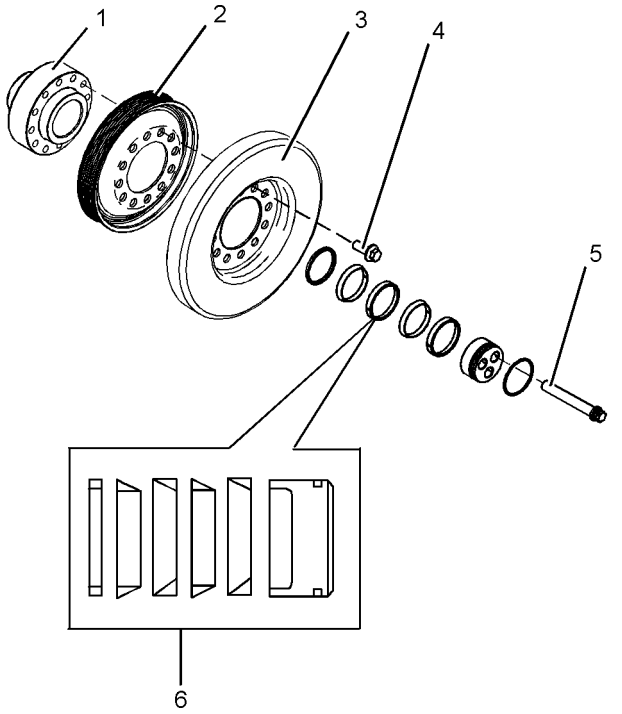
(2) Tighten the two fasteners to the following torque 15 N·m (11 lb ft).

(1) Tighten the two fasteners to the following torque 22 N·m (16 lb ft).

Loosen both fasteners (2). Install all the other fasteners and tighten all the fasteners to 22 N·m (16 lb ft).

i02634788

Vibration Damper and Pulley



g01332241

Illustration 47

Vibration damper with split lock assembly

(1) Crankshaft adapter

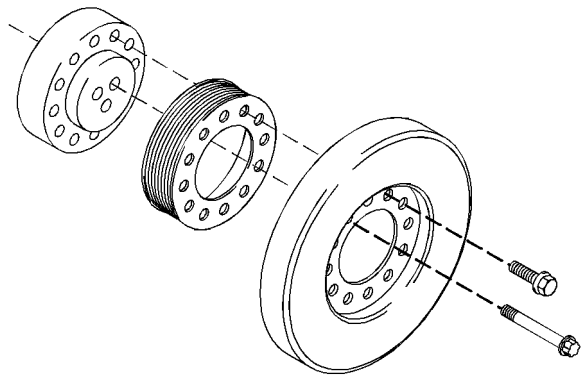
(2) Pulley

(3) Vibration damper

(4) Tighten the damper setscrews to the following torque. ..... 115 N·m (84 lb ft)

(5) Tighten the setscrews for the adapter to the following torque. ..... 200 N·m (147 lb ft)

(6) Split lock assembly



g01332246

Illustration 48

Vibration damper without split lock assembly

i02370557

Connecting Rod Bearing Journal

Refer to the Specifications Module, “Crankshaft” topic for information on the undersize crankshaft journals.

The original size of the connecting rod bearing journal ..... 71.980 to 72.000 mm (2.8339 to 2.8346 inch)

Maximum permissible wear of a bearing journal on a new connecting rod ..... 0.04 mm (0.0016 inch)

Width of the connecting rod bearing journals ..... 37.962 to 38.038 mm (1.4946 to 1.4976 inch)

Radius of the fillet of the connecting rod bearing journals ..... 3.68 to 3.96 mm (0.145 to 0.156 inch)

Surface finish of connecting rod bearing journals ..... Ra 0.2 microns

Surface finish of radii ..... Ra 0.4 microns

i02796837

Main Bearing Journal

Refer to Specifications, “Crankshaft” for information on the undersize main bearing journals, and information on the width of main bearing journals.

The original size of the main bearing journal ..... 83.99 to 84.01 mm (3.307 to 3.308 inch)

Maximum permissible wear of the main bearing journals ..... 0.040 mm (0.0016 inch)

Radius of the fillet of the main bearing journals ..... 3.68 to 3.96 mm (0.145 to 0.156 inch)

Surface finish of bearing journals and crank pins ..... 0.2 microns

Surface finish of radii ..... 0.4 microns

Width of new main bearing journal ..... 35.235 to 35.165 mm (1.3872 to 1.3844 inch)

The shell for the main bearings

The shells for the main bearings are available for remachined journals which have the following undersize dimensions.

Undersize bearing shell .... 0.25 mm (0.010 inch)
Undersize bearing shell .... 0.51 mm (0.020 inch)
Undersize bearing shell .... 0.76 mm (0.030 inch)

Thickness at center of the shells .. 2.083 to 2.089 mm (0.0820 to 0.0823 inch)

Width of the main bearing shells .. 31.62 to 31.88 mm (1.244 to 1.255 inch)

Clearance between the bearing shell and the main bearing journals ..... 0.026 to 0.084 mm (0.0010 to 0.0033 inch)

i02655599

Connecting Rod

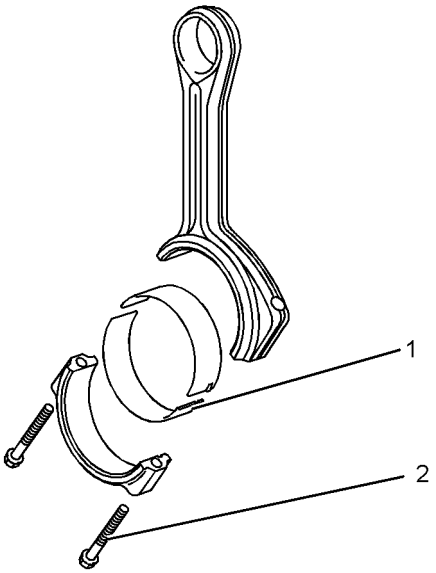


Illustration 49 g01333876

(1) The bearing shell for the connecting rod

Table 9

Thickness of Connecting Rod Bearing at the Center	1.994 to 2 mm (0.0785 to 0.0787 inch)
Thickness of Connecting Rod Bearing for the Cap at the Center	1.994 to 2 mm (0.0785 to 0.0787 inch)
Bearing Clearance	0.025 to 0.070 mm (0.0010 to 0.0028 inch)

Table 10

Undersized Connecting Rod Bearing
0.25 mm (0.010 inch)
0.51 mm (0.020 inch)
0.76 mm (0.030 inch)

The mating surfaces of the connecting rod are produced by hydraulically fracturing the forged connecting rod.

(2) Tighten the setscrews for the connecting rod to the following torque. ..... 18 N·m (13 lb ft)

Tighten the setscrews for the connecting rod again to the following torque. ..... 70 N·m (52 lb ft)

Tighten the setscrews for the connecting rod for an additional 120 degrees. The setscrews for the connecting rod (2) must be replaced after this procedure.

Note: Always tighten the connecting rod cap to the connecting rod, when the assembly is out of the engine. Tighten the assembly to the following torque 20 N·m (14 lb ft).

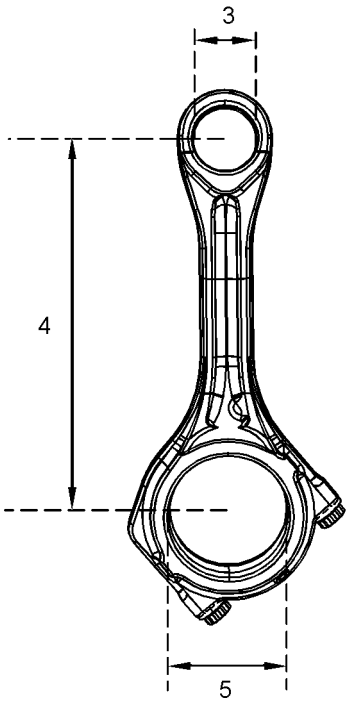


Illustration 50 g01333883

Typical example

(3) Diameter of the finished bore for the piston pin ..... 39.738 to 39.723 mm (1.5645 to 1.5639 inch)

(4) Distance between the parent bores ..... 219.05 to 219.1 mm (8.6240 to 8.6260 inch)

(5) Diameter for the finished bore for the connecting rod bearing ..... 72.025 to 72.05 mm (2.8356 to 2.8366 inch)

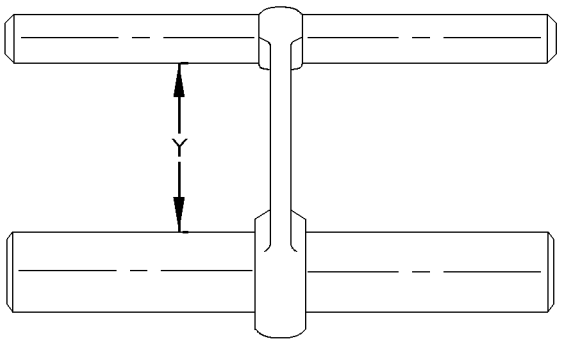


Illustration 51 g00915056

Connecting rods are color coded. The color code is a reference for the length (Y) of the connecting rod. Refer to table 11 for the different lengths of connecting rods.

Table 11

Length Grades for Connecting Rods		
Grade Letter	**Color Code**	**Length (Y)**
F	Red	161.259 to 161.292 mm (6.3488 to 6.3501 inch)
J	Green	161.183 to 161.216 mm (6.3458 to 6.3471 inch)
L	Blue	161.107 to 161.140 mm (6.3428 to 6.3441 inch)

i02696369

Piston and Rings

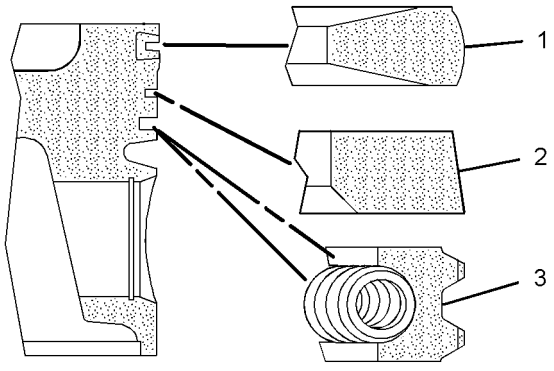


Illustration 52 g01352562

(1) Top compression ring

The shape of the top compression ring .. tapered

Ring gap ..... 0.30 to 0.45 mm (0.0118 to 0.0177 inch)

Note: When you install a new top compression ring, make sure that the word “TOP” is facing the top of the piston. New top piston rings have a yellow identification mark which must be on the left of the ring end gap when the top piston ring is installed on an upright piston.

(2) Intermediate compression ring

The shape of the intermediate compression ring ..... Internal bevel in the bottom edge with a tapered face

Width of intermediate compression ring .... 2.47 to 2.495 mm (0.0972 to 0.0982 inch)

The clearance between a new intermediate compression ring and the piston groove in a new piston ..... 0.065 to 0.011 mm (0.0026 to 0.0004 inch)

Ring gap ..... 0.65 to 0.85 mm (0.0256 to 0.0335 inch)

Note: When you install a new intermediate compression ring, make sure that the word “TOP” is facing the top of the piston. New intermediate rings have a blue identification mark which must be on the left of the ring end gap when the top piston ring is installed on an upright piston.

(3) The oil control ring

Width of oil control ring ..... 2.97 to 2.99 mm (0.1169 to 0.1177 inch)

The clearance between a new oil control ring and the groove in a new piston ..... 0.03 to 0.07 mm (0.0011 to 0.0027 inch)

Ring gap ..... 0.30 to 0.55 mm (0.0118 to 0.0216 inch)

Note: The oil control ring is a two-piece ring that is spring loaded. A 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 installed opposite the end gap of the oil control ring.

Note: Ensure that the ring end gaps of the piston rings are spaced 120 degrees from each other.

Piston

Note: An arrow which is marked on the piston crown must be toward the front of the engine.

Piston height above cylinder block .. 0.21 to 0.35 mm (0.008 to 0.014 inch)

Width of top groove in the piston ..... Tapered

Width of second groove in new piston ..... 2.56 to 2.58 mm (0.1008 to 0.1016 inch)

Width of third groove in new piston .. 3.02 to 3.04 mm (0.1189 to 0.1197 inch)

Piston pin

Diameter of a new piston pin ..... 39.694 to 39.700 mm (1.5628 to 1.5630 inch)

Oversize Piston

Table 12

Standard piston	
1 Oversize	+0.5 mm (0.0197 inch) piston
2 Oversize	+1.0 mm (0.0394 inch) piston

i02696381

Piston Cooling Jet

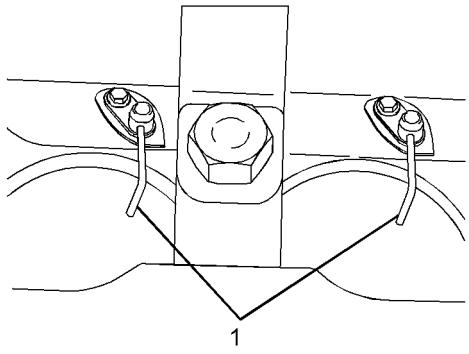


Illustration 53 g01352576

(1) Installed piston cooling jets

The valve must move freely. Tighten the bolt to the following torque. ..... 9 N·m (7 lb ft)

Piston Cooling Jet Alignment

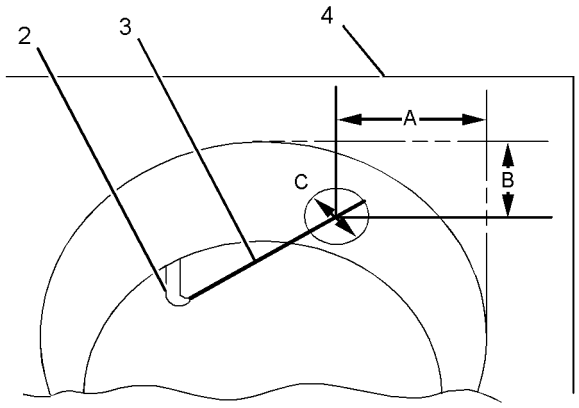


Illustration 54 g01352578

(2) Piston cooling jet
(3) Rod
(4) Cylinder block

Use the following procedure in order to check the alignment of the piston cooling jet.

1. Insert rod (3) into the end of the piston cooling jet (2). Rod (3) has a diameter of 1.70 mm (0.067 inch). Rod (3) must protrude out of the top of the cylinder block.

2. Dimension (A) is 50.75 mm (1.9980 inch) and dimension (B) is 9.35 mm (0.3681 inch). Dimension (A) and dimension (B) are tangential to the cylinder bore (4).

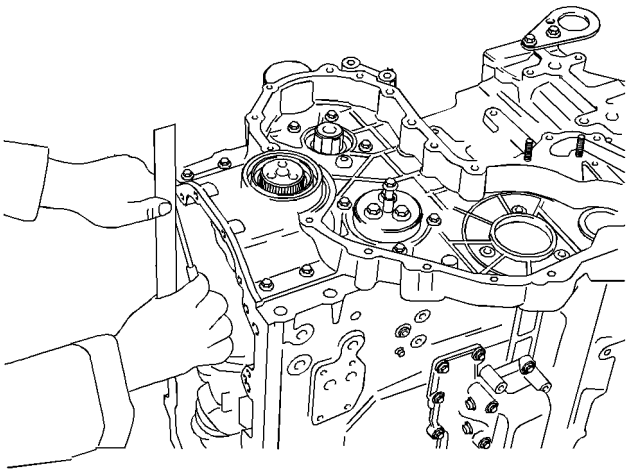
3. The position of the rod (3) must be within dimension (C). Dimension (C) is 14 mm (0.5512 inch).

Note: Ensure that the rod (3) can not damage the piston cooling jet when the alignment is checked. The piston cooling jets can not be adjusted. If a piston cooling jet is not in alignment the piston cooling jet must be replaced.

i02652093

Front Housing and Covers

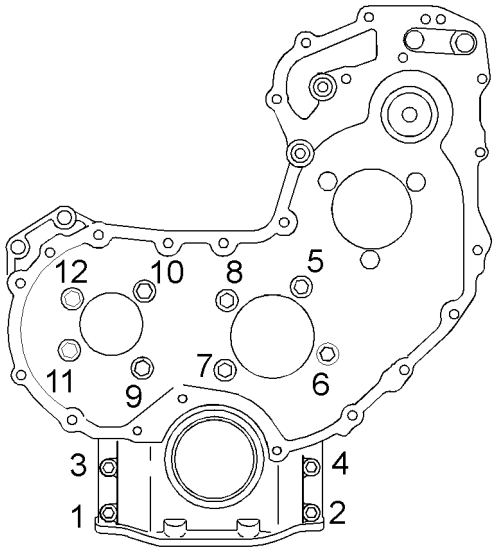
The front housing must be aligned to the cylinder block face. ..... + 0.05 to minus 0.05 mm (+ 0.0020 to minus 0.0020 inch)



g01332260

Illustration 55

Alignment



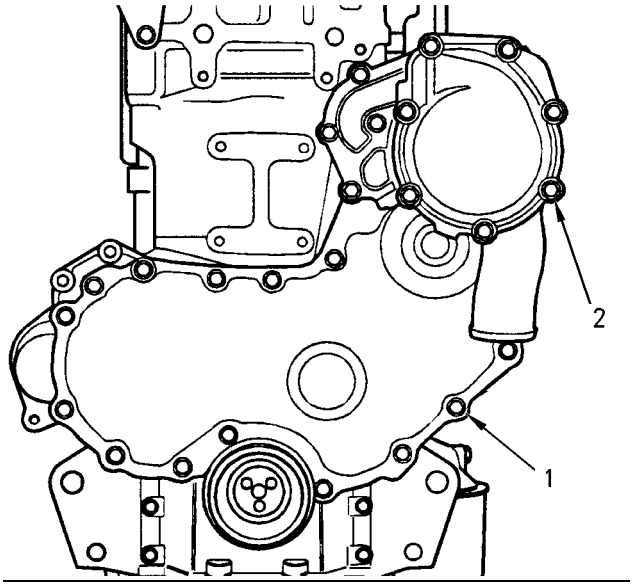
g01332261

Illustration 56

Typical example

Tighten the setscrew to the sequence that is shown in illustration 56 to the following torque. ..... 28 N·m (20 lb ft)

(1) Tighten the bolts that fasten the front cover to the front housing to the following torque. ..... 22 N·m (16 lb ft)



g00918672

Illustration 57

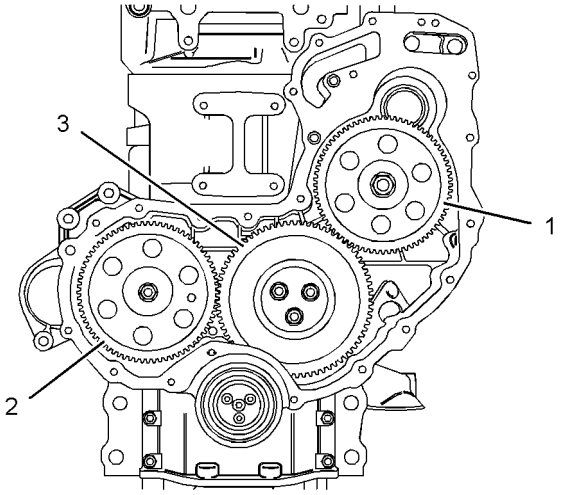
Typical example

(2) Tighten the bolts that fasten the water pump to the front housing to the following torque. ..... 22 N·m (16 lb ft)

Note: Refer to Specifications, “Water Pump” for the correct bolt tightening sequence for the water pump.

i02796838

Gear Group (Front)



g01332521

Illustration 58

Gear train

(1) Fuel injection pump drive gear

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

Release the lock on the fuel injection pump shaft. Torque the nut to the following torque. .... 90 N·m (66 lb ft)

Number of teeth 68

Note: Refer to the Specifications Module, “Fuel injection pump” for the locking torque for the fuel injection pump shaft.

(2) Camshaft gear

Tighten the bolt for the camshaft gear to the following torque. ..... 95 N·m (70 lb ft)

Number of teeth 68

(3) Idler gear and hub

Tighten the bolts for the idler gear to the following torque. ..... 44 N·m (33 lb ft)

Width of idler gear and split bearing assembly ..... 30.164 to 30.135 mm (1.1876 to 1.1864 inch)

Inside diameter of idler gear bearings with flanges ..... 50.797 to 50.818 mm (1.9999 to 2.0007 inch)

Outside diameter of idler gear hub ..... 50.716 to 50.737 mm (1.9967 to 1.9975 inch)

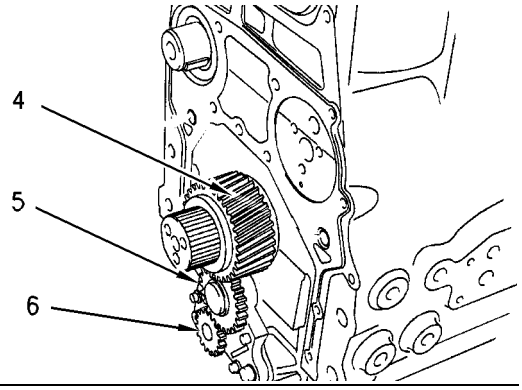
Clearance of idler gear bearing on hub .... 0.06 to 0.102 mm (0.0024 to 0.0040 inch)

Idler gear end play ..... 0.10 to 0.205 mm (0.0039 to 0.0081 inch)

Maximum permissible end play ..... 0.38 mm (0.015 inch)

Idler gear end play with roller bearings ..... 0.10 to 0.75 mm (0.0039 to 0.0295 inch)

Number of teeth 73



g00996214

Illustration 59

The gear train for the oil pump

(4) Crankshaft gear

Bore diameter of crankshaft gear ..... 51.00 to 51.03 mm (2.0079 to 2.0091 inch)

Outside diameter of crankshaft hub ..... 51.021 to 51.002 mm (2.0087 to 2.0079 inch)

Clearance of gear on crankshaft ..... −0.020 to +0.020 mm (−0.0008 to +0.0008 inch)

Number of teeth 34

(5) Oil pump idler gear

Inside diameter of oil pump idler gear bearing ..... 16.012 to 16.038 mm (0.6304 to 0.6314 inch)

Outside diameter of oil pump idler gear shaft ..... 15.966 to 15.984 mm (0.6286 to 0.6293 inch)

Clearance of oil pump idler gear bearing on shaft ..... 0.028 to 0.072 mm (0.0011 to 0.0028 inch)

End play of the oil pump idler gear ..... 0.050 to 0.275 mm (0.0019 to 0.0108 inch)

(6) Oil pump gear

The number of teeth on the oil pump gear 17

Backlash values

Backlash between the idler gear (5) and the oil pump drive gear (6) ..... 0.05 to 0.15 mm (0.0020 to 0.0059 inch)

Backlash between the oil pump idler gear (5) and the crankshaft gear (4) ..... 0.08 to 0.23 mm (0.0031 to 0.0091 inch)

Backlash between the idler gear (3) and the crankshaft gear (4) ..... 0.05 to 0.15 mm (0.0020 to 0.0059 inch)

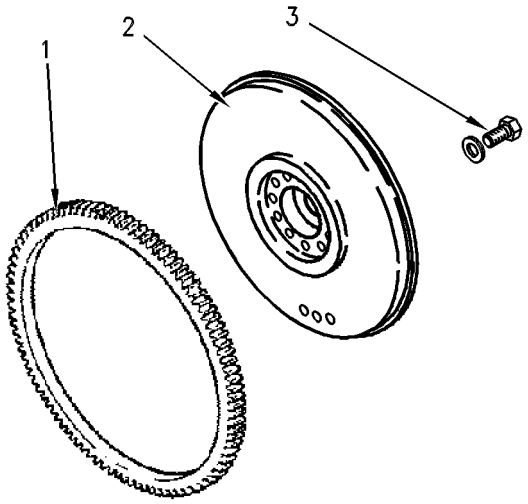
Backlash between the camshaft gear (2) and the idler gear (3) ..... 0.05 to 0.15 mm (0.0020 to 0.0059 inch)

Backlash between the fuel injection pump gear (1) and the idler gear (3) ..... 0.05 to 0.15 mm (0.0020 to 0.0059 inch)

Backlash between the water pump gear (not shown) and the fuel injection pump gear (1) ..... 0.05 to 0.15 mm (0.0020 to 0.0059 inch)
Backlash between the power take-off drive (if equipped) and the idler gear (3) ..... 0.05 to 0.250 mm (0.0020 to 0.0098 inch)

i02562488

Flywheel



g00584712

Illustration 60

Typical example

(1) Flywheel ring gear

Heat the flywheel ring gear to the following temperature. ..... 250 °C (480 °F)

Note: Do not use an oxyacetylene torch to heat the flywheel ring gear.

(2) Flywheel

(3) Bolt

Tighten the 12 flywheel bolts to the following torque. ..... 120 ± 10 N·m (90 ± 7 lb ft)

i02375337

Flywheel Housing

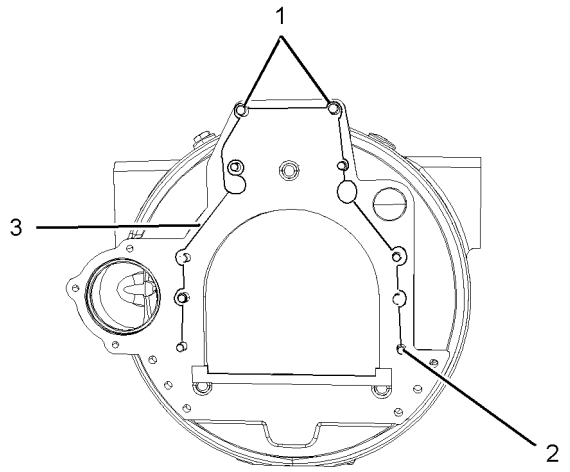


Illustration 61 g01185448

Note: Tighten the setscrew (2) before you tighten setscrews (1).

Setscrew

(1) Tighten the setscrew to the following torque. ..... 78 N·m (57 lb ft)

Setscrew

(2) Tighten the setscrew to the following torque. ..... 63 N·m (46 lb ft)

(3) If necessary, apply sealant 21826038 Power Silicone adhesive to the flywheel housing.

Flywheel Housing and Oil Seal

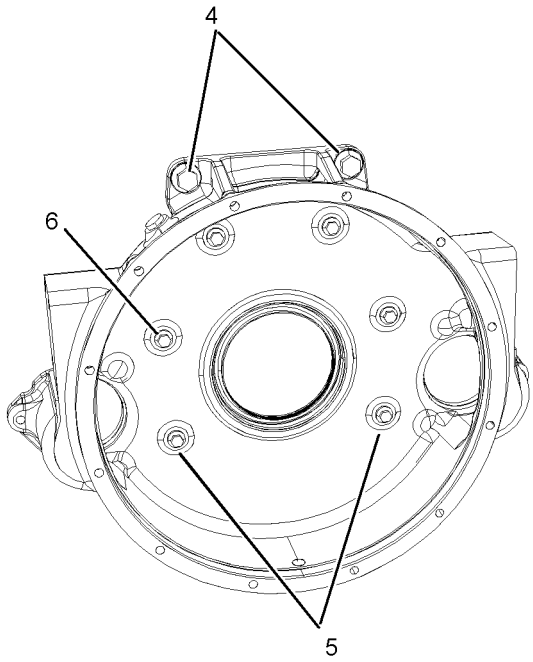


Illustration 62 g01185430

Note: Tighten the setscrew (5) before you tighten setscrews (4).

Setscrews

(4) Tighten the top setscrew to the following torque. ..... 190 N·m (140 lb ft)

Setscrews

(5) Tighten the bottom setscrew to the following torque. ..... 115 N·m (84 lb ft)

Setscrews

(6) Tighten the setscrew to the following torque. ..... 63 N·m (46 lb ft)

i01721280

Engine Lifting Bracket

All engines are equipped with two engine lifting brackets.

Tighten the two bolts on each engine lifting bracket to the following torque. .. 44 N·m (32 lb ft)

i02796839

Alternator

The 12 Volt and 24 volt Denso Alternators

Five types of alternator are available.

Output

Two 12 volt alternators are available. ..... 100 Amp and 120 Amp
Two 24 volt alternator ..... 55 Amp and 75 Amp

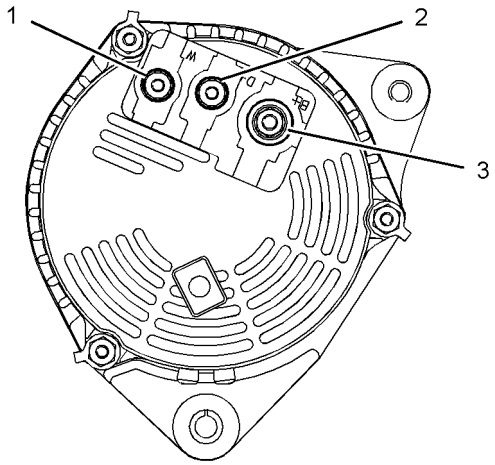


Illustration 63 g01332517
Typical example

(1) Terminal “W”

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

(2) Terminal “D+”

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

(3) Terminal “B+”

Tighten the terminal nut to the following torque. ..... 7 N·m (62 lb in)

The 24 volt Denso HDB Alternator

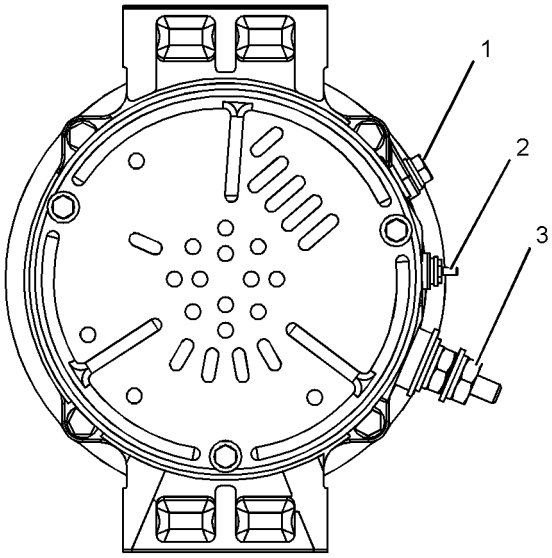


Illustration 64 g01332518
Typical example

(1) Terminal “G”

Tighten the nut on the terminal to the following. ..... 4 N·m (35 lb in)

(2) The connector “R” has one pin.

(3) Terminal “B”

Tighten the nut on the terminal to the following torque. ..... 18 N·m (13 lb ft)

Output

The output of the alternator ..... 95 Amp

The 12 Volt and 24 Volt Iskra Alternator

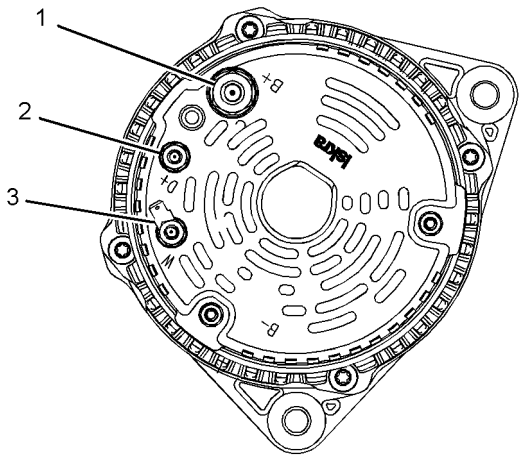


Illustration 65 g01332519
Typical example

(1) Terminal “B+”

Tighten the terminal nut to the following torque. ..... 11 N·m (97 lb in)

(2) Terminal “D+”

Tighten the terminal nut to the following torque. ..... 3.3 N·m (29 lb in)

(3) The terminal “W” is spade-type.

12 volt output

Two alternators are available. ..... 150 Amp and 175 Amp

24 volt output

The 24 volt alternator ..... 100 Amp

The 12 Volt Prestolite Alternator

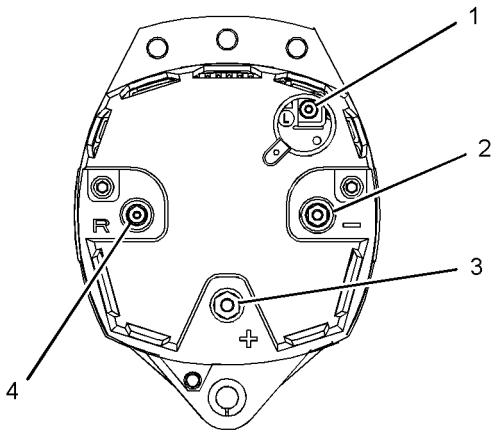


Illustration 66 g01332520
Typical example

(1) Terminal “L”

Tighten the terminal nut to the following torque. ..... 3.1 N·m (27.43 lb in)

(2) The negative terminal “-”

Tighten the terminal nut to the following torque. ..... 8.5 N·m (75.2314 lb in)

(3) The positive terminal “+”

Tighten the terminal nut to the following torque. ..... 11.5 N·m (101.78 lb in)

(4) Terminal “R”

In order to install a different design of terminal, tighten that terminal to the following torque. ..... 3.7 N·m (32.75 lb in)

Output

The output of the alternator ..... 160 Amp

i02796841

Starter Motor

24 Volt Starting Motor 8 Kw

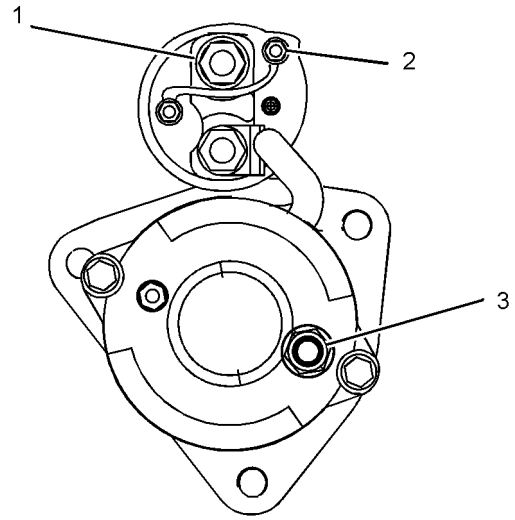


Illustration 67 g01332526
Typical example

(1) Tighten the positive terminal nut to the following torque. ..... 25 N·m (18 lb ft)

(2) Tighten the nut for the solenoid terminal to the following torque. ..... 2.5 N·m (22 lb in)

(3) Tighten the nut on the negative terminal to the following torque. ..... 25 N·m (18 lb ft)

Rated voltage ..... 24 volts

24 Volt Starting Motor 4.5 Kw

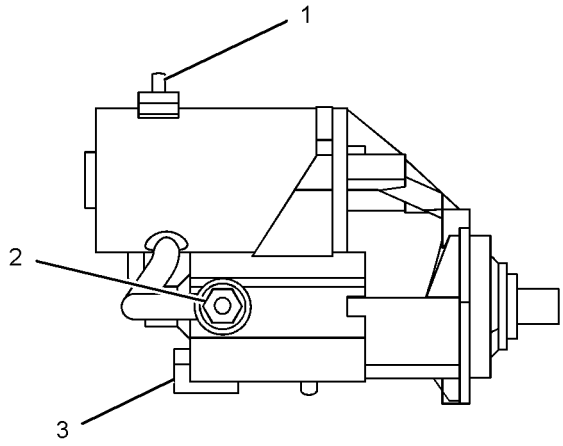


Illustration 68 g01332527
Typical example

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

(2) Tighten the positive terminal nut to the following torque. ..... 21 N·m (15 lb ft)

(3) Tighten the solenoid terminal to the following torque. ..... 3.5 N·m (31 lb in)

Rated voltage ..... 24 volts

12 Volt Starting Motor 3 Kw

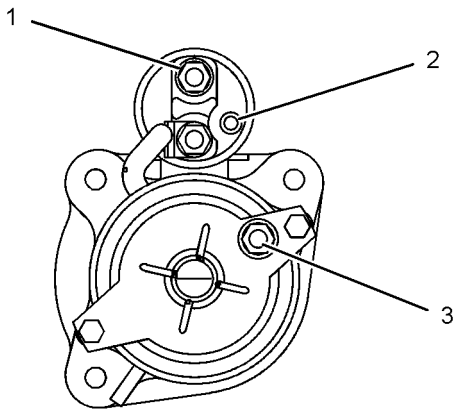


Illustration 69 g01332528
Typical example

(1) Tighten the positive terminal nut to the following torque. ..... 6 N·m (53 lb in)

(2) Tighten the solenoid terminal to the following torque. ..... 8 N·m (70 lb in)

(3) Tighten the negative terminal nut to the following torque. ..... 8 N·m (70 lb in)

Rated voltage ..... 12 volts

12 Volt Starting Motor 5 Kw

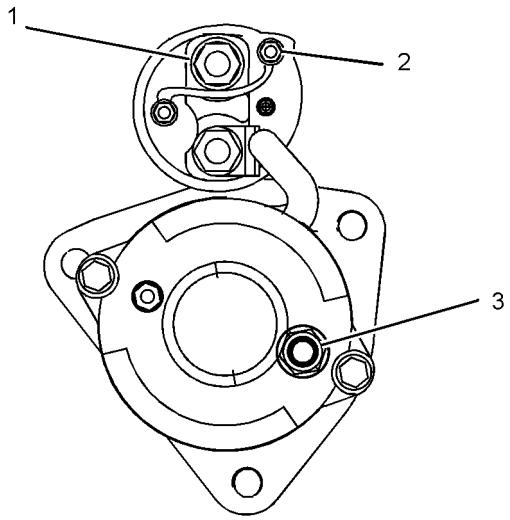


Illustration 70 g01332529

Typical example

(1) Tighten the positive terminal nut to the following torque. ..... 25 N·m (18 lb ft)

(2) Tighten the nut for the solenoid terminal to the following torque. ..... 2.5 N·m (22 lb in)

(3) Tighten the nut on the negative terminal to the following torque. ..... 25 N·m (18 lb ft)

Rated voltage ..... 12 volts

i02634787

Coolant Temperature Sensor

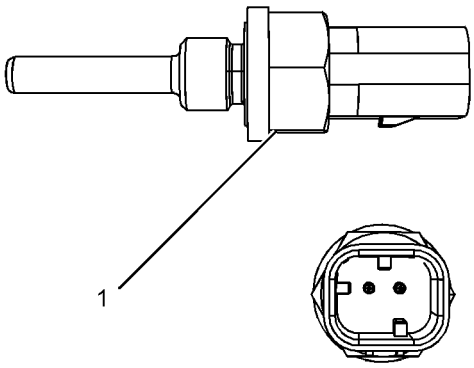


Illustration 71 g01332531

Typical example

(1) Sensor

Tighten the sensor to the following torque. ..... 20 N·m (15 lb ft)

i02652615

Fuel Pressure Sensor

⚠ WARNING

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

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

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

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

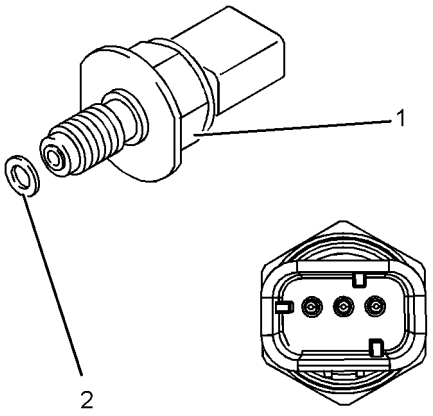


Illustration 72 g01332533

(1) Fuel pressure sensor
(2) Washer

Fuel pressure sensor

Tighten the fuel pressure sensor to the following torque. ..... 34 N·m (25 lb ft)

i02652617

Engine Oil Pressure Sensor

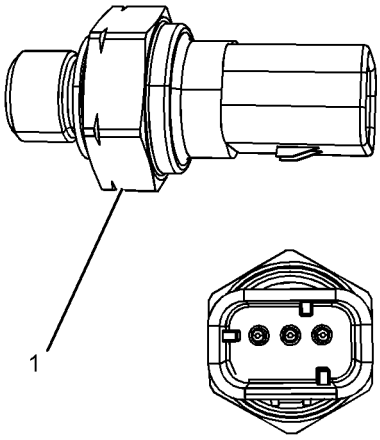


Illustration 73 g01332534

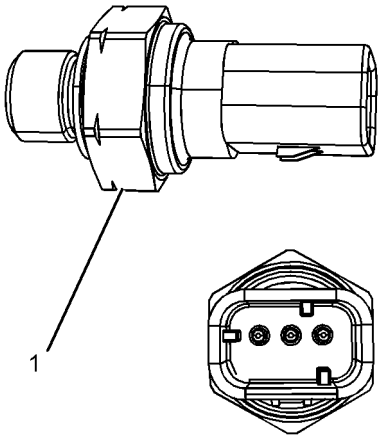
Typical example

(1) Sensor

Tighten the sensor to the following torque. ..... 10 N·m (7 lb ft)

i02652620

Boost Pressure Sensor



g01332534

Illustration 74

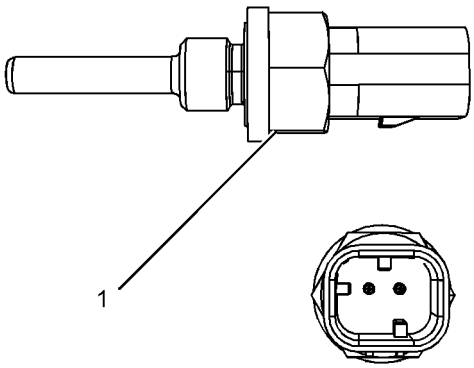
Typical example

(1) Sensor

Tighten the sensor to the following torque. ..... 10 N·m (7 lb ft)

i02652622

Inlet Manifold Temperature Sensor



g01332531

Illustration 75

Typical example

(1) Sensor

Tighten the sensor to the following torque. ..... 20 N·m (15 lb ft)

i02652623

Crankshaft Position Sensor

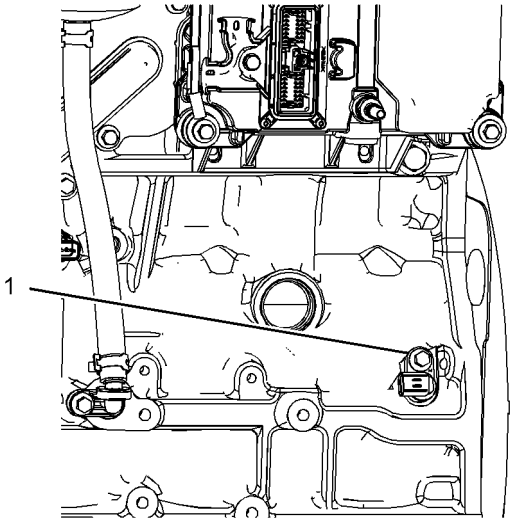


Illustration 76 g01332538

Typical example

(1) Tighten the bolt for the sensor to the following torque. ..... 22 N·m (16 lb ft)

i02652624

Electronic Control Module

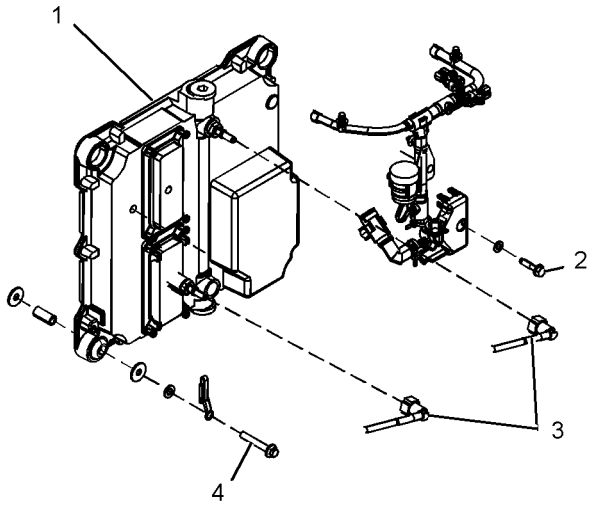


Illustration 77 g01332539

(1) Electronic control module (ECM)
(2) Setscrew
(3) Fuel line connectors
(4) Setscrew

(2) Setscrew

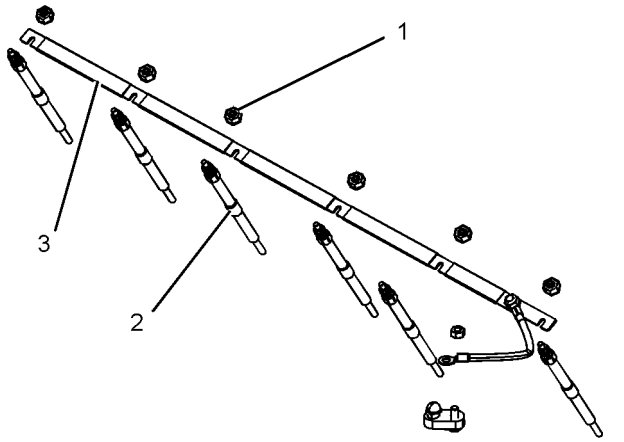
Tighten the setscrew to the following torque. ..... 5 N·m (44 lb in)

(4) Setscrew

Tighten the setscrew to the following torque. ..... 22 N·m (16 lb ft)

i02652625

Glow Plugs



g01332542

Illustration 78

Typical example

Tighten the glow plugs (2) in the cylinder head to the following torque. ..... 15 N·m (11 lb ft)

Tighten the nuts (1) for the bus bar (3) that is installed on top of the glow plugs to the following torque. ..... 2 N·m (18 lb in)

Voltage ..... 12 or 24 volts

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