SHOP MANUAL

KOMATSU

102 SERIES

DIESEL ENGINE

★ This Shop Manual is made by adding the special descriptions for the **102E-2** series to the Shop Manual for the current **102E-1** series.

Printed in Japan 10-08(02)

HOISTING INSTRUCTIONS

HOISTING

> ⚠ Heavy parts (25 kg or more) must be lifted with a hoist, etc. In the **DISASSEMBLY AND ASSEMBLY** section, every part weighing 25 kg or more is indicated clearly with the symbol kg

- If a part cannot be smoothly removed from the machine by hoisting, the following checks should be made:
  1) Check for removal of all bolts fastening the part to the relative parts.
  2) Check for existence of another part causing interference with the part to be removed.

WIRE ROPES

1) Use adequate ropes depending on the weight of parts to be hoisted, referring to the table below:

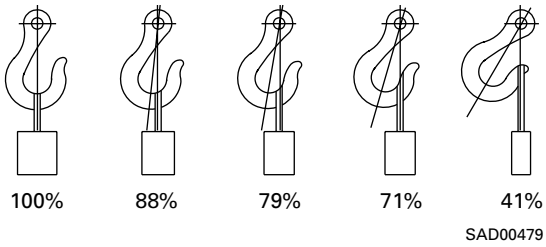
Wire ropes
(Standard "Z" or "S" twist ropes
without galvanizing)

Rope diameter	Allowable load	
mm	kN	tons
10	9.8	1.0
11.5	13.7	1.4
12.5	15.7	1.6
14	21.6	2.2
16	27.5	2.8
18	35.3	3.6
20	43.1	4.4
22.4	54.9	5.6
30	98.1	10.0
40	176.5	18.0
50	274.6	28.0
60	392.2	40.0

★ The allowable load value is estimated to be one-sixth or one-seventh of the breaking strength of the rope used.

2) Sling wire ropes from the middle portion of the hook.

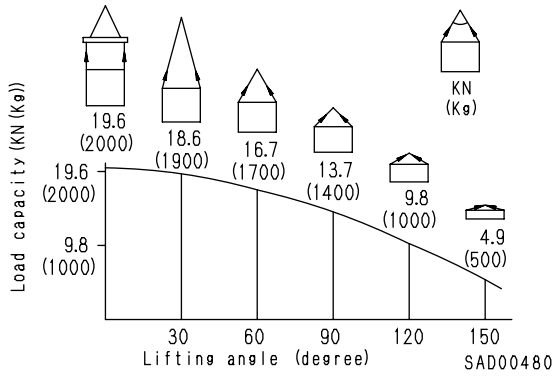
Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



3) Do not sling a heavy load with one rope alone, but sling with two or more ropes symmetrically wound onto the load.

> ⚠ Slinging with one rope may cause turning of the load during hoisting, untwisting of the rope, or slipping of the rope from its original winding position on the load, which can result in a dangerous accident.

4) Do not sling a heavy load with ropes forming a wide hanging angle from the hook.
When hoisting a load with two or more ropes, the force subjected to each rope will increase with the hanging angles. The table below shows the variation of allowable load kN {kg} when hoisting is made with two ropes, each of which is allowed to sling up to 9.8 kN {1000 kg} vertically, at various hanging angles.
When two ropes sling a load vertically, up to 19.6 kN {2000 kg} of total weight can be suspended. This weight becomes 9.8 kN {1000 kg} when two ropes make a 120° hanging angle. On the other hand, two ropes are subjected to an excessive force as large as 39.2 kN {4000 kg} if they sling a 19.6 kN {2000 kg} load at a lifting angle of 150°.



Millimeters to Inches

1 mm = 0.03937 in

	0	1	2	3	4	5	6	7	8	9
0	0	0.039	0.079	0.118	0.157	0.197	0.236	0.276	0.315	0.354
10	0.394	0.433	0.472	0.512	0.551	0.591	0.630	0.669	0.709	0.748
20	0.787	0.827	0.866	0.906	0.945	0.984	1.024	1.063	1.102	1.142
30	1.181	1.220	1.260	1.299	1.339	1.378	1.417	1.457	1.496	1.536
40	1.575	1.614	1.654	1.693	1.732	1.772	1.811	1.850	1.890	1.929
50	1.969	2.008	2.047	2.087	2.126	2.165	2.205	2.244	2.283	2.323
60	2.362	2.402	2.441	2.480	2.520	2.559	2.598	2.638	2.677	2.717
70	2.756	2.795	2.835	2.874	2.913	2.953	2.992	3.032	3.071	3.110
80	3.150	3.189	3.228	3.268	3.307	3.346	3.386	3.425	3.465	3.504
90	3.543	3.583	3.622	3.661	3.701	3.740	3.780	3.819	3.858	3.898

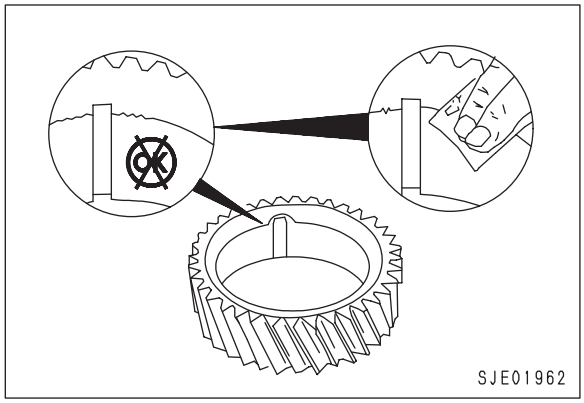
Kilogram to Pound

1 kg = 2.2046 lb

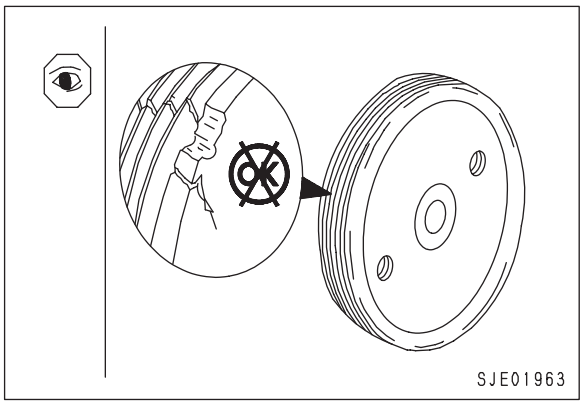
	0	1	2	3	4	5	6	7	8	9
0	0	2.20	4.41	6.61	8.82	11.02	13.23	15.43	17.64	19.84
10	22.05	24.25	26.46	28.66	30.86	33.07	35.27	37.48	39.68	41.89
20	44.09	46.30	48.50	50.71	51.91	55.12	57.32	59.53	61.73	63.93
30	66.14	68.34	70.55	72.75	74.96	77.16	79.37	81.57	83.78	85.98
40	88.18	90.39	92.59	94.80	97.00	99.21	101.41	103.62	105.82	108.03
50	110.23	112.44	114.64	116.85	119.05	121.25	123.46	125.66	127.87	130.07
60	132.28	134.48	136.69	138.89	141.10	143.30	145.51	147.71	149.91	152.12
70	154.32	156.53	158.73	160.94	163.14	165.35	167.55	169.76	171.96	174.17
80	176.37	178.57	180.78	182.98	185.19	187.39	189.60	191.80	194.01	196.21
90	198.42	200.62	202.83	205.03	207.24	209.44	211.64	213.85	216.05	218.26

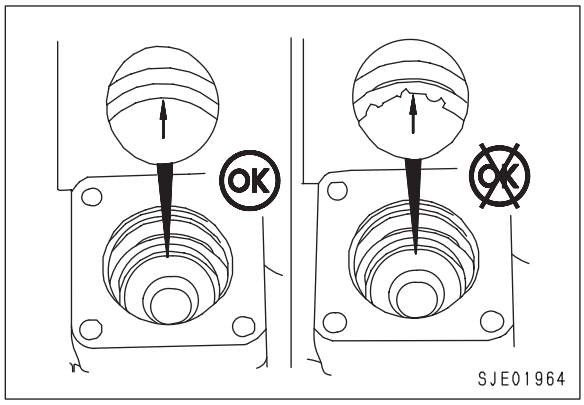
ILLUSTRATIONS

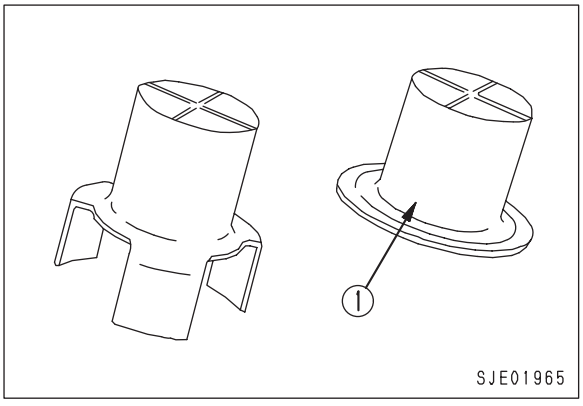
The illustrations used in the "Repair Sections" of this manual are intended to give an example of a problem, and to show what to look for and where the problem can be found. Some of the illustrations are 'generic" and will not look exactly like the engine or parts used in your application. Some illustrations contain symbols to indicate and action required, and an acceptable or not acceptable condition.



The illustrations are intended to show repair or replacement procedures with the engine "in-chassis". The illustration can differ from your application, but the procedure given will be the same.







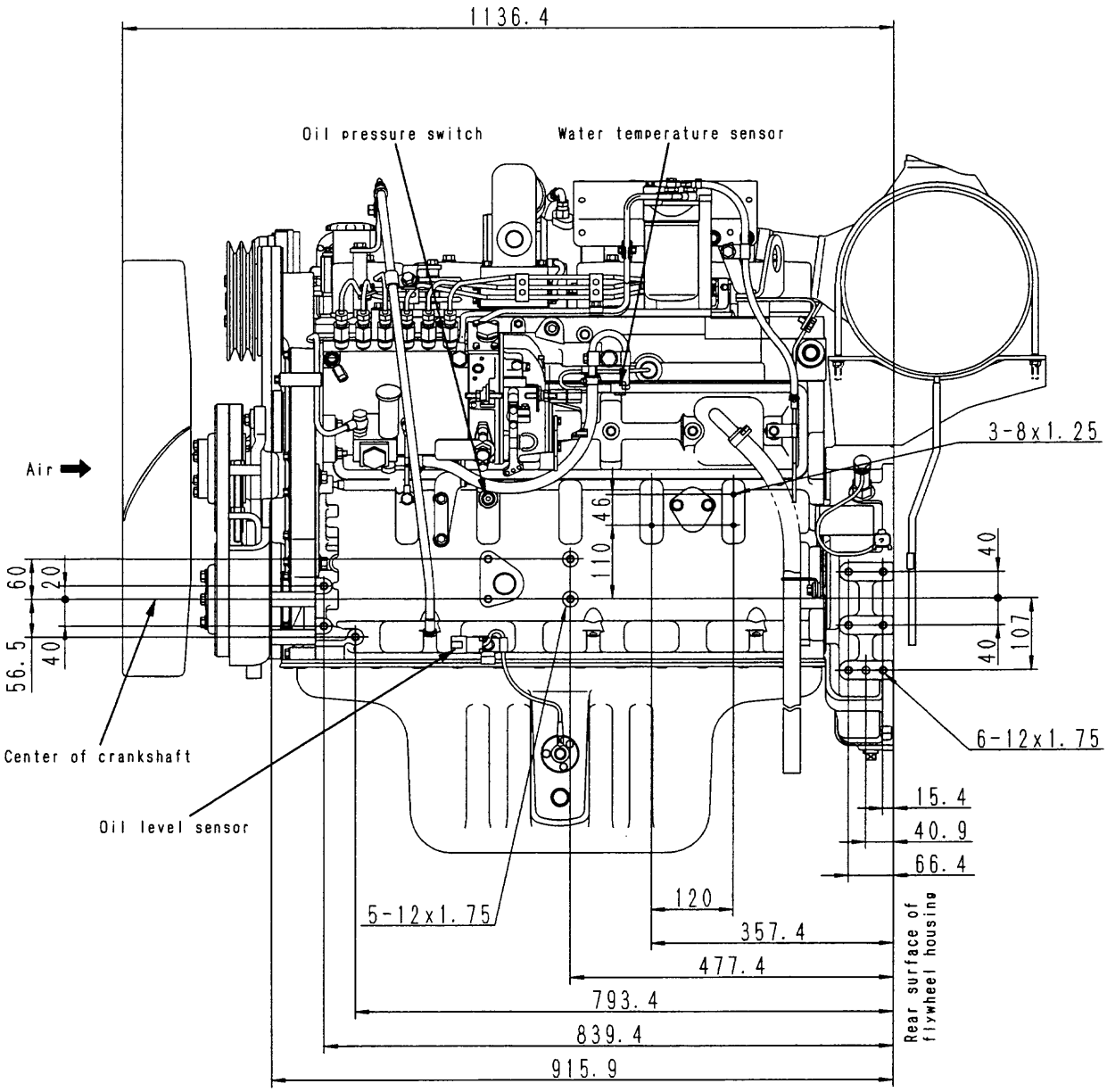
Engine			S6D102E-1	
Applicable model			PC200, 200LC-6 PC200, 200LC-6 HYPER GX PC210,210LC-6 MIGHTY, BR200S-1	PC200LC-6 PC200-6 CUSTOM PC200-6 EXCEL, (BKC)
No. of cylinders - Bore x Stroke		mm	6–102 x 120	
Total piston displacement		ℓ {cc}	5.88 {5,883}	
Firing order			1 – 5 – 3 – 6 – 2 – 4	
Dimensions	Overall length	mm	1,361	1,361
	Overall width	mm	760	760
	Overall height (excluding exhaust pipe)	mm	1,301	1,301
	Overall height (including exhaust pipe)	mm	—	—
Performance	Flywheel horsepower	kW{HP}/rpm	99.3/2,000 {133/2,00} (Net)	95.6/2,000 {128/2,000} (Net)
	Max. torque	Nm{kgm}/rpm	563/1,350 {57.4/1,350} (Net)	545/1,350 {55.6/1,350} (Net)
	High idling speed	rpm	2,140 – 2,260	2,140 – 2,260
	Low idling speed	rpm	1,000 – 1,050	1,000 – 1,050
	Min. fuel consumption ratio	g/kW•h {g/HP•h}	228 {170}	228 {170}
Dry weight		kg	540	510
Fuel injection pump			BOSCH PES-A type	
Governor			BOSCH RSV centrifugal, all speed type	
Lubricating oil amount (refil capacity)		ℓ	26.3 (24.0)	26.3 (24.0)
Coolant amount		ℓ	9.0 (engine only)	9.0 (engine only)
Alternator			24V, 35A	24V, 35A
Starting motor			24V, 4.5kW	24V, 4.5kW
Battery			12V110Ah x 2	12V110Ah x 2
Turbocharger			HOLSET HX35 type	HOLSET HX35 type
Air compressor			—	—
Others			—	—

SAA6D102E-2				
BR120T-1	WA200-5 WA200PT-5	WA250-5 WA250PT-5	WA320-5 WA320PT-5	GD555-3A GD555-3C
6 – 102 x 120				
5.88 {5,883}				
1 – 5 – 3 – 6– 2 – 4				
1,210	1,069	1,069	1,069	1,070
750	785	785	785	747
1,380	1,483	1,483	1,483	1,123
—	—	—	—	—
141{189}/2,050 (Gross)	95.2{127.7}/2,000 (Gross)	104.1{139.5}/2,000 (Gross)	127{170}/2,000 (Gross)	124.5{167}/2,000 (Gross)
740{75.7}/1,500 (Gross)	586{59.8}/1,400 (Gross)	627{64}/1,400 (Gross)	672{68.5}/1,500 (Gross)	743{75.7}/1,500 (Gross)
2,330 ± 50	2,250 ± 50	2,250 ± 50	2,250 ± 50	2,230 ± 50
1,050 ± 25	825 ± 50	825 ± 50	900 ± 25	900 ± 50
203 {151}	224 {167}	224 {167}	224 {167}	227
550	580	580	600	550
BOSCH PES-A type				
BOSCH RSV centrifugal, all speed type				
26.3 (24.0)	21.8 (19.5)	21.8 (19.5)	21.8 (19.5)	26.3 (24.0)
9.0 (engine only)	9.0 (engine only)	9.0 (engine only)	9.0 (engine only)	9.0 (engine only)
24V, 35A 24V, 4.5kW 12V120Ah x 2	24V, 35A 24V, 4.5kW 12V120Ah x 2	24V, 35A 24V, 4.5kW 12V120Ah x 2	24V, 60A 24V, 5.5kW 12V120Ah x 2	24V, 35A 24V, 5.5kW 12V140Ah x 2
HOLSET HX35 type — With air cooled aftercooler	HOLSET HX35 type — With air cooled aftercooler	HOLSET HX35 type — With air cooled aftercooler	HOLSET HX35 type — With air cooled aftercooler	HOLSET HX35 type — With air cooled aftercooler

S6D102E-1 (PC200-6)

LEFT-HAND VIEW

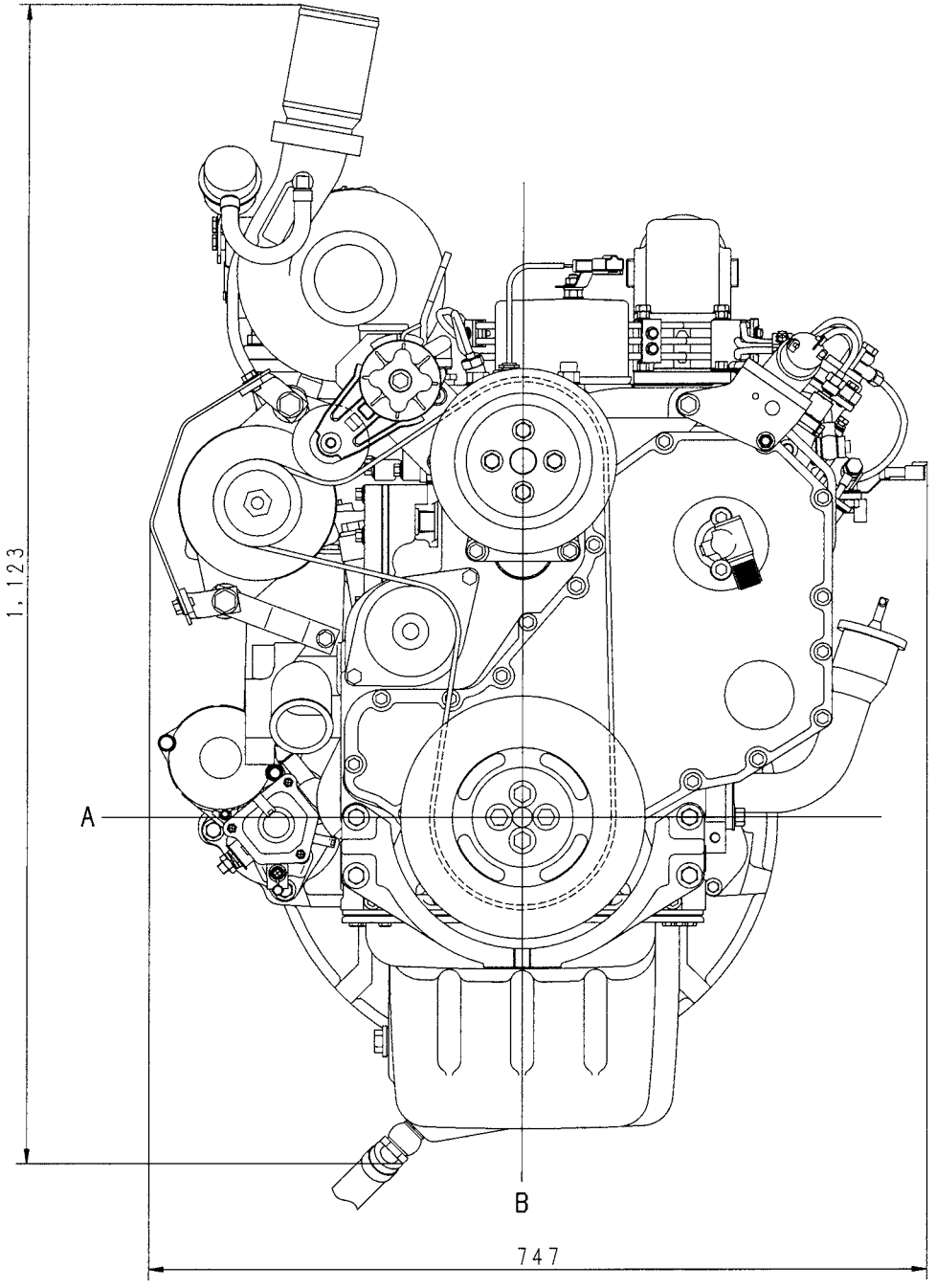
★ Depending on the applicable model, the view may be different from the drawing.



SDE00830

SAA6D102E-2 (GD555-3A, 3C)

FRONT VIEW

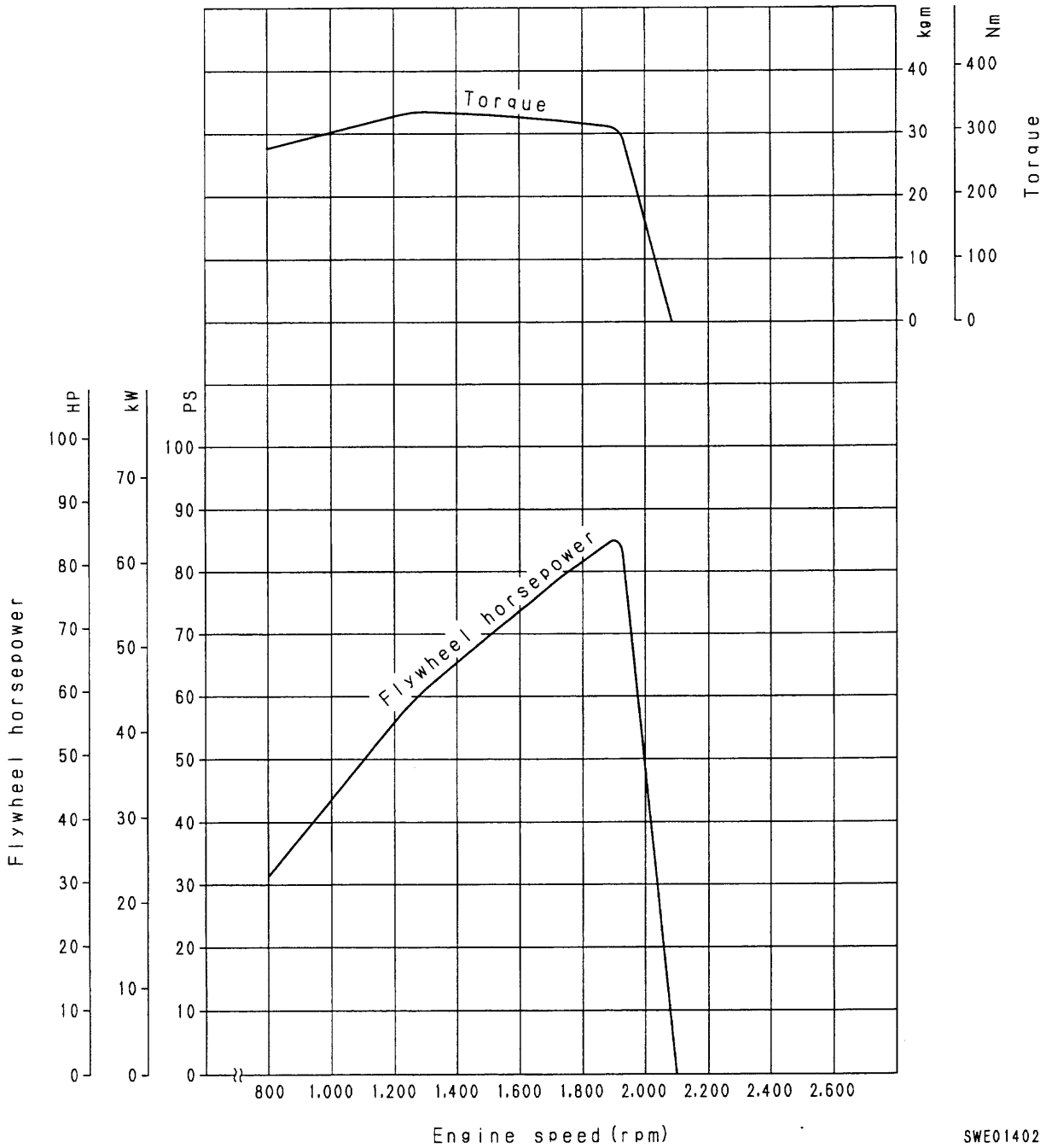


SJE02406

A. Center of crankshaft
B. Center of cylinder

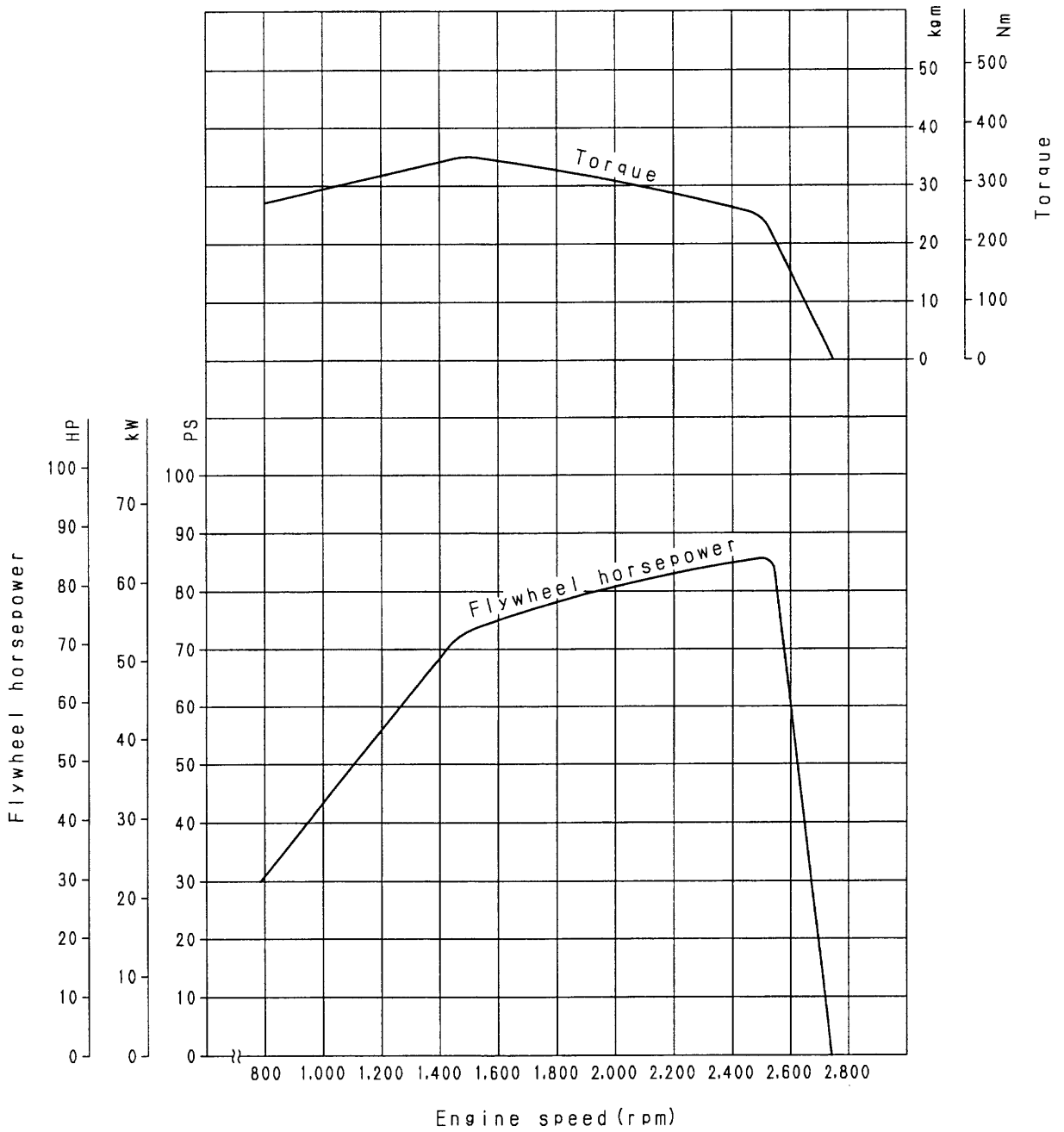
S4D102E-1 (PC128UU-1)

Flywheel horsepower : 62.5 kW {83.8 HP} /1,900 rpm (Net)
Maximum torque : 329 Nm {33.5 kgm} /1,300 rpm (Net)



S4D102E-1 (GD305A-3)

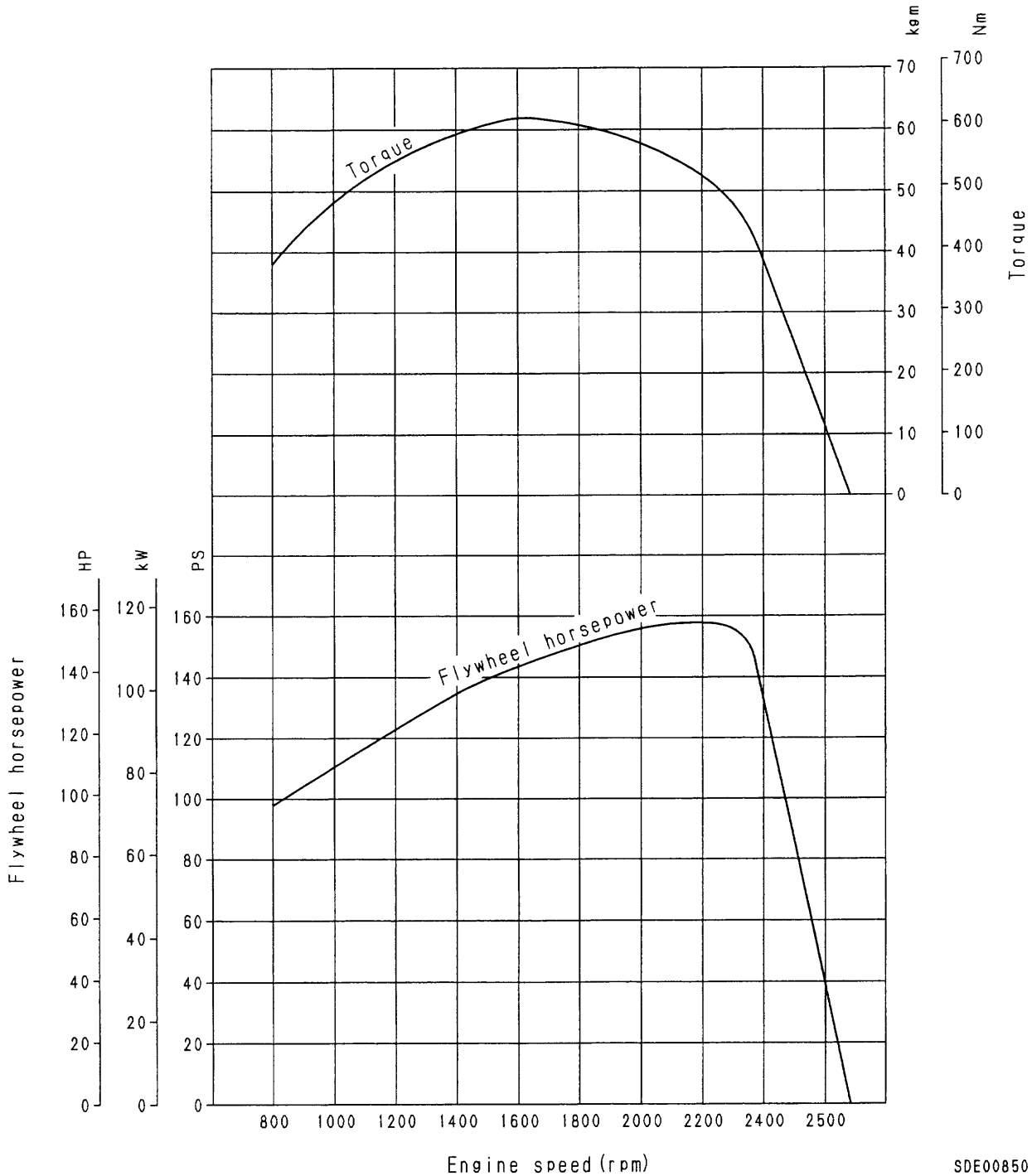
Flywheel horsepower : 63.0 kW {85.0 HP} /2,500 rpm (Net)
Maximum torque : 343 Nm {35.0 kgm} /1,500 rpm (Net)



SXE01407

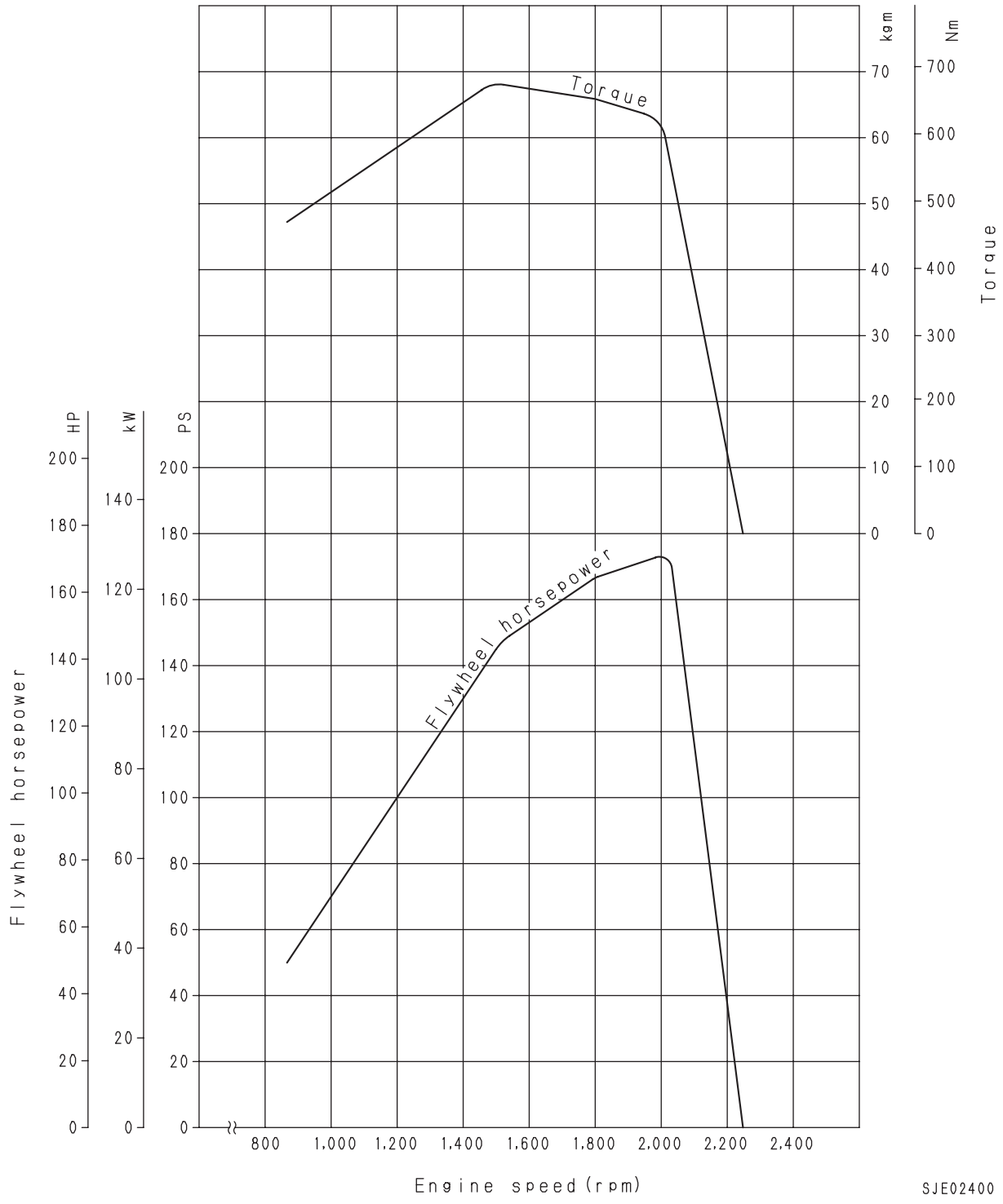
SA6D102E-1 (WA300L-3 (FOR USA), WA320-3, WA320-3 CUSTOM)

Flywheel horsepower : 114 kW {153 HP} /2,350 rpm (Net)
Maximum torque : 608 Nm {62.0 kgm} /1,600 rpm (Net)

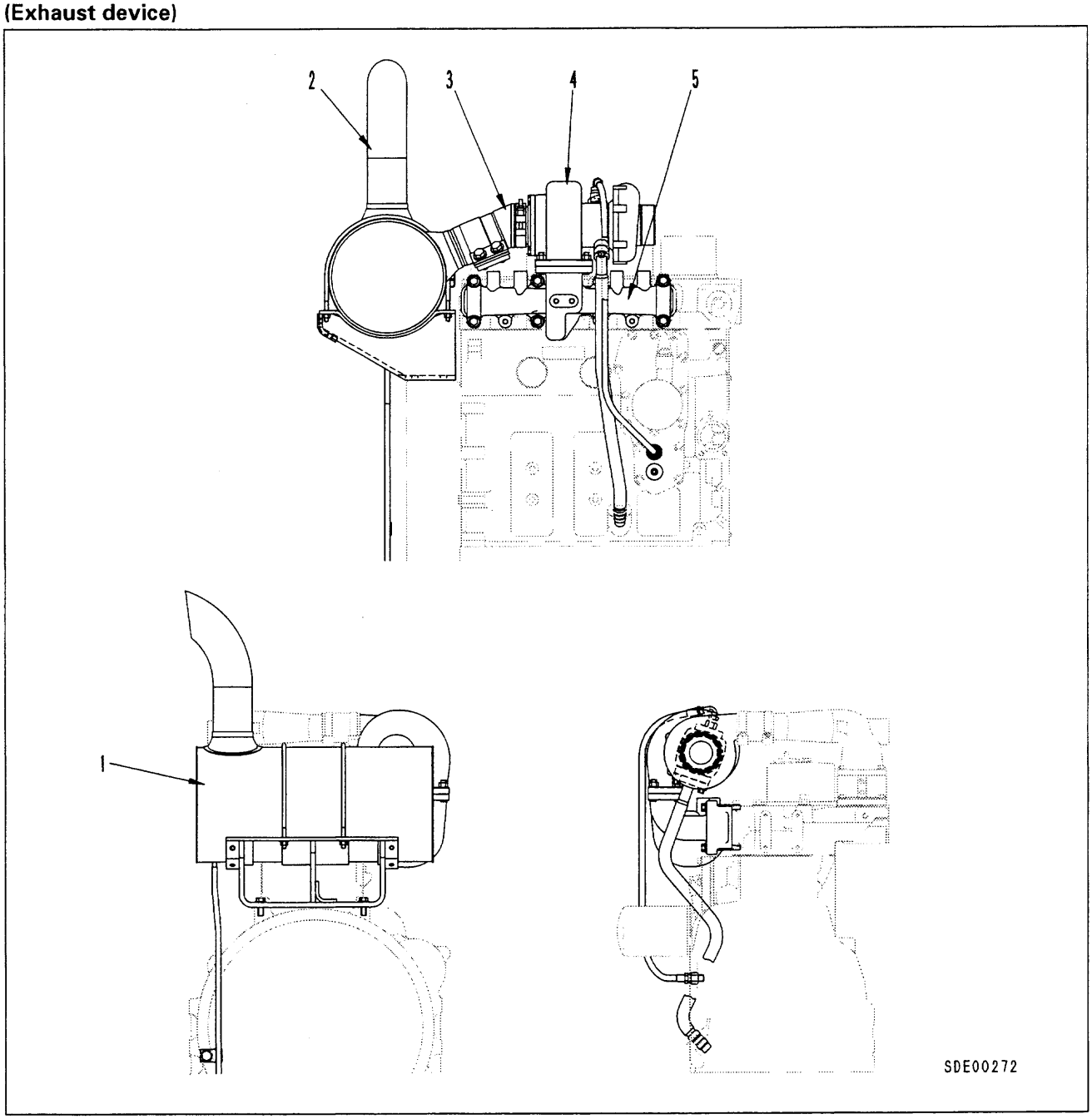


SAA6D102E-2 (WA320-5, WA320PT-5)

Flywheel horsepower : 127 kW {170 HP} /2,000 rpm (Gross)
Maximum torque : 672 Nm {68.5 kgm} /1,500 rpm (Gross)

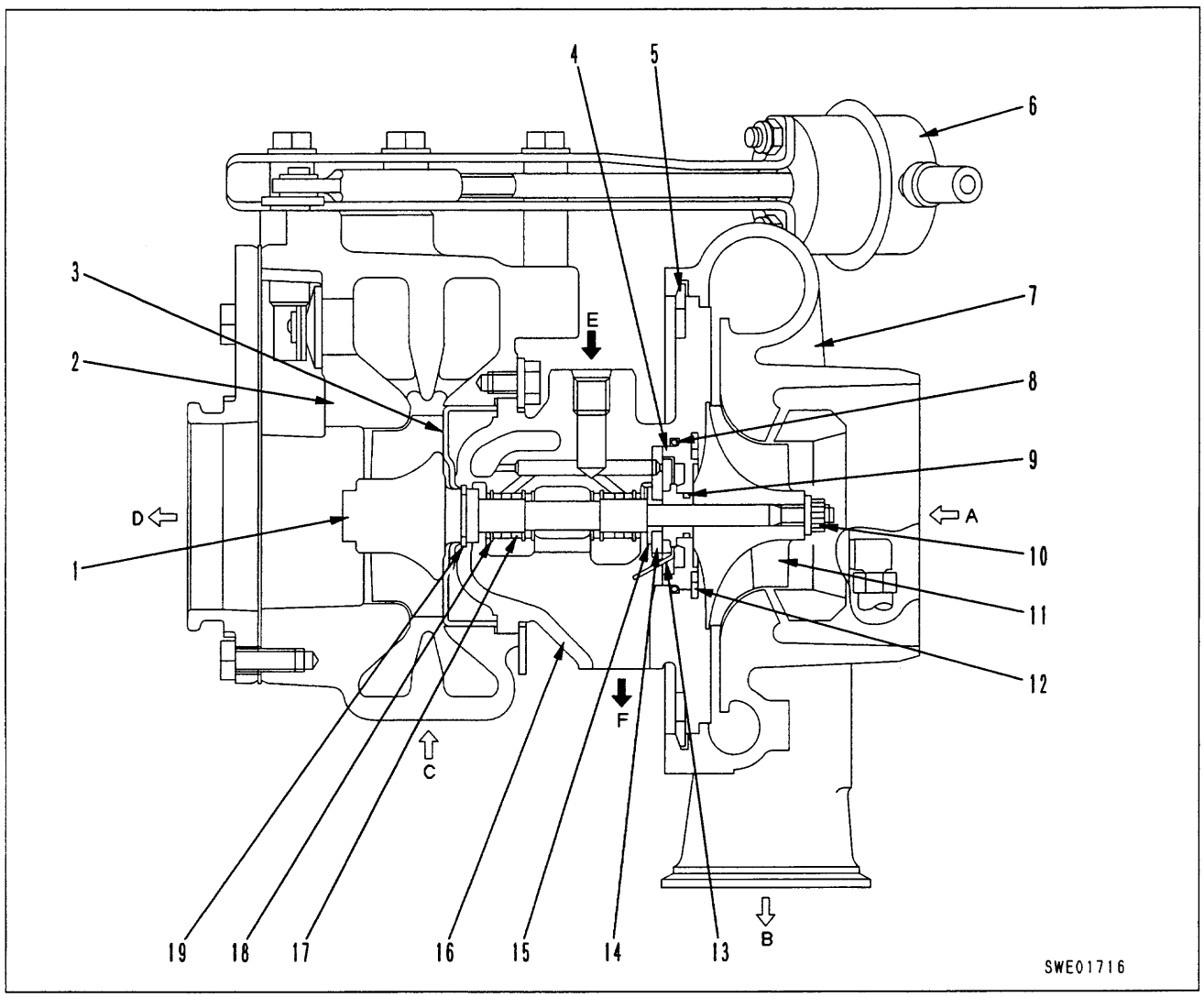


(Exhaust device)



1. Muffler
2. Exhaust pipe
3. Exhaust pipe (turbocharger - muffler)
4. Turbocharger
5. Exhaust manifold

SAA4D102E-2
SAA6D102E-2



1. Turbine impeller (hole shaft)
2. Turbine housing
3. Shroud (heat shield)
4. Oil seal
5. Retainer ring
6. Weight gate valve
7. Blower housing
8. O-ring
9. Split ring
10. Locknut
11. Blower impeller
12. Retainer ring
13. Baffle oil
14. Thrust bearing
15. Thrust collar
16. Center housing
17. Journal bearing
18. Retainer
19. Split ring

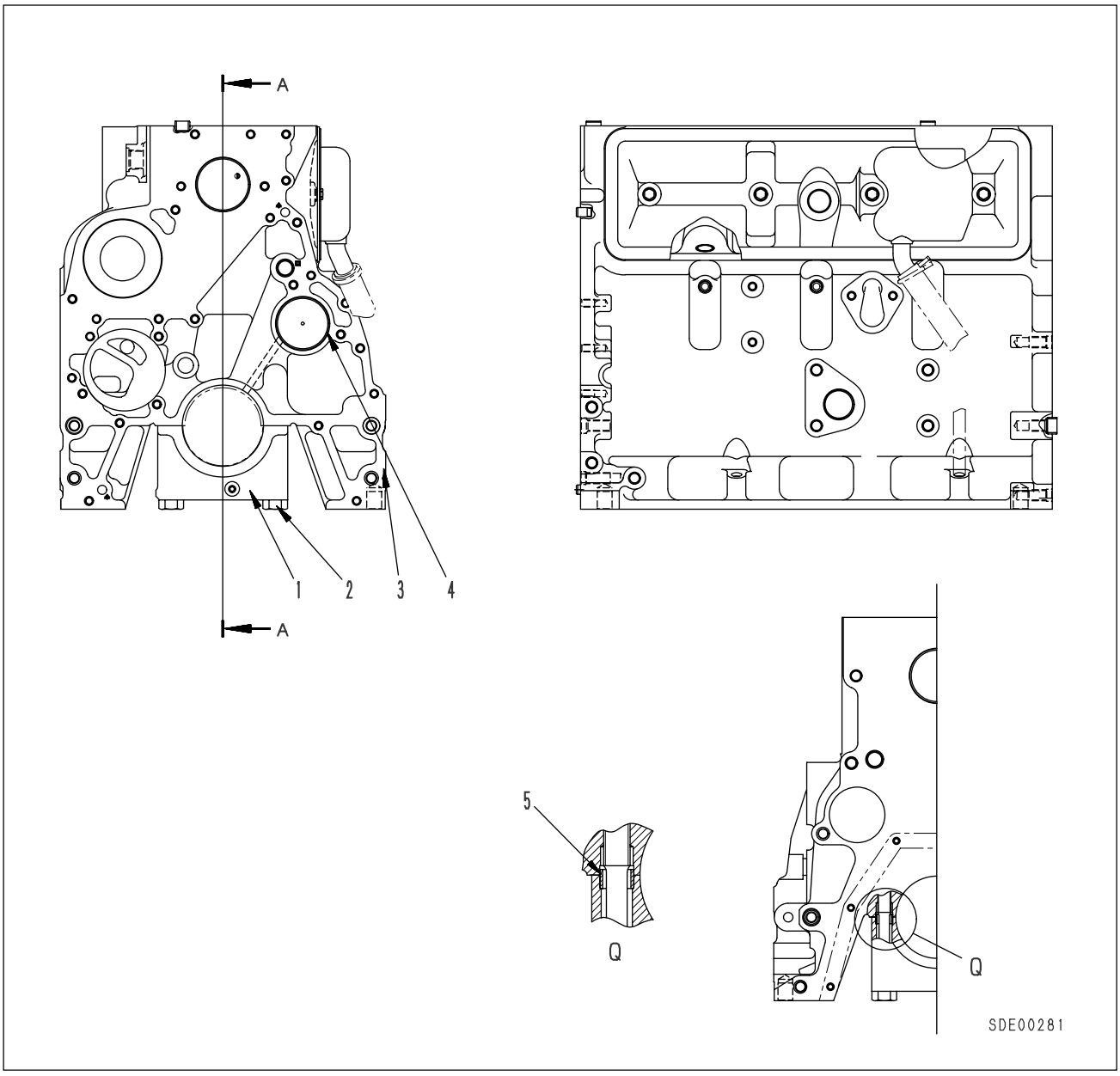
A. Intake inlet
B. Intake outlet
C. Exhaust inlet
D. Exhaust outlet
E. Oil inlet
F. Oil outlet

Turbocharger
Type: Holset HX25 [SAA4D102E-2]
Holset HX35 [SAA6D102E-2]
Applicable exhaust temperature:
Max. 700°C (inlet port)
Direction of rotation:
Clockwise
(as seen from blower end)

CYLINDER BLOCK

(S)4D102E-1
SAA4D102E-2

★ Depending on the machine model, the actual component may be different from the diagram.

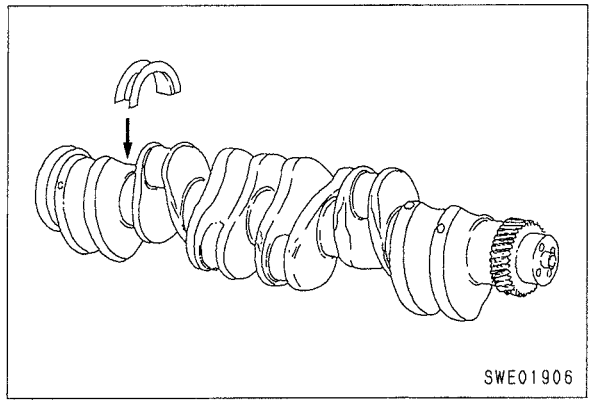


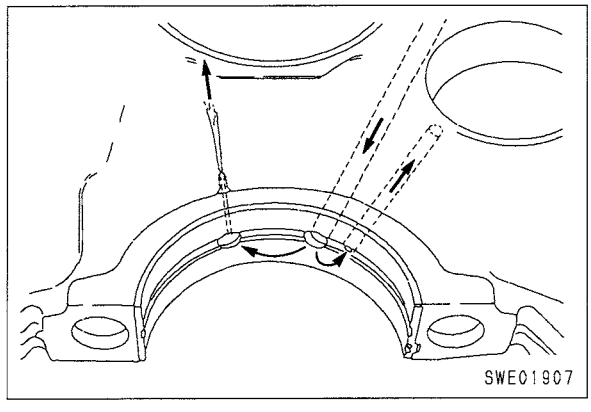
1. Main bearing cap
2. Main bearing cap bolt
3. Cylinder block
4. Cam bushing (journal No. 1)
5. Dowel ring (main bearing cap positioner)

a. Piston cooling nozzle
b. Thrust face (top face only, No. 4 journal)

Crankshaft and main bearing

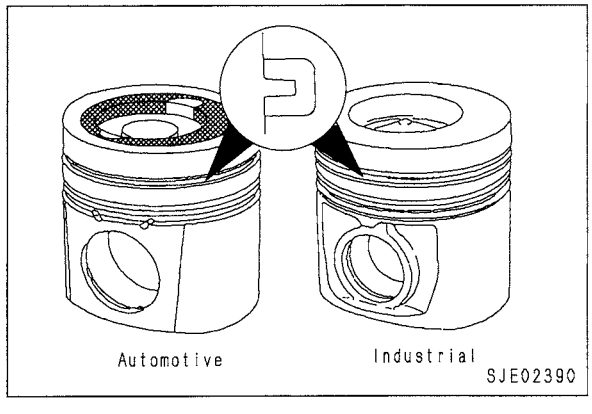
The crankshaft is a balance type cast steel product. On the 4-cylinder engine, there are five main bearings. On the 6-cylinder engine, there are seven main bearings. The bottom bearing shells are all the same. The top bearing shells are all the same except for the journal at the rear. A top bearing with flange is installed next to the rear journal. The flange controls the end thrust of the crankshaft.
There are three holes in the top bearing. The center hole takes the oil from the main oil rifle. The neighboring hole is aligned with the hole going to the crankshaft journal and acts as an orifice for the oil to flow to the journal. The final hole supplies oil for cooling the piston. This hole is not completely aligned with the cooling nozzle. The hole is offset in order to prevent it from being subjected to the high load of the bearing portion.

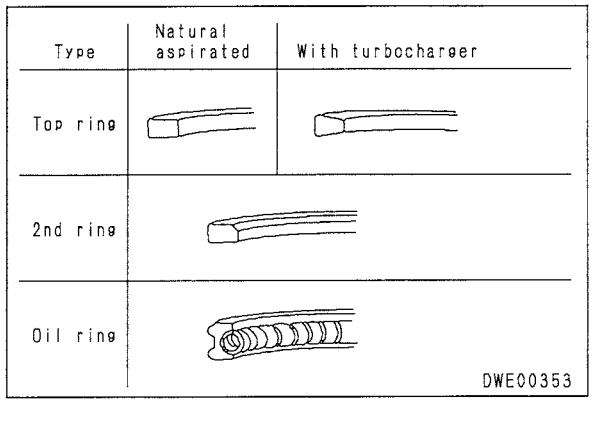




Piston connecting rod

The special features of the piston are the high swirl combustion bowl cast aluminium body and three ring group. The engine with turbocharger and engine with turbocharger/aftercooler are equipped with trapezoidal ni resist insert for top piston cooling. When replacing the piston, always check the part number and check that the structure is correct.
In addition to the ni resist insert, a feature of the engine with turbocharger for automobiles is that it has anode hardening of the piston surface.
The piston ring set is also different. Both have a 3-ring structure, but the top ring on the engine with turbocharger and aftercooler is a trapezoidal shape and is actuated by the ni resist insert cast into the piston. The top ring on the natural aspirated type is rectangular and is actuated as the group stamped on the aluminium piston.

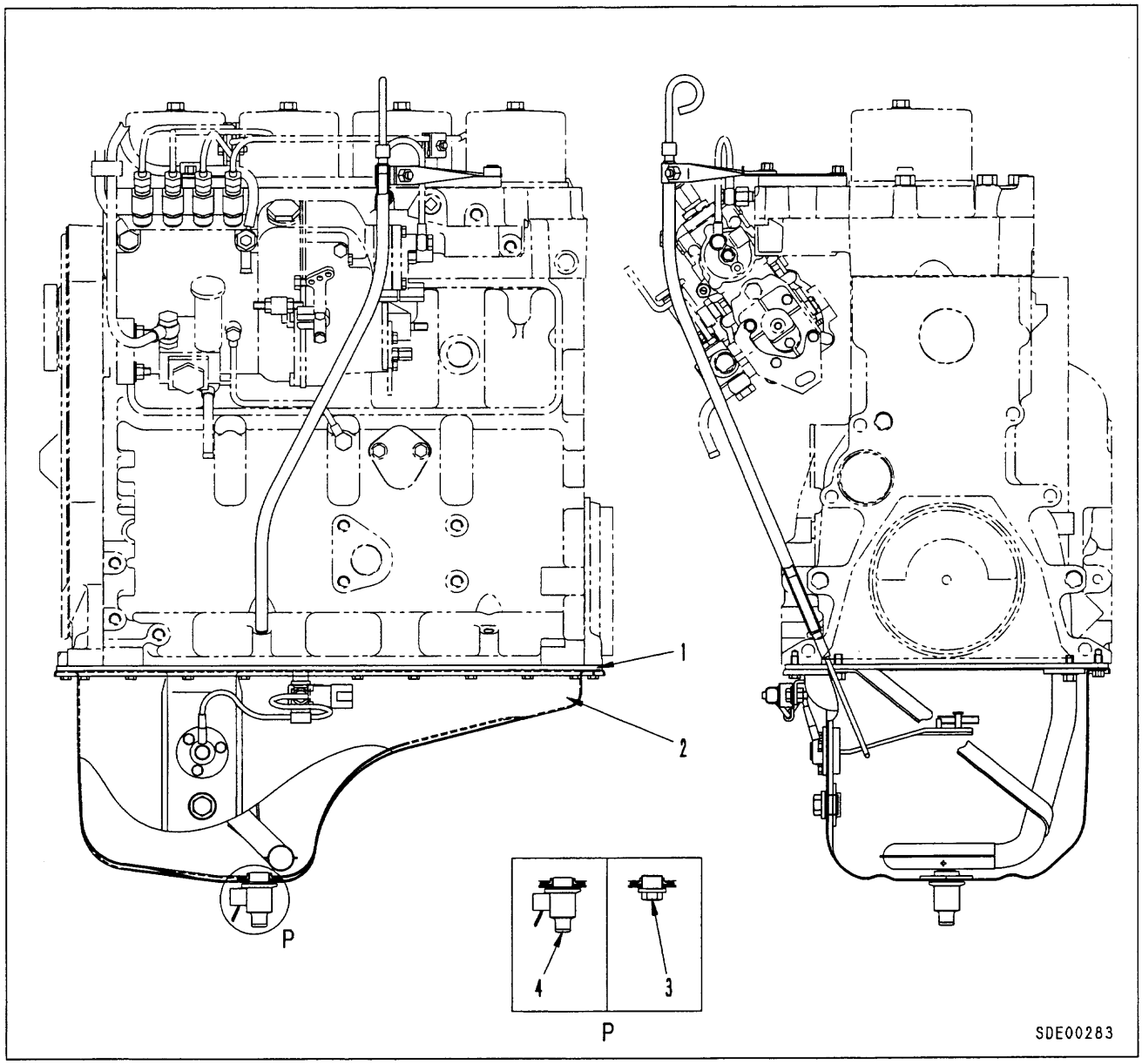




OIL PAN

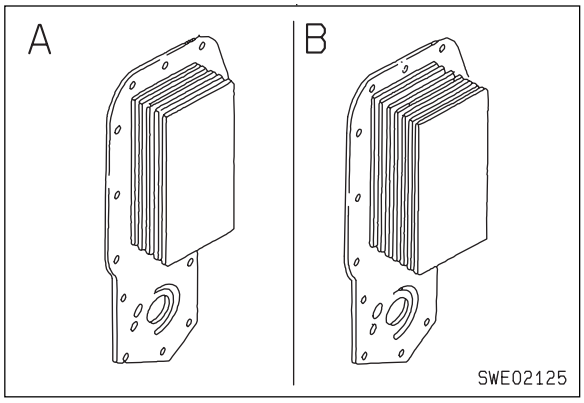
(S)4D102E-1
SAA4D102E-2

★ Depending on the machine model, the actual component may be different from the diagram.



1. Underplate
2. Oil pan
3. Drain plug
4. Drain valve

Oil cooler
On this engine, a full-flow plate shape oil cooler (3) is used. The oil flows through the passage cast in the cooler cover and goes to the element, where it is cooled in the element by the engine cooling water flowing through the plate. On the 4-cycle engine, element (A) with five plates is used, and on the 6-cycle engine, element (B) with seven plates is used.
There is a difference in the resistance and pump volume of the plates, so there is no interchangeability in the oil cooler components between the two engines. If the correct component is not used, it will cause high temperature, low temperature, or the formation of varnish or sludge.
Caution: Up to 10/21/86, a 9-plate oil cooler element was used for the 6-cylinder engine.



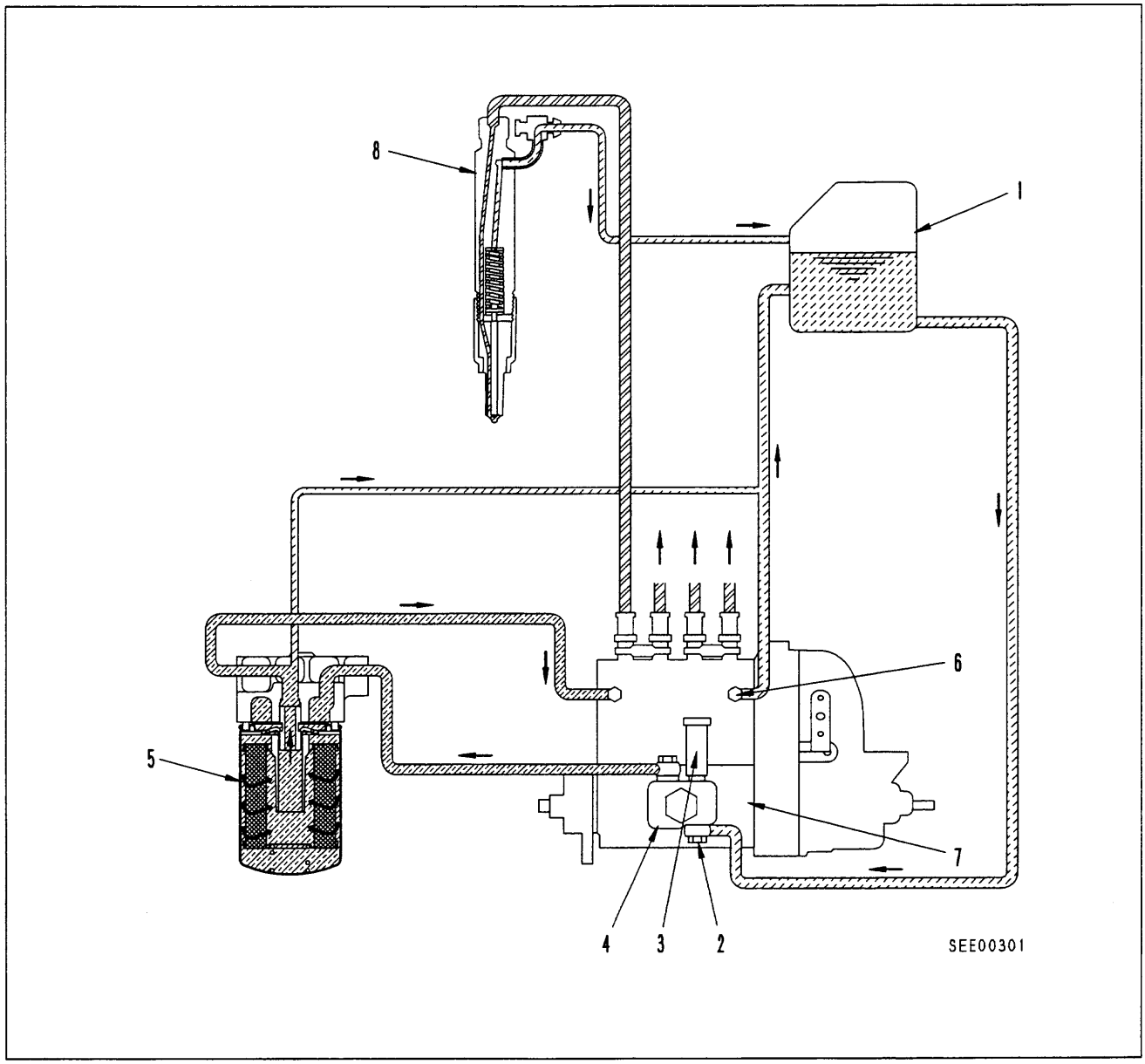
Oil filter
After the oil is cooled, it is sent to full-flow oil filter (4). The filter on the 6-cylinder engine is slightly longer than the filter on the 4-cylinder engine.

Caution: Even if the 6-cylinder engine filter is used on the 4-cylinder engine, there will be no increase in the replacement interval. Do not use a 4-cylinder engine filter on the 6-cylinder engine under any circumstances. This will cause a drop in the filtering capacity and will cause an increase in clogging.

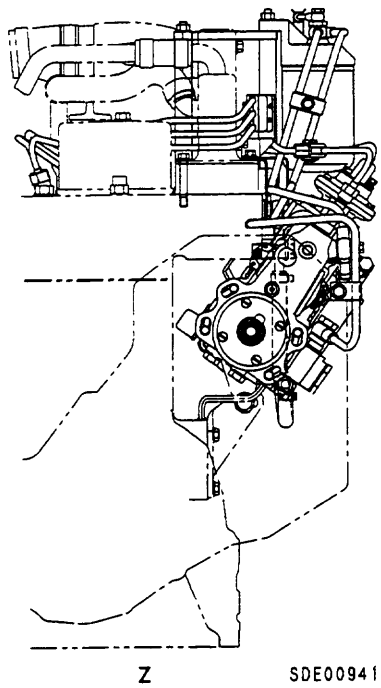
Oil cooler bypass valve
Bypass valve (5) is installed in the oil cooler cover to allow the oil to flow through the bypass when the filter is clogged. The valve is designed so that when the filter is clogged and the drop in pressure on both sides of the filter exceeds 1.4 kg/cm2 (138 kPa) (20 psi), the valve opens and allows the oil to flow to the engine. When the filter is clogged, the oil pressure drops within 0.6 kg/cm2 (60 kPa) (10 psi) lower than the normal operating oil pressure. This can be observed on the oil pressure gauge.
To avoid this condition, it is best to replace the filter at the drain interval given in the Operation and Maintenance Manual, Bulletin No. 3810205-10.

(S)4D102E-1

★ Depending on the machine model, the actual component may be different from the diagram.



1. Fuel tank
2. Gauze filter
3. Priming pump
4. Feed pump
5. Fuel filter
6. Overflow valve
7. Fuel injection pump
8. Fuel injection nozzle



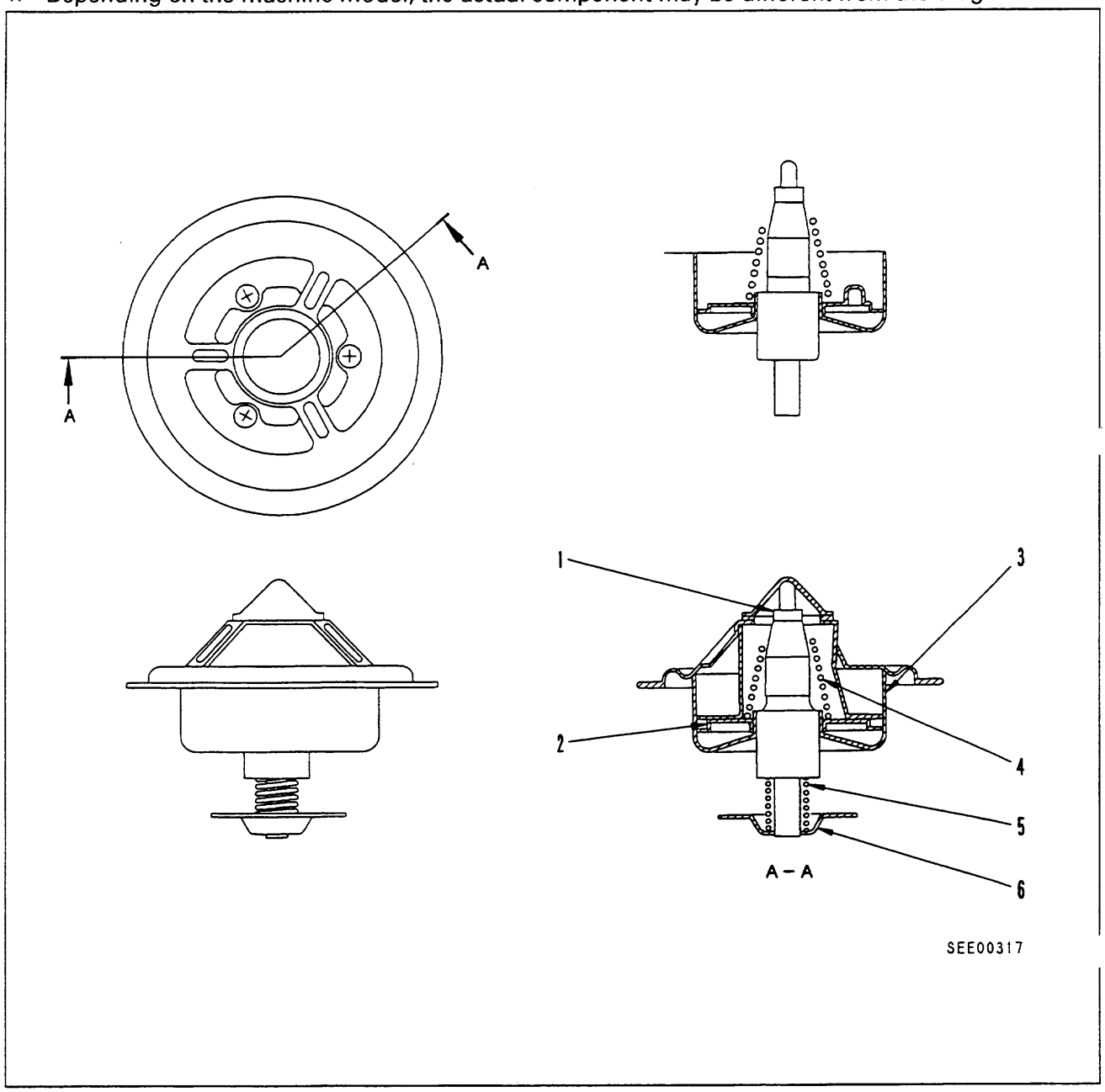
A. Fuel inlet port
B. To fuel filter
C. From fuel filter
D. To fuel injection nozzle
E. To fuel tank
F. From oil pump (oil)
G. To fuel tank

Fuel injection pump
- Type: Bosch PES-A
- Lubrication method:
  Forced lubrication using engine oil

Governor
- Type: Bosch RSV
  Centrifugal all-speed governor

THERMOSTAT

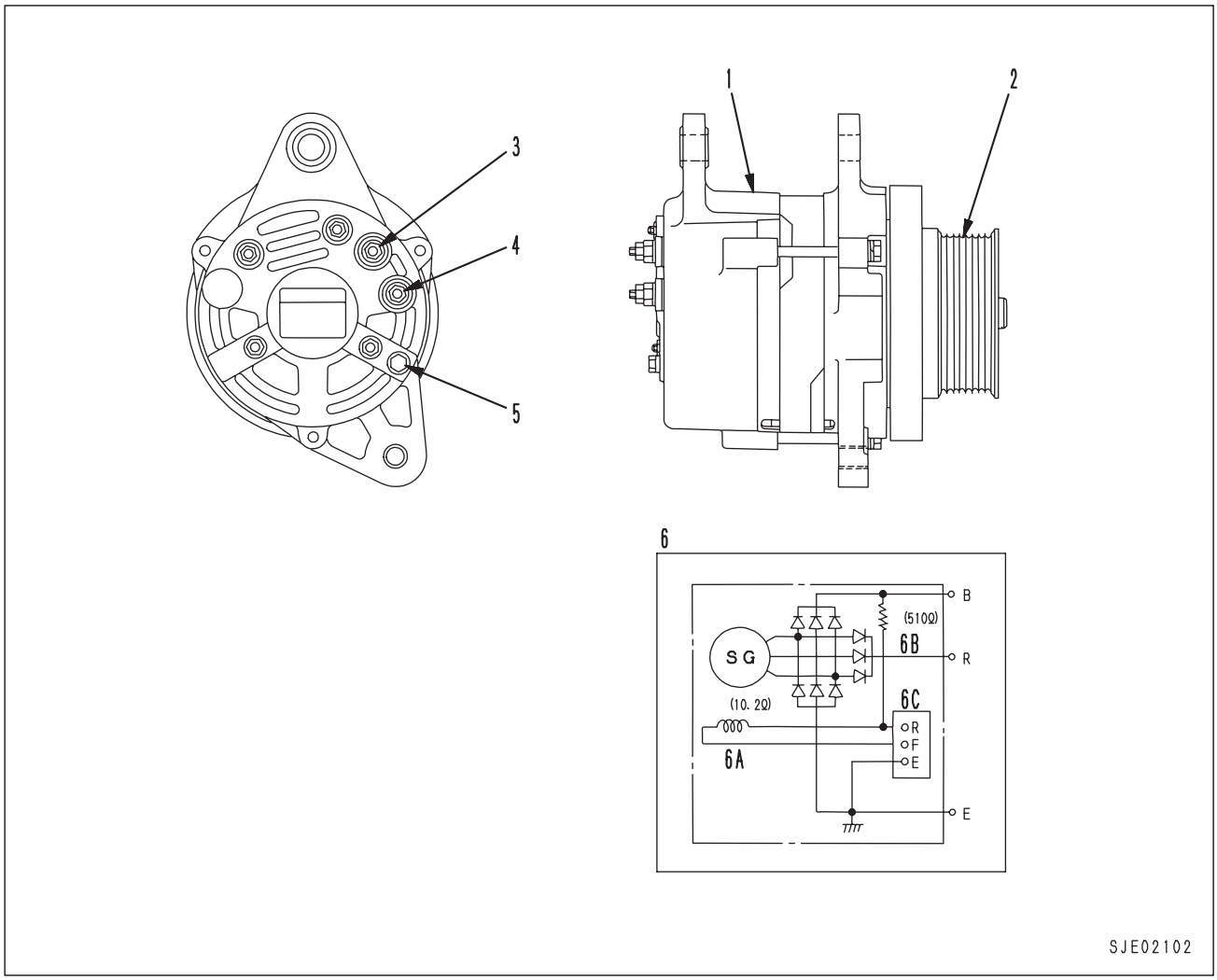
★ Depending on the machine model, the actual component may be different from the diagram.



1. Piston
2. Valve
3. Case
4. Spring
5. Bypass spring
6. Bypass valve

Alternator with built-in regulator (25A)

★ Depending on the machine model, the actual component may be different from the diagram.



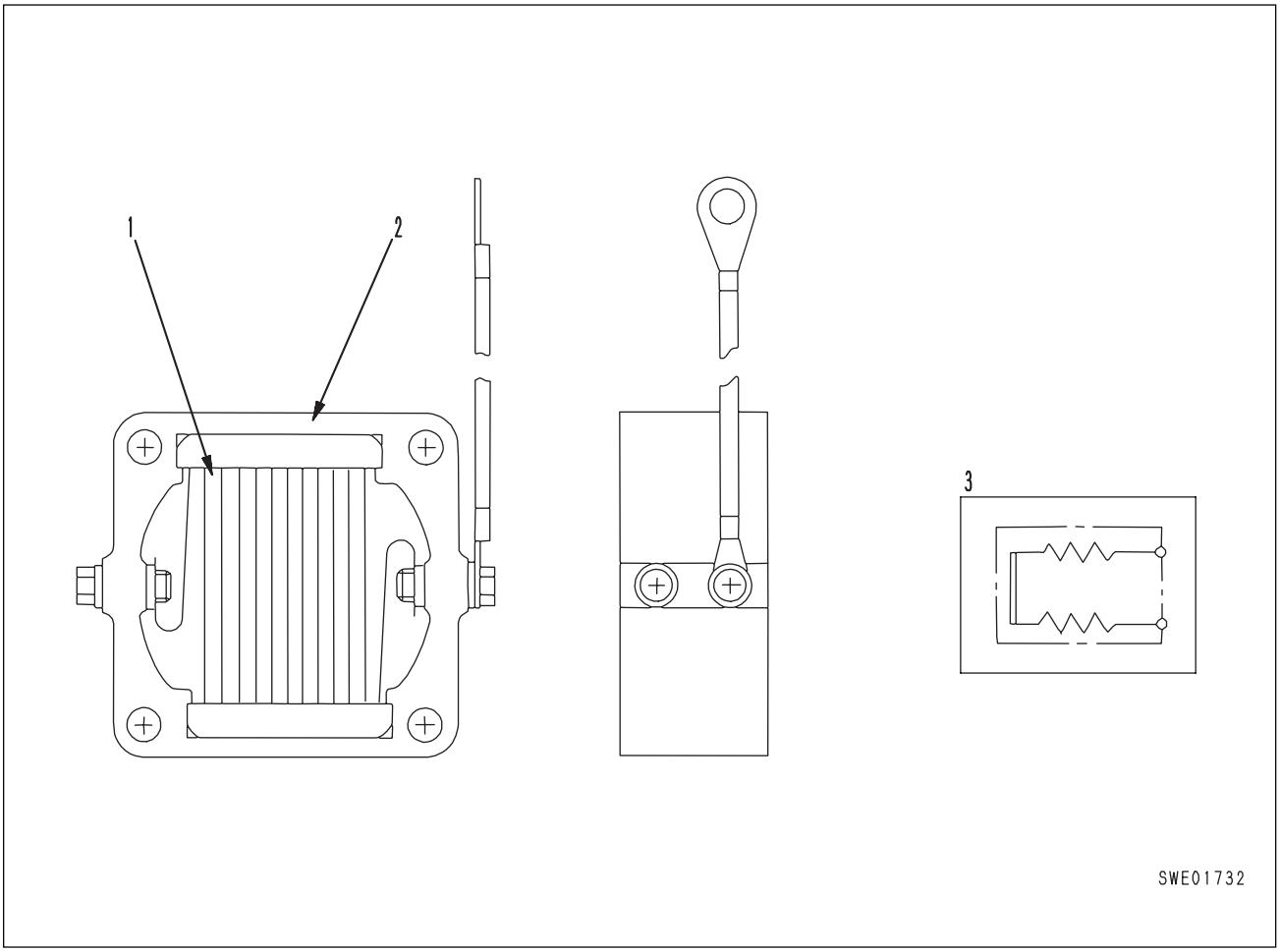
1. Alternator
2. Alternator pulley
3. Terminal R
4. Terminal B
5. Terminal E
6. Internal electric circuit diagram
   6A. Field coil
   6B. Primary energized resistance
   6C. Regulator

Engine	Machine model	Type	Specification	Pulley		Weight (kg)
				No. of steps	Outside diameter (mm)	
SAA4D102E-2	D31EX-21 D31PX-21 D37EX-21 D37PX-21 D39EX-21 D39PX-21 PC128US-2 PC138US-2	Nikko Denki, open type	24V, 25A	Polyethylene V-belt, 8 grooves	80	6.5

STARTING AID

Electrical heater (electrical intake air heater)

★ Depending on the machine model, the actual component may be different from the diagram.

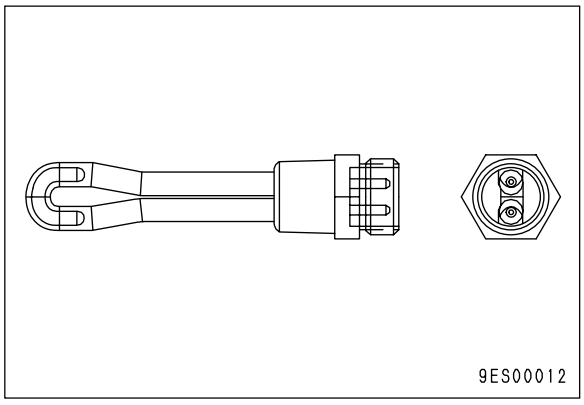


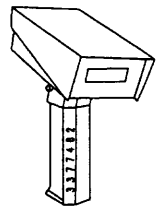
1. Heater coil
2. Housing
3. Internal connection diagram

Electrical heater (electrical intake air heater)
- Rated current: 100 A/22 V

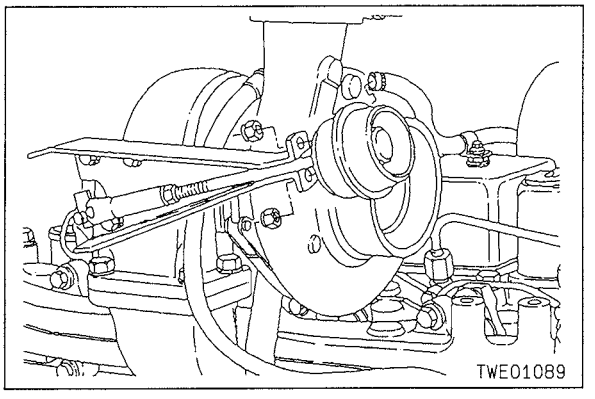
Coolant heater

Specification
- 230 V, 1.0 kW

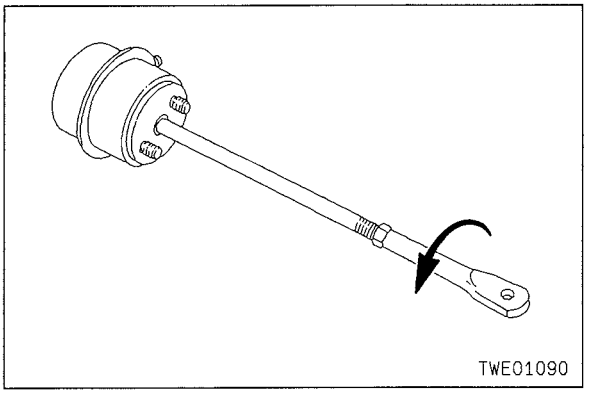


Tool No.	Explanation of tool	Sketch of tool
799-203-8001	**Tachometer** This is used to measure the engine speed (rpm).	 TWE01054

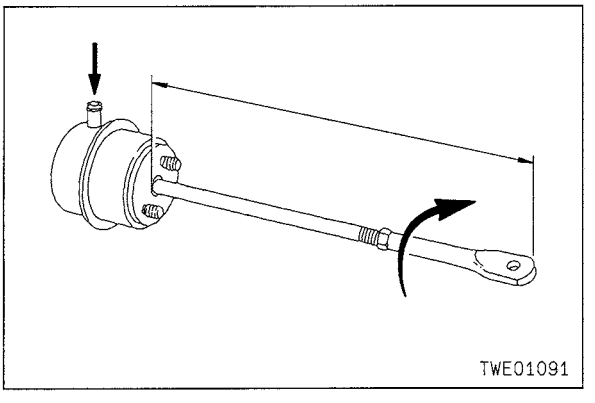
Loosen the capsule mounting bolts, then remove the air supply hose and remove the assembly from the mounting bracket.



Remove the tip of the adjustment link from the actuator.

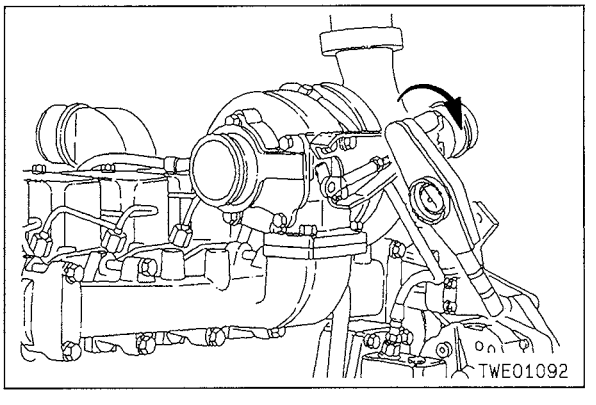


Install the tip of the adjustment link to the new actuator assembly at the position from which it was removed.

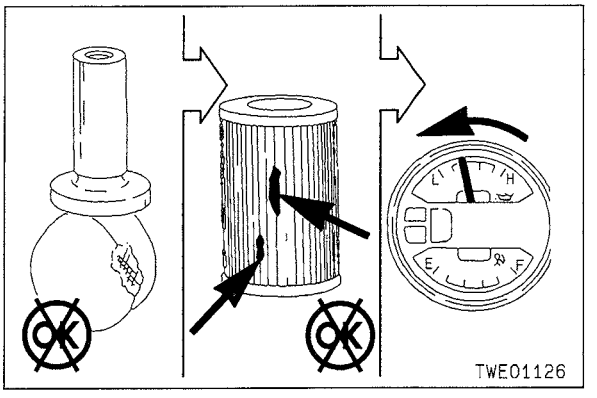


Install the new actuator assembly to the actuator mount bracket, then tighten the mounting bolts.

Mounting bolt: 4.5 Nm {0.46 kgm}

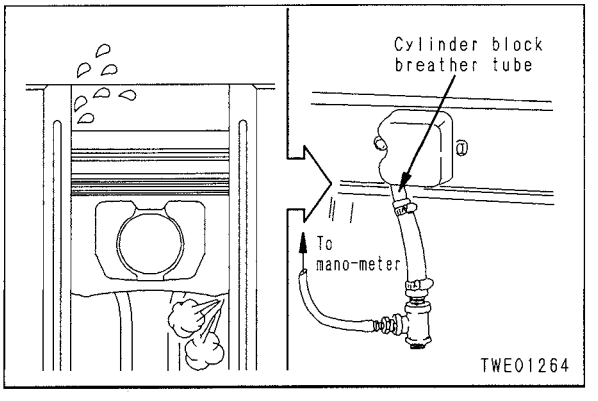


Excessive damage to the camshaft journal will occur when there are metal particles in the oil pan or oil filter. If the clearance between the bushing and journal increases, the oil pressure may drop.

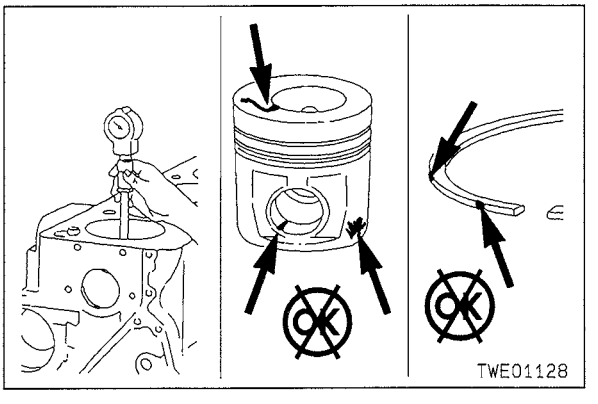


PISTON AND CONNECTING ROD

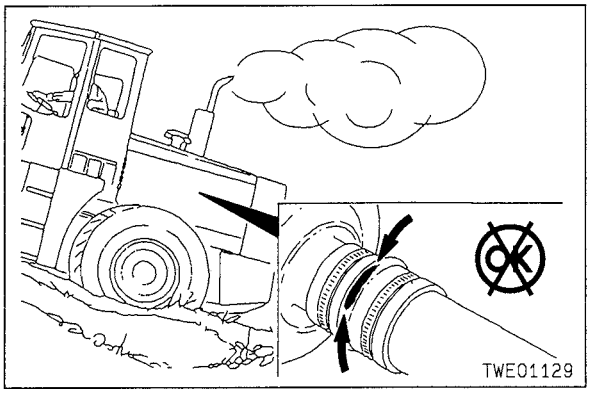
If the sealing between the piston ring and surface of the cylinder liner wall is defective, there will be various problems related to the output, such as excessive oil consumption, exhaust smoke and blow-by, and drop in the engine performance.
It is easy to recognize the existence of problems by measuring the blow-by.



When checking for wear or damage to components, check the rings, piston, and cylinder bore visually and check the dimensions.

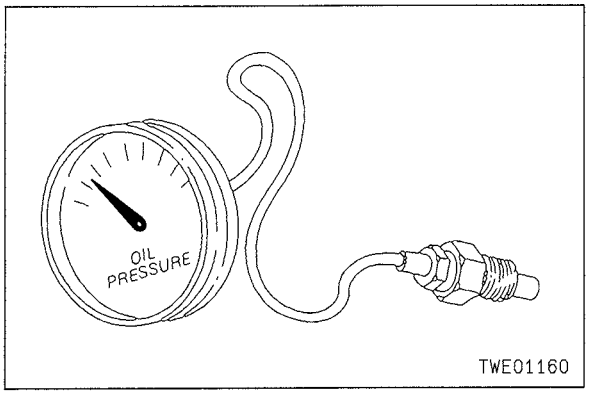


There are various causes of piston ring wear, ranging from long-term use to short-term accumulation of dirt resulting from poor maintenance of the intake system.



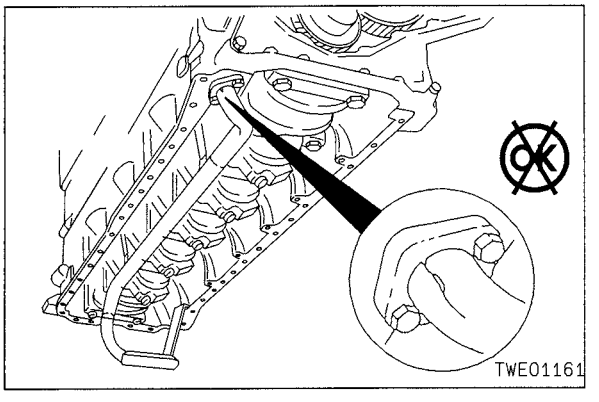
OIL PRESSURE GAUGE

Check the oil pressure with the manifold gauge and check the oil pressure gauge and supply portion to confirm that they are working normally.



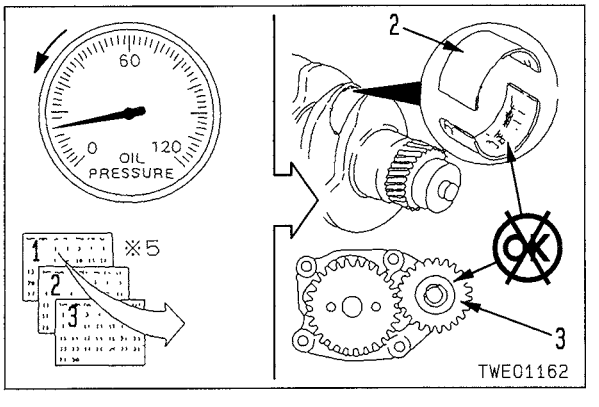
OIL PAN SUCTION TUBE

If the suction tube inside the oil pan becomes loose or the gasket is damaged, or the tube is cracked, the actuation of the oil pump will become temporarily defective. When starting the engine, the oil pressure is low or stays at 0, but usually it will return to the normal value as time passes.



BEARING AND OIL PUMP

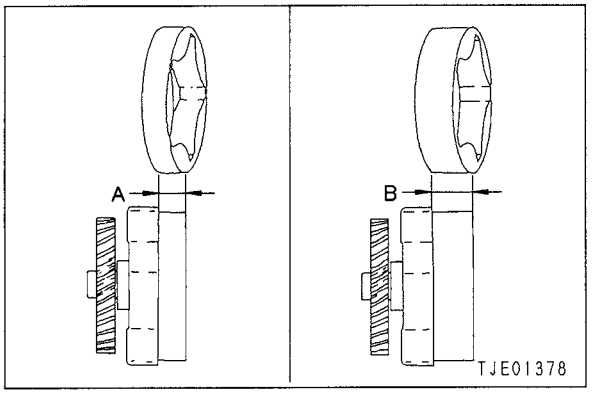
If the oil pressure gradually goes down over (see ※5) a long time, it means that the bearing (2) is worn or the oil pump (3) is worn.



UNSUITABLE OIL PUMP

The capacity of the oil pump used on a 6-cylinder engine is larger than that used on a 4-cylinder engine. After replacing the pump, if high or low pressure occurs, check that the proper pump is being used. For details, see page 2-24 "Replacing oil pump"

A - For 4-cylinder engine: 12.947 mm
B - For 6-cylinder engine: 17.947 mm



Injection Pump Assembly Number

6732-71-1121 (101402-3880) (Without boost compensator)

( ): Injection Pump Manufacture's part No.

Injection Pump Type	Injection Pump Manufactuer
PES-A	ZEXEL

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
PC100, 100L-6		S4D102E-1	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 3 – 4 – 2
Injection interval	89° 30' – 90° 30'
Plunger prestroke (mm)	2.45 – 2.55
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

Flywheel horsepower (kw{HP}/rpm)	63.0{84.4}/2,100 (Gross)
Maximum torque (Nm{kgm}/rpm)	333{34.0}/1,300 (Gross)
High idling speed (rpm)	2,240 – 2,360
Low idling speed (rpm)	900 – 950
Pump tester capacity for Service standard	Motor: 7.5 kW

Calibration Standard

( ) : Injenction pump manufacture's part number

Conditions

- **Service standard** indicates data using calibration test parts.
- **Manufacture standard** is data for factory test parts.

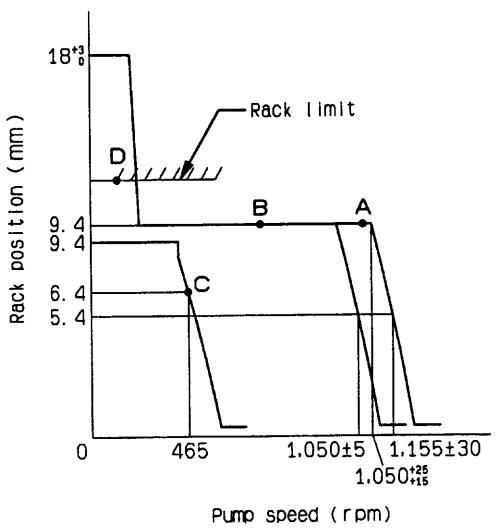
	Service standard	Manufacturer standard
Nozzle & Nozzle holder part No.	(105780 – 8140)	6732 – 11 – 3220
Nozzle part No.	(105780 – 0000)	
Nozzle holder part No.	(105780 – 2080)	6732 – 11 – 3230
Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 600
Test oil	ASTM D975 No.2 diesel fuel or equivalent	
Oil temperature (°C)	40 – 45	
Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	21.6 {220}
Transfer pump pressure (kPa{kg/cm^2})	157 {1.6}	157 {1.6}

Injection volume

- **Rack positions** B to E are the refernce volume when adjusting the injection volume.
- **Marks** ★ are average volumes.

Rack point	Rack position (mm)	Pump speed (rpm)	Service standard (cc/1,000 st) Injection volume	Service standard (cc/1,000 st) Maximum variance between cylinder	Manufacturer standard (cc/1,000 st) Injection volume	Manufacturer standard (cc/1,000 st) Maximum variance between cylinder
A(Basic point)	9.4	1,050	★ 89 – 91	± 2.5	★ 73.5 – 75.5	± 2.5
B	9.4	650	★ 86 – 90	—	★ 85 – 89	—
C	Approx.6.4	465	★ 11.5 – 13.5	± 15	★ 11.5 – 13.5	± 15
D	—	100	90 – 100		110 – 120	—

Governor perfomance curve



TWE01268

Injection Pump Assembly Number

6732-71-1240 (101402-3861)

( ): Injection Pump Manufacture's part No.

Injection Pump Type	Injection Pump Manufactuer
PES-A	ZEXEL

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
D37E-5 D37P-5A		S4D102E-1	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 3 – 4 – 2
Injection interval	89° 30' – 90° 30'
Plunger prestroke (mm)	2.45 – 2.55
Delivery valve retraction volume (mm^3/st)	70

Engine Specification

Flywheel horsepower (kw{HP}/rpm)	58.8{78.9}/2,500 (Gross)
Maximum torque (Nm{kgm}/rpm)	293{29.9}/1,400 (Gross)
High idling speed (rpm)	2,600 – 2,650
Low idling speed (rpm)	800 – 850
Pump tester capacity for Service standard	Motor: 7.5 kW

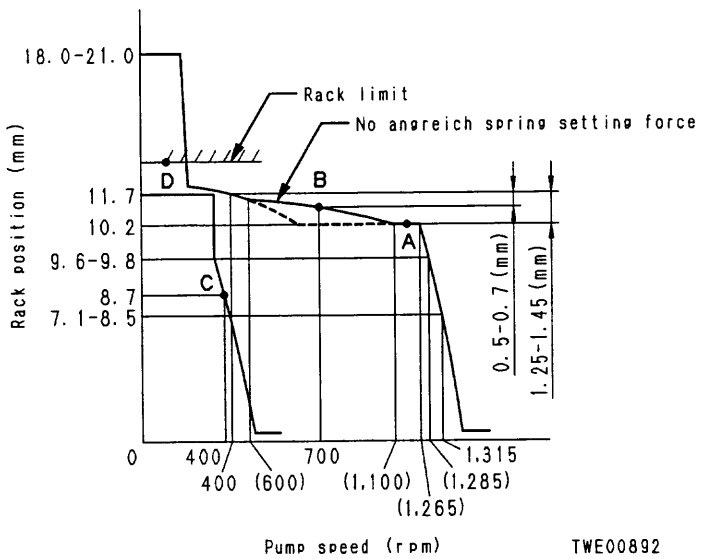
Calibration Standard

( ) : Injenction pump manufacture's part number

Conditions		Service standard	Manufacturer standard
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	6732 – 11 – 3220
	Nozzle part No.	(105780 – 0000)	
	Nozzle holder part No.	(105780 – 2080)	
	Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 600
	Test oil	ASTM D975 No.2 diesel fuel or equivalent	
	Oil temperature (°C)	40 – 50	
	Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	21.6 {220}
	Transfer pump pressure (kPa{kg/cm^2})	157 {1.6}	157 {1.6}

Injection volume	Rack point	Rack position (mm)	Pump speed (rpm)	Service standard (cc/1,000 st)		Manufacturer standard (cc/1,000 st)	
				Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
• **Rack positions** B to E are the refernce volume when adjusting the injection volume. • **Marks** ★ are average volumes.	A(Basic point)	10.2	1,250	★ 81 – 83	± 2.5	★ 67.5	
	B	10.8	700	★ 83 – 87	—	★ 77.5	
	C	Approx. 8.7	400	★ 12.5 – 14.5	± 15	★ 15	
	D	—	100	85 – 95	—	★ 90	

Governor perfomance curve



Injection Pump Assembly Number
6735-71-1160 (101609-3222)
6735-71-1161 (101609-3223)
( ): Injection Pump Manufacture's part No.

Injection Pump Type	Injection Pump Manufactuer
PES-A	ZEXEL

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
WA180-3 WA180PT-3 WA180-3 (for CIS)		S6D102E-1	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 5 – 3 – 6 – 2 – 4
Injection interval	59° 30' – 60° 30'
Plunger prestroke (mm)	2.45 – 2.55
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

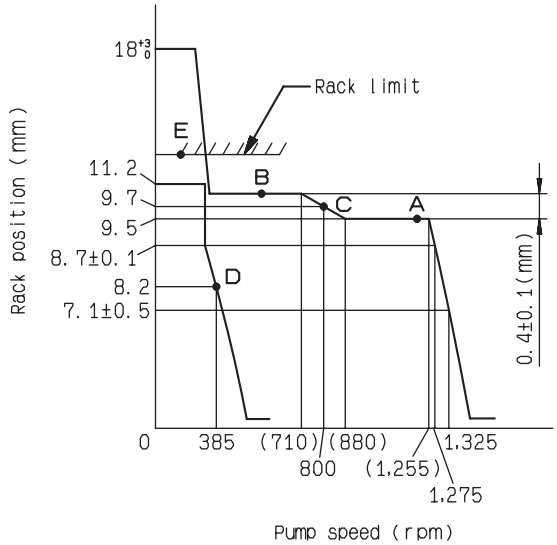
Flywheel horsepower (kw{HP}/rpm)	83.4{111.8}/2,400 (Gross)
Maximum torque (Nm{kgm}/rpm}	422{43}/1,600 (Gross)
High idling speed (rpm)	2,600 – 2,700
Low idling speed (rpm)	750 – 800
Pump tester capacity for Service standard	Motor: 7.5 kW

Calibration Standard ( ) : Injenction pump manufacture's part number

Conditions		**Service standard**	**Manufacturer standard**
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	6732 – 11 – 3120
	Nozzle part No.	(105780 – 0000)	
	Nozzle holder part No.	(105780 – 2080)	
	Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 800
	Test oil	ASTM D975 No.2 diesel fuel or equivalent	
	Oil temperature (°C)	40 – 50	
	Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	21.6 {220}
	Transfer pump pressure (kPa{kg/cm^2})	157 {1.6}	157 {1.6}

Injection volume	Rack point	Rack position (mm)	Pump speed (rpm)	**Service standard (cc/1,000 st)**		**Manufacturer standard (cc/1,000 st)**	
				Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
• **Rack positions** B to E are the refernce volume when adjusting the injection volume. • **Marks** ★ are average volumes.	A(Basic point)	9.5	1,200	★ 71 – 73	± 2.5	★ 64.5	
	B	9.9	500	★ 54.5 – 58.5	—	★ 79	
	C	9.7	800	★ 59.5 – 63.5	—	★ 70.5	
	D	Approx. 8.2	385	★ 8.5 – 10.5	± 15	★ 15	
	E	—	100	70 – 80	—	★ 85	

Governor perfomance curve



TWE01282

Injection Pump Assembly Number
6736-71-1140 (101609-3321)

( ): Injection Pump Manufacture's part No.

Injection Pump Type	Injection Pump Manufactuer
PES-A	ZEXEL

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
PC220 • 220LC-6 EXCEL PC220-6 CUSTOM		SA6D102E-1	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 5 – 3 – 6 – 2 – 4
Injection interval	59° 30' – 60° 30'
Plunger prestroke (mm)	2.45 – 2.55
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

Flywheel horsepower (kw{HP}/rpm)	122.8{165}/2,100 (Gross)
Maximum torque (Nm{kgm}/rpm)	606{61.8}/1,400 (Gross)
High idling speed (rpm)	2,240 – 2,360
Low idling speed (rpm)	975 – 1,025
Pump tester capacity for Service standard	Motor: 7.5 kW

Calibration Standard ( ) : Injenction pump manufacture's part number

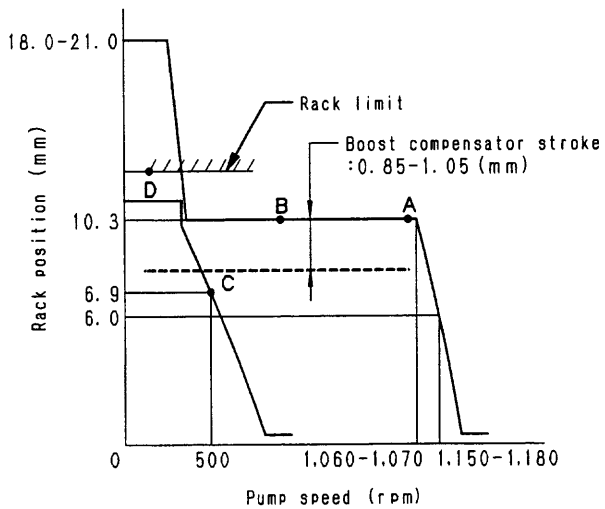
Conditions		**Service standard**	**Manufacturer standard**
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	6732 – 11 – 3120
	Nozzle part No.	(105780 – 0000)	
	Nozzle holder part No.	(105780 – 2080)	
	Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 950
	Test oil	ASTM D975 No.2 diesel fuel or equivalent	
	Oil temperature (°C)	40 – 50	
	Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	21.6 {220}
	Transfer pump pressure (kPa{kg/cm^2})	157 {1.6}	157 {1.6}

Injection volume

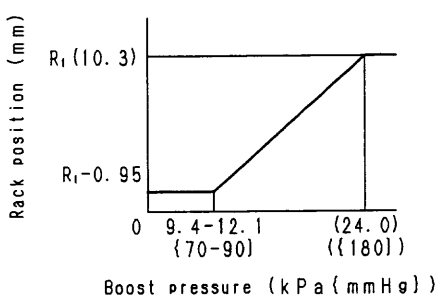
• **Rack positions** B to E are the refernce volume when adjusting the injection volume.
• **Marks ★** are average volumes.

Rack point	Rack position (mm)	Pump speed (rpm)	**Service standard (cc/1,000 st)**		**Manufacturer standard (cc/1,000 st)**	
			Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
A(Basic point)	10.3	1,050			★ 98 – 100	± 2.5
B	10.3	700			★ 107 – 111	—
C	6.9	500			★ 23 – 25	± 15
D	—	100			★ 85 – 95	—

Governor perfomance curve



Boost compensator performance curve



TWE00910

Injection Pump Assembly Number
6737-71-1120 (101405-3261)

( ): Injection Pump Manufacture's part No.

Injection Pump Type	Injection Pump Manufactuer
PES-A	BOSCH automotive system

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
D31EX-21 D31PX-21		SAA4D102E-2	

Injection Pump Specification

Rotating direction	Clockwise
Injection order	1 – 3 – 4 – 2
Injection interval	89° 30' – 90° 30'
Plunger prestroke (mm)	2.45 – 2.55
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

Flywheel horsepower (kw{HP)/rpm}	59.6{79.9}/2,000 (Gross)
Maximum torque (Nm{kgm)/rpm}	394.7{40.3}/1,300 (Gross)
High idling speed (rpm)	2,200 ± 50
Low idling speed (rpm)	800^{+50}_{0}
Pump tester capacity for Service standard	Motor: 7.5 kW

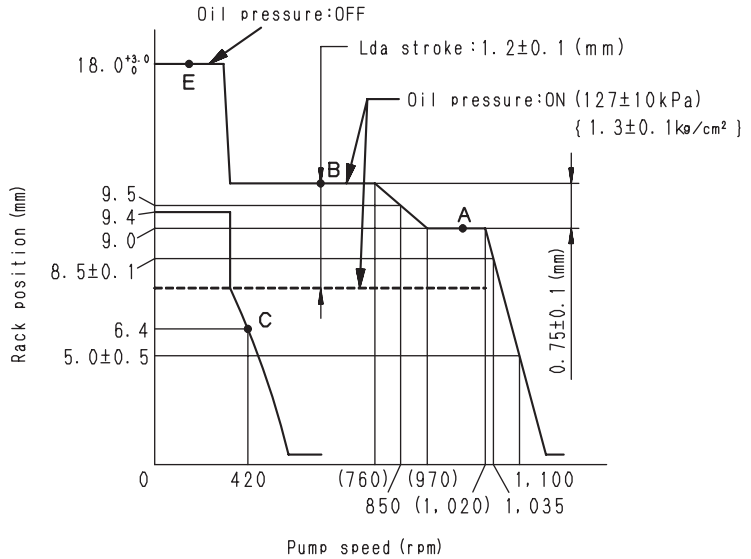
Calibration Standard

( ) : Injenction pump manufacture's part number

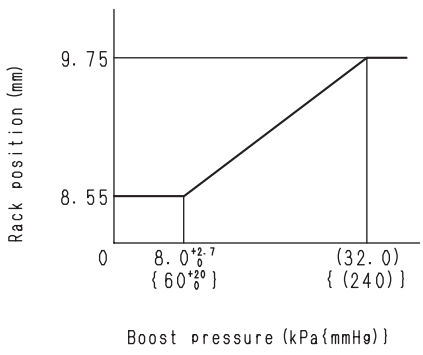
Conditions		**Service standard**	**Manufacturer standard**
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	(105158 – 5012)
	Nozzle part No.	(105780 – 0000)	(105017 – 2910)
	Nozzle holder part No.	(105780 – 2080)	(105088 – 2002)
	Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 600
	Test oil	ASTM D975 No.2 diesel fuel or equivalent	
	Oil temperature (°C)	40 – 50	
	Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	22.0 {224.3}
	Transfer pump pressure (kPa{kg/cm^2})	255 {2.6}	255 {2.6}

Injection volume	Rack point	Rack position (mm)	Pump speed (rpm)	**Service standard (cc/1,000 st)**		**Manufacturer standard (cc/1,000 st)**	
				Injection volume	Maximum variance between cylinder	Injection volume	Maximum variance between cylinder
• **Rack positions** B to E are the refernce volume when adjusting the injection volume. • **Marks** ★ are average volumes.	A(Basic point)	9.0	1,000	★ 79 ± 1	± 2.5	★ 81.5	± 2.5
	B	9.75	650	★ 92.5 ± 2	—	★ 106	—
	C	Apporox 6.4	420	★ 10 ± 1	± 15	★ 10	± 15
	E	18.0^{+3}_{0}	100	★ 70 ± 5	—	★ 92	—

Governor perfomance curve



Boost compensator performance curve



TJE01424

Fuel Injection Pump Assembly Number
6738-71-1620 (101609-3830)

( ): Fuel Injection Pump Manufacture's part No.

Fuel Injection Pump Type	Fuel Injection Pump Manufactuer
PES-A	BOSCH automotive system

Applicable Machine		Applicable Engine	
Model	Serial No.	Model	Serial No.
DCA-150ESK (DENYO generator)		SAA6D102E-2	

Fuel Injection Pump Specification

Rotating direction	Clockwise
Fuel Injection order	1 – 5 – 3 – 6 – 2 – 4
Fuel Injection interval	60° ± 30'
Plunger prestroke (mm)	2.6 ± 0.05
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

Flywheel horsepower (kw{HP)/rpm}	101.4{136.0}/1,500(50Hz)(Gross) 120.8{162.0}/1,800(60Hz)(Gross)
High idling speed (rpm)	Max. 1,580 (50Hz) Max. 1,890 (60Hz)
Low idling speed (rpm)	800 ± 50
Pump tester capacity for Service standard	Motor: 7.5 kW

Calibration Standard

( ) : Fuel Injenction pump manufacture's part number

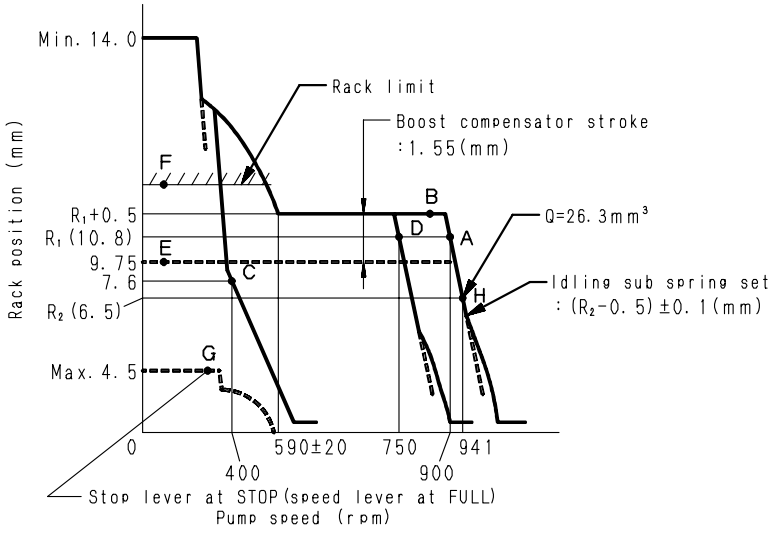
Conditions
- **Service standard** indicates data using calibration test parts.
- **Manufacture standard** is data for factory test parts.

	Service standard	Manufacturer standard
Nozzle & Nozzle holder part No.	(105780 – 8140)	(105158 – 5002)
Nozzle part No.	(105780 – 0000)	(105017 – 2910)
Nozzle holder part No.	(105780 – 2080)	(105088 – 2002)
Injection pipe (Outside dia.x Inside dia.x Length) (mm)	6 × 2 × 600	6 × 1.8 × 750
Test oil	ASTM D975 No.2 diesel fuel or equivalent	
Oil temperature (°C)	40 – 50	
Nozzle opening pressure (MPa{kg/cm^2})	17.2 {175}	24.5 {250}
Transfer pump pressure (kPa{kg/cm^2})	255 {2.6}	255 {2.6}

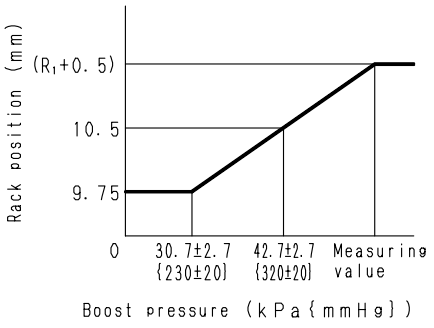
Injection volume
- **Rack positions** B to E are the refernce volume when adjusting the injection volume.
- **Marks** ★ are average volumes.

Rack point	Rack position (mm)	Pump speed (rpm)	Service standard (cc/1,000 st)		Manufacturer standard (cc/1,000 st)	
			Fuel Injection volume	Maximum variance between cylinder	Fuel Injection volume	Maximum variance between cylinder
A(Basic point)	10.8	900			★ 124 ± 1	± 2.5
B	11.3	900			—	—
C	Approx. 7.6	400			★ 10 ± 1	± 15
D	10.8	750			—	—
E	9.75	100			★ 55 ± 5	—
F	13.2	100			★ 145 ± 5	—
G	—	—			—	—

Governor perfomance curve



Boost compensator performance curve



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★ For fuel, use ASTM D975 No. 1 or No. 2.
★ For lubricant, use SAE15W-40 or SAE30 oil.

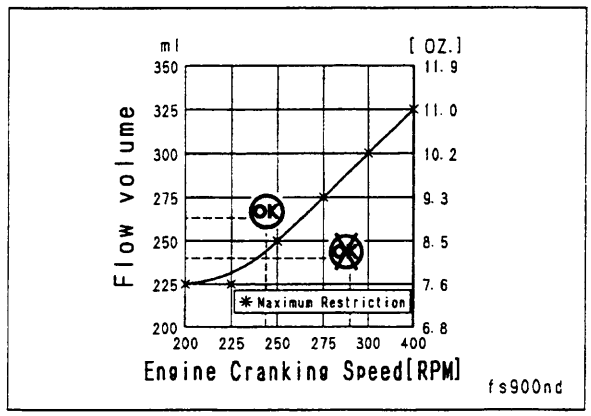
Flywheel hosepower (kW{HP})	Torque (Nm{kgm})	Fuel consumption (sec/100cc)	Cooling water temperature (°C)	Lubricating oil temperature (°C)	Lubricating oil pressure (kPa{kg/cm²})	Exhaust temperature (°C)
54.3–57.5 (Gross) {73.8–78.2}(Gross)	—	Min. 20.9	75 – 95	90 – 110	390 – 590 {3.5 – 6.0}	Max. 550
—	287–305 (Gross) {29.3–31.1}(Gross)	—	75 – 95	90 – 110	—	Max. 600
—	—	—	75 – 95	90 – 110	—	—
—	—	—	75 – 95	80 – 110	Min.147 {Min.1.5}	—
57.1–60.6 (Gross) {76.5–81.2}(Gross)	—	Min. 19.6	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 550
—	287–305 (Gross) {29.3–31.1}(Gross)	—	75 – 95	90 – 110	—	Max. 600
—	—	—	75 – 95	90 – 110	—	—
—	—	—	75 – 95	80 – 110	Min.147 {Min.1.5}	—
65.1–68.9 (Gross) {87.3–92.4}(Gross)	—		75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 600
—	333–373 (Gross) {34.0–38.0}(Gross)	—	75 – 95	90 – 110	—	Max. 650
—	—	—	75 – 95	90 – 110	—	—
—	—	—	75 – 95	80 – 110	Min.147 {Min.1.5}	—
65.1–68.9 (Gross) {87.3–92.4}(Gross)	—		75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 600
—	333–373 (Gross) {34.0–38.0}(Gross)	—	75 – 95	90 – 110	—	Max. 650
—	—	—	75 – 95	90 – 110	—	—
—	—	—	75 – 95	80 – 110	Min.147 {Min.1.5}	—
74.5–81.9 (Gross) {100.0–109.8}(Gross)	—		75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	376–415 (Gross) {38.3–42.3}(Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110	Min.147 {Min.1.5}	—
65.0–68.8 (Gross) {87.2–92.3}(Gross)	—		75 – 95	90 – 110	390 – 590 {3.5 – 6.0}	Max. 600
—	338–358 (Gross) {34.5–36.5}(Gross)	—	75 – 95	90 – 110	—	Max. 650
—	—	—	75 – 95	90 – 110	—	—
—	—	—	75 – 95	80 – 110	Min.118 {Min.1.2}	—

★ For fuel, use ASTM D975 No. 1 or No. 2.
★ For lubricant, use SAE15W-40 or SAE30 oil.

Flywheel hosepower (kW{HP})	Torque (Nm{kgm})	Fuel consumption (sec/100cc)	Cooling water temperature (°C)	Lubricating oil temperature (°C)	Lubricating oil pressure (kPa{kg/cm²})	Exhaust temperature (°C)
57.8–61.3 (Gross) {77.5–82.2}(Gross)	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	380–404 (Gross) {38.8–41.2}(Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110	Min.147{1.5}	—
65.6–69.7 (Gross) {87.9–93.4}(Gross)	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	392–431 (Gross) {40–44} (Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110	Min.147{1.5}	—
72.0–76.3 (Gross) {91.5–102.2}(Gross)	—	Min. 16.7	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	419–464 (Gross) {42.7–47.3}(Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110	Min.147{1.5}	—
81.4–90.0 (Gross) {109.1–120.6}(Gross)	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	413–459 (Gross) {42.2–46.8}(Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110		—
70.5–77.9 (Gross) {94.5–104.4}(Gross)	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	388–428 (Gross) {39.5–43.7}(Gross)	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	Max. 650
—	—	—	75 – 95	90 – 110	340 – 590 {3.5 – 6.0}	—
—	—	—	75 – 95	80 – 110	Min.147{1.5}	—

Look at the chart and find the correct flow specifications of the part number 3918000 fuel feed pump used on the 300 HP 102 engine.

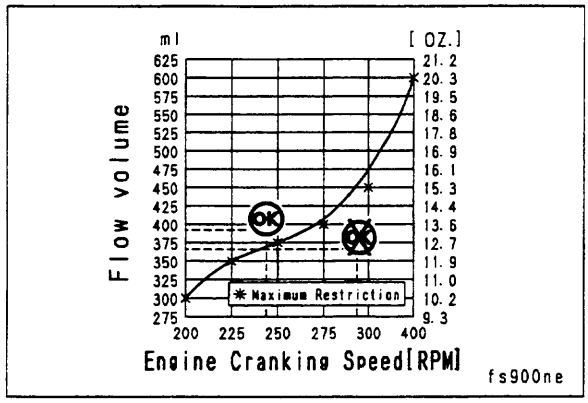
- Draw a vertical line up from the measurement for the speed.
- Draw a horizontal line from the measurement for the flow to the point where it intersects the vertical line for the engine speed.
- If the intersection is above the necessary flow line, it indicates that the flow is permissible.
- If the intersection is below the necessary flow line, it indicates that the flow is not permissible.
  This shows that the actuation of the pump is defective or that the line resistance is too high.



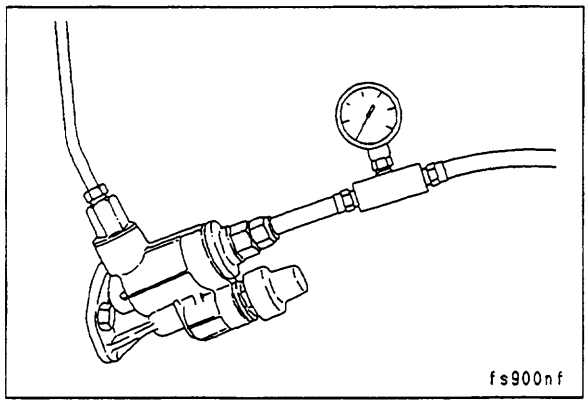
Example 1	Engine speed:	240 rpm
Passing pump	Flow:	260 mℓ
Example 2	Engine speed:	280 rpm
Failing pump	Flow:	235 mℓ

Look at the chart and find the correct flow specifications of the part number 3917334 fuel feed pump used on the Bosch P7100 in-line fuel injection pump.

- Draw a vertical line up from the measurement for the speed.
- Draw a horizontal line from the measurement for the flow to the point where it intersects the vertical line for the engine speed.
- If the intersection is above the necessary flow line, it indicates that the flow is permissible.
- If the intersection is below the necessary flow line, it indicates that the flow is not permissible.
  This shows that the actuation of the pump is defective or that the line resistance is too high.

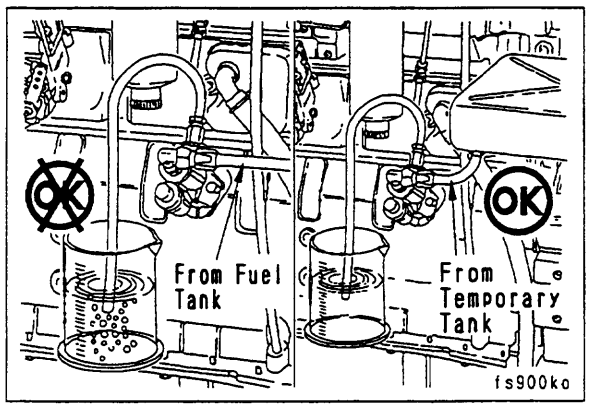


Example 1	Engine speed:	240 rpm
Passing pump	Flow:	390 mℓ
Example 2	Engine speed:	290 rpm
Failing pump	Flow:	360 mℓ



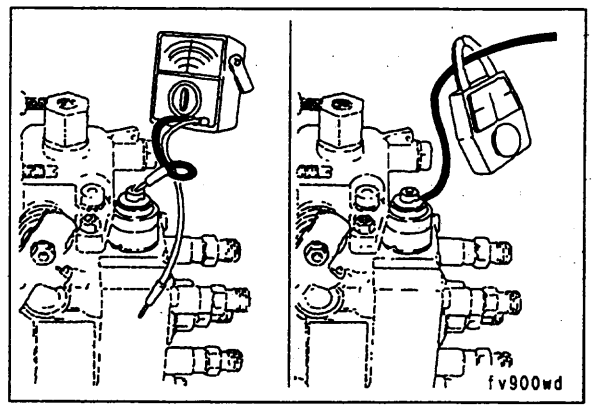
If the measured flow is below the line in the above charts, check the resistance at the inlet port before disassembly and cleaning the fuel feed pump.
The resistance at the inlet port must not exceed 100 mmHg.

If air enters the fuel or the amount of fuel is reduced, connect the inlet port of the fuel feed pump to a temporary supply line and isolate the fuel feed pump, then carry out the same checks as described above.



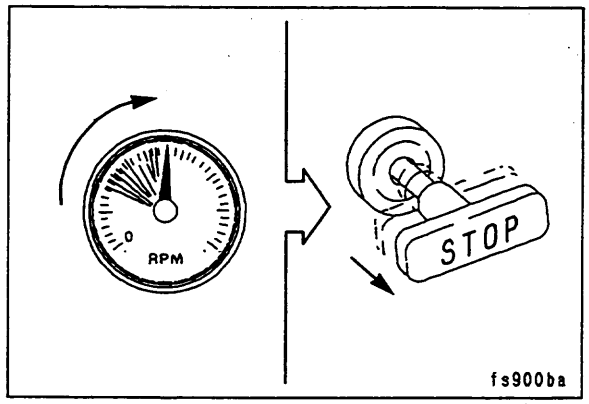
When the Robert Bosch valve is actuated, no sound can be heard, but the following values are obtained when checking with an ohmmeter.

Robert Bosch shut-off value	Resistance in ohms	Peak current
12	7.4+0.5	2
24	29.5+2.5	1



Caution: Do not connect the electric wire to the solenoid when the plunger is removed. If there is no plunger, the valve may be damaged.

When there is defective actuation of the valve or defective wiring of the valve, it is possible to carry out troubleshooting by removing the plunger and spring and installing the solenoid again.



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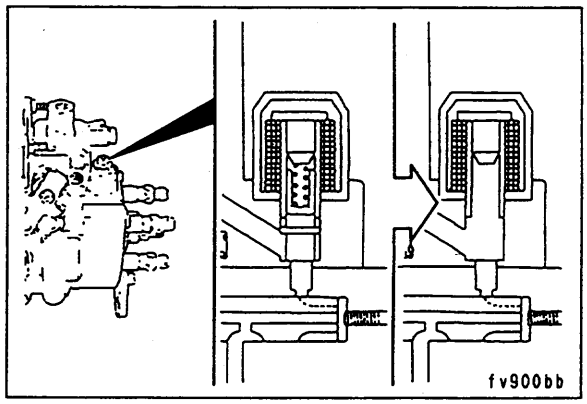
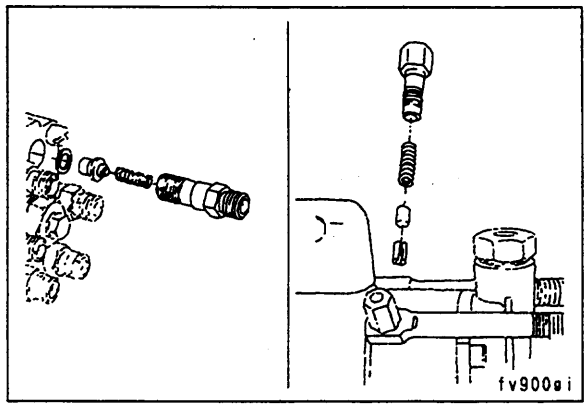
Caution: Stop the engine with the mechanical type shut-off lever.

If the engine is started without the valve, there will be defective actuation of the valve or wiring.
Use this method where the plunger is removed and the engine is started when the facilities must be moved to the place of maintenance.

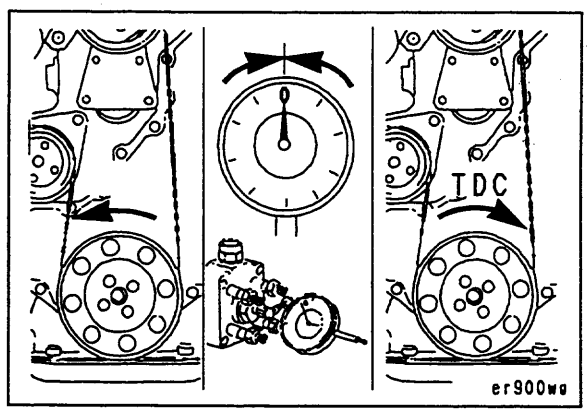


DELIVERY VALVE (LUCAS CAV)

A delivery tube is installed to the valve. The purpose of the valve is to control the residual pressure in the high-pressure line. If the valve actuation is defective, the residual value will become unequal, and the engine rotation will not be smooth or there will be surging.



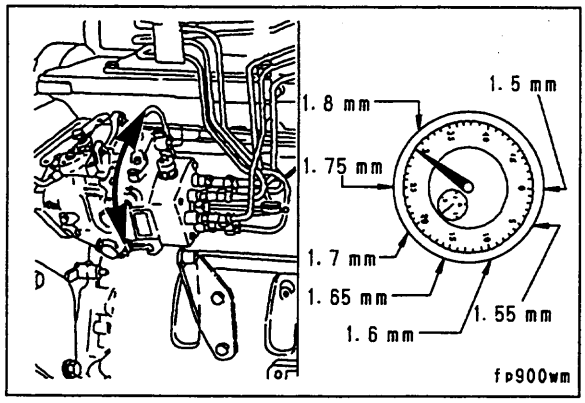
Until the movement of the indicator needle stops, block the crankshaft in the opposite direction to the engine rotation. Set the scale on the indicator to 0.
Return the crankshaft to TDC and count the number of rotations of the indicator needle. The reading at the point where the engine timing pin is meshed is the amount of plunger lift of the pump at that point.



13 mm

Rotate the pump with the mounting stud until the indicator gives the correct value for the plunger lift. The diagram shows examples of the indicator readings for various values of the plunger lift.
Tighten the plunger mounting nut.

kgm: 24 Nm{2.4 kgm}



673501

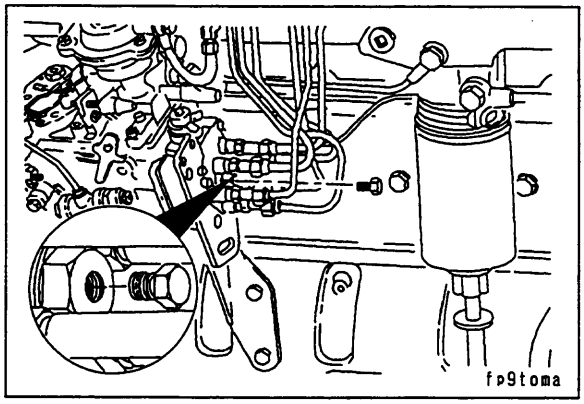
12 mm

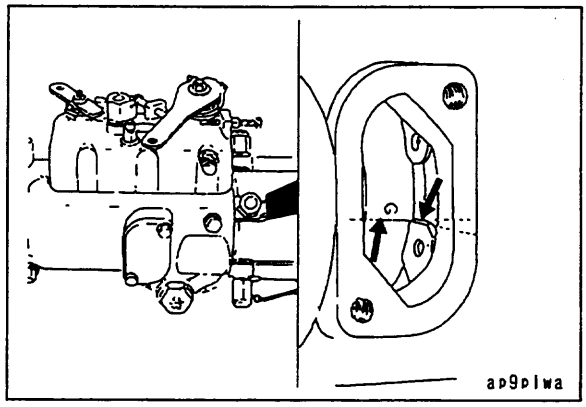
Rotate the timing indicator. Install the plug.
kgm: 10 Nm{0.1 kgm}

ADJUSTING FUEL INJECTION TIMING FOR LUCAS CAV

It is possible to check if the Lucas CAV DPA fuel injection pump timing is correct by removing the inspection plate.
Caution: Special facilities at an authorized repair shop are necessary for determining accurately the timing of the Lucas CAV DPA fuel injection pump. However, when carrying out troubleshooting or in emergencies, it is enough to rotate the engine and carry out visual checks of the timing mark alignment.

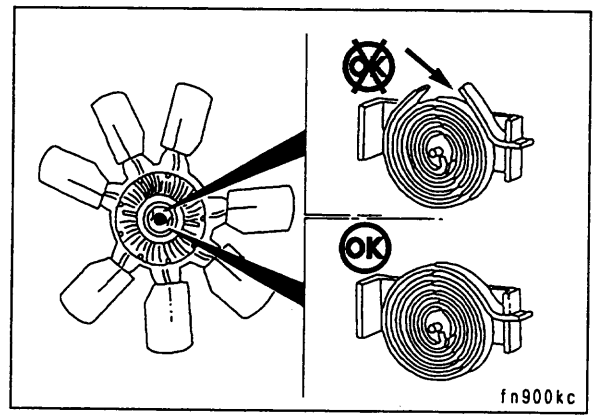
Explanation of both these checks is given in relation to replacement of the fuel injection pump. For details of installing the timing pin housing, the explanation is given in the section on basic engine components.





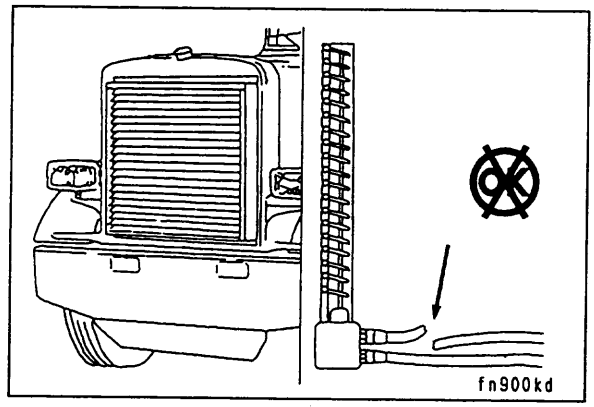
In some cases, a heat-sensitive fan may also be used. These types of fan are actuated only when it is necessary to maintain the cooling water at a fixed temperature. If the fan does not rotate even when the temperature of the cooling water rises, the engine will overheat. If the fan does not stop when the water temperature goes down, the engine will operate at low temperature.

Caution: Check that the temperature sensor is working properly.

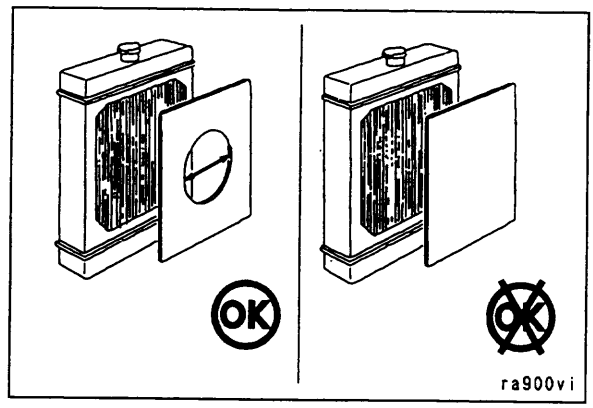


The shutter is designed to regulate the amount of air passing through the radiator.
If the shutter is not opened when necessary, the engine will overheat; if it is not closed when necessary, the flow of air will be excessive and the engine will overcool.

Caution: Check that the temperature sensor is working properly. Check the control of the air pressure actuated shutter. Check for leakage of air.

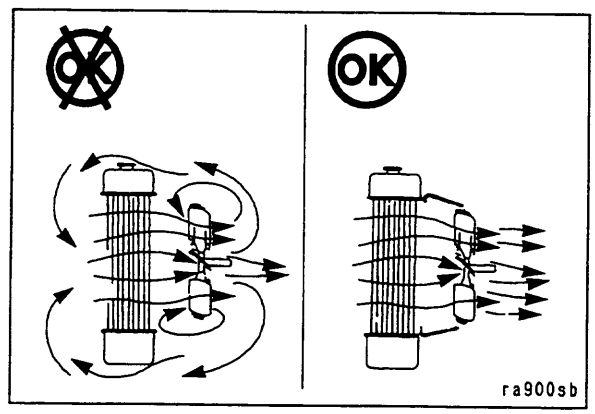


A winter front can be used on charge air-cooled engines, but the design must cover only one part of the front of the cooling system. With the front of the air-cooled system, an opening of at least 120 square inches must be made to allow the air to pass.



If the fan shroud is not suitable or is damaged, the flow of air will be reduced and the engine will overheat.

Caution: Check that the air is not circulating repeatedly. Check that the baffle is not missing.



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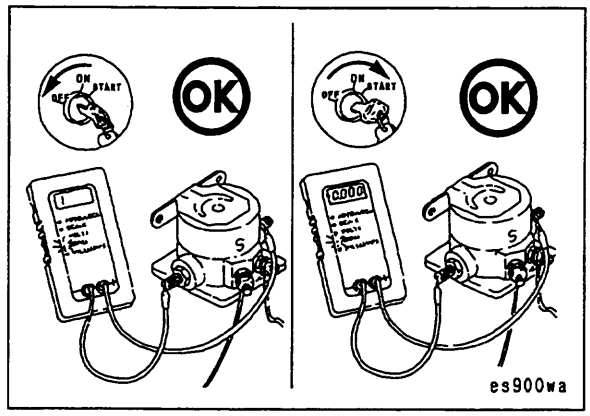
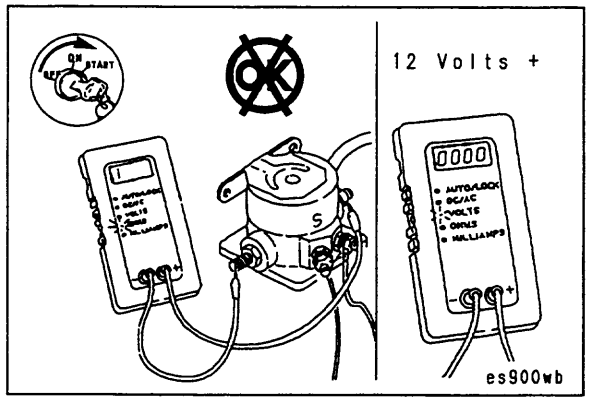
Set the multimeter in position and measure the resistance (ohms).
When the starting switch is turned OFF, the resistance of the multimeter should become infinity.
Turn the starting switch to the START position.
The multimeter reading should show 0 or an extremely small resistance.



When the starting switch is turned to the START position, if the multimeter resistance becomes infinity, do as follows.

- Turn the starting switch OFF.
- Set the scale on the multimeter to DC voltage.



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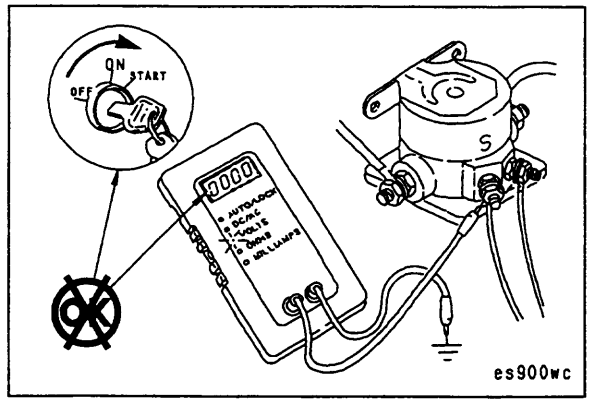
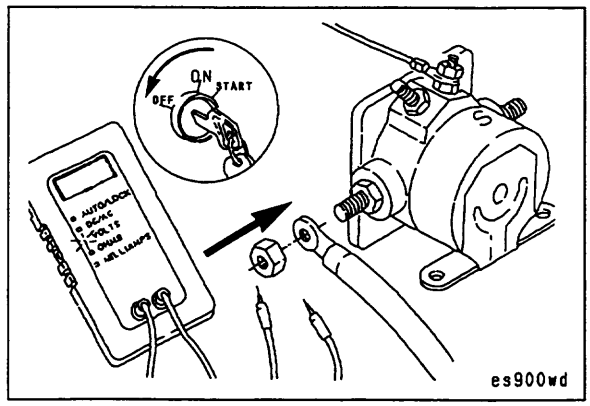
- Connect one of the leads of the multimeter to the terminal of the magnetic switch marked with S, and connect the other lead to the ground.
- Turn the starting switch to the START position.
- If the multimeter does not display any voltage, there is no problem in the magnetic switch. For details of this procedure, see "Checking starting switch".



- Turn the starting switch to the OFF position.
- Remove the lead from the multimeter, then connect the magnetic switch to the starting motor solenoid.



TESTING WHITE SMOKE

White smoke shows that there is incomplete combustion of the fuel when the engine is running at normal temperature.

The intake manifold heater system is not directly connected to the fuel system, but it observes the temperature of the air for the engine. The thermistor sends various resistance values to the electrical control module (ECM) or the equivalent. The ECM controls the "wait-to-start" lamp and heater solenoid.

The intake manifold heater element is actuated by both the preheating mode and postheating mode.

- In the preheating mode, the starting switch is turned to the ON position but the engine does not start.
- In the postheating mode, the engine is running.

If the actuation and starting procedure for the intake manifold heater system is correct, there will be no excessive of the starting motor and there will be a little white smoke in the exhaust gas when the engine is first started.

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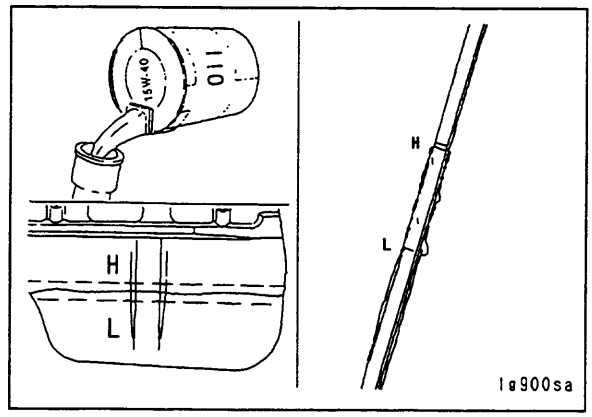
NORMAL ACTUATION OF INTAKE HEATER SYSTEM

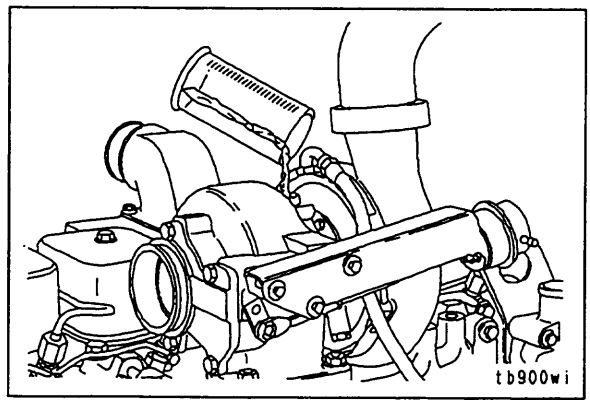
Engine intake manifold temperature	Preheating cycle time when starting key is turned ON before the crank cycle	Post heater cycle generated when starting key is turned ON after crank cycle
Above 15°C	0 sec	No
-9–15°C	*10 sec	Yes
-18–9°C	15 sec	Yes
-26–18°C	17 sec	Yes
Below -26°C	20 sec	Yes

* On the heater control module/electronic control module with serial number 008000A and below, there is no preheating cycle in this cycle.

If it is impossible to use an external pressure pump, prime the lubricating oil system as follows.
Add oil to the engine to the high level mark on the dipstick.



Remove the oil supply tube from the turbocharger.
Pour 50 - 60 cc of clean 15W-40 oil through the turbocharger oil filler port.
Connect the oil supply tube to the turbocharger.



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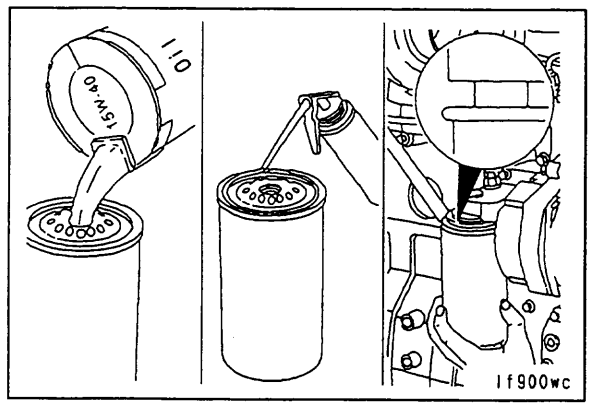
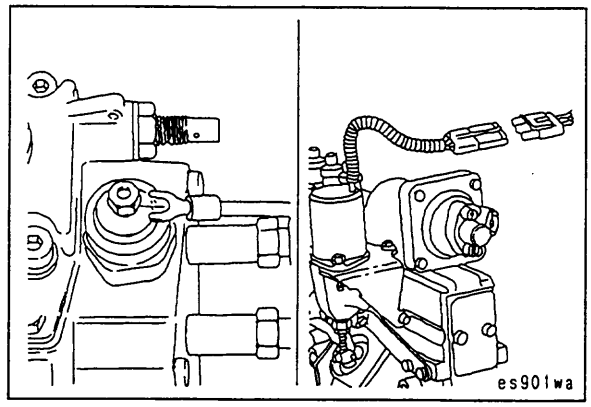
Caution: If it is tightened too much, the thread will be distorted and this will damage the seal of the filter element.

Add clean 15W-40 oil to the oil filter.
Screw the filter into the filter head fitting until the gasket contacts the filter head surface.
Tighten the filter according to the instructions.

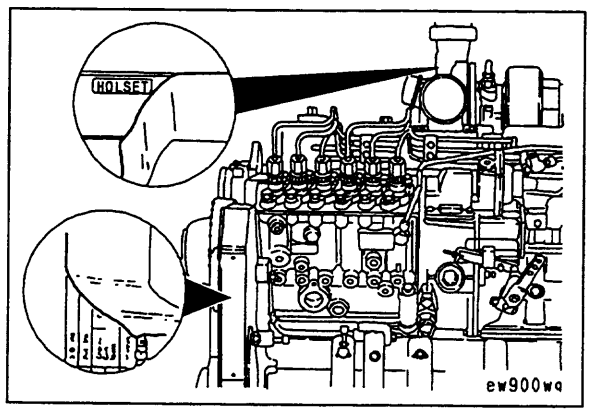


When checking that the oil pump supplies enough oil to the engine, first remove the wire from the fuel injection pump solenoid.

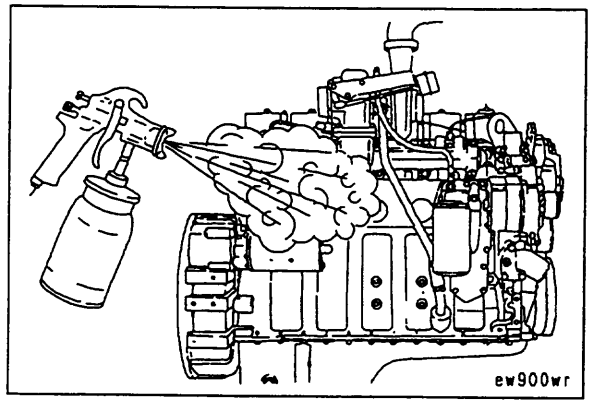


Be careful not to let paint get on the following components.

- Date plate
- Valve and injector match marks
- Exhaust manifold
- Turbocharger turbine housing
- Flywheel
- Flywheel housing transmission mounting surface



Paint the engine.



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Engine model				S6D102E-1			
Applicable machine model				PC200LC-2 EXCEL PC200-6Z CUSTOM		PC228USLC-1	
Category	item	Measurement conditions	Unit	Standard value	Permissible value	Standard value	Permissible value
Performance	Engine speed	High idling speed	rpm	2,140 – 2,260	2,140 – 2,260	2,140 – 2,260	2,140 – 2,260
		Low idling speed	rpm	975 – 1,025	975 – 1,025	1,000 – 1,050	1,000 – 1,050
	Nessary stating speed	0°C (without starting aid)	rpm	Max. 300	Max. 300	Min. 170	Min. 170
		-20° (with starting aid)	rpm	Max. 120	Max. 120	Min. 120	Min. 120
Intake, exhaust system	Intake resistance	At all speed	kPa {mmH2O}	Max. 2.94 {Max. 300}	7.47 {762}	Max. 2.94 {Max. 300}	7.47 {762}
	Boost pressure	At rated flywheel horsepower	kPa {mmHg}	Min. 124 {Min. 930}	117 {880}	—	—
	Exhaust pressure (turbine inlet pressure)	At rated flywheel horsepower	kPa {mmHg}	Min. 93 {Min. 700}	86 {650}	—	—
	Exhaust temperature (turbine inlet temp.)	All speed (20°C)	°C	Max. 650	*700	Max. 650	700
	Exhaust gas color	Quick acceleration (low idle → high idle)	Bosch index	Max. 5.0	7.0	Max. 5.5	7.5
		At rated flywheel horsepower		Max. 2.0	3.0	Max. 2.0	3.0
		High idling speed		Max. 1.0	2.0	Max. 1.0	2.0
	Valve clearance (When engine is hot or cold)	Intake valve	mm	0.25	—	0.25	—
		Exhaust valve	mm	0.51	—	0.51	—
Engine proper	Compression pressure (SAE30 or SAE15W-40)	Oil temperature: 40 – 60°C (engine speed)	MPa {kg/cm²} (rpm)	Min. 2.41 {Min. 24.6}	1.69 {17.2}	Min. 2.41 {Min. 24.6}	1.69 {17.2}
	Blow-by pressure (SAE30 or SAE15W-40)	At rated flywheel horsepower (water temp. : Min. 70°C)	kPa {mmH2O}	Max. 0.49 {Max. 50}	0.98 {100}	Max. 0.49 {Max. 50}	0.98 {100}
Lubrication system	Oil pressure (oil temperature : Min. 80°C)	At rated flywheel horsepower SAE 30 or SAE15 W–40 oil	kPa {kg/cm²}	340 – 590 {3.5 – 6.0}	245 {2.5}	340 – 590 {3.5 – 6.0}	245 {2.5}
		SAE10W oil	kPa {kg/cm²}	290 – 540 {3.0 – 5.5}	206 {2.1}	290 – 540 {3.0 – 5.5}	206 {2.1}
		At low idling SAE 30 or SAE15 W–40 oil	kPa {kg/cm²}	Min. 147 {Min. 1.5}	78 {0.80}	Min. 147 {Min. 1.5}	78 {0.80}
		SAE 10W oil	kPa {kg/cm²}	Min. 98 {Min. 1.0}	69 {0.70}	Min. 98 {Min. 1.0}	69 {0.70}
	Oil temperature	All speed (Oil in oil pan)	°C	90 – 110	120	90 – 110	120
	Oil consumption ratio	At continuous rated horsepower (Ratio for fuel consumption)	%	Max. 0.5	1.0	Max. 0.5	1.0
Fuel system	Fuel injection pressure	Nozzle tester	MPa {kg/cm²}	21.6 – 22.4 {220 – 228}	18.0 {184}	21.6 – 22.4 {220 – 228}	18.0 {184}
	Fuel injection timing	B. T. D. C	degree	16 – 18	16 – 18	16 – 18	16 – 18
Cooling system	Radiator pressure valve	Opening pressure (Differential pressure)	kPa {kg/cm²}	—	—	—	—
	Fan speed	At rated engine speed	rpm	1,750 – 1,850	1,750 – 1,850	1,690 – 1,790	1,690 – 1,790
	Fan belt tension	Deflection when pushed with a force of 60N {6 kg}	mm	9.5 – 12.7	11 – 15	9.5 – 12.7	11 – 15

Engine model				SAA6D102E-2			
Applicable machine model				WA200-5, WA200PT-5		WA250-5, WA250PT-5	
Category	item	Measurement conditions	Unit	Standard value	Permissible value	Standard value	Permissible vaalue
Performance	Engine speed	High idling speed	rpm	2,250 ± 50	2,250 ± 50	2,250 ± 50	2,250 ± 50
		Low idling speed	rpm	825 ± 50	825 ± 50	825 ± 50	825 ± 50
	Nessary stating speed	0°C (without starting aid)	rpm	Min. 170	Min. 170	Min. 170	Min. 170
		-20° (with starting aid)	rpm	Min. 120	Min. 120	Min. 120	Min. 120
Intake, exhaust system	Intake resistance	At all speed	kPa {mmH2O}	Max. 3.72 {Max. 380}	7.47 {762}	Max. 3.72 {Max. 380}	7.47 {762}
	Boost pressure	At rated flywheel horsepower	kPa {mmHg}	Min. 93 {Min. 700}	80 {600}	Min. 120 {Min. 900}	106 {800}
	Exhaust pressure (turbine inlet pressure)	At rated flywheel horsepower	kPa {mmHg}	Min. 93 {Min. 700}	80 {600}	Min. 120 {Min. 900}	106 {800}
	Exhaust temperature (turbine inlet temp.)	All speed (20°C)	°C	Max. 650	700	Max. 650	700
	Exhaust gas color	Quick acceleration (low idle → high idle)	Bosch index	Max. 5.5	7.5	Max. 5.5	7.5
		At rated flywheel horsepower		Max. 2.0	3.0	Max. 1.5	3.0
		High idling speed		Max. 0.5	1.5	Max. 0.5	1.5
	Valve clearance (When engine is hot or cold)	Intake valve	mm	0.25	—	0.25	—
		Exhaust valve	mm	0.51	—	0.51	—
Engine proper	Compression pressure (SAE30 or SAE15W-40)	Oil temperature: 40 – 60°C (engine speed)	MPa {kg/cm²} (rpm)	Min. 2.41 {Min. 24.6}	1.69 {17.2}	Min. 2.41 {Min. 24.6}	1.69 {17.2}
	Blow-by pressure (SAE30 or SAE15W-40)	At rated flywheel horsepower (water temp. : Min. 70°C)	kPa {mmH2O}	Max. 0.49 {Max. 50}	0.98 {100}	Max. 0.49 {Max. 50}	0.98 {100}
Lubrication system	Oil pressure (oil temperature : Min. 80°C)	At rated flywheel horsepower SAE 30 or SAE15 W–40 oil	kPa {kg/cm²}	340 – 590 {3.5 – 6.0}	245 {2.5}	340 – 590 {3.5 – 6.0}	245 {2.5}
		SAE10W oil	kPa {kg/cm²}	290 – 540 {3.0 – 5.5}	210 {2.1}	290 – 540 {3.0 – 5.5}	210 {2.1}
		At low idling SAE 30 or SAE15 W–40 oil	kPa {kg/cm²}	Min. 150 {Min. 1.5}	80 {0.80}	Min. 150 {Min. 1.5}	80 {0.80}
		SAE 10W oil	kPa {kg`/cm²}	Min. 100 {Min. 1.0}	70 {0.70}	Min. 70 {Min. 0.70}	70 {0.70}
	Oil temperature	All speed (Oil in oil pan)	°C	90 – 110	120	90 – 110	120
	Oil consumption ratio	At continuous rated horsepower (Ratio for fuel consumption)	%	Max. 0.2	0.6	Max. 0.2	0.6
Fuel system	Fuel injection pressure	Nozzle tester	MPa {kg/cm²}	$22\ ^{+1.4}_{0}$ {$224\ ^{+15}_{0}$}	18.0 {184}	$22\ ^{+1.4}_{0}$ {$224\ ^{+15}_{0}$}	18.0 {184}
	Fuel injection timing	B. T. D. C	degree	11 ± 1	—	10 ± 1	—
Cooling system	Radiator pressure valve	Opening pressure (Differential pressure)	kPa {kg/cm²}	—	—	—	—
	Fan speed	At rated engine speed	rpm	—	—	—	—
	Fan belt tension	Deflection when pushed with a force of 60N {6 kg}	mm	(Auto-tension)	—	(Auto-tension)	—

S-2 Engine does not start

(1) Engine does not turn

General causes why engine does not turn

- Internal parts of engine seized

  ★ If internal parts of the engine are seized, carry out troubleshooting for "Engine stops during operations".

- Defective electrical system
- Failure in power train

			Causes: Defective wiring of starting circuit	Defective or deteriorated battery	Defective starting motor	Broken ring gear	Defective safety relay or safety switch	Defective battery relay	Defective battery terminal connection	Defective fuel cut solenoid	Defective starting switch
Questions / Check items	Confirm recent repair history										
	Degree of use of machine	Operated for long period		△		△					
	Condition of horn when starting switch is turned ON	Horn sounds	◎						○		○
		Horn volume is low		◎							
	When starting switch is turned to START, pinion moves out, but	Speed of rotation is low		◎							
		Makes grating noise			◎	◎					
		Soon disengages pinion again					◎				
		Makes rattling noise and does not turn		○	○		○				
	When starting switch is turned to START, pinion does not move out		◎	○							○
	When starting switch is turned to ON, there is no clicking sound			○				◎			
	Battery terminal is loose								◎		
	When starting switch is turned ON, linkage is not actuated									◎	
	When battery is checked, battery electrolyte is found to be low			◎							
Troubleshooting	Specific gravity of electrolyte, voltage of battery is low			●							
	For the following conditions 1) - 5), turn the starting switch OFF, connect the cord, and carry out troubleshooting										
		1) When terminal B and terminal C of starting switch are connected, engine starts									●
		2) When terminal B and terminal C of starting motor are connected, engine starts			●						
		3) When terminal B and terminal C of safety relay are connected, engine starts					●				
		4) When terminal of safety switch and terminal B of starting motor are connected, engine starts					●				
		5) There is no 24V between battery relay terminal b and terminal E						●			
	When ring gear is inspected directly, tooth surface is found to be chipped				●						
	Cannot be moved by hand even when linkage of fuel cut solenoid is disconnected									●	
		Remedy	—	Replace	Replace	Replace	Replace	Replace	Replace	Replace	Replace

Troubleshooting of defective wiring in starting circuit

S-10 Fuel consumption is excessive

General causes why fuel consumption is excessive

- Leakage of fuel
- Improper condition of fuel injection
- Excessive injection of fuel

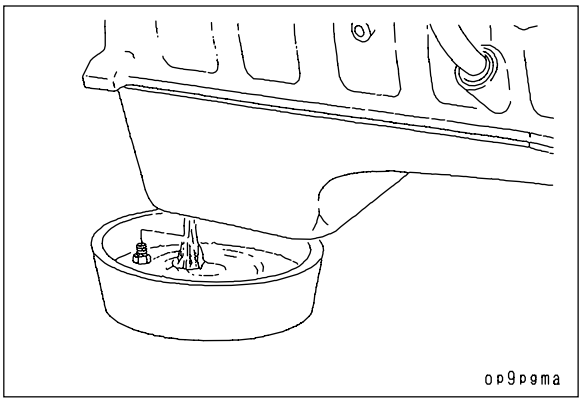
			Causes: Defective injection pump (excessive injection)	Defective nozzle holder spray	Defective injection pump plunger	Defective fuel injection timing	External leakage from fuel piping, fuel filter	Leakage of fuel inside head cover	Defective oil seal inside feed pump (piston)	Defective adjustment of fuel control linkage
Questions	Confirm recent repair history									
	Degree of use of machine	Operated for long period		△	△				△	
	Condition of fuel consumption	More than for other machines of same model	◎			○				
		Gradually increased		○	○					
		Suddenly increased					○	○		
Check items	Exhaust smoke color	Black	◎	○		○				○
		White						○		
	Seal on injection pump has come off		◎							
	There is irregular combustion			◎						
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low			◎	○					
	Match mark on injection pump is misaligned					◎				
	There is external leakage of fuel from engine						◎			
	Engine oil level rises and smells of diesel fuel		○					◎	◎	
	Engine low idling and high idling speeds are high		○							◎
Troubleshooting	Injection pump measurement shows that injection amount is excessive		●							
	Speed does not change when operation of certain cylinders is stopped			●						
	When control rack is pushed, it is found to be heavy, or does not return				●					
	When check is made using delivery method, injection timing is found to be incorrect					●				
	Remove head cover and inspect directly							●		
	Remove feed pump and inspect directly								●	
	When engine speed is measured, low idling and high idling speeds are found to be high									●
		Remedy	Adjust	Replace	Replace	Adjust	Correct	Correct	Correct	Adjust

DRAINING OIL

22 mm

Remove the drain plug.

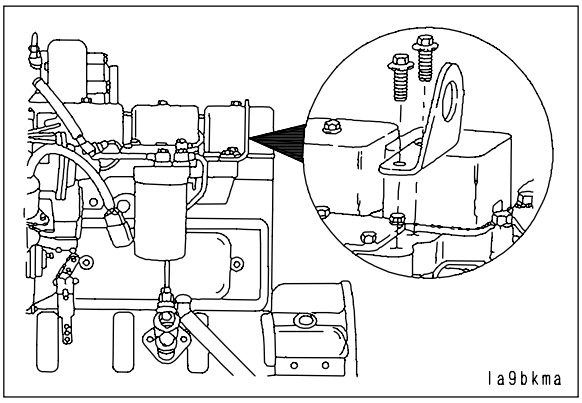
A drain pan with a 30 liter capacity is sufficient.



REMOVAL OF REAR LIFTING BRACKET

18 mm

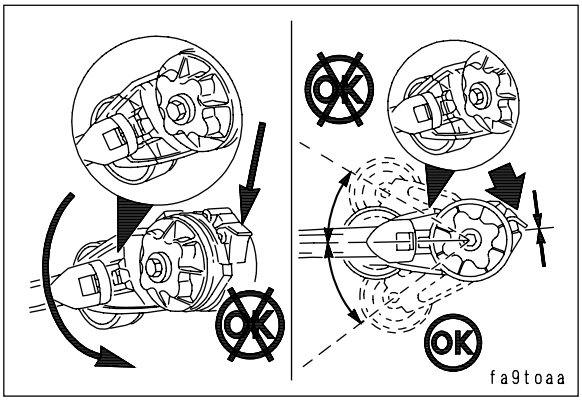
Remove the rear lifting bracket from the cylinder head.



REMOVAL OF BELT

If excessive force is applied to the tensioner in the opposite direction from winding in or when the tensioner has been wound in to the normal stop position, there is danger that the tensioner arm may break.

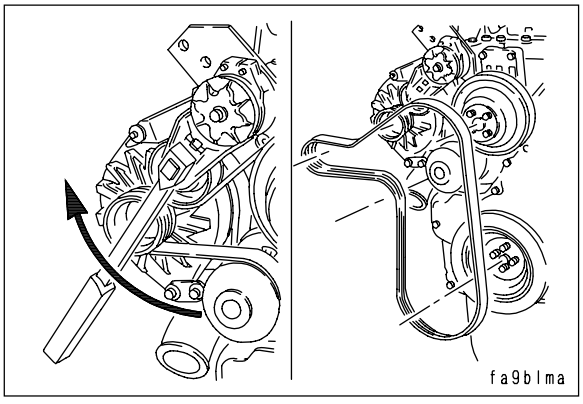
Warning : Make sure that the wrench is secured at the portion square hole before rotating it. (The spring of the tensioner is strong. If the wrench is loosely inserted, the wrench may accidentally come off while being rotated and it is extremely dangerous.)
: After removing the drive belt, return the tensioner slowly with care.
: Be careful not to get your fingers caught between the pulley and drive belt during work.



Caution: Do not put your hand near the path of the tensioner when it is under the force of the spring.

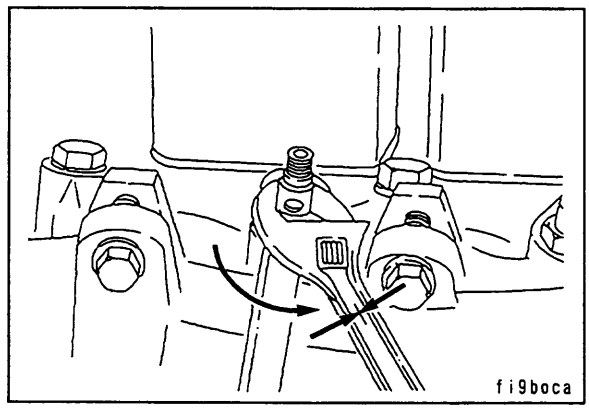
Loosen the tension with a 1/2 inch or 3/8 inch square headed wrench, then remove the drive belt.

Operating hint: Remove the drive belt after loosening the vibration damper crankshaft and hub pulley mounting bolt.



24 mm box wrench, universal wrench

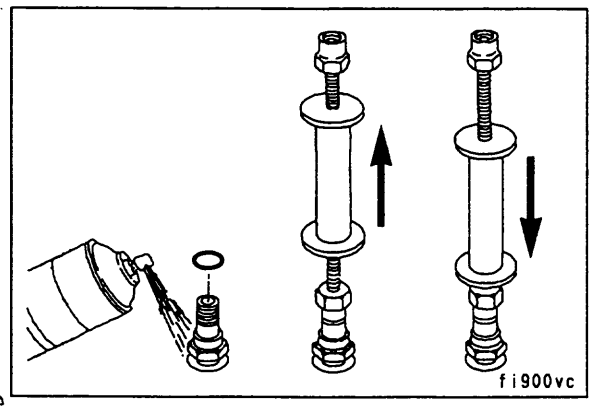
Hold the injector with a universal wrench and loosen the mounting nut with a 24 mm box wrench.



Puller (795-799-1170)

Remove the injector.
If it is difficult to remove, remove the injector O-ring and apply penetrant to the bore around the injector. Install an injector puller and pull the injector out as far as possible. Hit with the injector puller slide hammer in the direction of the puller nut to push the injector into the bore. By repeating this procedure, the penetrant penetrates the injector tip and softens the carbon deposited at the tip.

Caution: For details of the testing procedure for the injector, see Component.



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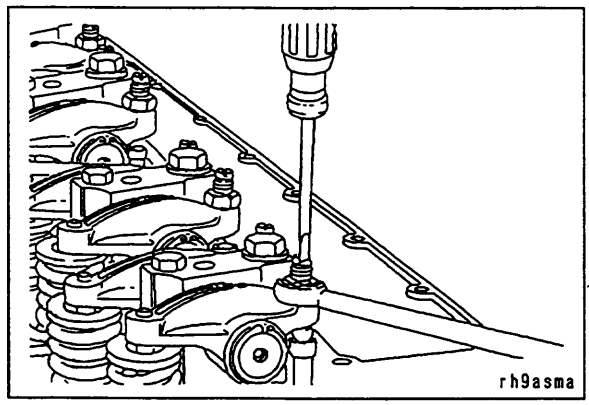
REMOVAL OF ROCKER LEVER

14 mm, screwdriver

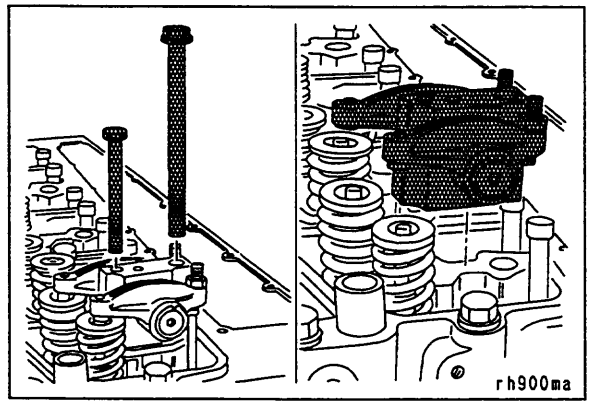
Loosen the rocker lever adjustment screw until it stops.



13 mm, 18 mm

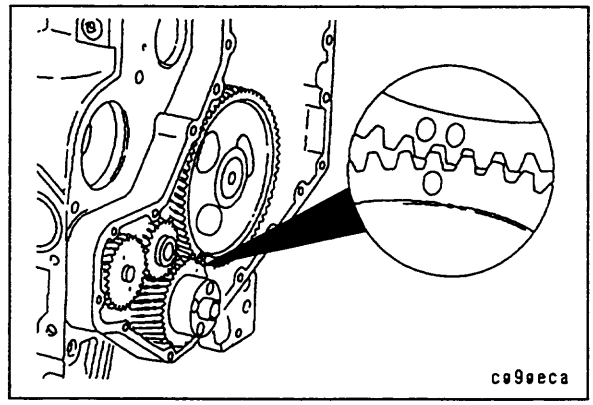
Remove the holder/head bolt from the rocker shaft holder, then lift up the holder and rocker lever assembly.

Caution: For details of the disassembly of the rocker lever assembly, see Component.



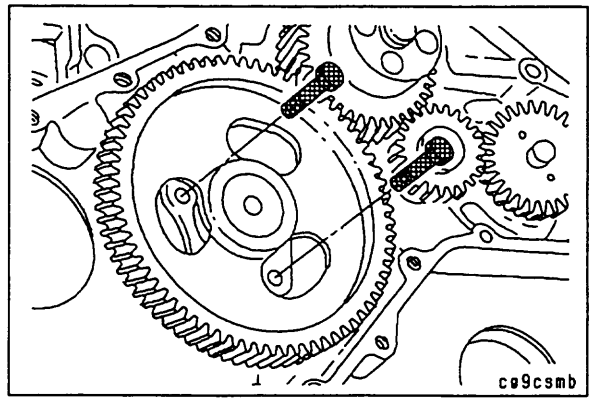
Rotate the crankshaft to set the No. 1 cylinder to the TDC position. If this is not done, the camshaft will catch on the connecting rod when the camshaft is removed.

Caution: The position of the cylinder block is shown in the upright position in the diagram to make it easy to understand.

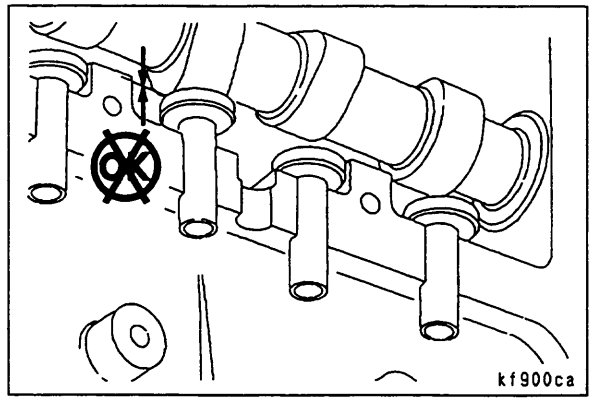


13 mm

Remove the mounting bolts from the thrust plate.



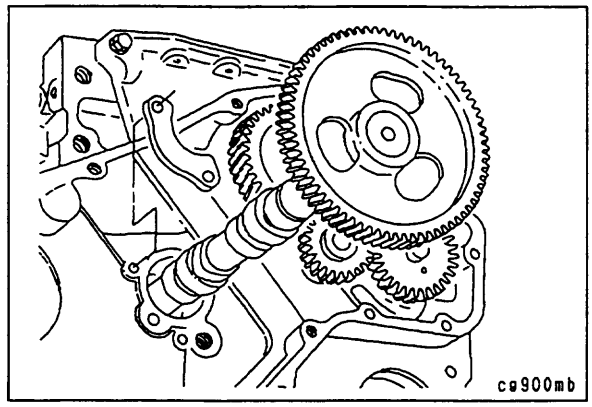
Inspect the tappet visually to check that it is separated from the camshaft lobe.



Remove the camshaft and thrust plate from the cylinder block. Be careful not to drop the thrust washer.

Operating hint:
When removing the camshaft, rotate it and pull it with a fixed force to the outside.

Caution: For details of the procedure for inspection and disassembly, see Component.



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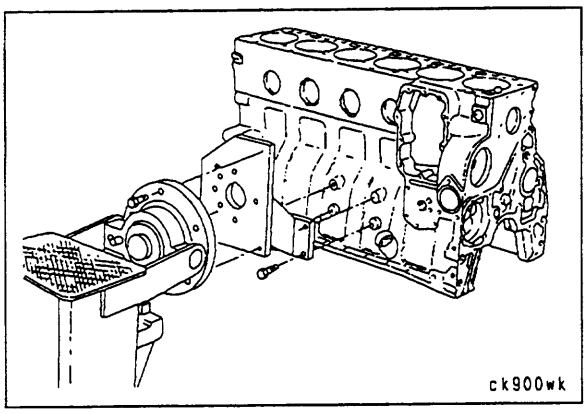
ASSEMBLY OF ENGINE

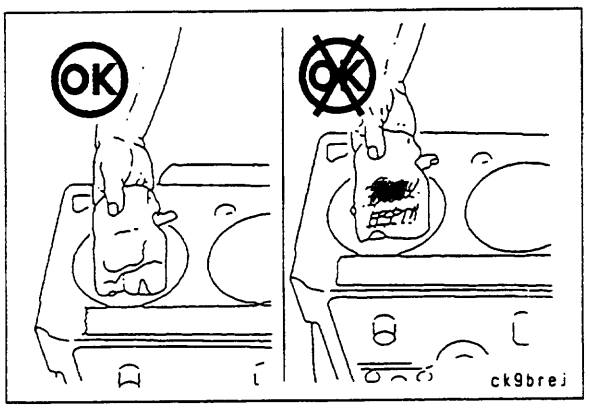
PREPARATION FOR ASSEMBLY OF CYLINDER BLOCK

Install the cylinder block to the roll-over stand.

Caution: Check that the cylinder block has been cleaned and inspected.

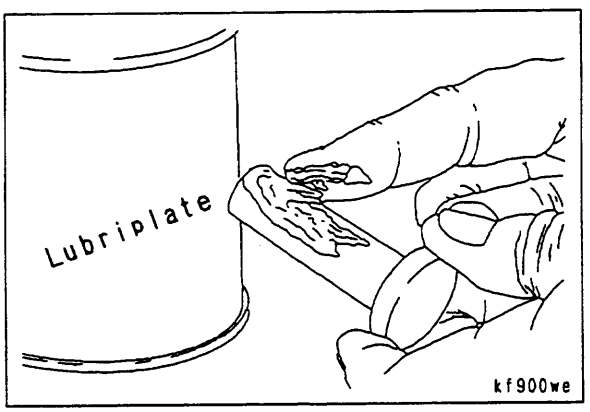


Caution: Check that the cylinder bore is clean.

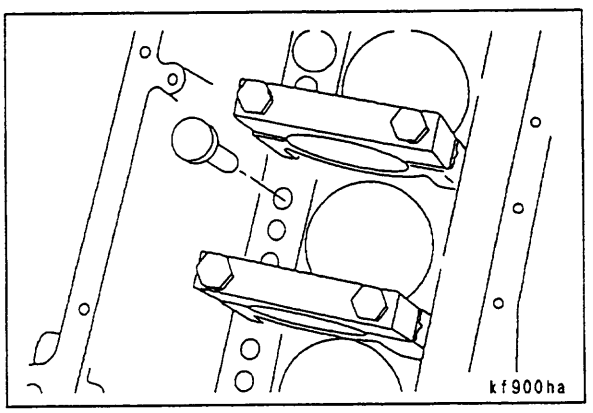


INSTALLATION OF TAPPET

Coat the tappet with lubricating oil.



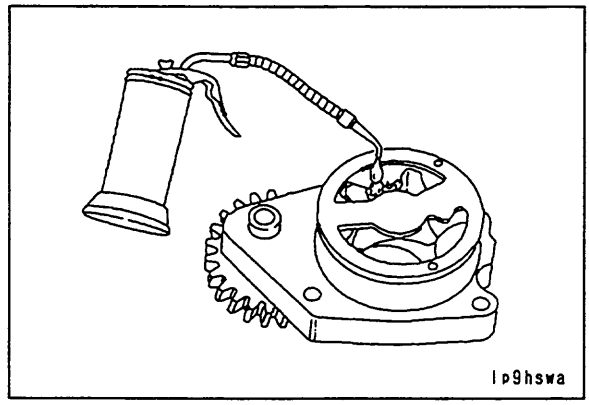
Install the valve tappet.



INSTALLATION OF OIL PUMP

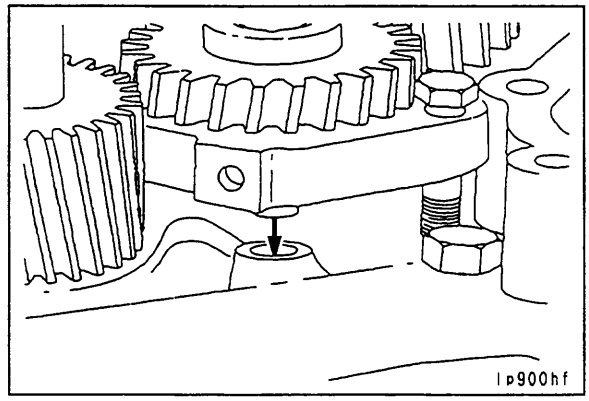
Coat the pump with clean oil.

Caution: To assist the priming when starting the engine, fill the lubricating oil pump with oil before installing.



Fit the idler gear pin exactly in the bore for positioning the cylinder block.

Install the lubricating oil pump.



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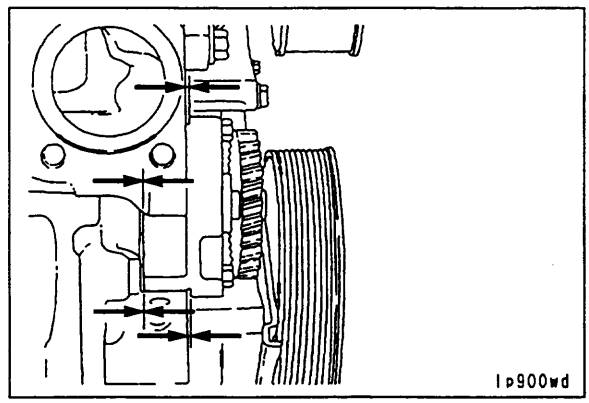
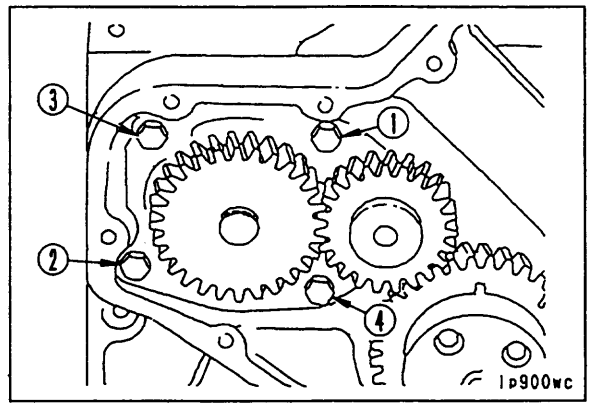
When installing the oil pump to the cylinder block, there should be a clearance between the pump flange and cylinder block. Do not tighten the mounting bolts excessively to close the gap. If the mounting bolts are tightened excessively, the oil pump will be damaged.



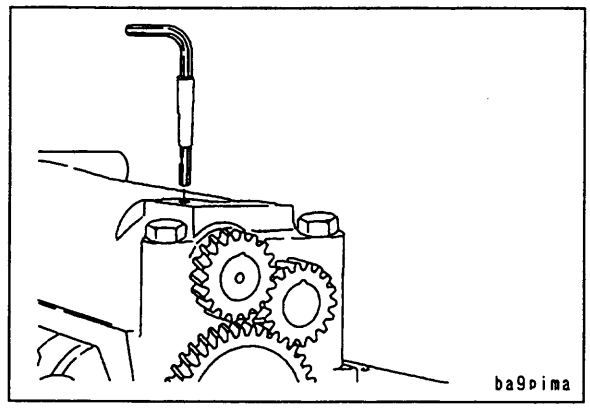
13 mm

Tighten the mounting bolts in the order shown in the diagram.

kgm: **24 Nm {2.4 kgm}**



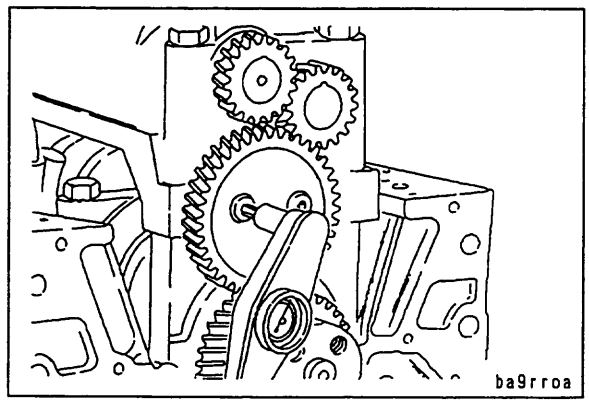
Remove the stopper bolt or hexagon wrench from the balancer.



8 mm hexagon wrench

Installation of idler gear retainer
Tighten the bolts.

kgm: **57 Nm {5.8 kgm}**



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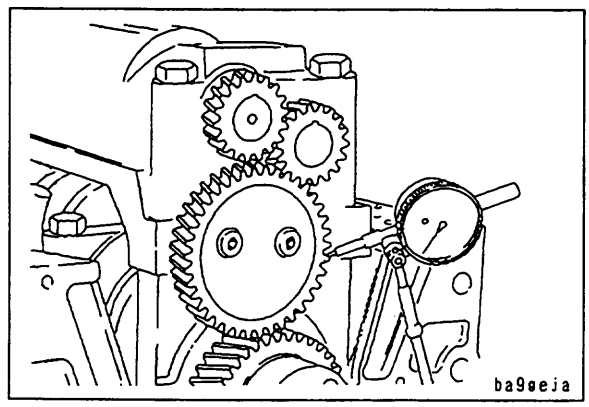
Note down the backlash of the idler gear.

Limit of backlash mm	
0.088	MIN
0.420	MAX

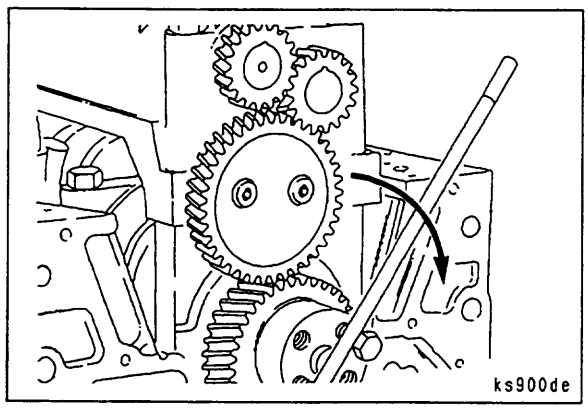
If the idler gear does not match the specifications, loosen the mounting bolts of the idler gear retainer. Position the idler gear again, then tighten the mounting bolts.

kgm: **57 Nm {5.8 kgm}**

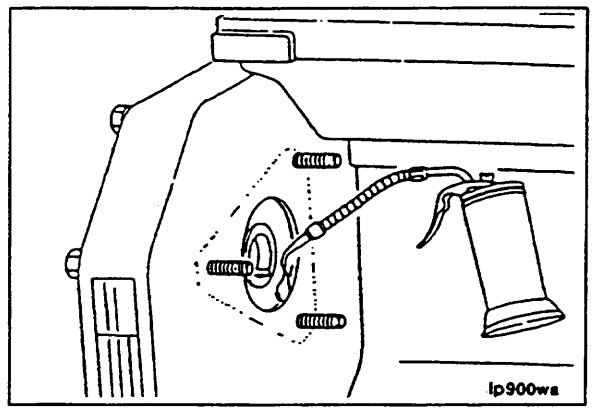


The crankshaft must be able to rotate freely.

If the crankshaft does not rotate freely, check if the balancer is causing interference.

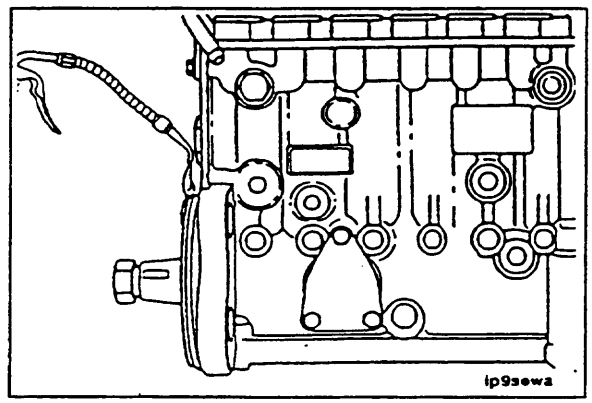


Pour clean engine oil into the gear cover housing to make it easier for the fuel injection pump to slide into the gear cover housing.

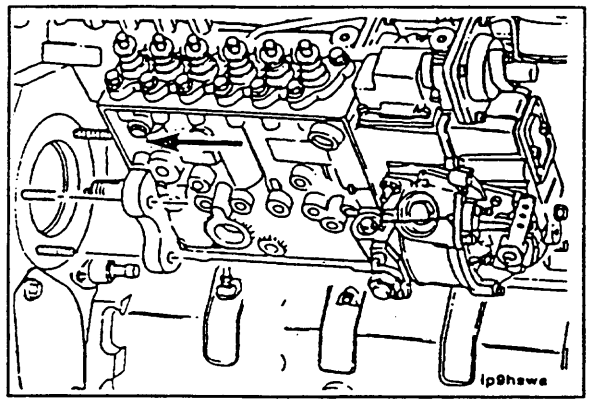


Add oil to the mounting flange of the fuel injection pump.

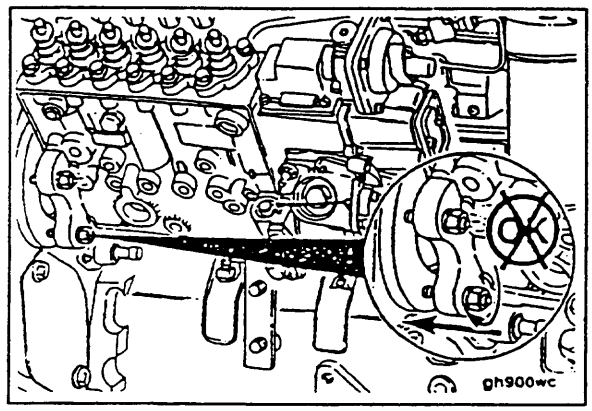
Caution: Before installing the gear, clean the inside diameter of the fuel injection pump drive gear and the outside diameter of the shaft, and dry them.



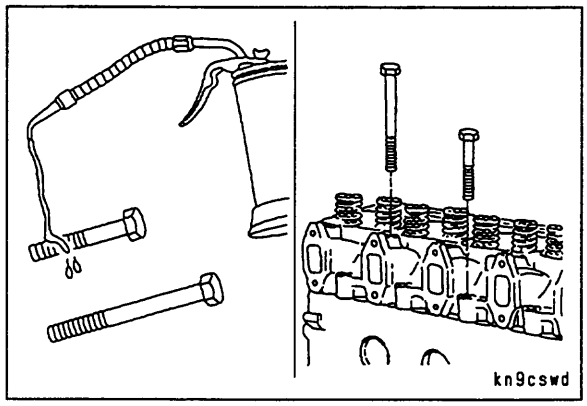
Slide the pump shaft into the drive gear. Install the pump flange on top of the mounting stud. Push the pump forward until the mounting flange and O-ring are aligned correctly with the bore of the gear housing.



Do not try to pull the pump flange into the gear housing with the mounting nut. There is danger that it may damage the housing.

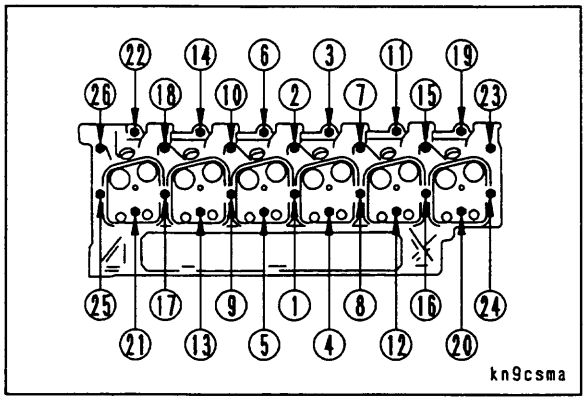


Add oil to the thread and bottom of the head of the other mounting bolts.
Install the mounting bolts and tighten by hand.



TIGHTENING OF CYLINDER HEAD

Tighten the cylinder head mounting bolts in the order shown in the diagram.



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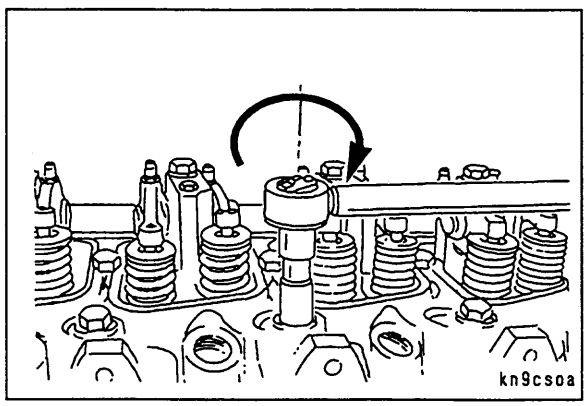
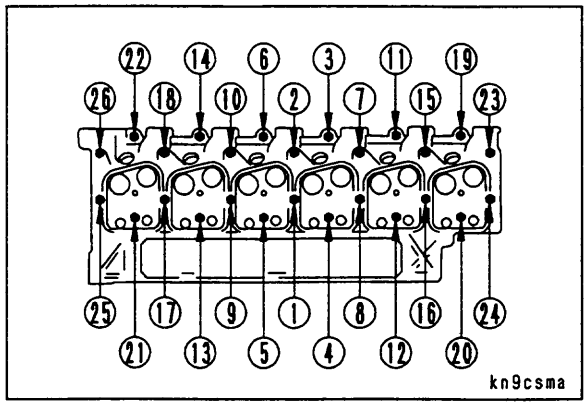
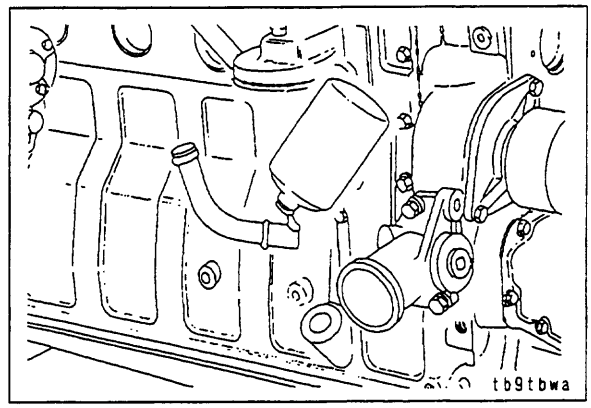
Tighten the mounting bolts in the order given above to 90 Nm {9.2 kgm}.



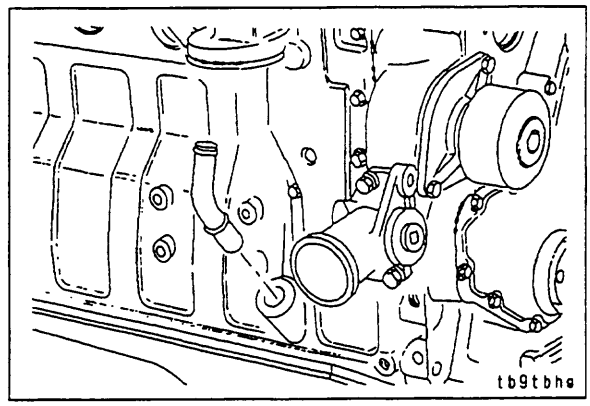
Check in the order given above that the torque of the mounting bolts is 90 Nm {9.2 kgm}.



If the block drain tube was removed, check that the O-ring is installed in the correct position to the tube mount on the block.



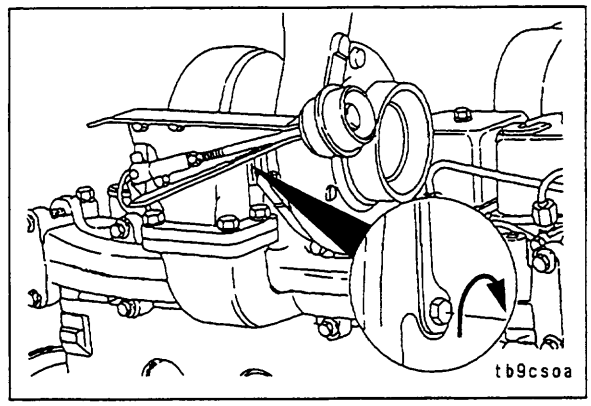
Coat the O-ring thinly with clean engine oil, then insert the tube into the block.



13 mm

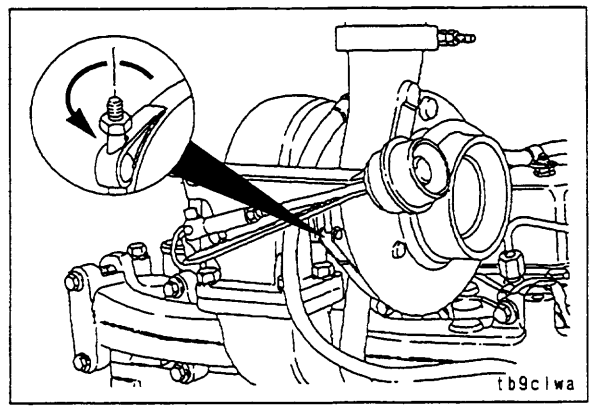
If the mounting bolts were loosened, tighten the turbine housing mounting bolts of the turbocharger.

kgm: **20 Nm {2.0 kgm}**



7/16 inch

If necessary, loosen the V-band clamp of the compressor housing, and align the housing with the center of the air crossover tube.



REPLACEMENT OF TURBOCHARGER (ENGINE WITH TURBOCHARGER)

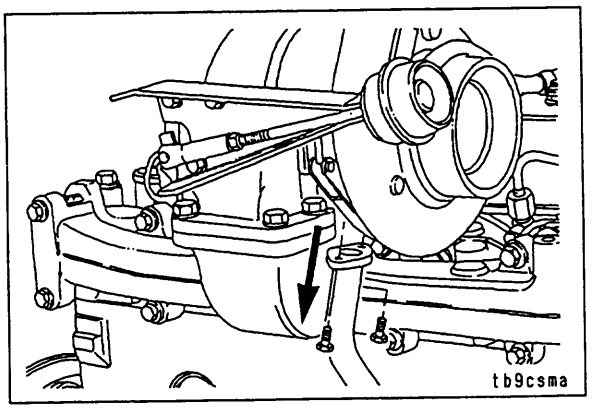
Preparatory work

- Remove the air crossover tube.
- Remove the connection of the charge air cooler hose.
- Remove the connection of the boost capsule actuator hose.
- Remove the connection of the intake and exhaust pipes.

REMOVAL

10 mm

Remove the bolts from the oil drain tube.



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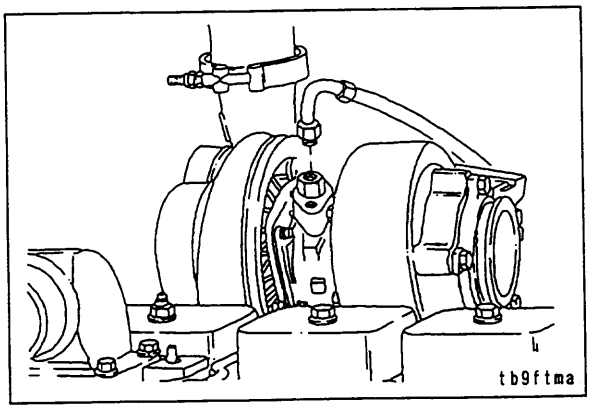
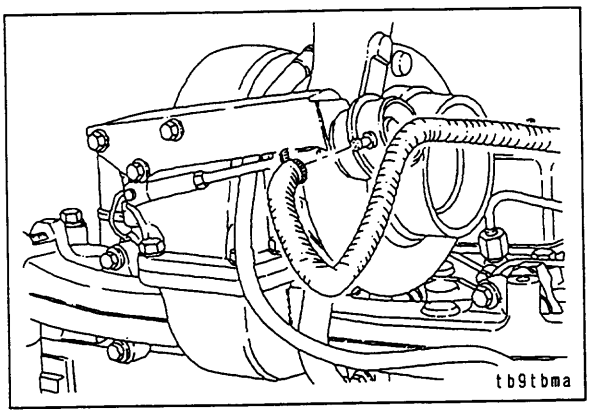
16 mm

Remove the connection of the oil supply line.

Caution: For engines assembled after June 1993, a copper gasket may be used at both ends of the turbocharger lubrication oil supply line. When removing the line, always replace the washer.



Remove the intake manifold pressure supply line from the boost capsule.

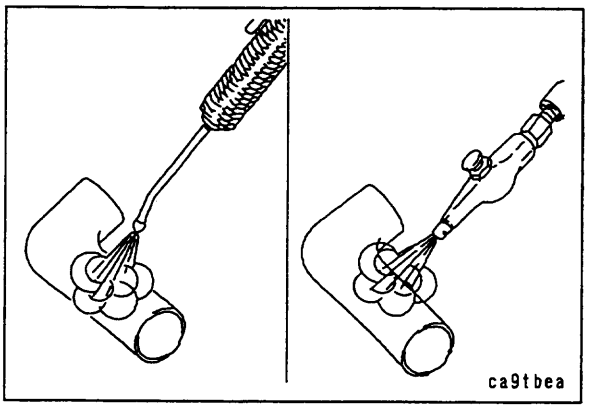


AIR CROSSOVER TUBE

CLEANING

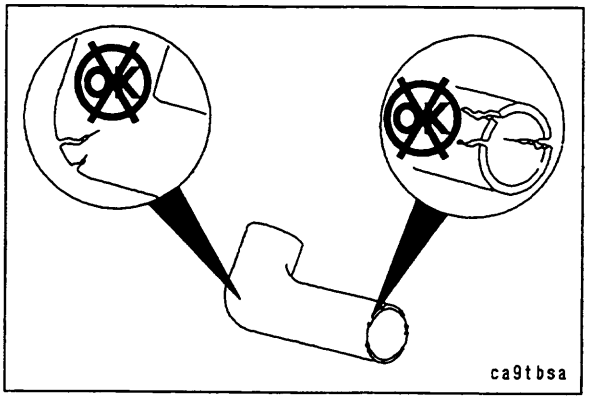
Warning: When carrying out steam cleaning, always use protective clothing, safety glasses, and face shield. Contact with the hot steam can cause serious burns.

Clean the air crossover tube with detergent or steam, then dry with compressed air.



INSPECTION

Check the air crossover tube visually for cracks or damage. Replace the tube if there is any damage. Check the hose sealing surface visually for dents or damage. Replace any damaged part.



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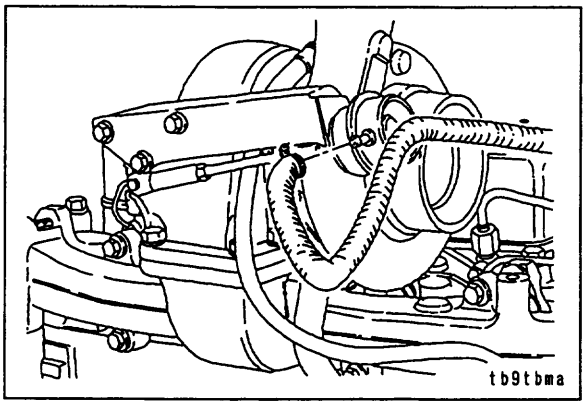
Screwdriver

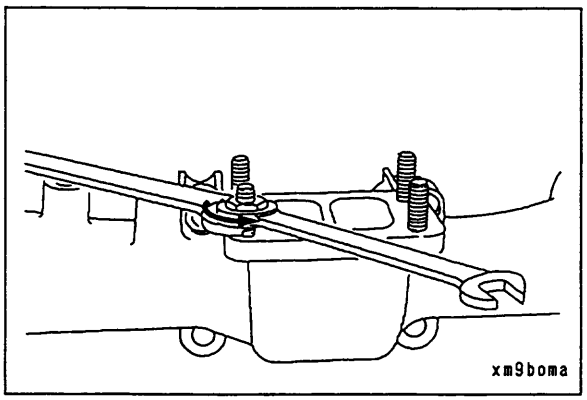
Connect the hose to the turbocharger westgate.



TURBOCHARGER MOUNTING STUD (ENGINE WITH TURBOCHARGER)

REPLACEMENT

Inspect the stud thread to check that there is no damage.
When replacing the stud, use 2 nuts jam locded on the stud.



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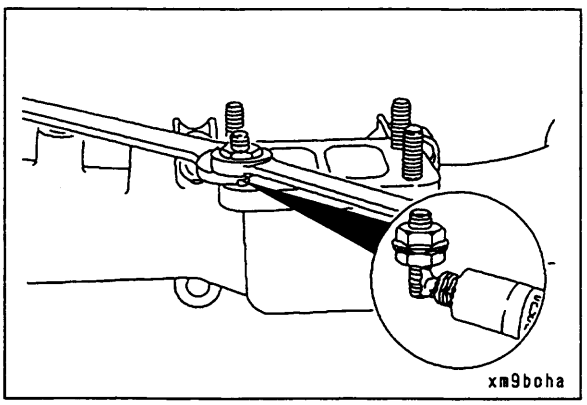
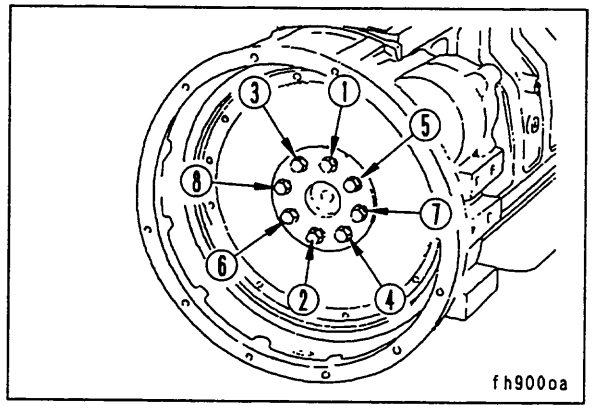
Before installing the stud, coat the thread with seizure-prevention agent.



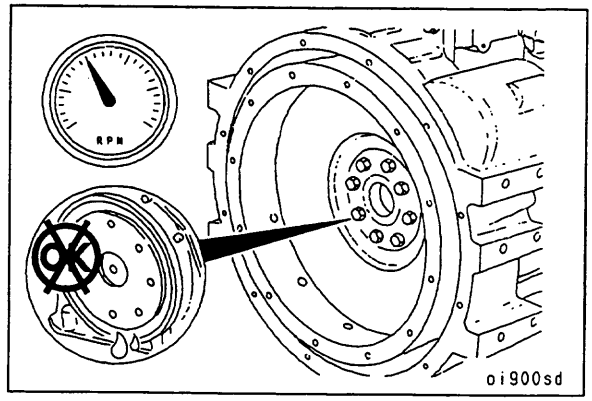
19 mm

Install the flywheel. Tighten the mounting bolts in the order shown in the diagram.

kgm: **137 Nm {14.7 kgm}**



Install the clutch, transmission, and starting motor. Run the engine and check for any leakage.



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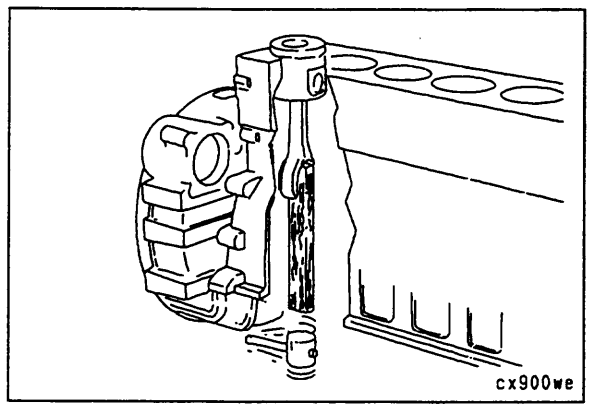
OUTLINE OF PISTON

The piston body is made of cast aluminium and there are three ring grooves. The top ring groove on turbochanged engines has a ni-resist insert with a keystone profile. The other pistons used in the engine look the same from the outside, but they are not interchangeable. Always check the part number and use the correct piston when replacing the piston.

OUTLINE OF VIBRATION DAMPER

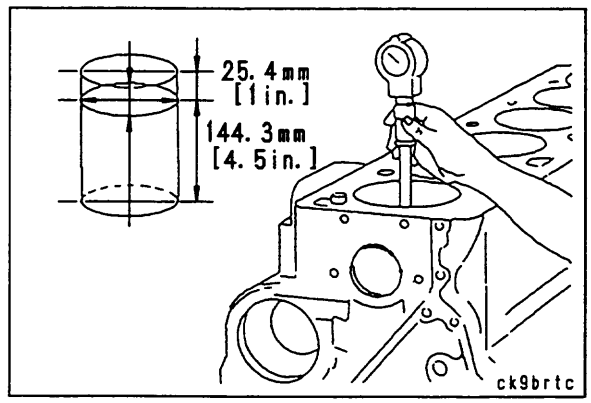
A vibration damper is installed to the 6-cylinder engine to control the torsional vibration of the crankshaft. The vibration damper is designed so that it can be used on particular engine models.
It is not economical to repair the vibration damper in the field. If inspection shows that the damper is defective, install a new damper or a reassembled damper.

Remove the piston and connecting rod assembly.



INSPECTION

Measure the cylinder bore at points 25.4 mm {1 in} and 170.0 mm {5.5 in} from the top of the cylinder block.



Max. bore diameter: 102.116 mm
Tolerance in bore: 0.035 mm
Bore taper: 0.076 mm

Caution: If the wear of the cylinder bore exceeds the specified limit, do not proceed with in-chassis overhaul.

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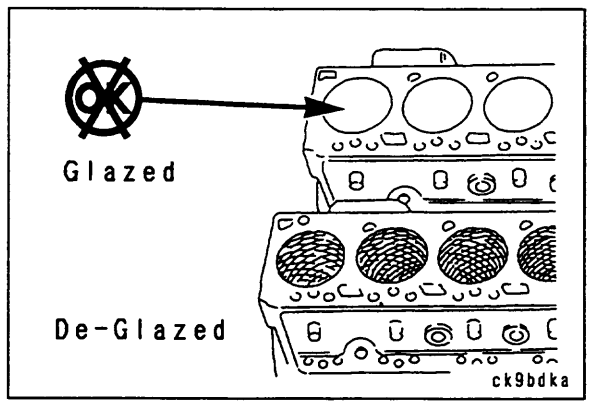
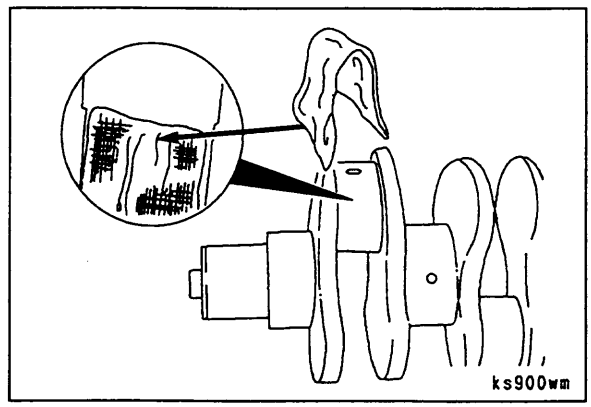
REMOVAL OF GLAZE

It is necessary to carry out finishing by removing the glaze in order for the ring to seat with the surface of the cylinder bore.

Caution: Do not seat new piston rings in cylinder bores where there is glaze.

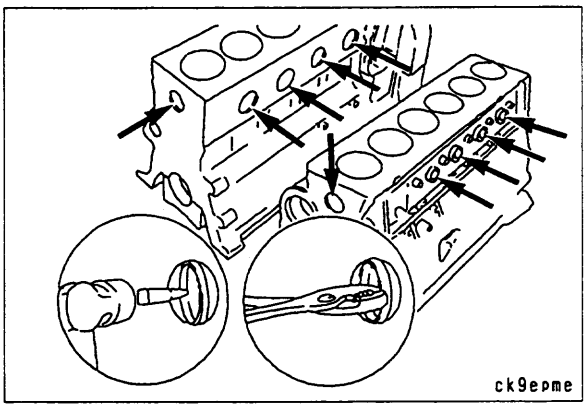


Wrap the connecting rod journal with a clean cloth.



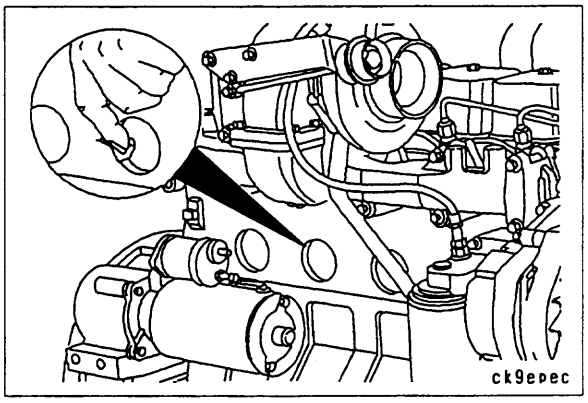
Punch, vice grip

Remove the large cup plug (58.06 mm) {2.29 in} from the cooling water passage.
Be careful not to let the expansion plugs out, in particular the plug at the end of the cylinder block, enter the water jacket.
Operating hint: If it is found that the cup plug does not rotate inside the bore, use a center punch, grip the tip of the cup plug, and use the block as a lever to remove the plug.



CLEANING

Use Scotch-Brite or equivalent to clean the expansion plug hole thoroughly.
Use spray cleaner (part number 3375433) or the equivalent to carry out final cleaning of the bore.



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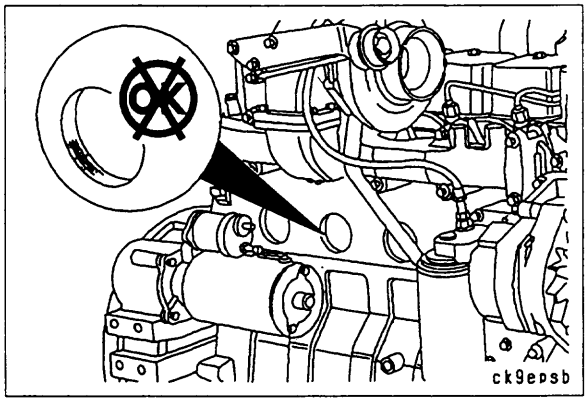
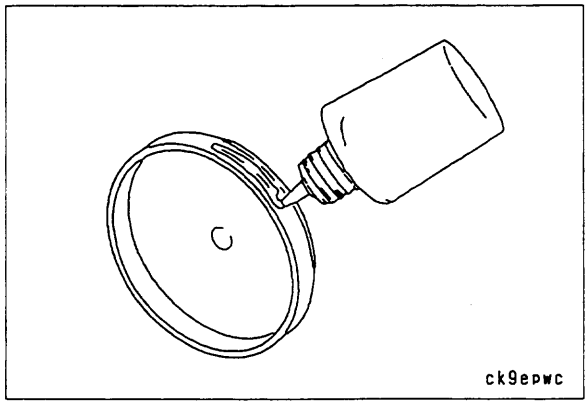
Check the cup plug bore visually for damage.



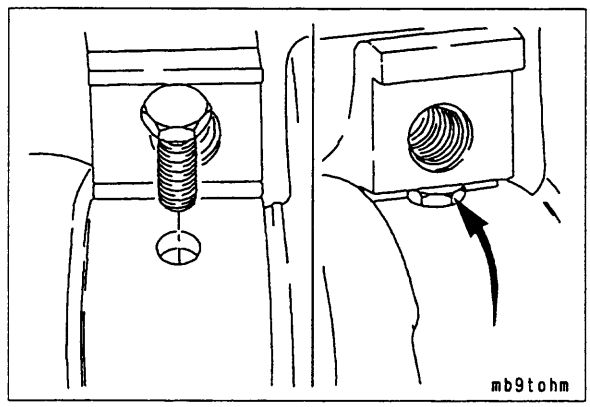
INSTALLATION

Caution: If too much sealant is used, it will flow back to the engine and damage other component. Leave the sealant to dry for at least 2 hours before starting the engine.

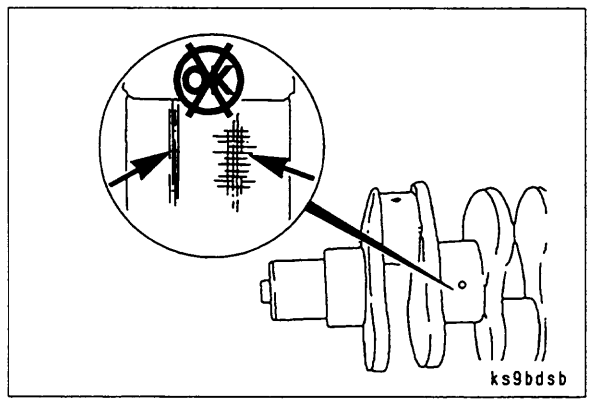
Coat the outside diameter of the expansion plug and the inside diameter of the mounting bore with a 2 mm {1/16 in} bead of expansion plug lock N seal (part number 3375068) or the equivalent.



Install the pin in the crankshaft oil hole. Rotate the crankshaft and push the pin towards the end of the main bearing on the opposite side from the tank. Remove the main bearing.
Repeat the same procedure to remove the other main bearings.



Check the main bearing cap and main bearing crankshaft journal.



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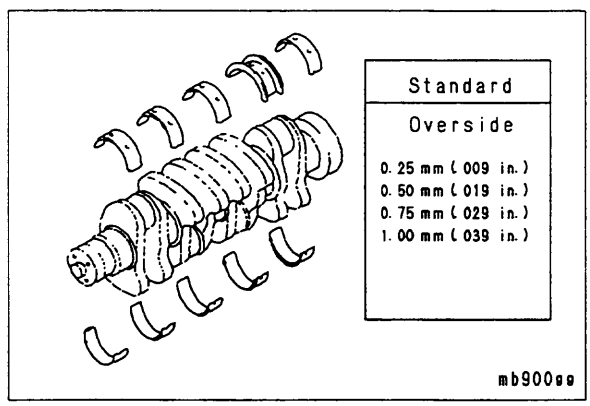
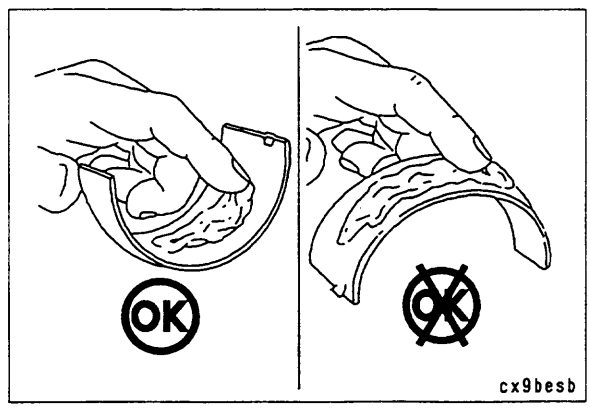
Measure the size of the removed main bearing, and prepare a bearing of the same size for installation. For details of the dimensions of the standard and undersize main bearing journals, see the section on using the base engine components.

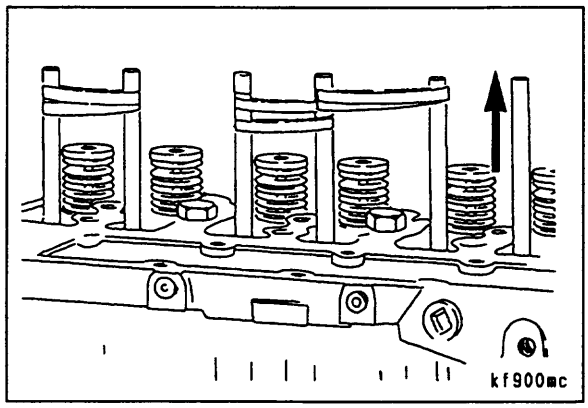


Caution: Do not put oil on the side facing the cylinder block.

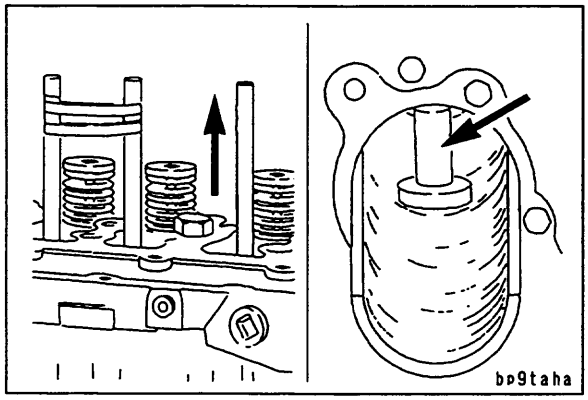
Coat the new upper main bearing with Lubriplate 105.



Install one tappet at a time. Leave the rubber band fitted to the tappets that are not removed. Remove the rubber band from 2 companion tappets.



Pull the wooden dowel from the tappet bore and drop the tappet into the plastic trough.



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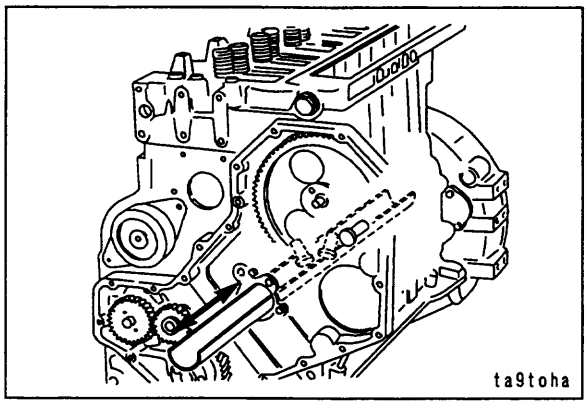
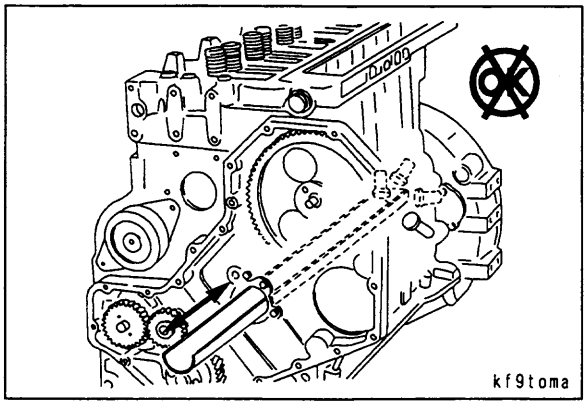
Flashlight

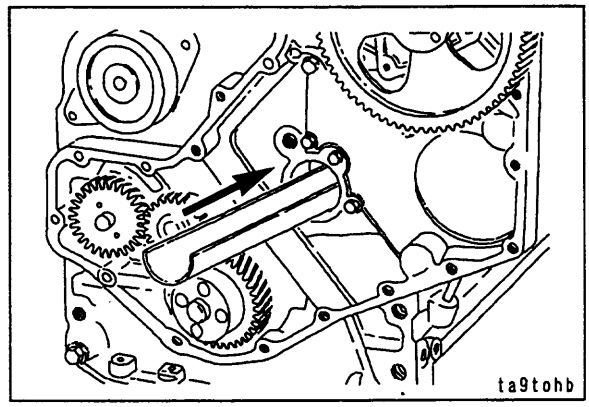
When the tappet falls into the trough, it will usually roll out, but if it does not come out, shake the trough carefully and remove the tappet before removing the trough.



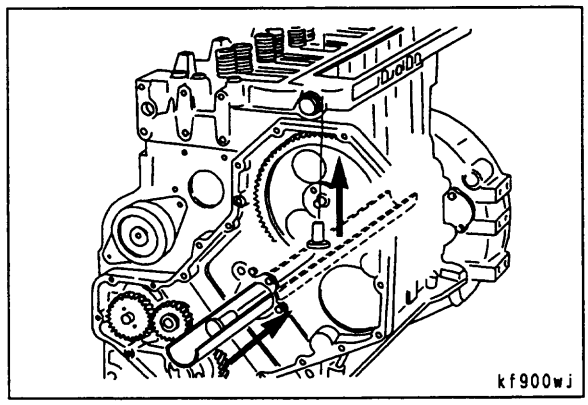
Caution: When removing the tappet from the No. 6 cylinder, be extremely careful not to let the tip of the trough hit or jolt the tappet.



Slide the trough into the cam bore.



Pass the tool and tappet through the cam bore then pull it up into the tappet bore.



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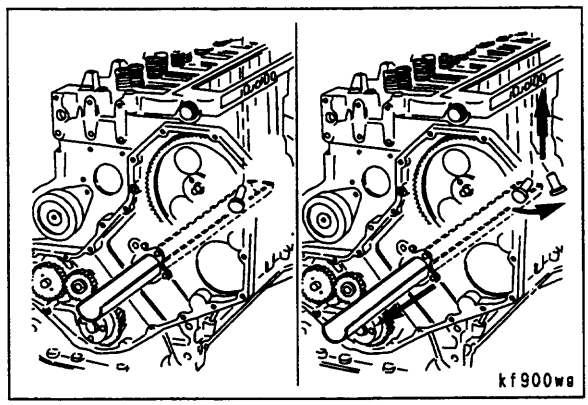
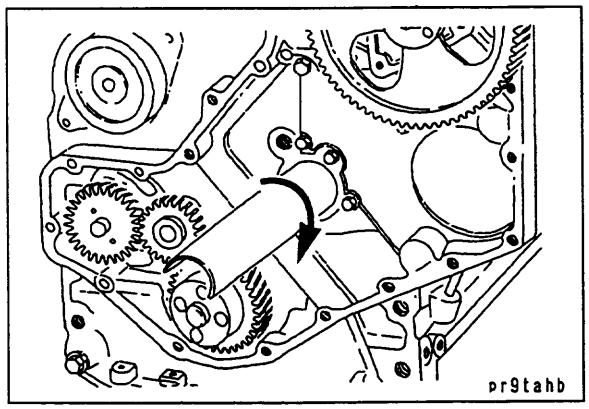
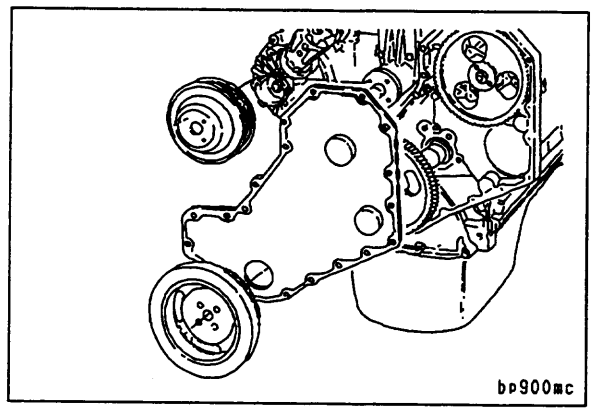
If it is difficult to get the tappet to make the bend from the trough to the tappet bore, put the trough out so that the tappet can go down and align itself, then pull the tappet up into the bore.



When the tappet is pulled up to the set position, slide the trough into the cam bore and rotate it 1/2 turns. This will set the rounded side of the trough at the top and will hold the tappet in the set position.



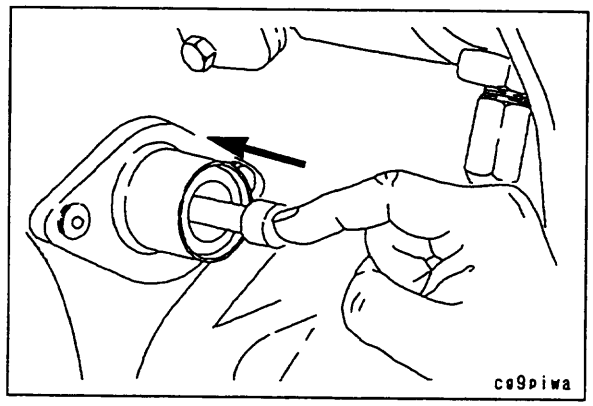
Install the camshaft.
Install the gear cover.
Install the crankshaft pulley.
Install the fan pulley.



REPLACEMENT OF TIMING PIN

1/2 inch drive, gear (795-799-1130)

Push the engine timing pin, carry out barring of the crankshaft slowly, and set the No. 1 cylinder to the top dead center (TDC) position.



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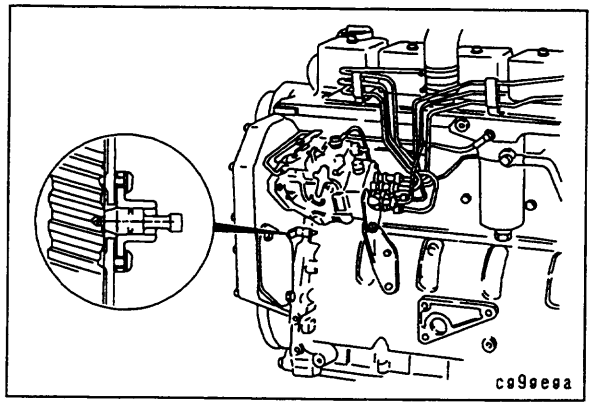
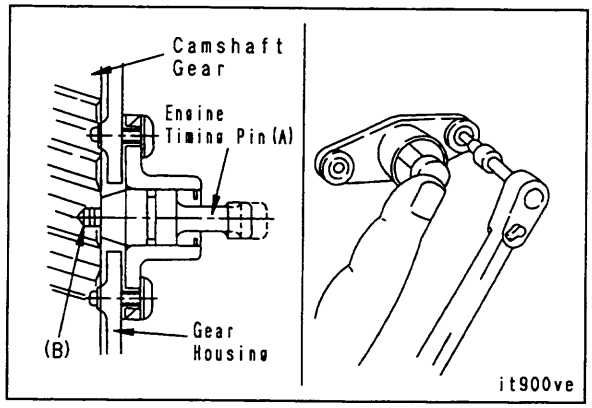
T-25 Torx

Remove the timing pin assembly and seal.

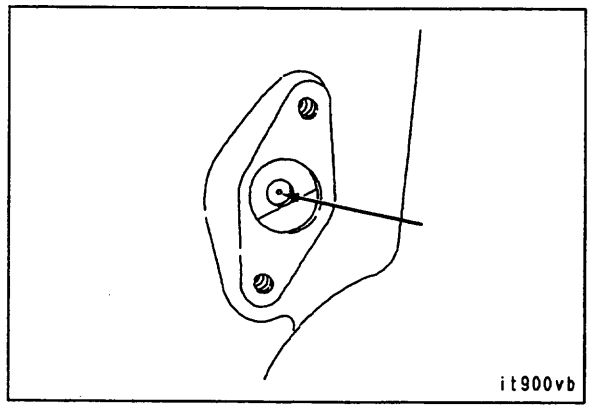


Install a new seal, and if necessary, install a new timing pin assembly. Insert pin (A) in hole (B) of the camshaft gear and center the housing.

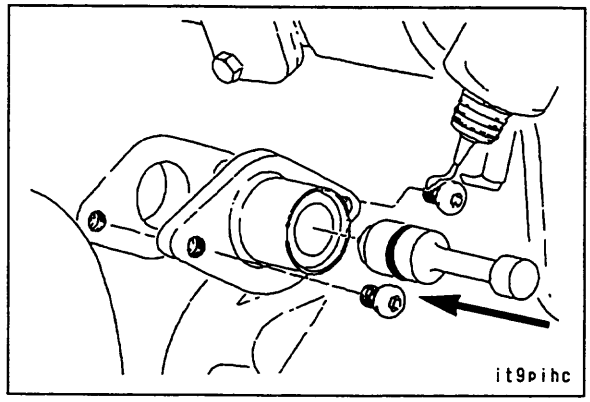
kgm: **5 Nm {0.51 kgm}**



The cam gear timing pin hole can be seen or can be felt through the rear of the gear housing. If it is not in this condition, rotate the crankshaft one more turn in the direction of rotation of the engine.



Coat the thread of the torx screw with Loctite™ 59241 and install the timing pin assembly and a new O-ring.



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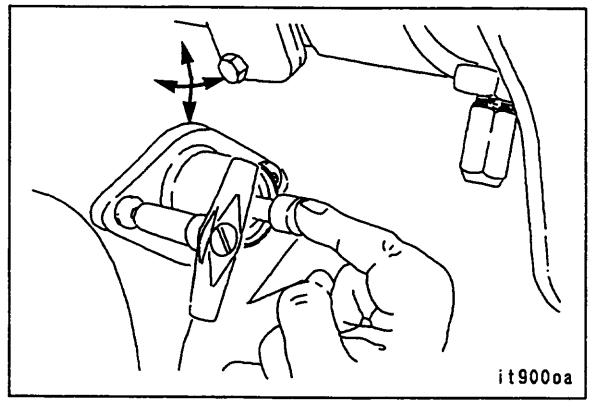
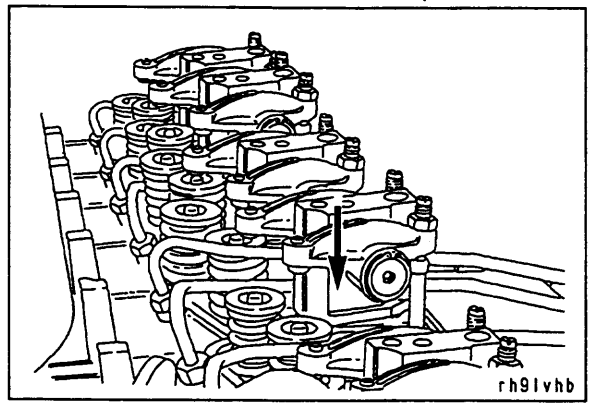
T-25 Torx

Align with the hole in the housing and insert the timing pin in the hole.

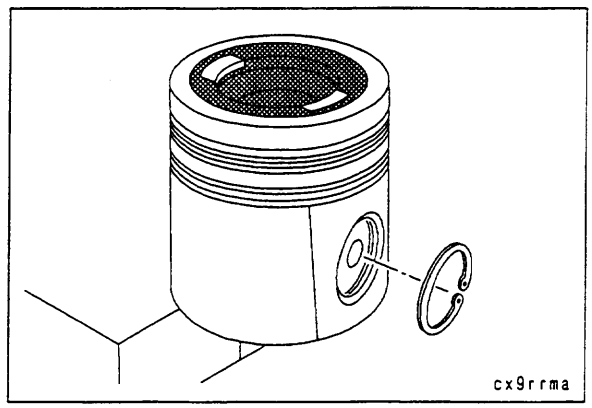
kgm: **5 Nm {0.51 kgm}**



Install the other rocker lever pedestal assemblies.

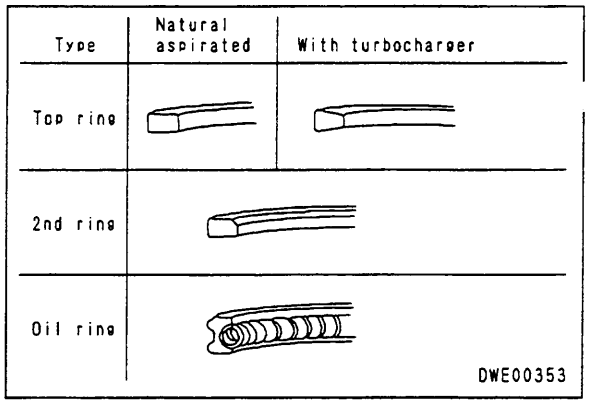


Install the 2nd retaining ring.

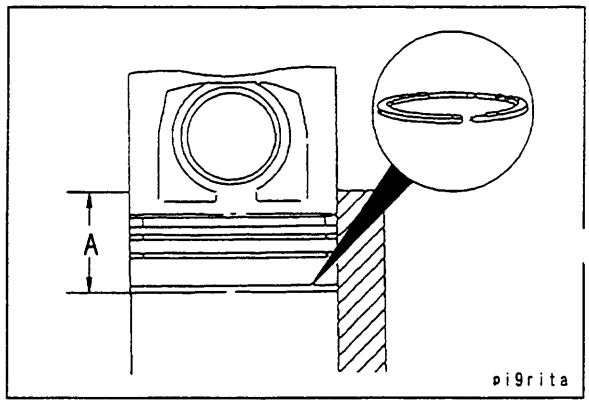


INSPECTION OF PISTON RING GAP

The top ring on engines equipped with a turbocharger is not the same as the top ring on naturally aspirated engines.

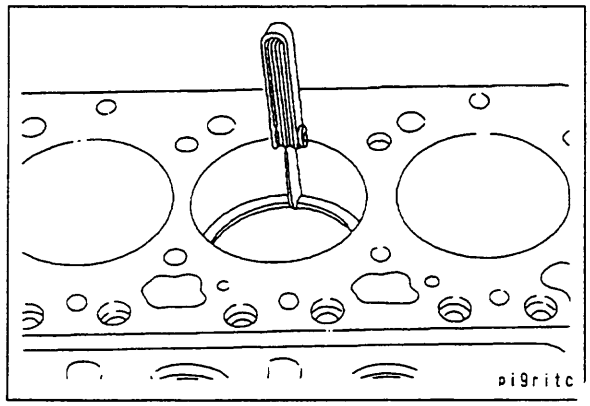


Set the ring in position in the cylinder, then use the piston to set at right angles to the bore.
A = 89 mm

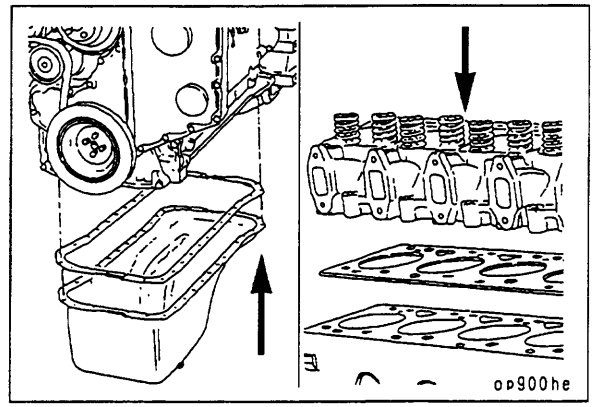


Using a clearance gauge, measure the gap.

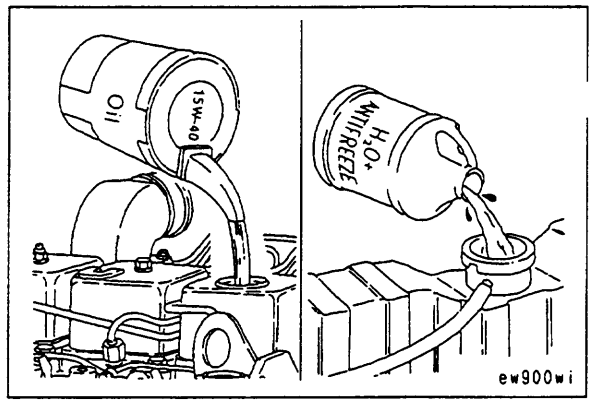
Ring gap			
Top ring (Engines with turbocharger)			
		Min	0.40 mm
		Max	0.70 mm
Top ring (naturally aspirated engines)			
		Min	0.25 mm
		Max	0.55 mm
2nd ring		Min	0.25 mm
		Min	0.25 mm
Oil ring	Min	0.25 mm	
		Min	0.25 mm



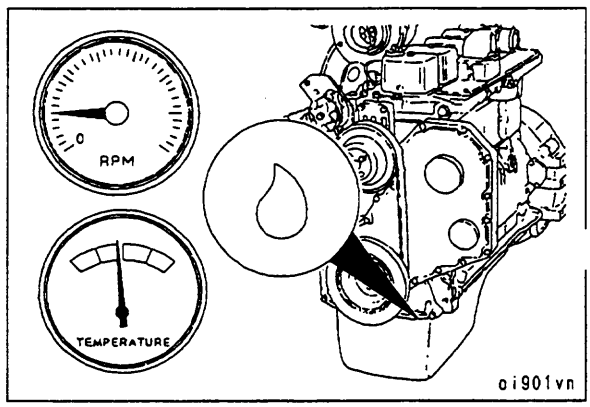
Install the oil pan.
Install the cylinder head.



Fill the oil pan with engine oil.
Fill the cooling system.



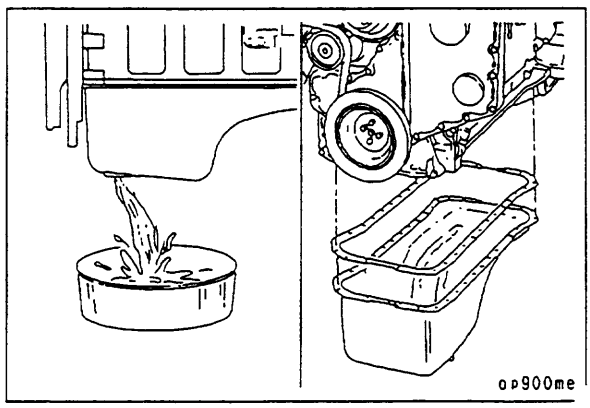
Run the engine at the normal operating temperature and check for leakage.



REPLACEMENT OF CONNECTING ROD BEARING

REMOVAL

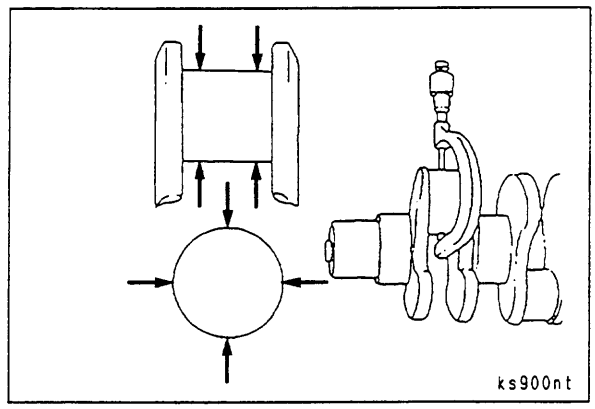
Drain the lubricating oil.
Remove the oil pan.



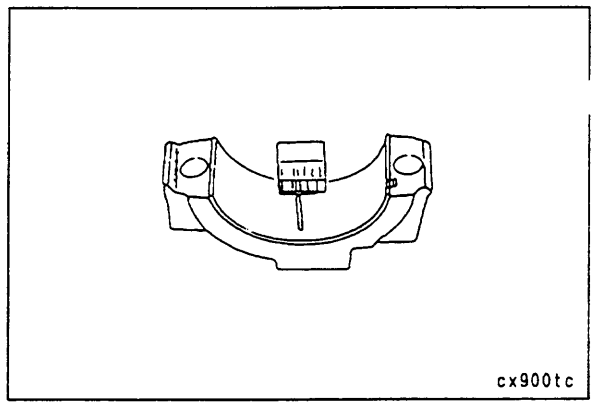
Measure the crankshaft rod journal and note down the average diameter.

Diameter mm	
68.926	Min
69.013	Max

Tolerance: 0.050 mm
Taper: 0.013 mm
Bearing clearance = Inside diameter of rod - diameter of crankshaft journal
Maximum bearing clearance limit: 0.114 mm



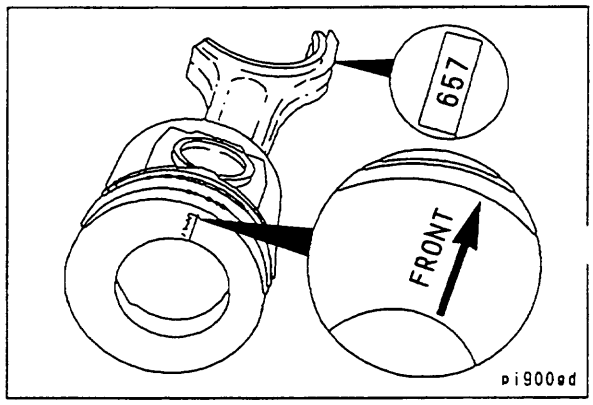
It is also possible to measure the bearing clearance with a plastigauge when the crankshaft is assembled to the engine.



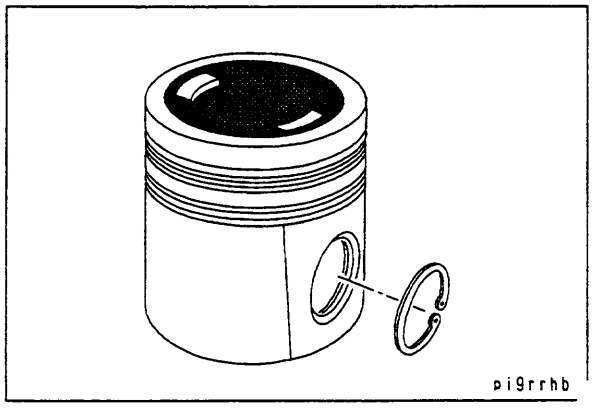
ASSEMBLY OF PISTON CONNECTING ROD

Check that the piston **FRONT** mark and the number on the connecting rod are facing in the direction shown in the diagram.

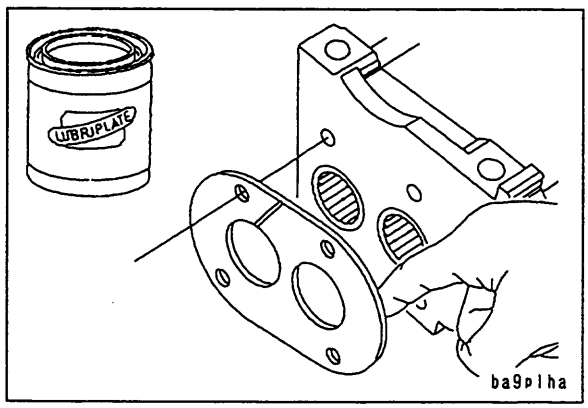
Caution: The number given in the diagram is only an example.



Install the retaining ring to the pin groove at the FRONT side of the piston.

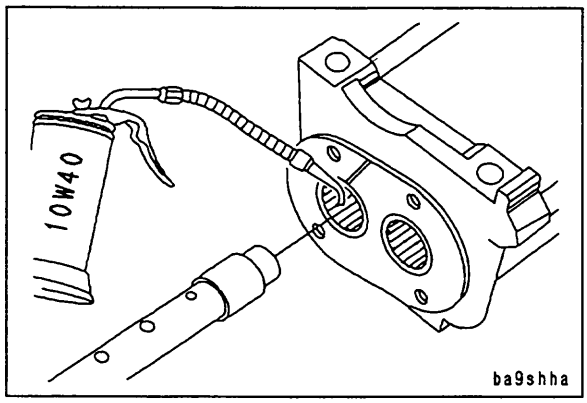


Coat the thrust plate with Lubriplate. Set the thrust plate to the housing.

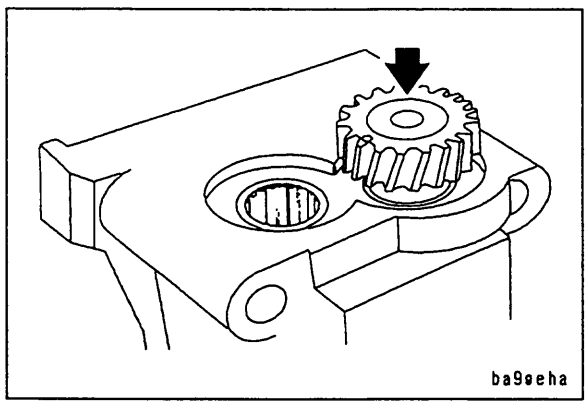


Add clean oil to the bearing. Install the bottom shaft to the housing. There is a timing pin hole in the bottom shaft.

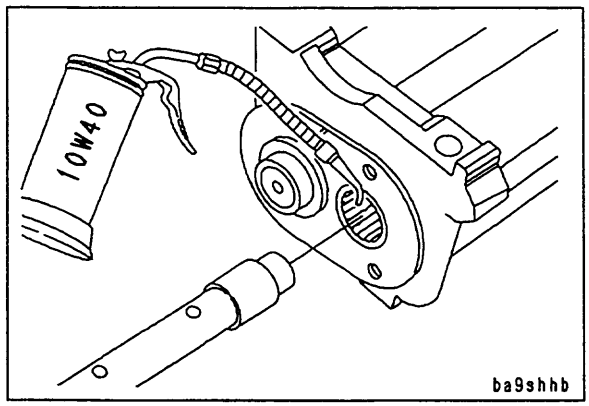
Caution: There is a tappet type hole for the timing pin on the shaft of later models. On the original shaft, there is a hole for the timing pin bored through the shaft.



Push the gear with one timing mark against the bottom shaft until the gear is level with the end of the shaft.



Add clean oil to the bearing and install the top shaft.



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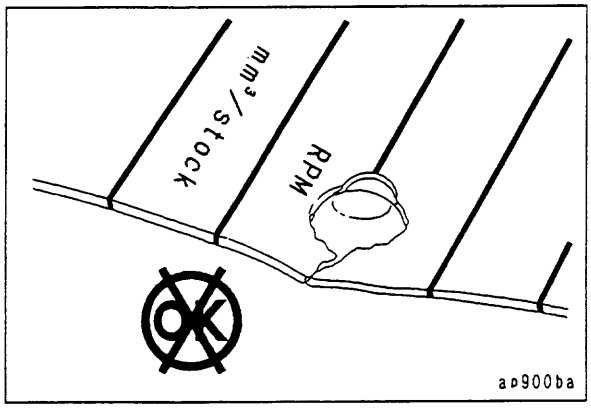
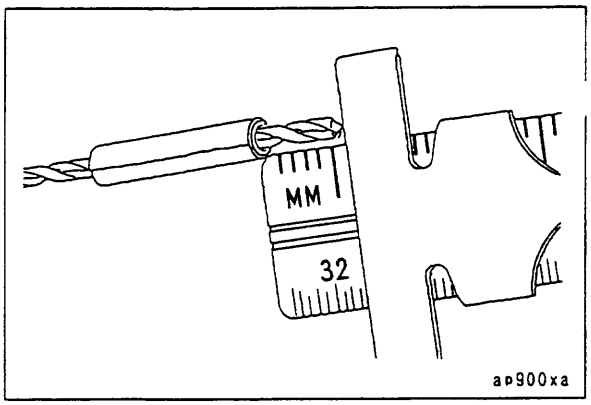
Caution: If the rivets are knocked in too far, they will tear through the data plate.

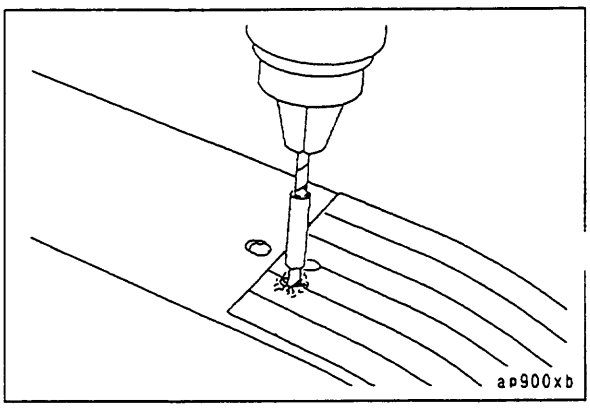


2.0 mm drill bit

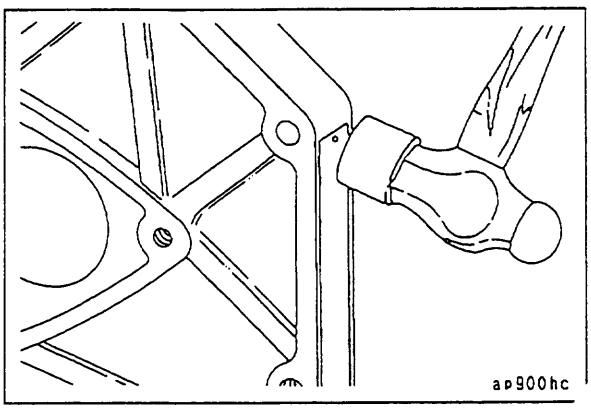
If the data plate is loose or damaged, make new holes and install with new rivets. Make a mark at the 6.0 mm point on the drill bit to make sure that the hole is not too deep.



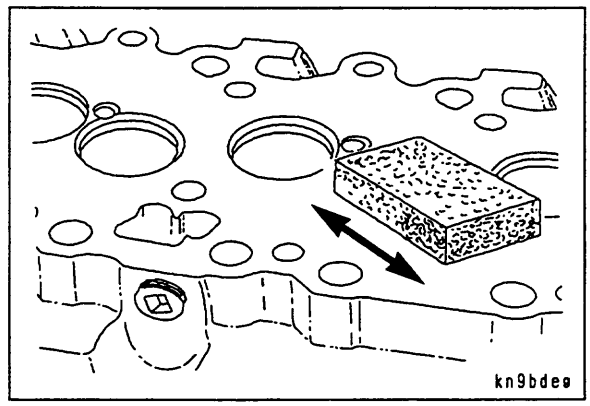
Be careful not to damage the data printed on the plate when making the holes in the data plate.



Knock in until the rivets contact the data plate.



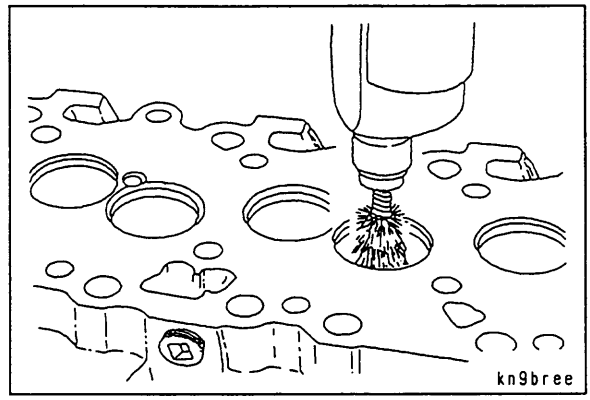
Using a Scotch-Brite pad or equivalent cleaning pad and diesel fuel or detergent, wash the combustion deck of the cylinder head.



Caution: Wear protective glasses.

Install a high-quality steel wire wheel to a drill or die grinder and remove the carbon deposit from the valve pocket.

Caution: If a low-quality wire wheel is used, the steel wire will come out during the operation and make the dirt worse.



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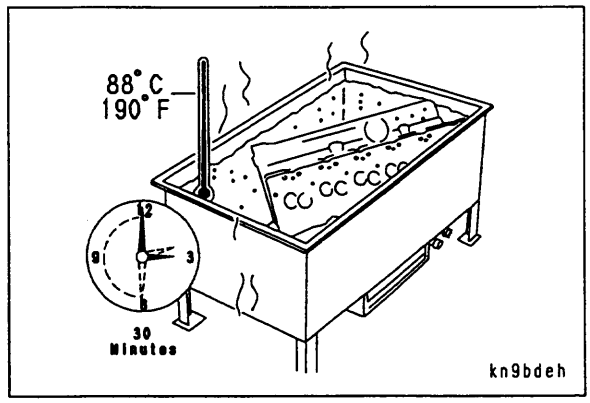
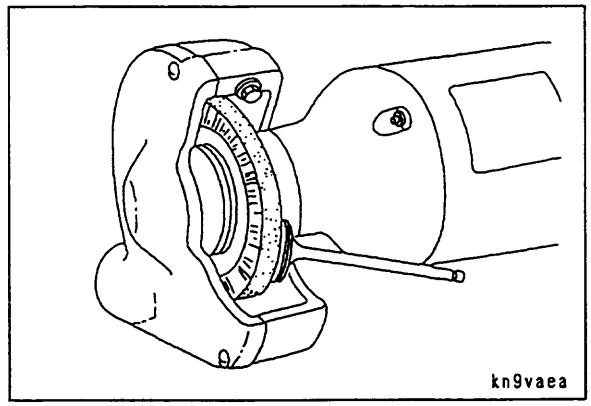
Wash the cylinder head with hot soapy solution.
Wash the cylinder head in hot soapy water solution, then dry with compressed air.



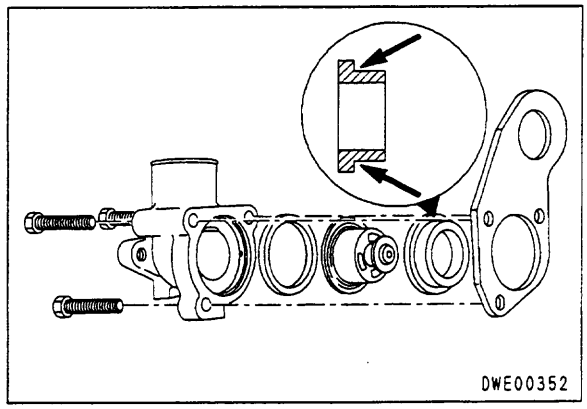
Warning: Wear protective glasses.

Clean the valve head with a soft wire wheel.
Before starting the measuring operation, put the valves on a labeled rack and be careful not to mix the valves.



INSTALLATION OF THERMOSTAT

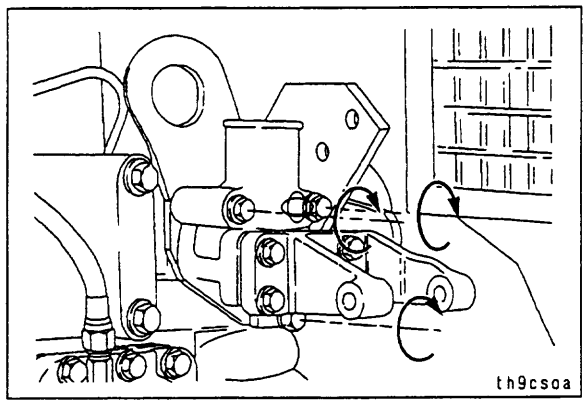
Set the thermostat in position as shown in the diagram.
Assemble the lifting bracket and thermostat gasket, then install the assembly to the thermostat and thermostat housing.
Check that the gasket is aligned with the mounting bolt holes.
Install the mounting bolts and tighten by hand.
Install the rubber thermostat with the notched end facing the opposite direction from the cylinder head.



10 mm

Install the assembly.

kgm: **24 Nm {2.4 kgm}**

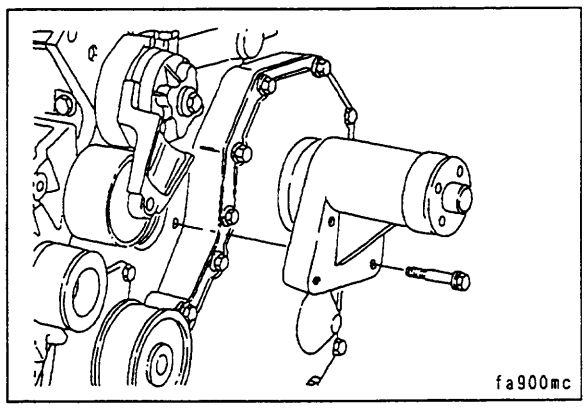


INSTALLATION OF FAN HUB

10 mm

Install the fan hub.

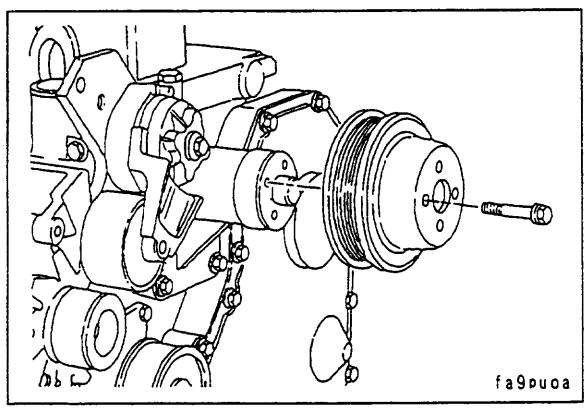
kgm: **24 Nm {2.4 kgm}**



10 mm or 13 mm

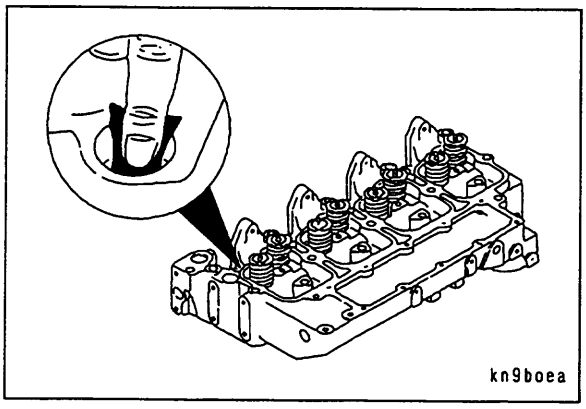
Install the fan hub pulley.

Tightening torque value	
8 mm mounting bolt:	24 Nm {2.4 kgm}
10 mm mounting bolt:	43 Nm {4.4 kgm}



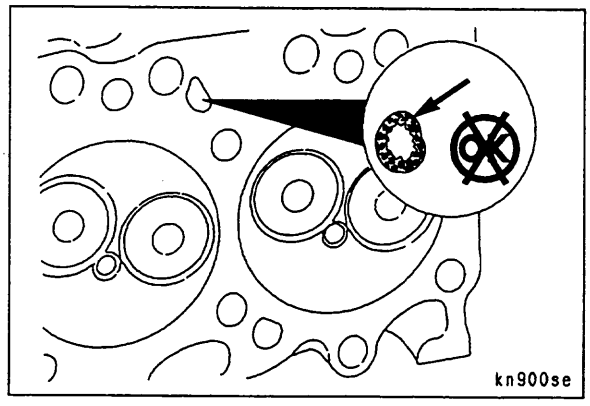
400 grit sandpaper, diesel fuel

Clean the cup plug hole.



Caution: Wear protective clothes to prevent injury.

Inspect the water cooling passage for deposited sediment.
If there is any deposit, it will cause overheating of the engine.
Check that the water passage is clean. If there is excessive sediment, it can be washed out in an acid-proof tank, but disassemble the cylinder head before this.



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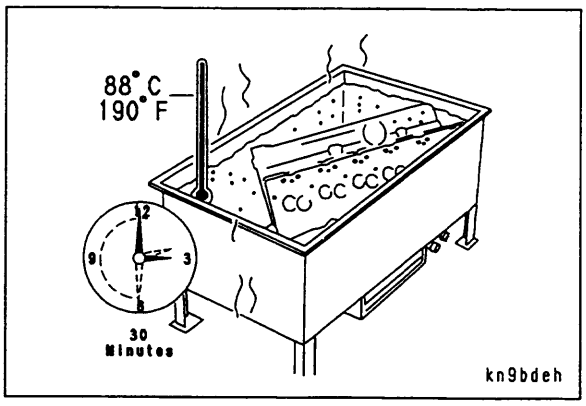
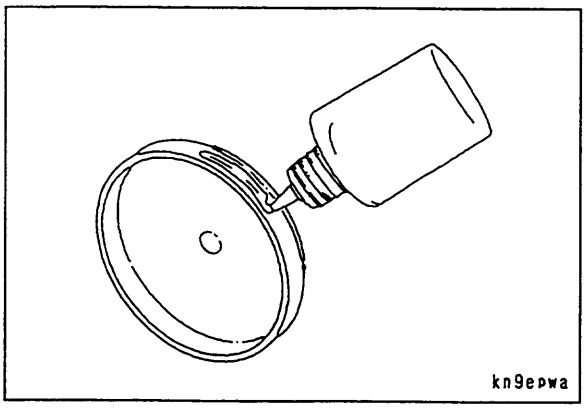
Caution: Wear protective clothes to prevent injury.

Put hot soapy water in a tank and wash the cylinder head.



Caution: Before installing the cup plug, wash the cup plug and cup plug hole and remove any oil.

Before installing, coat the outside circumference of the cup plug with LT-4.



Index No.	Part Name	Q'ty	Remarks
1	Rocker lever support	4	
2	Cup plug	8	
3	Rocker lever (intake)	4	
4	Grooved set screw	4	3/8 inch - 24 UNF-2A
5	Normal hexagonal nut	4	
6	Rocker lever (exhaust)	4	
7	Plain washer	8	
8	Retaining ring	8	
9	Hexagonal mounting bolt	4	M8 - 1.25 x 75 mm
10	Hexagonal mounting bolt	4	M12 - 1.75 x 180 mm
11	Push rod	8	

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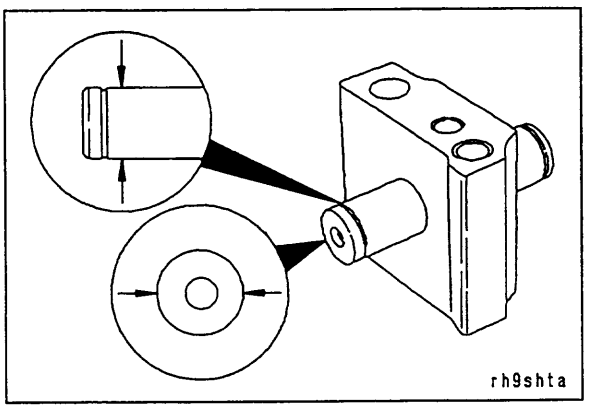
INSPECTION OF ROCKER LEVER SHAFT

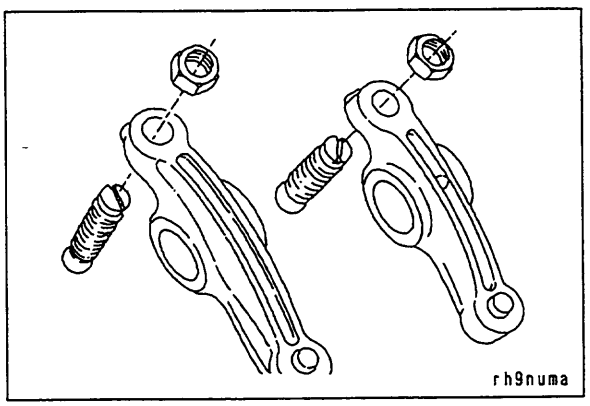
Check the pedestal and shaft for damage.

Diameter mm	
18.938	Min
18.975	Max



ASSEMBLY OF ROCKER LEVER

Install the adjustment screw and locknut.



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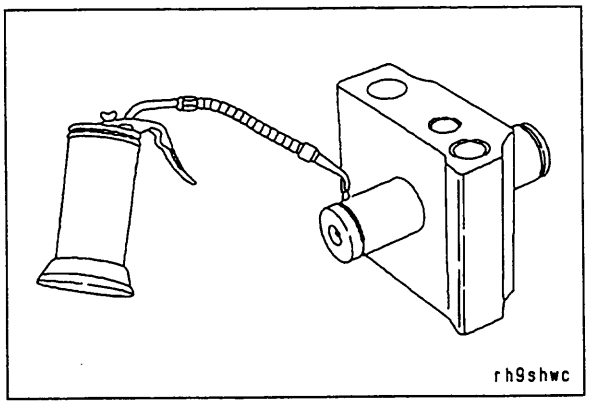
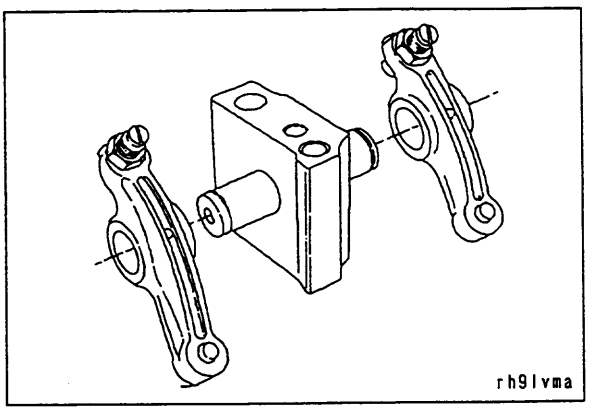
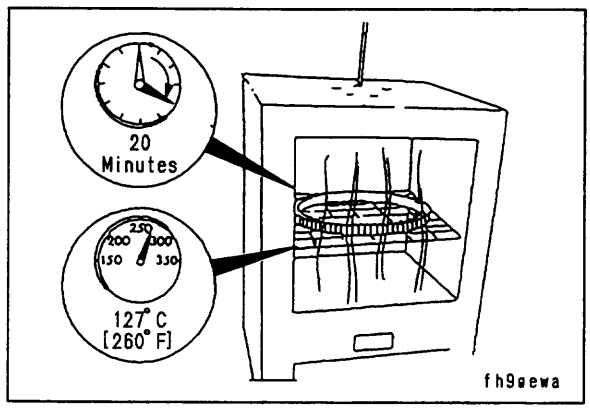
Add engine oil to the shaft.



Install the levers to the rocker shaft.

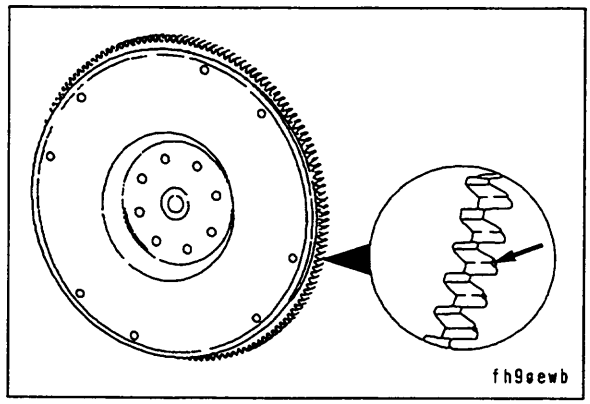


Heat the new ring gear in a heated oven for 20 minutes at 127 °C.



Warning: When installing the heated gear, wear protective gloves.

Install the ring gear. Set the tooth bevel facing the crankshaft end of the flywheel, and install the ring gear.



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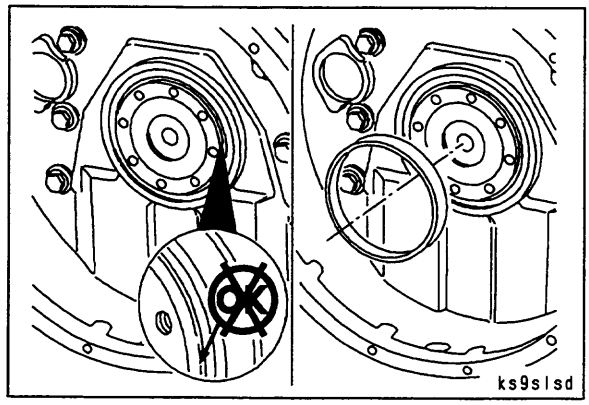
FLYWHEEL HOUSING

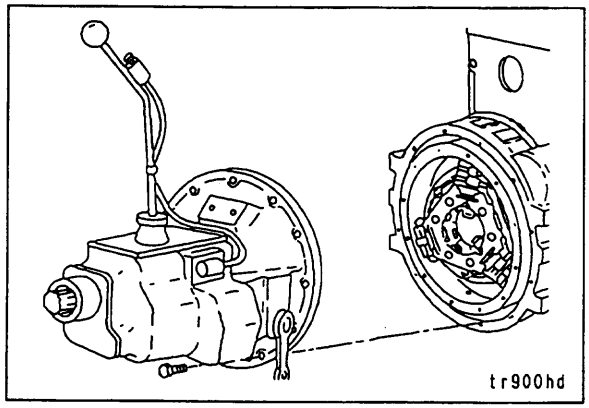
REPLACEMENT OF REAR OIL SEAL

REMOVAL

If the crankshaft seal is wearing the flange groove, install a wear sleeve to prevent leakage of oil.



Remove the drive line, and if the transmission is installed, remove the transmission.

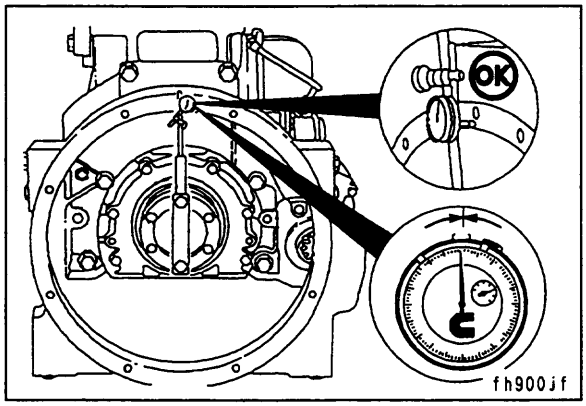


INSPECTION OF FACE RUNOUT OF FLYWHEEL HOUSING

Caution: Be careful not to let the tip of the dial indicator enter the mounting bolt hole. If it enters the hole, the gauge may be damaged.

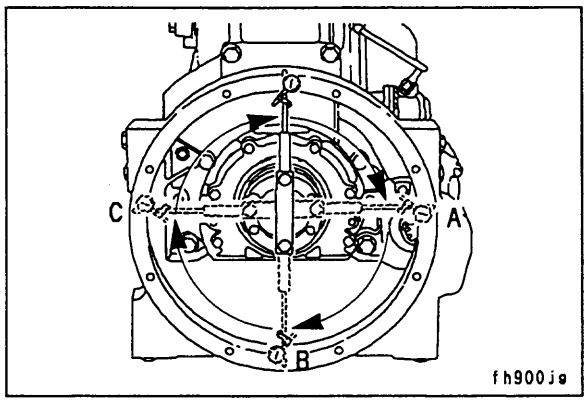
Install the dial indicator as shown in the diagram.

Caution: To ensure the accuracy of the reading, use a sturdy connecting bar. The bar must not bend. Set the indicator to the 12 o'clock position. Adjust the dial so that the indicator points to 0.



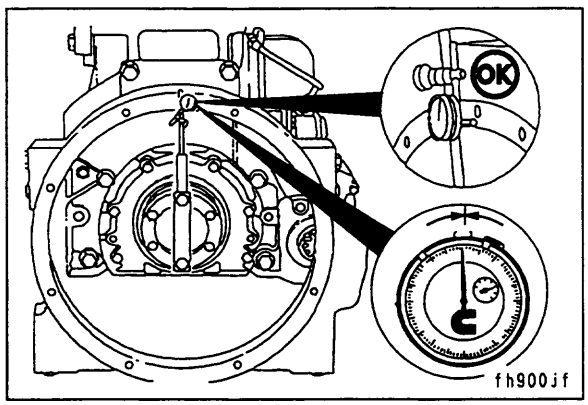
Rotate the crankshaft slowly and note down the readings at the 3 o'clock, 6 o'clock, and 9 o'clock positions.

Caution: Push the crankshaft towards the front of the engine to remove the clearance of the crankshaft in the axial direction each time the position is measured.



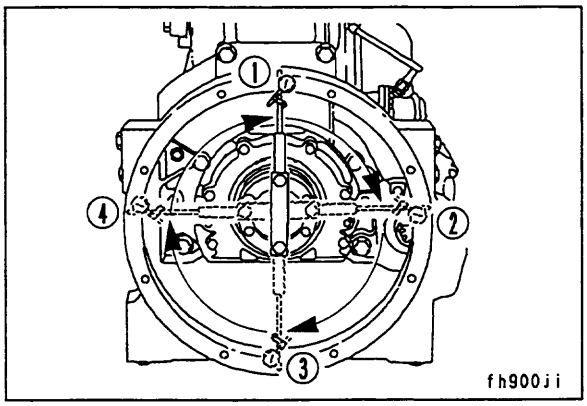
673501

Continue to rotate the crankshaft until the indicator comes to the 12 o'clock position. Check the indicator to confirm that the needle is pointing to the ZERO position. If it is not pointing to 0, the readings will not be accurate.



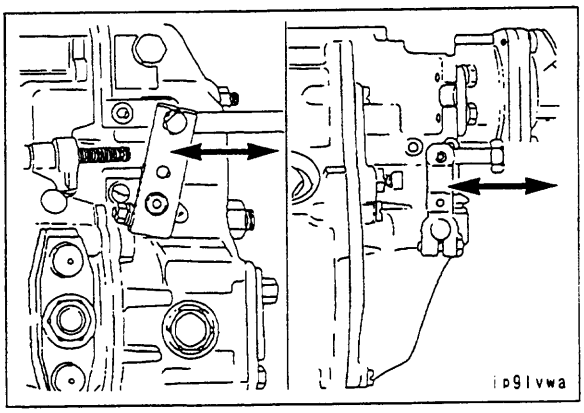
Calculate the total range for the indicator readings.

Example	mm
12 o'clock	0.00
3 o'clock	+0.08
6 o'clock	–0.05
9 o'clock	+0.08
TIR	0.13

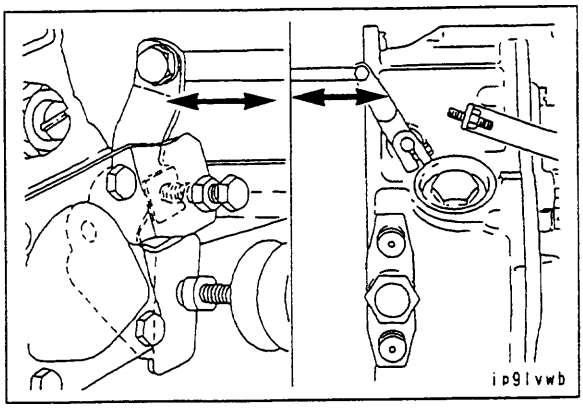


CONNECTION OF FUEL CONTROL LEVER

When connecting the cable/rod to the control lever, adjust the length so that the lever has stop to stop movement.



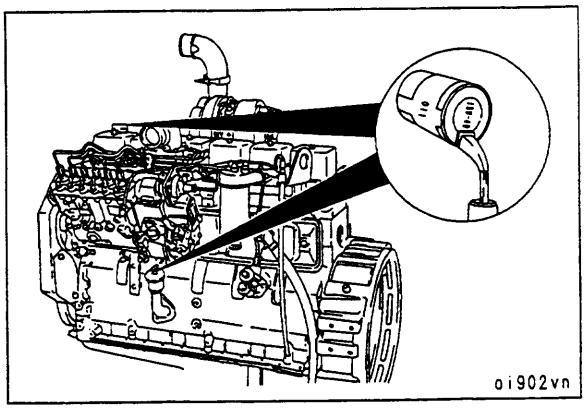
Adjust the length of the cable/rod so that the mechanical shut-off lever moves from stop to stop.



Fill the engine with clean 15W-40 lubricating oil.

Caution: The total capacity for the oil system, including the oil filter, is as follows.
(Use the following values for reference only since they depend on the mounted application.)

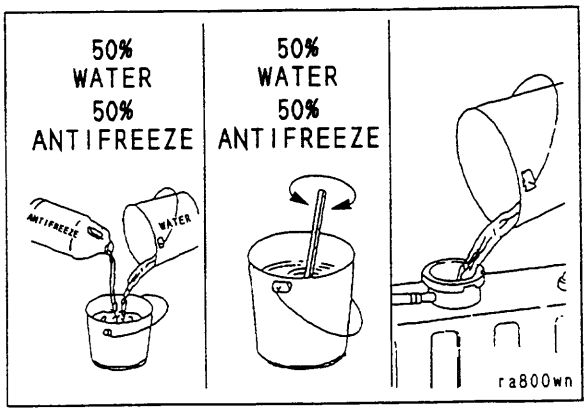
	Liters	US quarts
4-cylinder engine	11.0	11.6
6-cylinder engine	16.4	17.3
Optional 6-cylinder engine	12.6	13.3
Optional 6-cylinder engine (Ford)	18.9	20.0



Prepare a 50:50 mixture of ethylene glycol base anti-freeze and water and DCA4 corrosion resistor, and fill the cooling system.

Caution: The total coolant capacity (engine only) is as follows.

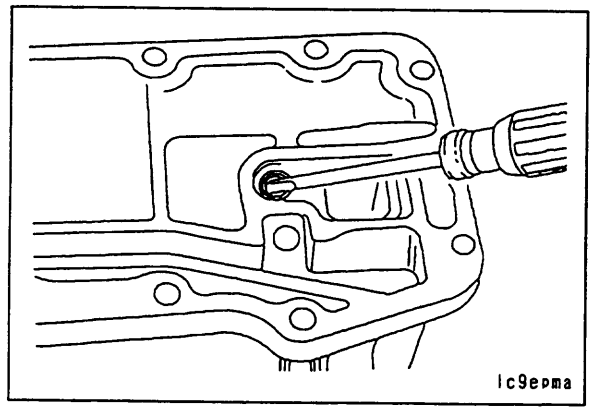
	Liters	US quarts
4-cylinder engine	7	7.4
4-cylinder engine (with water-cooled aftercooler)	9.7	10.3
6-cylinder engine	10.7	11.1
6-cylinder engine (with water-cooled aftercooler	14.5	15.3



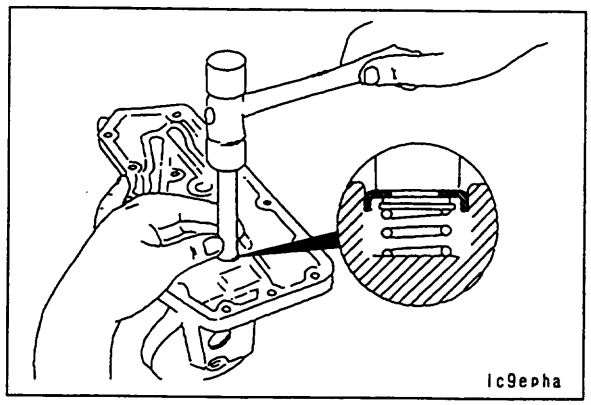
OIL FILTER BYPASS VALVE

REPLACEMENT

Remove the valve from the cooler cover.



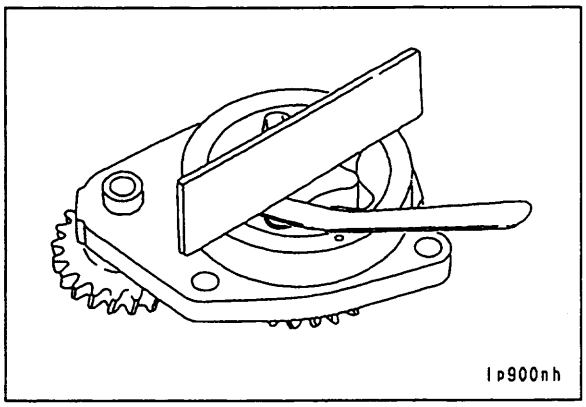
Tap the new valve until it contacts the step in the bore.



673501

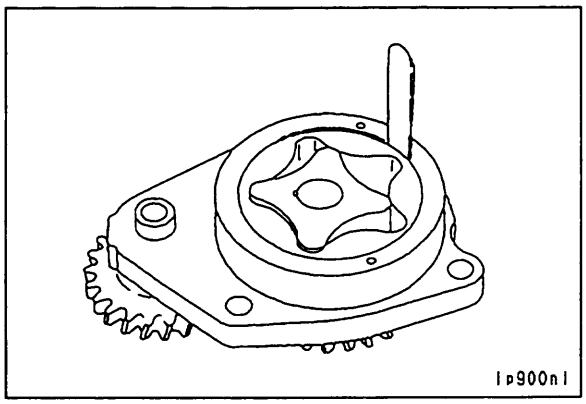
Measure the clearance from the Gerotor drive/planetary portion and port plate.

Wear limit
Max. permissible clearance: 0.127 mm



Measure the clearance between the planetary portion and the Gerotor bore.

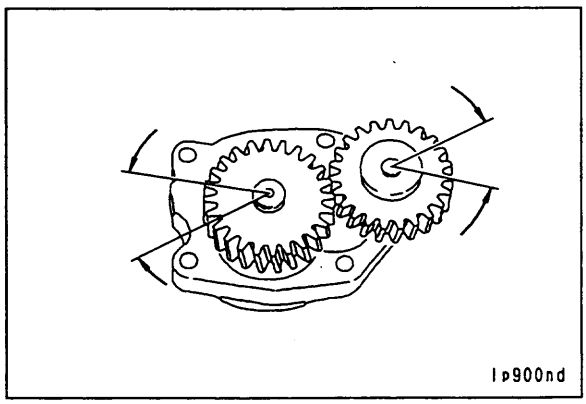
Wear limit
Max. permissible clearance: 0.381 mm



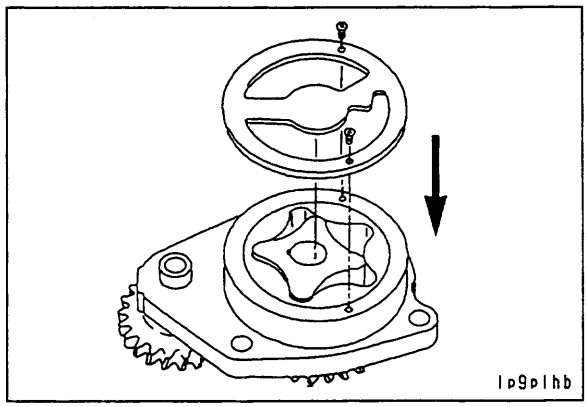
673501

Measure the backlash of the gears.

Wear limit (pump being used) mm	
0.076	Min
0.330	Max



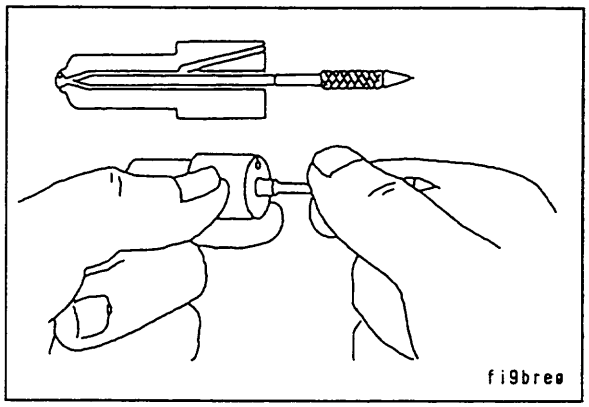
Install the back plate.



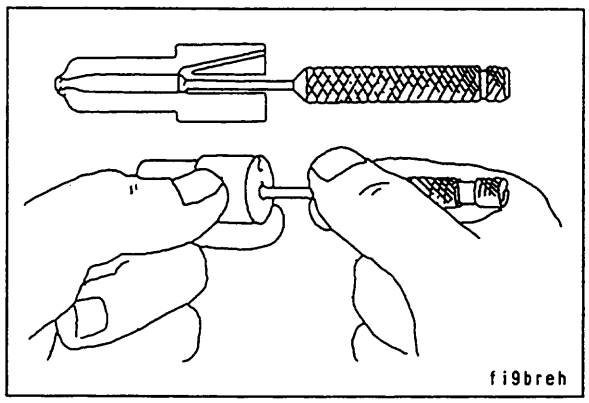
Cleaning kit (795-799-1310)

Caution: When cleaning the nozzle, never use emery paper or any metal scraper.

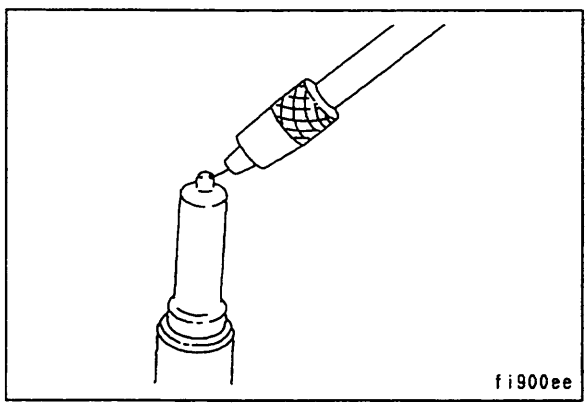
As shown in the diagram, put test oil on the scraper and clean the nozzle seat. Put test oil on a hard piece of wood and polish the needle seat.



As shown in the diagram, clean the ring groove inside the nozzle with a scraper. Rinse in solvent and remove the dirt and carbon deposit, then apply clean test oil.

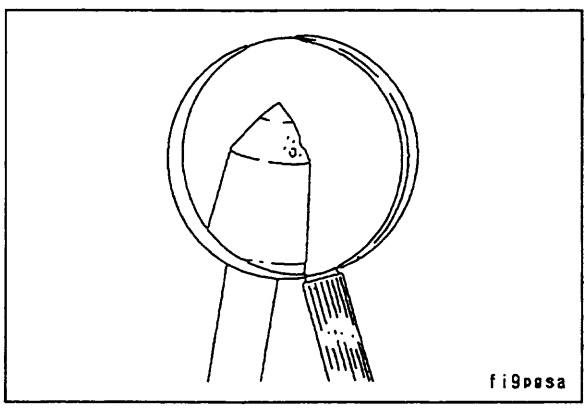


As shown in the diagram, clean the injection port of the hole type nozzle with a cleaning needle that matches the size of the port.
Remove any marks of burning from the nozzle with industrial use detergent. Rinse all parts in clean test oil.



Clean the needle valve tip with a brass wire brush. Check the surface for roughness and corrosion. Normally, the pressure shoulder has the remains of rough machining.

Caution: If the needle valve is deteriorated, replace it as a unit with a nozzle that has interchangeability.



673501

ASSEMBLY (PISTON TYPE)

Preparatory work:

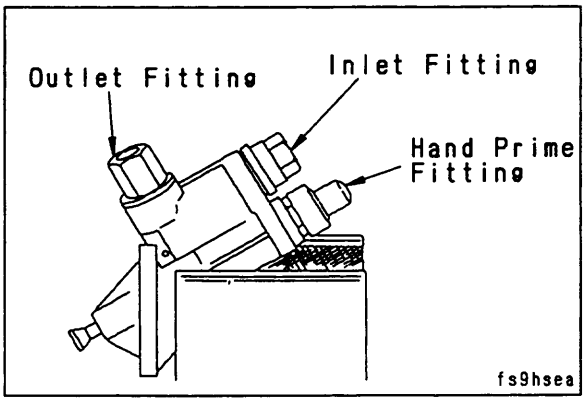
- Wash the dirt and dust off from the fuel line fitting and fuel feed pump.

673501

29 mm, 26 mm wrench

Caution: The hand prime fitting and inlet port fitting are spring type fittings. If these two fittings are removed suddenly, you may injure yourself.

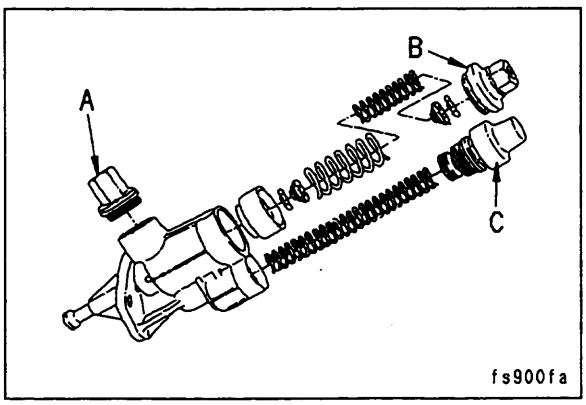
Fix the fuel feed pump in a vice. Be careful not to damage the pump housing.
Remove the rubber boot from the hand prime fitting.
Remove the three fittings shown in the diagram.



Remove all the internal components from the fuel feed pump.

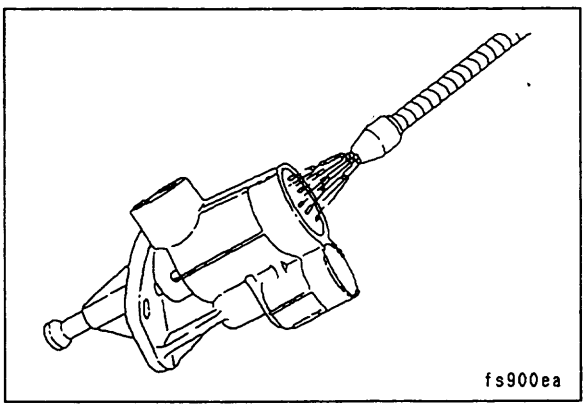
Caution: Check that the check valve gasket has been removed from the inlet port fitting.

(A) Outlet port fitting
(B) Inlet port fitting
(C) Hand prime fitting



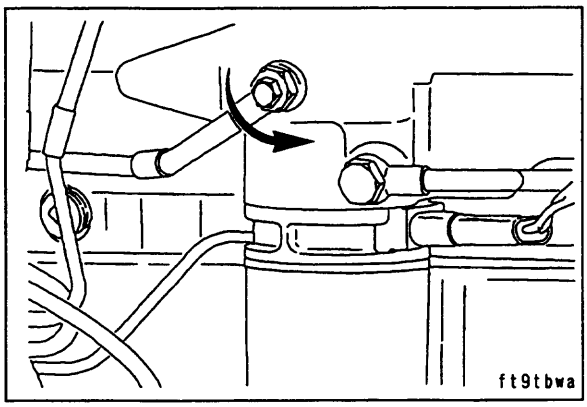
CLEANING

Wash the fuel feed pump thoroughly with detergent to remove the dirt.



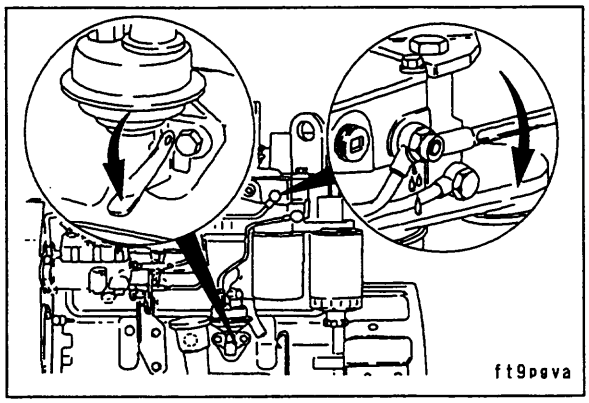
10 mm

Open the banjo bleed screw and bleed the air from the fuel line.



10 mm

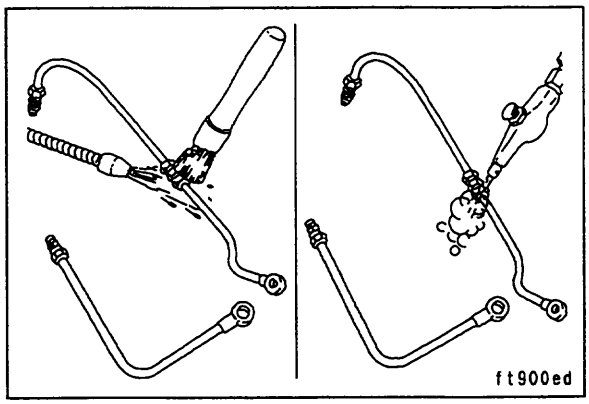
Operate the hand lever until no more bubbles come out with the fuel from the fitting.
Tighten the bleed screw.



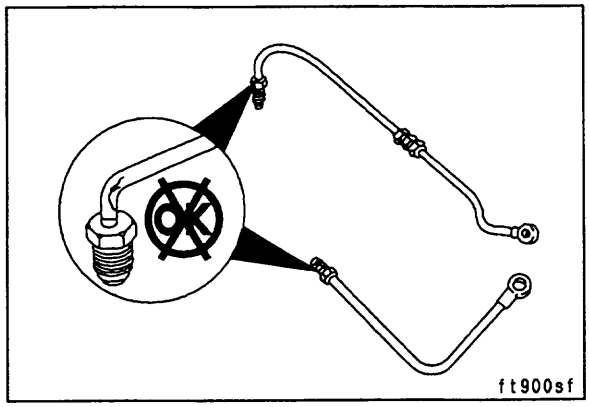
673501

CLEANING AND INSPECTION OF LOW-PRESSURE FUEL PIPING

Wash the low-pressure fuel line with clean detergent, then dry it with compressed air.



Check the line visually for cracks, wear, or other damage.



REPLACEMENT OF BELT

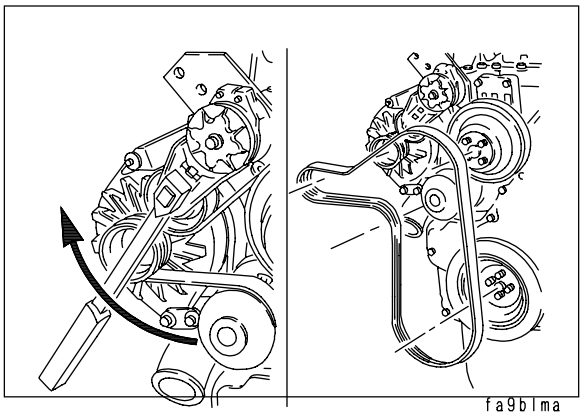
3/8-inch square head

Raise the tensioner and remove the belt.

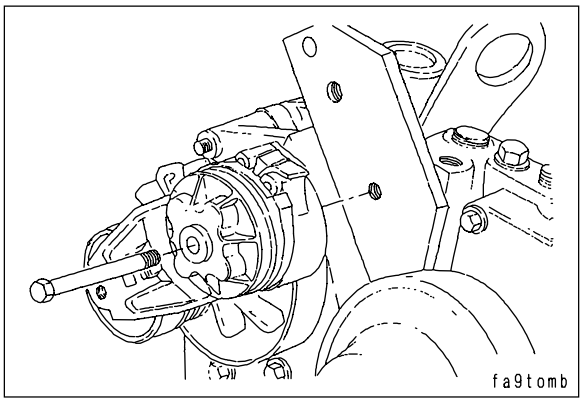
Warning : Make sure that the wrench is secured at the portion square hole before rotating it. (The spring of the tensioner is strong. If the wrench is loosely inserted, the wrench may accidentally come off while being rotated and it is extremely dangerous.)

: After removing the drive belt, return the tensioner slowly with care.

: Be careful not to get your fingers caught between the pulley and drive belt during work.



Caution: The belt tensioner is a spring type, so separate it from the drive belt and rotate it. If the direction of rotation is mistaken, the belt tensioner may be damaged.



REPLACEMENT OF BELT TENSIONER

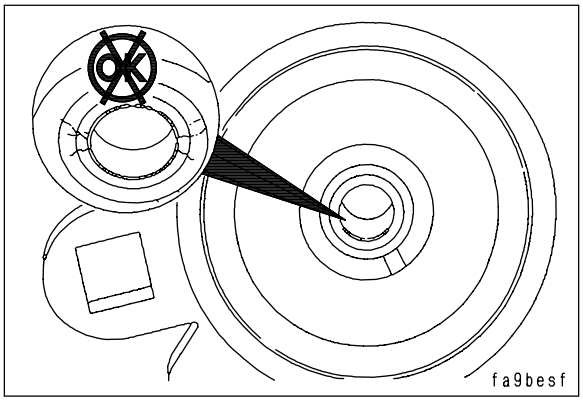
Preparatory work:

- Remove the belt.

15 mm

Remove the mounting bolts, then replace the tensioner.

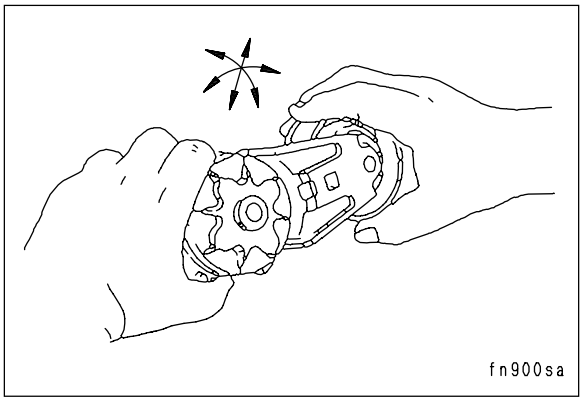
kgm: **43 Nm {4.4 kgm}**



INSPECTION

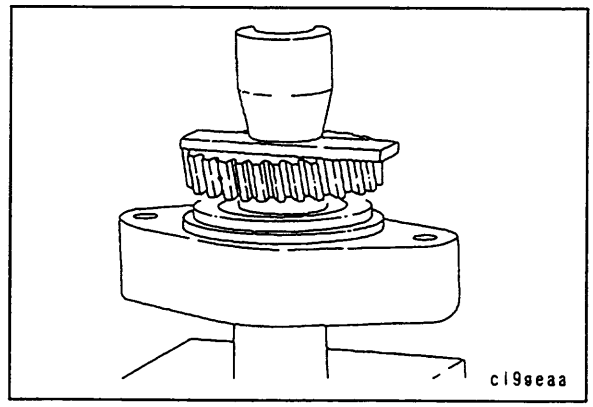
Check that there is no excessive wear and enlargement of the hole at the tensioner pivot tube portion. If the tensioner is excessively worn, replace it.

Rotate the bearing and check that there is no rough portion and that it rotates freely.



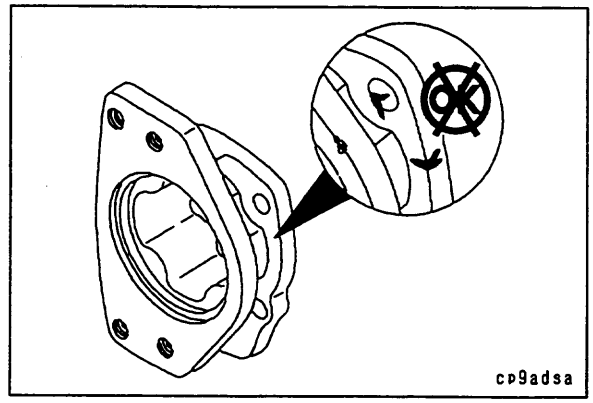
1.25-inch pipe connector

Support the bottom of the shaft with a 1.25-inch pipe connector, then push in until the gear contacts the bottom of the inner bearing race.



Power steering adapter

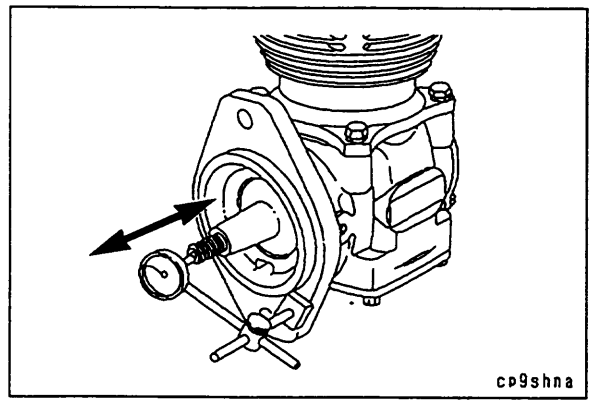
Check the adapter, if there is any damage, replace it.



673501

Measure the clearance at the crankshaft end of the single-cylinder air compressor.

Clearance at crankshaft end mm	
0.05	Min
0.15	Max



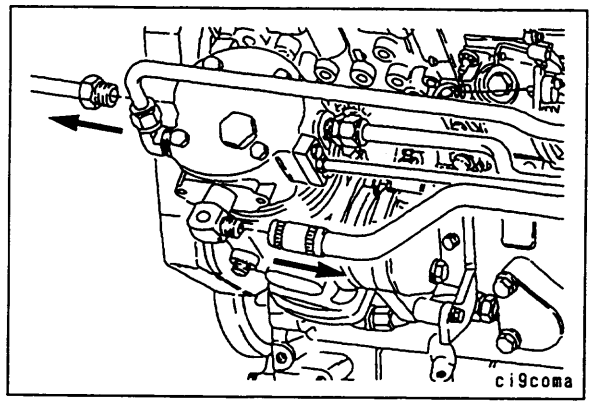
REPLACEMENT OF AIR COMPRESSOR

Preparatory work:

- Clean the air compressor with steam, then dry with compressed air.
- If there is a water-cooled cylinder head installed to the compressor, drain the engine coolant. If the air compressor is air cooled, there is no need to drain the engine coolant.
- Open the wet tank drain valve and release the air from the line.
  After releasing the pressure, close the drain valve.

REMOVAL

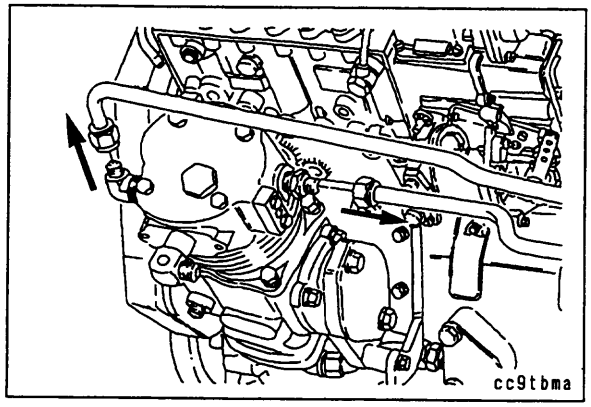
Remove the air connector from the air compressor.



673501

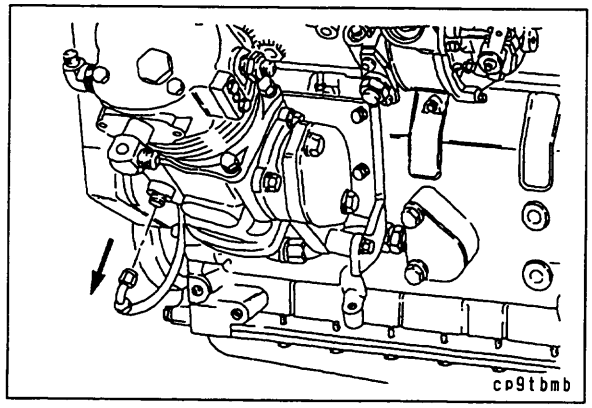
15/16 inch, 7/8 inch

Remove the coolant line from the air compressor (this does not apply to air-cooled compressors).



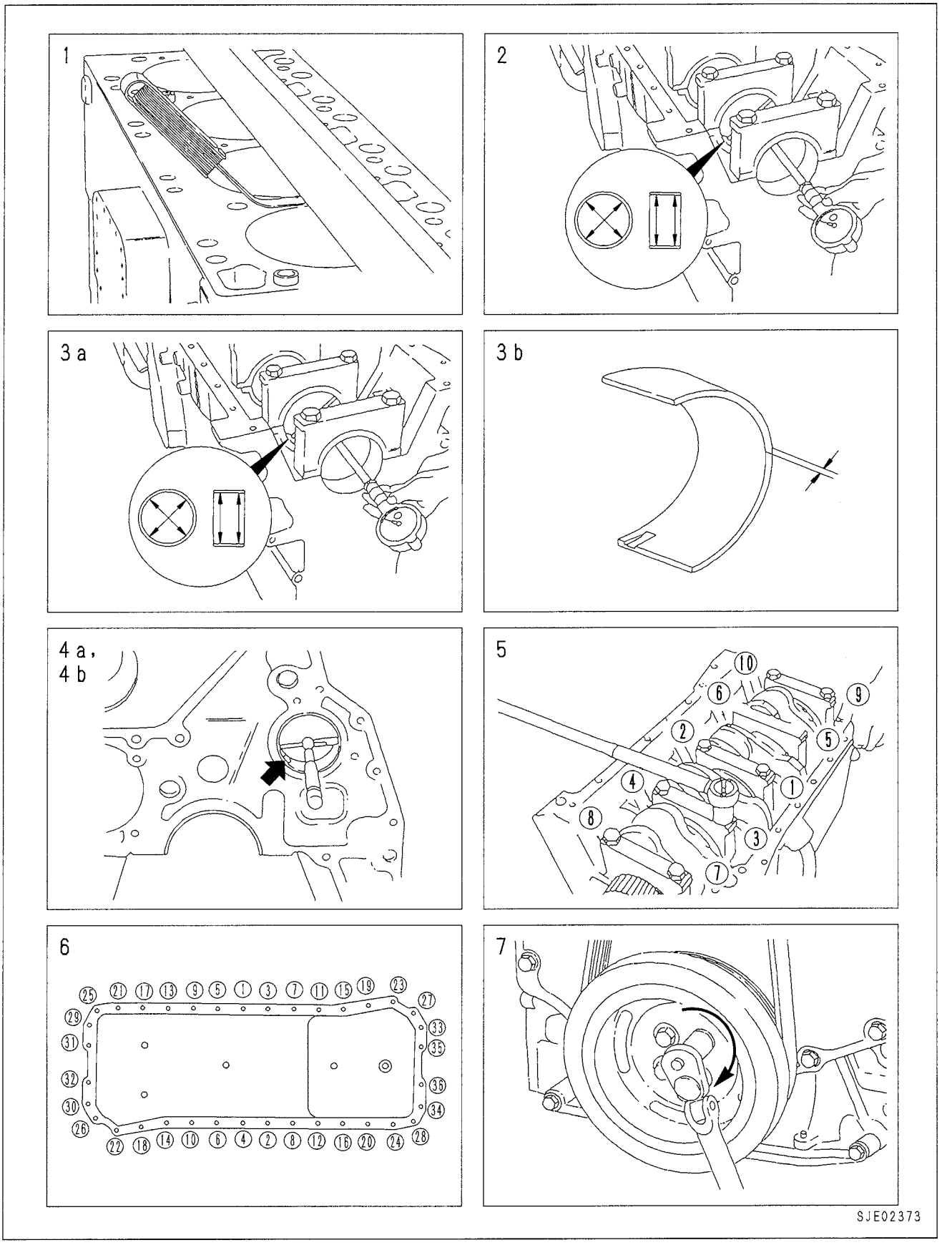
9/16 inch

Remove the oil supply line.

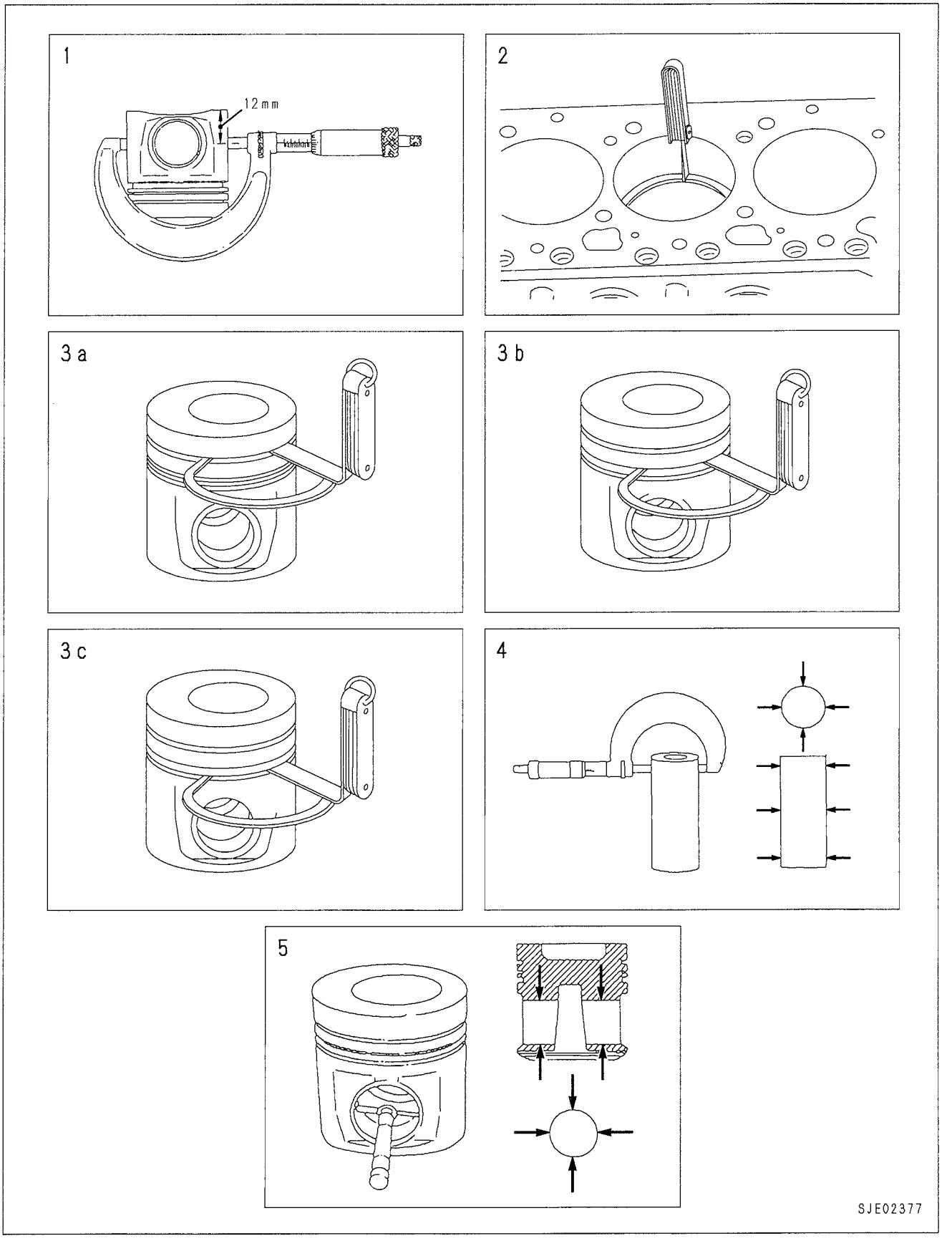


14 MAINTENANCE STANDARD

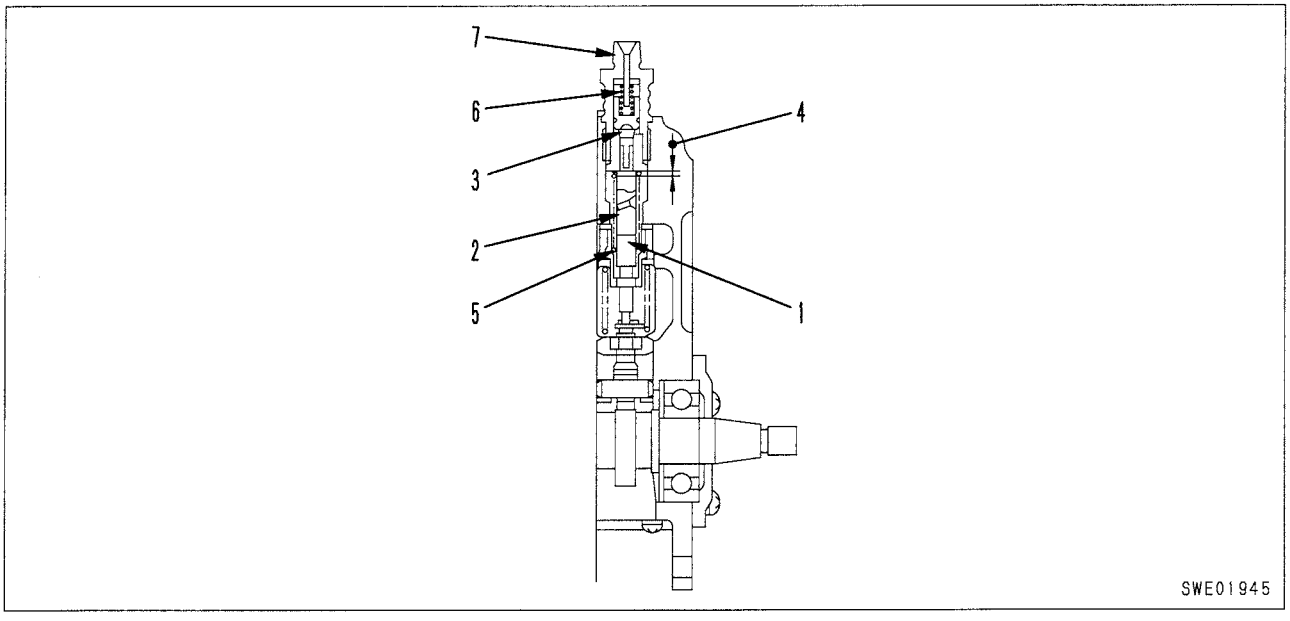
CYLINDER BLOCK



PISTON, PISTON RING AND PISTON PIN



FUEL INJECTION PUMP



Unit : mm

No.	Check item	Criteria			Remedy
1	Outside diameter of plunger	Standard size	Tolerance	Repair limit	Replace plunger assembly
		—	—	—	
2	Function of plunger	Generated pressure standard			
3	Function of delivery valve	Time for pressure to drop Standard:			Correct or replace
4	Clearance at plunger head	Standard clearance	Clearance limit		Replace plunger guide
		—	Cam lift at mm		
–	Sliding resistance of control rack	Repair limit: —			Correct
5	Free length of plunger spring	Standard size	Repair limit		Replace
		—	—		
	Installed load of plunger spring	Installed length	Installed load	Load limit	
		—	—	—	
6	Free length of delivery valve spring	Standard size	Repair limit		
		—	—		
	Installed load of delivery valve spring	Installed length	Installed load	Load limit	
		—	—	—	
7	Tightening torque of delivery valve holder	—			Tighten
–	Tightening torque of fuel injection pump mounting bolt	43Nm, {44 kgm}			

METHOD OF USING FILLER METAL IN EMERGENCY REPAIRS

The explanation for this procedure gives information regarding the method of use of compound filler metal in emergency repairs.

Repair methods using filler metal must not be used as a substitute for permanent repair or replacement of parts.

Filler metal can be used to provide temporary limitation of permeation, adjustment of the surface, or cover for chipped parts.

⚠ WARNING:
Do not attempt to use this method for repair of components or parts related to safety.

It is possible to obtain metal filler based on various metals, such as iron, brass, or aluminium. Check that the filler metal matches the material of the part being repaired. The filler metal must have the same resistance to temperature, stress, and pressure as the material of the part being repaired.

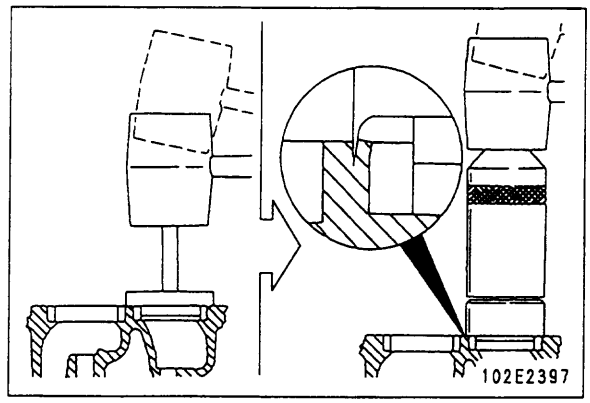
Metal filler compounds have many purposes: some can be used to join different types of metals, while others cannot be used for such purposes. To achieve a good result, follow the recommendations of the manufacturer.

673501

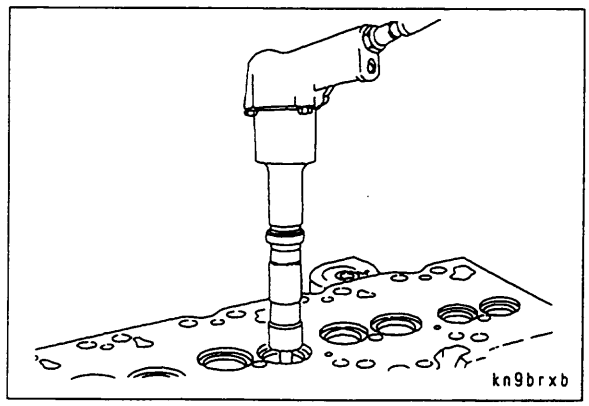
Staking tool

Push the valve seat into the valve seat pocket. For details of the current valve seat part number, see the parts.

Push the valve seat into the pocket.



Grind the valve seat lightly to provide a suitable seat angle.

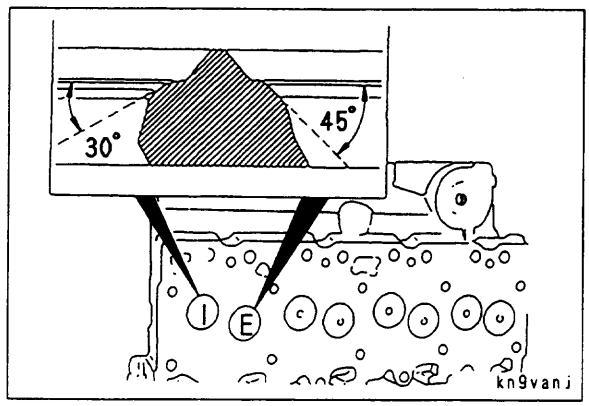


673501

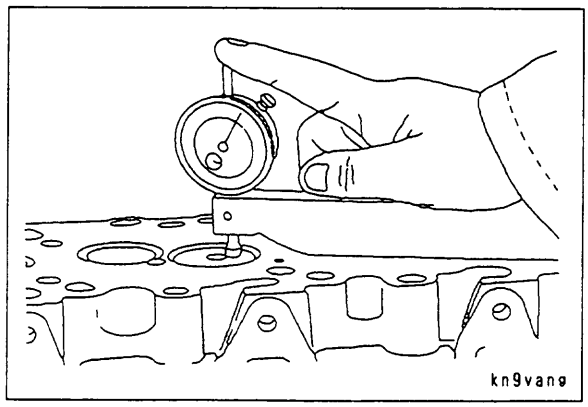
Seat angle

Intake valve: 30°

Exhaust valve: 45°



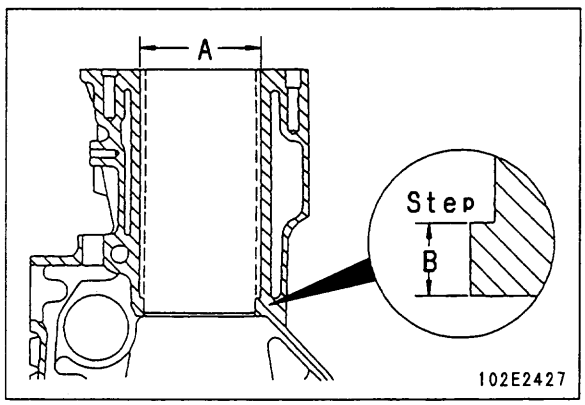
Install the valves to the specified position, then measure the depth.



INSTALLATION OF REPAIR SLEEVE

Repair sleeve part number 6736-29-2110

If an oversize bore of more than diameter 1.00 mm is needed, the hole must be made in the block again and the repair sleeve installed. After installing, the sleeve bore must be finished again to a diameter of 102.020±0.020 mm. Use the standard diameter piston and service piston ring set.



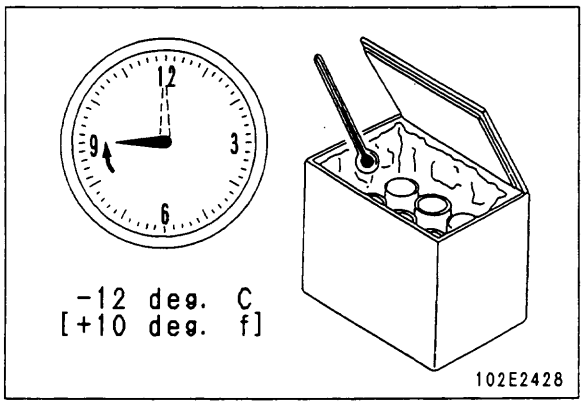
Making a new hole in block for repair sleeve

A = 104.515 + 0.015 mm
104.500 — 0.000 mm

B = 6.35 mm

After completely making the hole, remove all metal chips, particles, and oil completely from the bore, and install the repair sleeve.

Cool the repair sleeve at –12°C (+10°F) for at least one hour. Remove the sleeves one at a time and install them to the block as follows.



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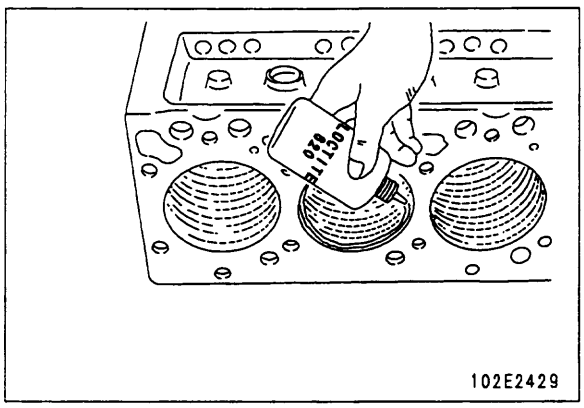
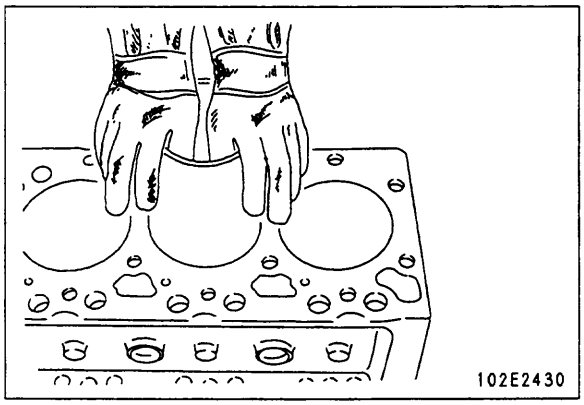
When installing the sleeve, coat each bore one at a time with Loctite™620.

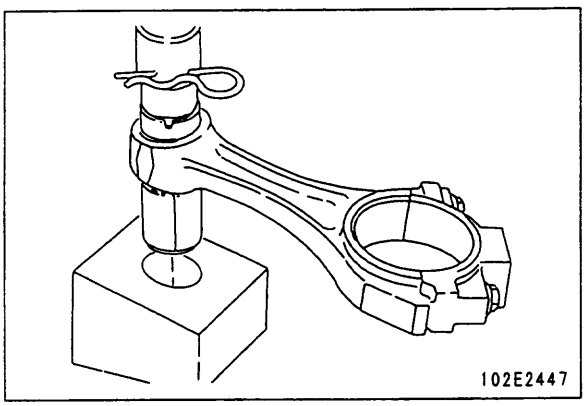


Using protective gloves, push the frozen sleeves as far as possible into the bore by hand.

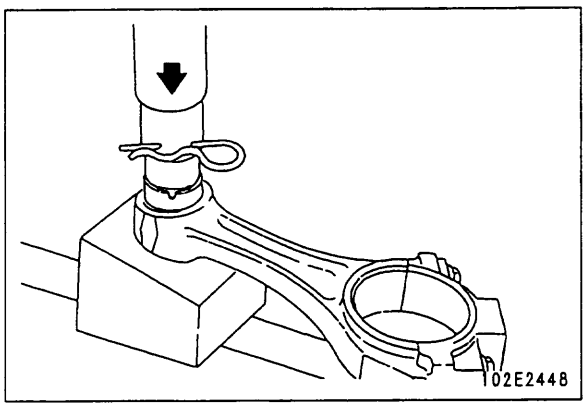


Install the mandril to the anvil.

Adjust the rod so that the angle of the rod matches the angle of the anvil. The rod should be horizontal.



Apply pressure to the top of the cup to push out the bushing. Push the bushing in to the bottom of the bore.



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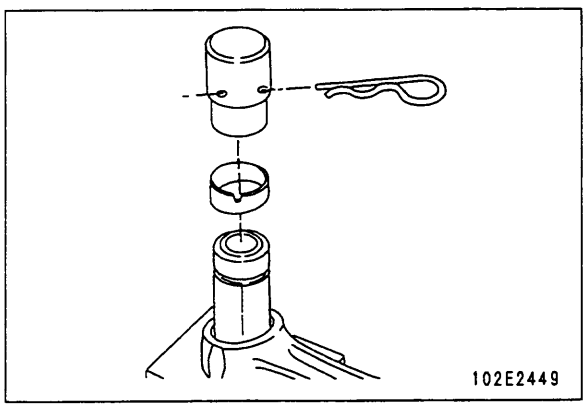
Remove the hair pin cotter. Remove the cup, then slide the rod from the mandril.



Remove the bushing and measure the connecting rod bushing bore.

Caution: If the connecting rod bushing bore is not the specified value, replace the connecting rod.

Diameter mm	
42.987	MIN
43.013	MAX