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 12-04(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:

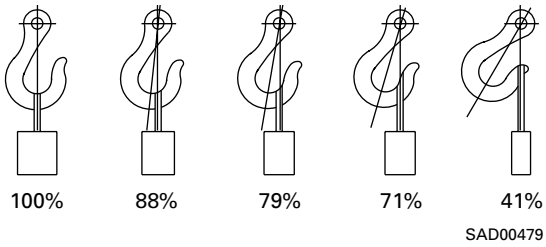
Wire ropes
(Standard "Z" or "S" twist ropes
without galvanizing)

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.

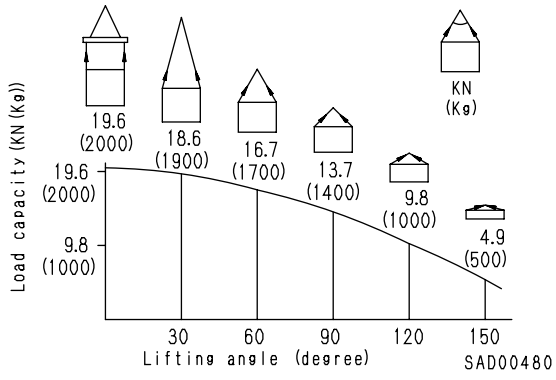
Slinging near the edge of the hook may cause the rope to slip off the hook during hoisting, and a serious accident can result. Hooks have maximum strength at the middle portion.



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

SYMBOLS

The following symbols have been used in this manual to help communicate the intent of the instructions. When one of the symbols appears, it conveys the meaning defined below:

WARNING - Serious personal injury or extensive property damage can result if the warning instructions are **not** followed.

CAUTION - Minor personal injury can result or a part, an assembly, or the engine can be damaged if the caution instructions are **not** followed.

Indicates a **REMOVAL or DISASSEMBLY** step.

Indicates an **INSTALLATION or ASSEMBLY** step.

INSPECTION is required.

CLEAN the part or assembly.

PERFORM a mechanical or time **MEASUREMENT.**

LUBRICATE the part or assembly.

Indicates that a **WRENCH or TOOL SIZE** will be given.

TIGHTEN to a specific torque.

PERFORM an electrical **MEASUREMENT.**

Refer to another location in this manual or another publication for additional information.

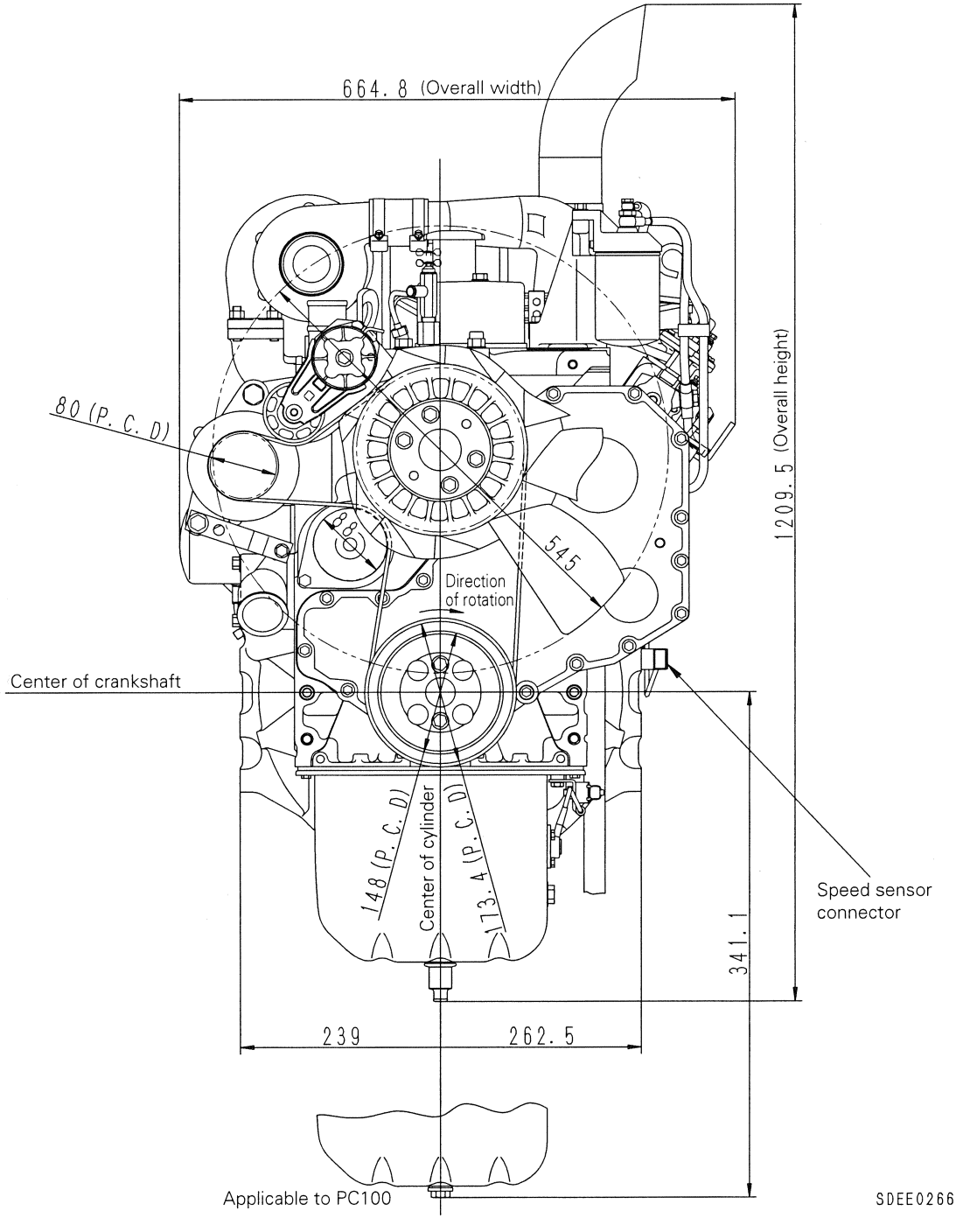
The component weights 23 kg (50 lb) or more. To avoid personal injury, use a hoist or get assistance to lift the component.

		6D102E-1		
D41A-6				
		6 – 102 x 120 5.88 {5,883} 1 – 5 – 3 – 6 – 2 – 4		
1,011 608 876 —				
59.7/2,400 {80.0/2,400} (Net) 343/1,300 {35.0/1,300} (Net) 2,650 825 219 {163}				
450				
		LUCAS rotary type all apeed type		
26.8 (22.8)				
9.0 (engine only)				
24V, 35A 24V, 4.5kW 12V65Ah x 2				
— — —				

Engine			SAA6D102E-2		
Applicable model			PC200-7 PC200LC-7	PC228US-3 PC228USLC-3	PC308USLC-3 BR380JG-1 PC270-7
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	1,320	1,320	1,320
	Overall width	mm	750	750	750
	Overall height (excluding exhaust pipe)	mm	1,380	1,380	1,443
	Overall height (including exhaust pipe)	mm	—	—	—
Performance	Flywheel horsepower	kW{HP}/rpm	107{143}/1,950 (Net)	107{143}/1,950 (Net)	134{180}/2,050 (Net)
	Max. torque	Nm{kgm}/rpm	610{62.2}/1,500 (Net)	610{62.2}/1,500 (Net)	718{73.3}/1,500 (Net)
	High idling speed	rpm	2,200 ± 30	2,200 ± 30	$2{,}330^{+70}_{-30}$
	Low idling speed	rpm	1,050 ± 25	1,050 ± 25	1,050 ± 25
	Min. fuel consumption ratio	g/kW•h {g/HP•h}	203 {151}	203 {151}	218 {160}
Dry weight		kg	550	550	550
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)	26.3 (24.0)
Coolant amount		ℓ	9.0 (engine only)	9.0 (engine only)	9.0 (engine only)
Alternator			24V, 35A	24V, 35A	24V, 35A
Starting motor			24V, 4.5kW	24V, 4.5kW	24V, 4.5kW
Battery			12V120Ah x 2	12V120Ah x 2	12V120Ah x 2
Turbocharger			HOLSET HX35 type	HOLSET HX35 type	HOLSET HX35 type
Air compressor			—	—	—
Others			With air cooled aftercooler	With air cooled aftercooler	With air cooled aftercooler

S4D102E-1 (PC100-6)

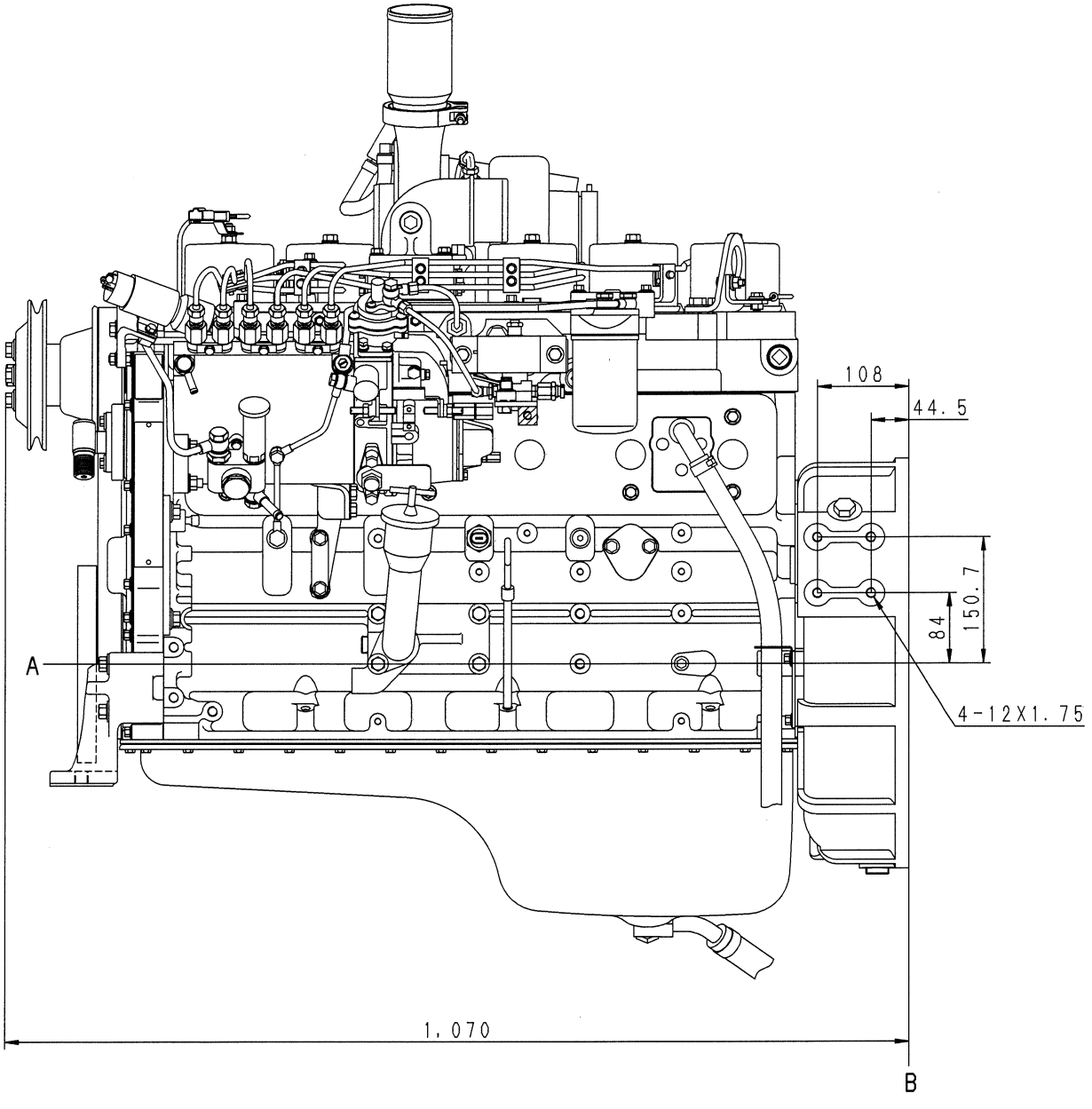
FRONT VIEW



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

LEFT-HAND VIEW

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

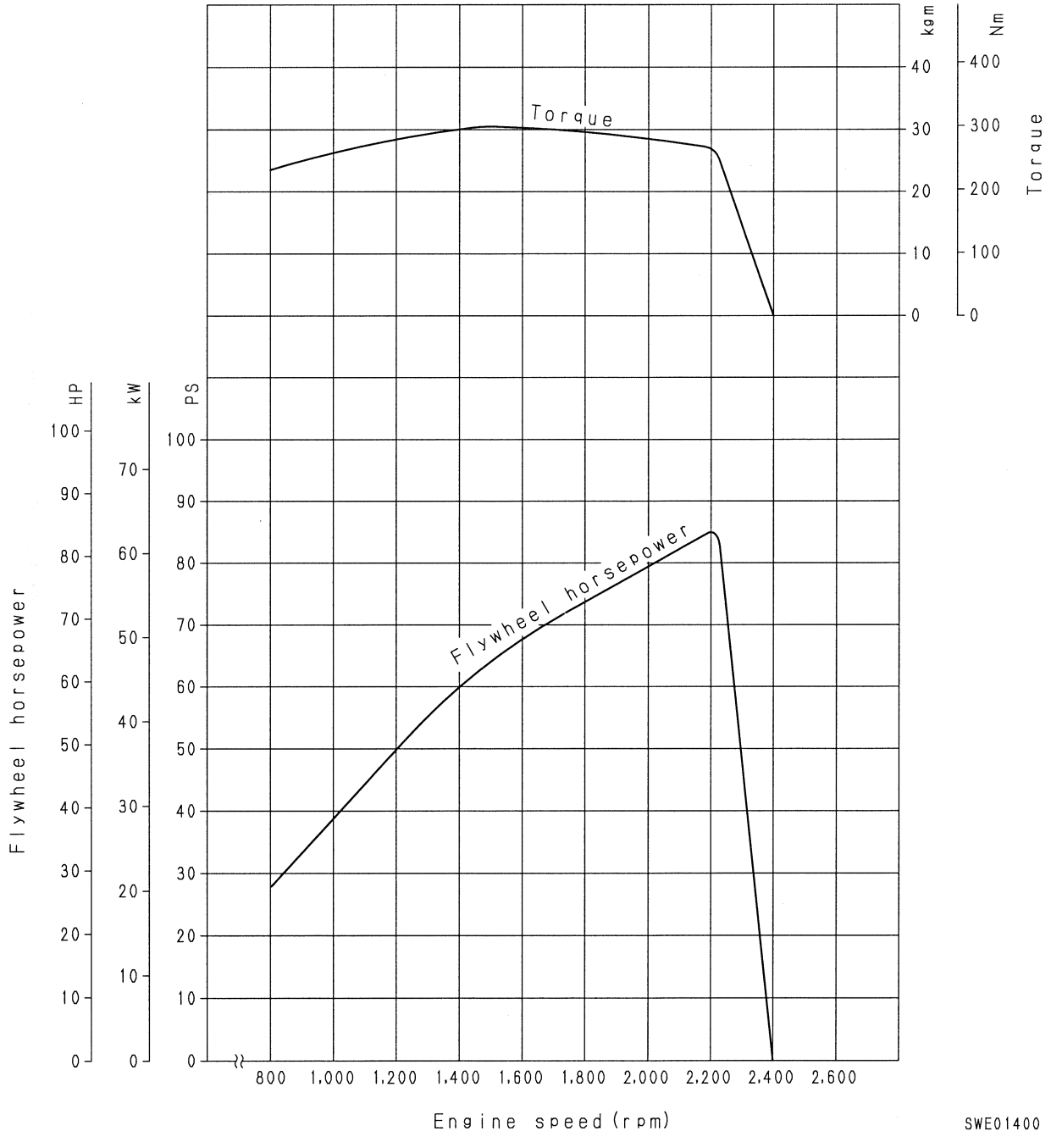


SJE02404

A. Center of crankshaft
B. Rear surface of flywheel housing

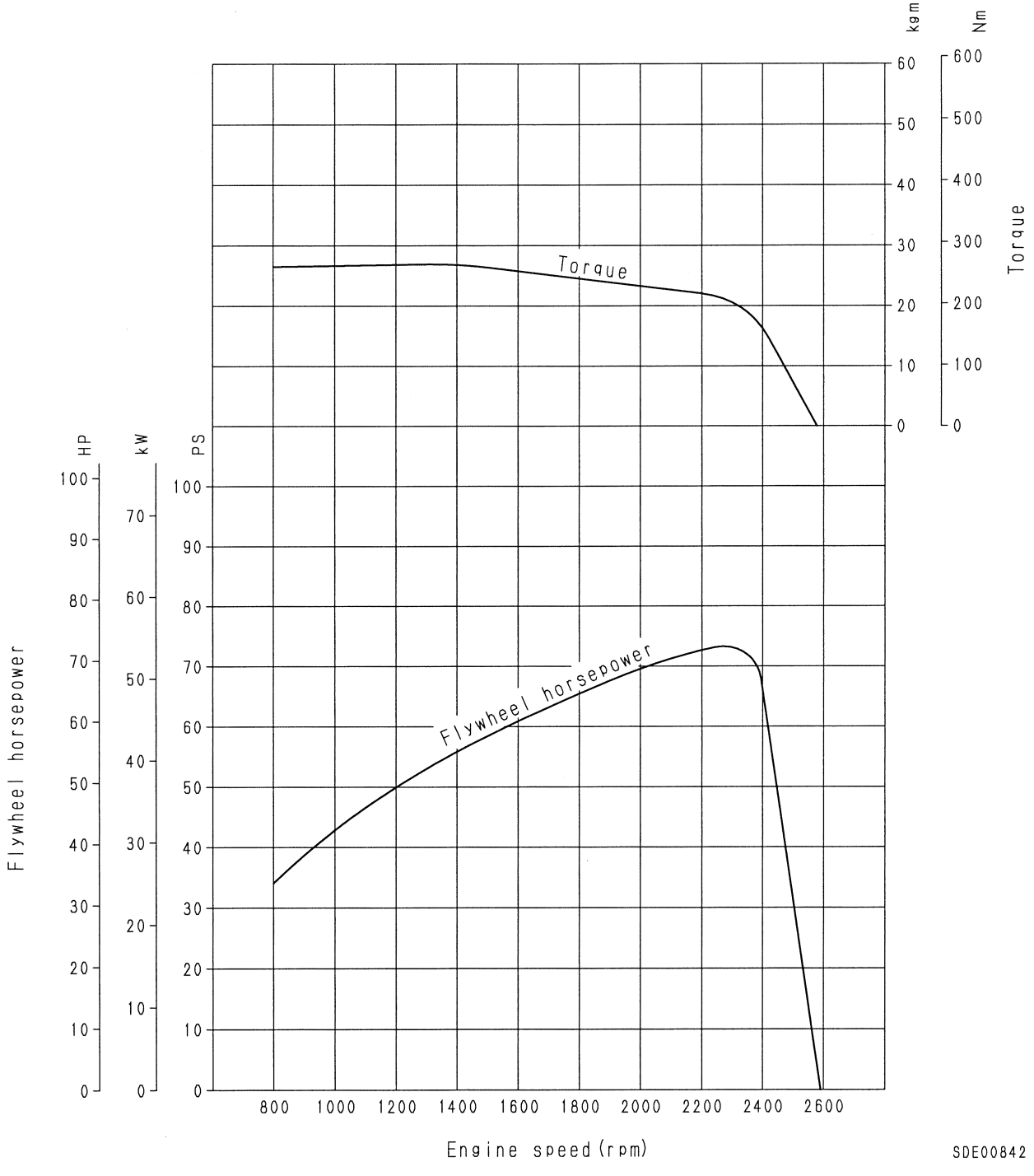
S4D102E-1 (PC120-6 EXCEL)

Flywheel horsepower : 62.5 kW {83.8 HP} /2,200 rpm (Net)
Maximum torque : 299 Nm {30.5 kgm} /1,500 rpm (Net)



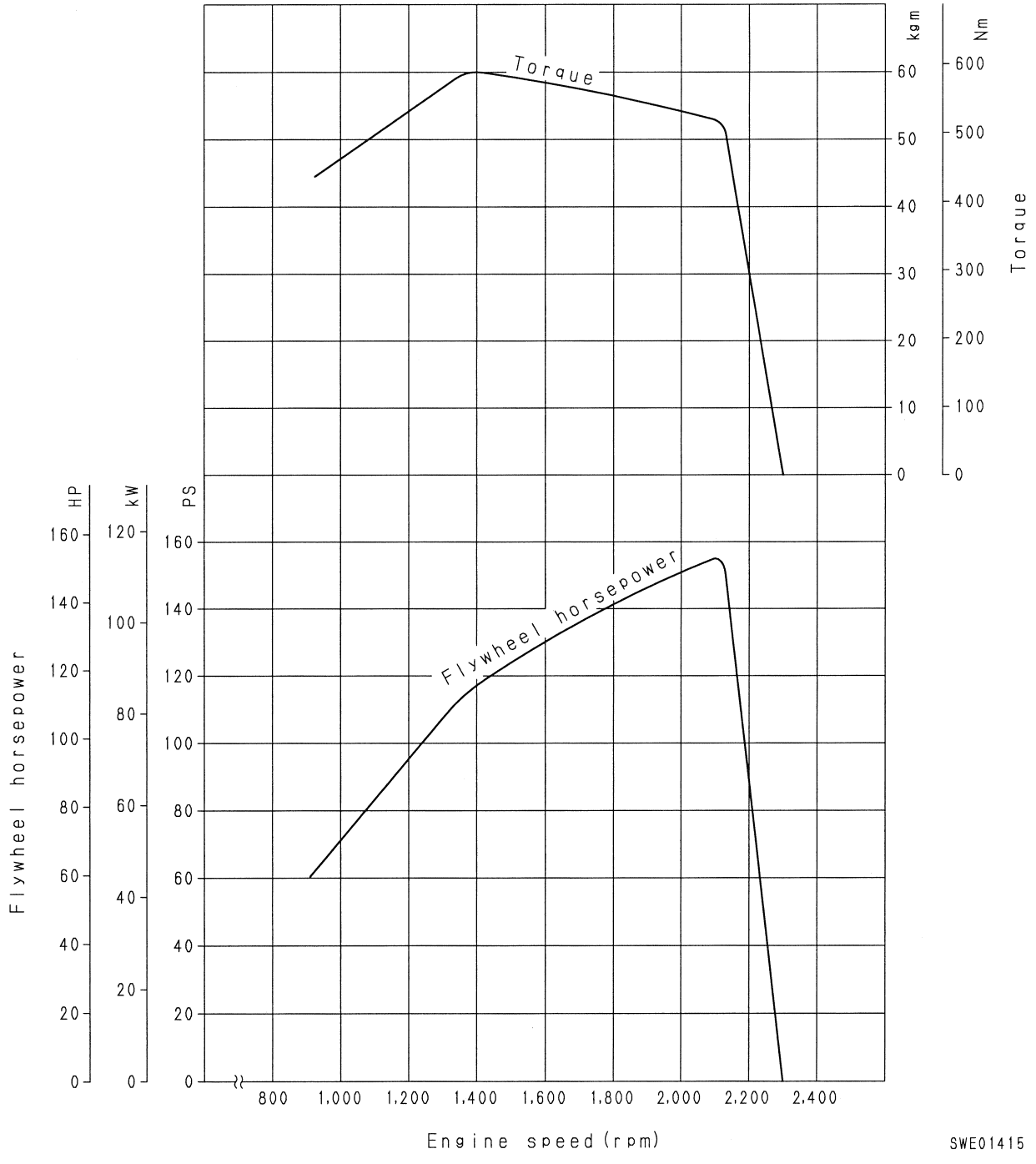
S4D102E-1 (D31E, S, Q, P, PL, PLL-20, D31P-20A)

Flywheel horsepower : 52.2 kW {70.0 HP} /2,350 rpm (Net)
Maximum torque : 265 Nm {27.0 kgm} /1,400 rpm (Net)



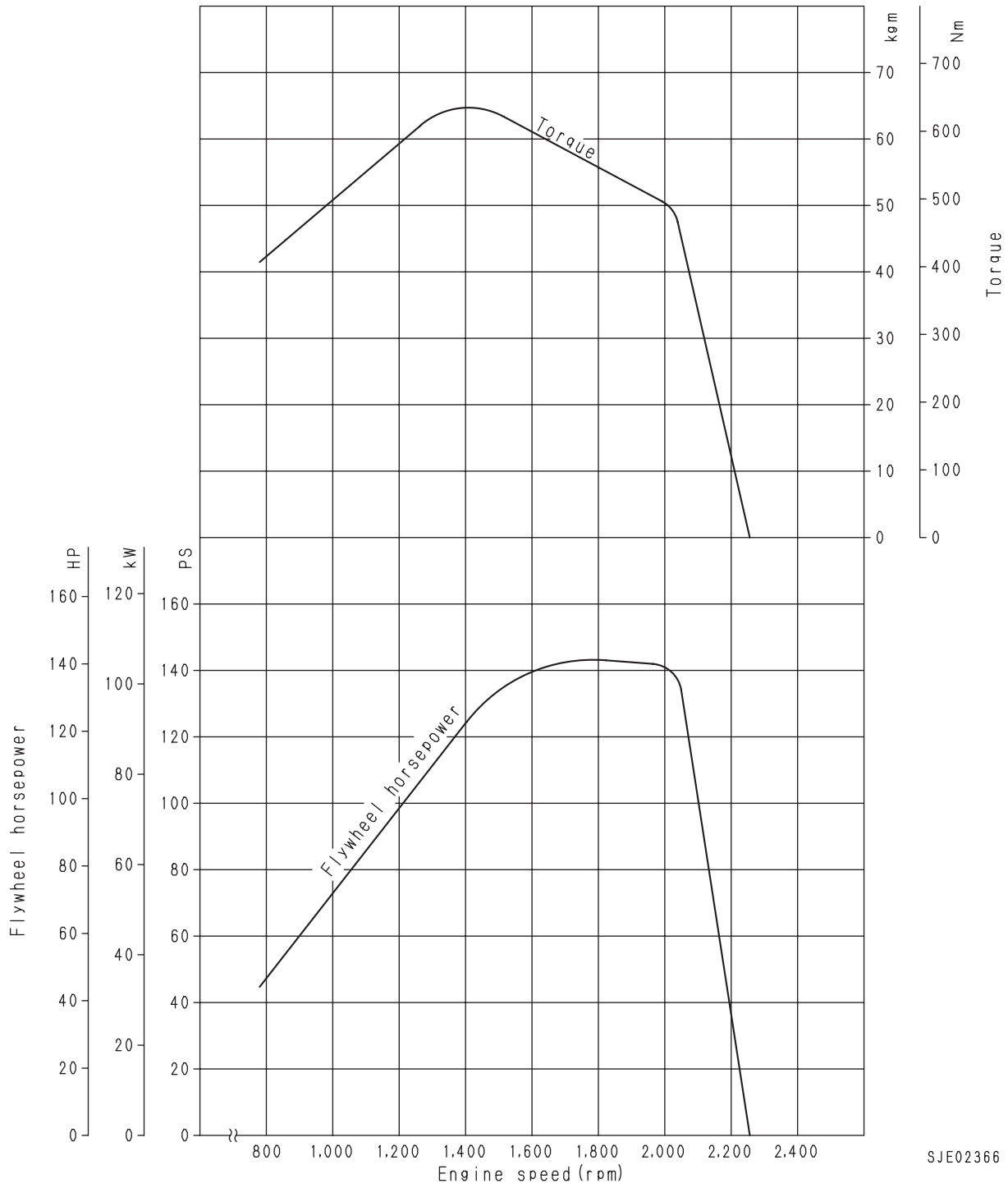
SA6D102E-1 (PC220 • 220LC-6 EXCEL)

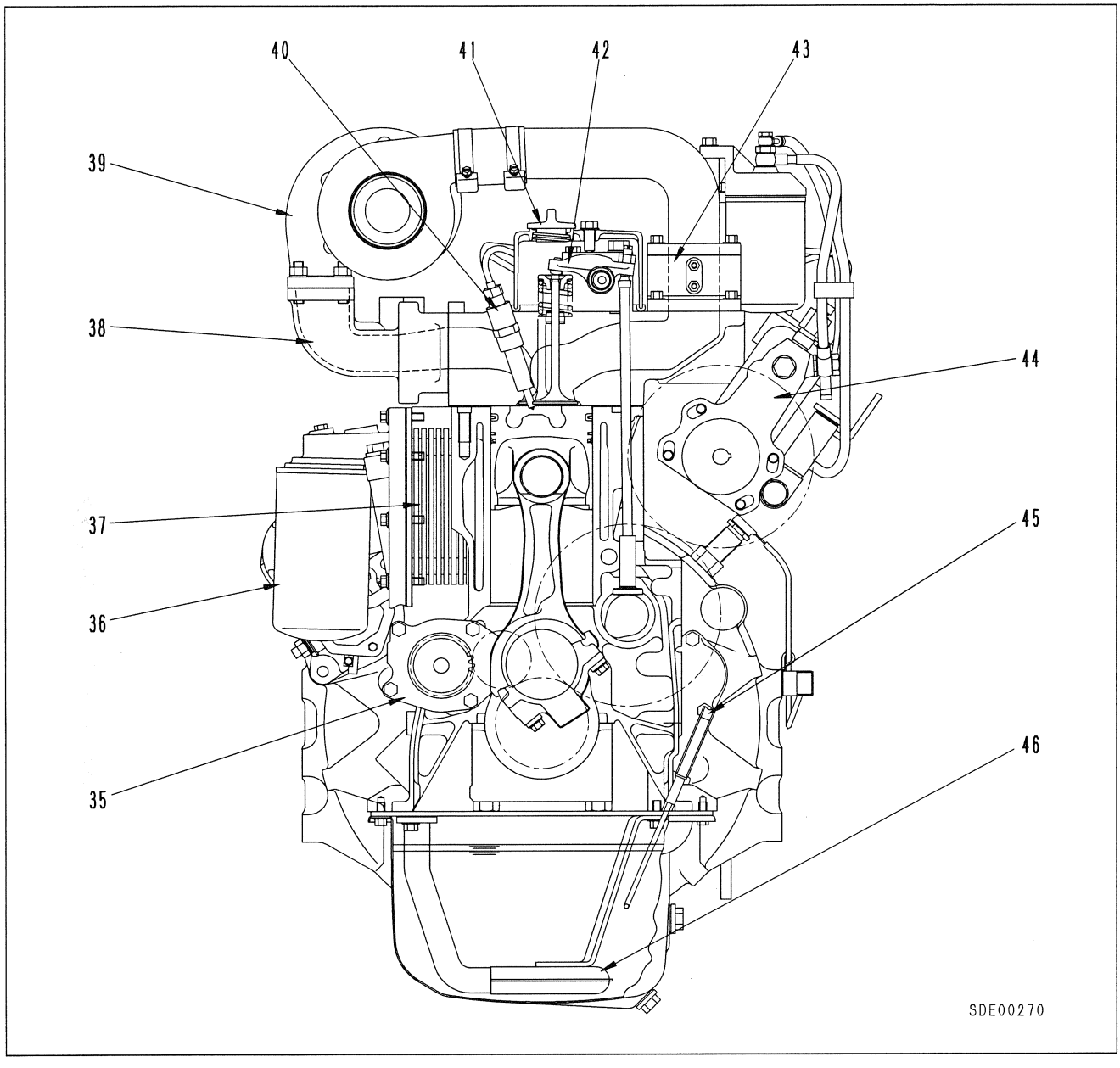
Flywheel horsepower : 114 kW {153 HP} /2,100 rpm (Net)
Maximum torque : 588 Nm {60 kgm} /1,400 rpm (Net)



SAA6D102E-2 (WA250-5, WA250PT-5)

Flywheel horsepower : 104.1 kW {139.5 HP} /2,000 rpm (Gross)
Maximum torque : 627 Nm {64 kgm} /1,400 rpm (Gross)





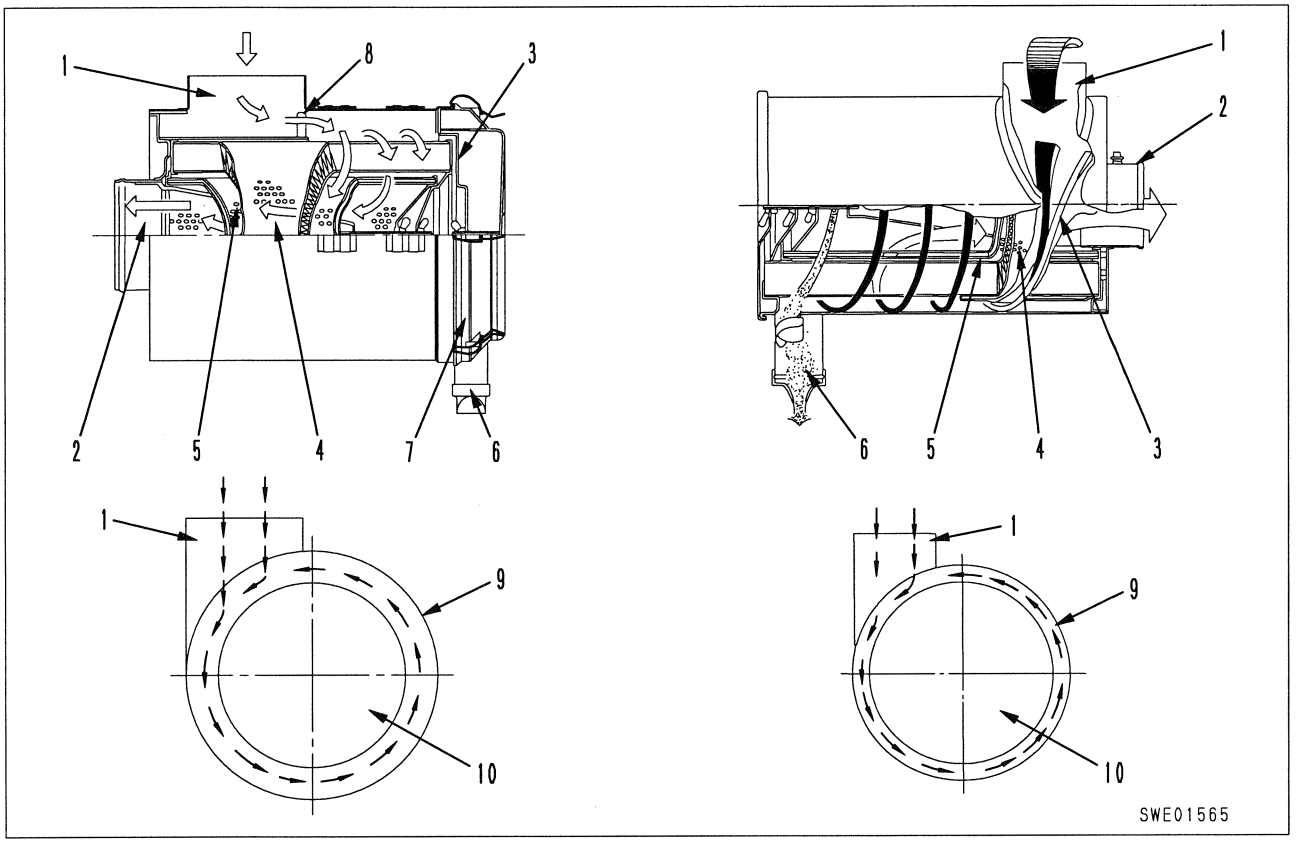
31. Rear seal
32. Oil pan
33. Camshaft
34. Connecting rod cap
35. Starting motor
36. Oil filter
37. Oil cooler
38. Exhaust manifold
39. Turbocharger (S4D102E-1)
40. Fuel injection nozzle
41. Oil filler cap
42. Rocker cam
43. Electrical heater (electrical intake air heater)
44. Fuel injection pump
45. Oil level gauge
46. Oil strainer

Engine
Name: (S)4D102E-1
SAA4D102E-2
Type: In-line, 4 cylinder, water cooled Direct injection type 4-cycle diesel engine

AIR CLEANER

★ Details may differ according to the machine model.

FRG type (radial seal type) **FTG type (cyclopack type)**



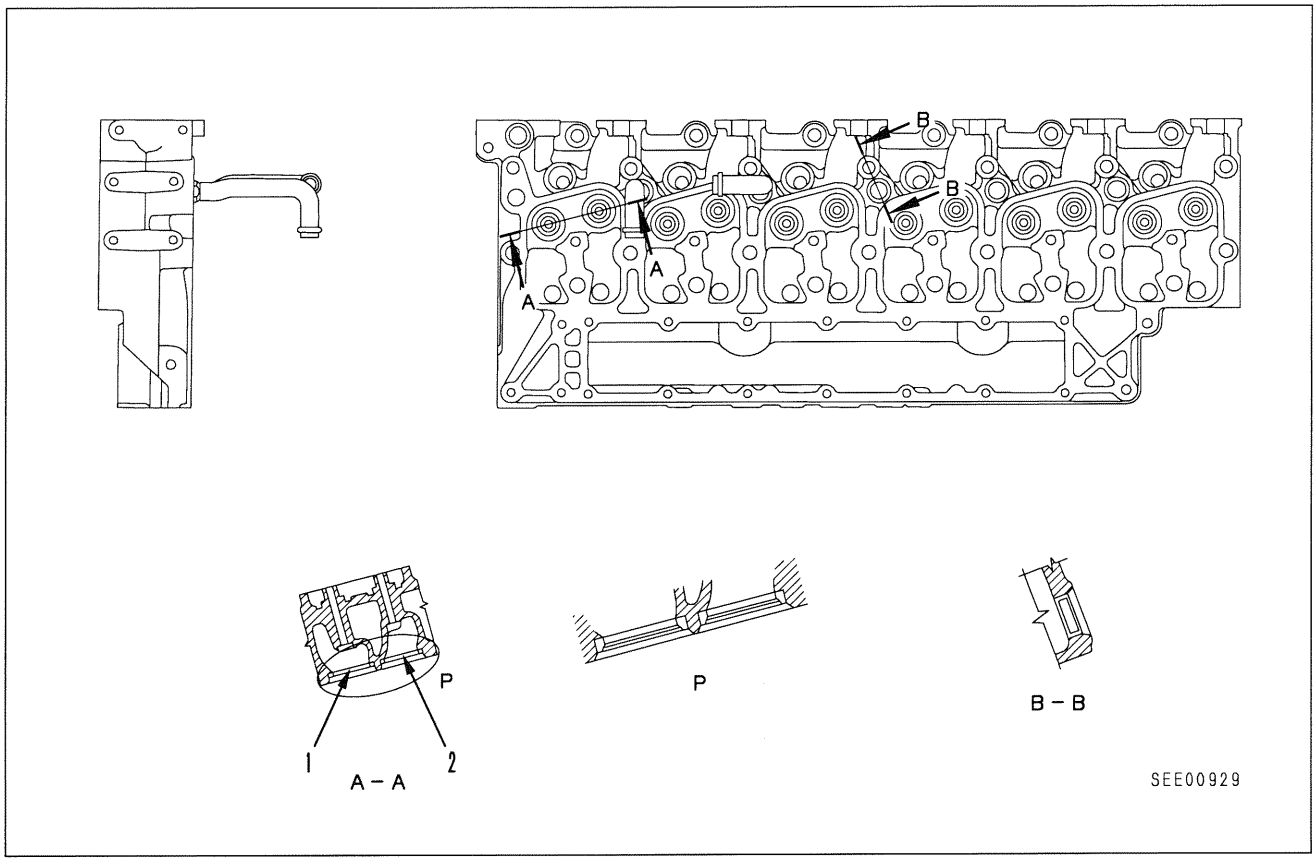
1. Inlet
2. Outlet
3. Guide vane
4. Primary element
5. Safety element
6. Vacuator valve
7. Dust pan
8. Guide vane (sleeve)
9. Body
10. Element

Features (FTG type)

- The element diameter is the same and the outside diameter of the body is small.
  The inlet is placed in the direction of connection, so no guide vane is used; a simple spiral guide vane can give ample centrifugal force.
- The dust pan has no guide vane and its structure is simple.

Structure

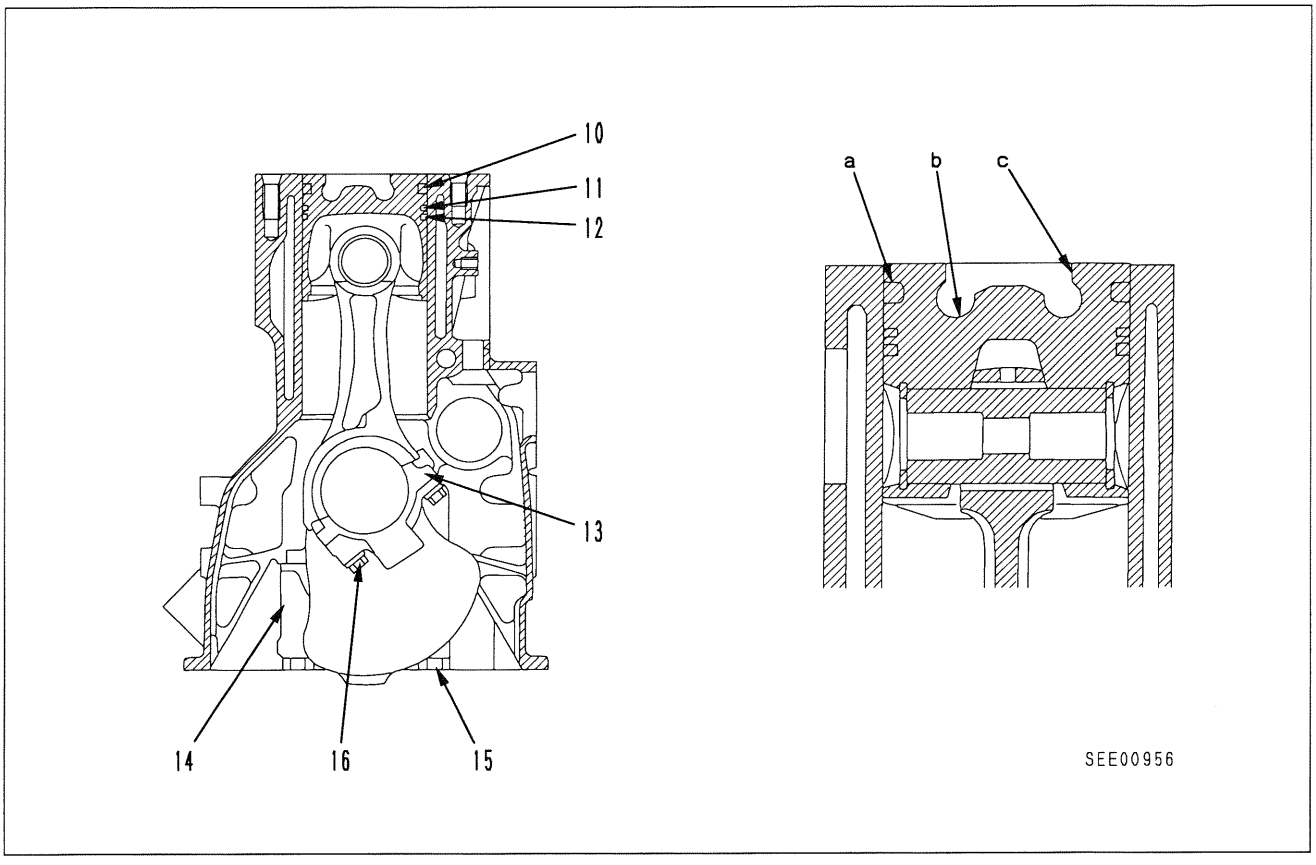
- Air containing dust is sucked into the tangential from inlet (1). The dust is separated by the centrifugal separation effect of guide vane (3). More than 99.9% of the dust is then removed by primary element (4), and the clean air then passes through safety element (5) and outlet (2), and is sent to the engine.
- The dust and water separated by guide vane (3) circulates around the inside wall of body(9), flies into vacuator valve (6), and is automatically discharged.



1. Valve insert (intake side)
2. Valve insert (exhaust side)

Cylinder head
- Direct fuel injection type
- One piece
- Two valves (1 cylinder)
- Fuel injection nozzle
  Mount: Dry type (no sleeve)

Valve seat
- Intake side (insert press fitted)
- Exhaust side (insert press fitted)



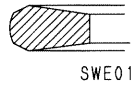
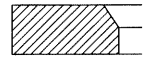
Crankshaft

- Closed die forging, induction hardened journal

Piston

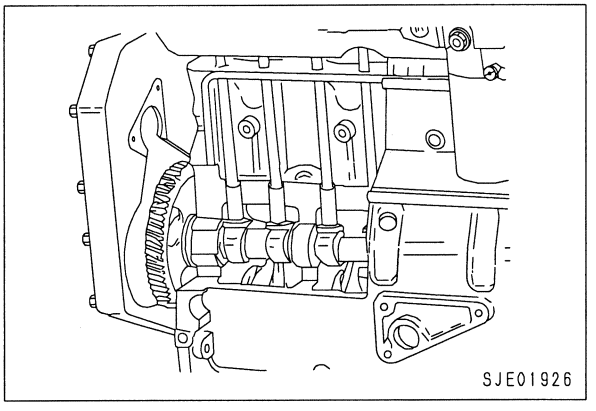
- Entrant combustion chamber for direct fuel injection type
- Toroidal combustion chamber for direct fuel injection type
- Aluminium piston

Piston rings

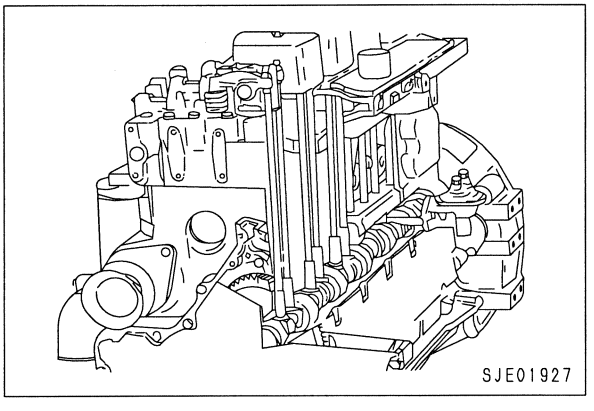
Top ring	Second ring	Oil ring
 SWE01719	 SWE01720	 SWE01721
Keystone barrel face, hard chrome plating	Rectangular inner cut taper face parkerizing	M type steel ring with coil expander, hard chrome plating

Camshaft, tappet, push rod

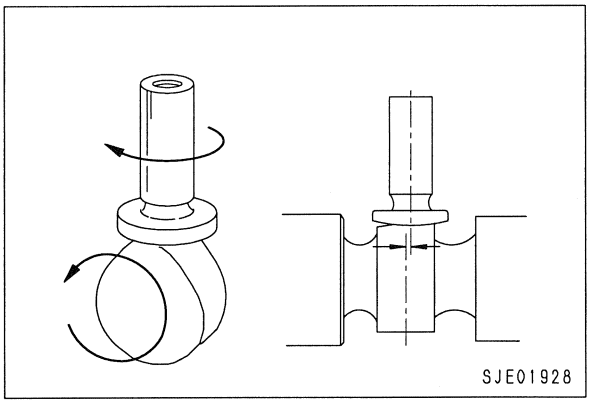
The camshaft is driven by the gear from the crankshaft. A replaceable bushing is used so that the front journal can transmit the side load from the accessory drive. The other journals are actuated inside the cast iron bore of the cylinder block, but if a maintenance bushing is installed, these bores can be repaired at a work shop.



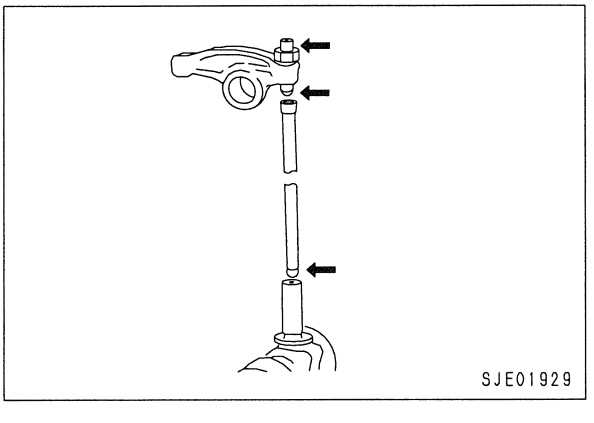
The camshaft is equipped with a lobe to actuate the intake and exhaust valves and with a special lobe to drive the fuel supply pump. The valve lobe is connected to a mushroom-shape valve tappet which actuates the push rod. The actuation arm of thefuel supply pump is mounted directly on the special lobe of the camshaft.



The tappet is a mushroom shape. The protruding part contacts the camshaft lobe, so the tappet lifts up the push rod as it rotates.



The ball at the tip of the push rod fits into the ball socket in the tappet. The other end of the push rod forms a socket, and the ball at the tip of the rocker lever adjustment screw fits into it.

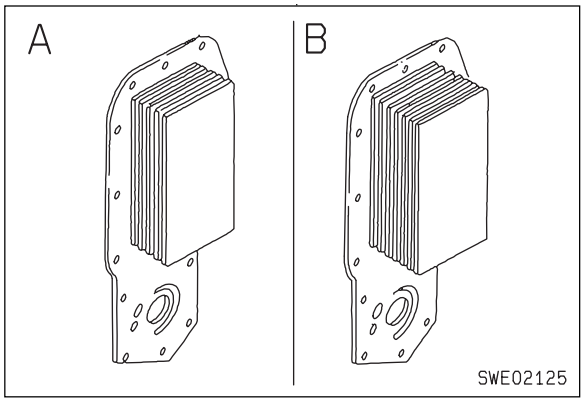


Oil cooler

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.

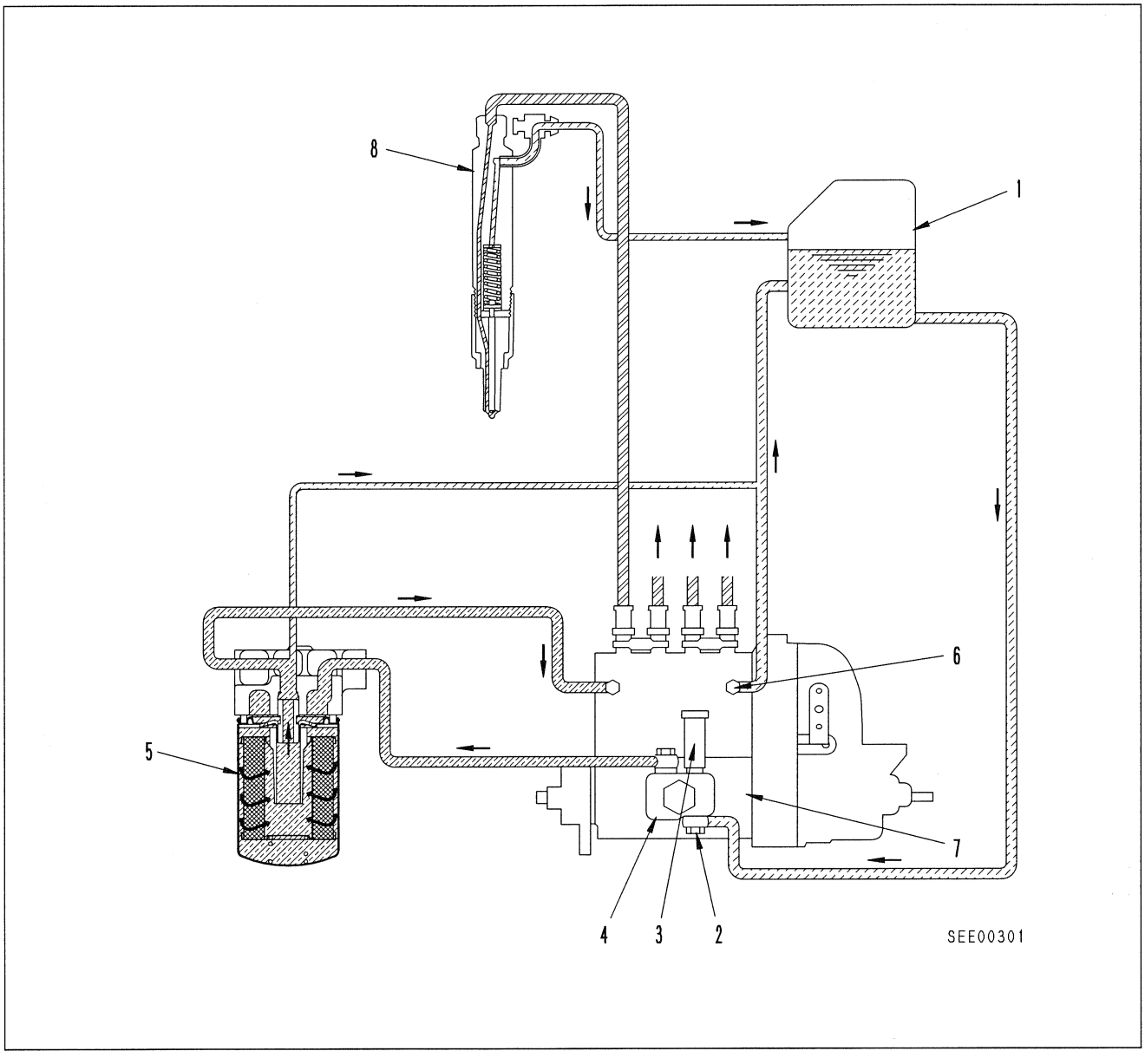
Oil cooler bypass valve

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.

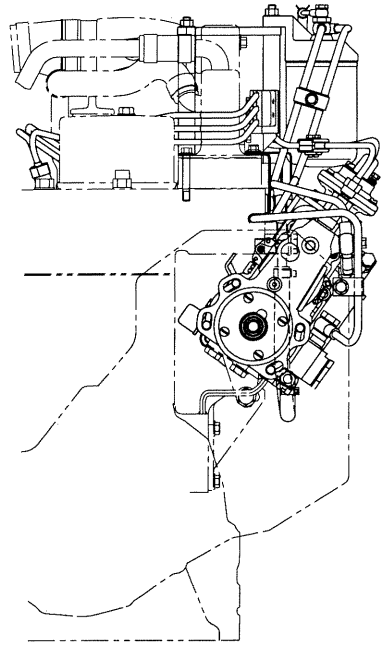
To avoid this condition, it is best to replace the filter at the drain interval given in the Operation and Maintenance Manual, Bulletin No. 3810205-10.

(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



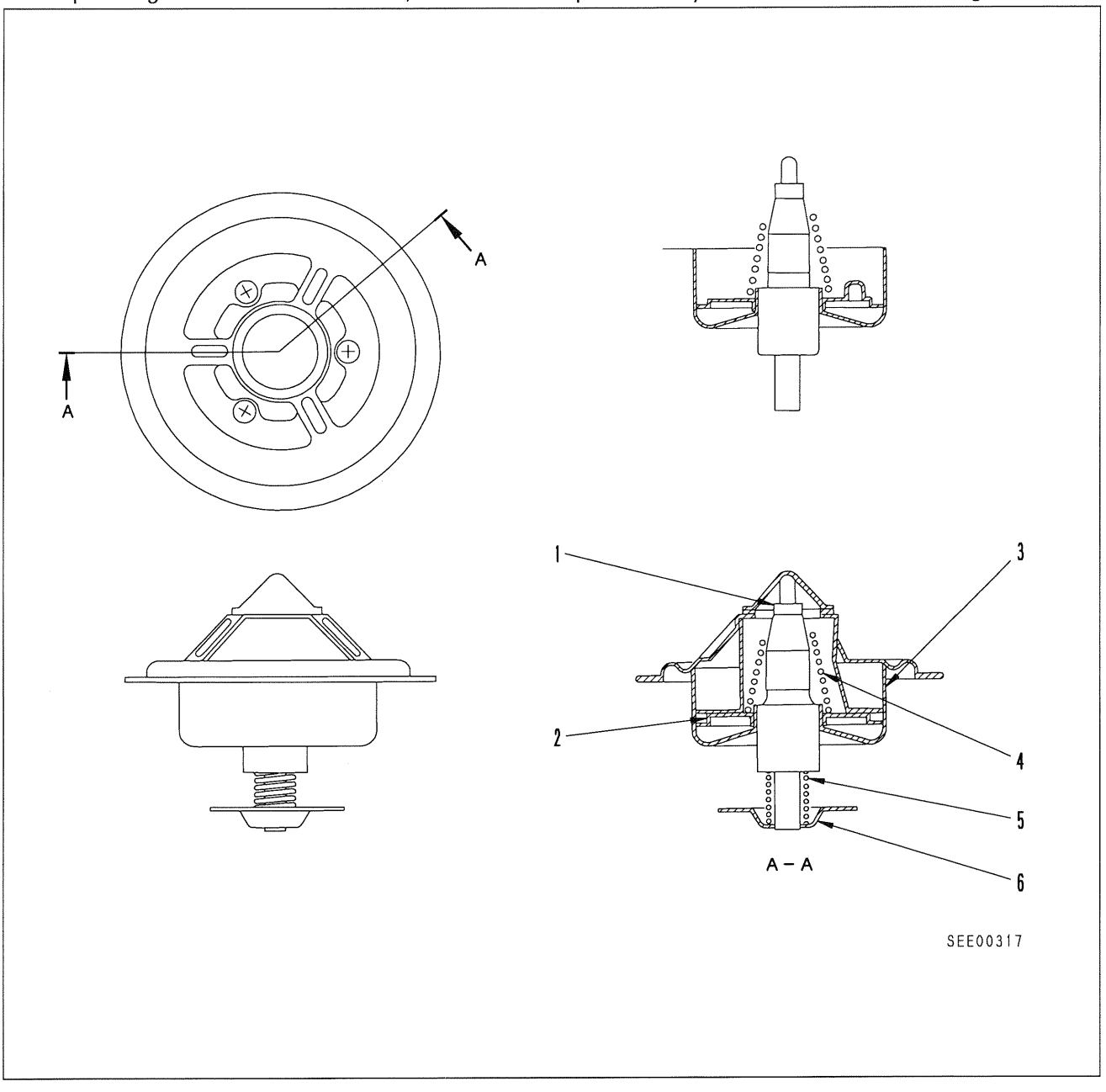
A. Fuel inlet port
B. To fuel filter
C. From fuel filter
D. To fuel injection nozzle
E. To fuel tank
F. From oil pump (oil)
G. To fuel tank

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

Governor
- Type: Bosch RSV
  Centrifugal all-speed governor

THERMOSTAT

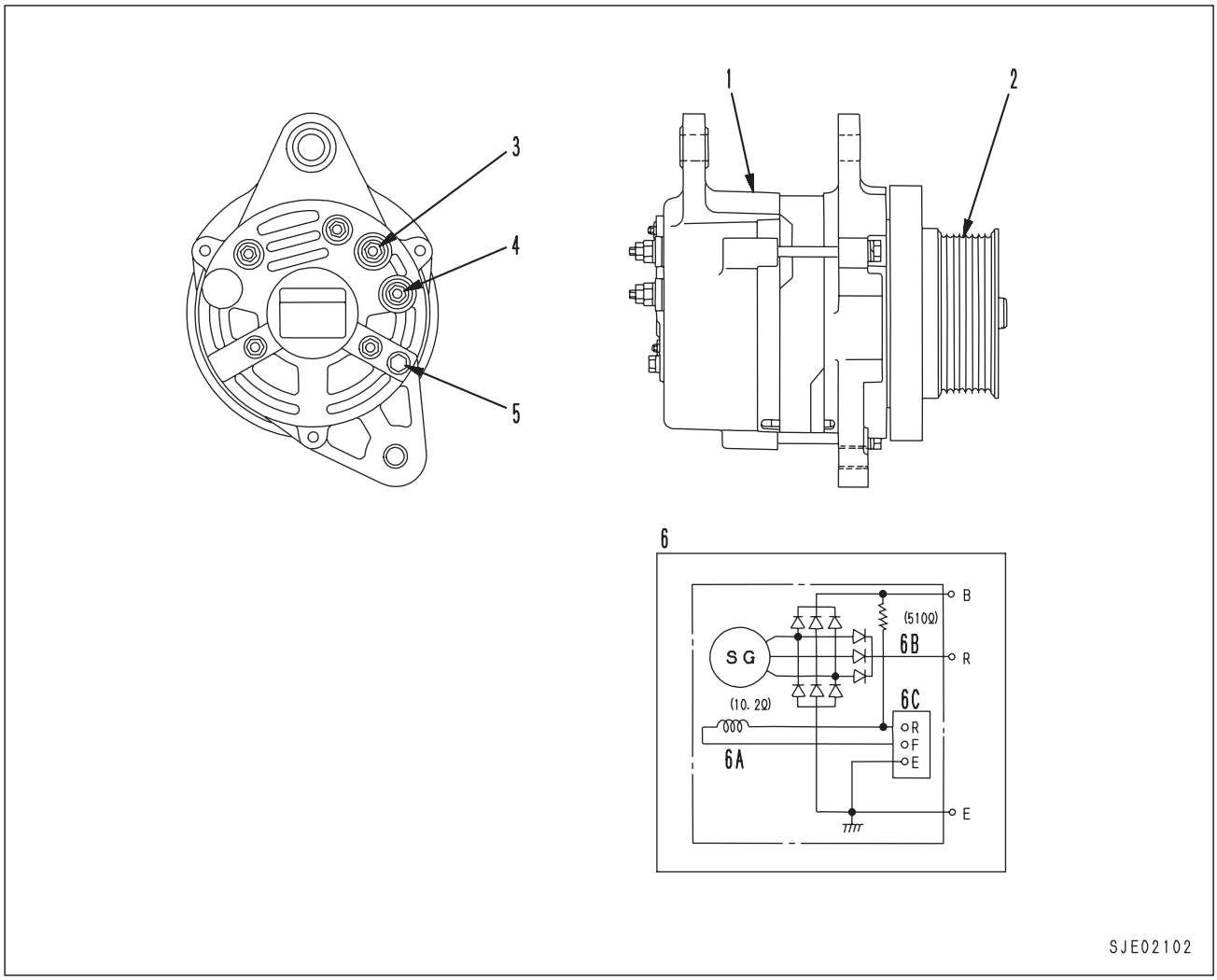
★ Depending on the machine model, the actual component may be different from the diagram.



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

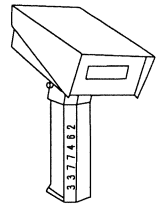
Alternator with built-in regulator (25A)

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

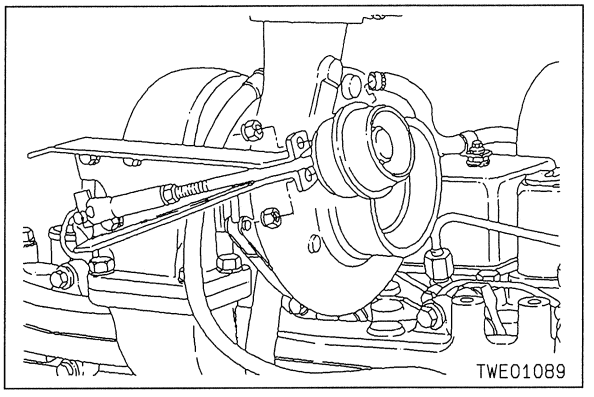


1. Alternator
2. Alternator pulley
3. Terminal R
4. Terminal B
5. Terminal E
6. Internal electric circuit diagram
   6A. Field coil
   6B. Primary energized resistance
   6C. Regulator

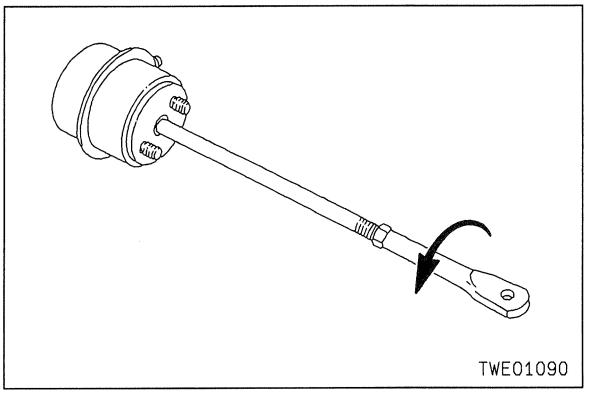
Engine	Machine model	Type	Specification	Pulley		Weight (kg)
				No. of steps	Outside diameter (mm)	
SAA4D102E-2	D31EX-21 D31PX-21 D37EX-21 D37PX-21 D39EX-21 D39PX-21 PC128US-2 PC138US-2	Nikko Denki, open type	24V, 25A	Polyethylene V-belt, 8 grooves	80	6.5

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

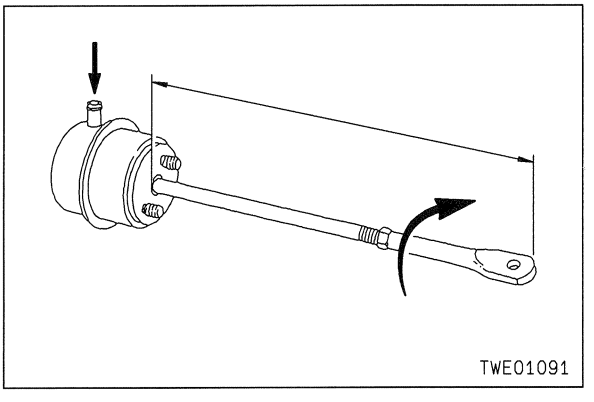
Loosen the capsule mounting bolts, then remove the air supply hose and remove the assembly from the mounting bracket.



Remove the tip of the adjustment link from the actuator.

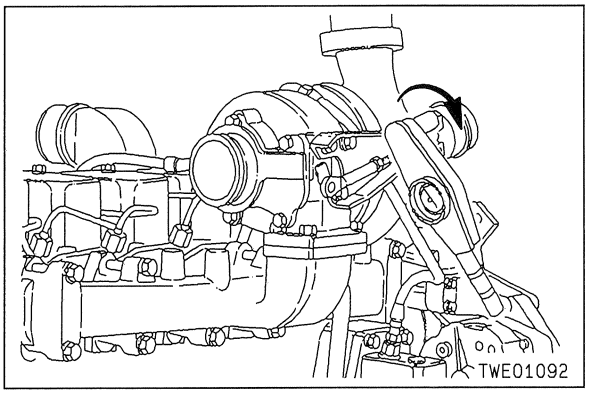


Install the tip of the adjustment link to the new actuator assembly at the position from which it was removed.

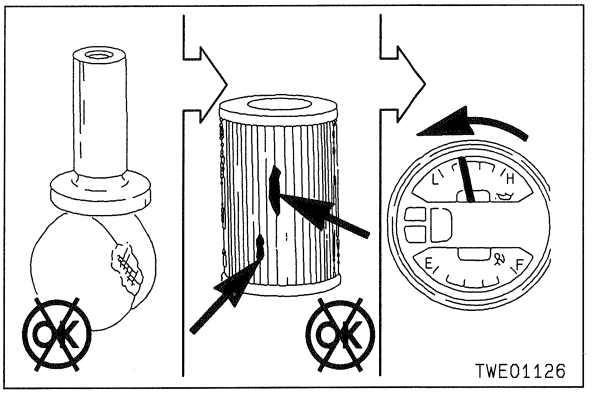


Install the new actuator assembly to the actuator mount bracket, then tighten the mounting bolts.

Mounting bolt: 4.5 Nm {0.46 kgm}

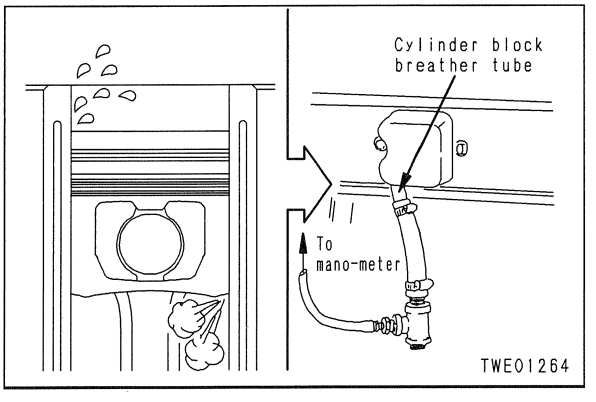


Excessive damage to the camshaft journal will occur when there are metal particles in the oil pan or oil filter. If the clearance between the bushing and journal increases, the oil pressure may drop.

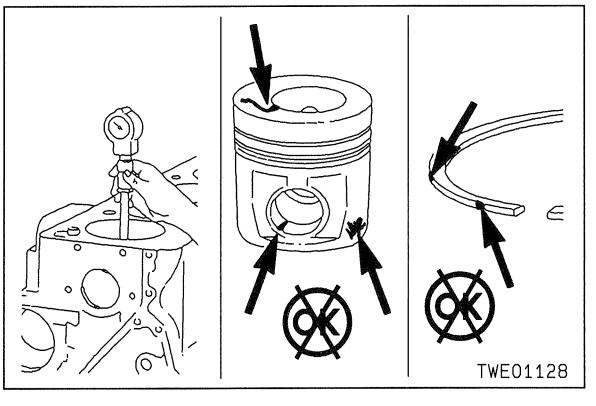


PISTON AND CONNECTING ROD

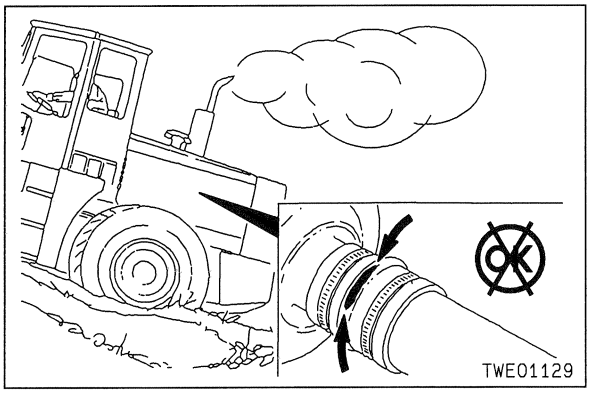
If the sealing between the piston ring and surface of the cylinder liner wall is defective, there will be various problems related to the output, such as excessive oil consumption, exhaust smoke and blow-by, and drop in the engine performance.
It is easy to recognize the existence of problems by measuring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



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

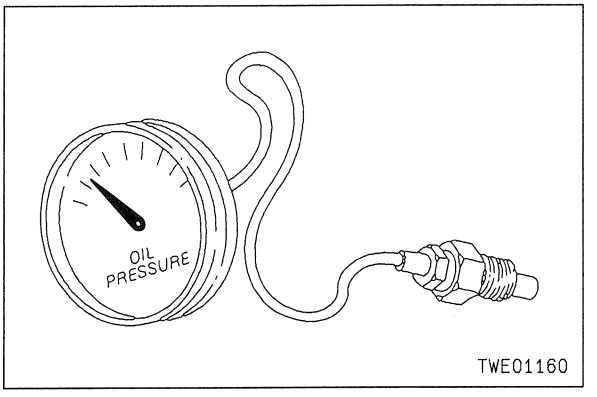


There are various causes of piston ring wear, ranging from long-term use to short-term accumulation of dirt resulting from poor maintenance of the intake system.



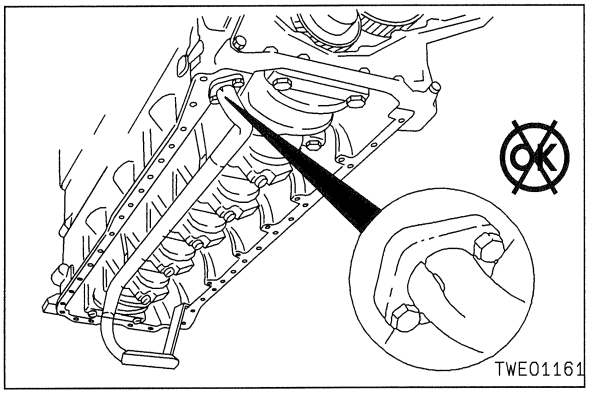
OIL PRESSURE GAUGE

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



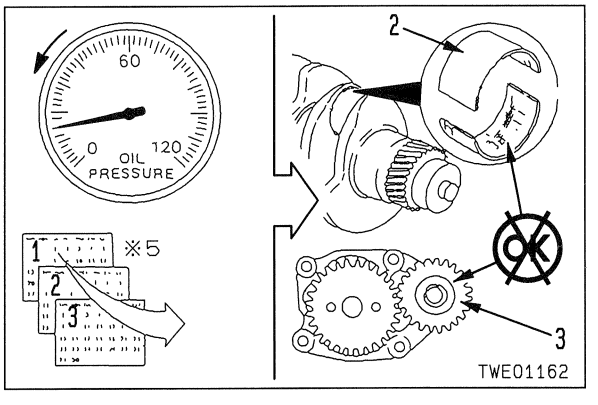
OIL PAN SUCTION TUBE

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

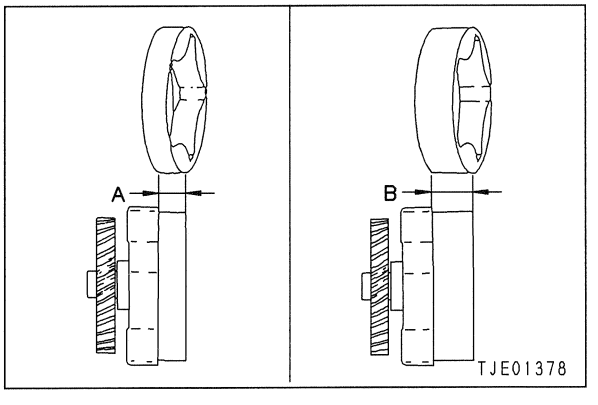
If the oil pressure gradually goes down over (see ※5) a long time, it means that the bearing (2) is worn or the oil pump (3) is worn.



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

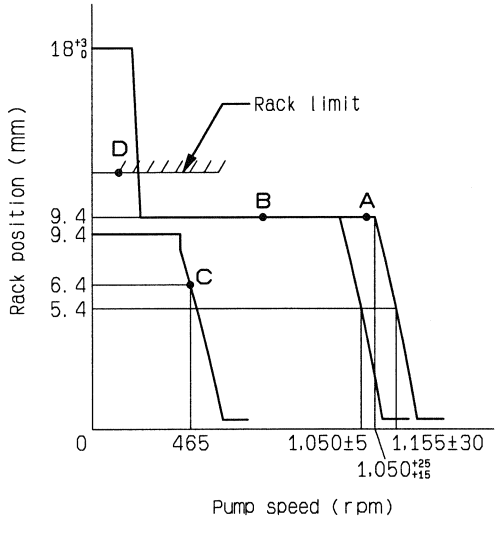
Calibration Standard

( ) : Injenction pump manufacture's part number

Conditions		Service standard	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)	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 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)	9.4	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

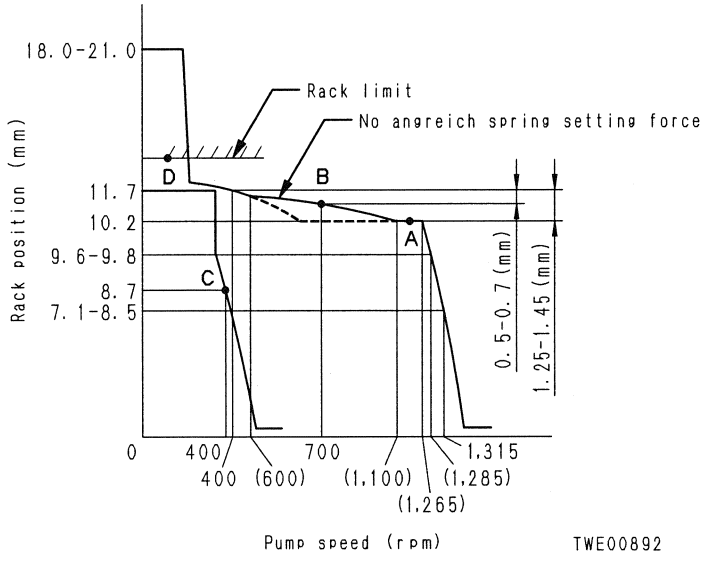
Calibration Standard

( ) : 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 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)	10.2	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		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

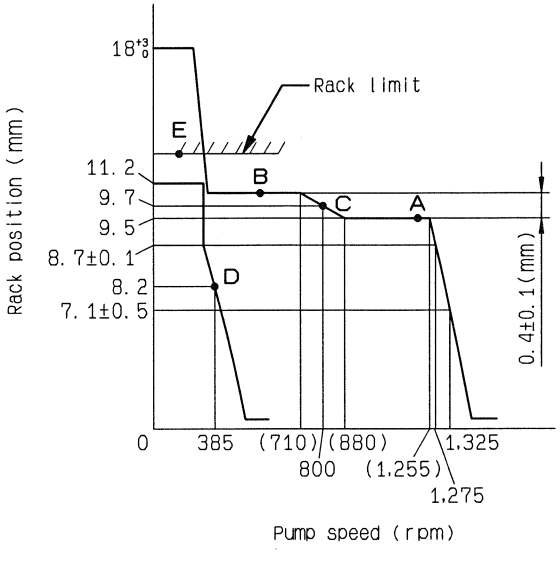
Flywheel horsepower (kw{HP}/rpm}	83.4{111.8}/2,400 (Gross)
Maximum torque (Nm{kgm}/rpm}	422{43}/1,600 (Gross)
High idling speed (rpm)	2,600 – 2,700
Low idling speed (rpm)	750 – 800
Pump tester capacity for Service standard	Motor: 7.5 kW

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 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)	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

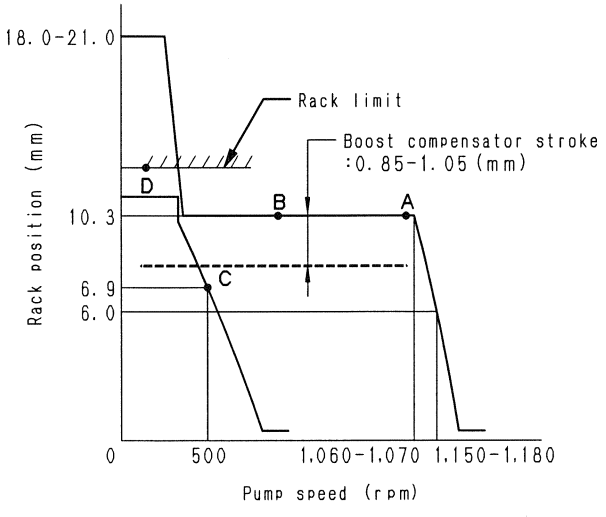
Flywheel horsepower (kw{HP})/rpm}	122.8{165}/2,100 (Gross)
Maximum torque (Nm{kgm)/rpm}	606{61.8}/1,400 (Gross)
High idling speed (rpm)	2,240 – 2,360
Low idling speed (rpm)	975 – 1,025
Pump tester capacity for Service standard	Motor: 7.5 kW

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

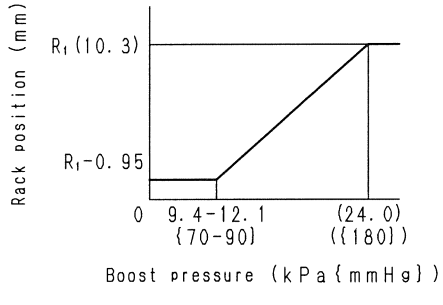
Conditions		Service standard	Manufacturer standard
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	6732 – 11 – 3120
	Nozzle part No.	(105780 – 0000)	
	Nozzle holder part No.	(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 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)	10.3	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

6735-71-1410 (101609-3450)
6735-71-1411 (101609-3500)
( ): 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.
PC200-6Z		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)	101.5{136.1}/2,000 (Gross)
Maximum torque (Nm{kgm}/rpm)	558{56.9}/1,350 (Gross)
High idling speed (rpm)	2,140 – 2,260
Low idling speed (rpm)	1,000 – 1,050
Pump tester capacity for Service standard	Motor: 7.5 kW

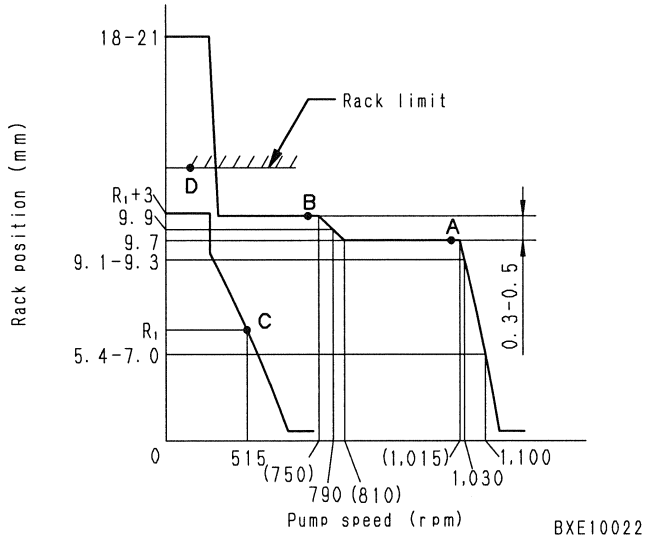
Calibration Standard

( ) : 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)	9.7	1,000	★ 91 – 93	± 2.5	★ 91	
	B	10.1	675	★ 96 – 100	—	★ 107.5	
	C	—	515	—	± 15	★ 25	
	D	—	100	70 – 80		★ 85	

Governor perfomance curve



Fuel Injection Pump Assembly Number
6738-71-1170 (101609-3700)

( ): 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.
WA200-5 WA200PT-5		SAA6D102E-2	

Fuel Injection Pump Specification

Rotating direction	Clockwise
Fuel Injection order	1 – 5 – 3 – 6 – 2 – 4
Fuel Injection interval	59° 30' – 60° 30'
Plunger prestroke (mm)	2.55 – 2.65
Delivery valve retraction volume (mm^3/st)	59

Engine Specification

Flywheel horsepower (kw{HP}/rpm}	95.2{127.7}/2,000 (Gross)
Maximum torque (Nm{kgm}/rpm}	586{59.8}/1,400 (Gross)
High idling speed (rpm)	2,200 – 2,300
Low idling speed (rpm)	775 – 875
Pump tester capacity for Service standard	Motor: 7.5 kW

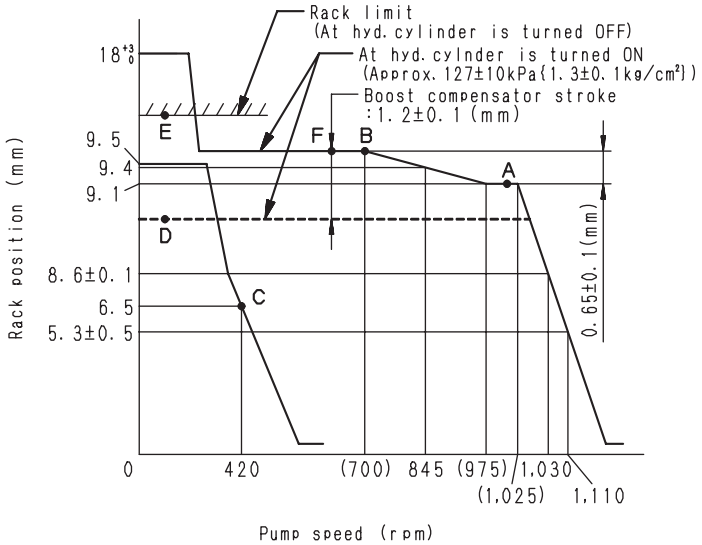
Calibration Standard

( ) : Fuel Injenction pump manufacture's part number

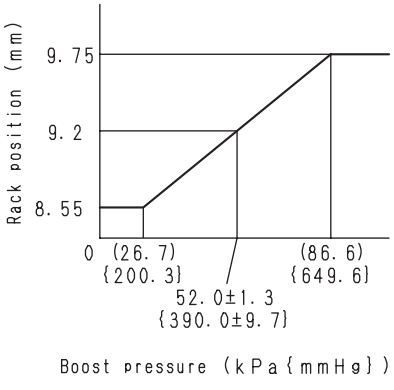
Conditions		**Service standard**	**Manufacturer standard**
• **Service standard** indicates data using calibration test parts. • **Manufacture standard** is data for factory test parts.	Nozzle & Nozzle holder part No.	(105780 – 8140)	(105158 – 5002)
	Nozzle part No.	(105780 – 0000)	(105017 – 2910)
	Nozzle 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}	22.0 {224}
	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)	9.1	1,000	★ 81 ± 1	± 2.5	★ 82	
	B	9.75	700	★ 95.5	—	★ 103	
	C	6.5	420	★ 9.5 ± 1	± 15	★ 9.5	
	D	8.55	100	★ 31 ± 5	—	★ 54	
	E	—	100	★ 85 ± 5	—	★ 105	
	F	9.75	650	★ 93 ± 3	—	★ 105	

Governor perfomance curve



Boost compensator performance curve



TJE01388

★ This table gives the standard values using the JIS compensation factor.
★ The values in the table are the standard values for machines with the muffler installed, air cleaner installed, alternator under no load, and air compressor opened (if installed).
★ The loads for the dynamometer are at an arm's length of 716 mm.

Engine model	Applicable machine	Test item	Specifications	Engine Speed (rpm)	Dynamometer (N{kg})
S4D102E-1	D31E,S,Q,P-20 D31,PL,PLL-20 D31P-20A	Flywheel horsepower	52.2 kW/2,350 rpm(Net) {70.0 HP/2,350 rpm}(Net)	2,345 – 2,355	309 – 325 {31.5 – 33.2}
		Max. torque	265 Nm/1,400 rpm(Net) {27 kgm/1,400 rpm}(Net)	1,300 – 1,500	402 – 425 {41.0 – 43.04}
		High idling speed	2,420 – 2,520 rpm	2,420 – 2,520	—
		Low idling speed	900 – 950 rpm	900 – 950	—
	D37E-5 D37P-5A	Flywheel horsepower	56.2 kW/2,500 rpm(Net) {75.3 HP/2,500 rpm}(Net)	2,495 – 2,505	305 – 323 {31.1 – 32.9}
		Max. torque	293 Nm/1,400 rpm(Net) {29.9 kgm/1,400 rpm}(Net)	1,300 – 1,500	402 – 426 {41.0 – 43.4}
		High idling speed	2,600 – 2,650 rpm	2,600 – 2,650	—
		Low idling speed	800 – 850 rpm	800 – 850	—
	PC128US-1	Flywheel horsepower	64.0 kW/2,200 rpm(Net) {85.8 HP/2,200 rpm}(Net)	2,195 – 2,205	395 – 417 {40.3 – 42.5}
		Max. torque	329 Nm/1,300 rpm(Net) {33.5 kgm/1,300 rpm}(Net)	1,200 – 1,400	466 – 520 {47.5 – 53.0}
		High idling speed	2,440 – 2,560 rpm	2,440 – 2,560	—
		Low idling speed	925 – 975 rpm	925 – 975	—
	PC128US-2	Flywheel horsepower	64.0 kW/2,200 rpm(Net) {85.8 HP/2,200 rpm}(Net)	2,195 – 2,205	395 – 417 {40.3 – 42.5}
		Max. torque	329 Nm/1,300 rpm(Net) {33.5 kgm/1,300 rpm}(Net)	1,200 – 1,400	466 – 520 {47.5 – 53.0}
		High idling speed	2,340 – 2,460 rpm	2,340 – 2,460	—
		Low idling speed	925 – 975 rpm	925 – 975	—
	PC158US-2	Flywheel horsepower	73.6 kW/2,300 rpm(Net) {98.7 HP/2,300 rpm}(Net)	2,295 – 2,305	432 – 475 {44.0 – 48.4}
		Max. torque	387 Nm/1,500 rpm(Net) {39.5 kgm/1,500 rpm}(Net)	1,400 – 1,600	525 – 580 {53.5 – 59.1}
		High idling speed	2,440 – 2,560 rpm	2,440 – 2,560	—
		Low idling speed	925 – 975 rpm	925 – 975	—
	GD305A-3	Flywheel horsepower	63 kW/2,500 rpm(Net) {85 HP/2,500 rpm}(Net)	2,495 – 2,505	347 – 367 {35.4 – 37.4}
		Max. torque	343 Nm/1,500 rpm(Net) {35 kgm/1,500 rpm}(Net)	1,400 – 1,600	472 – 499 {48.2 – 50.9}
		High idling speed	2,700 – 2,800 rpm	2,700 – 2,800	—
		Low idling speed	650 – 700 rpm	650 – 700	—

★ This table gives the standard values using the JIS compensation factor.
★ The values in the table are the standard values for machines with the muffler installed, air cleaner installed, alternator under no load, and air compressor opened (if installed).
★ The loads for the dynamometer are at an arm's length of 716 mm.

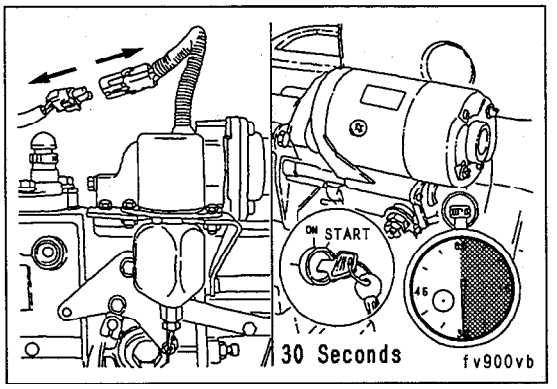
102-2

Engine model	Applicable machine	Test item	Specifications	Engine Speed (rpm)	Dynamometer (N{kg})
SAA4D 102E-2	D31EX-21 D31PX-21	Flywheel horsepower	55.9 kW/2,000 rpm(Net) {74.9 HP/2,000 rpm}(Net)	2,000 ± 5	361 – 384 {36.9 – 39.2}
		Max. torque	384 Nm/1,300 rpm(Net) {39.2 kgm/1,300 rpm}(Net)	1,300 ± 100	520 – 553 {53.1 – 56.4}
		High idling speed	2,200 ± 50 rpm	2,200 ± 50	—
		Low idling speed	800^{+50}_{0} rpm	800^{+50}_{0}	—
	D37EX-21 D37PX-21	Flywheel horsepower	63.3 kW/2,000 rpm(Net) {84.9 HP/2,000 rpm}(Net)	2,000 ± 5	409 – 434 {41.7 – 44.3}
		Max. torque	412 Nm/1,300 rpm(Net) {42 kgm/1,300 rpm}(Net)	1,300 ± 100	548 – 602 {55.9 – 61.4}
		High idling speed	2,200 ± 50 rpm	2,200 ± 50	—
		Low idling speed	800^{+50}_{0} rpm	800^{+50}_{0}	—
	D39EX-21 D39PX-21	Flywheel horsepower	70 kW/2,200 rpm(Net) {94 HP/2,200 rpm}(Net)	2,200 ± 5	436 – 462 {44.5 – 47.1}
		Max. torque	434 Nm/1,300 rpm(Net) {44.3 kgm/1,300 rpm}(Net)	1,300 ± 100	584– 647 {59.6 – 66.0}
		High idling speed	2,400 ± 50 rpm	2,400 ± 50	—
		Low idling speed	800^{+50}_{0} rpm	800^{+50}_{0}	—
	PC160LC-7	Flywheel horsepower	82 kW/2,200 rpm(Net) {110 HP/2,200 rpm}(Net)	2,200 ± 5	493 – 545 {50.3 – 55.6}
		Max. torque	431 Nm/1,500 rpm(Net) {44 kgm/1,500 rpm}(Net)	1,500 ± 100	577– 640 {58.9 – 65.3}
		High idling speed	2,490 ± 50 rpm	2,490 ± 50	—
		Low idling speed	1,050 ± 50 rpm	1,050 ± 50	—
	WA150-5	Flywheel horsepower	74.2 kW/2,000 rpm(Gross) {99.5 HP/2,000 rpm}(Gross)	2,000 ± 5	470 – 520 {48 – 53}
		Max. torque	408 Nm/1,300 rpm(Gross) {41.6 kgm/1,300 rpm}(Gross)	1,300 ± 100	541 – 598 {55.2 – 61}
		High idling speed	2,250 ± 50 rpm	2,250 ± 50	—
		Low idling speed	825 ± 50 rpm	825 ± 50	—
		Flywheel horsepower			
		Max. torque			
		High idling speed			
		Low idling speed			

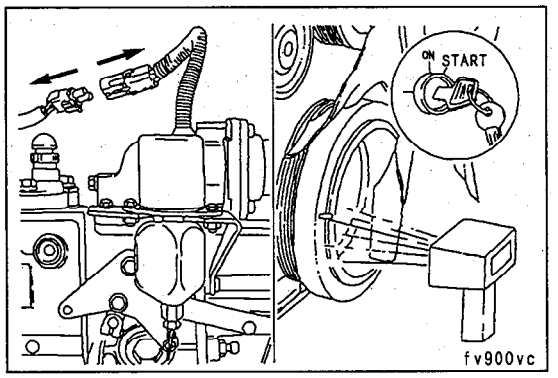
TEST 2: TESTING FLOW

Caution 1: To prevent the engine from starting, remove the connection of the fuel cut-off wiring. If there is fuel remaining in the injection pump, the engine may start.

Caution 2: Do not keep the starting motor rotating for more than 30 seconds continuously. If it is run continuously for more than 30 seconds, the starting motor may be damaged.

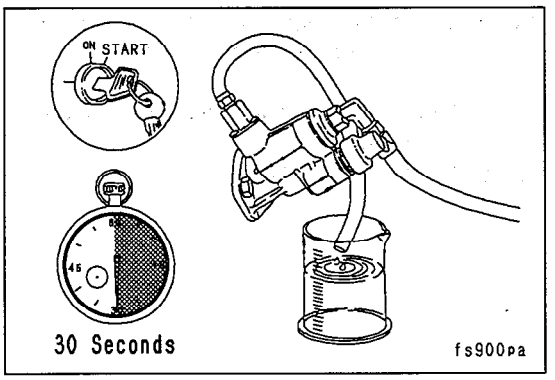


Remove the connection of the cut-off solenoid wire, hold the tachometer (799-203-8001) by hand, and measure the engine speed.



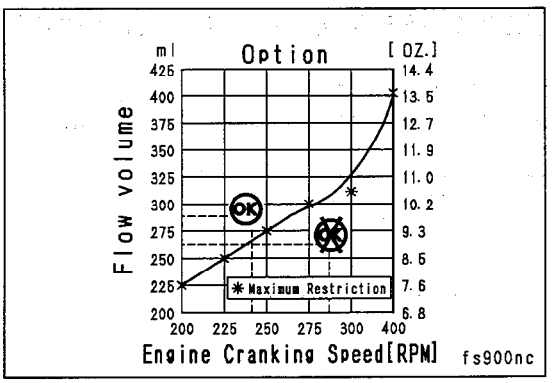
Caution: Leave the cut-off of solenoid wire disconnected and carry out the following check.

Remove the connection of the output pressure line from the fuel feed pump and insert it in a container. Crank the engine with the starting motor for 30 seconds and measure the flow of fuel from the fuel feed pump.



Look at the chart and find the correct flow specifications of the part number 3918076 fuel feed pump.

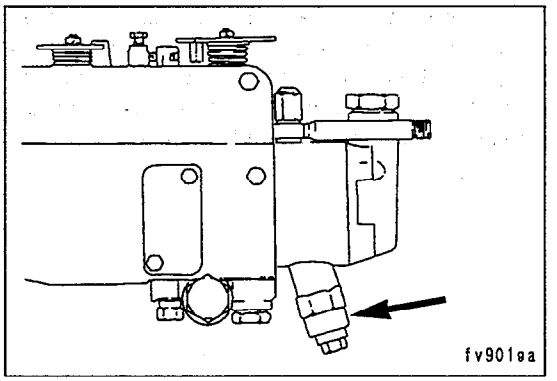
- Draw a vertical line up from the measurement for the speed.
- Draw a horizontal line from the measurement for the flow to the point where it intersects the vertical line for the engine speed.
- If the intersection is above the necessary flow line, it indicates that the flow is permissible.
- If the 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.



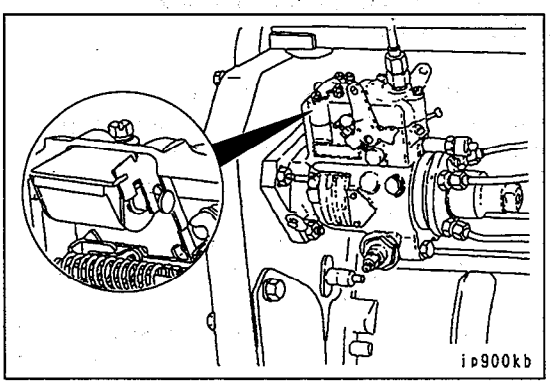
Example 1	Engine speed:	240 rpm
Passing pump	Flow:	280 mℓ
Example 2	Engine speed:	280 rpm
Failing pump	Flow:	260 mℓ

673501

The Lucas CAV DPA/DPS shut-off valve is installed to the bottom rear of the pump.
12V and 24V operation actuation solenoids and stop actuation solenoids can be used.



The Stanadyne DB4 shut-off valve is under the governor cover.
12V and 24V operation actuation solenoids and stop actuation solenoids can be used.

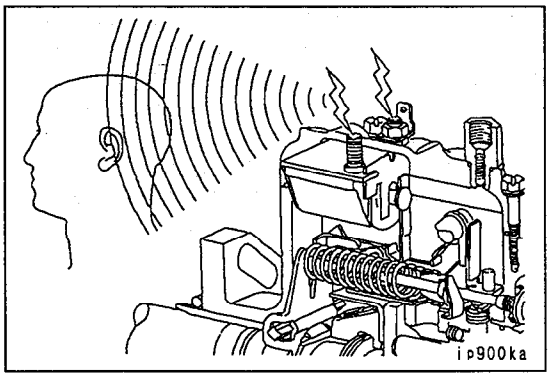


673501

Test the Stanadyne DB4 fuel injection pump shut-off solenoid by sending electricity to the terminal and listening for the click.
If a clear click sound can be heard, the solenoid is being actuated freely.

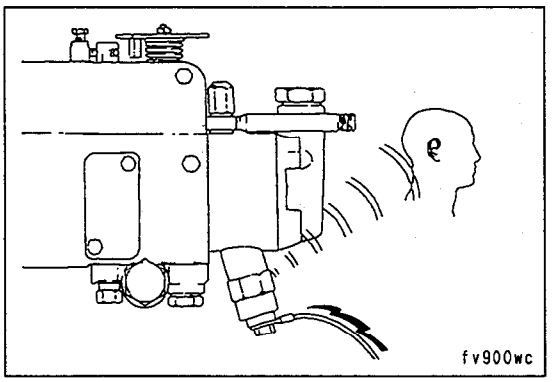
Caution: Do not check the actuation of the operation actuation solenoid with the governor cover removed from the fuel injection pump.

Using the following values, check the operation actuation solenoid with an ohmmeter.



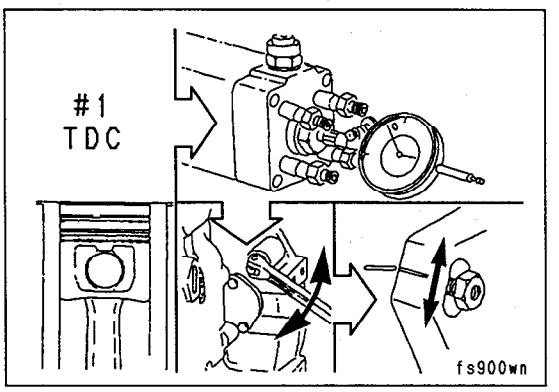
Stanadyne DB4 solenoid	
Voltage	Energizing voltage (min)
12	8.8
24	17.6

When the valve on the Lucas CAV DPA/DPS pump opens, a click can be heard.
Using the following values, check the operation actuation solenoid with an ohmmeter.



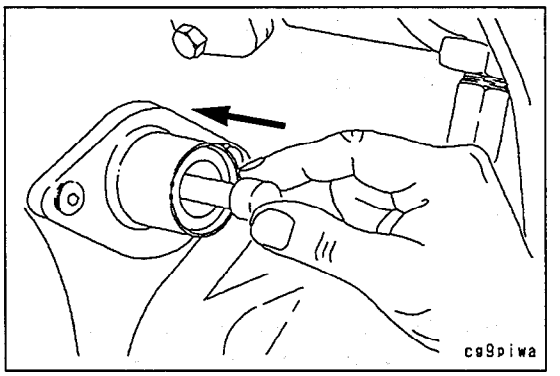
CAV solenoid value resistance in ohms		
Voltage	Energizing	voltage (min)
12	9 at 22°C	9
24	36 at 22°C	18

If the position of the plunger of the Robert Bosch VE fuel injection pump is measured using the special indicator, it is possible to check the timing of the pump.
For details, see Section 5-36 "Checking timing (Bosch VE pump)".



ADJUSTING FUEL INJECTION TIMING FOR BOSCH VE

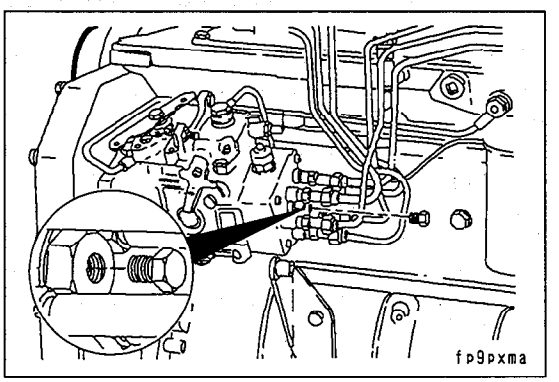
Rotate the crankshaft to TDC.



673501

12 mm

Remove the plug from the end of the pump.

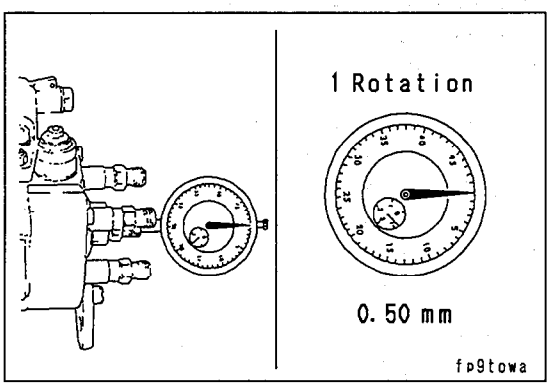


Timing tool (795-799-1270)

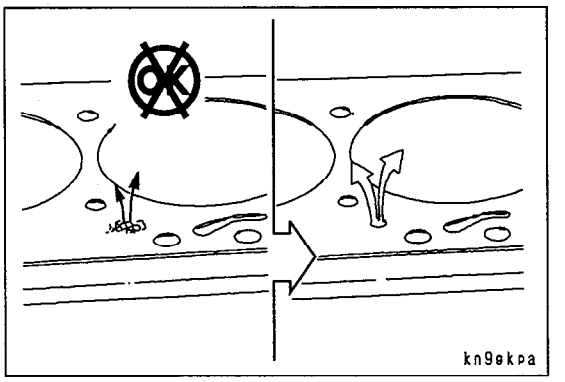
Caution: Do not bend the fuel line.

Install the timing indicator. Check that the stroke of the indicator is sufficient.
It may be necessary to remove some of the fuel lines from the fuel injection pump in order to install the timing indicator.

Caution: Make marks for 0.01 mm increase in the indicator.
One rotation of the indicator needle is equivalent to 0.50 mm.

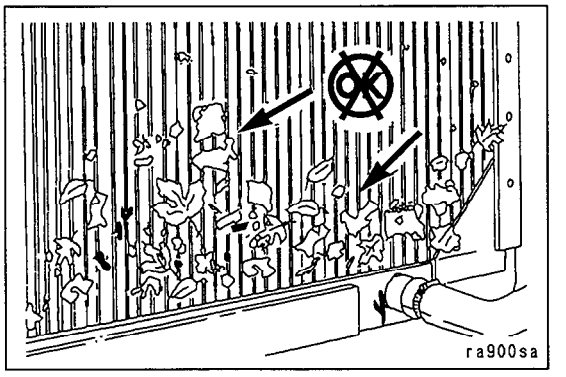


As mentioned in the explanation for the cooling water system, resistance in the passage may prevent the water from flowing.



RADIATOR, FAN, AND RADIATOR SHUTTER

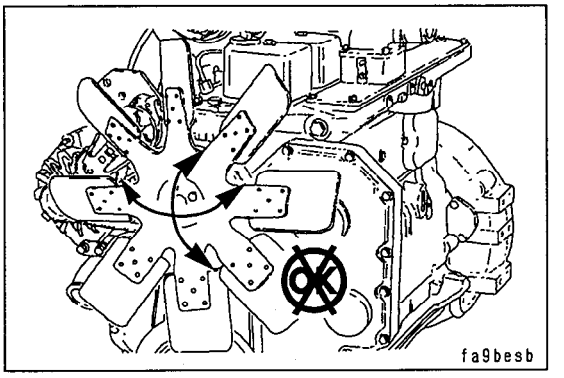
The air blown against the fins of the radiator by the fan acts to cool the water sent through the radiator. The dirt on jobsites (bits of paper, dry grass, pieces of cloth, dust, etc.), may clog the fins and prevent the flow of air, so the cooling effect of the radiator will be reduced.



673501

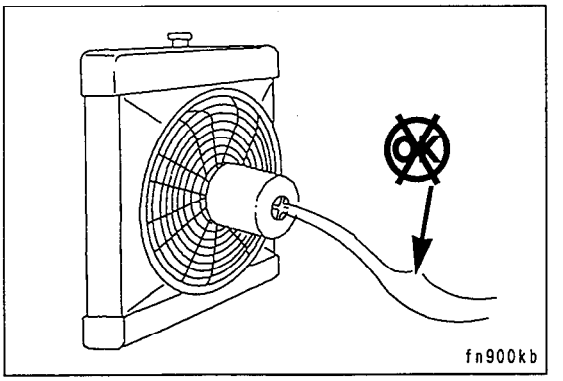
In cases where the fan is driven by a belt, if the belt slips, the speed of the fan will be reduced, and this will reduce the cooling effect. Defective actuation of the automatic belt tensioner is also a problem.

Caution: Check the bearings of the fan hub and other pulleys to confirm that they are not causing vibration or slipping of the belt.

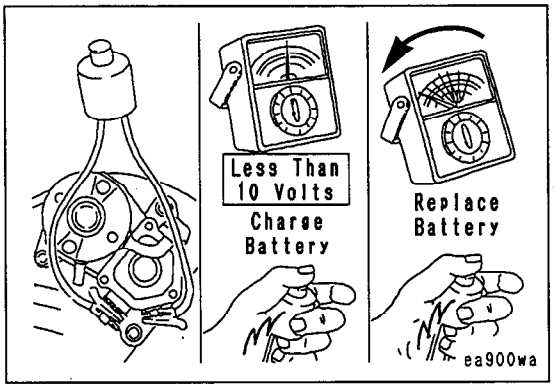


With electric fans, if there is a failure in the electrical circuit, the flow of air will be insufficient and this will lead to a rise in the temperature of the engine.

Caution: Check that the temperature sensor is working properly.

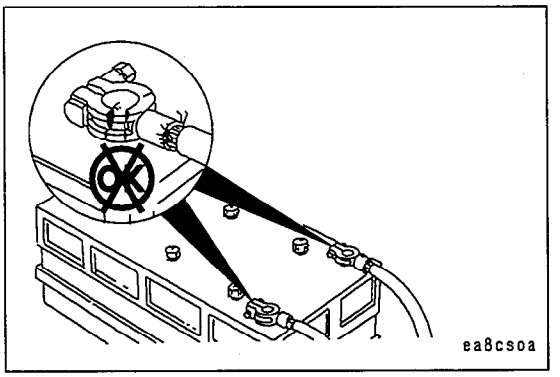


Connect the remote starter, then start the starting motor and observe the voltage.
If the voltage is less than 10V DC, charge the battery.
If the voltage suddenly drops below 2V DC, replace the battery.



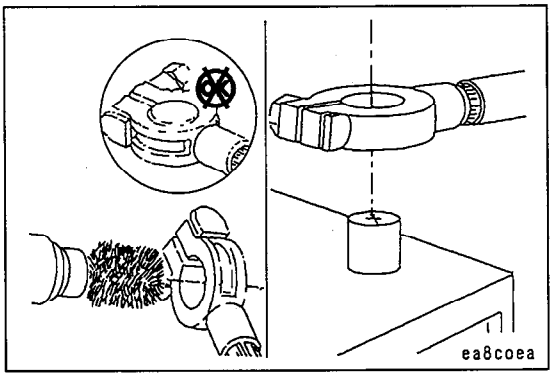
TESTING BATTERY TERMINAL CONNECTIONS

Check the battery terminals visually for looseness, damage, and corrosion. Repair or replace any damaged cables or terminals.



673501

If the connection is corroded, remove the cable and clean the cable and battery terminal with a battery brush.
Install the battery cable and tighten it.
Coat the battery terminal with grease to prevent corrosion.

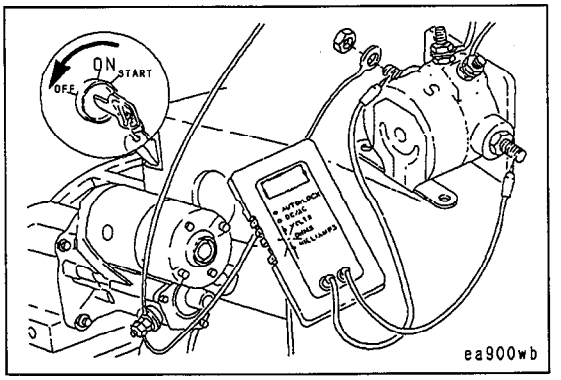


TESTING STARTING CIRCUIT

TESTING BATTERY RELAY

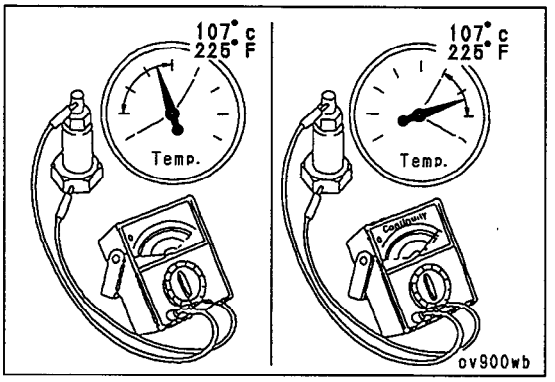
Caution: Always turn the starting switch to the OFF position and take steps to prevent electric shock and injury.

Remove the cable connecting the magnetic switch and starting motor solenoid from the terminal of the magnetic switch.
Connect the leads of a multimeter (commercially available) or equivalent equipment to the two large switch terminals.



TESTING WATER TEMPERATURE SENSOR

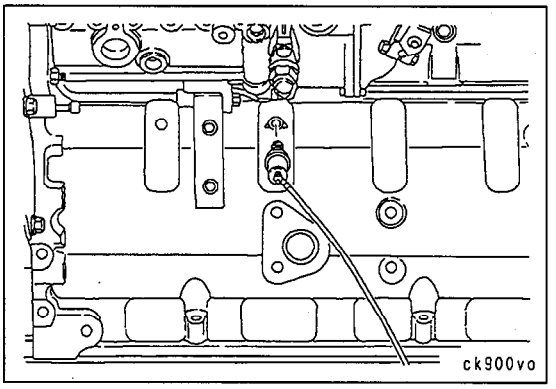
Check for continuity. Electricity flows in the sensor if the cooling water temperature goes above 107°C.



673501

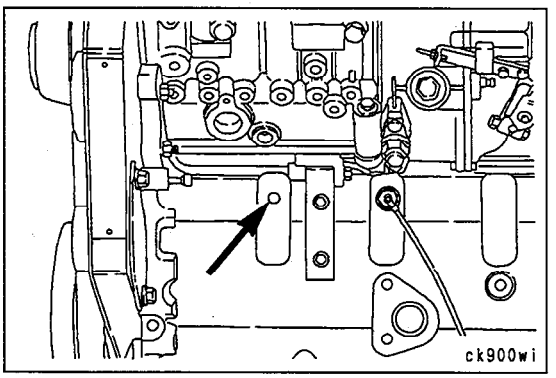
Connect the oil pressure sensor to the main oil rifle in the cylinder block.

Minimum gauge capacity: 1034 kPa{10.5 kg/cm²}

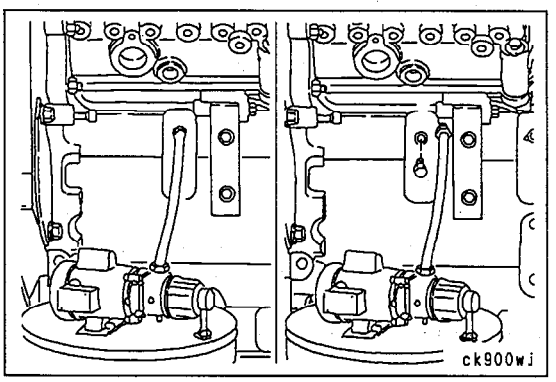


Caution: Before running the engine after assembly, prime the lubricating oil system to prevent internal damage.

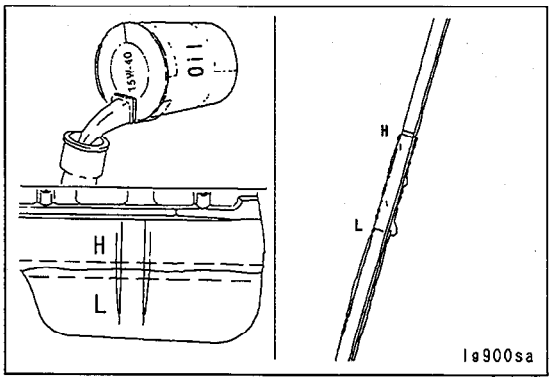
When using external pressure to prime the lubricating oil system, connect the supply to the tapped hole in the main oil rifle.



Use a pump that can supply pressure continuously at 210 kPa{2.1 kg/cm²}. Connect the pump to the main oil rifle port as shown in the diagram.
Prime the lubricating oil system with clean 15W-40 oil until the oil pressure is recorded by the gauge. Remove the oil supply tube and install the plug.

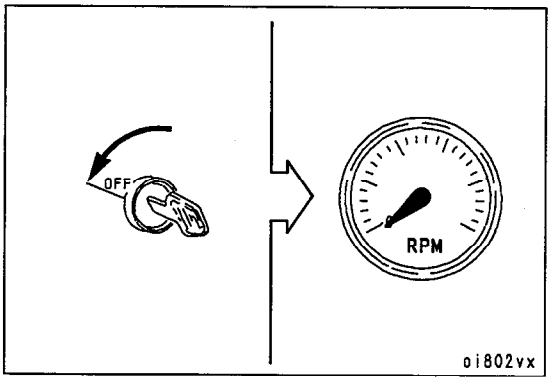


Check if there is time for the oil to drain to the pan, then measure with the dipstick and add oil to the high mark for the engine.



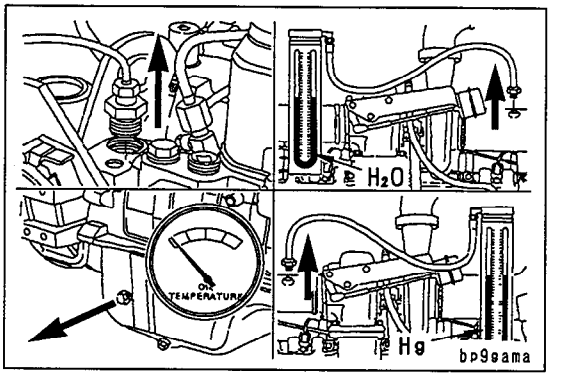
673501

After the engine cools down, stop the engine.



Remove all the test instruments. Remove the engine from the dynamometer.

Caution: If not use permanent antifreeze, When storing the engine for a short period, the cooling water must be drained. The position of the drain is given in the engine side view.



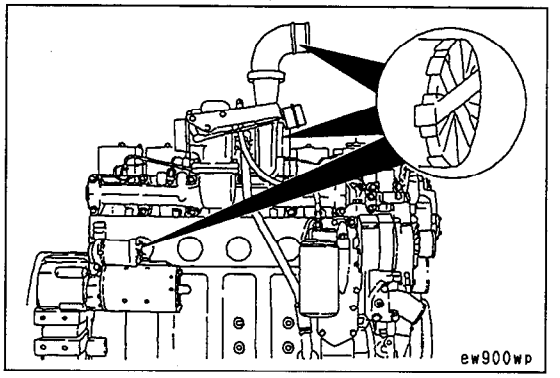
673501

Prepare the engine according to ENGINE PAINTWORK (8-08).

ENGINE PAINTWORK

Remove the belt from the engine.
Cover the following parts of the engine.

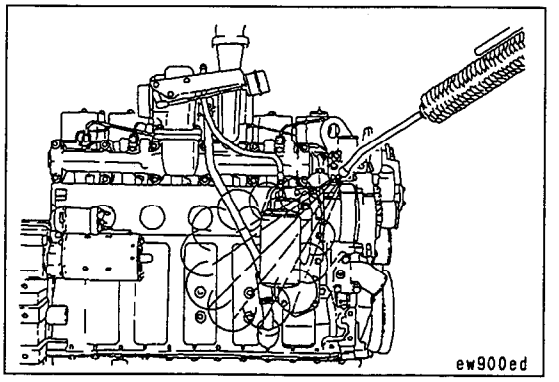
- Pulley belt surface
- Intake, exhaust ports
- Electric components
- Fuel suction, drain connections
- Exposed fittings, threads, electrical wiring terminals



Warning: When cleaning with steam, wear protective clothing, safety glasses, and face shield. Hot steam may cause serious burns.

Clean the engine with steam, then dry with compressed air.

Caution: Before painting the engine, check that the surface of the engine is clean and dry.



Engine model				6D102E-1			
Applicable machine model				D41A-6			
Category	item	Measurement conditions	Unit	Standard value	Permissible value	Standard value	Permissible value
Performance	Engine speed	High idling speed	rpm	2,600 – 2,700	2,600 – 2,700		
		Low idling speed	rpm	825 – 925	825 – 925		
	Nessary stating speed	0°C (without starting aid)	rpm	Min. 170	170		
		-20° (with starting aid)	rpm	Min. 120	120		
Intake, exhaust system	Intake resistance	At all speed	kPa {mmH_2O}	Max. 6.23 {Max. 635}	6.23 {635}		
	Boost pressure	At rated flywheel horsepower	kPa {mmHg}	—	—		
	Exhaust pressure (turbine inlet pressure)	At rated flywheel horsepower	kPa {mmHg}	—	—		
	Exhaust temperature (turbine inlet temp.)	All speed (20°C)	°C	Max. 550	550		
	Exhaust gas color	Quick acceleration (low idle → high idle)	Bosch index	—	—		
		At rated flywheel horsepower		Max. 2.5	4.5		
		High idling speed		—	—		
	Valve clearance (When engine is hot or cold)	Intake valve	mm	0.25	—		
		Exhaust valve	mm	0.51	—		
Engine proper	Compression pressure (SAE30 or SAE15W-40)	Oil temperature: 40 – 60°C (engine speed)	MPa {kg/cm^2} (rpm)	Min. 2.41 {Min. 24.6}	2.10 {21.1}		
	Blow-by pressure (SAE30 or SAE15W-40)	At rated flywheel horsepower (water temp. : Min. 70°C)	kPa {mmH_2O}	Max. 0.43 {Max. 44}	0.87 {89}		
Lubrication system	Oil pressure (oil temperature : Min. 80°C)	At rated flywheel horsepower SAE 30 or SAE15 W–40 oil	kPa {kg/cm^2}	280 – 520 {2.8 – 5.3}	210 {2.1}		
		SAE10W oil	kPa {kg/cm^2}	—	—		
		At low idling SAE 30 or SAE15 W–40 oil	kPa {kg/cm^2}	Min. 100 {Min. 1.0}	70 {0.7}		
		SAE 10W oil	kPa {kg/cm^2}	—	—		
	Oil temperature	All speed (Oil in oil pan)	°C	80 – 110	120		
	Oil consumption ratio	At continuous rated horsepower (Ratio for fuel consumption)	%	Max. 0.5	1.0		
Fuel system	Fuel injection pressure	Nozzle tester	MPa {kg/cm^2}	22.0 – 23.0 {224 – 235}	19.0 {194}		
	Fuel injection timing	B. T. D. C	degree	18	—		
Cooling system	Radiator pressure valve	Opening pressure (Differential pressure)	kPa {kg/cm^2}	0.10 {1.0}	0.10 {1.0}		
	Fan speed	At rated engine speed	rpm	2,300	2,300		
	Fan belt tension	Deflection when pushed with a force of 60N {6 kg}	mm	9.5 – 12.7	9.5 – 12.7		

102-2

Engine model				SAA4D102E-2			
Applicable machine model				D39EX-21, D39PX-21			
Category	item	Measurement conditions	Unit	Standard value	Permissible value	Standard value	Permissible value
Performance	Engine speed	High idling speed	rpm	2,400 ± 50	2,400 ± 50		
		Low idling speed	rpm	800 $^{+50}_{0}$	800 $^{+50}_{0}$		
	Nessary stating speed	0°C (without starting aid)	rpm	Min. 170	Min. 170		
		-20° (with starting aid)	rpm	Min. 120	Min. 120		
Intake, exhaust system	Intake resistance	At all speed	kPa {mmH_2O}	Max. 3.72 {Max. 380}	7.47 {762}		
	Boost pressure	At rated flywheel horsepower	kPa {mmHg}	Min. 133 {Min. 1,000}	127 {950}		
	Exhaust pressure (turbine inlet pressure)	At rated flywheel horsepower	kPa {mmHg}	Min. 153 {Min. 1,150}	147 {1,100}		
	Exhaust temperature (turbine inlet temp.)	All speed (20°C)	°C	Max. 650	700		
	Exhaust gas color	Quick acceleration (low idle → high idle)	Bosch index	Max. 4.0	6.0		
		At rated flywheel horsepower		Max. 2.0	3.0		
		High idling speed		Max. 1.0	2.0		
	Valve clearance (When engine is hot or cold)	Intake valve	mm	0.25	—		
		Exhaust valve	mm	0.51	—		
Engine proper	Compression pressure (SAE30 or SAE15W-40)	Oil temperature: 40 – 60°C (engine speed)	MPa {kg/cm^2} (rpm)	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 {mmH_2O}	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/cm^2}	340 – 590 {3.5 – 6.0}	245 {2.5}		
		SAE10W oil	kPa {kg/cm^2}	290 – 540 {3.0 – 5.5}	206 {2.1}		
		At low idling SAE 30 or SAE15 W–40 oil	kPa {kg/cm^2}	Min. 147 {Min. 1.5}	78 {0.80}		
		SAE 10W oil	kPa {kg/cm^2}	Min. 98 {Min. 1.0}	69 {0.70}		
	Oil temperature	All speed (Oil in oil pan)	°C	90 – 110	120		
	Oil consumption ratio	At continuous rated horsepower (Ratio for fuel consumption)	%	Max. 0.2	0.6		
Fuel system	Fuel injection pressure	Nozzle tester	MPa {kg/cm^2}	22 $^{+1.4}_{0}$ {224 $^{+15}_{0}$ }	18.0 {184}		
	Fuel injection timing	B. T. D. C	degree	13 ± 1	—		
Cooling system	Radiator pressure valve	Opening pressure (Differential pressure)	kPa {kg/cm^2}	—	—		
	Fan speed	At rated engine speed	rpm	1,825 ± 55	—		
	Fan belt tension	Deflection when pushed with a force of 60N {6 kg}	mm	(Auto-tension)	—		

S-1 Starting performance is poor (Starting always takes time)

General causes why exhaust smoke comes out but engine takes time to start

- Defective electrical system
- Insufficient supply of fuel
- Insufficient intake of air
- Improper selection of fuel
  (At ambient temperature of -10°C or below, ASTM D975 No. 2 diesel fuel is used)

★ Battery charging rate

Ambient temperature \ Charging rate	100 %	90 %	80 %	75 %	70 %
20°C	1.28	1.26	1.24	1.23	1.22
0°C	1.29	1.27	1.25	1.24	1.23
–10°C	1.30	1.28	1.26	1.25	1.24

- The specific gravity should exceed the value for the charging rate of 70% in the above table.
- In cold areas the specific gravity must exceed the value for the charging rate of 75% in the above table.

			Causes: Worn piston ring, cylinder	Defective contact of valve, valve seat	Clogged air cleaner element	Clogged fuel filter, strainer	Clogged feed pump gauze filter	Electrical intake air heater
Questions	Confirm recent repair history							
	Degree of use of machine	Operated for long period			△	△	△	
	Ease of starting	Gradually became worse	◎	◎	○	○	○	
		Starts when warm						◎
	Indicator lamp does not light up							◎
	Engine oil must be added more frequently		◎					
	Replacement of filters has not been carried out according to operation Manual				◎	◎	◎	
	Non-specified fuel has being used					○	○	
Check items	Dust indicator lamp is red				◎			
	Battery charge lamp is ON							
	Starting motor cranks engine slowly							
	When exhaust manifold is touched immediately after starting engine, temperature of some cylinders is low							
	Engine does not pick up smoothly, and combustion is irregular		○	○				
	Blow-by gas is excessive		◎					
	Timing lock on fuel injection pump does not match							
	Mud is stuck to fuel tank cap							
	When engine is cranked with starting motor,							
	1) Little fuel comes out even when injection pump piping sleeve nut is loosened							
	2) Little fuel comes out even when fuel filter air bleed plug is loosened				◎	◎		
	Leakage from fuel piping							
	There is hunting from engine (rotation is irregular)				○	○		
Troubleshooting	When compression pressure is measured, it is found to be low		●	●				
	When air cleaner element is inspected directly, it is found to be clogged				●			
	When fuel filter, strainer are inspected directly, they are found to be clogged					●		
	When feed pump strainer is inspected directly, it is found to be clogged						●	
	Heater mount does not become warm							●
	Is voltage 26–30V between alternator terminal B and terminal E with engine at low idling?	Yes						
		No						
	Either specific gravity of electrolyte or voltage of battery is low							
	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 (check after removing fuel injection pump)							
	When fuel tank cap is inspected directly, it is found to be clogged							
	Remedy		Replace	Correct	Clean	Clean	Clean	Replace

※ Use a test stand

S-9 Oil becomes contaminated quickly

General causes why oil becomes contaminated quickly

- Entry of exhaust gas due to internal wear
- Clogging of lubrication passage
- Improper fuel
- Improper oil used
- Operation under excessive load

			Causes: Worn piston ring, cylinder liner	Clogged breather, breather hose	Clogged oil filter	Worn valve, valve guide	Clogged oil cooler	Clogged turbocharger oil drain tube	Defective seal at turbocharger turbine end	Exhaust smoke is black
Questions / Check items	Confirm recent repair history									
	Degree of use of machine	Operated for long period	△			△			△	
	Engine oil must be added more frequently		◎							
	Non-specified oil is being used				○					
	Color of exhaust gas	Blue under light load	◎							
		Black								◎
	Amount of blow-by gas	Excessive	◎			○		○	○	
		None		◎						
	When oil filter is inspected, metal particles are found		○		◎	○				
	When exhaust pipe is removed, inside is found to be dirty with oil					◎				
	Engine oil temperature rises quickly						◎			
Troubleshooting	When compression pressure is measured, it is found to be low		●			●				
	When breather element is inspected directly, hose is broken or is found to be clogged with dirty oil			●						
	When oil filter is inspected directly, it is found to be clogged				●					
	When oil cooler is inspected directly, it is found to be clogged						●			
	Turbocharger oil drain tube is clogged							●		
	Excessive play of turbocharger shaft								●	
	When safety valve is directly inspected, spring is found to be catching or broken									
	Remedy		Replace	Clean	Replace	Replace	Clean	Clean	Replace	—

Carry out troubleshooting for "Exhaust smoke is black".

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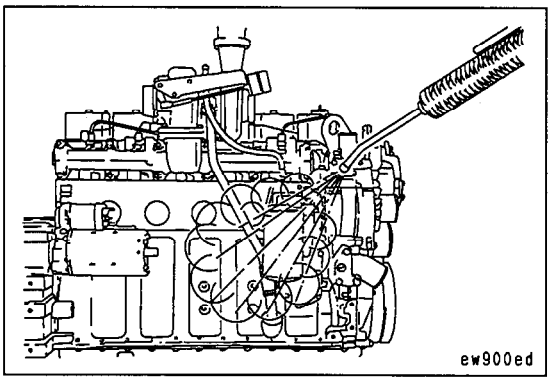
DISASSEMBLY OF ENGINE

STEAM CLEANING OF ENGINE

Warning: When cleaning with steam, wear protective clothing, safety glasses, and face shield. Hot steam may cause serious burns.

Caution: Fit covers to the openings of the engine and to the electrical components, and be careful not to get water on these parts.

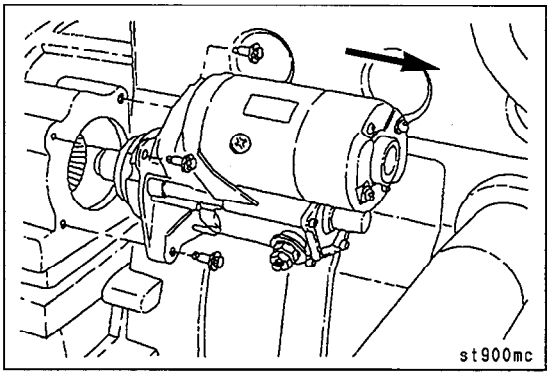
Use steam to clean off any excessive dirt on the outside of the engine.



REMOVAL OF STARTING MOTOR

10 mm

Remove the starting motor.



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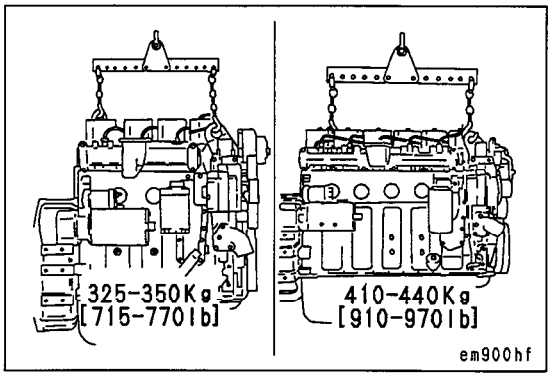
WEIGHT OF ENGINE (REFERENCE VALUE NOT INCLUDING AUXILIARIES SUCH AS MUFFLER)

3822512 Engine lifting equipment

kg 4D102 engine (wet): 325 - 350 kg

kg 6D102 engine (wet): 410 - 440 kg



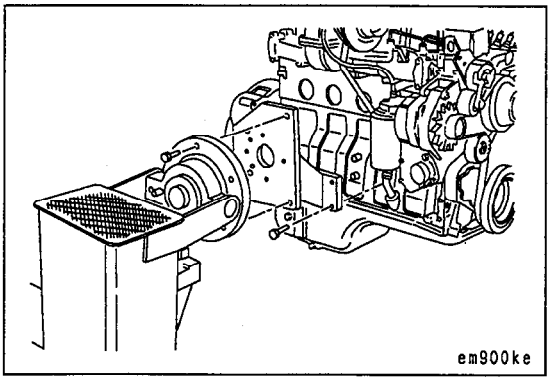
INSTALLATION TO ENGINE STAND

18 mm, engine rebuilding stand, adapter (795-799-1160)

Install the engine to the rebuilding stand.

kgm : **77 Nm{7.9 kg}**

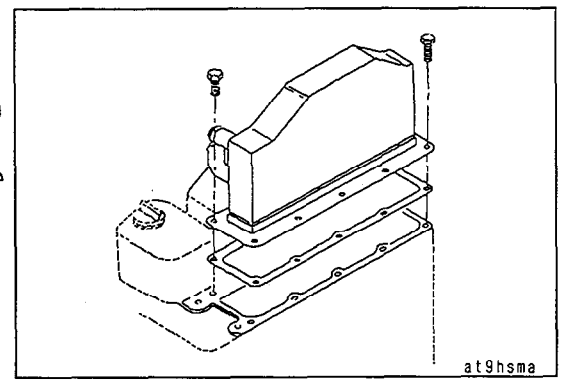
Installation hardware: M12 x 1.75



REMOVAL OF AFTERCOOLER (ENGINE WITH AFTERCOOLER)

10 mm

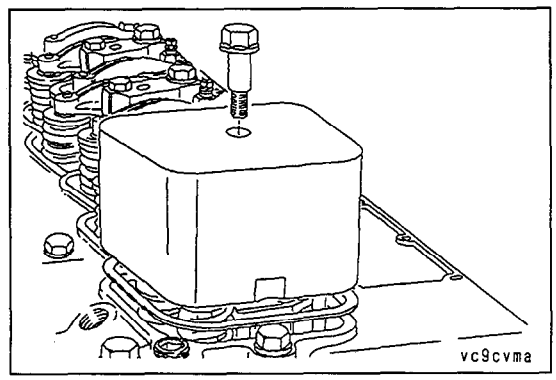
If an aftercooler is installed, remove the housing.



REMOVAL OF CYLINDER HEAD COVER

15 mm

Remove the special mounting bolts, O-ring, valve cover, and gasket.



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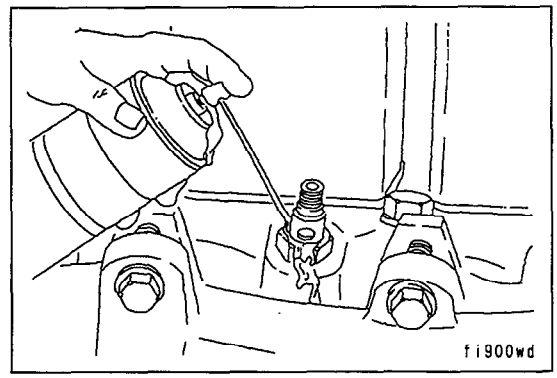
REMOVAL OF FUEL INJECTION NOZZLE

Rust penetrant

Caution: If there is rust on the mounting nut, the injector will rotate in the bore when the nut is loosened. If this happens, the injector locating ball will cut a groove on the inside surface of the bore and damage the head.

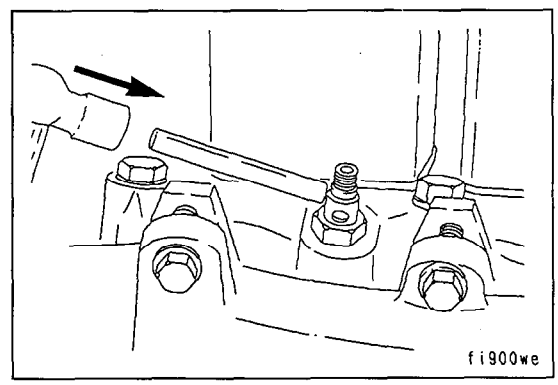
Apply rust penetrant to the mounting nut and soak for at least 3 minutes.



Brass drive pin, hammer

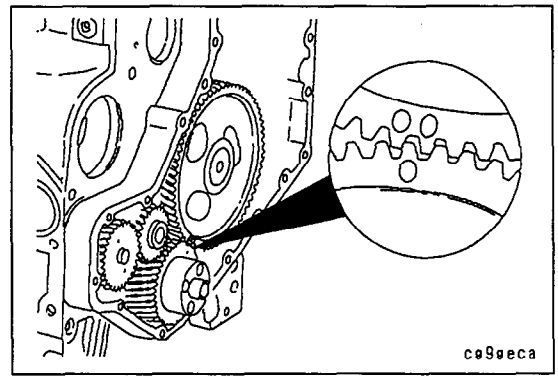
Caution: If the force is too strong, the injector will be damaged.

Hit the injector with a hammer and drive pin and remove the rust.



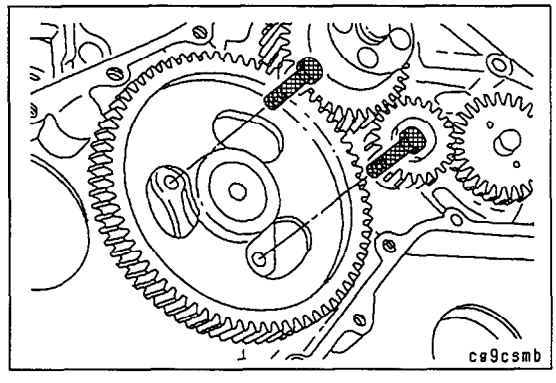
Rotate the crankshaft to set the No. 1 cylinder to the TDC position. If this is not done, the camshaft will catch on the connecting rod when the camshaft is removed.

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.



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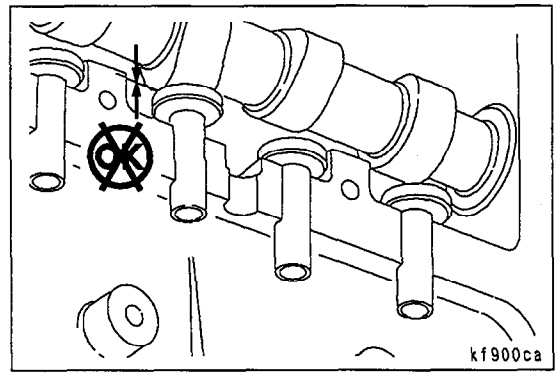
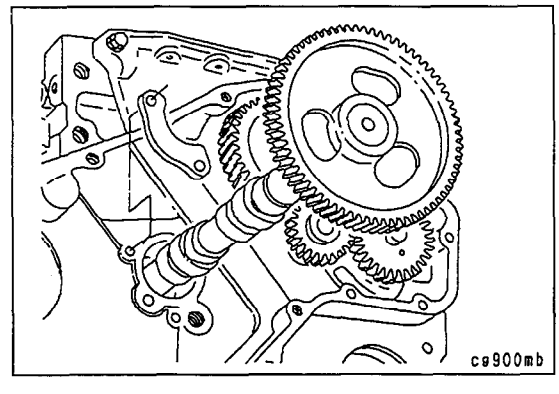
Inspect the tappet visually to check that it is separated from the camshaft lobe.



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.

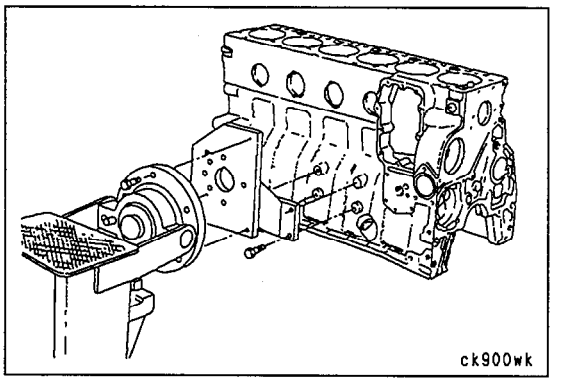


ASSEMBLY OF ENGINE

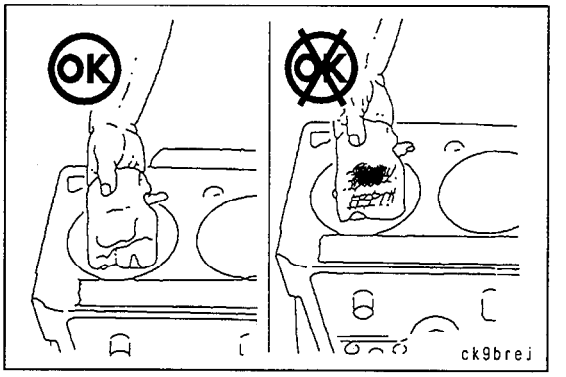
PREPARATION FOR ASSEMBLY OF CYLINDER BLOCK

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.



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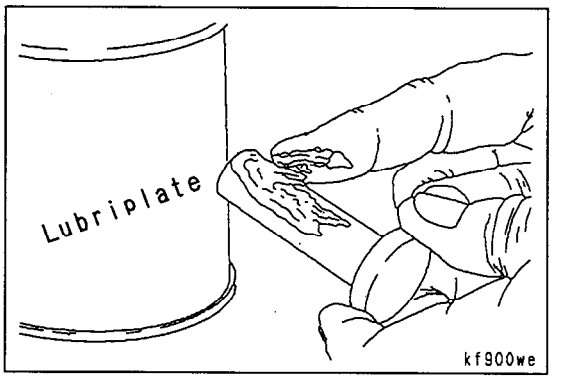
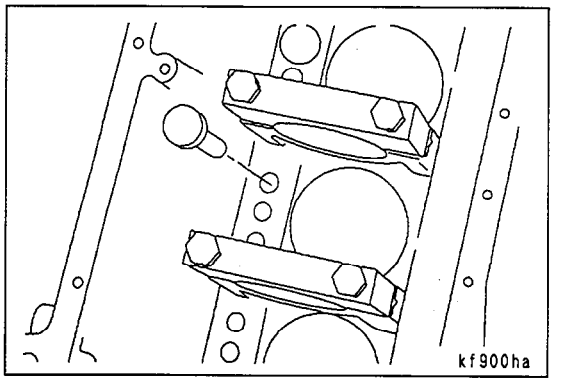
INSTALLATION OF TAPPET

Coat the tappet with lubricating oil.



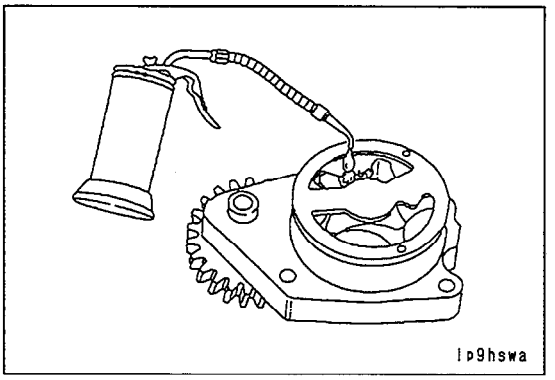
Install the valve tappet.



INSTALLATION OF OIL PUMP

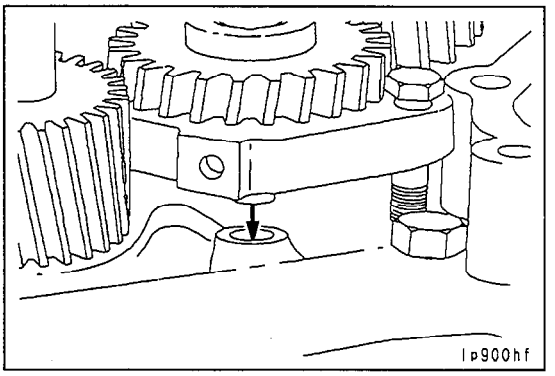
Coat the pump with clean oil.

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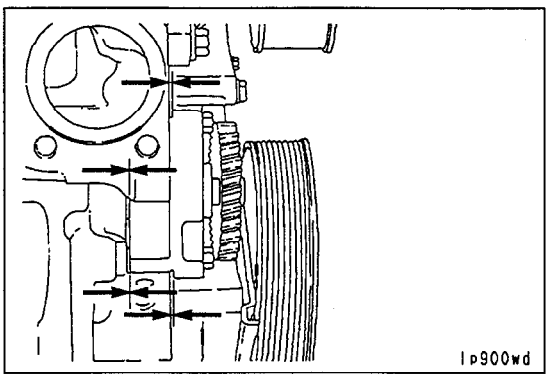
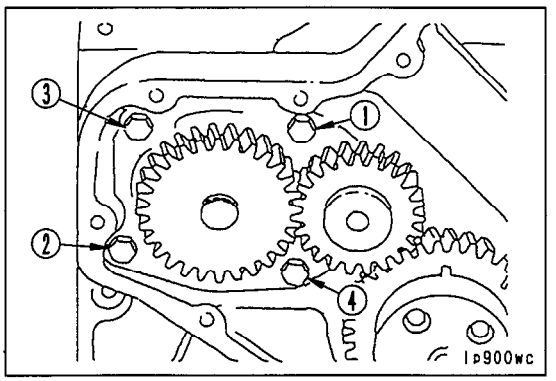
When installing the oil pump to the cylinder block, there should be a clearance between the pump flange and cylinder block. Do not tighten the mounting bolts excessively to close the gap. If the mounting bolts are tightened excessively, the oil pump will be damaged.



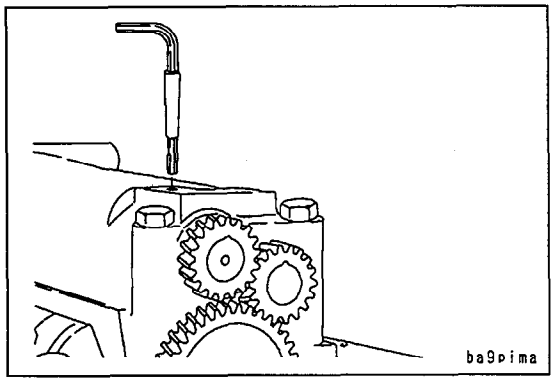
13 mm

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

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



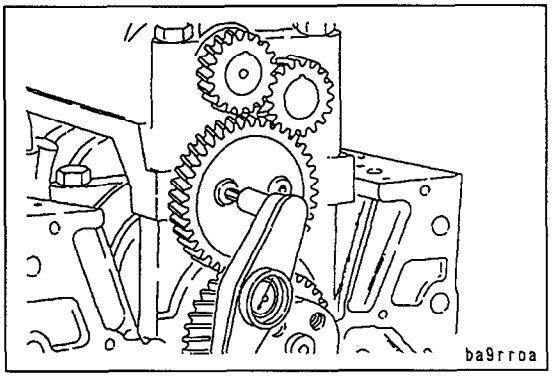
Remove the stopper bolt or hexagon wrench from the balancer.



8 mm hexagon wrench

Installation of idler gear retainer
Tighten the bolts.

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



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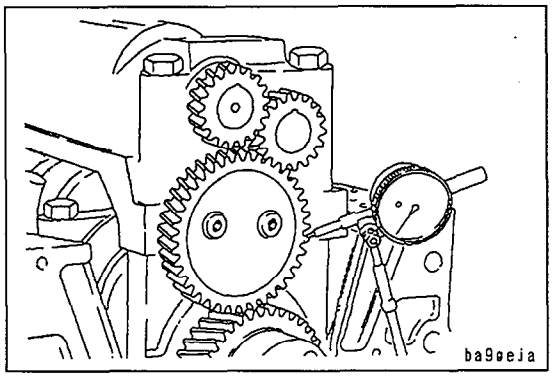
Note down the backlash of the idler gear.

Limit of backlash mm	
0.088	MIN
0.420	MAX

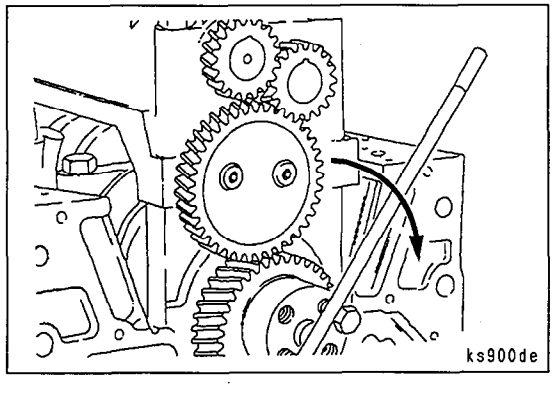
If the idler gear does not match the specifications, loosen the mounting bolts of the idler gear retainer. Position the idler gear again, then tighten the mounting bolts.

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



The crankshaft must be able to rotate freely.

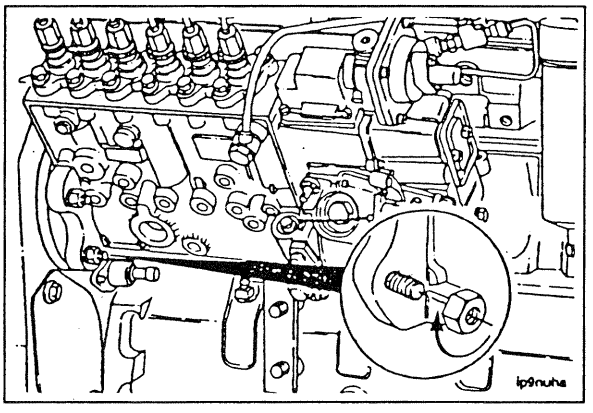
If the crankshaft does not rotate freely, check if the balancer is causing interference.



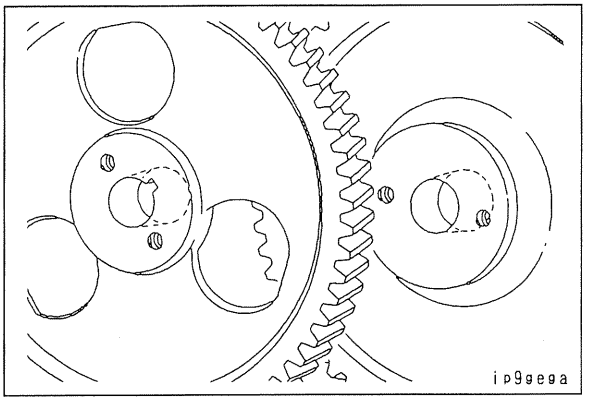
15 mm

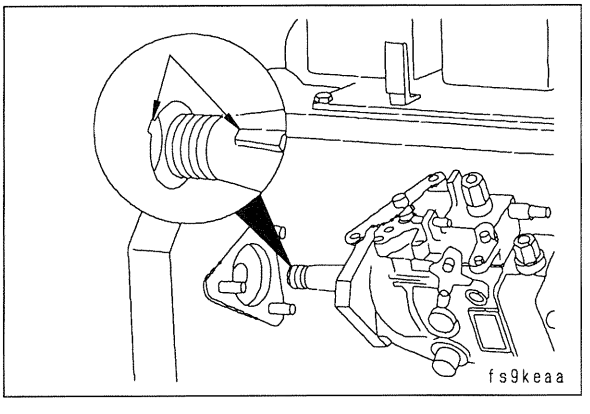
Install the mounting nut.

kgm: **43 Nm {4.37 kgm}**



There are tapered holes in the fuel injection pump drive gear. Set so that the face with the larger diameter tapered hole is facing the engine.
(The fuel injection pump of Zexel A does not have a positioning key.)



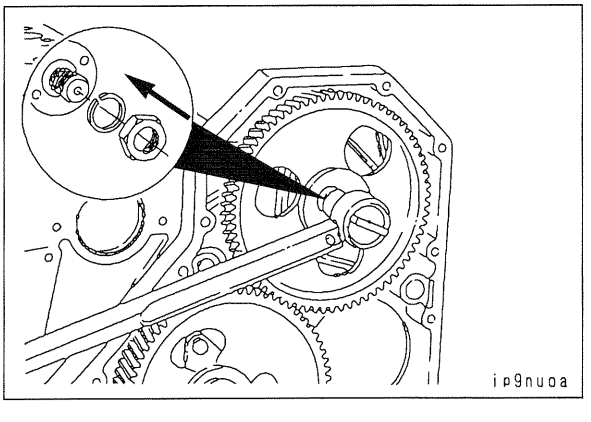


22 mm

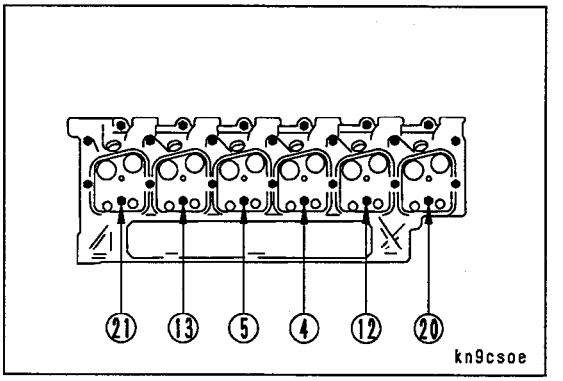
Install the drive gear mounting nut and washer. The pump will rotate slightly because of the gear helix and clearance, but if the pump moves freely in the flange slot and the crankshaft does not move, there is no problem.

kgm: **15 Nm {1.5 kgm}**

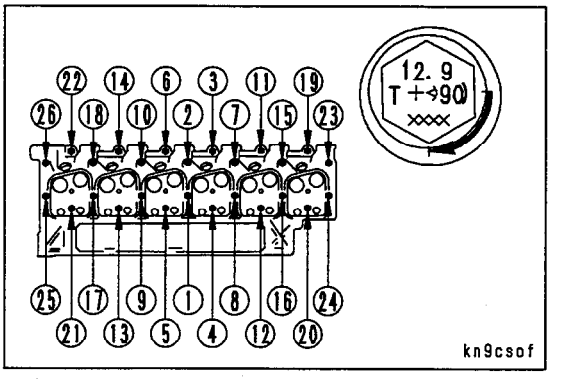
This is not the final torque value. After unlocking the pump, tighten the drive shaft nut to the specified value.



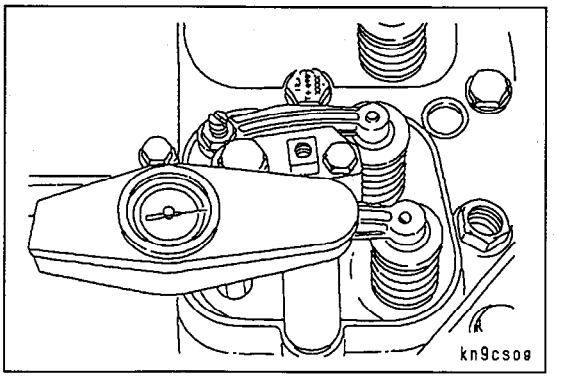
Tighten only the 6 long mounting bolts (No. 4, 5, 12, 13, 20, 21) in the number order to 120 Nm {12.2 kgm}.



Tighten the mounting bolts in the order given a further 90°.



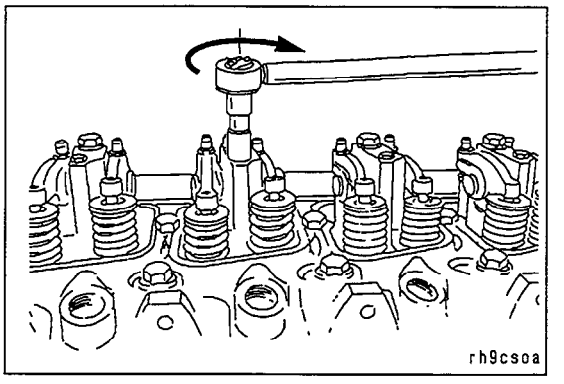
To check that all the mounting bolts have been turned 90°, check that the torque of the tightening bolts is 136 Nm {13.9 kgm}. When tightening the mounting bolts to 136 Nm {13.9 kgm}, loosen only that bolt and tighten again according to the procedure given above.



13 mm

Tighten the 8 mm holder mounting bolts.

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

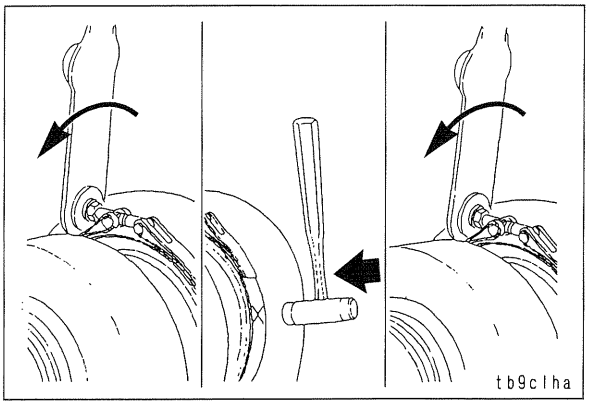


673501

7/16 inch plastic hammer

Tighten the band clamp. Tap around the clamp with a plastic hammer, then tighten again.

kgm: **8.5 Nm {0.87 kgm }**

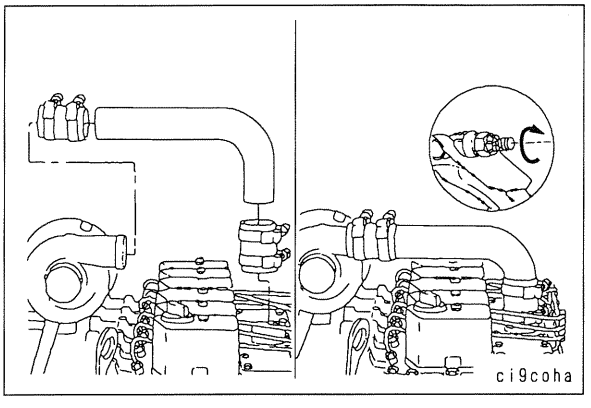


10 mm screwdriver

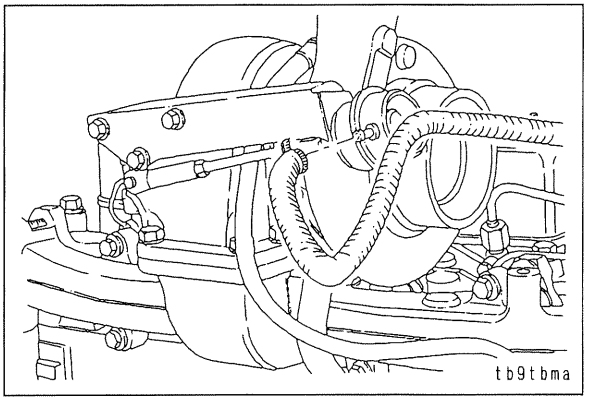
Install the air crossover tube and clamp, then tighten.

kgm: **10 Nm {1.0 kgm}** : Clamp
24 Nm {2.5 kgm} : Crossover flange

Note: Proper tightening torque for the clamp depends on the type of the clamp.

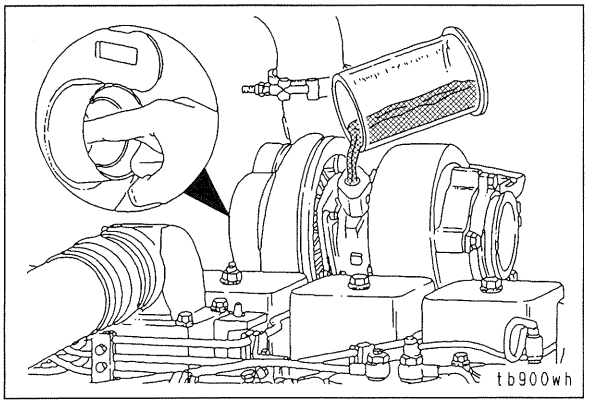


Install the boost control capsule actuator hose.



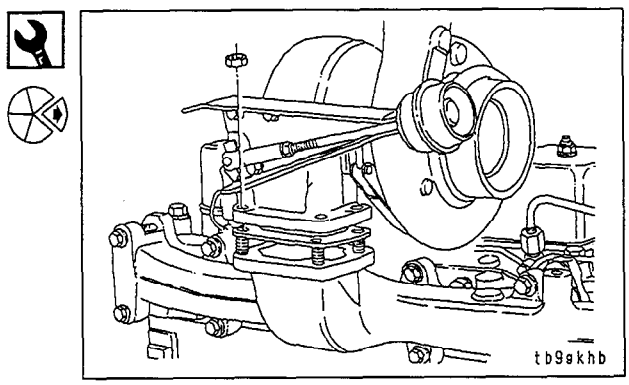
Caution: Lubricate the turbocharger.

Add 50 - 60 cc of clean oil through the oil inlet port fitting at the top of the turbocharger and rotate the turbocharger impeller to send oil to the bearing.



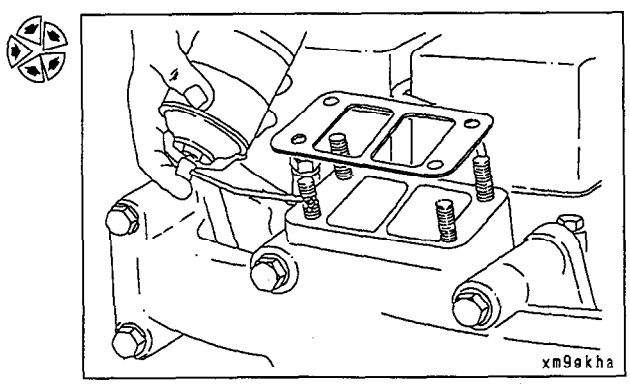
15 mm and 7/16 inch

Remove the exhaust clamp, turbocharger, and gasket.



INSTALLATION

Install a new gasket, then coat the mounting stud with seizure prevention compound.



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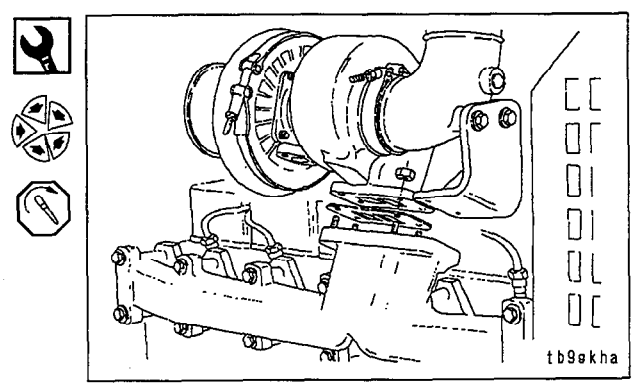
15 mm

Install the turbocharger.

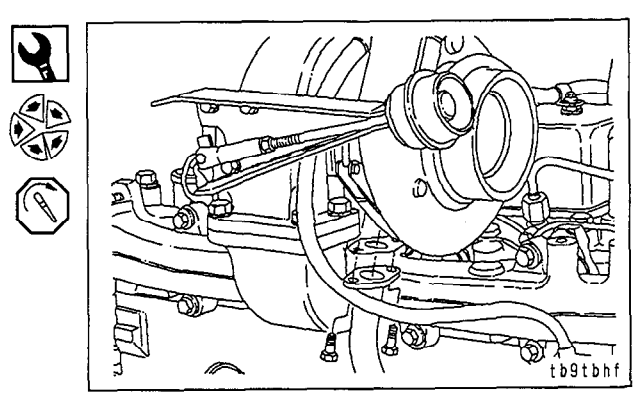
kgm : **45 Nm {4.6 kgm}**



10 mm and 7/16 inch

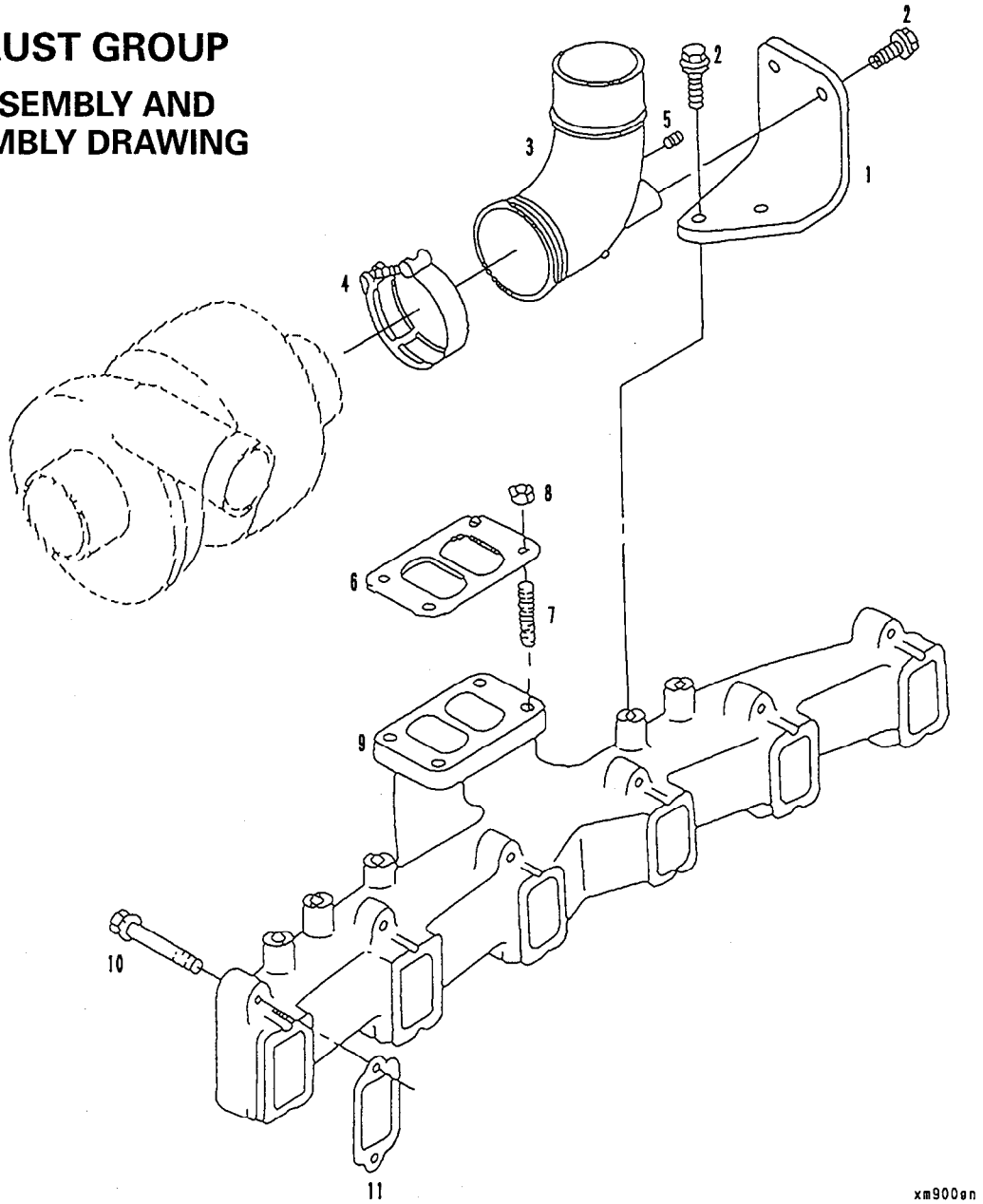
Use a new gasket and connect the oil drain tube.

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



EXHAUST GROUP

DISASSEMBLY AND ASSEMBLY DRAWING



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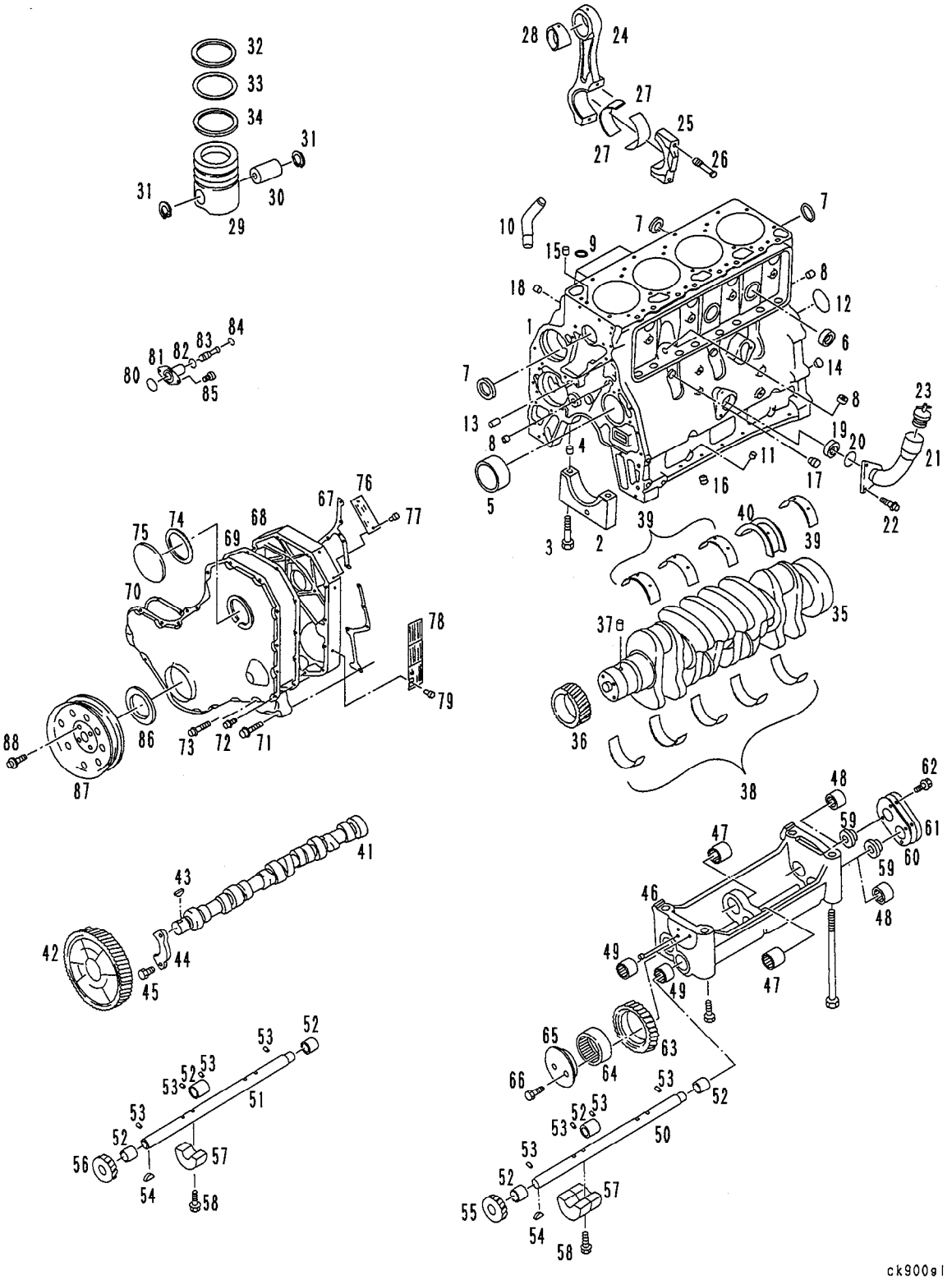
Index No.	Part Name	Q'ty	Remarks
1	Exhaust external connection brace	1	
2	Hexagonal mounting bolt	4	
3	Exhaust external connection	1	90° turbocharger exhaust elbow
4	V-band clamp	1	
5	Pipe plug	1	
6	Turbocharger gasket	1	
7	Stud	4	
8	Nut	4	
9	Exhaust manifold	1	
10	Hexagonal mounting bolt	12	
11	Manifold gasket	6	

CYLINDER BLOCK GROUP

DISASSEMBLY AND ASSEMBLY DRAWING



CHECK LIST FOR CYLINDER BLOCK GROUP

- Flatness of head deck ☐
- Inside diameter of main bearing ☐
- Inside diameter of camshaft ☐
- Inside diameter of tappet ☐
- Accumulation of sediment in cooling water passage ☐
- Crankshaft seal wear surface ☐
- Damage to rod and main journal ☐
- Vibration damper index line and rubber parts ☐
- Visual check of damage to piston assembly ☐
- Measurement of piston skirt diameter ☐
- Piston ring clearance ☐
- Measurement of inside diameter of piston pin ☐
- Visual check of connecting rod assembly ☐
- Clearance of main bearing ☐
- Clearance of connecting rod bearing ☐

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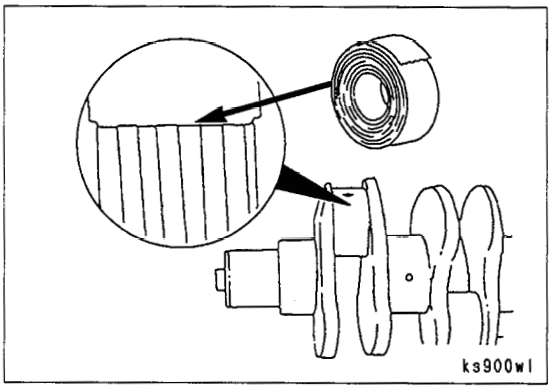
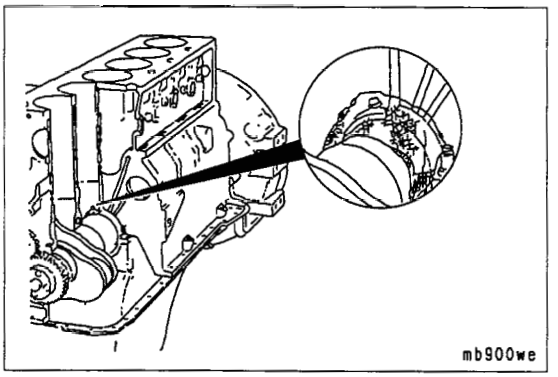
Cover the cloth with water-proof tape.



Place a clean towel around the upper main bearing saddle and catch the residue and water that comes out from the piston cooling nozzle.



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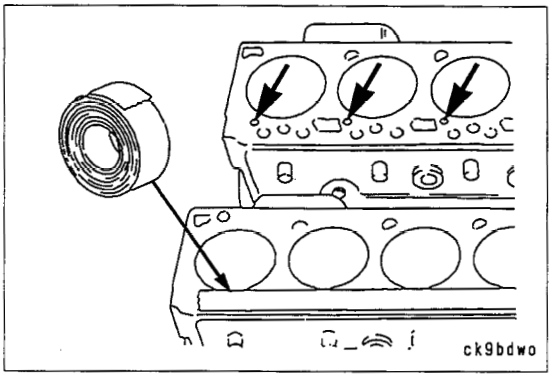
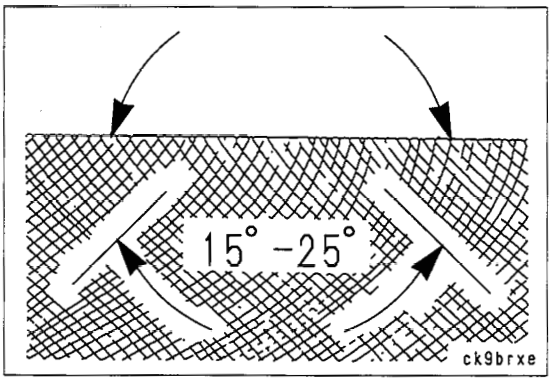
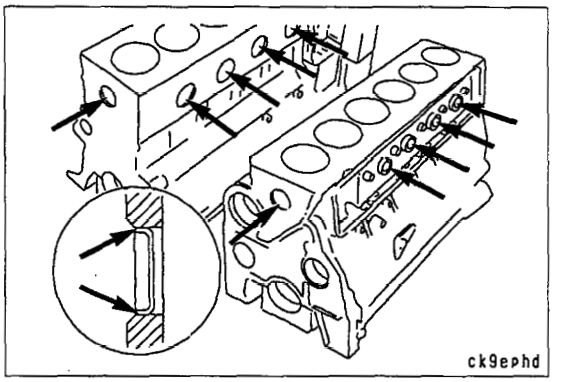
Cover the tappet hole and oil hole at the top of the cylinder block with water-proof tape.



On surfaces where the glaze has been properly removed, a cross-hatch pattern consisting of lines at an angle of 15 - 25° to the top of the cylinder bore is formed.

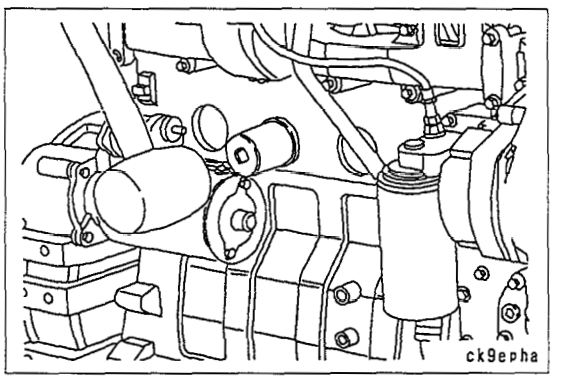


Use a socket of a suitable depth as a driver and install the cup plug.



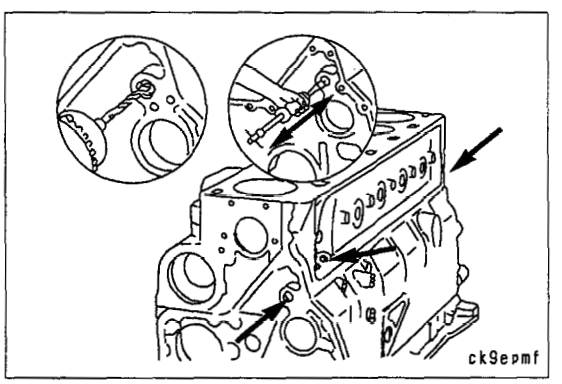
Make the tip of the cup plug 0.5 - 1.0 mm {0.020 - 0.040 in} deeper than the inlet port chamber of the bore, and install the cup plug.

Caution: Do not make the installation of the cup plug too deep. If it is impossible to install the cup plug straight and flat, replace it with a new cup plug.



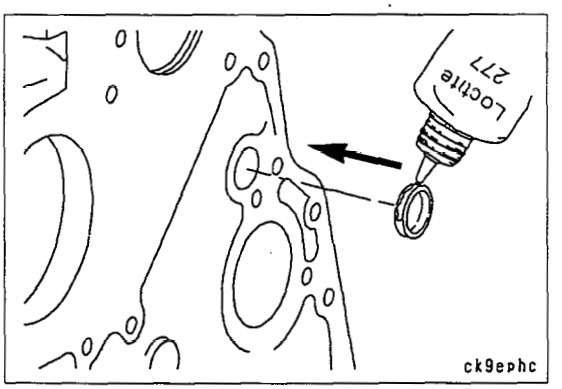
673501

Remove the cup plug from the oil passage.

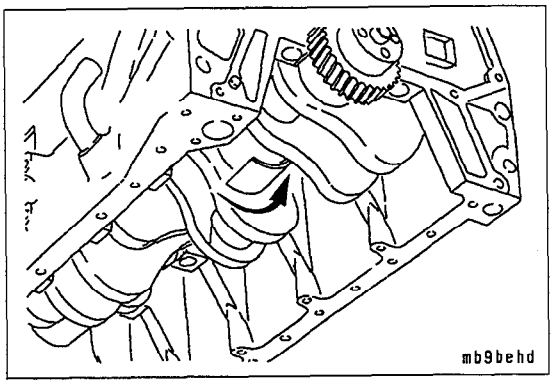


INSTALLATION OF CUP PLUG

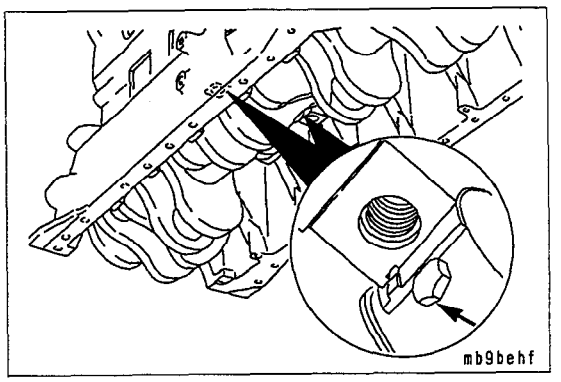
Coat the area around the plug with Loctite 277.



Set the new main bearing in position on the crankshaft, then install as strongly as possible by hand.



Using the pin, check that the main bearing is aligned with the cylinder block, and push the main bearing slowly. Check that the tongue of the main bearing has entered the notch.



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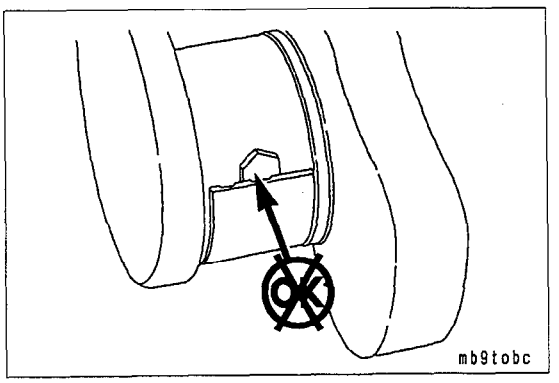
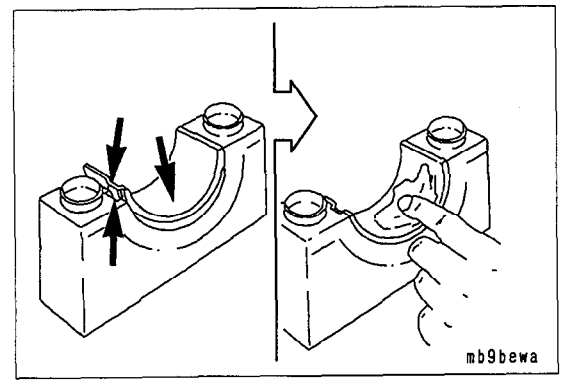
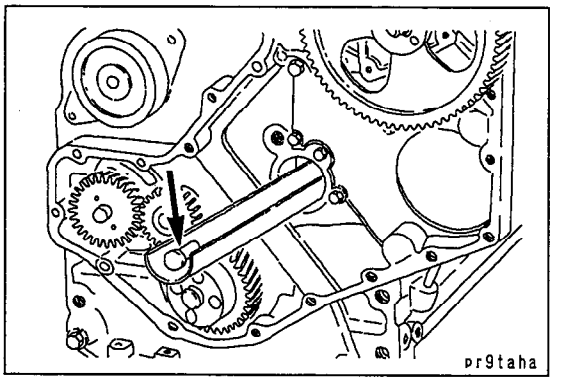
Caution: Check that the pin has not slipped under the bearing.



Install the lower main bearing to the main bearing cap.
Coat the main bearing with Lubriplate 105®.



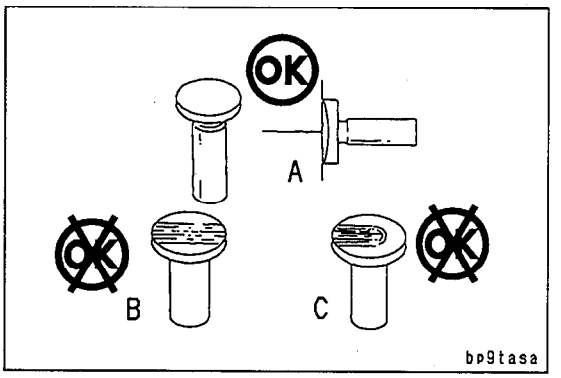
Pull the trough and tappets out carefully from the cam bore, and remove the tappets. Repeat this procedure to remove all the tappets.



INSPECTION OF TAPPET

Check the socket, stem, and face for excessive wear, cracks, and other damage.

Visual limit
(A) - normal contact (it is exaggerated) (B) and (C) - abnormal contact: do not reuse.



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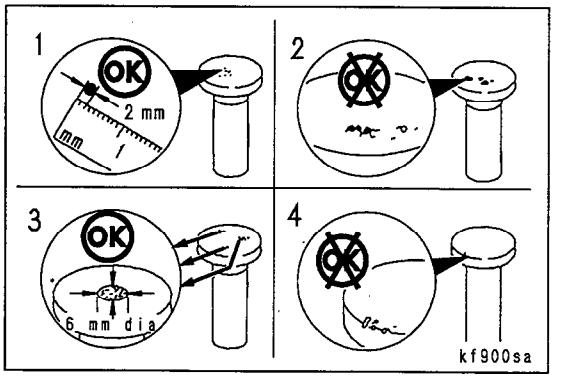
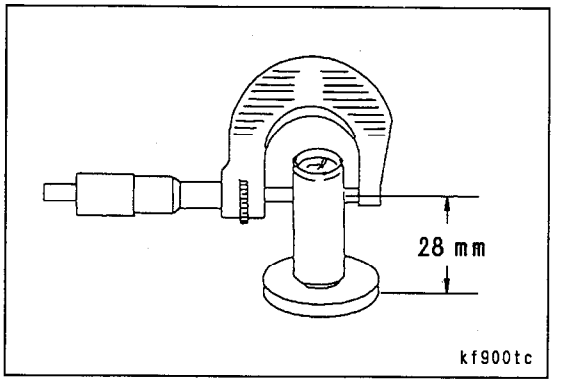
It is possible to use the tappet even if there is a hollow in the tappet face.
The following standards show the permissible size of the hollow.

1. A single hollow must not be greater than 2 mm.
2. The tappet cannot be reused if there are connected hollows.
3. The total for multiple hollows must not exceed 4% of the tappet face or a diameter of 6 mm.
4. There must be no hollow at the tip of the tappet wear surface.

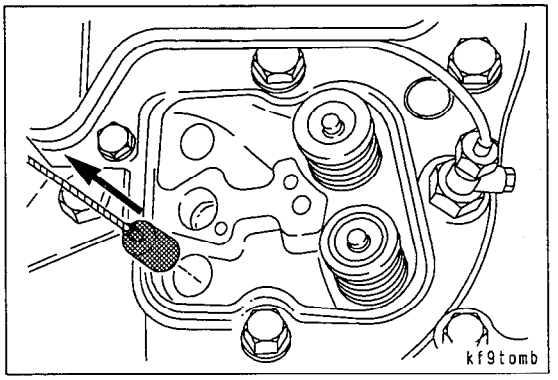


Measure the valve tappet stem.

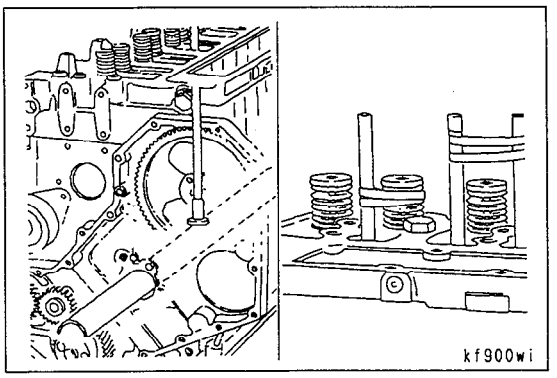
Diameter mm	
15.936	Min
15.977	Max



Remove the installing tool from the tappet.



Insert a wooden dowel into the top of the tappet, then fit a rubber band around the wooden dowel to hold the tappet in position.
Repeat this procedure to install all the tappets.



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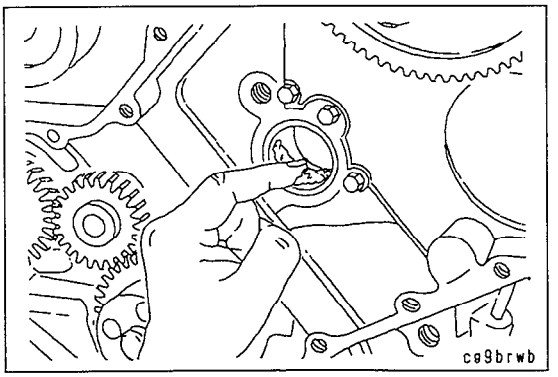
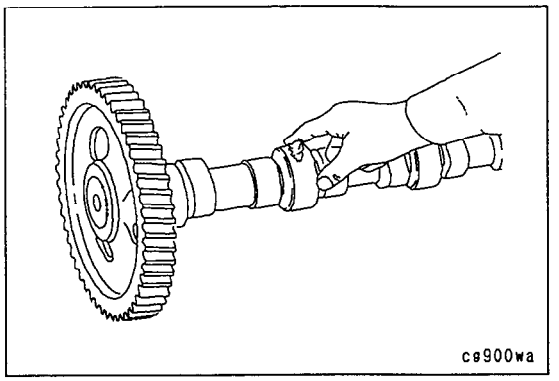
INSTALLATION OF CAMSHAFT

Coat the front camshaft bore with Lubriplate 105.



Put lubricating oil on the camshaft lobe, journal, and thrust washer.

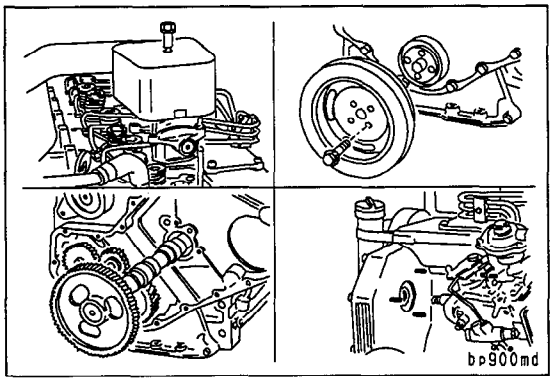


REPLACEMENT OF GEAR HOUSING, GASKET

REMOVAL

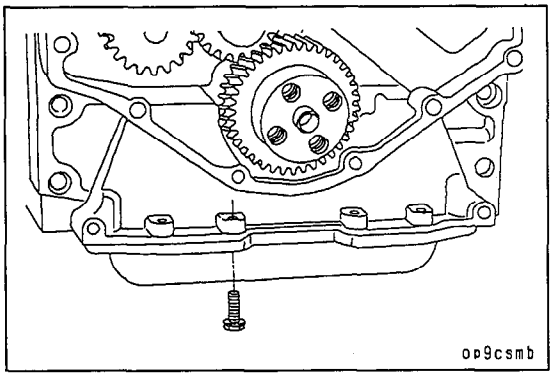
Preparatory work:

- Remove the valve cover rocker lever and push rod.
- Remove the vibration damper.
- Remove the camshaft.
- Remove the fan pump.



10 mm

Remove 6 mounting bolts from the front oil pan.



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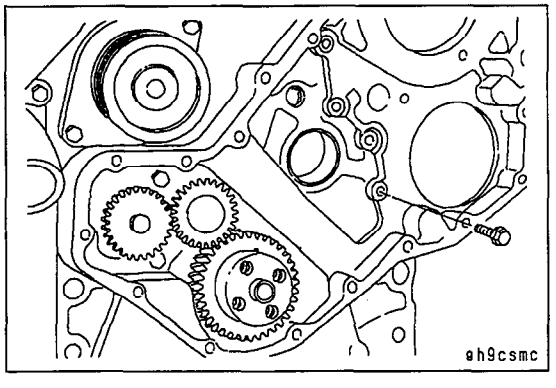
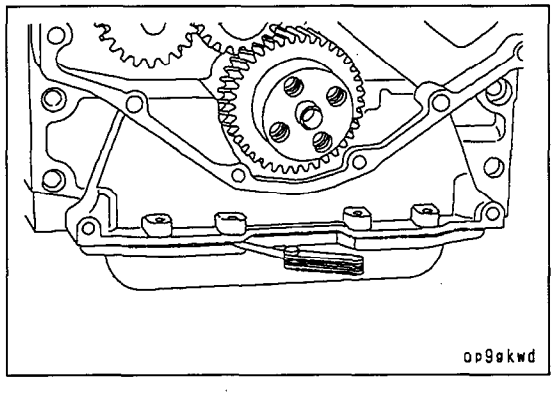
10 mm

Remove the gear housing mounting bolts.

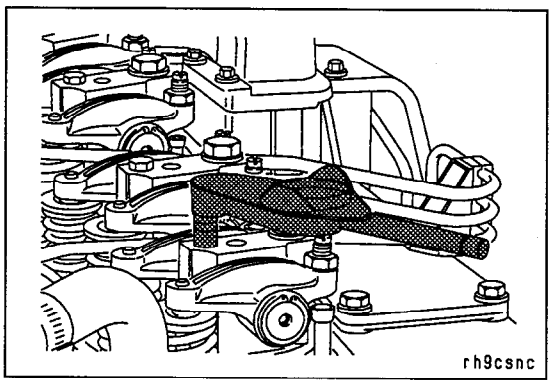


Using a clearance gauge, try to separate the oil pan gasket from the gear housing.



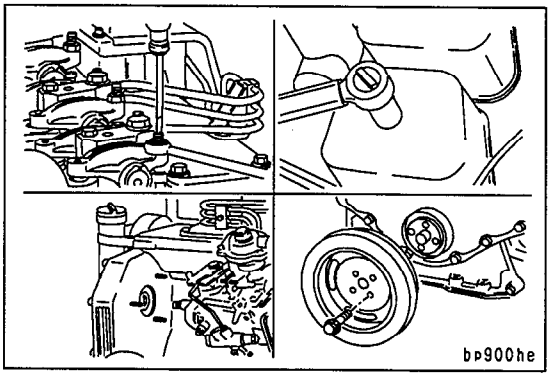
10 mm

Tighten the rocker lever pedestal mounting bolts.
For details of the procedure, see 7-03.



Install the removed components.

- Adjust the valves.
- Injector.
- Fuel injection pump.
- Gear cover.
- Vibration damper.



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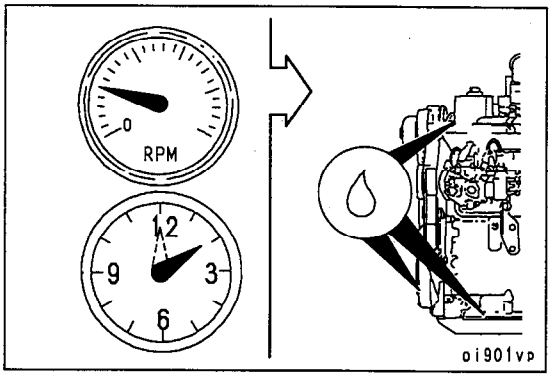
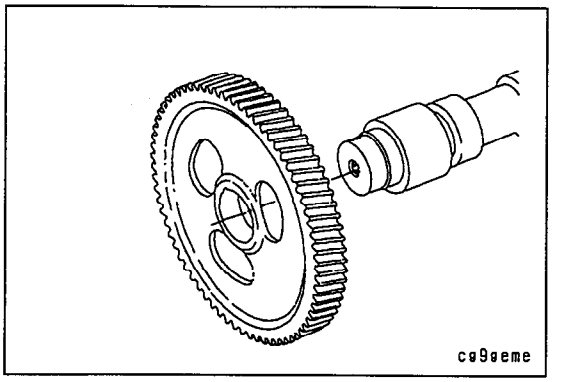
Run the engine at idling for 5 - 10 minutes and check for leakage and loose parts.



REPLACEMENT OF CAMSHAFT GEAR

REMOVAL

Remove the gear.

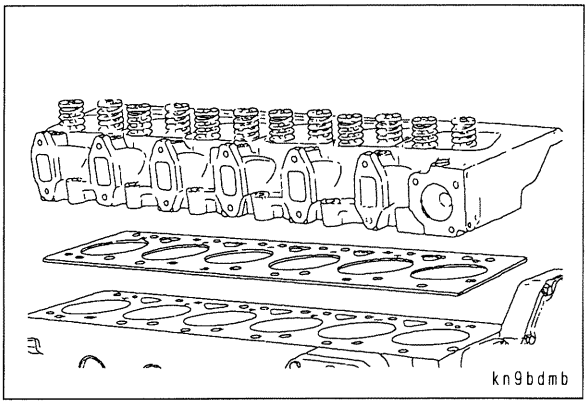


PISTON, PIN, CONNECTING ROD

REPLACEMENT OF PISTON AND RING

Preparatory work:

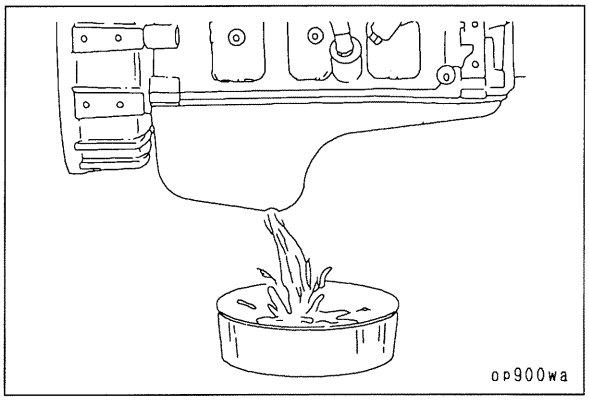
- Drain the coolant.
- Remove the cylinder head.



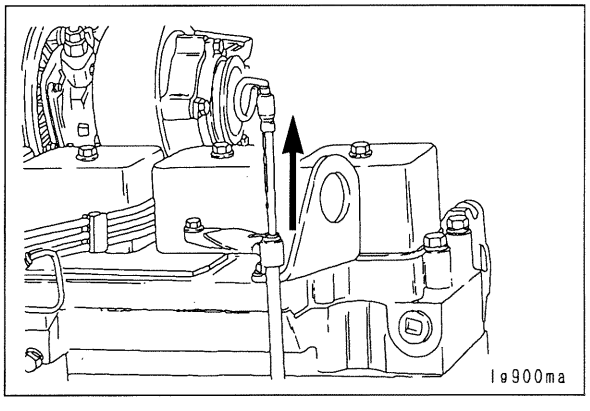
22 mm

Drain the oil.
After draining the oil, install the drain plug and a new sealing washer.

kgm : **102-1: 80 Nm {8.2 kgm}**
102-2: 59 Nm {6 kgm}

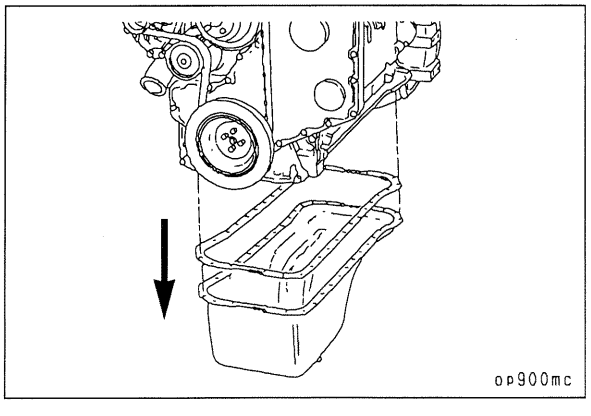


Remove the dipstick bayonet.

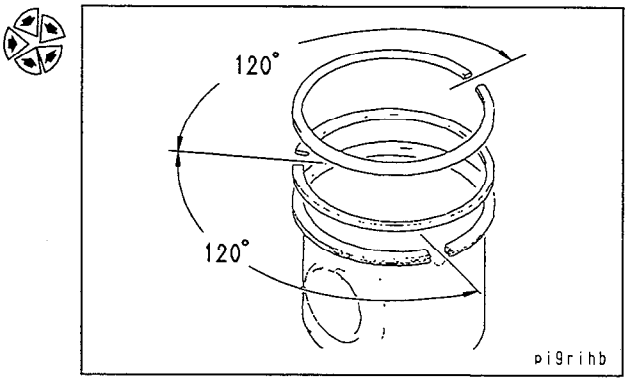


10 mm

Remove the oil pan.



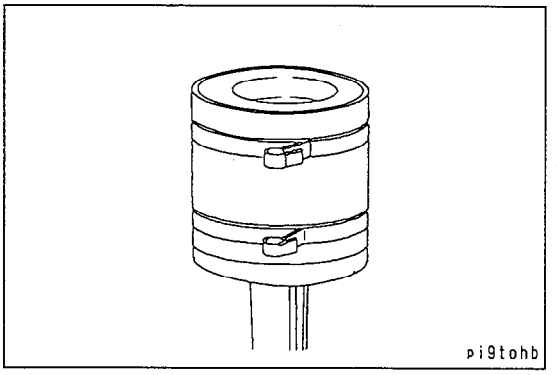
Set the rings in position.



75 - 125 mm ring compressor

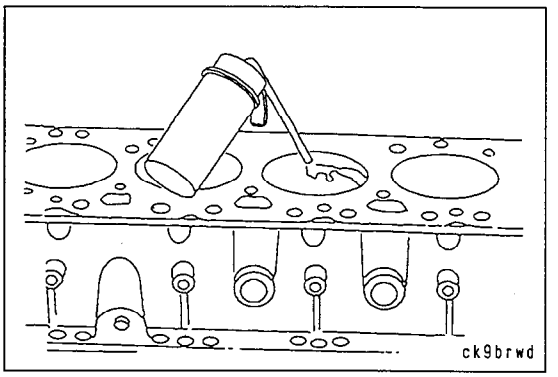
Caution: When using a strap type ring compressor, be careful that the tip of the strap on the inside does not catch in the ring gap and damage the ring.

Compress the ring with the compressor.

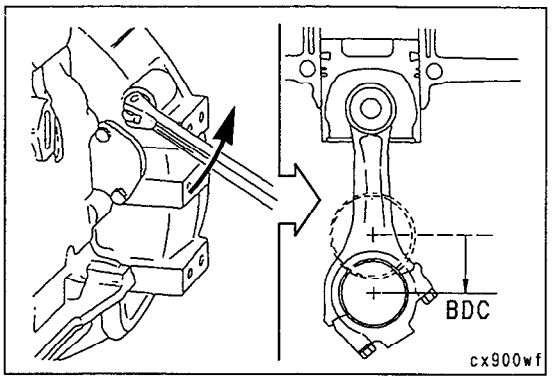


673501

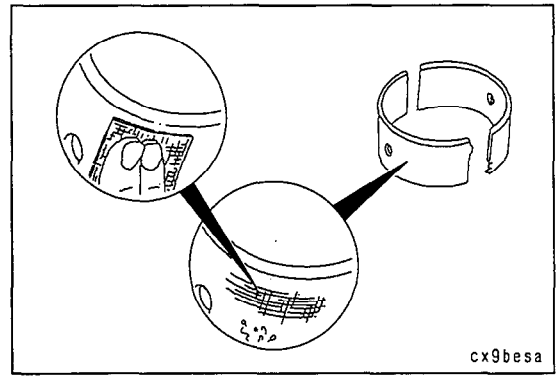
Coat the cylinder bore with clean oil.



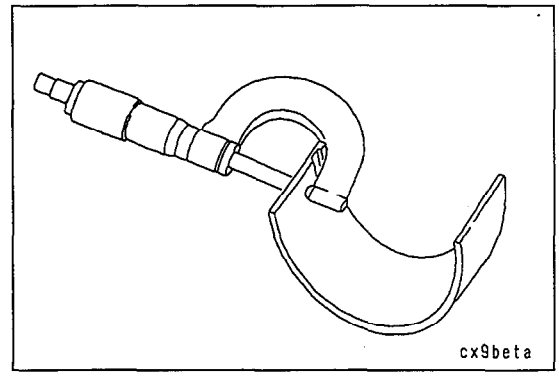
Set the connecting rod journal of the piston to be installed to the bottom dead center (BDC) position.



Check the bearing shell seat surface for scuffing and flashes. If the scuffing or flashes cannot be removed with Scotch-Brite® 7448 or equivalent, replace the bearing.



Using an outside diameter ball tipped micrometer, measure the thickness of the connecting rod bearing.



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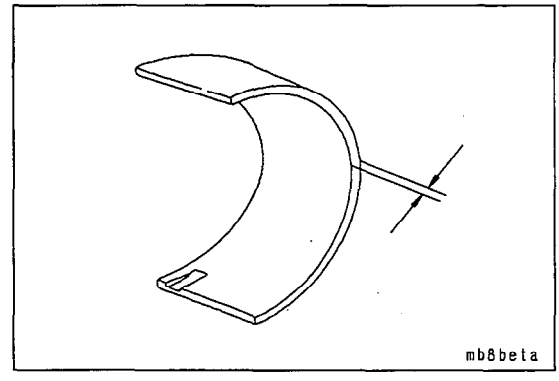
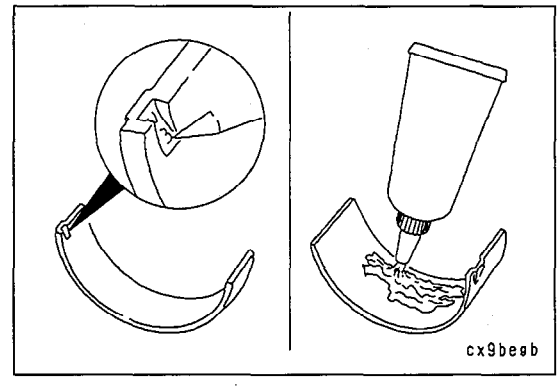
Dimensions of connecting rod bearing	
Standard	1.955-1.968 mm
0.25 mm O/S	2.080-2.093 mm
0.50 mm O/S	2.205-2.218 mm
0.75 mm O/S	2.330-2.343 mm
1.00 mm O/S	2.455-2.468 mm



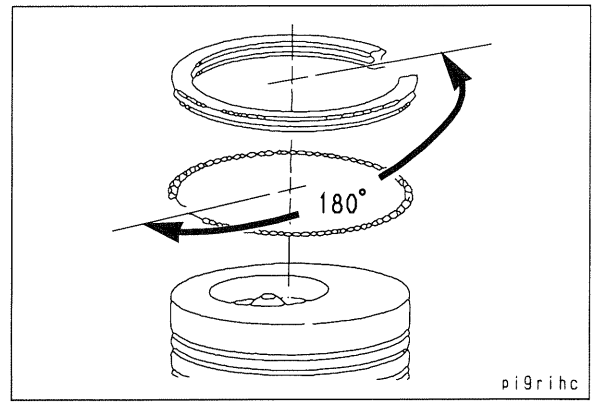
INSTALLATION

Caution: Be sure to install the bearings in the same position from which they were removed.

Coat the inside diameter of the bearing shell with Lubriplate 105® or equivalent.

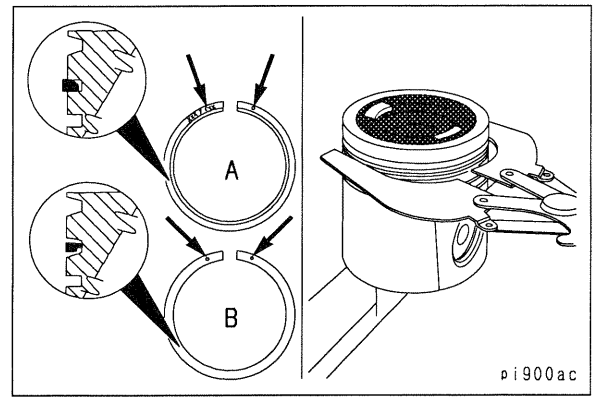


Install the oil control ring with the end gap 180° from the end of the expander.



Piston ring tool (795-100-2800)

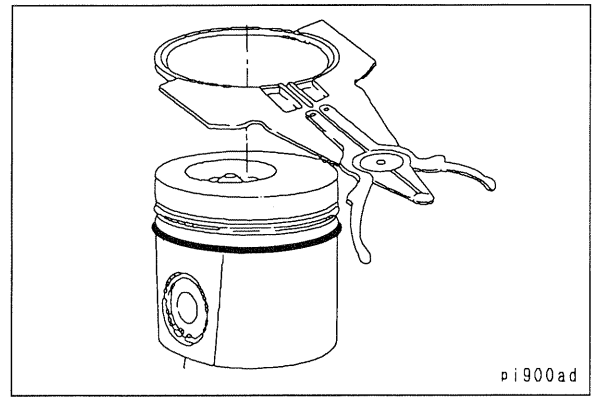
Install the 2nd ring.



Piston ring tool (795-100-2800)

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

Install the top ring.



BALANCER

DISASSEMBLY

For details of the procedure and specifications, see procedures in the section on disassembly of the engine.

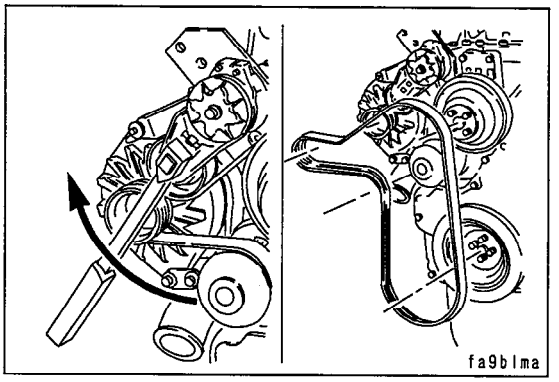
- If the backlash end play exceed the specification, replace the idler gear.
- If the backlash exceeds the specification, replace the shaft gear.
- If the play of the shaft in the axial direction exceeds the specification, replace the thrust bearing.

GEAR COVER

REPLACEMENT OF GEAR COVER

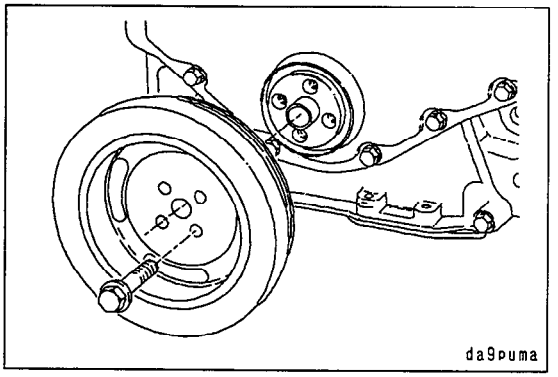
REMOVAL

Remove the drive belt.



15 mm

Remove the crankshaft pulley.



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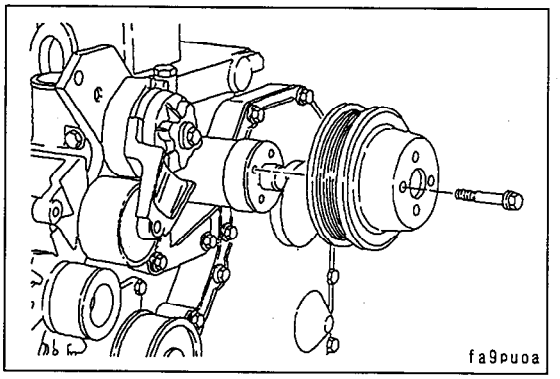
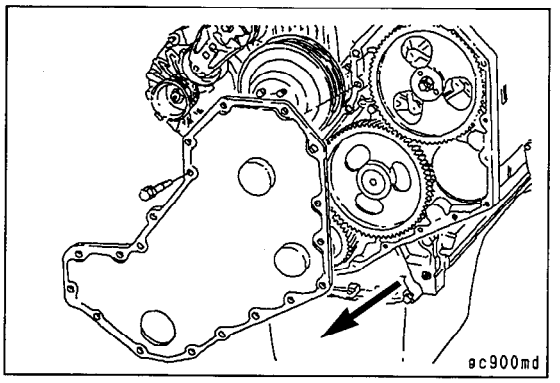
10 mm

If necessary, remove the hub pulley.



10 mm

Remove the front gear cover.



OUTLINE

The cylinder head has 2 valves installed to each cylinder and has a 1-piece cross-flow design. The features of the cylinder head are that it is fully equipped type with cast valve guides, induction hardened seat surface, integrated intake manifold, fuel filter head, and thermostat housing.

On the high-output 6-cylinder engine equipped with in-line fuel injection pump, the fuel filter head has been removed to give a larger clearance for the fuel injection pump. The injectors are installed to the cylinder head, so they can carry out direct injection into the cylinder.

The cylinder head gasket forms a composite design with the fire ring which seals the cylinder bore. The gasket orifices control the flow of the cooling water.

The valve seat can be ground once. If a valve seat has already been ground, it is possible to replace it with a service valve seat. A service valve guide can also be used when replacing a worn guide.

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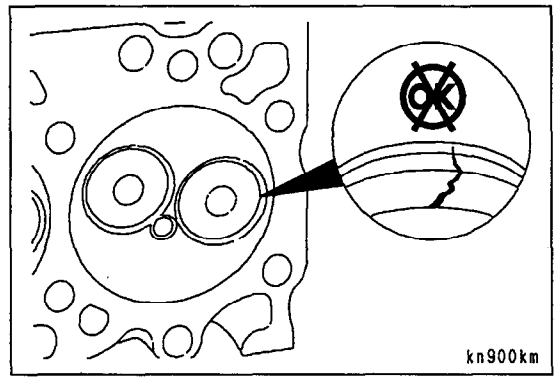
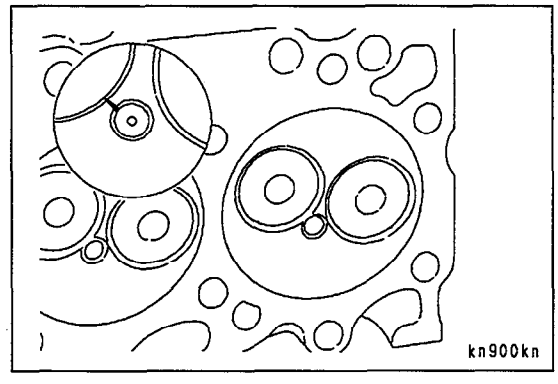
INSPECTION OF VALVE SEAT

Check the valve seat for cracks or signs of burning. If there are any cracks, refer to the following standards for reuse. If it is necessary to grind more than 0.254 mm to finish the seat smooth, it is possible to use a service valve seat. For details of the procedure for installing the valve seat, see replacement repair manual.

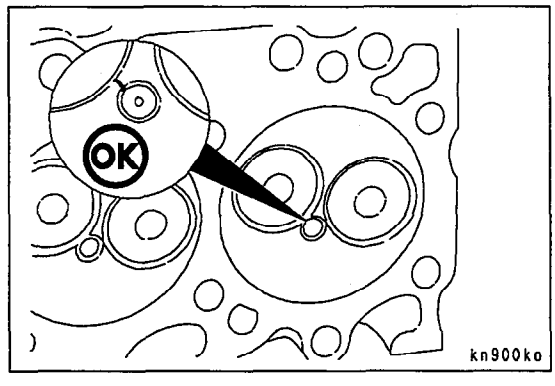


STANDARDS FOR CRACKS IN CYLINDER HEAD WHEN REUSING

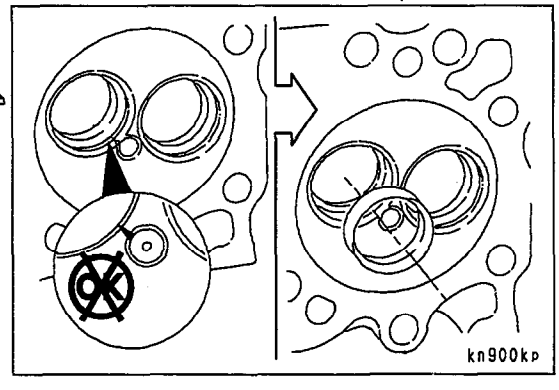
These standards apply only when the crack extends from the injector bore to the intake valve seat. If there are cracks in the valve bridge in any other place, replace the cylinder head.



The standards for reuse when the crack extends from the injector bore to the intake valve seat are as follows.
If the crack does not enter the valve seat, it is possible to reuse the cylinder head.



If the crack extends into the valve seat or passes through it, install a valve seat insert to repair the cylinder head. For details, see replacement repair manual.



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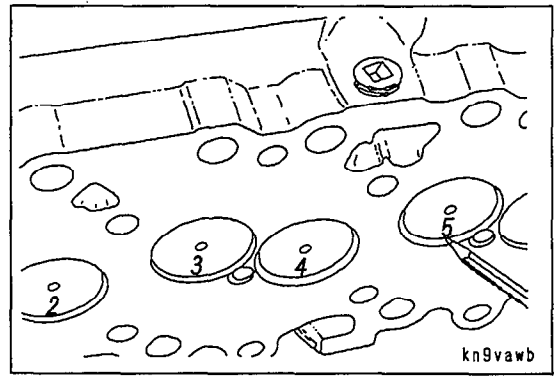
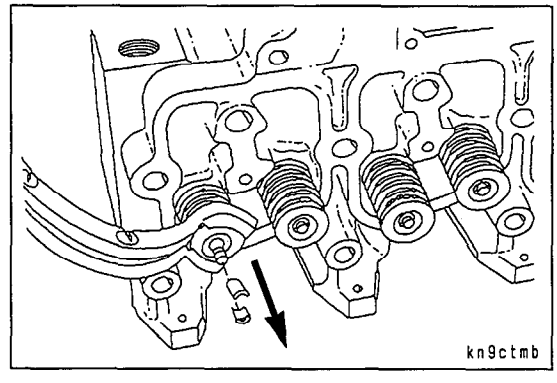
DISASSEMBLY OF CYLINDER HEAD

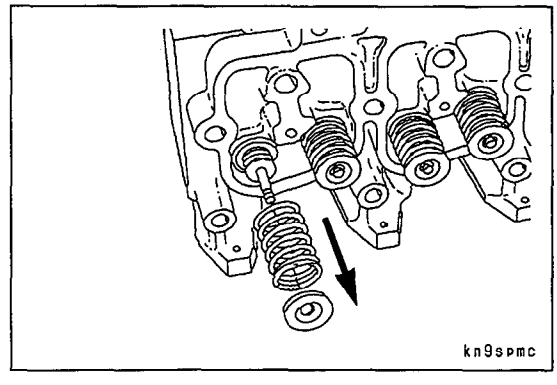
Make marks on the valves to distinguish the position.



Compress the valve spring and remove the valve stem collet.

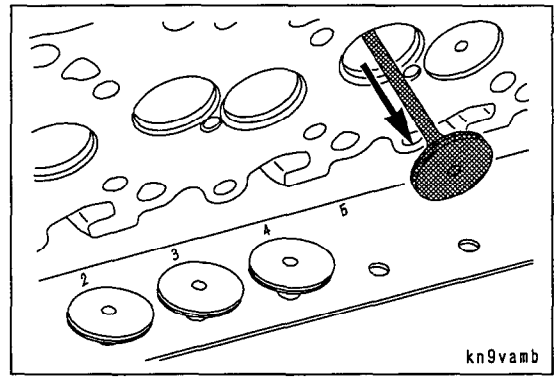


Remove the valve spring, then remove the retainer and spring.



Remove the other collets, retainers, springs, and valves.

When measuring, keep the valves on the labeled rack in sets with their companion seat.



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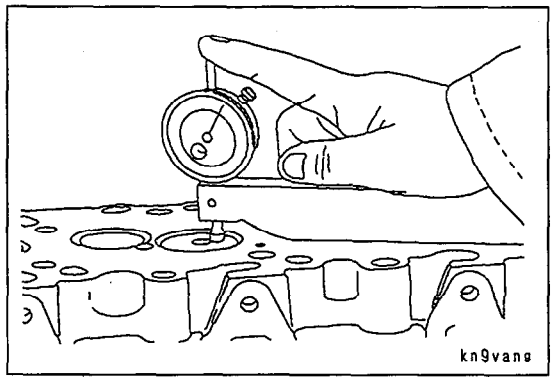
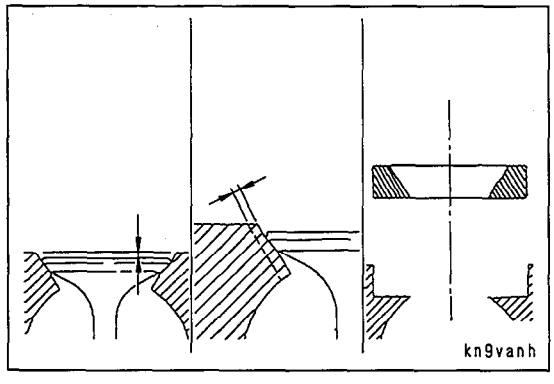
CALCULATING GRINDING DEPTH AND MEASURING DEPTH OF VALVE

Depth gauge (295-290-1300)

Install the valve in the specified position and measure the valve depth.



There are two important parameters for the valve seat when grinding the valve.
The first is to match the limit for the valve depth, and the second is to observe the limit for the grinding depth, and to make sure that the grinding does not penetrate the hardened layer of the valve seat.
If these two parameters do not match the specifications, see Bulletin No. 3810234 replacement repair manual.



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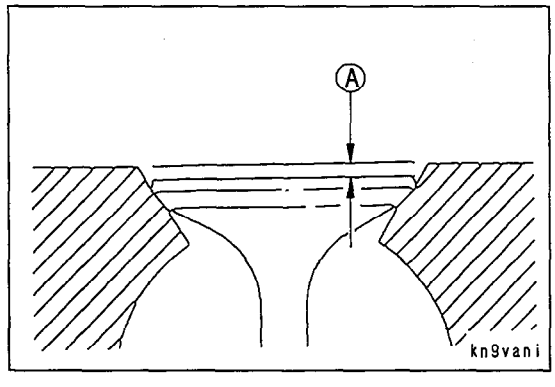
The valve depth is the distance from the valve face to the head deck.

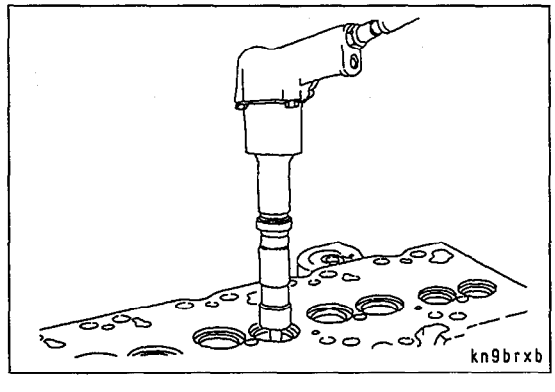
Note down depth (A) for each valve.

Valve depth mm	
0.99	Min
1.52	Max

If the valve depth does not match the specifications, replace the valve seat.

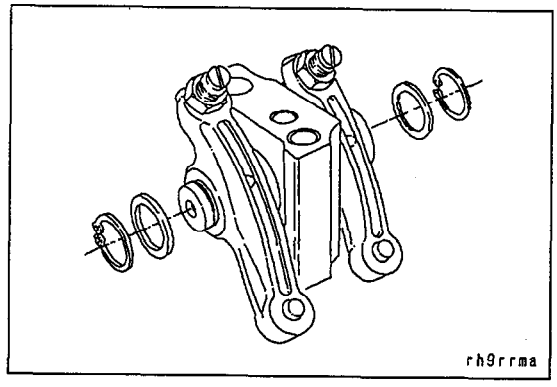


If the valve meets the standard for the initial valve depth, grind the valve seat to remove any chips, scratches, burns, or other damage.

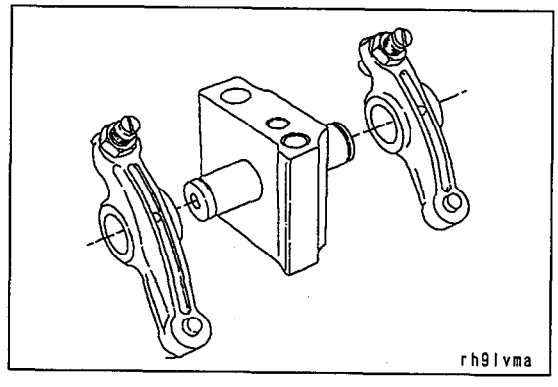


DISASSEMBLY OF ROCKER LEVER

When inspecting the rocker lever and push rod to judge if they can be used again, do as follows.
Remove the retaining ring and thrust washer.



Remove the rocker lever.



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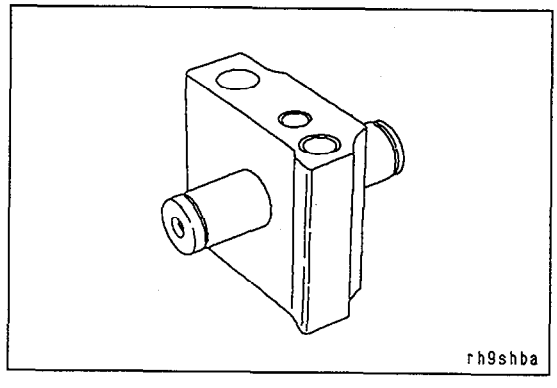
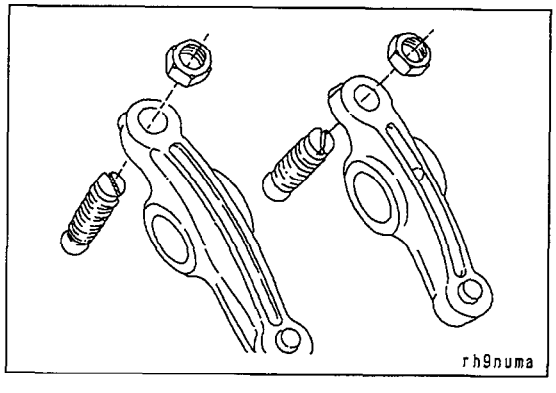
Caution: Do not disassemble the rocker lever shaft and pedestal. Replace the pedestal and shaft as an assembly.



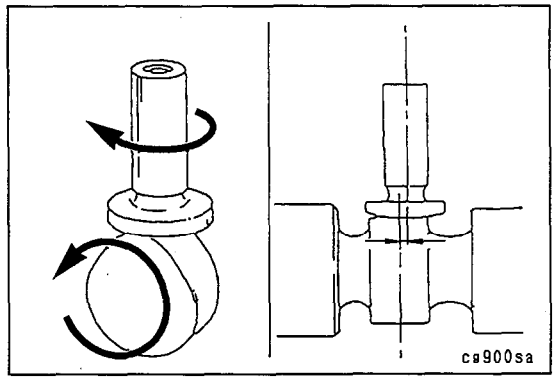
Remove the locknut and adjustment screw.



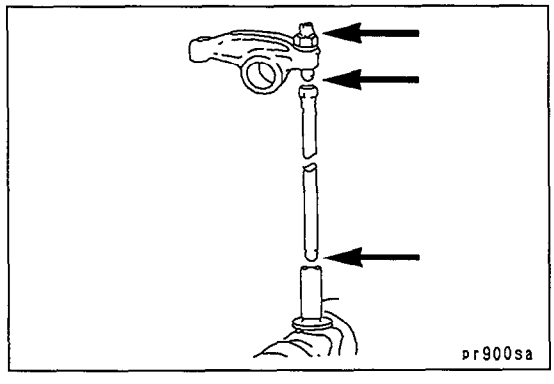
OUTLINE

The camshaft is equipped with a lobe to move the intake and exhaust valves and a special lobe to drive the lift pump. The valve lobe lifts up the push rod, opens the valve, and contacts the valve tappet.

The tappet is a mushroom shape, and is installed so that the center line of the tappet is offset from the center line of the cam lobe. Because of this offset, the tappet rotates and lifts up the push rod.



The ball end of the push rod fits into the ball socket of the tappet. The other end is fitted with a ball socket which moves the ball end of the rocker lever adjustment screw.



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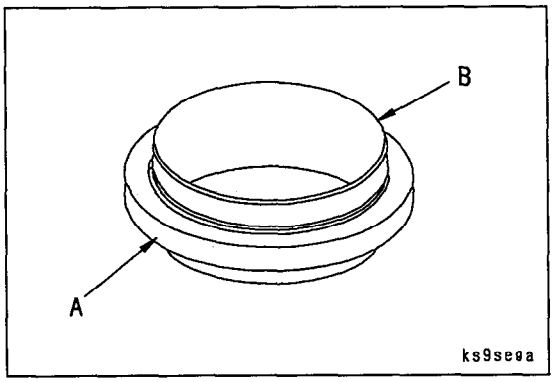
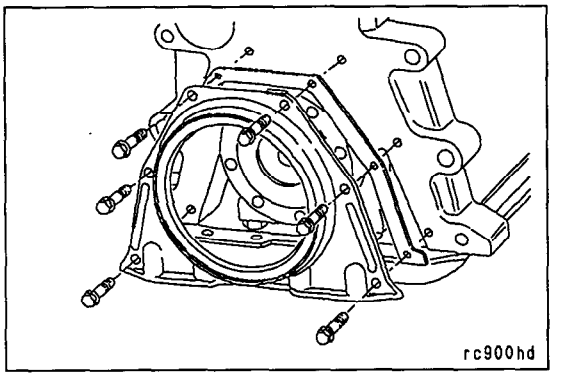
Caution: Install the service crankshaft oil seal (A)/ wear sleeve (B) assembly replacement kit to the crankshaft as an assembly. Do not remove the crankshaft rear oil seal from the rear seal wear sleeve.



Install the rear cover and gasket.

Caution: Install the rear cover mounting bolts. Do not tighten them. When installing the oil pan, loosen the oil pan mounting bolts and make a clearance at the rear cover and at the gasket.

Caution: Using the seal mount, correct the alignment of the rear cover. After installing the seal, to prevent the position of the seal lip from moving, do not push the cover or apply any force in any direction.



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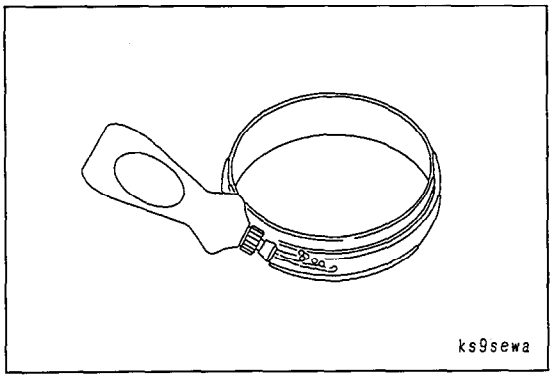
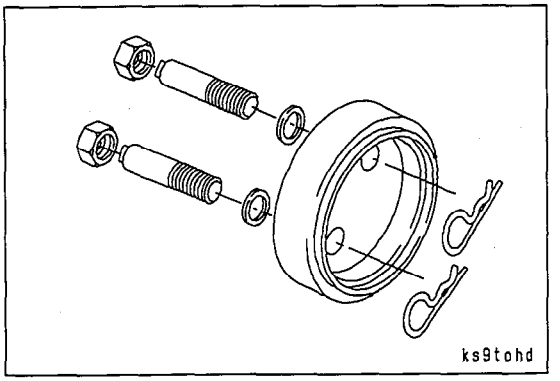
Caution: For the wet flywheel housing oil seal, it is necessary to apply soap around the outside diameter of the seal case. Nothing is needed on the outside diameter of the dry housing seal case.



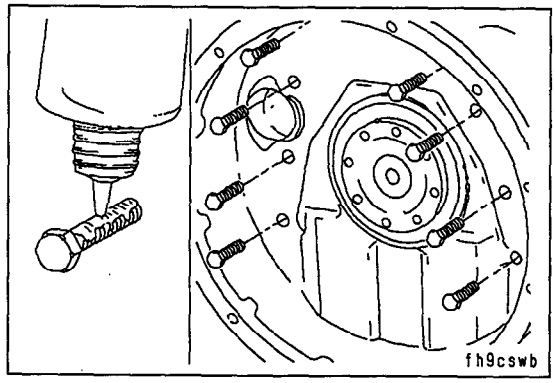
Using the service tool (Part No. 3824078), install the oil seal/wear sleeve assembly. Install 2 threaded studs in the crankshaft mounting bolt holes.

Coat the crankshaft, threaded studs, and crankshaft rear seal/wear sleeve installation tool inside diameter with a small amount of clean 15W-40 engine oil.

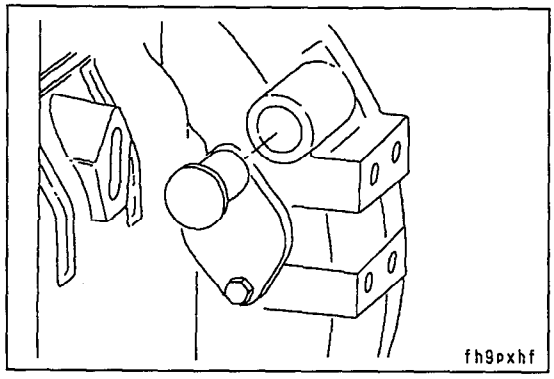


Coat the thread of the mounting bolts with Loctite TM 277.
Install the mounting bolts and tighten them.

kgm: **60 Nm {6.1 kgm}**



Install the plug in the barring gear hole.



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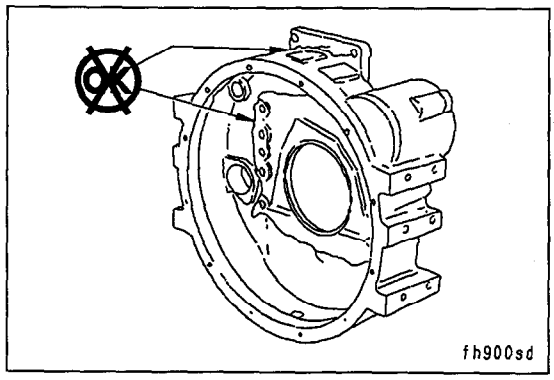
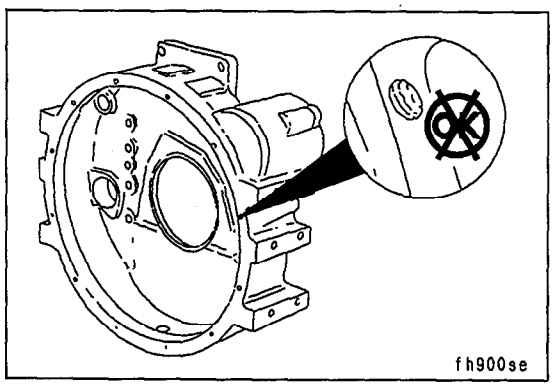
INSPECTION

Inspect the flywheel housing for cracks, and particularly for cracks in the bolt pattern portion.

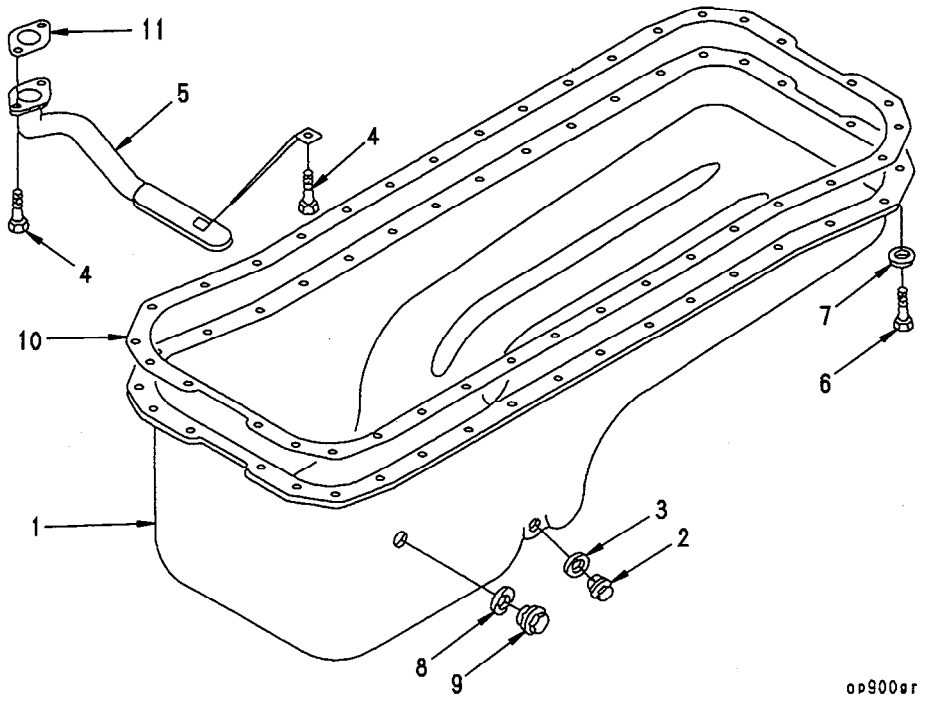


Check that there is no bending of the mating thread of the mounting bolts or damage to the thread caused by installing improper mounting bolts. A helicoil can be used for repairing the damaged thread.



OIL PAN AND SUCTION TUBE

DISASSEMBLY AND ASSEMBLY DRAWING



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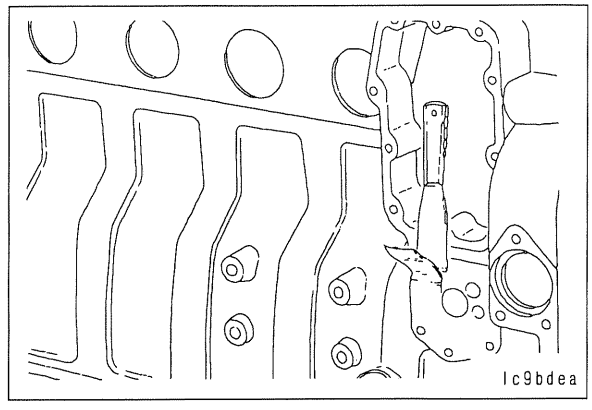
Index No.	Part Name	Q'ty	Remarks
1	Oil pan	1	
2	Threaded plug	1	M18 - 1.5 x 12 mm
3	Sealing washer	1	Thickness 1.5 mm, 18.40 I.D.
4	Hexagonal mounting bolt	3	M8 - 1.25 x 16 mm
5	Oil suction connector	1	
6	Hexagonal mounting bolt	36	M8 - 1.25 x 20 mm
7	Spring washer	36	
8	Spring washer	1	Thickness 1.5 mm, 22.2 I.D.
9	Threaded plug	1	M22 x 1.5 mm
10	Oil pan head plate	1	
11	Flange gasket	1	

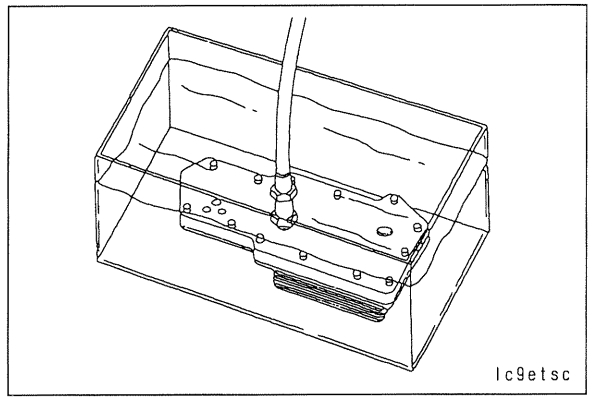
Clean the seal surface.



Leakage test kit 3823876

Test the element pressure to check for leakage. If there is any leakage, replace the element.

Air pressure test	
58 kPa {0.6 kg/cm²}	Min
449 kPa {4.6 kg/cm²}	Max

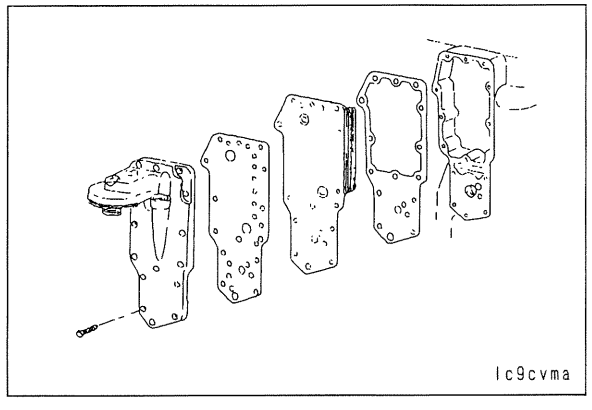


10 mm

Assemble the oil cooler gasket, element, and cover.

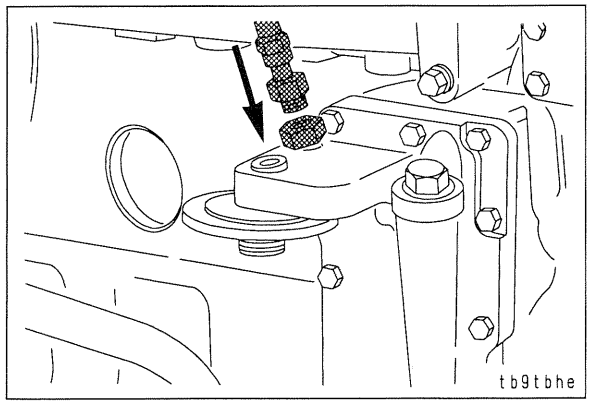
kgm: **24 Nm {2.4 kgm}**

Caution: Always remove the transportation plug from the element.

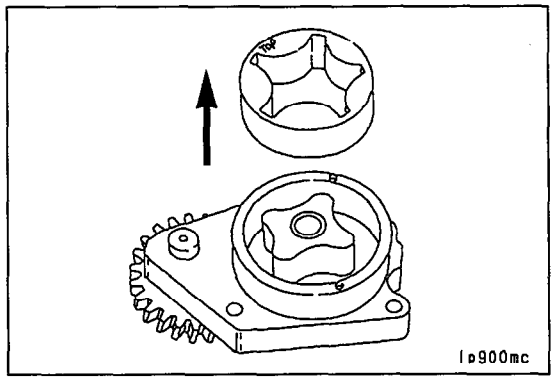


16 mm, 19 mm

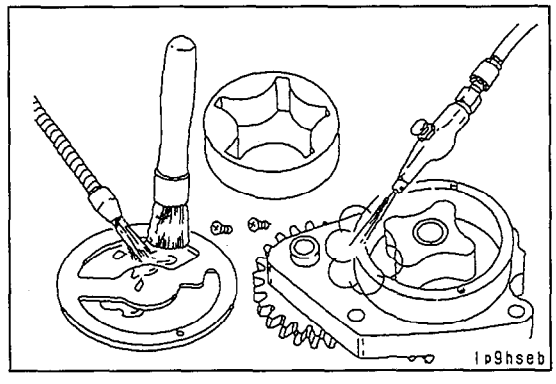
Install the turbocharger oil supply line.



Remove the Gerotor planetary portion.
Check for excessive wear or damage.

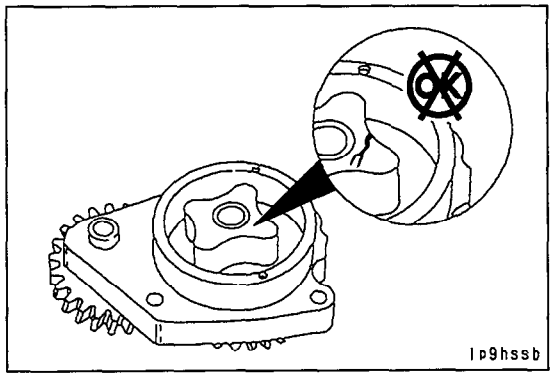


Wash all the parts in detergent, then dry with compressed air.



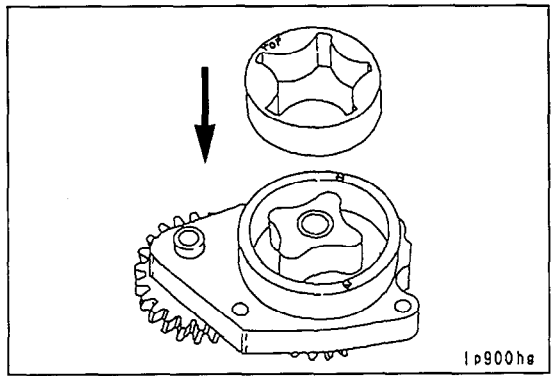
673501

Check the pump housing and Gerotor drive for damage and excessive wear.



Check that the Gerotor planetary portion is installed to its original position.

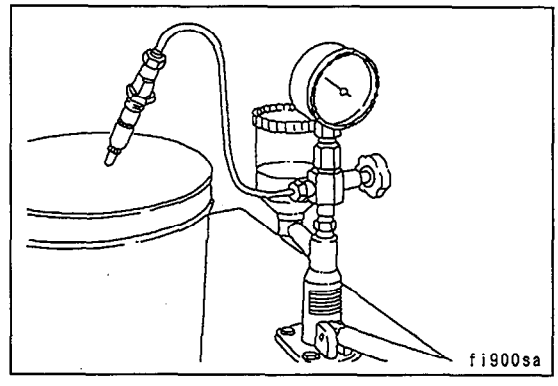
Install the Gerotor planetary portion.



TEST

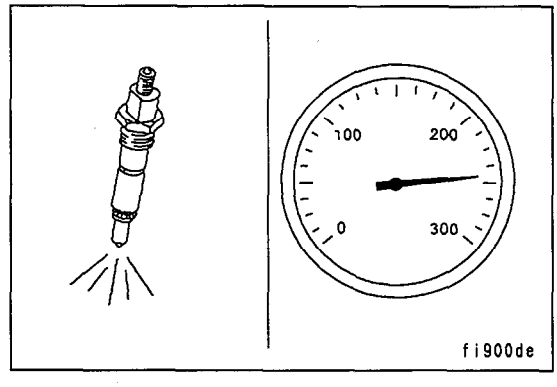
Warning: Be careful not to get the test spray on yourself. If this fluid gets into the bloodstream, it will cause septicemia, which may lead to death.

All nozzle must be tested for opening pressure, chatter and spray pattern.



Test the opening pressure.

a. Open the valve.
b. Operate the lever one stroke every second.
c. Read the displayed pressure when the spray starts.



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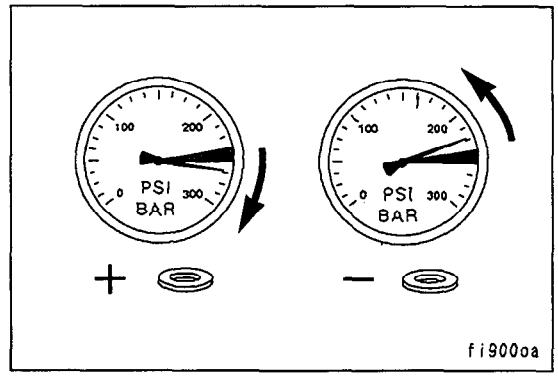
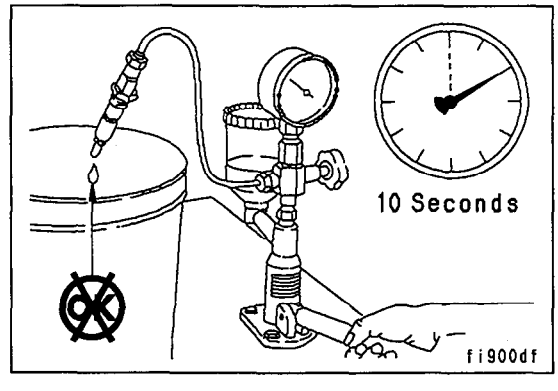
If the port pressure is not within the specification value, replace the shim pack. If the shim thickness is increased, the pressure will rise.



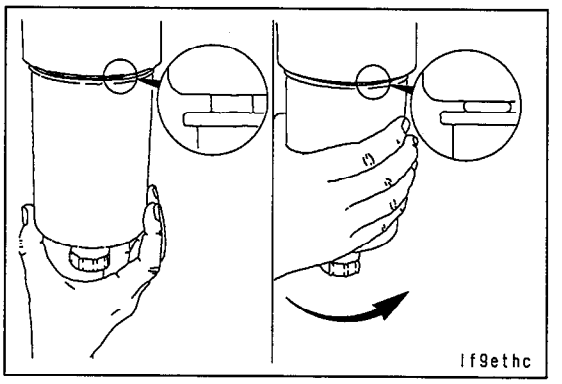
Leakage test:

a. Open the valve.
b. Operate the lever and keep the pressure 14.6 kg/cm² {20 bar} lower than the port pressure.
c. No drops must come from the tip within 10 seconds.

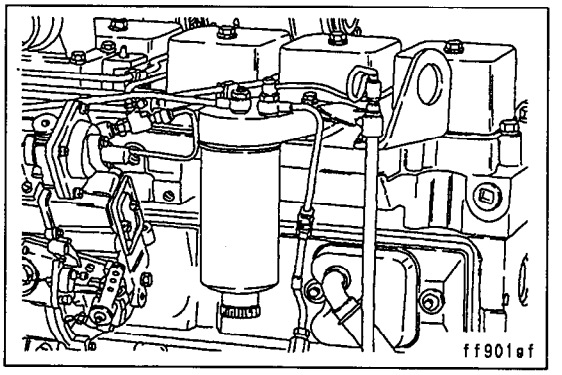


Caution: If the tightening is carried out by machine, the thread may be shredded and the filter element seal and filter can may be damaged.

Install the filter according to the instructions from the manufacturer.



For models of the automobile 102 series engine after 1991 which are equipped with the Bosch P7110 in-line fuel injection pump, the fuel filter is installed to the rear of the intake manifold as shown in the diagram.



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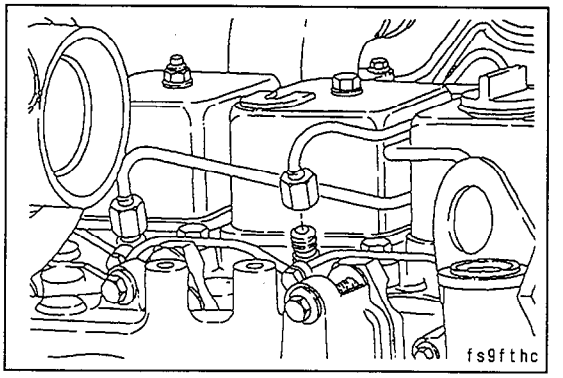
FUEL PIPING

REPLACEMENT OF HIGH-PRESSURE FUEL PIPING (BOSCH VE, LUCAS CAV)

17 mm

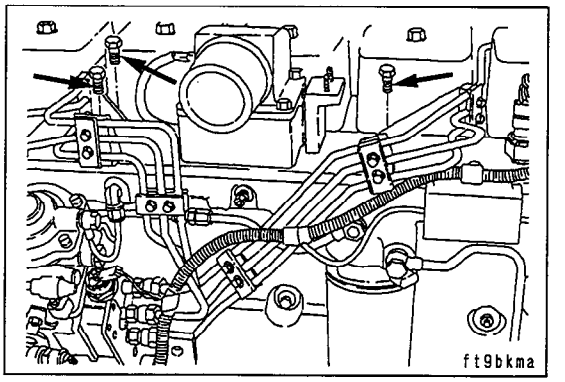
Remove the high-pressure fuel line from the injector, then do as follows.

Caution: Before removing, clean the area around the fuel line thoroughly.



10 mm

Remove the fuel line clamp mounting bolts from the intake cover.



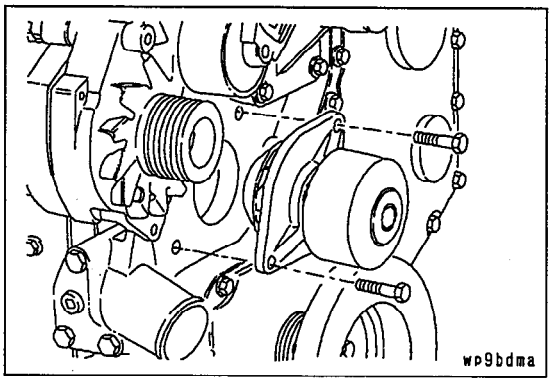
REPLACEMENT OF WATER PUMP

Preparatory work:

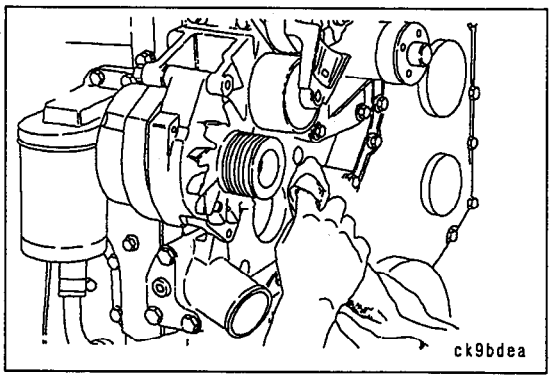
- Drain the coolant.
- Remove the belt.

13 mm

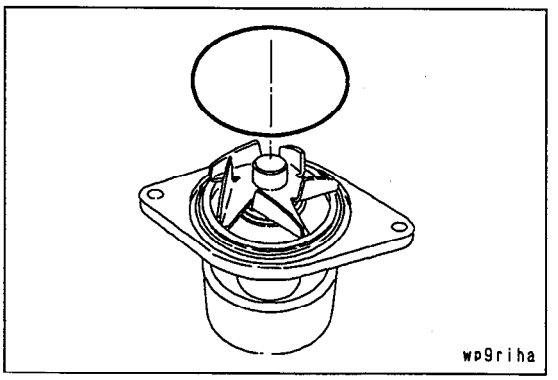
Remove the 2 mounting bolts, then remove the water pump and do as follows.



Clean the mounting surface of the cylinder block.



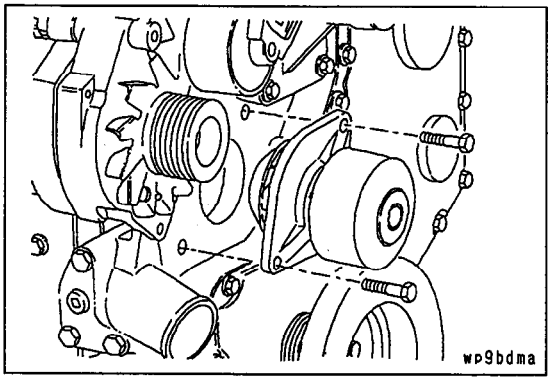
Install a new sealing ring in the pump groove.



13 mm

Install the water pump.

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



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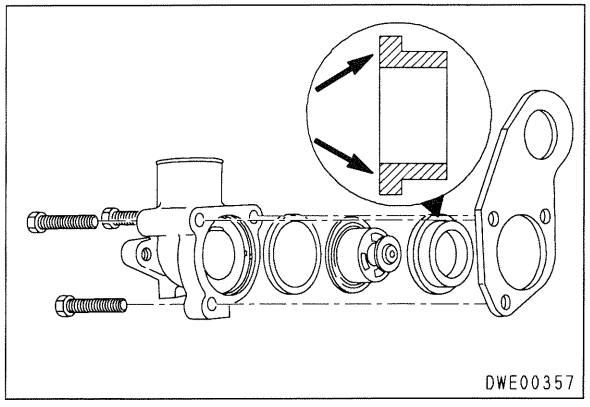
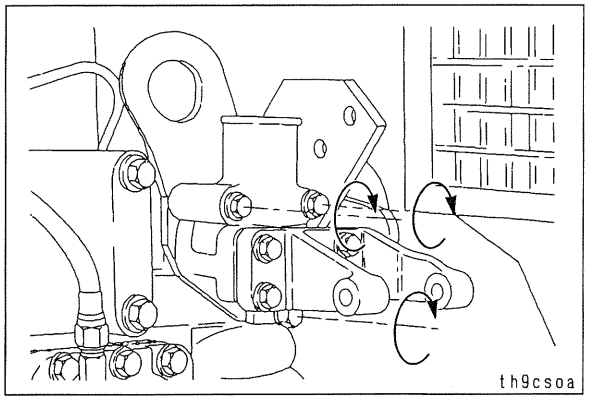
Set the rubber seal in position as shown in the diagram.



10 mm

Assemble the parts in the reverse order to removal.

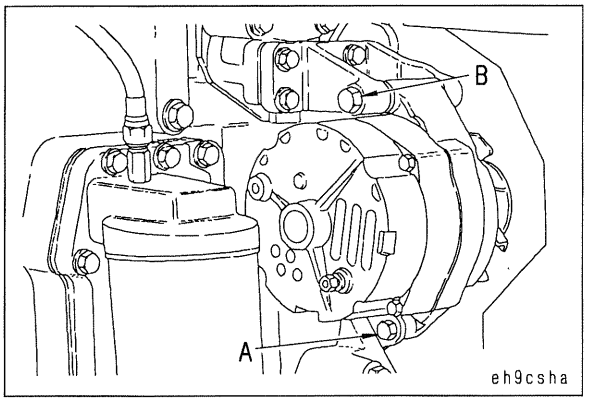
kgm: **24 Nm {2.4 kgm}**



13 mm, 16 mm

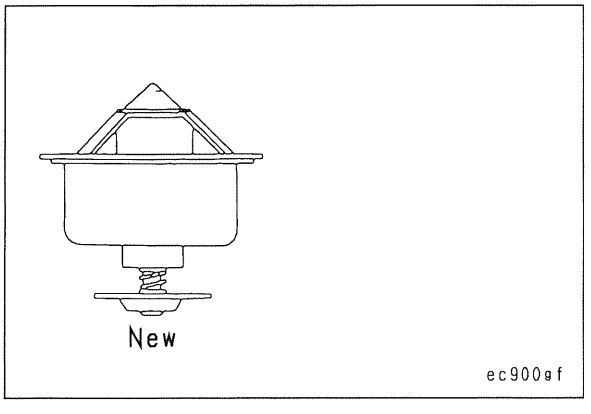
Install the alternator.

kgm: (A) **24 Nm {2.4 kgm}**
(B) **43 Nm {4.4 kgm}**



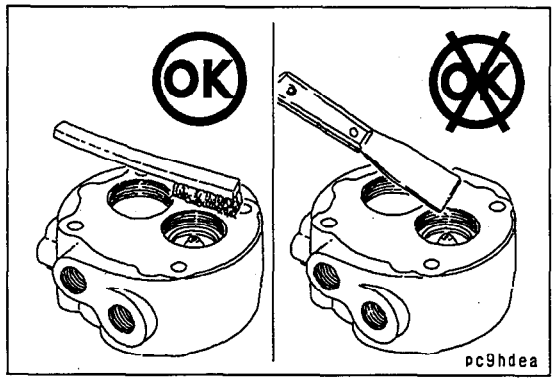
INSPECTION

Check the thermostat visually for obvious damage such as obstructions caused bedris, broken springs, or stuck or missing bent pins.



Caution: When removing the carbon or scale, do not use a scraper. It will damage the seal surface.

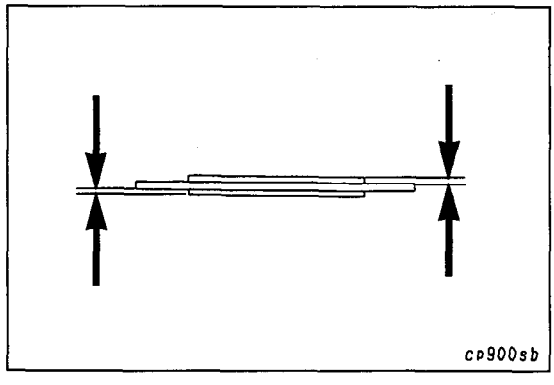
Clean the parts with a stiff non-metal brush.



INSPECTION

Valve disc

Check the disc, and if there are any cracks exceeding 0.13 mm, or holes or grooves, replace the disc.



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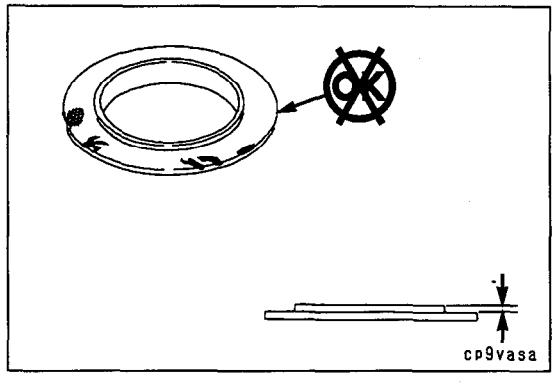
Intake valve seat

Measure the distance between the valve seat contact surface and the valve gauge contact surface.

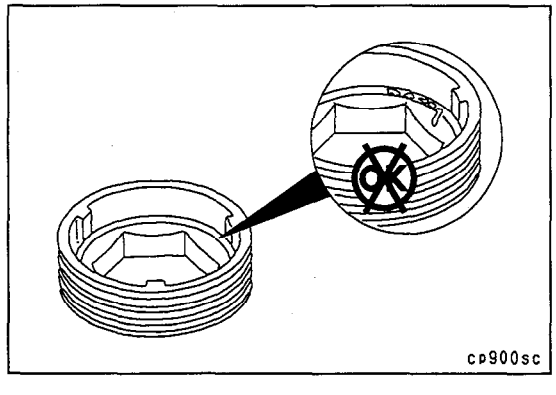
Intake valve seat mm	
0.597	Min.
0.673	Max.

If the seat exceeds the limit or there are cracks or damage, replace the valve seat.

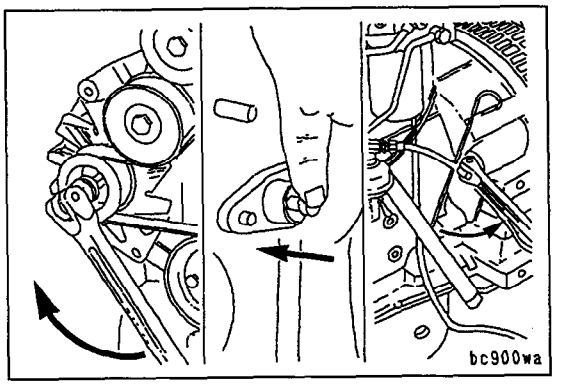


Exhaust valve seat

Check the seat for damage and wear.

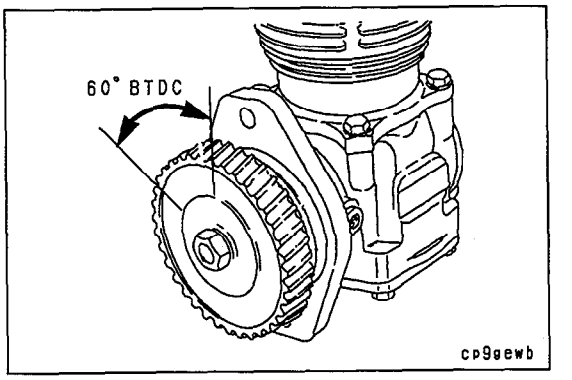


After determining the TDC position, check if the timing pin is out of position.
Push the timing pin and slowly bar the crankshaft to determine the TDC position of the No. 1 cylinder.



Rotate the compressor TDC mark 60° forward from the TDC position or 6 teeth forward (if the gear has 36 teeth). This position becomes approximately the 10 o'clock position as seen from the front of the air compressor.

Caution: On the Holset air compressor series SSQE120, 296, and 338, a radial line indicating the TDC position is etched on the gear.



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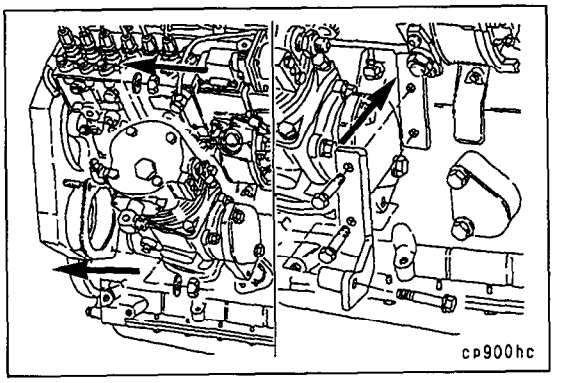
INSTALLATION

18 mm, 14 mm, 10 mm

Fit a new gasket and install the air compressor to the gear housing.
Install the air compressor support bracket.

kgm:
Mounting nut : **77 Nm {7.9 kgm}**
Support mounting bolts : **24 Nm {2.4 kgm}**

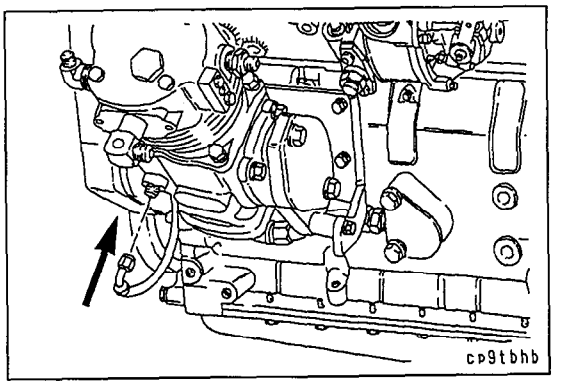
Caution: The gear timing is unnecessary.



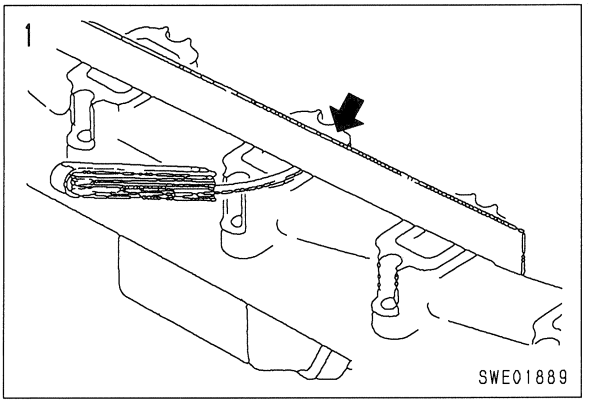
9/16 inch

Install the oil supply line.

kgm: **15 Nm {1.5 kgm}**



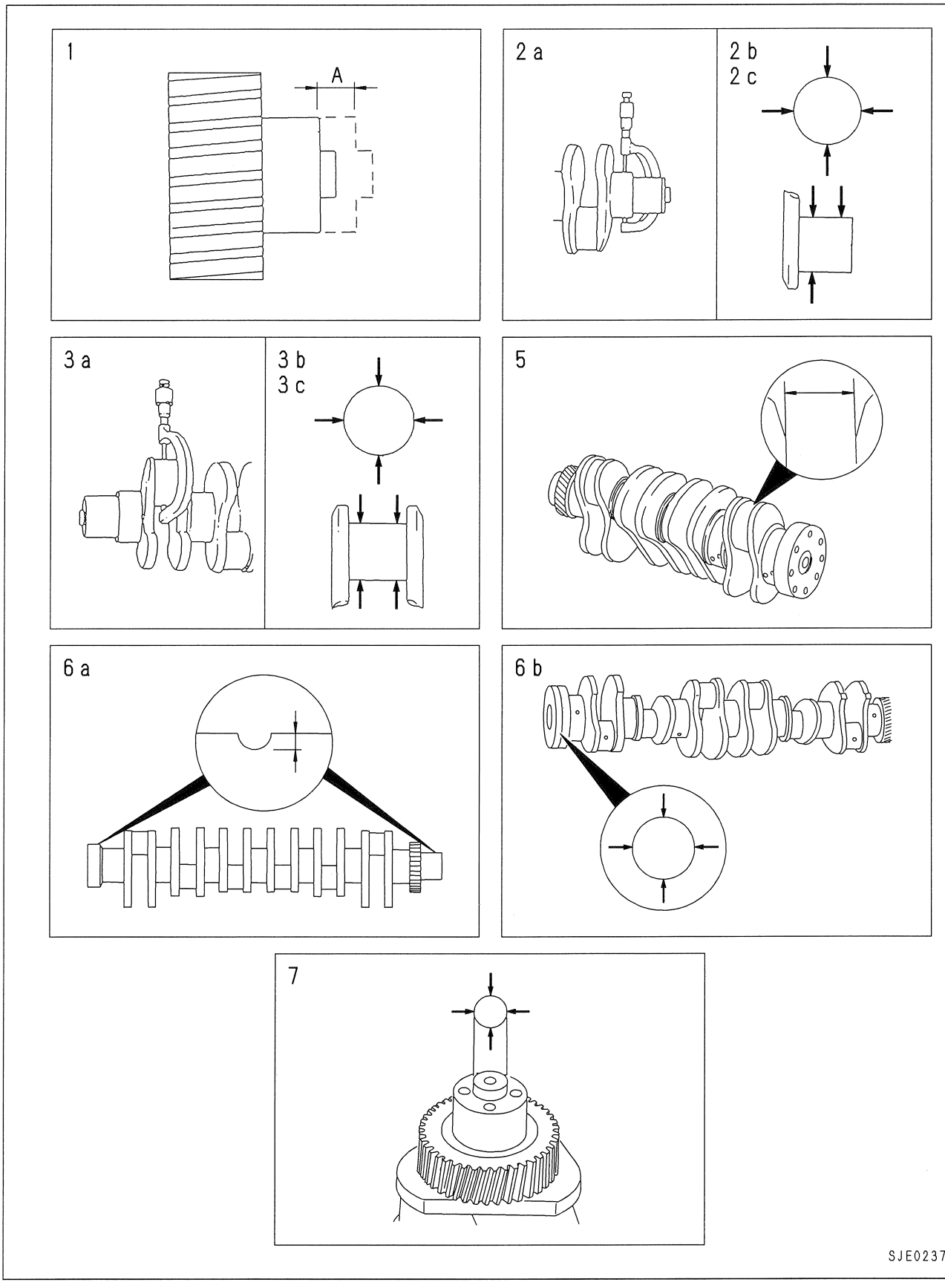
EXHAUST MANIFOLD



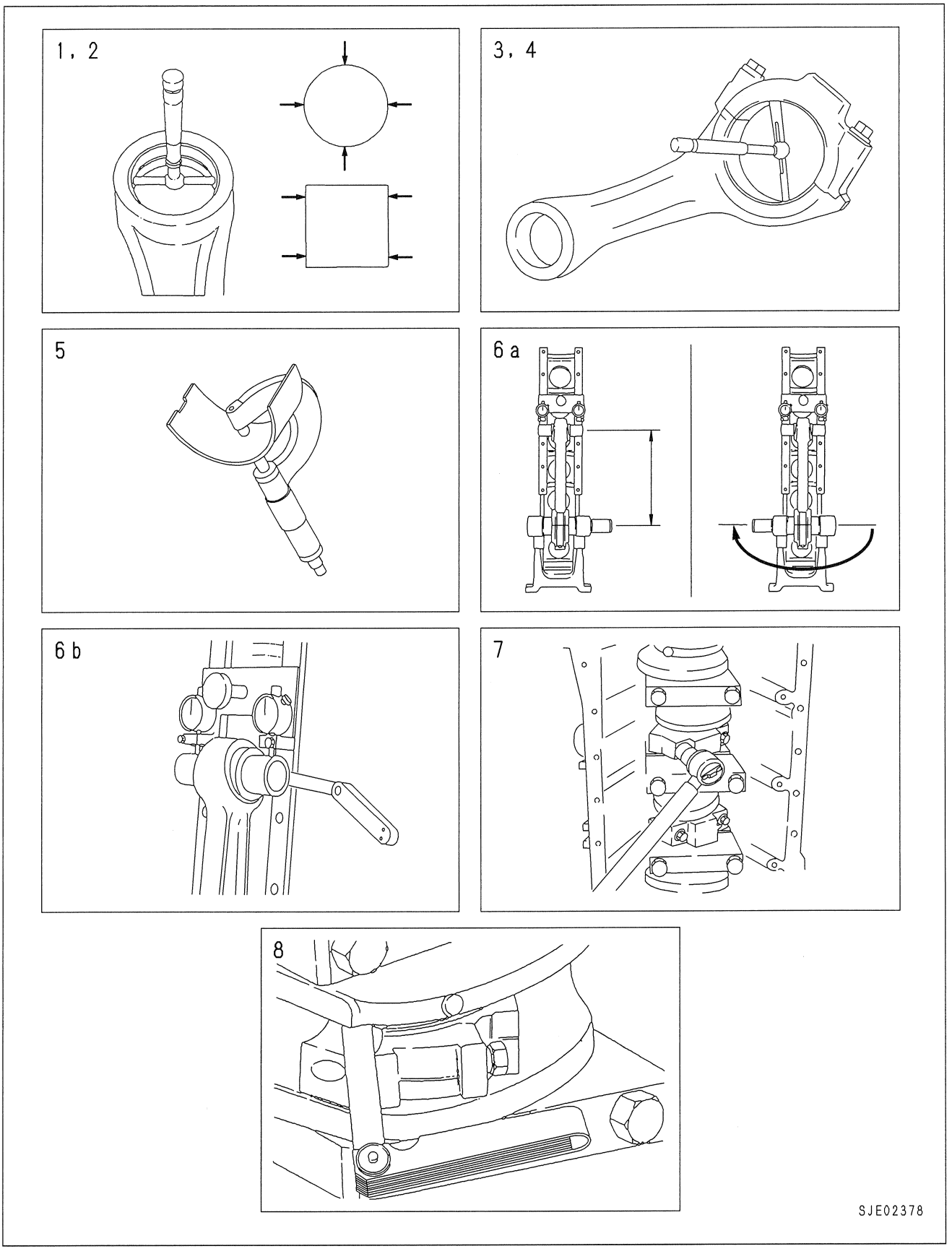
Unit : mm

No.	Check item	Criteria	Remedy
1	Flatness of exhaust manifold	0.10	Replace

CRANKSHAFT

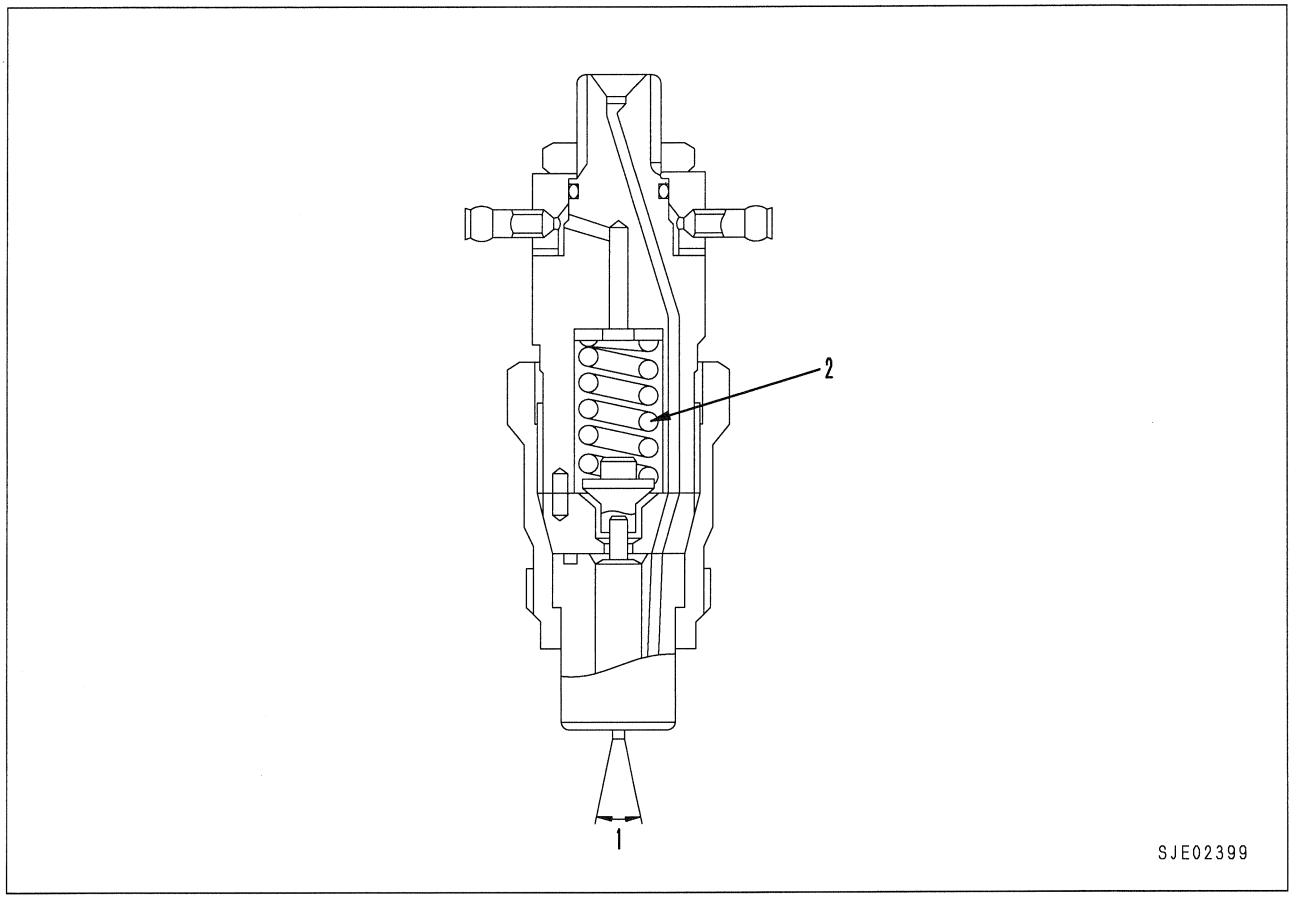


CONNECTING ROD



FUEL INJECTION NOZZLE

102E-1



Unit : mm

No.	Check item	Criteria			Remedy
1	Spray angle	Standard: —			Replace nozzle
	Nozzle cracking pressure (injection pressure)	Standard	Repair limit		Adjust or replace
		—	—		
2	Free length of nozzle spring	Standard size	Repair limit		Replace
		—	—		
	Installed load of nozzle spring	Installed length	Installed load	Load limit	
		—	—	—	

PROCEDURE AND TOOLS FOR REPAIRING CYLINDER BLOCK

Valve refacer

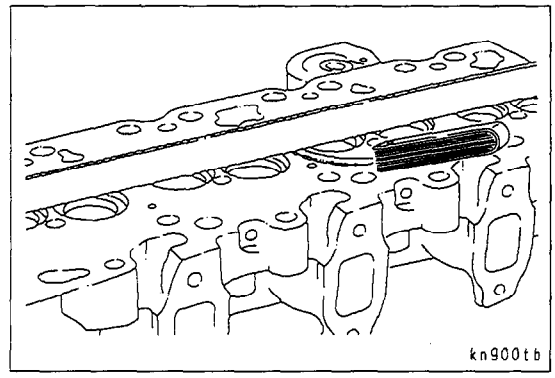
Valve seat grinding machine

Valve guide installation tool

INSPECTION AND GRINDING TO REPAIR COMBUSTION DECK

Check the head surface and look for chipped or scratched places and corrosion

Check that there is no deformation of the head as shown in the diagram.



Limit

Variation value: 0.010 mm (0.0004 in) for area of any radius of 50.8 mm (2.0 in)
The limit for the overall variation value from one edge to the other edge is as shown below.

0.20 mm - 4-cylinder engine
0.30 mm - 6-cylinder engine

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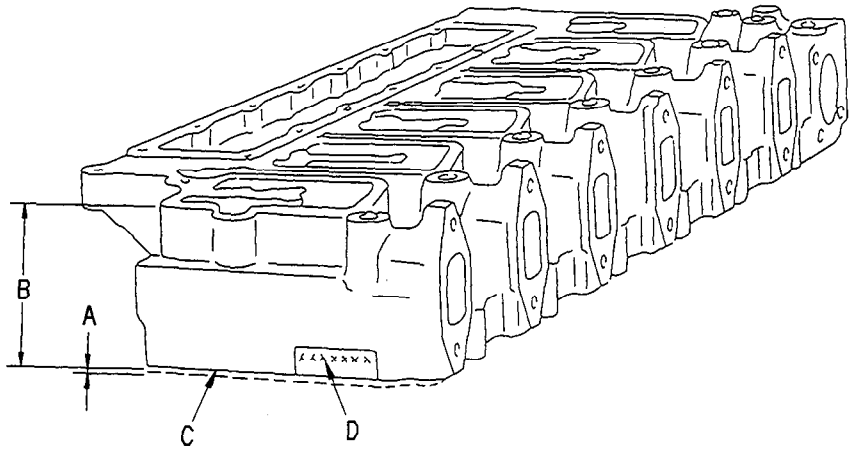
Remove any dirt from the surface of the combustion deck. If there is any need to maintain the surface smoothness or the repair limit for flatness, it is possible to grind the desired amount provided the amount that is ground does not exceed a total of 1.00 mm. Each amount of grinding must be displayed with a steel stamp at the bottom right corner of the rear face immediately above the edge of the combustion deck.

A = Total 1.00 mm

B = Min. 94.00±0.25 mm (given only for reference)

C = Surface finishing 1.5 to 3.2 micrometres

D = Location to display amount of grinding with stamp

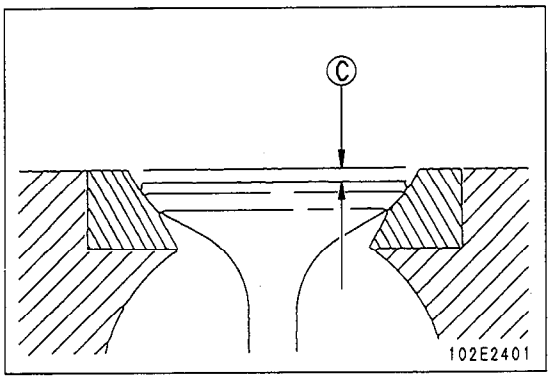


102E2372

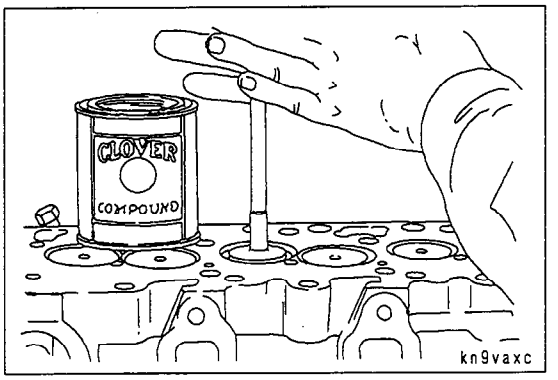
Check depth (C) of the valve.

Limit

Depth: 0.99 mm - 1.52 mm



Coat each valve lightly with valve lapping compound, then fit a bar to each valve and rub the valve until it fits.



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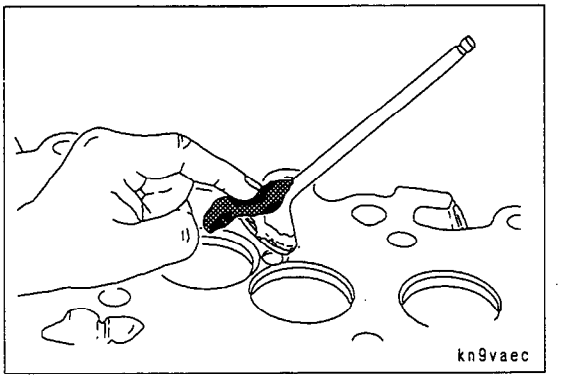
Remove the valve, and wipe off all the lapping compound from the valve and seat.

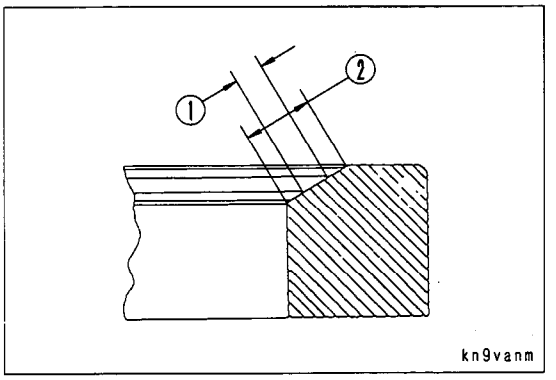


Measure the width of the valve seat to the lapped surface.

Limit for valve seat width

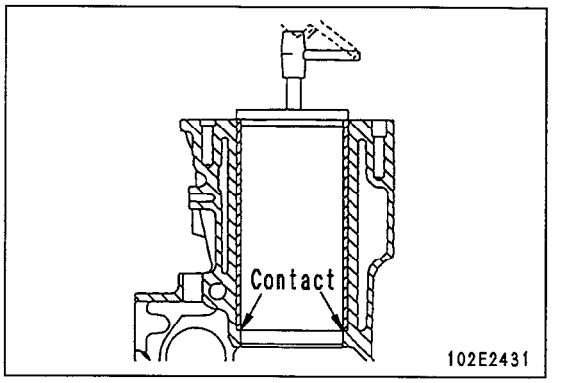
Min. value 1: 1.5 mm

Min. value 2: 2.0 mm



Komatsu part number 3823230

Using a sleeve driver, push the sleeve in until it contacts the step at the bottom of the bore.



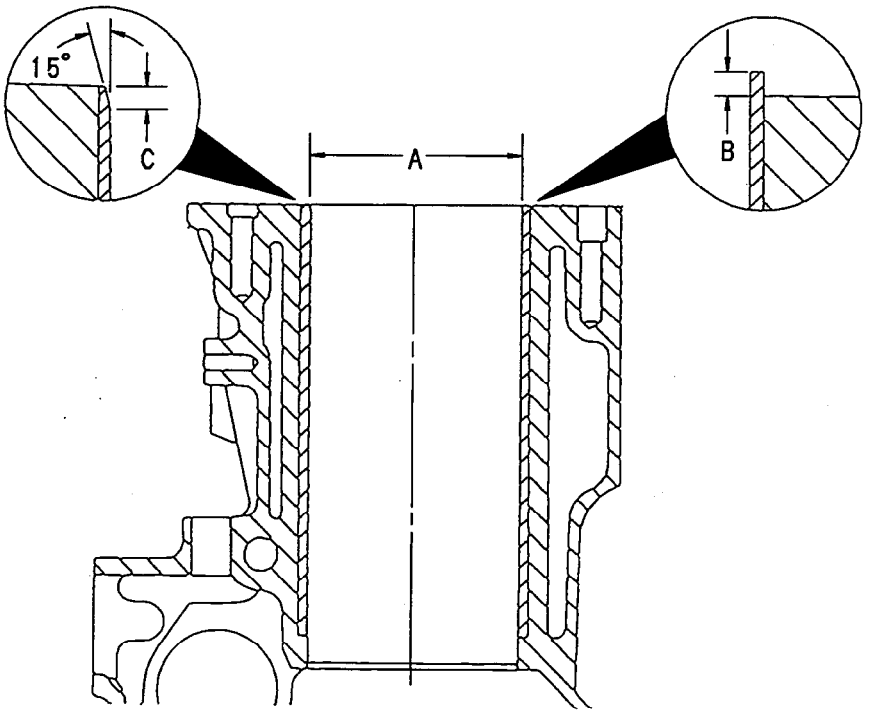
Set up the boring bar and machine to the following dimensions.

A = 101.956 mm

B = Min. - level with block
Max. - protrudes 0.050 mm

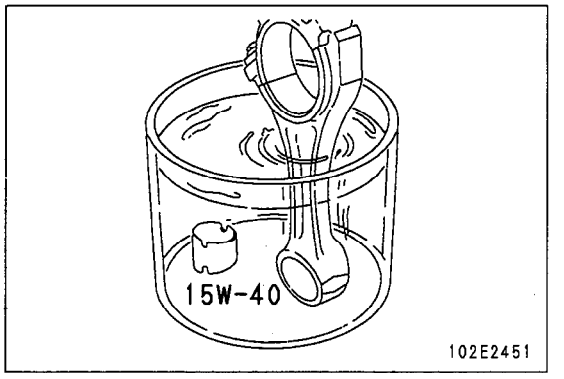
After removing the boring bar, use a honing grindstone to grind the edge of the repair sleeve to dimension C.

C = Approx. 1.25 mm x 15°

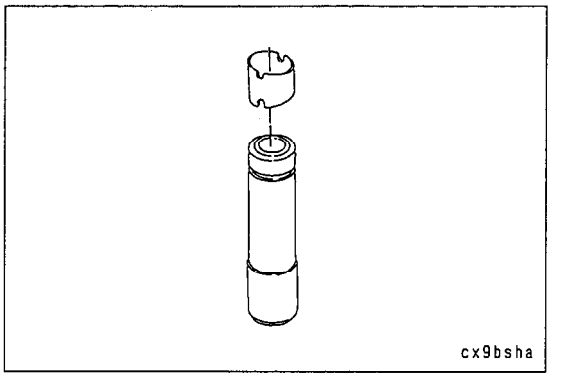


INSTALLATION OF PIN BORE BUSHING

Before installing the bushing, soak the bushing and connecting rod pin end in clean 15W-40 engine oil.

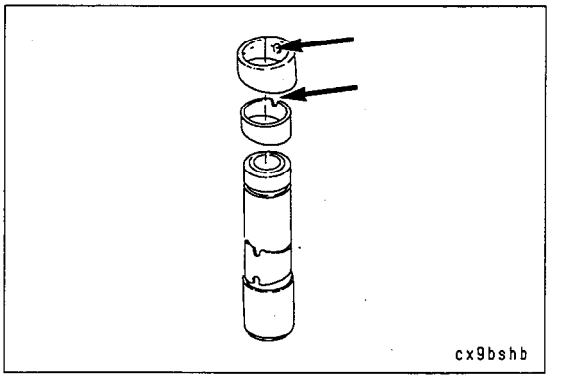


Install the bushing to the mandril.

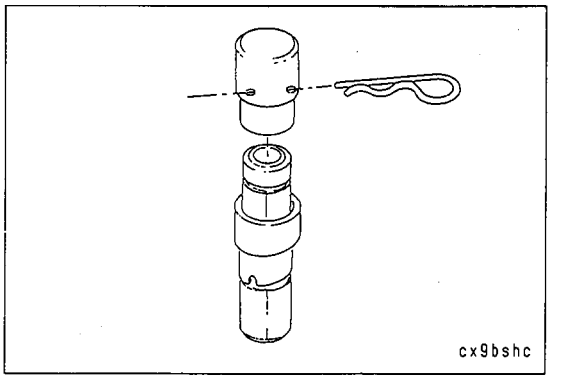


Insert the removal/installation ring on the inside of the stop ring.

Align the angle, set the side with the angle at the bottom, then align the notch of the removal/installation ring with the pin on the inside of the stop ring, and slide it on the mandril.



Install the cap and secure with the hair pin cotter.



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