



## 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.**

# Table of Contents

## Specifications Section

Engine Design .....	4
Fuel Injection Lines .....	5
Fuel Injection Pump (Delphi DP210 for the 1103 and 1104 engines) .....	5
Fuel Injection Pump (Bosch EPVE for the 1104 engines only) .....	6
Fuel Injection Pump (Delphi STP) .....	7
Fuel Injectors .....	7
Fuel Transfer Pump .....	8
Lifter Group .....	8
Rocker Shaft .....	8
Valve Mechanism Cover .....	9
Cylinder Head Valves .....	10
Cylinder Head .....	11
Turbocharger .....	13
Exhaust Manifold .....	14
Camshaft .....	14
Camshaft Bearings .....	15
Engine Oil Filter .....	16
Engine Oil Pump .....	16
Engine Oil Pressure .....	19
Engine Oil Bypass Valve .....	19
Engine Oil Pan .....	20
Crankcase Breather .....	21
Water Temperature Regulator and Housing .....	22
Water Pump .....	23
Cylinder Block .....	23
Crankshaft .....	25
Crankshaft Seals .....	29
Connecting Rod Bearing Journal .....	30
Main Bearing Journal .....	30
Connecting Rod .....	31
Piston and Rings .....	32
Piston Cooling Jet .....	33
Front Housing and Covers .....	34
Gear Group (Front) .....	35
Flywheel .....	37
Flywheel Housing .....	37
Crankshaft Pulley .....	37
Fan Drive .....	38
Engine Lifting Bracket .....	38
Alternator .....	38
Starter Motor .....	39
Glow Plugs .....	40

## Index Section

Index .....	41
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# Specifications Section

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## Engine Design

### Four Cylinder Engine

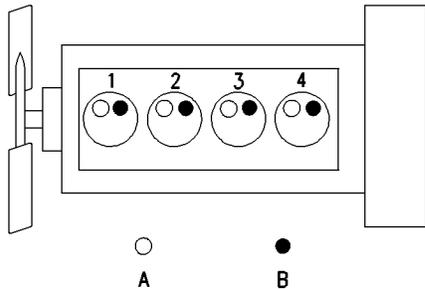


Illustration 1 g00984281

Cylinder and valve location

- (A) Inlet valve
- (B) Exhaust valve

Bore .....	105 mm (4.133 inch)
Stroke .....	127 mm (5.000 inch)
Displacement .....	4.4 L (269 in <sup>3</sup> )
Cylinder arrangement .....	In-line
Type of combustion .....	Direct injection
Compression ratio	
Naturally aspirated engines .....	19.3:1
Turbocharged engines .....	18.2:1
Number of cylinders .....	4
Valves per cylinder .....	2
Valve lash	
Inlet valve .....	0.20 mm (0.008 inch)
Exhaust valve .....	0.45 mm (0.018 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. The left side and the right side of the engine are viewed from the flywheel end. The No. 1 cylinder is the front cylinder.

### Three Cylinder Engine

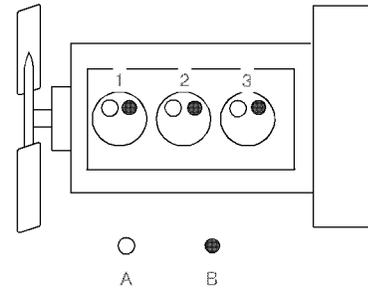


Illustration 2 g01014247

Cylinder and valve location

- (A) Inlet valve
- (B) Exhaust valve

Bore .....	105 mm (4.133 inch)
Stroke .....	127 mm (5.000 inch)
Displacement .....	3.3 L (201 in <sup>3</sup> )
Cylinder arrangement .....	In-line
Type of combustion .....	Direct injection
Compression ratio	
Naturally aspirated engines .....	19.3:1
Turbocharged engines .....	18.2:1
Number of cylinders .....	3
Valves per cylinder .....	2
Valve lash	
Inlet valve .....	0.20 mm (0.008 inch)
Exhaust valve .....	0.45 mm (0.018 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. 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

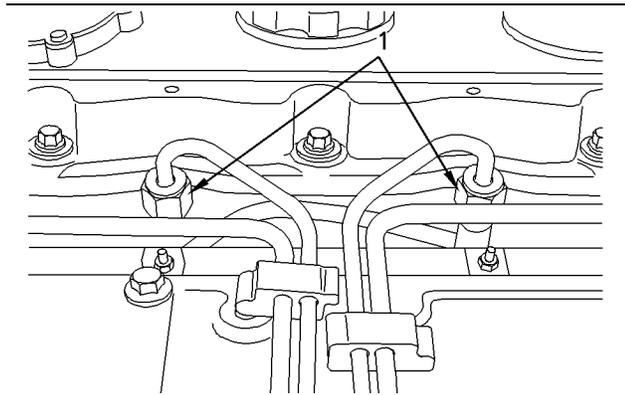


Illustration 3

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A typical fuel line

- (1) Tighten the union nuts for the fuel injector to the following torque. .... 30 N·m (22 lb ft)

**Note:** Tighten the union nuts at the fuel injection pump to the following torque. 30 N·m (22 lb ft)

i02074849

## Fuel Injection Pump (Delphi DP210 for the 1103 and 1104 engines)

**Note:** Before the fuel injection 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.

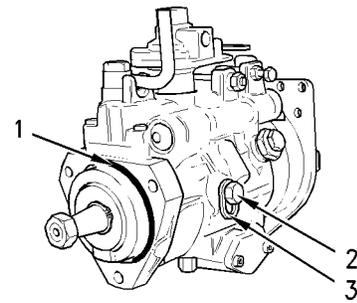


Illustration 4

g00922601

The Delphi DP 210 fuel injection pump

**Note:** The solenoid on the fuel injection pump is a serviceable item. The fuel injection pump is a non-serviceable item.

- (1) O-ring
- (2) Locking screw
- (3) Washer

### Locking the shaft

Loosen locking screw (2) and move the washer (3) to the locked position. Tighten the bolt to the following torque. .... 17 N·m (12 lb ft)

### Unlocking the shaft

Loosen locking screw (2) and install the washer (3) to the unlocked position. Tighten the bolt to the following torque. .... 12 N·m (9 lb ft)

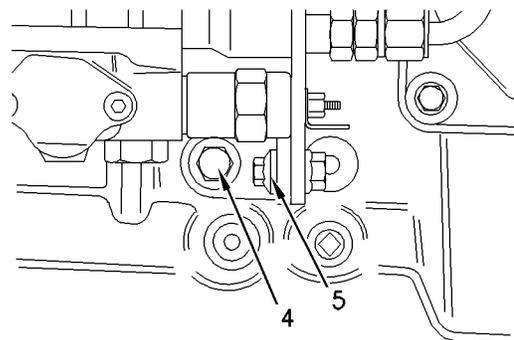


Illustration 5

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Support bracket

- (4) Tighten the mounting bolt to the following torque. .... 44 N·m (32 lb ft)
- (5) Tighten the mounting bolt 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 bolt (4) and then tighten the nut and bolt (5). Tighten the bolt (4).

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

i02074846

## Fuel Injection Pump (Bosch EPVE for the 1104 engines only)

**Note:** Before the fuel injection 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 properly timing the engine and locking the shaft, the fuel injection pump will need to be timed by trained personnel.

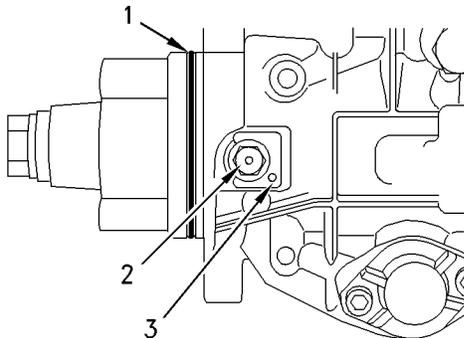


Illustration 6 g00986530  
Bosch EPVE fuel injection pump

**Note:** The solenoid on the fuel injection pump is a serviceable item. The fuel injection pump is a non-serviceable item.

- (1) O-ring
- (2) Locking screw
- (3) Spacer

### Locking the shaft

Remove spacer (3) before locking screw (2) is tightened to the following torque. .... 31 N·m (23 lb ft)

### Unlocking the shaft

Loosen the bolt and place spacer (3) behind locking screw (2). Tighten the bolt to the following torque. .... 12 N·m (9 lb ft)

The lift of the ER fuel injection pump plunger ..... 1.55 mm (0.0610 inch)

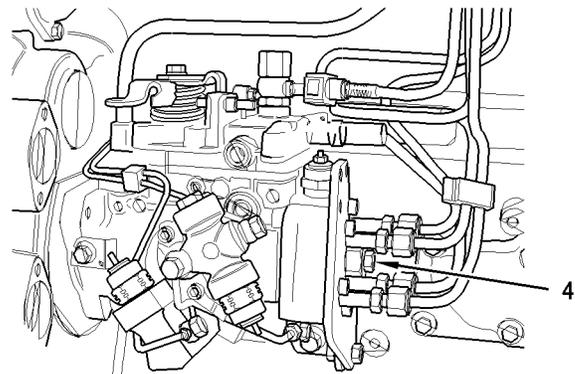


Illustration 7 g00988408  
Installed EPEP fuel injection pump

(4) Tighten the plug for the fuel injection pump plunger to the following torque. .... 29 N·m (21 lb ft)

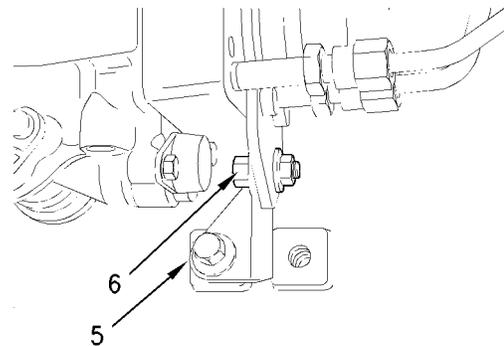


Illustration 8 g00986295  
Support bracket

**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 bolt (5) and then tighten the nut and the bolt (6). Tighten the bolt (5).

(5) Tighten the bolt to the following torque. ... 44 N·m (32 lb ft)

(6) Tighten the nut and the bolt to the following torque. .... 22 N·m ( 16 lb ft)

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

i02074902

## Fuel Injection Pump (Delphi STP)

**Note:** Before the fuel injection 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.

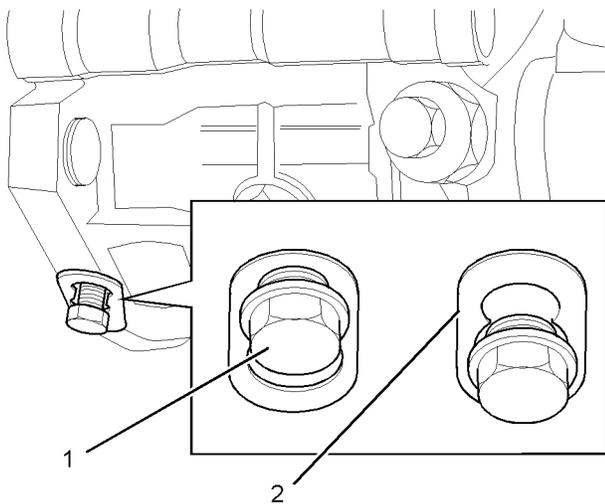


Illustration 9  
The Delphi STP fuel injection pump  
g01061708

**Note:** The solenoid on the fuel injection pump is a serviceable item. The fuel injection pump is a nonserviceable item.

(1) Locking screw

(2) Washer

### Locking the shaft

Loosen locking screw (1) and move the washer (2) to the locked position. Tighten the bolt to the following torque. .... 13 N·m (10 lb ft)

### Unlocking the shaft

Loosen locking screw (2) and install the washer (3) to the unlocked position. Tighten the bolt to the following torque. .... 12 N·m (9 lb ft)

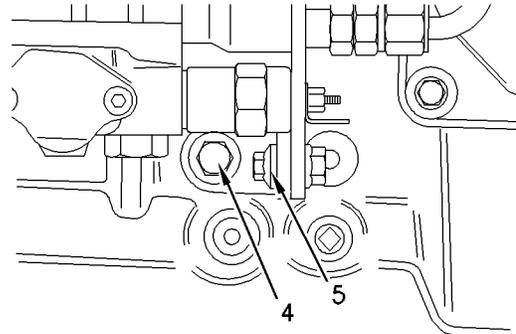


Illustration 10  
Support bracket  
g00986531

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

(5) Tighten the mounting bolt 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 bolt (4) and then tighten the nut and bolt (5). Tighten the bolt (4).

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

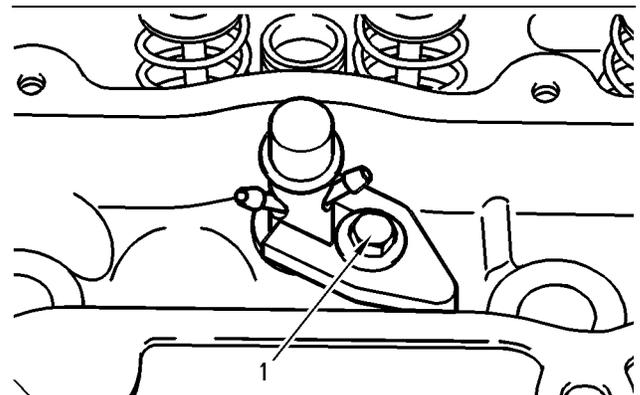


Illustration 11  
Fuel injector clamp  
g00908211

(1) Tighten the bolt in the clamp for the fuel injector to the following torque. .... 35 N·m (26 lb ft)

The fuel injector nozzle should be tested at the pressure in Table 1.

Leakage in 10 seconds ..... 0 drops

Table 1

Service Setting for the Fuel Injection Nozzle	
Color	Injection Pressure
Yellow	29.4 + 0.8 MPa (4264 + 116 psi)
Blue	29.4 + 0.8 MPa (4264 + 116 psi)
Red	29.4 + 0.8 MPa (4264 + 116 psi)

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## Fuel Transfer Pump

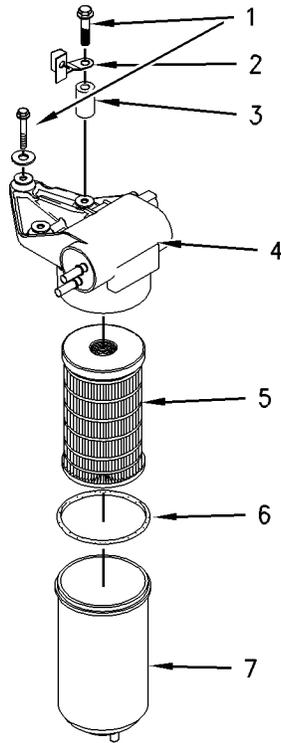


Illustration 12

g00986823

(1) Retaining bolts

(2) Clip

(3) Spacer

(4) Fuel transfer pump

Type ..... 12 or 24 volt electric motor

(5) Fuel filter element

(6) O ring

(7) Fuel filter bowl

**Note:** Tighten the fuel filter bowl by hand. Rotate the bowl 1/8 of a turn more by hand.

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## Lifter Group

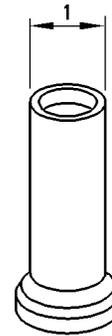


Illustration 13

g00629433

(1) Diameter of the lifter body .... 18.99 to 19.01 mm  
(0.7475 to 0.7485 inch)

Clearance of the lifter in the cylinder block  
bore ..... 0.04 to 0.09 mm (0.0015 to 0.0037 inch)

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## Rocker Shaft

**Note:** The rocker shaft assembly for the 3 cylinder engine and the rocker shaft assembly for the 4 cylinder engine use the same components. The exception is the length of the rocker shaft.

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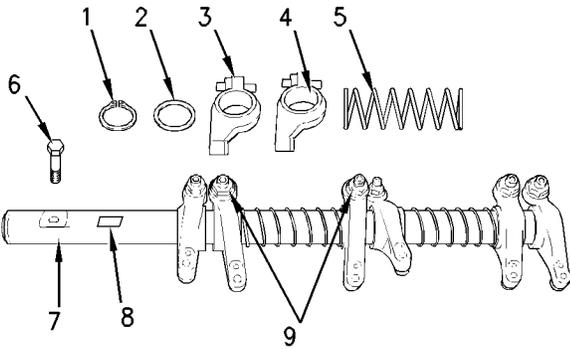


Illustration 14  
The rocker shaft g00985174

**Note:** In order to install the rocker shaft assembly, the tool 27610227 Spacing Tool is required.

- (1) Snap ring
- (2) Washer
- (3) Rocker arm
- (4) Rocker arm bore

Diameter of the rocker arm bore for the bushing ..... 25.01 to 25.05 mm  
(0.9847 to 0.9862 inch)

**Rocker arm bushing**

Clearance between the rocker arm bushing and the rocker shaft ..... 0.03 to 0.09 mm  
(0.0010 to 0.0035 inch)

Maximum permissible clearance between the rocker arm bushing and the rocker shaft ..... 0.17 mm (0.007 inch)

- (5) Spring

**Note:** Install the longest screw at the front of the rocker shaft assembly.

- (6) Tighten the screws evenly. Begin in the center and work toward the outside. Tighten the screws to the following torque. .... 35 N·m (26 lb ft)

- (7) Rocker shaft

Diameter of the rocker shaft .. 24.96 to 24.99 mm  
(0.9827 to 0.9839 inch)

- (8) In order to install the rocker shaft assembly, ensure that the machined square is to the top of the rocker shaft.

- (9) Locknut

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

## Valve Mechanism Cover

### The Cover for the Four Cylinder Engine

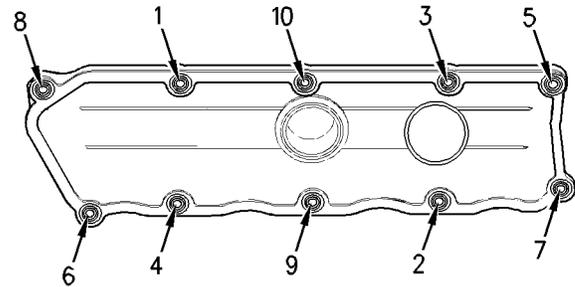


Illustration 15  
Cover g00908011

Tighten the bolts for the valve mechanism cover in the sequence that is shown to the following torque. .... 9 N·m (7 lb ft)

### The Cover for the Three Cylinder Engine

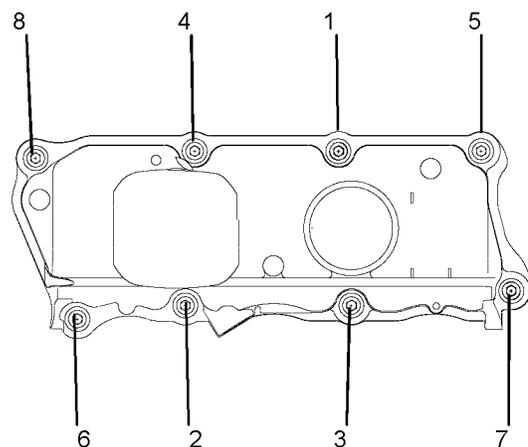


Illustration 16  
Cover g01018519

Tighten the bolts for the valve mechanism cover in the sequence that is shown to the following torque. .... 9 N·m (7 lb ft)

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## Cylinder Head Valves

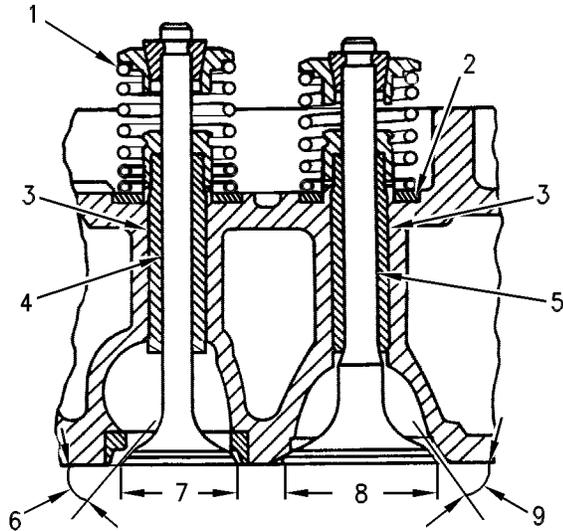


Illustration 17  
Cross section of cylinder head

g00294082

### (1) Valve spring

#### Naturally aspirated engines

The installed length of the valve springs ..... 33.5 mm (1.318 inch)

The load for the installed valve springs ..... 254 N (57.1 lb)

#### Turbocharged engines

The installed length of the valve springs ..... 34.5 mm (1.358 inch)

The load for the installed valve spring ..... 229 N (51.4 lb)

### (2) Valve spring recess

### (3) The finished valve guides

Inside diameter of valve guide ..... 9.000 to 9.022 mm (0.3543 to 0.3552 inch)

Outside diameter of the exhaust valve guide ..... 13.034 to 13.047 mm (0.5131 to 0.5137 inch)

Outside diameter of the inlet valve guide ..... 13.034 to 13.047 mm (0.5131 to 0.5137 inch)

Interference fit of valve guide in cylinder head ..... 0.007 to 0.047 mm (0.0003 to 0.0019 inch)

Length of Valve guide ..... 51.00 to 51.50 mm (2.018 to 2.027 inch)

Projection of the valve guide above the valve spring recess (2) ..... 12.35 to 12.65 mm (0.486 to 0.498 inch)

**Note:** When new valve guides are installed, new valves and new valve seat inserts must be installed. The valve guides and the valve seat inserts are supplied as partially finished parts. The unfinished valve guides and unfinished valve seat inserts are installed in the cylinder head. The guides and inserts are then cut and reamed in one operation with special tooling. This procedure ensures the concentricity of the valve seat to the valve guide in order to create a seal that is tight. Refer to the Disassembly and Assembly Manual for removal and installation procedures.

### (4) Exhaust valve

Diameter of the exhaust valve stem ..... 8.938 to 8.960 mm (0.3519 to 0.3528 inch)

Clearance of valve in valve guide ..... 0.040 to 0.840 mm (0.0016 to 0.033 inch)

Overall length of the exhaust valve ..... 128.92 to 129.37 mm (5.075 to 5.093 inch)

The face of the exhaust valve is recessed below the cylinder head by the following amount.

Naturally aspirated engines ..... 0.53 to 0.81 mm (0.021 to 0.032 inch)

Service limit ..... 1.06 mm (0.042 inch)

Turbocharged engines ..... 1.53 to 1.81 mm (0.060 to 0.071 inch)

Service limit ..... 2.06 mm (0.0811 inch)

### (5) Inlet valve

Diameter of the inlet valve stem ..... 8.953 to 8.975 mm (0.3525 to 0.3533 inch)

Clearance of valve in valve guide .. 0.025 to 0.069 mm (0.001 to 0.0027 inch)

Overall length of the inlet valve ..... 128.92 to 129.37 mm (5.075 to 5.093 inch)

The face of the inlet valve is recessed below the cylinder head by the following amount.

Naturally aspirated engines ..... 0.58 to 0.84 mm  
(0.023 to 0.033 inch)

Service limit ..... 1.09 mm (0.043 inch)

Turbocharged engines ..... 1.58 to 1.84 mm  
(0.062 to 0.072 inch)

Service limit ..... 2.09 mm (0.0823 inch)

(6) Exhaust valve face angle from the vertical axis

Valve face angle ..... 30 degrees

Valve seat angle ..... 30 degrees

(7) Diameter of the exhaust

valve head ..... 41.51 to 41.75 mm  
(1.634 to 1.643 inch)

(8) Diameter of the head of the inlet

valve ... 46.20 to 46.45 mm (1.818 to 1.828 inch)

(9) Angle of the inlet valve face from the vertical axis

Valve face angle ..... 30 degrees

Valve seat angle ..... 30 degrees

The valve lash is the following value when the engine is cold:

Inlet valves ..... 0.20 mm (0.008 inch)

Exhaust valves ..... 0.45 mm (0.018 inch)

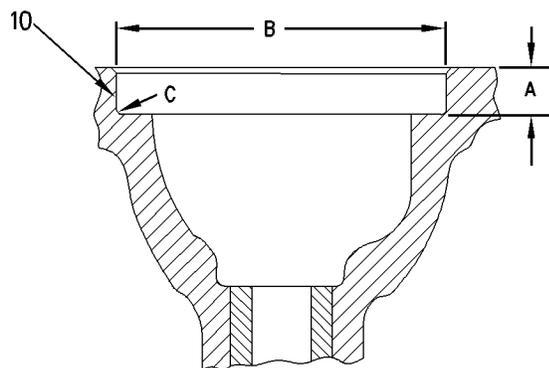


Illustration 18

g00809016

Recess for the valve seat insert

(10) Machine the recess in the head for valve seat inserts to the following dimensions.

Recess for Inlet Valve Seat for Naturally Aspirated Engines

(A) .. 9.910 to 10.040 mm (0.3901 to 0.3952 inch)

(B) ..... 47.820 to 47.845 mm  
(1.8826 to 1.8836 inch)

(C) Maximum radius ..... 0.38 mm (0.015 inch)

Recess for Exhaust Valve Seat for Naturally Aspirated Engines

(A) .. 9.910 to 10.040 mm (0.3901 to 0.3952 inch)

(B) ..... 42.420 to 42.445 mm  
(1.6701 to 1.6711 inch)

(C) Maximum radius ..... 0.38 mm (0.015 inch)

Recess for Inlet Valve Seat for Turbocharged Engines

(A) ..... 10.910 to 11.040 mm  
(0.4295 to 0.4346 inch)

(B) ..... 47.820 to 47.845 mm  
(1.8826 to 1.8836 inch)

(C) Maximum radius ..... 0.38 mm (0.015 inch)

Recess for Exhaust Valve Seat for Turbocharged Engines

(A) ..... 10.910 to 11.040 mm  
(0.4295 to 0.4346 inch)

(B) ..... 42.420 to 42.445 mm  
(1.6700 to 1.6710 inch)

(C) Maximum radius ..... 0.38 mm (0.015 inch)

i01899306

## Cylinder Head

The maximum distortion of the cylinder head is given in table 3.

Table 2

Required Tools		
Part Number	Part Description	Qty
21825607	Angle gauge	1

The cylinder head bolts are two different lengths. The following information provides the proper torque for the cylinder head bolts.

## Four Cylinder engine

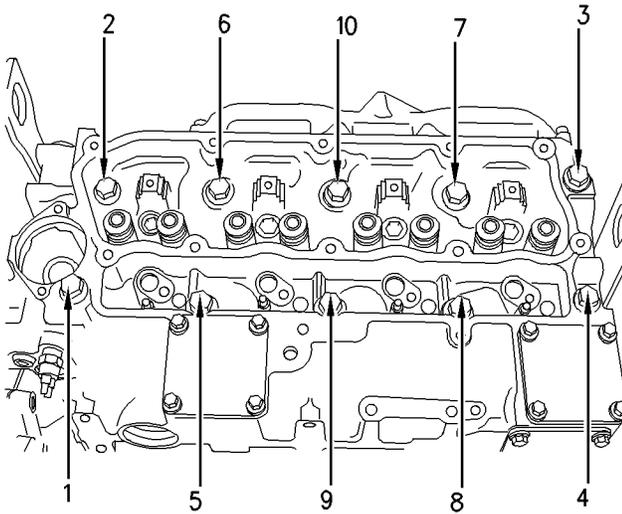


Illustration 19  
The tightening sequence

g00987480

## Three Cylinder engine

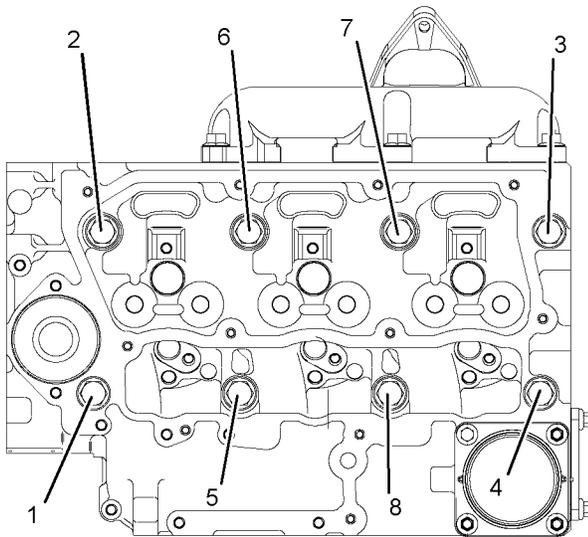


Illustration 20  
The tightening sequence

g01017007

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

Tighten the bolts in the sequence that is shown in Illustrations to the following torque. .... 50 N·m (37 lb ft)

Tighten the bolts again to the following torque. .... 100 N·m (74 lb ft)

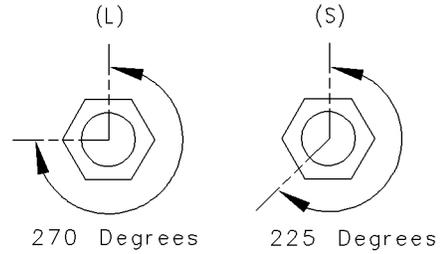


Illustration 21

g00905621

The head bolts require an additional torque turn procedure. The numbers (1, 3, 4) are three long cylinder head bolts. All the other bolts are short bolts. The tightening sequence is shown in the Illustrations .

Place the angle gauge on the top of each bolt head. Tighten the short bolts to the additional amount. .... 225 degrees  
Place the angle gauge on the top of each bolt head. Tighten the long bolts for the additional amount. .... 270 degrees

Thickness of the cylinder head .. 117.95 to 118.05 mm (4.643 to 4.647 inch)

Minimum thickness of cylinder head ..... 117.20 mm (4.614 inch)

**Note:** The maximum distortion of the cylinder head is given in table 3.

## Four Cylinder Engine

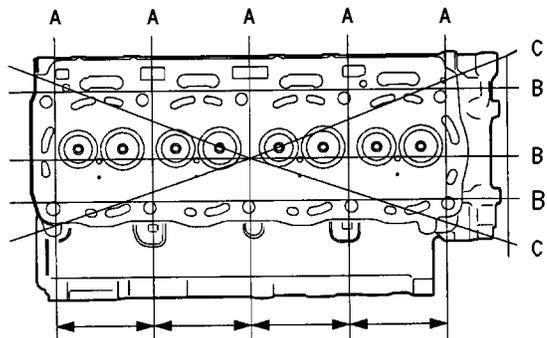


Illustration 22

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## Three Cylinder Engine

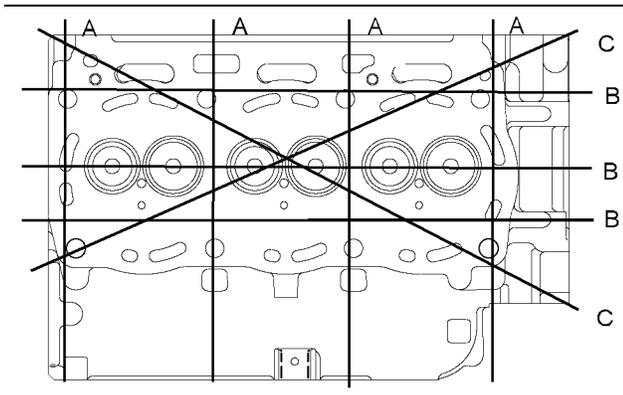


Illustration 23

g01017008

Table 3

Dimension	Maximum Permissible Distortion
Width (A)	0.03 mm (0.0018 inch)
Length (B)	0.05 mm (0.0019 inch)
Diagonal Line (C)	0.05 mm (0.0019 inch)

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## Turbocharger

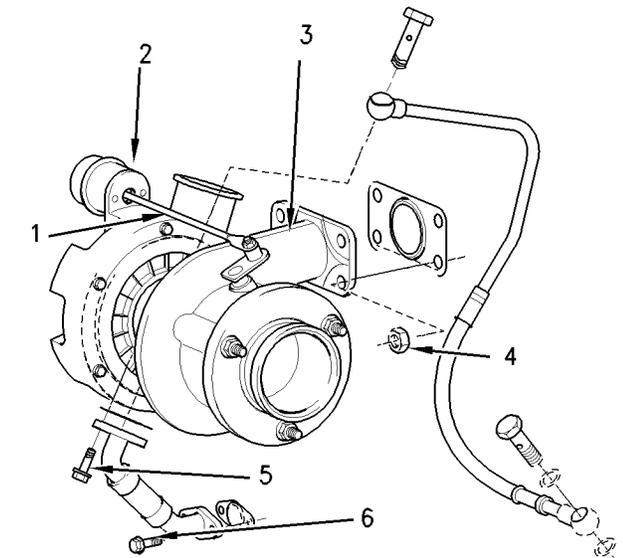


Illustration 24

g00991357

Typical turbocharger

- (1) Actuator rod
- (2) Actuator
- (3) Turbocharger

(4) Tighten the nuts to the following torque. ... 47 N·m  
(34 lb ft)

(5) Tighten the bolt to the following torque. .... 9 N·m  
(80 lb in)

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

The maximum test pressure for the waste gate ..... 205 kPa (30 psi)

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

## Four Cylinder Engine

Table 4

The part number for the turbocharger	The pressure for the waste gate
2674A200	100 ± 5 kPa (14.5040 ± 0.7252 psi)
2674A201	110 ± 5 kPa (15.9544 ± 0.7252 psi)
2674A202	128 ± 5 kPa (18.5651 ± 0.7252 psi)
2674A209	100 ± 5 kPa (14.5040 ± 0.7252 psi)
2674A211	128 ± 5 kPa (18.5651 ± 0.7252 psi)
2674A215	128 ± 5 kPa (18.5651 ± 0.7252 psi)
2674A223	136 ± 5 kPa (19.7254 ± 0.7252 psi)
2674A224	136 ± 5 kPa (19.7254 ± 0.7252 psi)
2674A225	136 ± 5 kPa (19.7254 ± 0.7252 psi)
2674A226	100 ± 5 kPa (14.5040 ± 0.7252 psi)
2674A227	128 ± 5 kPa (18.5651 ± 0.7252 psi)

## Three Cylinder Engine

Table 5

The part number for the turbocharger	The pressure for the waste gate
2674A405	100 ± 3 kPa (14.5040 ± 0.4351 psi)

i01957427

i01956585

## Exhaust Manifold

### Four Cylinder Engine

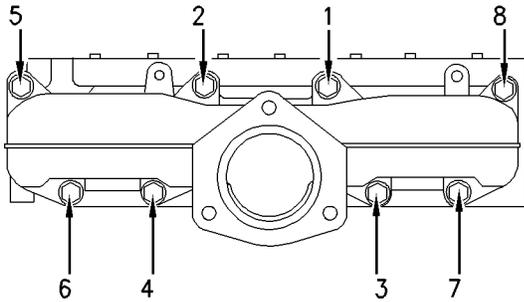


Illustration 25  
Tightening sequence  
g00907527

**Note:** The exhaust manifold must be aligned to the cylinder head. Refer to the Disassembly and Assembly manual.

Tighten the exhaust manifold bolts in the sequence that is shown in illustration 25 to the following torque. .... 33 N·m (24 lb ft)

### Three Cylinder Engine

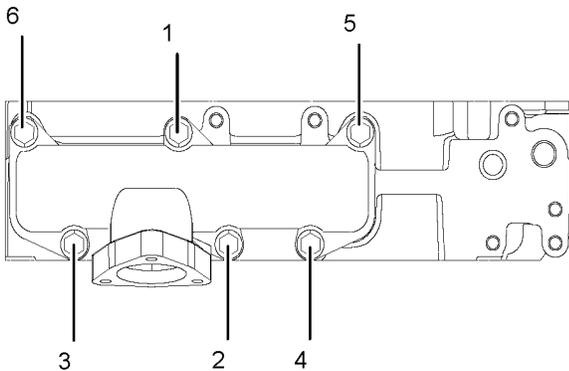


Illustration 26  
g01017009

**Note:** The exhaust manifold must be aligned to the cylinder head. Refer to the Disassembly and Assembly manual.

Tighten the exhaust manifold bolts in the sequence that is shown illustration 26 to the following torque. .... 33 N·m (24 lb ft)

## Camshaft

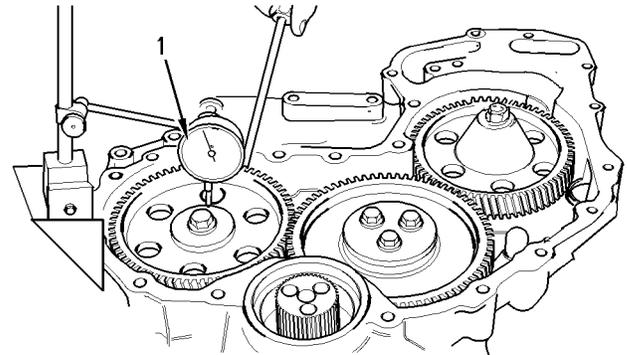


Illustration 27  
Checking the end play of the camshaft  
g00987750

(1) End play of a new camshaft ..... 0.10 to 0.55 mm  
(0.004 to 0.022 inch)

Maximum permissible end play of a worn camshaft ..... 0.60 mm (0.023 inch)

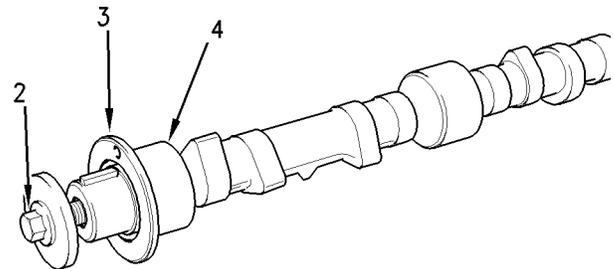


Illustration 28  
Typical camshaft  
g00976195

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

(3) Camshaft thrust washer  
Thickness of the thrust washer .. 5.49 to 5.54 mm  
(0.216 to 0.218 inch)  
Depth of the recess in the cylinder block for the thrust washer ..... 5.54 to 5.64 mm  
(0.218 to 0.222 inch)

Tolerance of the thrust washer in cylinder block front face ..... -0.154 to -0.003 mm (-0.0006 to -0.0001 inch)

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

Table 6

1104 Diameters of Camshaft Journals	
Camshaft Journals	Standard Diameter
1	50.71 to 50.74 mm (1.9965 to 1.9975 inch)
2	50.46 to 50.48 mm (1.9865 to 1.9875 inch)
3	49.95 to 49.98 mm (1.9665 to 1.9675 inch)

Table 7

1103 Diameters of Camshaft Journals	
Camshaft Journals	Standard Diameter
1	50.71 to 50.74 mm (1.9965 to 1.9975 inch)
2	50.46 to 50.48 mm (1.9865 to 1.9875 inch)
3	50.46 to 50.48 mm (1.9865 to 1.9875 inch)
4	49.95 to 49.98 mm (1.9665 to 1.9675 inch)

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

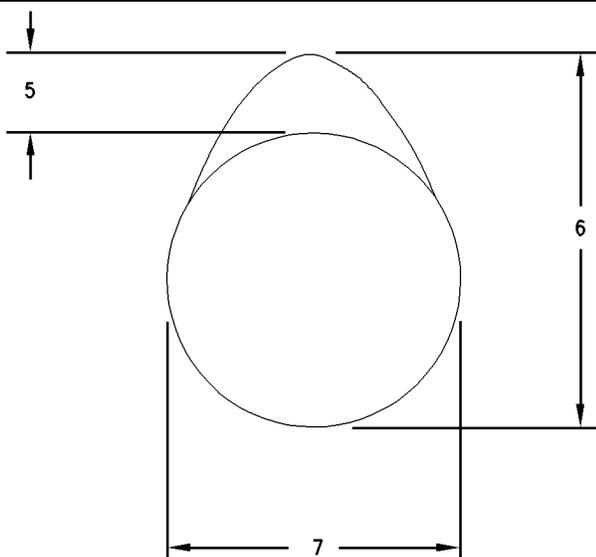


Illustration 29

g00629702

(5) Camshaft lobe lift

Naturally aspirated

Inlet lobe ..... 7.382 to 7.482 mm (0.2906 to 0.2946 inch)

Exhaust lobe ..... 7.404 to 7.504 mm (0.2914 to 0.2954 inch)

Turbocharged

Inlet lobe ..... 7.031 to 7.130 mm (0.2768 to 0.2807 inch)

Exhaust lobe ..... 7.963 to 8.063 mm (0.3135 to 0.3174 inch)

(6) Camshaft lobe height

(7) Base circle

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

1. Measure the camshaft lobe height (6).
2. Measure the base circle (7).
3. Subtract the base circle that is found in Step 2 from the camshaft lobe height that is found in Step 1. The difference is the actual camshaft lobe lift.

Maximum permissible clearance between the actual lobe lift and the specified lobe lift of a new camshaft ..... 0.05 mm (0.021 inch)

i01914527

## Camshaft Bearings

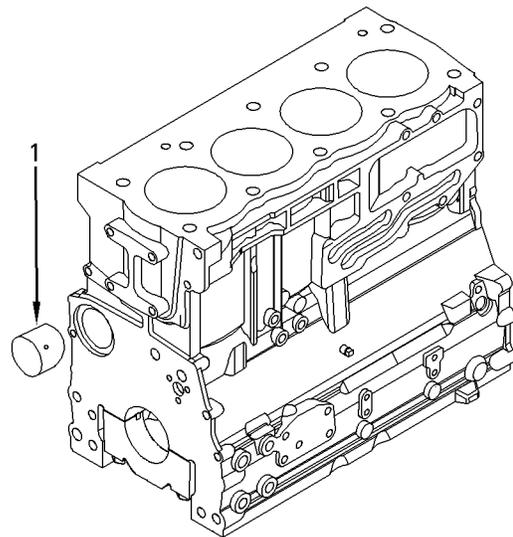


Illustration 30

g00997348

A typical four cylinder engine

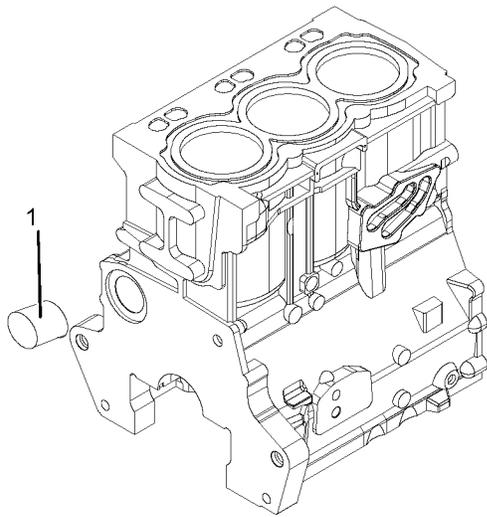


Illustration 31 g01017012  
A three cylinder engine

(1) Camshaft bearing

The diameter for the installed camshaft bearing ..... 50.790 to 50.850 mm (1.9996 to 2.0020 inch)

i01958095

## Engine Oil Filter

### Spin-on Oil Filter

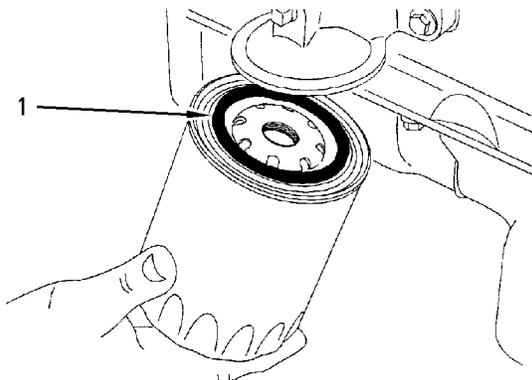


Illustration 32 g00915984

(1) Seal

**Note:** Lubricate the top of the seal with clean engine oil before installation.

Type ..... Full flow

Pressure to open engine oil filter bypass valve ..... 80 to 120 kPa (12 to 18 psi)

## Replaceable Element

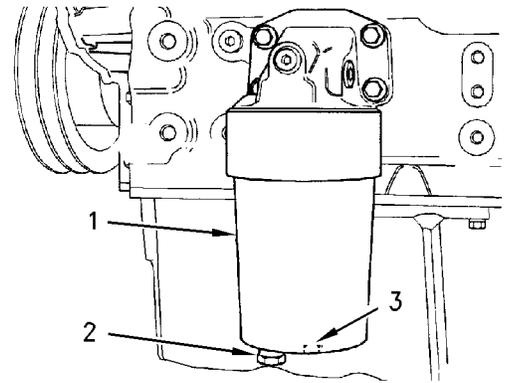


Illustration 33 g00915985

**Note:** Lubricate the seal on the oil filter housing with clean engine oil before installation.

Type ..... Full flow

Pressure to open engine oil filter bypass valve ..... 130 to 170 kPa (19 to 25 psi)

(1) Tighten the oil filter housing to the oil filter base to the following torque. .... 25 N·m (18 lb ft)

(2) Tighten the drain plug on the oil filter housing to the following torque. .... 12 N·m (9 lb ft)

**Note:** The horizontal filter as a drain plug in the filter head

(3) Recess for 1/2 inch square drive

i01957426

## Engine Oil Pump

### Four Cylinder Engines with Balancer Group

Type ..... Gear-driven differential rotor

Number of lobes

Inner rotor ..... 6  
Outer rotor ..... 7

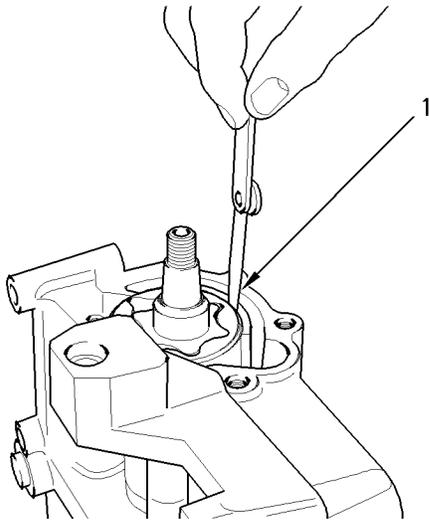


Illustration 34 g00989248  
The oil pump for the balancer

(1) Clearance of the outer rotor to the body .. 0.130 to 0.24 mm (0.0050 to 0.0094 inch)

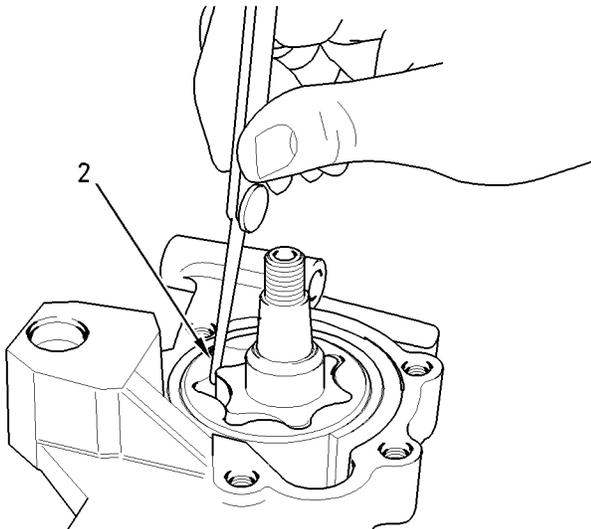


Illustration 35 g00989236  
Inner rotor

(2) Clearance of inner rotor to outer rotor ..... 0.050 to 0.200 mm (0.0020 to 0.0079 inch)

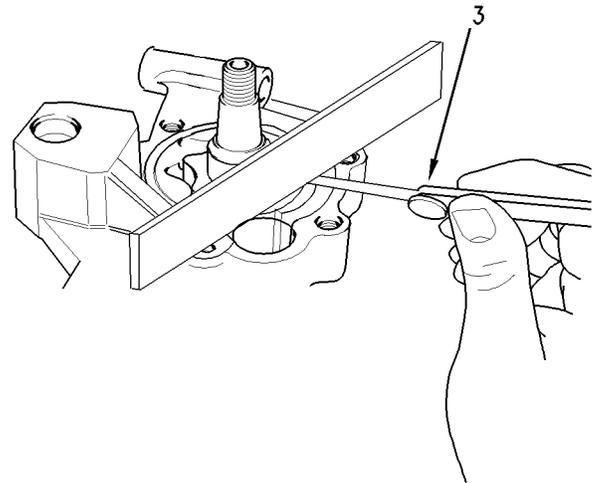


Illustration 36 g00989217  
The end play for the rotor

(3) End play of rotor assembly

Inner rotor .....	0.04 to 0.11 mm
	(0.0016 to 0.0043 inch)
Outer rotor .....	0.04 to 0.00 mm
	(0.0016 to 0.0043 inch)

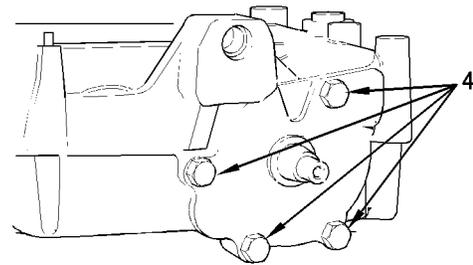


Illustration 37 g00938724  
The end cover

(4) Torque for cover bolts for oil pump ..... 26 N·m (19 lb ft)

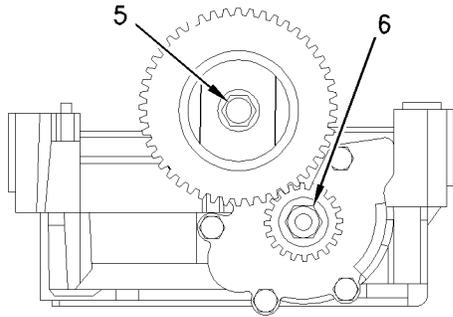


Illustration 38 g00989519  
Idler gear and pump gear

**Note:** Replace the idler gear bolt (5) and the nut for the oil pump gear (6).

(5) Tighten the idler gear bolt to the following torque. .... 26 N·m (19 lb ft)

**Note:** Set the engine to the TC position. Refer to Testing and Adjusting , “Finding Top Center Position for No. 1 Piston”. Install the balancer. Refer to the Disassembly and Assembly manual. Install the gear for the oil pump and tighten the nut (6).

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

Tighten the bolts that hold the balancer to the cylinder block to the following torque. .... 54 N·m (40 lb ft)

### Four Cylinder and Three Cylinder Engines without Balancer Group

Type ..... Gear-driven differential rotor

Number of lobes

- Inner rotor ..... 5
- Outer rotor ..... 6

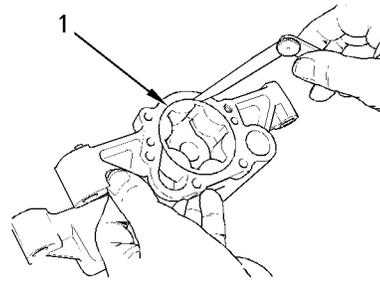


Illustration 39 g00938064  
The oil pump

(1) Clearance of the outer rotor to the body ..... 0.152 to 0.330 mm (0.0059 to 0.0129 inch)

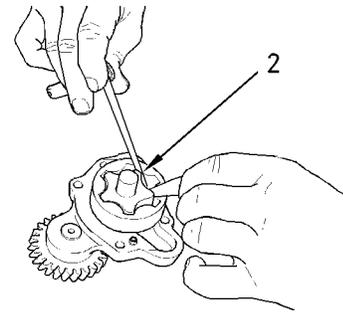


Illustration 40 g00938061  
Checking the clearance

(2) Clearance of inner rotor to outer rotor ..... 0.040 to 0.127 mm (0.0015 to 0.0050 inch)

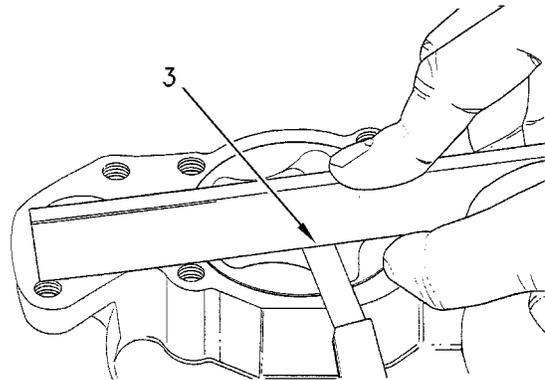


Illustration 41 g00938799  
Checking the end play

(3) End play of rotor assembly

- Inner rotor ..... 0.038 to 0.089 mm  
(0.0014 to 0.0035 inch)
- Outer rotor ..... 0.025 to 0.076 mm  
(0.0010 to 0.0029 inch)

Tighten the bolts that hold the front cover of the oil pump assembly to the following torque. .... 26 N·m (19 lb ft)

i01958104

## Engine Oil Pressure

The minimum oil pressure at the maximum engine speed and at normal operating temperature is the following value. .... 300 kPa (43 psi)

i01958107

## Engine Oil Bypass Valve

### Installed in the Oil Pump

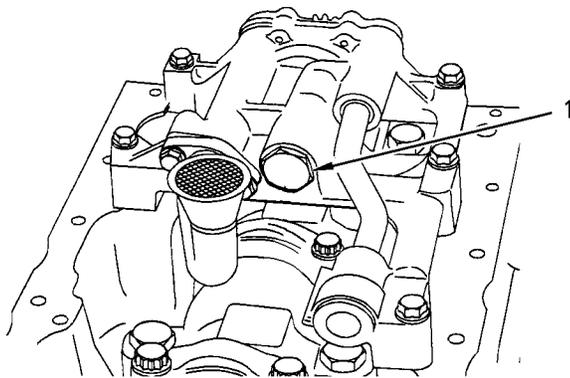


Illustration 42  
Typical engine oil pump

g00919893

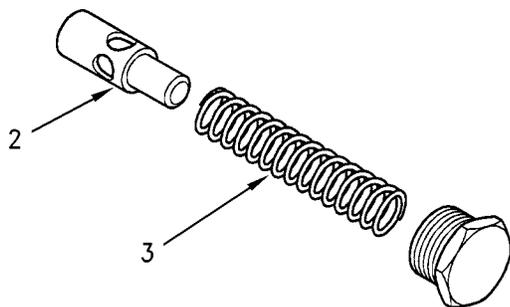


Illustration 43  
Relief valve and spring

g00921377

(1) Tighten the plug for the relief valve to the following torque. .... 35 N·m (26 lb ft)

(2) Plunger

Diameter of the plunger ..... 19.186 to 19.211 mm  
(0.7554 to 0.7563 inch)

Clearance of plunger in bore .. 0.039 to 0.114 mm  
(0.0015 to 0.0045 inch)

### Installed in the Balancer

1104 engines only

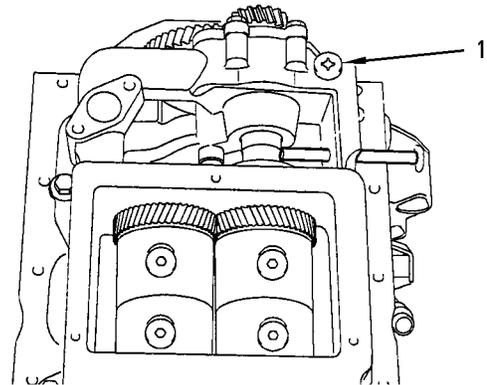


Illustration 44  
Plug

g00919890

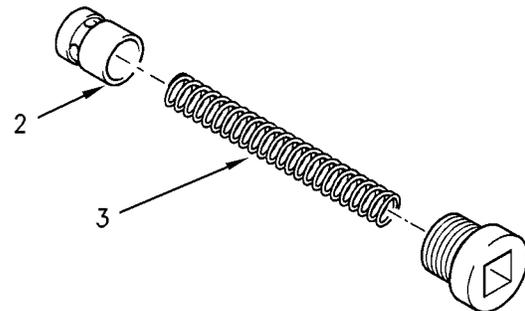


Illustration 45  
The relief valve for the balancer

g00921379

(1) Tighten the plug for the relief valve to the following torque. .... 35 N·m (26 lb ft)

(2) Plunger

Diameter of the plunger ..... 14.46 to 14.48 mm  
(0.5692 to 0.5700 inch)

Clearance of the plunger in the bore .... 0.04 to 0.08 mm (0.0015 to 0.0031 inch)

i01902947

# Engine Oil Pan

**Note:** The oil pan must be installed within 10 minutes of applying the sealant.

## Front sealant

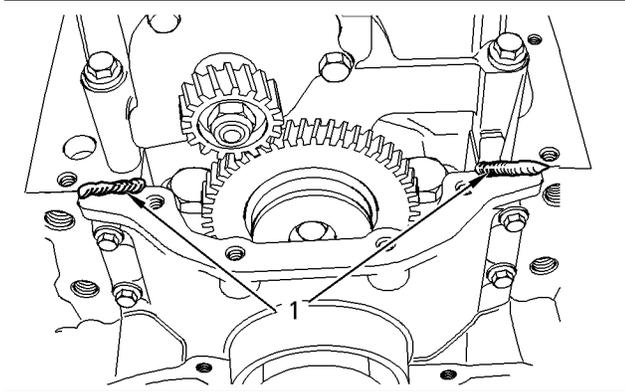


Illustration 46  
Applying sealant

- (1) Apply 1861108 Powerpart silicone rubber sealant to the cylinder block and to the timing case.

**Note:** Apply a sealant bead of 3.5 mm (0.1378 inch) that is shown in illustration 46.

## Rear sealant

**Note:** Install the rear oil seal before sealant is applied to the bridge.

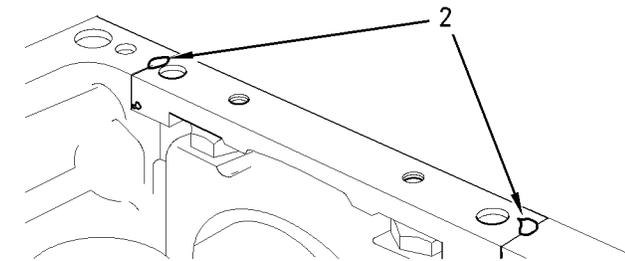


Illustration 47  
Applying sealant

- (2) Apply 1861108 Powerpart silicone rubber sealant to the bridge. The sealant must not protrude more than 5 mm (0.1969 inch) above the bridge.

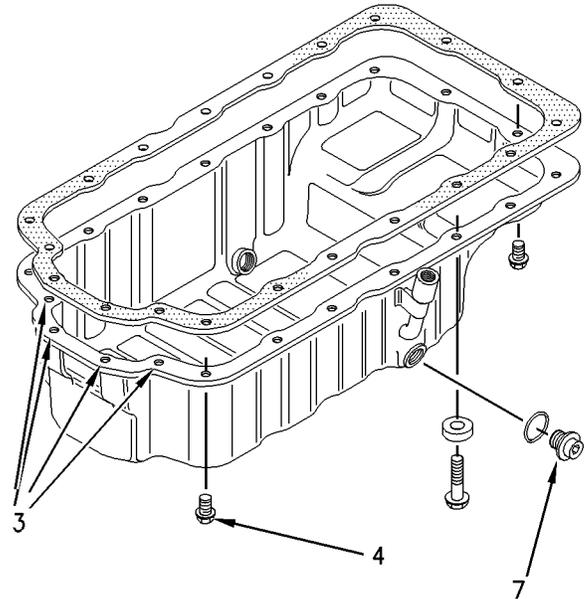


Illustration 48  
Typical oil pan

- (3) Tighten the four front bolts to the following torque. .... 22 N·m (16 lb ft)
- (4) Tighten the remaining bolts to the following torque. .... 22 N·m (16 lb ft)

## The cast iron oil pan

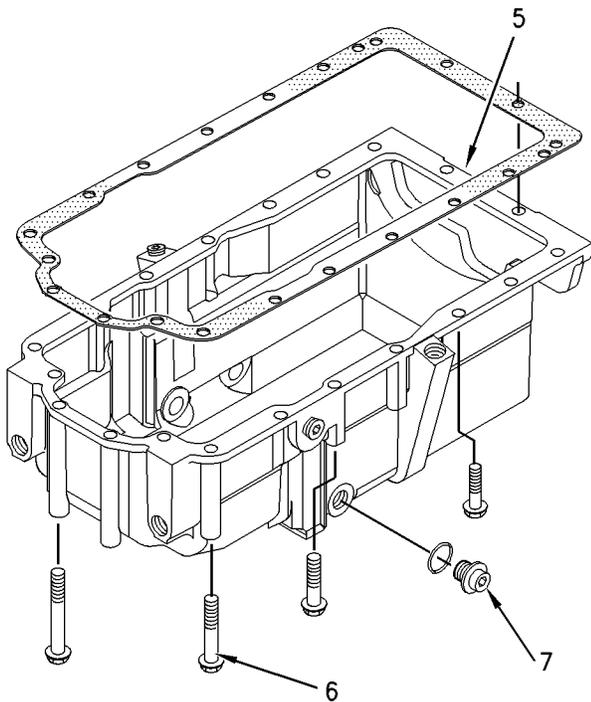


Illustration 49 g00990249  
The cast iron oil pan

**Note:** The rear face of the cast iron oil pan (5) must be aligned to the rear face of the cylinder block.

(5) The maximum allowed value of the rear face misalignment. .... 0.1 mm (0.0039 inch )

(6) Bolt

Tighten the front four bolts. Refer to illustration 48. Tighten the remaining bolts and the nuts that fasten the engine oil pan to the cylinder block to the following torque. .... 22 N·m (16 lb ft)

**Note:**

**Note:** The sealant is applied to new bolts. In order to reuse the bolts, apply 21820117 Powerpart threadlock and nutlock to the first three threads of the used bolts.

**Note:** The engine may be equipped with an oil drain plug or the engine may be equipped with a drain valve.

(7) Drain plug

Tighten the drain plug for the engine oil pan to the following torque. .... 34 ± 5 N·m (25 ± 4 lb ft)

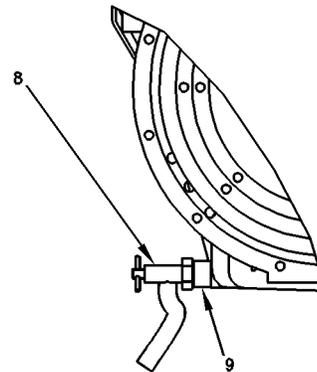


Illustration 50 g00990677  
The drain valve

(8) Drain valve

Tighten the drain valve into the adapter to the following torque. .... 34 ± 5 N·m (25 ± 4 lb ft)

(9) Adapter

Tighten the adapter into the engine oil pan to the following torque. .... 34 ± 5 N·m (25 ± 4 lb ft)

i01958112

## Crankcase Breather

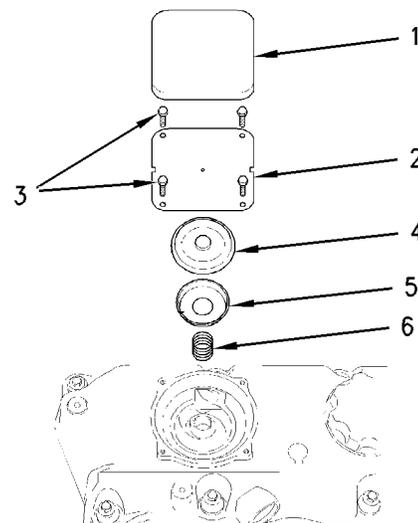


Illustration 51 g00926199  
Breather valve

(1) Plastic cover

(2) Cover plate

(3) Bolts

Tighten the bolts for the cover plate with a plastic valve mechanism cover to the following torque. .... 1.3 N·m (11.5 lb in)  
Tighten the bolts for the cover plate with a metal valve mechanism cover to the following torque. .... 1.8 N·m (16 lb in)

- (4) Diaphragm
- (5) Cap
- (6) Spring

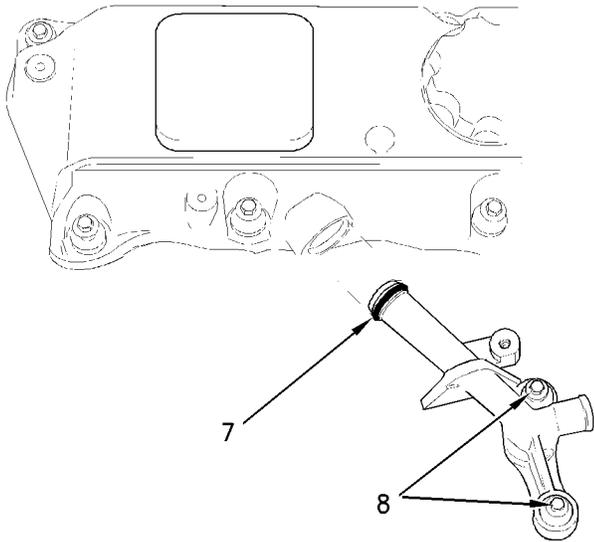


Illustration 52 g00926200

- (7) O-ring

**Note:** Apply 21820221 Powerpart red rubber grease to the O-ring before installing the breather pipe in the valve mechanism cover.

- (8) Tighten the bolts that secure the breather pipe to the cylinder head to the following torque. ... 9 N·m (80 lb in)

i01914256

## Water Temperature Regulator and Housing

Tighten the bolts (not shown) that fasten the housing to the following torque. .... 22 N·m (16 lb ft)

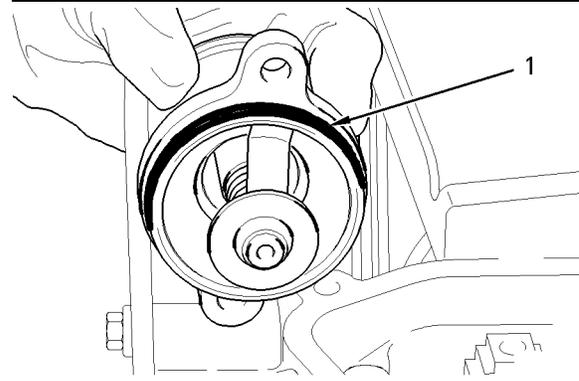


Illustration 53 g00997234

O ring

**Note:** Apply 21820221 Powerpart red rubber grease to the O-ring (1) in order to install the thermostat housing.

## Water Temperature Regulator

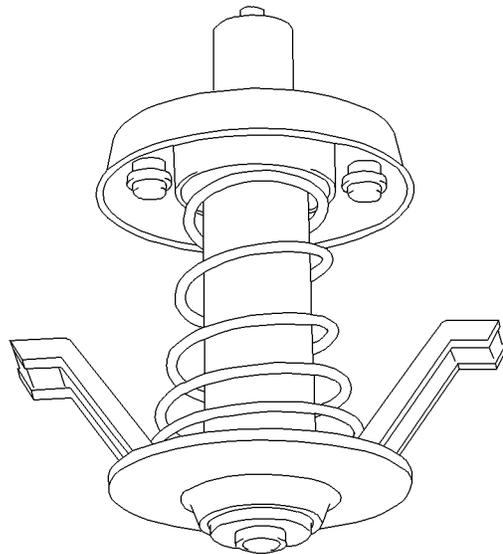


Illustration 54 g00906121

A typical water temperature regulator

Opening temperature ..... 79 ° to 84 °C  
(174 ° to 151 °F)

Full opening temperature ..... 93 °C (199 °F)

Minimum stroke at full open temperature ..... 10 mm  
(0.3937 inch)

i01904883

i01908154

## Water Pump

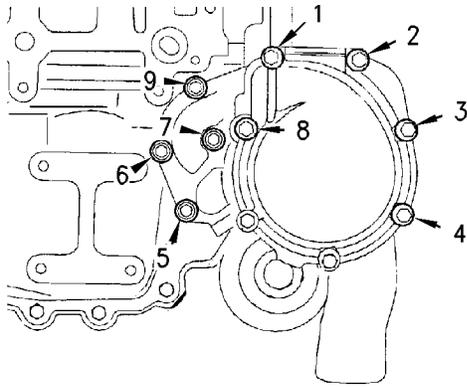


Illustration 55 g00915951

Tightening sequence

**Note:** Apply 21820117 Powerpart threadlock nutlock to the first three threads of the bolts before installation.

Tighten the nine bolts that secure the water pump to the front housing in the numerical sequence that is shown to the following torque. .... 22 N·m (16 lb ft)

**Note:** Refer to the Disassembly and Assembly manual in order to service the water pump.

## Cylinder Block

### Four Cylinder Engine

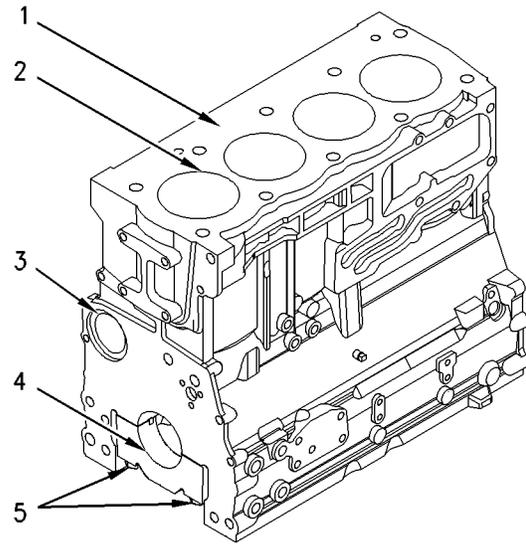


Illustration 56 g00924764

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 to 0.15 mm (0 to 0.0059 inch)

(3) Camshaft bearings for the four cylinder engine

Diameter of the bore 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 ..... 50.038 to 50.089 mm  
(1.9700 to 1.9720 inch)

- (4) Main bearings for the four cylinder engine  
 Bore in the cylinder block for the main bearings ..... 80.416 to 80.442 mm  
 (3.1660 to 3.1670 inch)

- (5) Main bearing cap bolts for the four cylinder engine

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. .... 245 N·m  
 (180 lb ft)

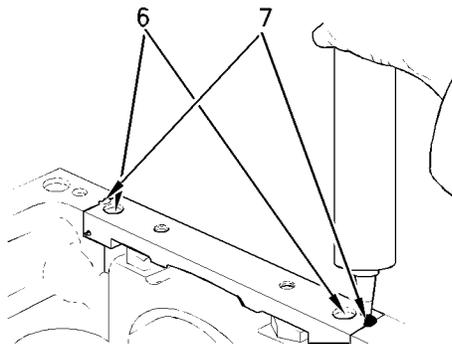


Illustration 57

g00938203

Use the following procedure in order to install the Allen head bolts for the bridge.

**Note:** Install the rear seal before sealant is applied.

1. Use a straight edge in order to ensure that the bridge is aligned with the rear face of the cylinder block.
2. Tighten the Allen head bolts (6) for the bridge.  
 Torque for the Allen head bolts .. 16 N·m (12 lb ft)
3. When the bridge is installed on the cylinder block, apply 21826038 POWERPART Silicon Adhesive into groove (7) at each end of the bridge. Apply the sealant into the groove until the sealant is forced through the bottom end of the groove in the bridge.

Total height of the cylinder block between the top and the bottom faces. .... 441.173 to 441.274 mm  
 (17.3689 to 17.3729 inch)

## Three Cylinder Engine

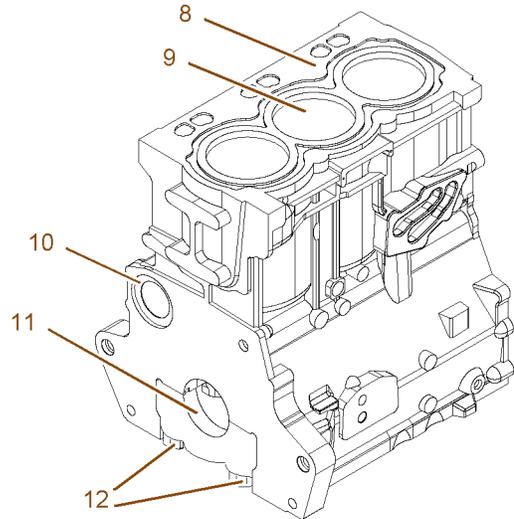


Illustration 58

g01018250

- (8) Cylinder block

(9) 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 to 0.15 mm (0 to 0.0059 inch)

- (10) Camshaft bearings for the four cylinder engine

Diameter of the bore 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 ..... 50.546 to 50.597 mm  
 (1.9900 to 1.9920 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)

(11) Main bearings for the three cylinder engine

Bore in the cylinder block for the main bearings ..... 80.416 to 80.442 mm (3.1660 to 3.1670 inch)

(12) Main bearing cap bolts for the four cylinder and three cylinder engines

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. .... 245 N·m (180 lb ft)

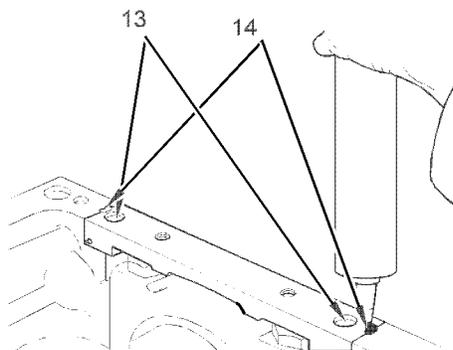


Illustration 59

g01018262

Use the following procedure in order to install the Allen head bolts for the bridge.

**Note:** Install the rear seal before sealant is applied.

1. Use a straight edge in order to ensure that the bridge is aligned with the rear face of the cylinder block.

2. Tighten the Allen head bolts (13) for the bridge.

Torque for the Allen head bolts .. 16 N·m (12 lb ft)

3. When the bridge is installed on the cylinder block, apply 21826038 POWERPART Silicon Adhesive into groove (14) at each end of the bridge. Apply the sealant into the groove until the sealant is forced through the bottom end of the groove in the bridge.

Total height of the cylinder block between the top and the bottom faces. .... 441.173 to 441.274 mm (17.3689 to 17.3729 inch)

i01956920

## Crankshaft

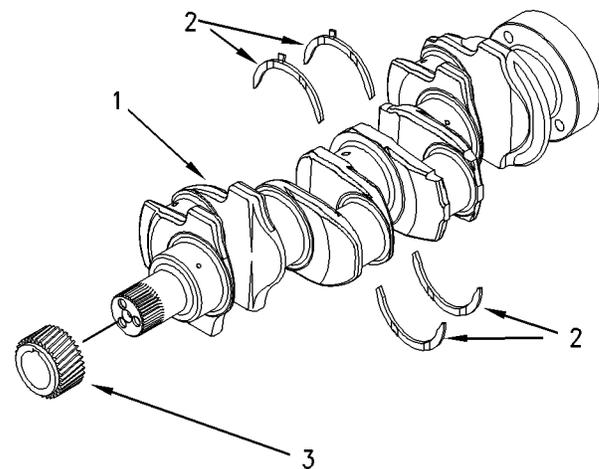


Illustration 60

g00992214

The crankshaft for the four cylinder engine

(1) Crankshaft for the four cylinder engine

The maximum end play of the crankshaft ... 0.51 mm (0.0201 inch)

(2) Thrust washers

Standard thickness ..... 2.26 to 2.31 mm (0.089 to 0.091 inch)

Oversize thickness ..... 2.45 to 2.50 mm (0.097 to 0.098 inch)

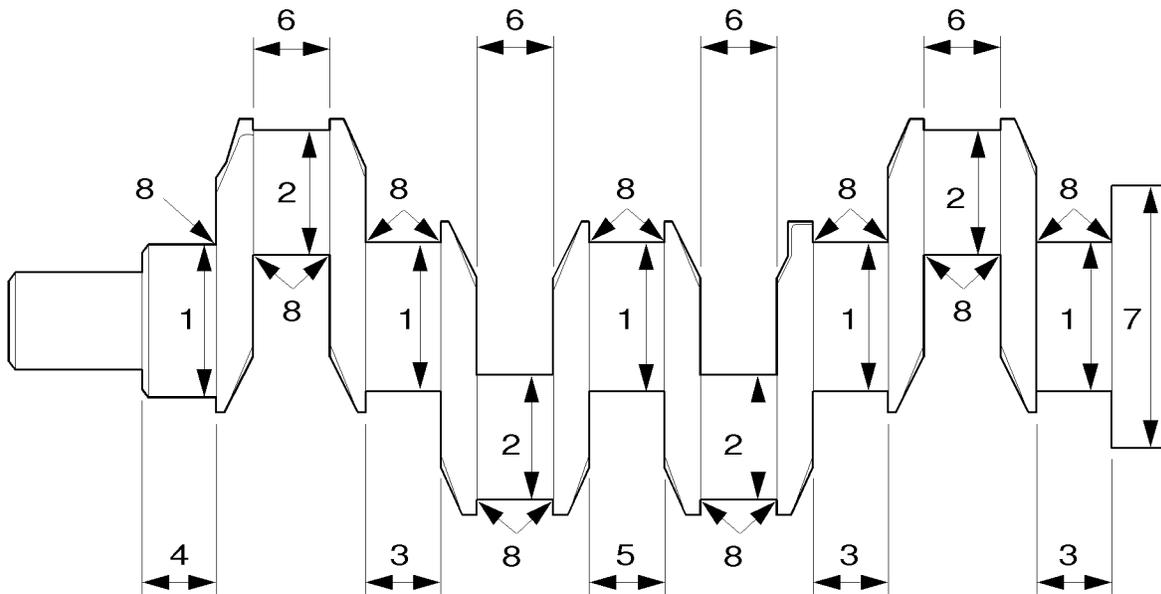
(3) The crankshaft gear

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

**Note:** The timing mark is toward the outside of the crankshaft when the gear is installed on the crankshaft.

**Note:** All new turbocharged engines and turbocharged aftercooled engines have crankshafts that are nitrocarburised. The crankshaft can also be nitrided for 20 hours, if the nitrocarburised process is not available. After a crankshaft has been machined, the crankshaft must be rehardened. Inspect the crankshaft for cracks before machining and after machining. Naturally aspirated engines have induction hardened crankshafts.

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Illustration 61  
The 1104 engine crankshaft

g01017233

**Note:** Refer to illustration 61 in order to use table 8.

**The four cylinder engine.**

Table 8

<b>The undersize diameter of the Crankshaft Journals</b>			
<b>NUMBER</b>	<b>0.25 mm (0.010 inch)</b>	<b>0.51 mm (0.020 inch)</b>	<b>0.76 mm (0.030 inch)</b>
1	75.909 mm (2.9885 inch) to 75.930 mm (2.9894 inch)	75.649 mm (2.9783 inch) to 75.670 mm (2.9791 inch)	75.399 mm (2.9685 inch) to 75.420 mm (2.9693 inch)
2	63.220 mm (2.4890 inch) to 63.240 mm (2.4898 inch)	62.960 mm (2.4787 inch) to 62.982 mm (2.4796 inch)	62.708 mm (2.4688 inch) to 62.728 mm (2.4696 inch)
3	39.47 mm (1.5539 inch)maximum	N/A	N/A
4	37.44 mm (1.4740 inch)maximum	N/A	N/A
5	44.68 mm (1.7591 inch)maximum	N/A	N/A
6	40.55 mm (1.5965 inch)maximum	N/A	N/A
7	Do not machine this diameter.	N/A	N/A
8	3.68 mm (0.1449 inch) to 3.96 mm (0.1559 inch)	N/A	N/A

Refer to table 9 for the maximum run out of the crankshaft journals.

The maximum difference in value between one crankshaft journal and the next crankshaft journal ..... 0.10 mm (0.0039 inch)

Table 9

<b>Journal</b>	<b>Excessive run out</b>
(1)	Mounting
(2)	0.08 mm (0.0031 inch)
(3)	0.15 mm (0.0059 inch)
(4)	0.08 mm (0.0031 inch)
(5)	Mounting

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.



Table 10

The undersize diameter of the Crankshaft Journals			
NUMBER	0.25 mm (0.010 inch)	0.51 mm (0.020 inch)	0.76 mm (0.030 inch)
1	75.926 mm (2.9892 inch) to 75.905 mm (2.9884 inch)	75.672 mm (2.9792 inch) to 75.651 mm (2.9784 inch)	75.418 mm (2.9692 inch) to 75.397 mm (2.9684 inch)
2	63.236 mm (2.4896 inch) to 63.216 mm (2.4888 inch)	62.982 mm (2.4796 inch) to 62.962 mm (2.4788 inch)	62.728 mm (2.4696 inch) to 62.708 mm (2.4688 inch)
3	39.74 mm (1.5646 inch)maximum	N/A	N/A
4	44.68 mm (1.7591 inch)maximum	N/A	N/A
5	40.551 mm (1.5965 inch)maximum	N/A	N/A
6	133.17 mm (5.2429 inch) Do not machine this diameter.	N/A	N/A
7	3.68 mm (0.1449 inch) to 3.96 mm (0.1559 inch)	N/A	N/A

Refer to table 11 for the maximum run out of the crankshaft journals.

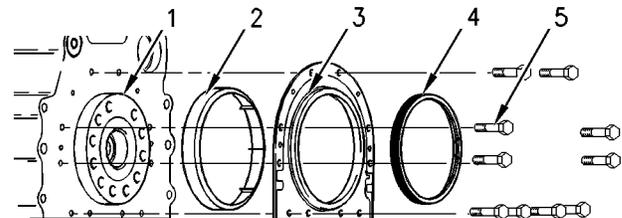
i01958114

The maximum difference in value between one crankshaft journal and the next crankshaft journal ..... 0.10 mm (0.0039 inch)

## Crankshaft Seals

Table 11

Journal	Excessive run out
(1)	Mounting Dia
(2)	0.051 mm (0.0020 inch)
(3)	0.051 mm (0.0020 inch)
(4)	Mounting Dia



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

Illustration 63

g00915078

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

- (1) Crankshaft
- (2) Plastic sleeve
- (3) Crankshaft seal
- (4) Alignment tool

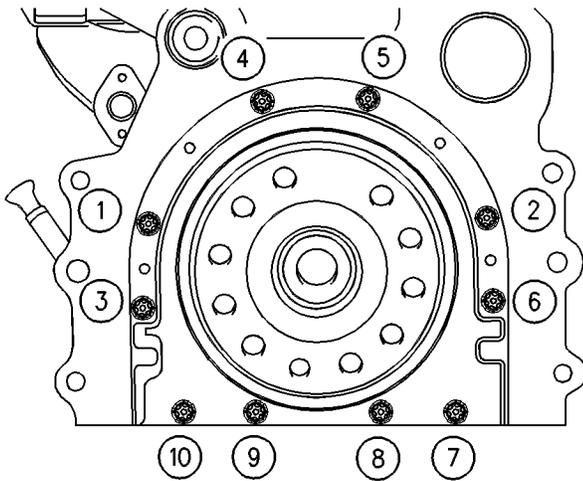


Illustration 64

g00915076

(5) Tighten bolts 1, 2, 3, 4, 5, 6, 7, and 10 in the sequence that is shown in Illustration 64 to the following torque. .... 22 N·m (16 lb ft)

Remove the alignment tool.

Tighten bolts 8 and 9 in the sequence that is shown in Illustration 64 to the following torque. .... 22 N·m (16 lb ft)

i01958137

## 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 ... 63.47 to 63.49 mm (2.4988 to 2.4996 inch)

Maximum permissible wear of the connecting rod bearing journals ..... 0.04 mm (0.0016 inch)

Width of the connecting rod bearing journals ..... 40.35 to 40.42 mm (1.589 to 1.591 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 and radii ..... Ra 0.4 microns (16 μ inch)

## Main Bearing Journal

Refer to the Specifications module, “Crankshaft” topic 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 ..... 76.159 to 76.180 mm (2.9984 to 2.9992 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 3.69 mm (0.1448 to 0.1452 inch)

Surface finish of bearing journals, crank pins and radii ..... 0.4 microns (16 μ inches)

## 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 .... 0.75 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 ..... 0.057 to 0.117 mm (0.0022 to 0.0046 inch)

i01958156

## Connecting Rod

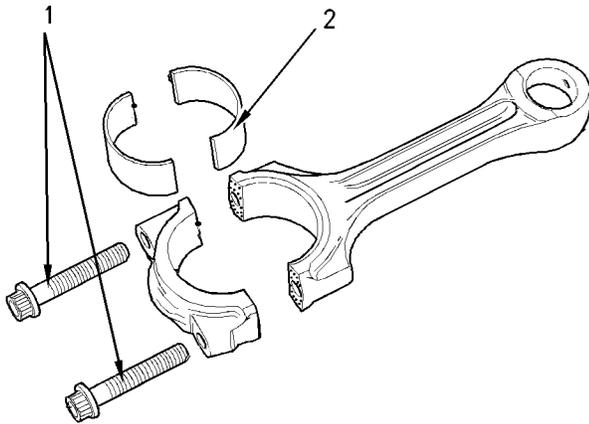


Illustration 65

g00907738

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

(1) Tighten the torx screws for the connecting rod to the following torque. .... 18 N·m (13 lb ft)

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

Tighten the torx screws for the connecting rod for an additional 120 degrees. The torx screws for the connecting rod (1) 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).

(2) The bearing shell for the connecting rod

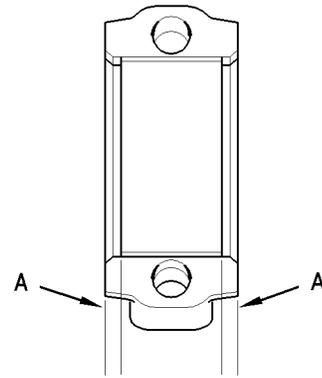


Illustration 66

g00995584

Alignment of the bearing shell

**Note:** The bearing shell for the connecting rod must be aligned equally from both ends of the connecting rod. Refer to (A) in figure 66. Refer to the Disassembly and assembly manual for information on the alignment tool.

Table 12

<b>Bearing Width for the Connecting Rod</b>	31.62 to 31.88 mm (1.245 to 1.255 inch)
<b>Bearing Width for the Connecting Rod Cap</b>	31.55 to 31.88 mm (1.2405 to 1.255 inch)
<b>Thickness of Connecting Rod Bearing at the Center</b>	1.835 to 1.842 mm (0.0723 to 0.0725 inch)
<b>Thickness of Connecting Rod Bearing for the Cap at the Center</b>	1.835 to 1.842 mm (0.0722 to 0.0725 inch)
<b>Bearing Clearance</b>	0.030 to 0.081 mm (0.0012 to 0.0032 inch)

Table 13

<b>Undersized Connecting Rod Bearing</b>	
	0.25 mm (0.010 inch)
	0.51 mm (0.020 inch)
	0.76 mm (0.030 inch)

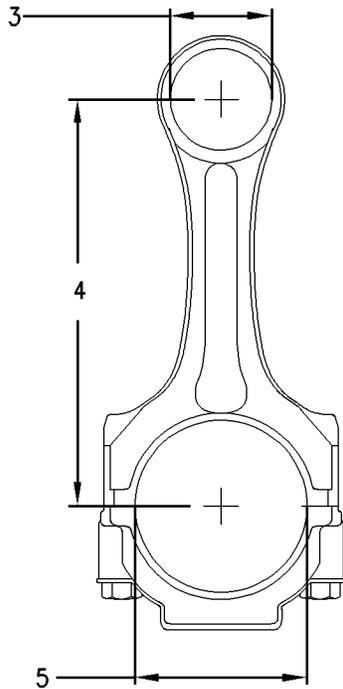


Illustration 67

g00907744

- (3) Diameter of the parent bore for the piston pin ..... 43.01 to 43.04 mm (1.693 to 1.694 inch)
- (4) Distance between the parent bores ..... 219.05 to 219.10 mm (8.624 to 8.626 inch)
- (5) Diameter for the parent bore for the connecting rod bearing ..... 67.21 to 67.22 mm (2.6460 to 2.6465 inch)

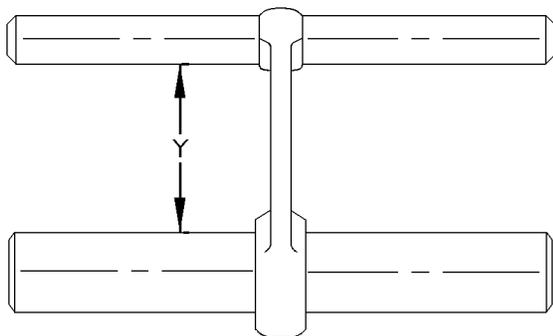


Illustration 68

g00915056

Connecting rods are color coded. The color code is a reference for the length (Y) of the connecting rod. Refer to table 14 for the different lengths of connecting rods.

Table 14

Length Grades for Connecting Rods		
Grade Letter	Color Code	Length (Y)
F	Red	165.728 to 165.761 mm (6.5247 to 6.5260 inch)
G	Orange	165.682 to 165.715 mm (6.5229 to 6.5242 inch)
H	White	165.637 to 165.670 mm (6.5211 to 6.5224 inch)
J	Green	165.591 to 165.624 mm (6.5193 to 6.5206 inch)
K	Purple	165.545 to 165.578 mm (6.5175 to 6.5188 inch)
L	Blue	165.499 to 165.532 mm (6.5157 to 6.4961 inch)

i01958185

## Piston and Rings

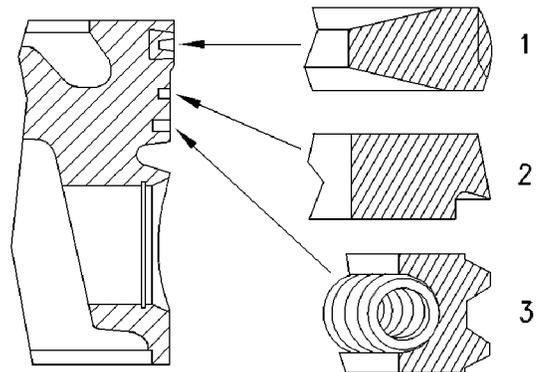


Illustration 69

g00888215

A typical example of a piston and rings

### (1) Top compression ring

#### Naturally Aspirated

The shape of the top compression ring ..... Rectangular with a barrel face

Width of the top compression ring ..... 2.475 to 2.49 mm (0.097 to 0.098 inch)

Clearance between the top compression ring and the piston groove ..... 0.09 to .15 mm (0.0035 to 0.0059 inch)

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

Turbocharged  
The shape of the top compression ring ..... Keystone with a barrel face  
Width of the top compression ring ..... tapered  
Ring gap ..... 0.30 to 0.55 mm  
(0.0118 to 0.0216 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 red 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 step in the bottom edge with a tapered face  
Width of intermediate compression ring ..... 2.47 to 2.49 mm (0.097 to 0.098 inch)  
Clearance between the intermediate compression ring and the piston groove ..... 0.05 to 0.09 mm (0.002 to 0.003 inch)  
Ring gap ..... 0.70 to 0.95 mm (0.0275 to 0.0374 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 green 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) Oil control ring

Shape of oil control ring ..... two-piece coil that is spring loaded  
Width of oil control ring ..... 3.47 to 3.49 mm (0.1366 to 0.1374 inch)  
Clearance between the oil control ring and the groove in the 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:** 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.

The combustion bowl re-entrant angle for the turbocharged engine ..... 80 degrees

The combustion bowl re-entrant angle for the naturally aspirated engine ..... 70 degrees

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

Width of top groove in piston for the naturally aspirated engine ..... 2.58 to 2.60 mm (0.1016 to 0.1024 inch)

Width of top groove in piston for the turbocharged engine ..... Tapered

Width of second groove in piston .... 2.54 to 2.56 mm (0.1000 to 0.1008 inch)

Width of third groove in piston ..... 3.52 to 3.54 mm (0.1386 to 0.1394 inch)

Piston pin

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

Diameter of the bore for the piston pin ..... 39.703 to 39.709 mm (1.5631 to 1.5633 inch)

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## Piston Cooling Jet

**Note:** The three cylinder naturally aspirated engine may have installed piston cooling jets as an option.

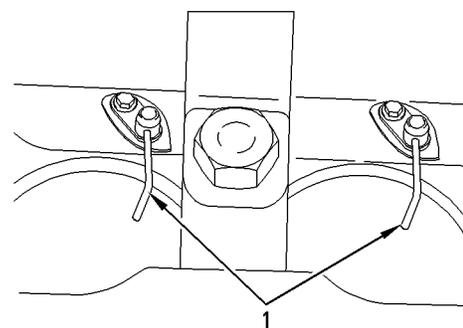


Illustration 70

g00942652

(1) Installed piston cooling jets

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

## Piston Cooling Jet Alignment

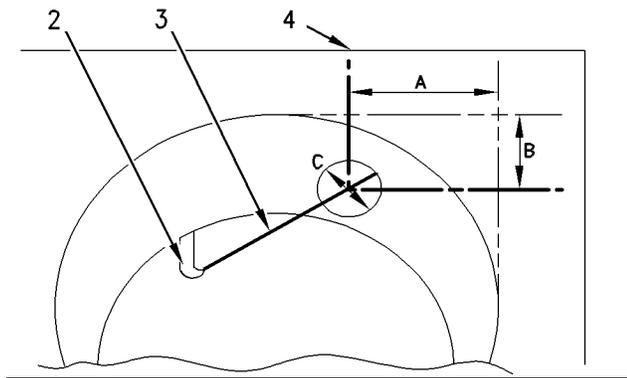


Illustration 71 g01006929

- (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 55.25 mm (2.1752 inch) and dimension (B) is 14 mm (0.5512 inch). Dimension (A) and dimension (B) are tangent 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).

i01957083

## 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 )

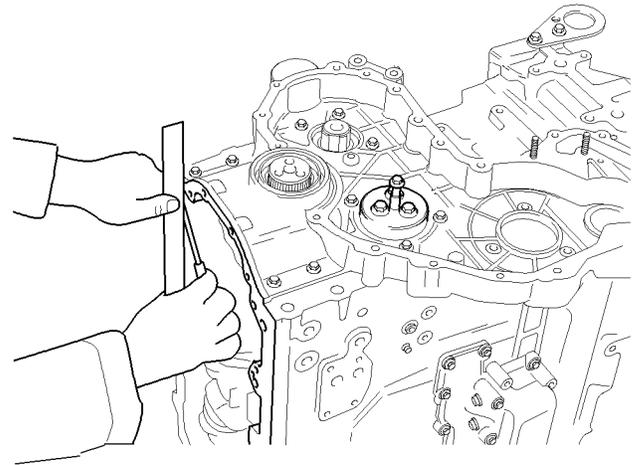


Illustration 72 g00995663  
Alignment

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

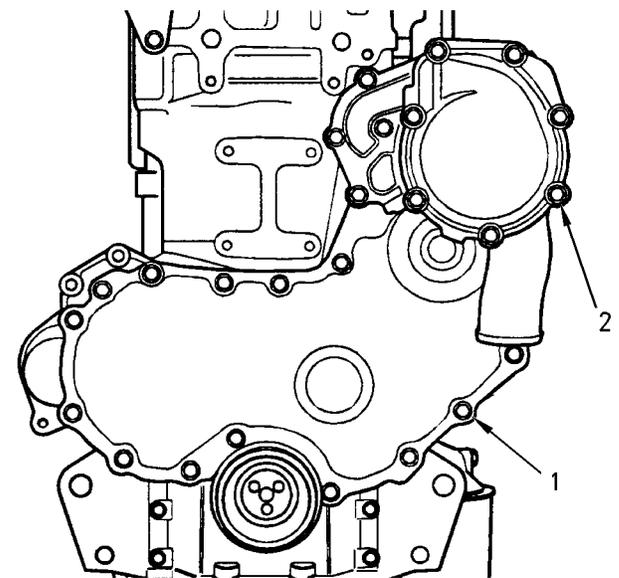


Illustration 73 g00918672  
Front cover

- (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.

i01912958

## Gear Group (Front)

The 1104 mechanical engines use two types of fuel injection pumps. The fuel injection pump can be either a Delphi 210 fuel injection pump or a Bosch EPVE fuel injection pump.

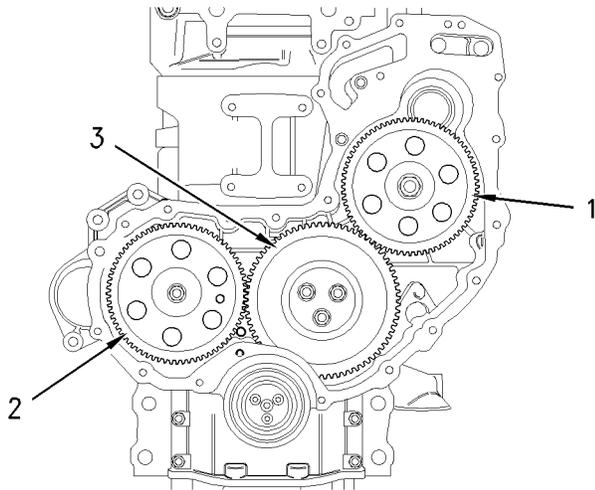


Illustration 74  
Gear train

g00995886

### (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)

Bore diameter of the camshaft gear ..... 34.93 to 34.95 mm  
(1.3750 to 1.3760 inch)

Outside diameter of the camshaft hub .. 34.90 to 34.92 mm (1.3741 to 1.3747 inch)

Clearance between the camshaft gear and the camshaft hub ..... 0.003 to 0.048 mm  
(0.0001 to 0.0019 inch)

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)

Bore diameter of the idler gear ..... 57.14 to 57.18 mm (2.2495 to 2.2512 inch)  
Bore diameter of the idler gear with roller bearings ..... 72.35 to 72.36 mm  
(2.8484 to 2.8488 inch)

Width of idler gear and split bearing assembly ..... 30.14 to 30.16 mm  
(1.186 to 1.187 inch)

Inside diameter of idler gear bearings with flanges ..... 50.78 to 50.80 mm  
(1.999 to 2.000 inch)

Outside diameter of idler gear hub .. 50.70 to 50.74 mm (1.9961 to 1.9976 inch)  
Outside diameter of idler gear hub with roller bearings ..... 49.975 to 49.988 mm  
(1.9675 to 1.9680 inch)

Clearance of idler gear bearing on hub ..... 0.04 to 0.10 mm (0.0016 to 0.0039 inch)

Idler gear end play ..... 0.10 to 0.20 mm  
(0.004 to 0.008 inch)

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

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

Number of teeth ..... 73

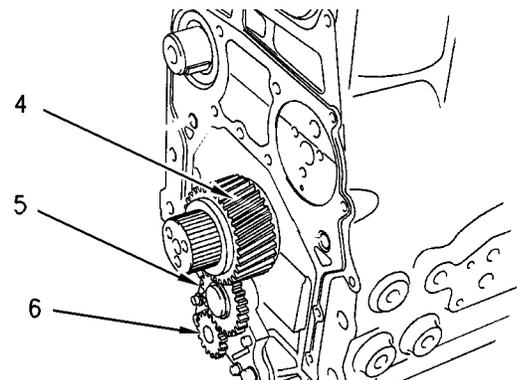


Illustration 75

g00996214

The gear train for the oil pump

### (4) Crankshaft gear

Bore diameter of crankshaft gear .... 47.625 to 47.650 mm (1.8750 to 1.8760 inch)

Outside diameter of crankshaft  
hub ..... 47.625 to 47.645 mm  
(1.8750 to 1.8758 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) ..... 0.046 to 0.106 mm  
(0.0018 to 0.0041 inch)

Backlash between the oil pump idler gear (5) and  
the crankshaft gear (4) ..... 0.095 to 0.160 mm  
(0.0037 to 0.0063 inch)

Backlash between the idler gear (3) and the  
crankshaft gear (4) ..... 0.064 to 0.124 mm  
(0.0025 to 0.0049 inch)

Backlash between the camshaft gear (2) and the  
idler gear (3) ..... 0.052 to 0.107 mm  
(0.0020 to 0.0042 inch)

Backlash between the fuel injection pump gear  
(1) and the idler gear (3) ..... 0.054 to 0.109 mm  
(0.0021 to 0.0043 inch)

Backlash between the water pump gear (not  
shown) and the fuel injection pump gear  
(1) ... 0.073 to 0.133 mm (0.0028 to 0.0052 inch)

Backlash between the power take-off  
drive ( if equipped) and the idler gear  
(3) .... 0.112 to 0.172 mm (0.0044 to 0.0068 inch)

## Engines that have a Balancer

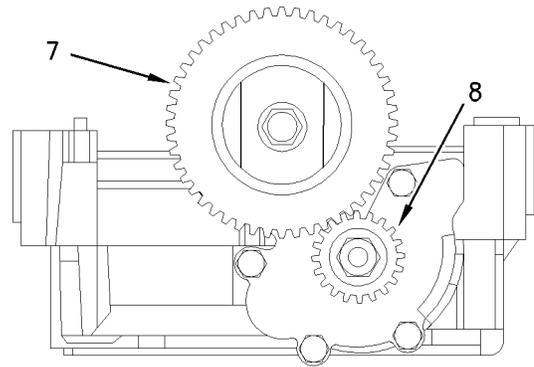


Illustration 76

g00996003

Balancer gears

(7) Idler gear for the oil pump that has a balancer

The number of teeth on the gear ..... 44  
The bore diameter of the idler  
gear ..... 37.197 to 37.212 mm  
(1.4644 to 1.4650 inch)

The hub diameter for the idler  
gear ..... 37.152 to 37.162 mm  
(1.4627 to 1.4631 inch)

The end play for the idler gear .. 0.12 to 0.27 mm  
(0.0047 to 0.0106 inch)

(8) Gear for the oil pump that has a balancer

The number of teeth on the gear ..... 17

Backlash between the oil pump gear (8) and the idler  
gear (7) ... 0.097 to 0.17 mm (0.0038 to 0.0067 inch)

i01913541

## Flywheel

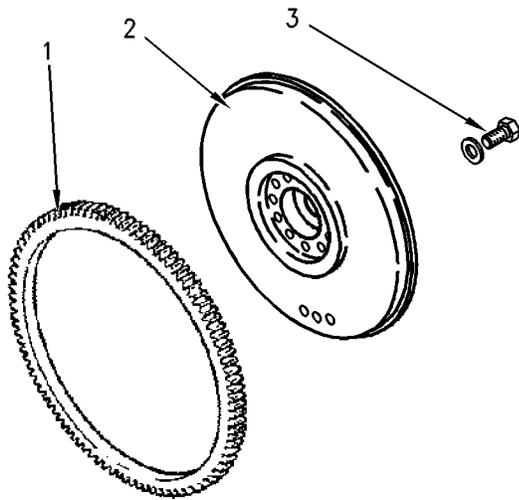


Illustration 77

g00584712

(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 flywheel bolts to the following torque. .... 105 N·m (77 lb ft)

i01957025

## Flywheel Housing

### Four cylinder

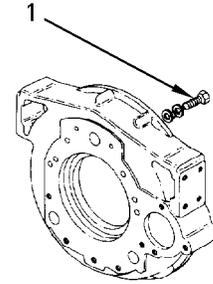


Illustration 78

g00631781

(1) Bolt

Tighten the bolts for the cast iron flywheel housing to the following torque:

M10 "8.8" .....	44 N·m (33 lb ft)
M10 "10.9" .....	63 N·m (47 lb ft)
M12 "8.8" .....	75 N·m (55 lb ft)
M12 "10.9" .....	115 N·m (85 lb ft)

### Three cylinder

The three cylinder engine is equipped with a back plate.

i01958322

## Crankshaft Pulley

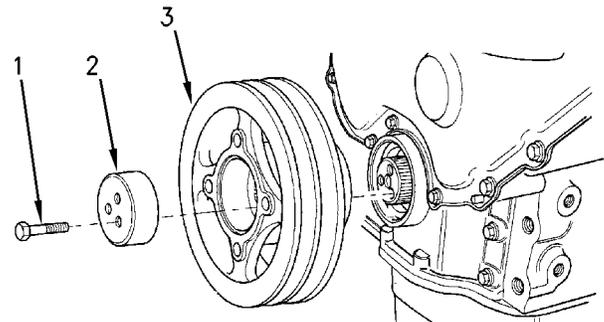


Illustration 79

g00915497

A typical pulley

**Note:** Lubricate the threads of the bolts with clean engine oil before installation.

- (1) Tighten the three bolts for the crankshaft pulley to the following torque. .... 115 N·m (85 lb ft)

**Note:** Recheck the torque of the bolts (1) twice.

- (2) Thrust block
- (3) Crankshaft pulley

i01958344

## Fan Drive

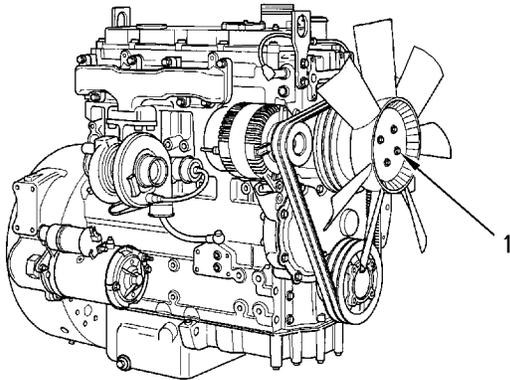


Illustration 80  
A typical fan drive

- (1) Tighten the bolts for the fan to the following torque. .... 22 N·m (16 lb ft)

Tighten the bolts that secure the fan drive pulley to the hub to the following torque (not shown). ... 22 N·m (16 lb ft)

## Fan drive housing

Tighten the bolts that secure the fan drive housing to the cylinder head to the following torque (not shown). .... 44 N·m (32 lb ft)

Bearing bore for the housing .. 61.986 to 62.005 mm (2.4404 to 2.4411 inch)

Outer bearing diameter ..... 61.987 to 62.000 mm (2.4404 to 2.4409 inch)

Interference fit for the bearing ..... 0.014 to minus 0.018 mm (0.0006 to minus 0.0007 inch)

The outer diameter of the shaft ... 25.002 to 25.011 mm (0.9843 to 0.9847 inch)

Maximum permissible end play of the shaft .. 0.20 mm (0.0079 inch)

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)

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## Alternator

### 12 Volt and 24 Volt Alternator

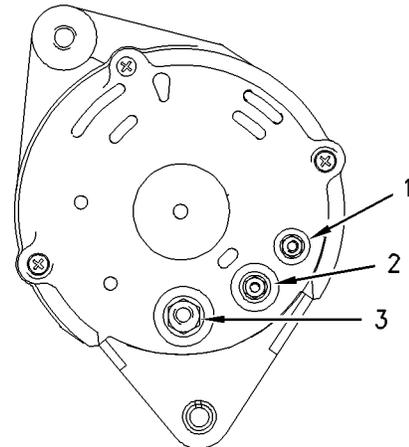


Illustration 81  
A typical alternator

- (1) Tighten terminal nut "W" to the following torque. .... 2 N·m (17 lb in)

- (2) Tighten terminal nut "D+" to the following torque. .... 4.3 N·m (38 lb in)

- (3) Tighten terminal nut "B+" to the following torque. .... 4.3 N·m (38 lb in)

Tighten the pulley nut (not shown) to the following torque. .... 80 N·m (59 lb ft)

Alignment of the alternator pulley to the crankshaft pulley .....  $\pm 2.4$  mm ( $\pm 0.0945$  inch)

Rotation ..... clockwise

Polarity ..... Negative earth

## V-Belt

**Note:** The V-belt must be checked by a gauge. Refer to the Testing and Adjusting, "V-Belt-Test" for the correct type of gauge in order to check the V-belt.

V-belt tension ..... 535 N (120 lb)

i01958653

## Starter Motor

### 24 Volt Starter Motor

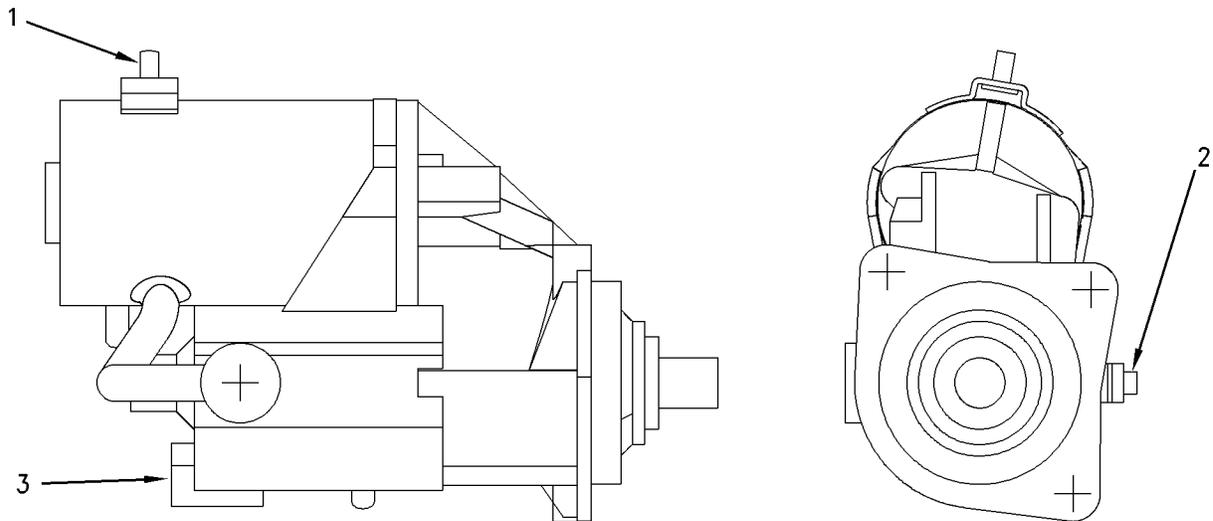


Illustration 82

g00974968

The 24 volt starter motor which shows the electrical connections

- (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

Pull in voltage ..... 16 volts

## 12 Volt Starter Motor

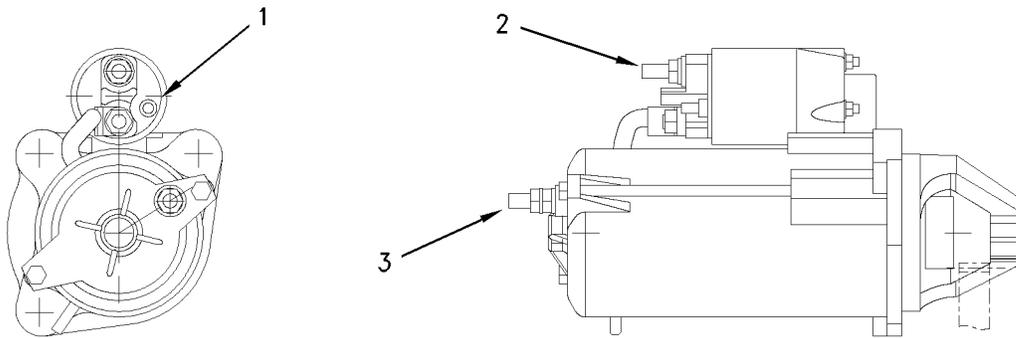


Illustration 83

g00977365

The 12 volt starter motor which shows the electrical connections

- (1) Tighten the solenoid terminal to the following torque. .... 8 N·m ( 70 lb in)
- (2) Tighten the positive terminal nut to the following torque. .... 6 N·m ( 53 lb in)
- (3) Tighten the negative terminal nut to the following torque. .... 8 N·m (70 lb in)

- (1) Tighten the glow plugs (3) in the cylinder head to the following torque. .... 18 N·m (13 lb ft)

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

Voltage ..... 12 or 24 volts

Rated voltage ..... 12 volts

Pull in voltage ..... 8 volts

i01957005

## Glow Plugs

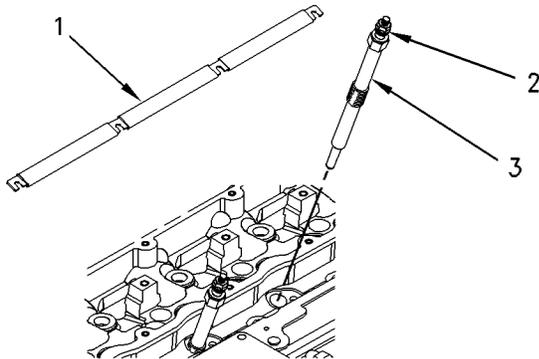


Illustration 84

g00955714

Typical example

# Index

## A

Alternator .....	38
12 Volt and 24 Volt Alternator .....	38
V-Belt .....	39

## C

Camshaft .....	14
Camshaft Bearings .....	15
Connecting Rod .....	31
Connecting Rod Bearing Journal .....	30
Crankcase Breather .....	21
Crankshaft .....	25
Crankshaft Pulley .....	37
Crankshaft Seals .....	29
Cylinder Block .....	23
Four Cylinder Engine .....	23
Three Cylinder Engine .....	24
Cylinder Head .....	11
Four Cylinder engine .....	12
Four Cylinder Engine .....	12
Three Cylinder engine .....	12
Three Cylinder Engine .....	13
Cylinder Head Valves .....	10

## E

Engine Design .....	4
Four Cylinder Engine .....	4
Three Cylinder Engine .....	4
Engine Lifting Bracket .....	38
Engine Oil Bypass Valve .....	19
Installed in the Balancer .....	19
Installed in the Oil Pump .....	19
Engine Oil Filter .....	16
Replaceable Element .....	16
Spin-on Oil Filter .....	16
Engine Oil Pan .....	20
Front sealant .....	20
Rear sealant .....	20
The cast iron oil pan .....	21
Engine Oil Pressure .....	19
Engine Oil Pump .....	16
Four Cylinder and Three Cylinder Engines without Balancer Group .....	18
Four Cylinder Engines with Balancer Group .....	16
Exhaust Manifold .....	14
Four Cylinder Engine .....	14
Three Cylinder Engine .....	14

## F

Fan Drive .....	38
Fan drive housing .....	38
Flywheel .....	37

Flywheel Housing .....	37
Four cylinder .....	37
Three cylinder .....	37
Front Housing and Covers .....	34
Fuel Injection Lines .....	5
Fuel Injection Pump (Bosch EPVE for the 1104 engines only) .....	6
Fuel Injection Pump (Delphi DP210 for the 1103 and 1104 engines) .....	5
Fuel Injection Pump (Delphi STP) .....	7
Fuel Injectors .....	7
Fuel Transfer Pump .....	8

## G

Gear Group (Front) .....	35
Engines that have a Balancer .....	36
Glow Plugs .....	40

## I

Important Safety Information .....	2
------------------------------------	---

## L

Lifter Group .....	8
--------------------	---

## M

Main Bearing Journal .....	30
The shell for the main bearings .....	30

## P

Piston and Rings .....	32
Piston .....	33
Piston Cooling Jet .....	33
Piston Cooling Jet Alignment .....	34

## R

Rocker Shaft .....	8
--------------------	---

## S

Specifications Section .....	4
Starter Motor .....	39
12 Volt Starter Motor .....	40
24 Volt Starter Motor .....	39

**T**

Table of Contents.....	3
Turbocharger .....	13
Four Cylinder Engine .....	13
Three Cylinder Engine .....	13

**V**

Valve Mechanism Cover.....	9
The Cover for the Four Cylinder Engine .....	9
The Cover for the Three Cylinder Engine .....	9

**W**

Water Pump.....	23
Water Temperature Regulator and Housing .....	22
Water Temperature Regulator.....	22